THE N.R.C. RECEIVER REFERENCE MANUAL

2ND EDITION — MAY 1978

The NRC Receiver Reference Manual is the second in a series of such booklets, each devoted to a different subject area in the hobby of medium wave DX'ing. Some of the articles appearing herein have previously appeared in the pages of DX NEWS, while others have been especially prepared for this manual. Every effort has been made to include the most popular and most generally useful articles. We wish to thank the following authors whose works make up this manual: Leo Alster, Russell J. Edmunds, Robert Foxworth, Chuck Hutton, Raymond S. Moore, Gordon P. Nelson, Ron Schatz, Thomas Sundstrom and Robert Fischer.

The NRC has numerous other articles dealong with the subjects of receivers antennas, and a variety of other areas. Those which have appeared in DX NEWS are generally available through the NRC Reprints Service. Additional manuals are available on antennas and on Beginners' subjects. Further still, a series of articles by non-members, generally from the amateur and scientific press are available through the NRC Monographs Service. A complete listing of Reprints, Manuals and other DX books published by the NRC may be obtained from the NRC Membership Center, address below. A listing of NRC Monographs may be obtained for an SASE plus 50¢ from NRC Monographs, P.O. Box 127, Boonton, NJ 07005. All other published materials should be ordered from the NRC Publications Service, P.O. Box 401, Gales Ferry, CT 06335.

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Second Printing, May 1978.

REDOING OLDER RECEIVERS FOR MW RECEPTION

Chuck Hutton

About six months ago I bought an HQ129X for $50 (the going price is usually $50-$75) and immediately began a rejuvenation program. The results were so pleasing that I decided to share the results in DX News. By pleasing I mean that for about $100 I have a receiver that outperforms the much more expensive Collins R390A and R388 with added mechanical filters.

The biggest objections to older receivers in my mind were lack of selectivity and lack of sensitivity. The first is a valid complaint but as I have found out there is absolutely no truth to the latter; a point to bear in mind is that sensitivity to the order of a few microvolts is not needed on the MW band and in fact is detrimental to the receiver. The explanation for this is that atmospheric noise levels are the controlling factors in what you can hear and what you can't, rather than the sensitivity and noise figure of the receiver front end. As for the detrimental effects of what is considered "good" sensitivity-say in the order of .5 to 5 microvolts-it must be remembered that since such sensitivity is not necessary for weak reception, that gain is only increasing the signal voltage applied to the stages that overload on strong signals.

I do want to emphasize that these comments apply only to reception on the MW band. As the frequency is raised, atmospheric noise decreases and the gain of the receiver becomes all important in determining what can be heard. The HQ129X as is or modified as per this article will be a very poor receiver for frequencies above 8 mHz. In no particular order here is what I have done to the 129X.

RF stage: the gain of this stage is very low by modern standards. On the surface this sounds bad but as explained before for MW reception it makes good sense to use as little gain as possible. The 6SS7 tube in the set is probably OK but I do think that the receiver became a little hotter when I pulled it and put in a 6SG7-the 6SS7 has a transconductance of 1800 micromhos and the 6SG7 4300 micromhos. To use the 6SG7 merely disconnect the wire that runs from the suppressor grid (pin 3) to ground. The extra gain does not seem to hurt the strong signal handling capabilities of the set.

Mechanical filter: this will help the receiver more than any other change. Collins has made a variety of mechanical filters, and over the years they have gotten better in terms of shape factor and insertion loss. Size has also decreased remarkably, so that in many cases they can easily be mounted near the tube socket that they are connected to. I chose an F455FA21 filter as it has a low insertion loss (6 dB) and is the smallest filter that I have seen to date. The shape factor is also adequate. By way of comparison some of the older filters have insertion losses of up to 25 dB and are 3 to 4 times as large. The low insertion loss will spare you all the trouble of building a stage of IF amplification to compensate for the insertion loss; in my experience most of the trouble encountered in installing filters is caused by the amplifier stage. In the case of the 129X the secondary of the IF transformer between the mixer stage and the first IF is voltage tapped so that all of the signal voltage is not applied to the tube. When I pulled the transformer and installed the filter the insertion loss of the filter exactly balanced the voltage loss from the tap that was no longer used, the net effect being that signal levels were the same before and after. I mounted the filter on a small piece of perf board that was epoxied at each end to the shields that run around the coils near the area between the mixer socket and the first IF. Connections were made with miniature shielded coax. The mechanical filter itself was not shielded although I will admit that there is probably a small amount of leakage around it that could be eliminated thru a shield. The bandpass of this filter is 2.1 kHz; a bit too narrow for AM reception unless highpass audio filtering is used. It is a necessity to remove some of the lows, otherwise the audio will sound too muffled and bassy and intelligibility will suffer greatly. It is standard knowledge among audiologists that the center frequency for the portions of the audio range contributing most to intelligibility is raised half an octave by the presence of lows below 400 hZ; speech can be made perfectly intelligible if these lows are removed. The MFJ SSB audio filter is the only commercial unit short of professional types I am aware of that is a combined lowpass-highpass filter and as such is the only filter that will help improve the audio from a narrow bandpass mechanical filter. The Autek QF1 is a bandpass filter and therefore not what is needed under these circumstances.

AVC system: AVC voltage is not applied to the third IF stage on the 129X. Slightly better gain control can be had by disconnecting the black IF transformer lead from ground, connecting a 10K decoupling resistor to it, and running the other end of the resistor to the AVC buss. At the terminal of the resistor that is tied to the transformer lead add a .01 mfd capacitor to the nearest ground. Also added was a sinking diode to make the system into a delayed AVC. This holds the AVC voltage to zero until a strong signal comes along, so that gain is not lessened on weak signals. For details see the CQ article in the reference.
Q-Multiplier: exalted carrier reception is still an unknown technique to most MW DX'ers. Those that have tried this trick agree that it is a great help in weak signal reception. For background read Ray Moore's article in the NRC Receiver Reference Manual and the original Q-Multiplier article by Villard and Rorden. Most receivers will not have enough extra front panel room to mount all the controls (if you want a Q-M that will peak and null) so outboard connection becomes necessary. I mounted an octal power jack on the rear panel to supply the needed B+, filament, and ground connections; for the shielded cable to the IF transformer a phono jack was also mounted on the rear. It doesn't seem to matter to which IF transformer it is connected, as long as it is after the mechanical filter.
Semiconductor power rectifiers: heat in the power transformer and the rx becomes a problem with the added filament consumption of the 6SG7, calibration oscillator, and Q-multiplier. To lessen the current draw and insure long life the 5U4 rectifier was replaced with a pair of 1N4007 diodes rated at 1000 volts and 1 ampere. The slight increase in B+ voltage that resulted was ignored; the increase resulting from the negligible forward voltage drop of the semiconductors as compared to the 25-50 volt drop across a vacuum tube rectifier. In some rigs with little safety factor in bleeder resistor and filter capacitor ratings it will be necessary to add some extra resistance in the power supply.
Semiconductor detector: further decrease in power draw from the transformer and increased efficiency in dteection can be had by pulling the 6H6 tube diode and replacing it with suitable high back resistance diodes. I used a pair of 1N914's as they are cheap and easily available; other types are available which will probably function a bit better. Using the 1N914 will yield too low a clipping level for the noise limiter but as I consider it practically useless for MW DX'ing anyhow no effort was made to correct this.
Speaker terminals: I know you don't like those inconvenient screw terminals provided. Go get a pair of binding posts, remove the screws, and screw the posts thru the vacant holes. Tighten them down with a lockwasher and nut on the inside. No more breaking your back to use a screwdriver in a place you can't even see.
Antenna terminals: also the screw type. In addition to being inconvenient, they do have some pickup from strong signals and noise. Replace them with coax type connectors as per Foxworth in the NRC Receiver Refernece Manual. The whole thing can be done very quickly as the terminal board almost exactly fits 2 SO239's.
Antenna switcher: getting up and bending over a receiver on a crowded desk to change antennas can be rather tiring. I ran shielded coax from thetwo antenna terminals on the rear panel to a double pole double throw toggle switch mounted on the front panel. It automatically grounds the antenna not in use so that there will be no pickup from the line.
Product detector: while not of much interest to most NRC'ers, a product detector can be easily installed for sideband reception. Basically the BFO tube is pulled and replaced with a similar tube that has both an oscillator section and mixer section, allowing product detection without major rewiring or an outboard unit. The CQ article (see references) was followed with no trouble and I now use the 129X for 80 and 40 meter ham bands.
Crystal calibrator: for dial alignment on higher frequencies and for a steady signal source during alignment a crystal calibrator is handy. I used a 6BZ6 as an oscillator and mounted the unit on top of the cover for the tuning capacitors. A front panel switch disconnects the cathode from ground to turn the oscillator off. Cheap CMOS semiconductor units are available that are more versatile and require less power-the Rainbow Industries unit sells for $19.95 and puts out markers every 100, 50, and 25 kHz.
Alignment: can range from difficult to impossible with the receiver out of the cabinet. The dial calibration is always off a bit when the rx is back inside its shell. You can add a front panel trimmer as per Foxworth but a cheaper and easier alternative is to drill access holes in the bottom of the cabinet. The coils and trimmers are easily reached.
Wax paper capacitors: have limited lifespans. I guarantee that they won't last much longer if they aren't gone already. Run, not walk, to the near-

Cont'd on pg. 71

another SPR-4 test

- Robert Fischer

1. SENSITIVITY.

Two SPR4 receivers, serial numbers 1443 and 201, were compared with a 1970 model HQ-180AC and a realigned National NC-183D. Both tube receivers were known to be in peak operating condition. Antennas used were a 100 foot long wire and the SM-2. The two SPR4's proved to be just as sensitive as the tube receivers. #1443 had slightly greater sensitivity and slightly lower internal noise than did #201. John had some trouble with noisy mixer transistors in #201 shortly after the warranty expired. The manufacturer made the repairs and paid shipping charges....at no cost to John. He said the company was most cooperative.

A Canadian DX'er reports that the very expensive Collins 51S1 and 651S1 receivers are no more sensitive on the BCB than the HQ-180 (and therefore, no more sensitive than the SPR4). (Refer to IRCA DX Monitor, p. 13, Aug. 12, 1972 issue) Receiver specifications on BCB sensitivity were given as:

Receiver	Signal required for 10 dB S+N/N (AM)	
Collins 51S1 with preselector	5 uV on BCB	
Collins 651S1	10 uV on BCB	
HQ-180A	1-1.5 uV typically	all bands
Drake SPR-4 (manufacturer's specs)	0.5 uV	MW, SW

In my opinion, the two SPR-4's reviewed easily meet the manufacturer's specifications. I might add that the receivers were compared on the SW bands as well as on the BCB.

To get good long wave reception with the SPR-4, the antenna impedance must be matched exactly to the receiver input using an electrical pi network device.

2. SELECTIVITY

Using the 1000 kHz calibration signal, plots of the receiver selectivity were made by first calibrating the receiver to exactly 1000 kHz, then switching the receiver to the AM, CW, USB and LSB modes and taking S-meter readings at 200 Hz intervals. This receiver has a crystal filter in the 5645 kHz 1st IF and an LC filter in the 2nd IF (50 kHz). The results are shown in the four graphs. In terms of selectivity, the most significant finding was the very steep slopes of the SSB and AM filters, giving the receiver excellent deep skirt selectivity even though the filter was 4.9 kc wide on the top for the AM function. The shape factor of the AM filter was 1.4 which is nearly as good as a mechanical filter. The slope of the selectivity curve is considerably sharper than that for the corresponding 6 dB selectivity in the HQ-180A receiver.

2. SELECTIVITY (continued)

The graphs shown are for SPR4 #1443. Briefly, the receiver's deep skirt selectivity was found to be much better than the manufacturer's specifications.

MODE	MANUFACTURERS SPECS-BANDWIDTH		SPR-4 #1443 ACTUAL SELECTIVITY	
	at 6 dB	at 60 dB	at 6 dB	at 60 dB
AM	4.8 kHz	10.0 kHz	4.9 kHz	6.8 kHz
USB	2.4 kHz	7.2 kHz	2.5 kHz	4.5 kHz
LSB	2.4 kHz	7.2 kHz	2.7 kHz	4.9 kHz
CW	0.4 kHz	2.7 kHz	0.6 kHz	1.7 kHz

Of course, one should realize that AM signals on the BCB are much sloppier than the one generated by the crystal calibrator, which puts out about a 15-20 dB over S-9 signal on most bands.

In brief, the AM filter is quite broad at the top but it has steep slopes. Double peaks were noted on both #201 and #1443. On #201 the variation was about 2 dB, and on #1443 it was about 4 dB. The peaks have no significance in actual receiver operation.

3. DIAL ACCURACY

Calibration is accomplished by switching the receiver to SSB or CW mode and tuning for zero beat on the 100 kHz harmonics. The dial can be slipped so that the receiver can be calibrated exactly.

On set #201, the dial accuracy was within 200 Hz when calibrated at the nearest 100 kHz harmonic. Maximum error over the 500 kHz band was 1 kHz without resetting the calibration.

On SPR4 #1443, the VFO was almost perfectly linear. Dial accuracy was within 100 Hz (and typically zero, or 50 Hz) when calibrated at the nearest 100 kHz harmonic. Maximum error over the 500 kHz was only 100 Hz without having to reset the calibration. I doubt if a receiver could be calibrated much better than this!

The two relative maxima in the crystal filter do not interfere with calibration or determining the exact frequency (to 100 Hz or less) of an unknown station. I might add that all crystal filters (except very expensive ones) probably have a few maxima and minima.

In switching from 1 band to another, the maximum change in calibration(1.1 kHz) was on the 11.5 MHz band. The drift for the other bands was: 9.5 MHz: 800 Hz. 6 MHz: 400 Hz. 15 MHz: 200 Hz. 17.5 MHz: 200 Hz. 0.2, 0.5, 1.0, 1.5, and 21.5 MHz: Zero. 7 MHz: 100 Hz.

4. S METER

The meter works well. It produces a noticeable deflection on a weak signal but does not pin except on extremely strong signals. Meter needle deflection is roughly a function of the logarithm of signal strength. (the meter has a wide dynamic range) It gives very true indications of relative strength of signals. On many receivers, including the HQ-180 and the DX-150, almost any substantial signal will pin the meter. I do not consider this to be very useful after all the function of an S meter should be to measure signal strength!

5. IMAGE REJECTION

The SPR-4 is free from images. No cross modulation was observed when tuning to a 50,000 watt station 4 miles from John's home near Philadelphia using a 100 foot long wire or the Space magnet.

6. BIRDIES

The SPR-4 does have some. They are not operationally significant. On #1443, only 3 major birdies were found on the 0.2, 0.5, 1.0, 1.5, 6.0, 7.0, 9.5, 11.5, 15.0, 17.5, and 21.5 MHz bands. (the only bands I have on this receiver) These birdies were at 9698, 9963, and 15334 kHz. The 9963 kHz birdie measured out at S-9 on SSB and S-8 on AM. The other 2 birdies did not produce an S Meter reading. Besides these a few other very weak spurs were found. Only the nominal 500 kHz ranges, plus or minus 50 kHz on the ends of each band, was considered. John reports there are some birdies on the 4.5 and 5.0 MHz bands, with one on 4973 kHz being very strong. The birdies tune out sharply and I do not consider them to be a handicap to reception.

7. NOISE LIMITER

Each noise blanker must be aligned to match the receiver it is installed in. This is not a difficult process. John aligned the noise blanker in his set and discovered that LORAN impulse type noise was reduced by as much as 40 dB.

8. NOTCH FILTER

The filter must be tuned carefully because of the very sharp null. Null depth ranged from 38 to 68+ dB on SSB and CW, and was typically 65 dB or more on the AM function. John reports that the HQ-180A notch filter is slightly more effective but the SPR-4 filter seems to be able to get the job done.

9. AGC RESPONSE TIME

Without the noise blanker operating, a strong noise pulse may cut out the audio for 1/2 to 1 second, because of the slow AGC response time in the AM mode. When the noise blanker is operating properly, the AGC should be affected only by a received signal and not by the noise pulses. I have not had the adjustments made in the blanker in my set, so I cannot comment on this at the present time.

10. AUDIO

The audio quality was judged to be good. The MS-4 speaker yielded somewhat better low frequency response than the one built into the set, on a qualitative judgement.

The RF gain switch, when set at zero, caused the S meter reading to jump to 60 dB over S-9. This is due to circuitry design. S meters on some Collins receivers behave similarly. I don't consider this important because when I listen I do not set the RF gain to Zero, and I don't think anybody else would either.

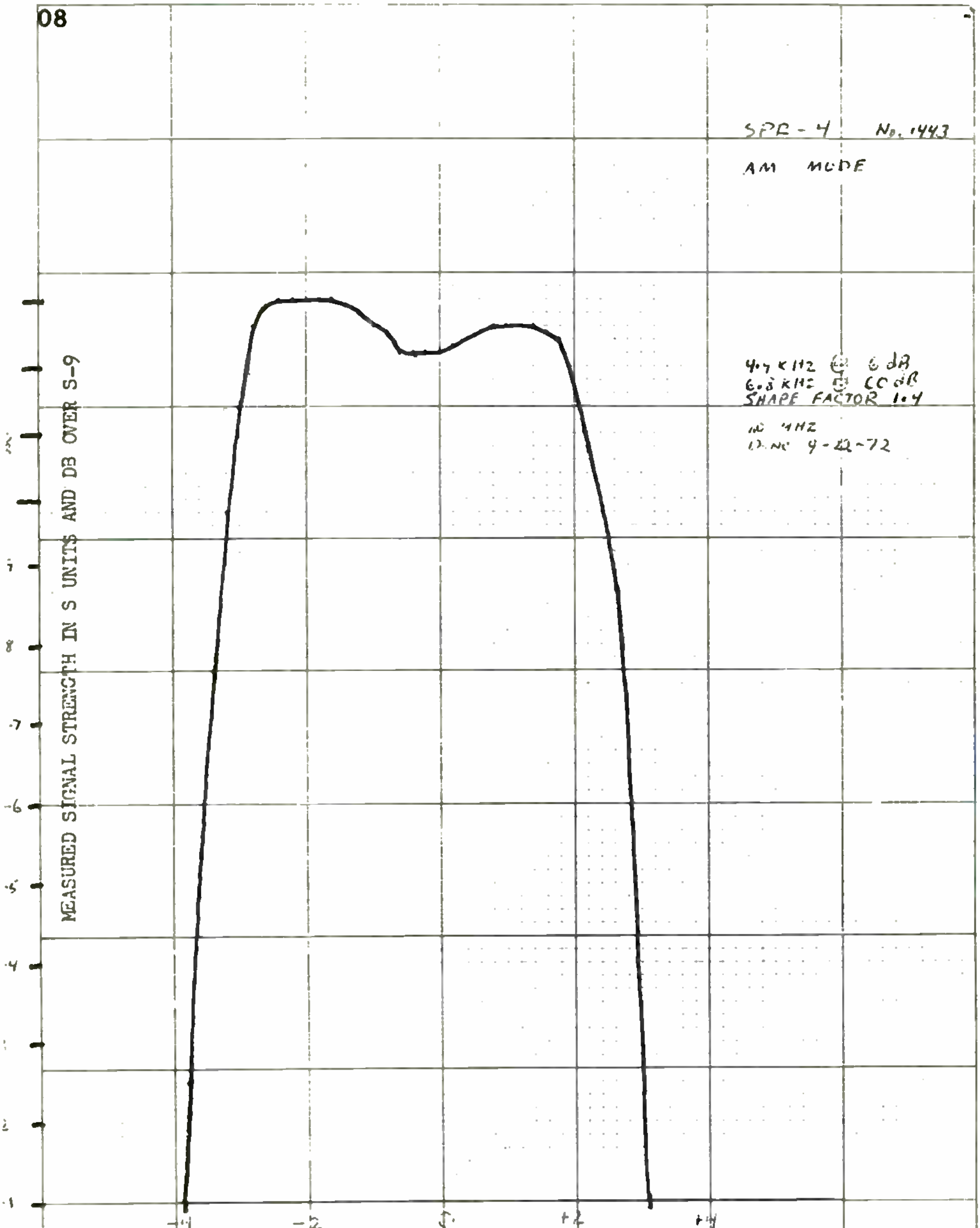
The volume control, when set at the minimum volume setting, does not shut off the audio completely. Again, I have no qualms about this.

11. FINAL COMMENTS

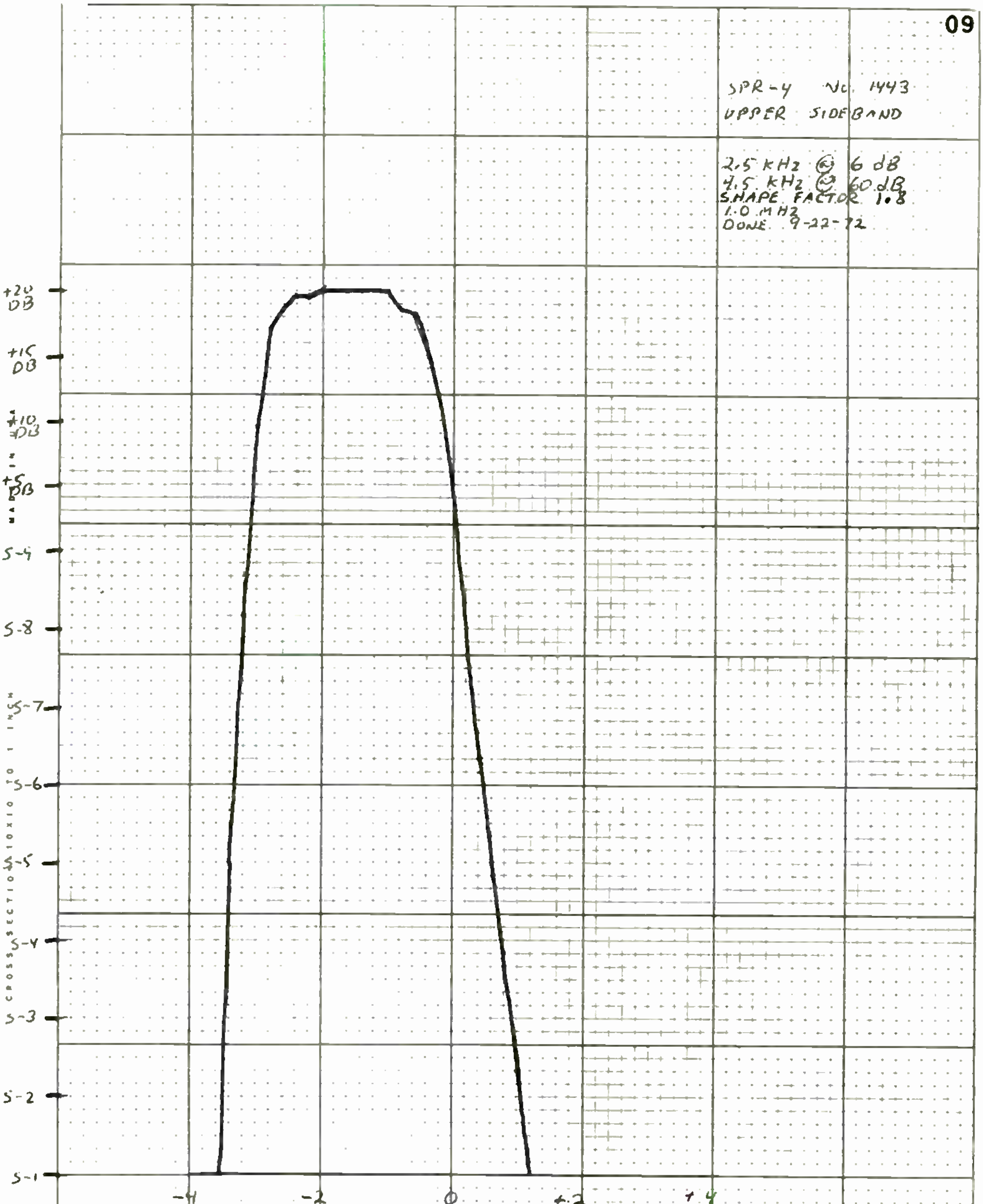
In light of our experiences with these two receivers, we believe the SPR-4 is an excellent receiver and probably the best receiver available in it's price range. The SPR-4 reviewed by Mr. Behr undoubtedly does not measure up to other SPR-4's. It is unfortunate that a few "lemons" did escape the factory. One could hope for a narrow AM filter, but, even without this, the SPR-4 does quite well. Of course, reception of splits very close to strong domestic stations may be difficult.

The SPR's strong points are, in review, excellent frequency stability, very accurate dial calibration and frequency determination, high sensitivity, excellent signal handling capability and image rejection, and a good S metering system, as well as excellent deep skirt selectivity.
The only improvements that might be made on this receiver might be the addition of a narrow AM filter, and a choice of AGC response times for a given reception mode. Perhaps the noise blanker could be included as standard equipment and adjusted at the factory during the manufacturing process.

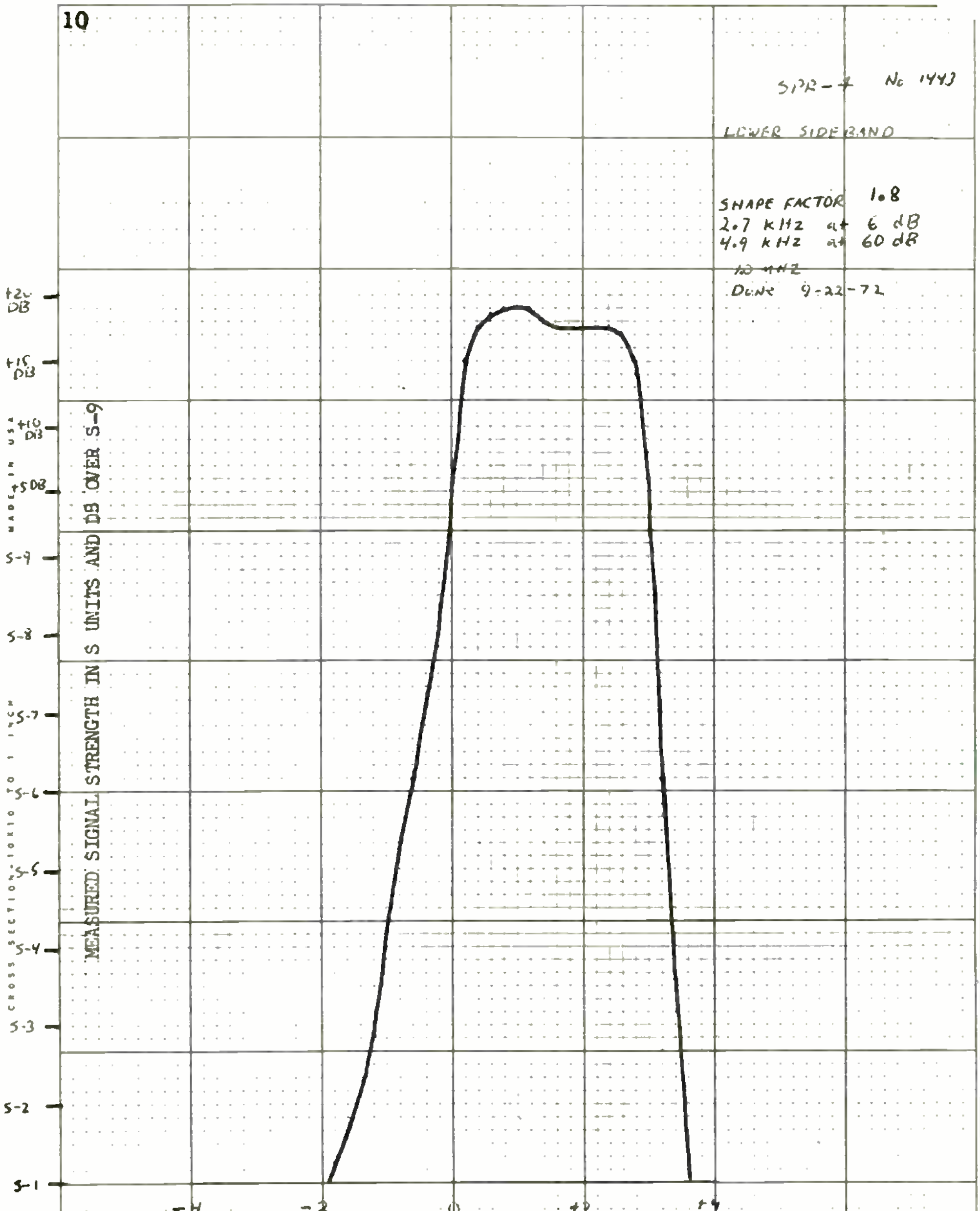
I might add that I observed no frequency shift in the SPR-4 when changing from AM to CW or SSB. The apparent shift is due to the shape of the filter selectivity curve. By tuning the signal to zero beat you notice no frequency shift.



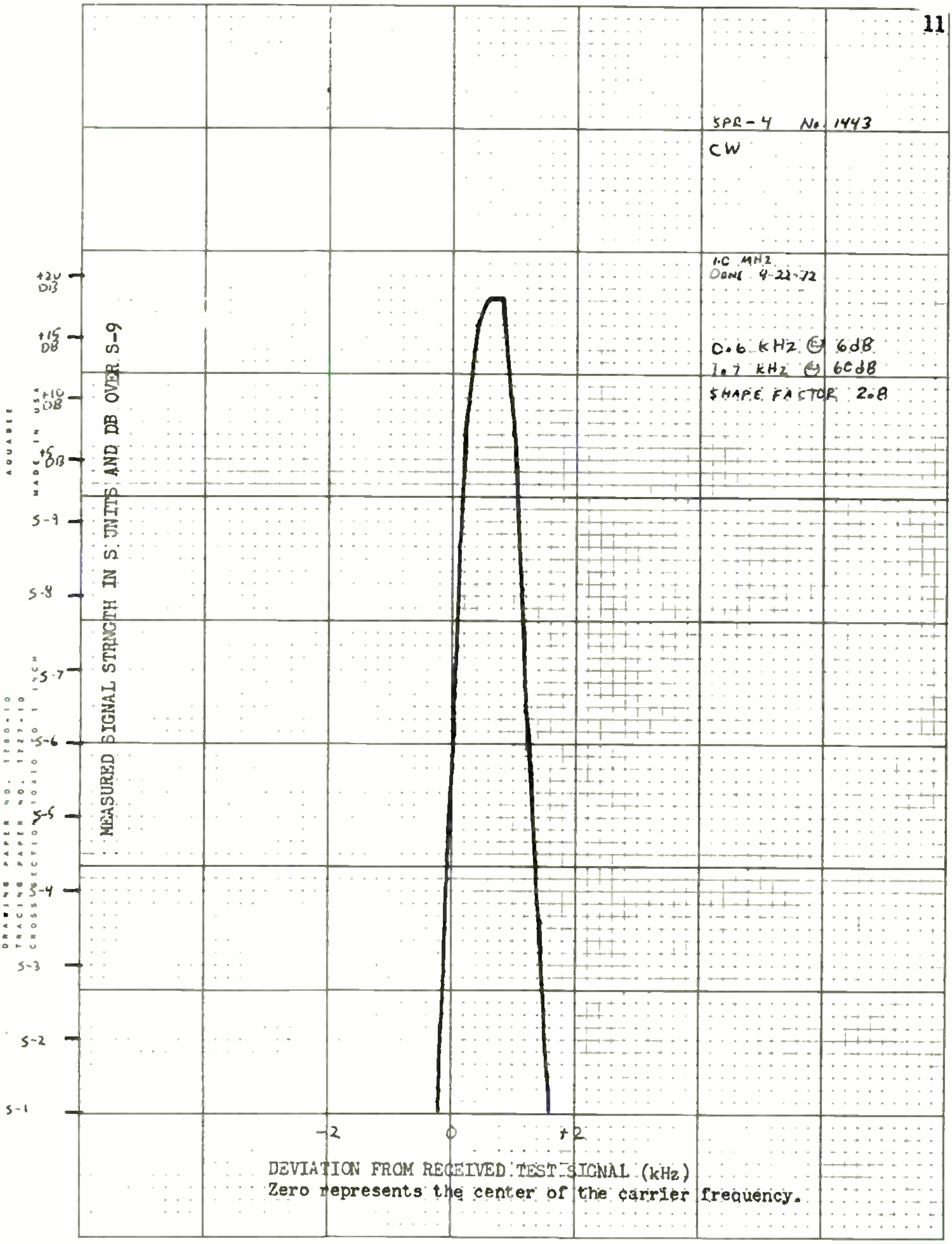
DEVIATION FROM RECEIVED TEST SIGNAL (kHz)
Zero represents the center of the carrier frequency.



DEVIATION FROM RECEIVED TEST SIGNAL (kHz)
Zero represents the center of the carrier frequency, in this plot the upper sideband is suppressed.



DEVIATION FROM RECEIVED TEST SIGNAL (kHz)
Zero represents the center of the carrier frequency, in this plot the lower sideband is suppressed.


SPR-4 No. 1443
CW
1.0 MHz
Done 4-22-72
0.6 kHz @ 6dB
1.7 kHz @ 60dB
SHAPE FACTOR 2.8
MEASURED SIGNAL STRENGTH IN S UNITS AND DB OVER S-9
+20 DB
+15 DB
+10 DB
+5 DB
S-9
S-8
S-7
S-6
S-5
S-4
S-3
S-2
S-1
-2
0
+2
DEVIATION FROM RECEIVED TEST SIGNAL (kHz)
Zero represents the center of the carrier frequency.

RECEIVER REPORT:

Lafayette HA-600-A

by Ron Schatz

The passing of recent years has witnessed a number of trends in the field of DX receivers. Other than the inevitable switch to solid state, we find most Q-multipliers, crystal filters, and even some IF coils falling to ceramic and mechanical filters; product detectors (which extract the audio as a heterodyne rather than by rectifying and smoothing the RF with a diode and capacitor) are now commonplace for CW and SSB reception; many receivers now include the long-wave beacon/broadcast band in their repetoire; and few lack facilities for instant mobile use.

Unfortunately, another trend is apparent: Communications receivers just aren't selling well enough these days, so their manufacturers are limiting the number of new designs available, thus leaving the DX'er with a much smaller list of choices from which to choose. Lafayette Radio Electronics is one such company; all they have left for us today is their HA-600A; but, like their highly successful HE-30 of a decade ago, it is THE model of today's communications receivers selling in the range of $100.

Lafayette has a well-known policy of employing simple, textbook circuitry and Japanese labour in their products, enabling them to offer features otherwise not available at such prices. Their HA-600A, while it does have some annoying limitations, is no exception. All the features mentioned in the first paragraph are present, also 2 FET's in the RF stage, series-gate ANL, "send" position, muting facilities, S-meter, electrical bandspread, BFO, and antenna trimmer. Internally, the S-meter, AVC, and regulated power supply are all adjustable via small disc potentiometers, and a two-element mechanical filter offers the usual no-device selectivity.

The Lafayette HA-600A may qualify as the most hansome communications receiver on the market. The light-grey cabinet contrasts well with the black frame in front and the aluminium controls. And the dial itself is in living colour: The main-tuning and amateur bandspread scales (five each) glow an iridescent blue and are divided by Lafayette's familiar zig-zag logging scale in gold. The S meter glows blue and red on the units and dB-over portions respectively. The indicators are in red. The front of the set is swept back "windshield" fashion, which tends to offer a better viewing angle for most situations as well as give the receiver a "sleek" (we quote the company) appearance.

Well, so it's pretty; but how does the HA-600A perform - quality wise?:

Sensitivity: The HA-600A is extremely sensitive on all bands, from the European broadcasters below 200 kHz to the din of CB bootleggers around 27 MHz. WWV pins the S-meter on 25 mHz at noon and on 2.5 MHz at night, even in Miami. We just cannot see adding a preamp to this receiver, even after modification with a mechanical filter.

Selectivity: As long as you don't want to hear splits it's OK - adequate enough for domestic DX. Otherwise, remove the filter-coil cans on the underside and replace them directly with (preferably) two Kokusai mechanical filters or equivalent. Then you can match general reception to that of the SPR-4 or R-390!

Frequency determination: We must rate this as poor. Although frequency-dial alignment is excellent (no uncomfortable side-viewing at all!), the bandspread is too non-linear for determining frequencies by interpolation. However, accurate guesses to within a kHz or two are possible on the lower bands with some practise. (The author solved the whole problem - with a frequency counter!)

Other characteristics: AVC action is extremely strong, so that some distant Cubans seem to be received as well as the locals in Miami during the daytime. Tune the dial to a dead spot, and the background noise will be overwhelming (the high sensitivity pulls it in), but anything but the weakest splits will cover the noise completely with a solid carrier. This gives the impression that reception on the HA-600A is rather noisey, but remember that a receiver that doesn't pick up noise won't receive equal-strength signals neither!

For some reason, the S-meter seems to read the same for any signal falling under the influence of the powerful AVC, be it a superlocal or a weak semi-local. Enough delay is present in the AVC circuitry to permit viewing SAH's (sub-audible heterodynes, i.e., what you see when your meter pointer wiggles) but no more.

Because of the extremely high sensitivity of the HA-600A, external mixing may be a problem in the vicinity of powerful local stations. Keeping the RF Gain control at 4/5 maximum position seems to remedy the situation. The ANL works very well relative to its detrimental effect on audio quality.

Other anatomical features of the HA-600A include both 8 and 500-ohm speaker outputs, low-impedance headphone jack in front, and a tape-recorder output (which takes a standard RCA-type plug).

The Lafayette HA-600A weighs about 26 pounds and costs some $109 with its matching speaker (HE-48C). For those DX'ers who plan to add the appropriate mechanical filter(s), we highly recommend this receiver over any other in its price range.

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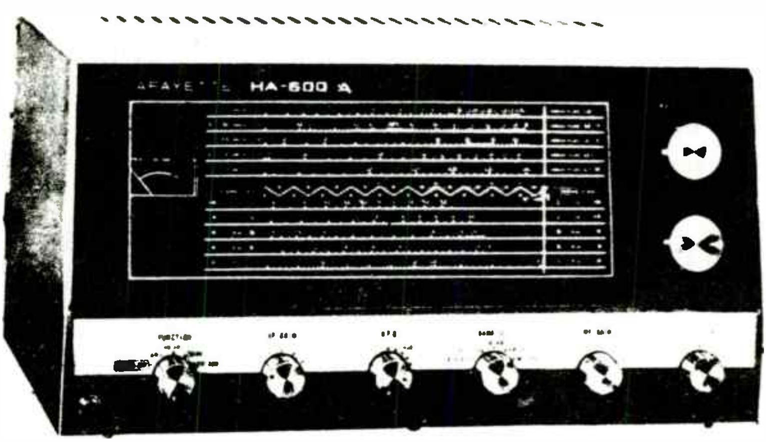


REVIEW OF COLLINS RECEIVERS R–388 & R–390A

Ron Schatz

A Collins radio is no ordinary receiver, it is a fine precision instrument; just ask any DX'er who owns one. It is the equivalent in its category to a Mercedes-Benz or a Stradivarius. While other receivers wind up junked or cannibalised in short order, a Collins almost invariably endures decades of hard use and the hands of many ownerships, yet still performs beautifully and demands hundreds of dollars in resale value. Obviously, a Collins receiver is no casual purchase. If you plan to buy one, read this article carefully; it may save you a fortune in otherwise wasted money.

The following features distinguish the R-388 and the R-390A from other receivers:

1) LINEAR, INDUCTIVE TUNING: Instead of employing the usual set of ganged capacitors, these receivers have a clockwork coördination of gears, cams, and racks which raise and lower a set of ferrite cores within respective RF and IF coils, this in coöperation with an inductively-tuned "VFO", forming the final local oscillator, which is especially wound in order to cover linearly its one-megaHertz frequency range in exactly ten turns of its tuning shaft. Tuning is linear; all frequencies are equally spaced throughout the range of the receiver (i.e., no "bunching up" on the high ends.)

2) PRECISION FREQUENCY CALIBRATION: Most communications receivers have only 4 or 5 bands; the R-388 has 30, and the R-390A 32. Each band is only one megaHertz wide, excluding slight overtravel. This arrangement permits a high order of calibration accuracy, and Collins claims it officially to be within 300 Hertz for both receivers. The R-388 combines a slide-rule "megacycles" dial and a vernier "kilocycles" dial in a "micrometer" arrangement; the R-390A has a mechanical digital counter. The latter is somewhat more attractive to the wide-eyed DX'er, but both systems are equally accurate, an important factor when considering the purchase of the less-expensive R-388.

3) HIGH FREQUENCY STABILITY: Frequency drift is so slight as to go undetected - unless a deliberate attempt is made to look for it. Most owners describe it as "rock solid". This is achieved primarily through the use of crystal-controlled local oscillators and voltage regulation. The R-390A goes further, employing crystal heaters and current regulation. In spite of this, there is no appreciable difference in stability between the R-388 and the R-390A, so this factor should be ignored when trying to decide between the two receivers for purchasing.

Other features tend to resemble those on other receivers, but their quality and abundance still mark a Collins as "top grade":

a) SENSITIVITY: Both the R-388 and the R-390A are about equally sensitive on the lowest band - roughly at the 5-uV level. This is poor enough to invite use of a preselector in some cases, but few owners complain loudly. The R-390A has an extra IF and AF stage over the R-388, but it is only to compensate for notable signal losses through the mechanical filter and cathode follower that the R-388 does not possess.

b) SIGNAL-TO-NOISE RATIO: The R-390A tends to generate an unusual amount of internal noise, the major causes likely being the complex AF system and the wide-band IF circuits. A recent comparison test showed a 12-dB better S/N ratio on the R-388 over the R-390A.

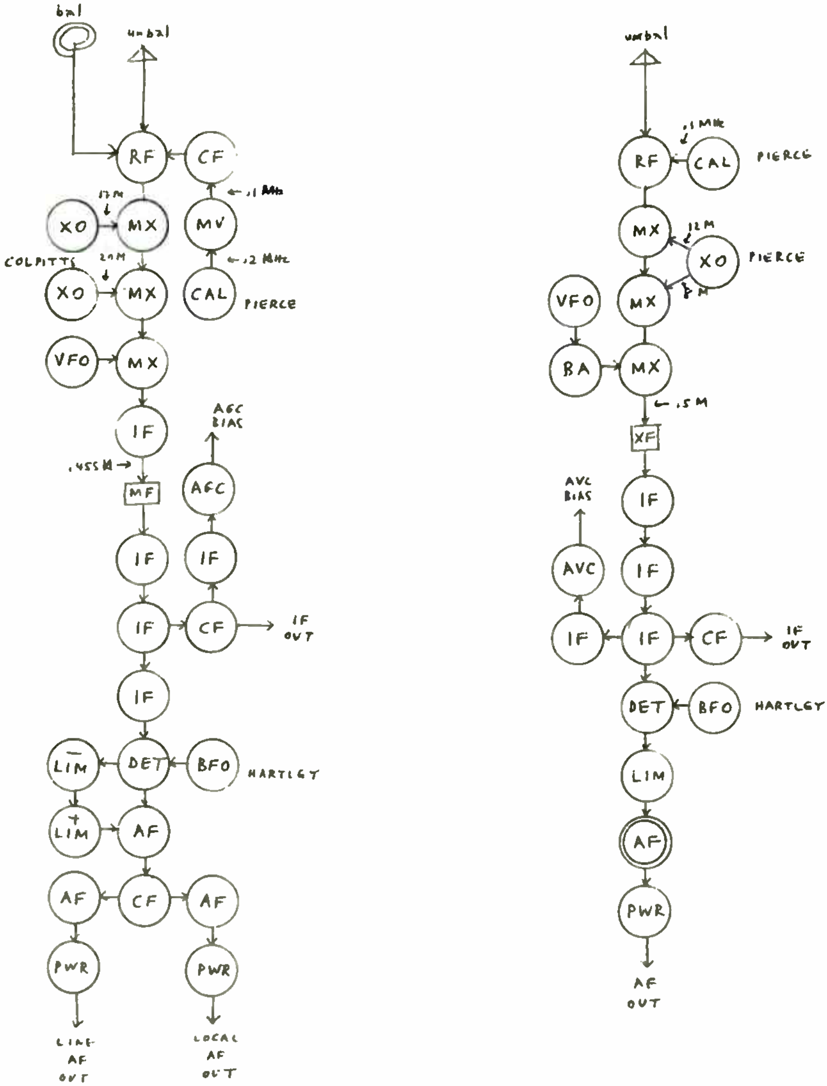
c) SELECTIVITY: The R-388 uses a crystal filter for selected bandwidths of 6 (no filter), 2, 1, .5, and .25 kHz at 6 dB down. The R-390A has mechanical filters for 16, 8, 4, and 2 kHz respectively, as well as a crystal filter for 1 and .1 kHz. A "phasing" control is present on the R-388 only for positioning a rejection slot over any selected interfering signal. This 500-Hertz slot is extremely effective (unlike the one on the HQ-180), and resembles a "super-loop" in its nulling capabilities. There is no rejection slot on the R-390A.

d) LIMITING: The series diode noise limiter on the R-390A is similar to the one on the HQ-180 - and is about as ineffective. It is manually controlled with a potentiometer. It reduces the noise level to the signal level, making both equally loud at best; any further reduction distorts the signal. The limiter on the R-388, however, is a true noise "blanker", it literally "cuts off" the receiver during noise peaks. The effect is to all but eliminate the presence of noise in the audio. Why Collins chose to substitute an inferior limiting device in their "newer" R-390A is incomprehensible to us.

e) AUTOMATIC GAIN CONTROL: Both receivers have amplified AGC, and it is extremely effective. In addition, the R-390A, like the HQ-180, has "slow-med-fast" selection, although it is of limited, if any, practical use for working anything other than CW.

f) CALIBRATION: Both receivers have a 100-kHz crystal calibrator. In a receiver of this precision such a device is an absolute necessity. The R-390A uses the basic oscillator to trigger a multivibrator, resulting in a rich set of harmonics that cover the entire band well, even in the highest frequency ranges. The simple device in the R-388 tends to produce somewhat weak points in the 30-mHz area; often they are lost behind incoming signals. This is no problem with the R-390A, which automatically disconnects the antenna from the set whenever the calibrator is active. The advantages of such an antenna-disconnecting relay probably outweigh the disadvantage in aligning the calibrator, since the arrangement cannot permit WWV and the calibrator signal to share the same signal path at the same time. On the R-388, however, calibrator alignment is easy, and there is even a convenient front-end adjustment that the R-390A lacks.

g) "ZERO" ADJUSTMENT: This is another absolute "must" for a precision receiver. The R-388 has a metallic hair-line cursor mounted over the vernier "kilocycles" dial in a"windshield-wiper" arrangement. Adjustment is a split-second tweak of a knob. The R-390A has a clutch that disengages the mechanical counter from the rest of the tuning mechanism, the latter is then adjusted to catch up to what the counter is reading. Operation of the clutch is by



R-390A/URR R-388/URR

Collins receiver circle schematic diagrams.

twisting a knob tight. Obviously, "zero"-adjusting the R-390A is no picnic, but the mechanical digital counter permits no better way.

	R-388	R-390A
Band I:	750 - (4000 x 3) = -11250 -11250 + (4000 x 2) = -3250 -3250 + 2750 = 500 -500/det. = AF	750 + 17000 = 17750 17750 - (10000 x 2) = -2250 -2250 + 2700 = 455 455/det. = AF
Band II:	1750 - 2750 = -500 -500/det. = AF	1750 + 17000 = 18750 18750 8 (10500 x 2) = -2250 -2250 + 2700 = 455 455/det. = AF

The tables above show the superheterodyning schemes of the first two bands of each receiver. Entered are sample frequencies of 750 and 1750 kHz. Factors in parentheses are base crystal frequencies and their respective harmonic multipliers. Except for the final IF's and crystal oscillators, all frequencies are variable. Only single conversion takes place on Band II of the R-388, since the incoming signal already corresponds to the receiver variable IF. Both receivers provide facilities for tapping the final IF signal for feeding into auxiliary equipment and circuits. The 500-kHz IF if the R-388 may be disadvantageous here, however, since it is incompatable with 455-kHz standards.

Note the following features in the circle diagrammes of the R-388 and the R-390A, both based on "band I" (500 kHz to 1000/1500 kHz): 1) Fixed crystal-controlled local oscillators (XO), 2) IF signal output tap (perfect for spectrum analysers), 3) Amplified AGC/AVC, 4) In the R-390A only, a balanced antenna input (perfect for loops) and a dual, separately-controlled audio output.

CONTROL & INDICATOR SUMMARY: The quality or "usefullness" of the various controls, indicators, and connexions found on the two receivers will be graded as follows:

A - if missing or not working, receiver is useless.
B - if missing or not working, receiver is not worth buying.
C - nice to have.
D - take it or leave it.
F - a waste of money.

Note that these grades apply strictly to the interests of AM "broadcast" DX'ers, who ignore CW, amateur bands, etc. Utility DX'ers may wisely upgrade certain "F" controls to "B". § Where a given feature performs notably better on one receiver over another, that receiver will be indicated in the range "R-388 ... equal ... R-390A" under a separate column.

The following controls, etc., are found on both the R-388 and the R-390A:

Band/Megacycles Change	A	equal
Audio/Local Gain	A	equal
Ant. Trim	C	equal
Zero Adj. (A chore on the R-390A)	B	R-388
RF Gain	B	equal
Function/Off-Stby-On	A	equal
Limiter (R-388 has noise blanker)	B	R-388

AVC/AGC On-Off	C	equal
Calibrate/Cal.	B	equal
BFO On-Off	C	equal
BFO Pitch	C	equal
Phones jack	C	equal
Selectivity/Bandwidth	B	equal
Carrier/Output meter /on R-388)	B	equal
Line/Input meter (Single Input/Output meter	C	R-390A
IF output (500-kHz IF on R-388)	C	R-390A
Cal. Adjust	C	R-388
Break-in connexion	F	R-390A

These items are found only on the R-388:

Phasing (Rejection slot)	B
Front speaker jack	D
4-ohm speaker terminals	C

While these are found on the R-390A only:

Dial Lock ("Toddler" protection)	F
Break-in (Front control)	F
Line-meter switch	C
Line Gain	C
Audio Response (800-Hz audio filter)	F
Adjustable limiter	D
Remote RF Gain terminals	F
Diode-load terminals	F
Balanced antenna jack	C
Crystal ovens	F

Advantages of the R-388 over the R-390A:

1) Lighter - only 35 lb. R-390A weighs 75 lb.
2) Higher S/N ratio (12 dB).
3) Excellent noise reduction and elimination (noise blanker)
4) Economical - much more performance for the money.
5) Effective rejection slot ("Phasing" control)
6) Less useless (and expensive) "extras".

And the disadvantages:

1) Older - more likely to be found in poorer condition than R-390A.
2) No balanced antenna input for loops.
3) Incompatable 500-Hz IF output.
4) No mechanical filters.

HOW TO BUY A COLLINS RECEIVER: Read the following carefully; save yourself a fortune:

1) First of all, never judge a receiver primarily by how it looks, but by how it works. The R-388 especially may be unattractive, corroded, scratched up, etc., but as long as it's structurally sound and electrically operational, it's worth considering. It is a lot cheaper to buy a can of spray paint, some sandpaper, and new knobs from Radio Shack than to be a starry-eyed sucker. Don't dish out several hundred dollars more just because the dealer polished the furniture.

2) Try out the receiver at the store, but don't underestimate the re-sults; the receiver may need alignment, and the environment is usually noisy

usually noisy in the storeroom. If the dealer won't let you make the tests, then don't risk your bills.

3) Check all knobs, switches, meters, etc. Variable controls should rotate without sounding or feeling "scratchy" or otherwise sticking. Everything should work as expected.

4) Remove the top cover and check out the innards. Forget the dust and corrosion, concentrate on structural defects.

5) Check the bank of trimmer capacitors for excessive wear; use a wide-blade screwdriver if necessary. Shorted trimmers are a common malady, and they can make proper alignment of the receiver difficult or impossible.

6) Check the tuning racks: There should be no ferrite cores missing. The wire threads connecting the cores to the racks should be unbent. The rack assemblies should firmly ride the cams with smoothe precision while the band-change and tuning controls are rotated from end to end. Lift each cam by hand; observe spring tension, it must be present.

7) Use the crystal calibrator to check calibration accuracy. On the best specimens, the "zero-adjust" control may not have to be varied at all. If you have to readjust the control more than four kiloHertz from one end of the band to the other, that means the VFO is kaput and needs to be replaced - an expensive proposition (ca. $200).

8) If at all possible, check around to verify current prices, as well as the "condition/price" ratio. Remember that most of what you will pay goes into the tuning mechanism. § During these times of inflation it is useless to quote prices here. We CAN mention that, on the average, the price of an R-388 tends to run some 2/3 that of an R-390A.

CONCLUSION: It is our humble opinion that the Collins R-388 and R-390A are the finest communications receivers commonly available to the "broadcast" DX'er. Their only major drawback - low sensitivity - is far outweighed by their frequency calibration accuracy and their ease in finding any frequency on the short-wave bands in an instant. These are "surplus" receivers, however, so there are no standard prices, and the potential buyer must shop around carefully.

APPENDIX NOTES:

1) Technical manuals:

R-388/URR	TM 11-854	(April 1952)	101 pp.
R-390A/URR	TM 11-856A	(Janu. 1956)	196 pp.

2) R-388/390A comparison tests noted herein involved two receivers aligned per instructions and sharing the same antenna facilities. Both receivers were in top condition, per tech-manual standards.

3) Internal repair and alignment of an aged VFO (one without a precise 1-mHz/10-turn ratio) is possible in skilled hands; it involves graphing, "end-point" adjustment, and "corrector-stack" alignment, but KNOW WHAT YOU'RE DOING!

4) We wish to acknowledge and recognise, in particular, Richard Clark (FL), Bob Foxworth (NY), and Grant Manning (CA), whose material and opinions were helpful in the preparation of this article.

A REVIEW OF THE REALISTIC DX-150 SERIES RECEIVERS WITH A PEEK AT THE DX-160

Thomas R. Sundstrom

The production of new "communications receivers" has all but dried up in the United States, what with Hammarlund, Hallicrafters, and National withdrawing from the SWL and ham markets. Among the first receivers to be dropped from the product line were the relatively inexpensive (under $200) units, leaving only the Realistic and Lafayette pieces to share this portion of the market. Both Popular Electronics and the now-defunct Electronics Illustrated prepared reports on the under-$150 Japanese-manufactured receivers marketed by Radio Shack and Lafayette, and found them to be virtually identical in performance. Since those reports appeared (several years ago), it seems that Radio Shack has made more of a marketing effort to present its product line through countless numbers of local outlets supported by frequent catalog mailings and television advertising.

The DX-150 proved to be a popular performer at a popular price of just over $100 at the time of its introduction in the early 1970s. Rather quickly, the DX-150A updated some circuitry and remained unchanged for about 4 years. The DX-150B, in some experienced DXers' opinions, cheapened the performance of the unit somewhat, with some engineering shortcuts; fortunately, this unit was only around for about a year. The DX-160 was introduced for the 1974 product line; more about this later.

This writer uses, with other receivers, a DX-150A, and the balance of the comments shall pertain to this model...

The DX-150A is a four-band (.54-30 mc) single-conversion transistorized (16 transistors, 14 diodes) receiver that will function either on 117 v.a.c. or 12 v.d.c. Features and controls (in no particular order): bandspread, calibrated for the popular ham bands; BFO control; audio gain/on-off control; band selector; antenna trimmer; RF gain; AVC switch (fast/slow); mode switch (AM/CW-SSB); IF noise limiter switch; s-meter; headphone jack. The rear apron has a fuse holder, antenna connections, power source switch with a jack for inputing 12 v.d.c.; standby jack for remote switching (as in an amateur radio setup for transmitting, to mute the receiver).

Receiver specifications, as per the shop manual: the intermediate frequency is 455 khz; sensitivity on the AM band is less than 50 uv, and 10 uv on each of the SW bands; signal-to-noise ratio 10 dB; image rejection 40 dB on band 1, 30 dB on band 2, 16 dB on band 3, and 4 dB on band 4 (band 1 is the standard BCB).

Unfortunately receiver specs on selectivity are not given and I do not have the equipment to measure same; I would speculate (based upon correspondence re the DX-160) that the rated selectivity specifications are 4 khz at -6 dB and 20 khz at -40 dB.

How's this all translate into performance for the user? Not bad... for domestic BCB DXing. The DX-150A is reasonably decent for getting up next to some of the area superpowers (WFIL-560, WIBG-990, WCAU-1210) at night. This writer has only a longwire attached to the DX-150A, and no doubt a loop or Space Magnet would help significantly.

The DX-150A is poor on DXing "splits." Although an SB-620 shows the presence of Latin American splits, the bandpass is just too broad to allow decent copy on anything except the stronger signals such as Haiti-1035 and St. Kitts-1265 and Belize-834.*

It should be noted that the DXer using a loop/SM will have to perform a bit of surgery on the DX-150 (and probably on the DX-160). A loopstick antenna is tied into band 1 (band 2 on the DX-160), and causes loop nulls to be blunted. The job is not difficult. The input should be rewired to conform with those for the SW bands, and I understand (from those who have done such surgery) that BCB sensitivity improves rather markedly.

Calibration of the main dial, despite being of the dial cord assembly type, is surprisingly accurate on mine... all the way through 10/11 meters. As with all receivers of this type however, the DXer would do well to purchase a calibrator and install an input jack on the rear apron. The FMS-3 calibrator is utilized by this writer.**

There is also room, on the rear apron, for mounting a tape recorder jack which should be wired to the hot side of the volume control. If wired properly, the setting of the gain will have no effect on the audio fed to the tape recorder.

The DX-150 is capable of hearing DX both on the AM and SW bands. The FMS-3 calibrator and the SB-620 panadaptor, albeit I would not expect a DX-150 owner to have the latter piece unless he has other, better, receivers, solve for me the problem of knowing what frequency I'm tuned to. With the FMS-3 alone, no problem spotting to the nearest 5 khz (with the SB-620, to the nearest 1 khz).

There are a couple of complaints that continually crop up wherever this receiver is discussed, to whit: the s-meter tends to "pin" at the drop of a hat (or should it be a carrier) and this would probably cause problems for someone using a loop. A 3.3K resistor, tied to the negative terminal of the s-meter, should be increased in value to reduce the reading. Experiment to find the correct value, probably something up to 10K. The second problem concerns mostly the SW DXers; the bandspread dial lacks a 0-100 logging scale to facilitate calibration chart preparation for SWBC bands et al. Fortunately, a quasi-chart can be made up using the 80 m calibration (which can be be fine-tuned with a calibrator).

Now let's turn to the later units...

I have read of several comments that the DX-150B does not compare favorably with the DX-150A or the DX-150. Nothing specific (no changes in the exterior makeup), but an IC was added in the audio stage in lieu of some printed circuitry and some DXers have said the image rejection was "poorer."

The new DX-160 represents a marked change, and not just in the price of $160 (up $20 over the DX-150B). A longwave band was added, covering 150-400 khz. In a letter from Radio Shack (June 13, 1974), the longwave specs were given as: selectivity 4 khz at -6dB, 18 khz at -40 dB; sensitivity 10 dB s + n/n, 50 uv, at band center; image response at band center -48 dB. A logging scale (0-100) was added to the bandspread dial, retaining the amateur band calibrations (it would be interesting to ask if the dial would be interchangeable with the DX-150 series); in addition, SWBC calibration charts were added to the operators manual. Other bands have had minor improvements, with broadcast sensitivity improved to 10 uv from 50 uv. -40 dB selectivity was improved 2 khz on all bands. According to the letter, "all else remained virtually the same."

By the way, service manuals may be obtained from Radio Shack, 2617 West 7th St., Fort Worth, TX 76107. Unless things have changed, the operators manual on the DX-150A was totally useless for servicing and one needs a microscope to read the schematic. The service manual, in contrast, is quite complete and well worth the $1 cost.

(30)

...prepared July 1974

HALLICRAFTERS Model SX 122 Receiver.

by Leo Alster.

This receiver is a ten tube, four band, dual-conversion Superheterodyne receiver tuning from 540 kc. to 34 mc. in four bands with a gap from 1600 kc. to 1750 kc. The bandspread dial is calibrated for the 80, 40, 15 and 10 meter bands.

Front panel controls are: Main tuning dial, bandspread dial, R.F.Gain, Band Selector, antenna trimmer, selectivity, calibration on-off switch, anti-noise limiter on-off switch, audio gain, Variable B.F.O. control, function switch (Off-AM-SSB/CW) and earphone jack.

Rear Panel has speaker terminals, provisions for remote control, S Meter zero control, antenna terminals for standard lead in wire and provision for coaxial cable.

The tube lineup is 6DC6 R.F.Amplifier, 6AU6 First Mixer, 6C4 first conversion amplifier, 6DC6, 1650 kc.I.F. Amplifier, 6BL8 Second Mixer and 1700 kc.crystal oscillator, 6BA6, 50 kc. I.F.Amplifier, 6BE6 BFO/Product Detector, 6BN8 AVC Amplifier, AVC Rectifier, AM Detector, 6GW8 First Audio and Audio Output, 5Y3 Rectifier, OA2 Voltage Regulator.

A socket is provided on the chassis to plug in their optional Model HA7, 100 kc. Crystal Calibrator.

Because of dual conversion on all frequencies, there is almost a complete absence of image frequencies; and harmonics are seldom encountered.

Selectivity is variable in three steps: 5.0 Kc., 2.5 Kc., and 0.5 kc. A unique method is used in achieving this. The Q of the input IF transformer of the 50 Kc. IF amplifier is veried by changing the value of resistance and capacitance. This makes for ease of operation. It also achieves a narrow, steep sloped wave form in the 2.5 kc.mode which is the one most often used, for reception of voice when maximum selectivity is desired. The 0.5 kc.step is only usable for CW. Although in some unusual cases a voice signal can be made intelligible by the use of the BFO.

The B.F.O. has a center frequency of 50.85 Kc. and is variable over a range of plus or minues 2 kc.

The antenna trimmer control operates a variable capacitor connected across the secondary of the antenna coil in use.

The anti-noice limiter in the On position, places a automatic series noise limiter circuit in operation. This consists of a biased detector circuit that cuts off peaks in the signal. It is effective in reducing noises such as ignition and electrical interference.

One of the shortcomings of the receiver is that only the 80, 40, 20, 15 and 10 meter bands (this includes the citizens band from 25.965 to 27.255 mc.) are calibrated. For the SWL tuning the International Short Wave Bands, a problem is presented in knowing the frequency he is tuned to. The bandspread dial does not havea 0-100 logging scale. However, the calibrations for the 80 meter band from 3.5 to 4.0 mc. is evenly spaced over the entire dial. Over a period of time, this dial can be calibrated for a readout of frequency on any band. I now have enough data where I know within 5 kc. what frequency I am tuned to. For the medium wave DXer, it is easy tocalibrate the frequency that one is tuned to. For example, using the bandspread dial with the main tuning dial set at 1600 kc., there are 20 divisions between 1590 kc. and 1600 kc. Between 540 kc. and 550 kc. with the main tuning dial set at 550 kc. there are 40 divisions.

The crystal calibrator can be kept accurate by beating it against a signal from WWV. A trimmer is provided to adjust it.

My setup for Medium Wave DXing is in the basement of my house which is situated below street level. Using a 3 ft. tuned spiral loop alongside the set, I have received any number of split frequency TAs at sunset and early evening. I have never tried for them at any other time. For short wave listening, I use an all-wave doublet located in the attic. There is no station in the world that I have gone after that I have failed to receive if conditions are normal. Sometimes for increased signal strength on medium wave, I use this antenna as a long wire. With this setup I was able to receive a signal from a Portuguese station 5 kc. from WNBC whihh normally puts in a 40 db. signal in this area.

A REVIEW OF THE HAMMARLUND COMMUNICATION RECEIVERS SUITABLE FOR THE MW BCB.

R.J. Edmunds

Leaf through the pages of the NRC's DDXD or IDXD columns, and look at the contributor credits. Chances are one name will stand out among the receivers listed. That name is Hammarlund, and there's a good reason. Not only are these receivers quite plentiful on the surplus market, but they generally combine the most useful features for the BCB DX'er with the greatest ease of operation. This is not to demean Hallicrafters, National, or others, but simply to point out that all things, including price and supply considered, the chances are that a Hammarlund will be the best value, unless money is no object. There are numerous models of Hammarlund general coverage receivers on the surplus market, many as old as World War II, and still going strong, and there are many gradations of them to give the DX'er a wide choice on almost any basis.

The following pages will give a detailled rundown of the most common Hammarlund receivers available, their capabilities, features, and options. Likewise, the author has assigned a rather arbitrary rating number from 1 to 5 to attempt to evaluate them comparatively with regard to their overall performance on the BCB. Several of the categories, however, should be explained in more detail than is given in the notes. First, we'll discuss bandspread. This feature is a selectivity consideration, which allows much greater fine tuning, and acts to extend the tuning range between channels assigned domestically. Although there is no direct calibration for the BCB on the Hammarlund bandspread scales, many models have a bandspread that functions on the BCB. These are noted on the chart. Most models have a crystal filter and phasing system for attenuation of unwanted signals in the receiver's passband. The later models also have a slot filter, for even more precise (and deep) attenuation. Most are either equipped with a crystal calibrator or able to accept one as an optional accessory. Other options are less common throughout and can be derived from the chart.

Naturally, the more of these selectivity features a receiver has, the more desirable it is, but there is one sensitivity feature that is only available in a few models, but which is most valuable, especially to the urban DX'er, or the DX'er with strong locals. This is the feature of dual conversion. Dual conversion means that the receiver has two IF frequencies, so that the signal must be converted through both stages. In single conversion units, the incoming signal is only coverted once, and therefore some spurious responses such as harmonics and mixing products are passed through and appear to torment the DX'er. In addition, some pure images are created by interaction between the signal and the IF due to imbalances in the receiver's circuitry. The second conversion significantly reduces the liklihood of spurious responses of these types being passed through.

The originally more expensive sets on the Hammarlund line are naturally the most expensive on the surplus market. Of course the set which is most commonly used by BCB DX'ers is the HQ-180A, which, per the chart, is probably the best of the Hammarlund line for BCB'ers. While the HQ-180AX has the same circuitry, and has been rated equal, the added features really aren't necessary for BCB work, unless you get to the point where most of your DX'ing is foreign, and sufficiently difficult to require SW paralleling.

Distinguishing features for the Hammarlund line include rotary-gear type readout, through a front panel window, as opposed to Hallicrafters' horizontal spread bandspread with geared main dial. This arrangement insures against possible de-calibration of the bandspread scales due to changes of a dimensional nature of the dial cord. Hammarlund receivers also feature larger main and bandspread tuning knobs than most communications receivers, which generally allows for easier fine tuning with the main dials as opposed to the fine-tuning sections.

Many Hammarlunds have a split broadcast band, with some splitting the band almost evenly in half, and others splitting it around 1300 kHz. This may be of minor inconvenience in fast tuning, but it again offers advantages in the area of selectivity. The older Hammarlund models (pre-1956) are housed in cabinets which are rectangular, with no rounded corners common in the later models, and they also feature a trap-door assembly on the top of the cabinet. This allows immediate access to the top of the chassis for tube changes, alignment and so on. Anyone who has ever tried to make quick work of such a project on a later-model Hammarlund will agree that such a feat is well nigh unto impossible. In addition, the older type of cabinet incorporated standard rack mount spacing for the mounting screws, so that the cabinet could be discarded, and the unit rack mounted without any metalwork being done on the receiver.

Probably the most regularly-used models for BCB DX are (in order of frequency) the 180A, 180, 150, 145, and 129X. Any of these, as well as the SP-600 series, or the SP-400 series (which are now sufficiently rare that they have not been included in the chart) would be a good to excellent BCB DX machine. The HQ-100, 100A, and 200 are, quite frankly, the budget class of the Hammarlunds, and the DX'er interested in foreign or even serious trans-continental DX on the BCB would do well to avoid them. For the beginner, or the domestic DX'er who's not overly concerned with hearing quantities of trans-continental DX, these receivers will do quite nicely.

Another bonus feature of Hammarlund receivers is the amount of cabinet and chassis space available for add-on's. Again, the older "box-type" cabinets also offer the most houseroom inside, and once again the access feature becomes significant. Some of the newer models, specifically the HQ-145 series, have a rather serious design flaw. There is loads of vacant chassis space -- but all in the wrong places. When viewing the underside of the chassis, one quickly discovers that the set wasn't designed for such things as attaching external Q-multipliers or spectrum analysers or suchlike. Not only that, but it was also not designed with the idea of easy alignment or replacement of components in mind, for the entire gang of oscillator and RF coils are mounted on a piece of mounting metal attached to the chassis directly obscuring and hindering access to the first three tubes in line and all of the associated components. To compound the matter, those tubes are bunched together adjacent to the main tuning capacitors, and a couple of IF cans such that use of a test socket is also not particularly easy.

Common features on the Hammarlunds, which are occasionally taken for granted, are 3.2 ohm speaker output, capacity for either balanced or unbalanced antenna input, headphone jack with shorting plug on the front panel, and very heavy construction (for example, the HQ-150 weighs in at 70 pounds). Other common features are listed in the notes accompanying the chart found elsewhere herein.

Receiver	No. of Tubes[1]	No. of Ranges[2]	Tuning Range	Band-spread[3]	Xtal Filter	Xtal Calib.	Q-Mult	Slot Filter	Rating[4]	Notes
HQ-129X	11	6	.54-31	x	x				3	
SP-600JX	20	unk.	.54-54	x	x					[5]2 RF's
HQ-140X/XA	11	6	.54-31	x	x	opt.			3	
HQ-150	13	6	.54-31		x	x	x		4	
HQ-100	12	5	.54-30	x					1	
HQ-100A	10	5	.54-30	x					1	
HQ-160	13	6	.54-31	x		x	x	x	4	[6]Dual Conv.
HQ-145	13	4	.54-30	x	x	opt.		x	3	
HQ-145X	13	4	.54-30		x	opt.		x	3	[7]1 Fixed Xtal. Pos.
HQ-145A	13	5	.54-30	x	x	opt.		x	4	[8]Dual Conv.
HQ-200	8	5	.54-30						2	[9].1-12 kHz. var. select.
HQ-180	18	6	.54-30		x	x		x	4	Adj. Select.; SB switch; adj. noise limiter; adj. AGC, Dual conv.
HQ-180 A	18	6	.54-30		x	x		x	5	[10]Ampl. S-met. 1-6 kHz. Switchable select.
HQ-180 AX	18	6	.54-30		x	x		x	5	[11]same as 180 A; plus 12 fixed freq. xtal pos.

Notes to accompany chart comparing receiver types.

1 - Includes rectifier & voltage regulator.
2 - All models noted "5" have 5th band as 20-meter bandspread position.
3.- Indicates bandspread operational on BCB, but uncalibrated for same.
4.- Author's arbitrary performance rating based on features & use. Author has no first-hand experience with HQ-160, HQ-145X, HQ-180AX.
5 - SP-600JX features 2 RF stages.
6 - HQ-160 features dual conversion.
7.- HQ-145X features 1 fixed-frequency crystal position.
8 - HQ-145A features dual conversion.
9.- HQ-200 features .1-12 kHz. continuously tuneable selectivity.
10 - HQ-180 features adjustable selectivity, adjustable noise limiter, adjustable AGC, dual conversion, & sideband selector switch.
11 - HQ-180A features all of the above plus 1-6 kHz. switchable selectivity and amplified S-meter.
12 - HQ-180AX features same as HQ-180A plus 12 fixed-frequency crystal positions.
13 - HQ-200 has diodes not included as they are solid state.

All models feature antenna trimmer, sensitivity & audio gain controls, variable BFO, noise limiter, s-meter and send/receive switch.

All models except HQ-180 series have AVC switchable.

Clock/timer is available as an option on the HQ-100, HQ-100A, HQ-145, HQ-145A, HQ-145X, HQ-180, HQ-180A.

The HQ-150 Receiver

Random thoughts about Receivers-Bob Foxworth

DXers using Hammarlund or similar receivers with 100kHz crystal calibrators (XC-100 in Hammarlund's case) find a great difference in calibrator level when comparing MW and SW. The reason for the much greater calibrator level on the MW band is that the calibrator (a 100 kHz crystal oscillator driven to produce a comb spectrum, that is, harmonics every 100 kHz up through the SW bands) must bè powerful enough to produce usable harmonics in the SW band. See Fig. 1 for a graphical representation of the output spectrum. When using such a calibrator on the MW band, the signal is so strong that it obliterates any received signal on the channel. Strong signals in the East, such as WLW-700, CKLW-800, WCFL-1000, WKYC-1100 are entirely masked when the calibrator is switched on.

The solution to the problem is to mount a small SPST switch on the rear deck of the receiver chassis. Any type of switch may be used as only a fraction of a volt of RF, and no DC is involved. A miniature toggle is the easiest to mount however. The single wire signal lead from the calibrator (orange in the case of the XC-100) running from the calibrator subchassis to one side of the ant. input terminal strip is cut, and the switch installed in series so as to open or close the circuit. (Do not wire so as to ground the lead!) When DXing shortwave, the switch will be "closed" to allow full calibrator signal to be heard. When DXing MW, the switch is set to "open" and capacitive coupling around the switch allows a greatly attenuated calibrator signal to be heard. The reduction in signal appears to be greater than about 30 db. This makes the calibrator signal roughly equal to a moderately strong off-the-air signal. Statios such as the ones mentioned above exhibit a pronounced SAH with the calibrator signal with the switch opened and it is possible to get a rough idea if such stations are near their assigned frequency. Use caution, though. Short-term stability of the unheated crystal is no better than a few cycles per minute drift. If it is desired to make an approximate frequency check on a station on an even-hundred dial setting, an acceptable procedure might be to operate the calibrator continuously for several minutes, with the receiver warmed up thoroughly. A minute current through the quartz crystal will heat it up and slightly change the fundamental frequency; it is necessary to let the drift stabilize. While carefully monitoring the beat of the calibrator output with a second receiver, a SW set tuned to 10 mHz and placed near the calibrator so as to allow some signal coupling. This will permit zero-beating the calibrator exactly to WWV at 10 mHz. If you can get your calibrator to within 1 Hz of WWV at 10 mHz, the accuracy will be 0.1 Hz at 1000 kHz. While monitoring your SW set to maintain calibrator zero-beat with WWV, you can simultaneously monitor the BC station being checked and note the difference in cycles per second. The simultaneous monitoring of the calibrator signal on both MW and SW is necessary to ensure against drift of the calibrator. Unless care is exercised the calibrator might drift a few cycles in the time needed to change the set from 10 mHz back to BC frequencies. Another advantage of having a weak calibrator signal on the BCB would lie in tuning to, say, 1200 kHz (in the East anyway) on an auroral Monday morning with nothing but LA's being hrd. This allows one to determine whether his LA is on 1200.00, or 1199.95 (i.e., 50 Hz low) and so on. Unfortunately - this only works on 11 different MW freqs. It should be noted that use of the 10:1 integrated circuit dividers being widely advertised in the ham radio magazines allow generation of an accurate calibrator signal on every one of the 107 discrete MW channels!.. if there is sufficient interest, further details will be run in DX News.

An additional benefit of the addition of the switch is to remove the direct connection of the calibrator output from one side of the antenna input circuit. If the DXer is using a balanced loop, with the 2 parallel coax transmission line, this might help improve loop balance, as signal pickup by the calibrator itself would be eliminated from getting into the input. This could be influenced by the use or absence of a FET pre-amp on the loop, and the output impedance of such an amplifier. Use of an emitter follower might be advisable on the loop pre-amp, in any case, if a long transmission line is used.

While the receiver is out of the cabinet and on the bench for the addition of the calibrator level switch, it might be advantageous to consider adding some modern connectors to the antenna input circuit itself. This can be quite important if the use of a balanced loop is planned or being done. This modification is applicable to receivers with a 3-lug terminal strip on the rear deck, marked A1 - A2 - G. Such an input signifies that the receiver has an antenna input coil which is almost essential for use with a modern loop. See Fig. 2 for a diagram of what is involved. Hammarlund receivers such as the HQ-129X, HQ-140 series and the HQ-150 are excellent examples of such an input circuit. The HQ-180 series receivers, it should be noted, have a single-ended coax input with one connector, in addition to the binding post. This one coaxial input is not a balanced input. What is to be done is: remove the phenolic strip and add two coax connectors, one for each of the two coax feedlines from the loop; connect each of the two antenna input coil leads to the respective center terminal on the coax jack on the rear deck. The connectors are type SO-239 which are made by Amphenol or Dage (among others), they cost less than a dollar each. They mate with PL-259 plugs. (same comments). (Note that if single-ended input to the receiver is desired, such as use of a longwire, the second coax jack may be filled by a shorting plug - this is a PL-259 with the center and shell strapped together). (Note also that the calibrator lead, discussed on the previous page, should lead to the A-1 coax jack, and the A-2 coax jack will be the one that the shorting plug would conceivably used in. This is to avoid shorting out the calibrator signal when using single-ended input).

When I modified my HQ-150, I drilled out the heads of the rivets and went down to the rivet core, drilling from the outside with a 1/8 drill. Then, with a metal chisel, pop pop the rivets from the inside and the phenolic strip will come off. This leaves the two wires from the bandswitch (ant. input coil leads) floating. The resulting hole in the rear chassis looks like a sideways silhouette of a doughnut. Fortunately in the HQ-receiver's case, the radii of the ends is just enough to accomodate a pair of side-by-side SO-239 jacks (with the flange on the outside). All that has to be done is to file off about 1/16 inch of one side of the flange on each jack so they will fit snugly in the hole. It is just not quite wide enough, as it stands, for both jacks as they are supplied.

See Fig. 3 for an exploded view of this procedure. Of course, if desired by the reader, if mechanical considerations warrant, BNC or other coax connectors may be used. It should be noted that the idea behind using coaxial imputs to the receiver, rather than screw terminals with bare wire, or binding posts, is to eliminate "vertical pickup" on the loop feedline with resulting weakening of nulls. On my receiver, with a 10-foot parallel coax feedline connected, I can hear local WTHE weakly, and that is all. This is with the loop end disconnected and free, of course. This test shows that the feedline by itself exhibits substantially no pickup by itself, which is desirable.

Any questions, send them to Bob Foxworth. More from time to time.

Fig. 1

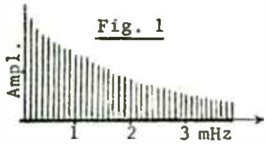


Fig. 3

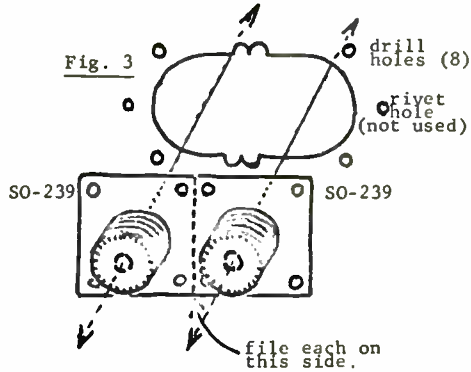
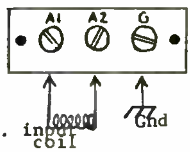


Fig. 2



LIVING WITH A BUDGET RECEIVER

Perhaps the initial consideration should be to define the term, "budget receiver". Rather loosely, any receiver costing less than $500, list new should be categorized as a budget receiver. No doubt this will come as something of a shock to a good many DX'ers who feel that they have a perfectly good set for which they paid far less, and likewise to those who can't even think of spending that much. All generalities, of course, have their exceptions, but on the whole this one stands up fairly well.

Thus the category of budget receivers includes most of the general coverage receivers currently available, as well as some 99.9% of all transistor portables commercially available, and obviously many other types of radios ranging from "All American-Fives" to vintage console models and hi-fi types.

The quality general coverage communications receiver under $600 is a disappearing breed, as receiver manufacturers are becoming more and more pressed by rising inflation, increased costs of labor and component parts, etc. In step with solid state technology, the trend in past years has been away from the tube type general coverage receiver, toward specialized pieces of transistorized gear such as the programmable Drake SPR-4 and the Barlow-Wadley XCR-30 receivers. The potential MW DX'er is advised to carefully check his individual MW requirements against the advertised features of these lines of transistorized equipment.

While it may be possible to obtain fairly good results from a budget receiver, it isn't likely unless you perform several modifications. This is not to say that you can't be perfectly satisfied with one either. The truth of the matter is simply that you can't expect above-average results (comparatively speaking) in all areas of receiver performance without an above-average receiver. The problem is twofold, in that unlike the budget receivers which are quite plentiful, there aren't too many good, commercially produced communications receivers which any more than adequately cover the Medium Wave band, and unlike the budget receivers again, they're EXPENSIVE.

It has been the general experience of the technical experts and many MW DX'ers in the NRC that superior performance on the Medium Wave band can be obtained from an elder tube type communications receiver which has been modified by the DX'er to fit the particular application in question.

There are several things a DX'er can do to insure that the performance of his receiver is a reasonable compromise between that of the unmodified budget receiver and the several-hundred-dollar high quality set. The first items of importance, however, are those to be considered before actually choosing the receiver. Therefore, this article is divided into a number of sections, the first of which deals with the choice of a receiver. Subsequent sections deal with various areas of overall receiver performance which can be significantly improved by means of supplemental equipment or receiver modification. In this way, the reader may gain valuable insight into the myriad ways to rectify the problems posed by budget receivers.

I. SELECTING A RECEIVER

There are, of course, many considerations to be taken when buying a receiver. Some of these are basic and generally used by most DX'ers. Others are strictly personal preferences which usually have little influence on receiver performance, but rather, are concerned with such factors as ease and comfort, or compatability with the DX'ers existing accessories. Still others are more subtle, as they deal with the more intricate aspects of the receiver's operation and these are the considerations which are of primary importance here.

Obviously the receiver should possess good sensitivity, but how does one go about checking this point? Generally, it is best to compare the performance of several receivers (if the salesperson will allow it) on a predetermined set of stations. Just which stations you choose will depend upon how far from your DX shack you must travel to purchase the set. Pick stations of such a combination of power and distance to be easily audible at the point of sale, and yet weak enough to permit a comparison of relative strength when other receivers are tested. To be sure, select five or six such stations. This will give you a fairly good idea as to the relative sensitivity of the receiver you are interested in.

Selectivity can be checked by investigating the sidebands of strong local stations for splatter. Check especially those frequencies where another station should be audiable on an adjacent frequency to the local. Be certain to check the tuning distance between adjacent frequencies. A turn of the knob will reveal how many kiloHertz are covered by a single revolution of the tuning knob; this is especially important at the upper end of the MW band, where "top-band bunch" all too frequently occurs. Should you be unable to tune the set, a close inspection of the dial will give you a reasonable indication of the severity of this problem.

A feature which greatly affects selectivity is the presence or absence of electronic bandspread that is operative on the MW BCB. Many quality receivers are not so equipped. In the case of the well-known Hammarlund receivers: HQ-180(A), HQ-145 and HQ-150, a separate bandspread is not really necessary, since the Medium Wave range, 535 - 1602 kHz is separated into two bands. Band one covers approximately 535-1050 kHz; band two, 1050-2000 kHz. These "spread" ranges on the Hammarlund receivers, because of the relatively large physical separation of adjacent frequencies on the Hammarlund receiver's dial, result in easier location, tuning and resetability of DX stations for the MW enthusiast. This is in opposition to a receiver that compresses the entire MW range, 535-1602 kHz into a single band, such as the majority of the Hallicrafters receivers. The Hammarlund HQ-180(A), in addition to two MW ranges, employs an 8-to-1 vernier tuning control for precise fine frequency adjustment. The elder Hammarlund receivers, notably the HQ-145 and the HQ-150 lack this vernier refinement. These two receivers may be purchased on the second-hand market for $100-$160 dependent upon condition, should the DX'er not want to spend the extra amount of money for the Hammarlund HQ-180(A). The newer Hammarlund model HQ-200 places the 535-1602 kHz range in a single band. Other aids to selectivity are also important; an internal Q-multiplier will be of use, as will a crystal filter, filter-phasing system, or a T-notch filter.

Further considerations are often overlooked entirely. If you have thoughts of adding sets of mechanical filters, you must be careful to choose a receiver with an IF frequency of 455 kHz; also a set with lots of extra room inside will save you the trouble of an "outboard" mounting of mechanical filters. If you plan to use a balanced FET Altazimuth loop antenna, you will require A1, A2 and Ground terminals for the antenna connection. Most of the elder Hammarlund receivers meet these requirements. Receivers having only a single antenna terminal will require a special matching circuit for the loop's feedline.

A factor important to the urban DX'er is image rejection. If you can try the set before purchasing, it will pay for you to calculate some of the mixing products of the nearest and strongest locals, and see if they are audible. Likewise check for true images: those removed from the station's frequency by 910 kHz in the case of a receiver having an IF frequency of 455 kHz. If you can't test the set, a good rule to remember is that a receiver with either double or triple conversion is significantly better with respect to image and spurious response rejection than one with only single conversion. If you don't know offhand, the instruction manual will tell you, and speaking of instruction manuals, be absolutely certain to get one when you do buy.

A very important precaution to be taken before buying a second-hand receiver is to check that the set is aligned properly. Many suppliers will insist on aligning the receiver before you take it home, but that is not always the case, and even so, the alignment the dealer promises may not be complete. It is best to take the receiver to a technician or "ham" you can trust to do a thorough and competent job. Signs of improper alignment or a total lack thereof, are poor dial calibration, improper crystal alignment (check against WWV), poor or intermittant noise limiter action and (lo and behold, images do serve at least one useful purpose) the appearance of images which will suggest a lack of alignment. If a true image, it would <u>not</u> be located exactly 910 kHz from the originating station, thus indicating that the IF was not tuned to 455 kHz. See Section IV for a discussion of images and spurious responses. Finally, check the underside of the receiver chassis for burned or charred components. If the receiver exhibits this characteristic, let it stay at the store.

II. SENSITIVITY

The sensitivity of a receiver, that is to say, its ability to receive DX stations of low powers at great distances, is perhaps the most important consideration for the DX'er. The unfortunate truth, however, is that there is not very much one can do to improve upon that sensitivity..... either it's there or it isn't.

The way to maintain optimum sensitivity of a receiver is to vigilantly weed out weak tubes, with special attention to the RF and Mixer sections, where they will do the most damage. It is also advisable to replace hot-running tubes such as the 6SK7 and 12SK7 with cooler-running substitutes as the 6SG7 and 12SG7. This will help to reduce signal loss in the RF stages. Likewise, defective or old bypass and filter capacitors may be contributing to RF signal loss. These should be rechecked periodically and replaced if necessary prior to each DX season.

Improper alignment will preclude some rare DX loggings; this, of course, is true primarily in communications receivers. Although table radios have been known to drift far out of line, the results of such misalignment are not nearly as serious. The practice of having a receiver re-aligned before every DX season may seem expensive, but is most assuredly worthwhile.

In the "All American Five" or common table radio, there is yet another way to reduce RF signal loss. This is by the replacement of the RF cathode resistor. In its place, insert a 5000 ohm potentiometer. This is used to vary the resistance for peak signal strength. In general, you will find that very little resistance is required. However, on strong signals cross-modulation may occur, which will nesessitate additional resistance in order to eliminate it.

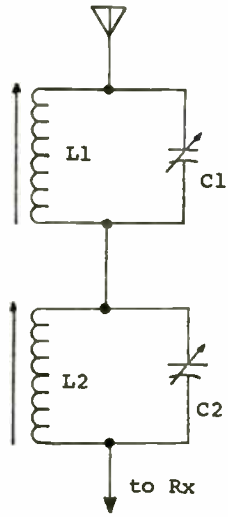
Assuming that the lack of sensitivity does not originate in the RF section, or that it has been sufficiently remedied, the only other place to effectively attack the problem is in the antenna system and its tuning circuit. This is true with most receivers because the manufacturer cannot compensate for all of the possible antenna systems which might be employed with any given receiver, and therefore, a mismatch is quite likely to occur.

There are several ways to improve the sensitivity of the antenna system to DX signals. One of these methods is the employment of a directional loop antenna, which is the ultimate solution. However, significant improvement in the operation of a longwire system may be achieved through modification of the tuning system. As many DX'ers have noticed, the major problem encountered when using a longwire is a means of trimming it electronically in order to produce selective peaking of the desired signal. While many manufacturers of communications receivers attempt to compromise the problem by means of a simple trimming circuit within the receiver, it is as already mentioned, a compromise. It is for this reason that many DX'ers have found it advantageous to construct an external antenna trimmer built for their own particular antenna-receiver combination.

Perhaps the most versatile of all antenna trimming circuits is that shown in figure 1 on the following page, which employs two simple trimming circuits of identical construction, connected in series. In each circuit, a 365 picofarad variable capacitor is connected in parallel with a BCB Hi-Q Ferrite Loopstick antenna and then connected to the antenna on one side of the first circuit, and the receiver connected to the opposite side of the second circuit.

The only major consideration to be taken in the use of the tuner is to keep your hands away from the metal parts, such as the variable capacitors or chassis box, as stray body capacitance may be transmitted into the tuner and cause erratic operation. The main benefit of this tuner lies in its ease of construction and use, and its ability to match a wide variety of antenna lengths and configurations.

Figure 1



Another type of tuner for the longwire is used for antennas in excess of 125 feet in length, or where the longwire consists of a geometrical pattern. It was successfully used by one DX'er for about three years in conjunction with a triangular array 40 feet on a side. This tuner, while slightly more complex, is based upon a principle similar to that used in the previous one. The schematic diagram appears in figure 2, below.

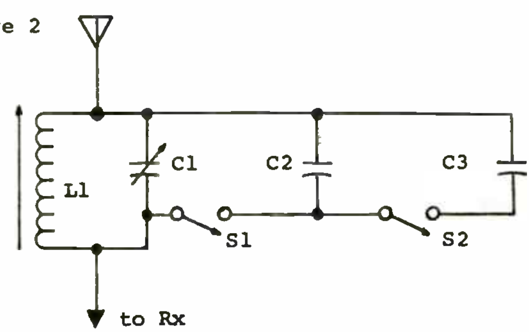
* *

NOTE: For all tuners calling for a BCB Hi-Q Ferrite Loopstick, use either J.W. Miller part # 2001; Allied Radio part # 54 B 4398 or equivalent. All SPST switches should be either slide switches or toggles equipped with plastic handles to avoid transmitting body capacitance into the tuner.

* *

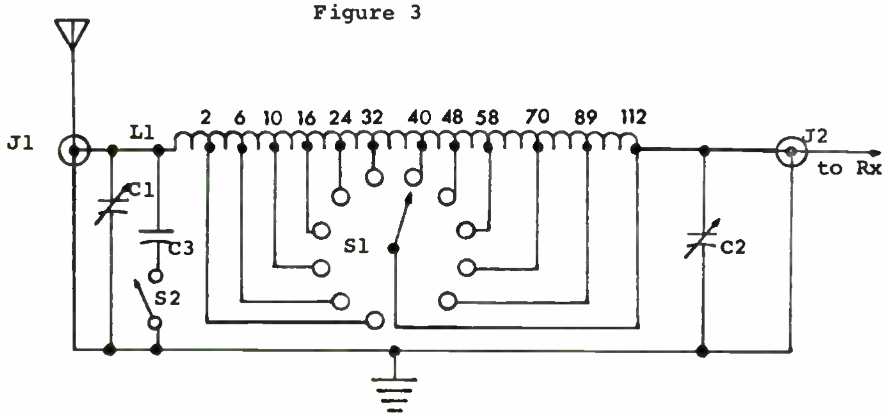
Initially, we have the same basic circuit as before, with the 365 picofarad variable capacitor and BCB ferrite loopstick connected in parallel; however, still more capacitance must be added in order to compensate for the increased length of the longwire. This is accomplished by wiring two fixed value capacitors of equal value in parallel with the existing circuit and providing for their selective addition or removal from the circuit by means of SPST switches. The value of these capacitors should be as close to 365 pfd. as possible and if not exactly so, should be slightly lower in value. This is to provide continuous tuning of the band without either excessive overlap (too low a value) or "dead spots" (too high a value).

Figure 2



Still another type of antenna tuner employs a coil which the DX'er must wind himself. This type of tuner is a more complicated construction project, but is well worth the effort and is illustrated in figure 3. The tuner features two variable capacitors, one fixed capacitor, a coil and a rotary switch. The coil (L1) consists of 112 turns of # 18 gauge wire wound on a coil form with a diameter of one and three-quarters inches, and a length of four and five-sixteenths inches. The coil should be tapped as it is wound at 2, 6, 10, 16, 24, 32, 40, 48, 58, 70 and 89 turns. Each of these taps in turn, is connected to a different position of the rotary switch, while the 112th turn is wired to the rotor or pole of the switch. The rest of the circuit is then constructed as shown. It is advisable to connect the metal chassis, should you use one, to ground.

Figure 3



Parts List: C1 - 250 pfd. Variable
C2 - 365 pfd. Variable
C3 - 270 pfd. fixed
J1,J2 - RCA phono jacks
S1 - Single pole 12 position shorting rotary switch
S2 - SPST switch
L1 - see text

* * * * * * * * * *

This particular tuner is technically known as a "Pi-Network Coupler" and functions best when the antenna runs straight-line distances of 30 to 100 feet. As the length of the antenna approaches 100 feet, C3 (figure 3) will have to be switched into the circuit for tuning over most of the band, and the value may even have to be increased by 200-300 pfd. in order to provide adequate operation at the low end of the band. At shorter antenna lengths, C3 need only be 270 pfd. and is only used in tuning the low end of the band.

We shall now discuss the concept of the transistor portable and other sets not equipped with external antenna connectors. As most DX'ers already know, a standard MW loop antenna is based primarily on the principle of inductive coupling. With a communications receiver, the coupling turns of a standard loop's winding are connected to the receiver and simply wound around the main or tank coil. With a receiver lacking antenna terminals, one may either hold the receiver within the circumference of the loop, which will inductively affect the receiver's built-in antenna, or utilize a passive booster as a coupler to the receiver. This technique enables the DX'er to connect an inductive tuning circuit (the basic circuit described in the first two tuners discussed) to the antenna itself, be it a longwire as in figure 4, or a loop as in figure 5. The tuning circuit is then placed in close physical proximity to the internal antenna of the receiver and the inductive coupling is achieved. C1 is the 365 pfd. variable capacitor, while L1 is the Hi-Q Ferrite Loopstick.

Figure 4

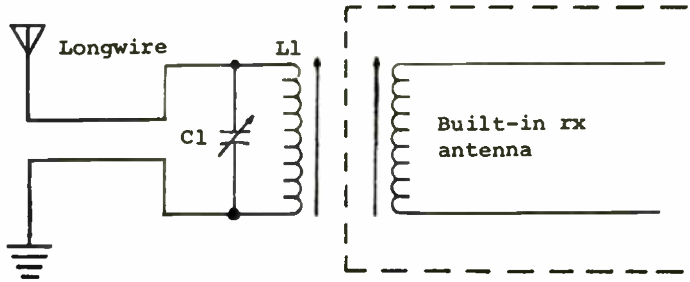
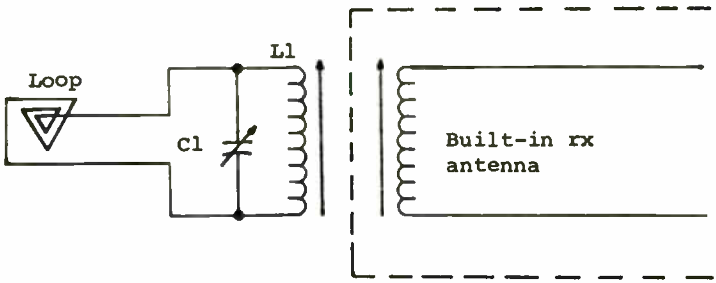


Figure 5



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The ultimate antenna for use in BCB DX'ing is the loop antenna. This type of antenna is particularly suited for MW DX'ing for a number of reasons: a) Because it is a magnetic antenna it will actually pick up less <u>local</u> electrical noise than a longwire with equal pickup; b) Because a properly designed loop antenna is a tuned circuit and the antenna selectivity will greatly reduce spurious and overload effects from powerful local stations; c) The directional pattern of the loop antenna often permits the separation of distant stations on the same frequency; d) The null of the loop pattern can be used to greatly reduce or eliminate interference from local stations; and e) A good loop antenna can serve as a simple, but highly accurate direction finder to aid in the location and identification of distant Medium Wave stations.

While loop antennas have been used by MW DX'ers for many years, the design has progressed very little since the 1930's. The loops commonly in use all suffer from the same basic design limitations: poor nulling of local stations, relatively low signal pickup, broad low Q tuning characteristics, and distorted pickup patterns which produce questionable direction finding.

The loop antenna to be described here incorporates a number of new features stemming from extensive experience and research by Gordon Nelson with the theory and design of magnetic antennas. Properly constructed, this 35 inch square antenna (figure 6) will provide signal output equivalent to many 100-foot longwires, but with considerably less local noise pickup. The use of totally balanced geometry and circuitry eliminates "vertical effect" - the most common cause of poor performance in other loop designs. The exclusive "altazimuth" design permits the user to tilt the loop face to compensate for polarization wave tilt from local signals, thus providing extremely deep nulls on local stations; in many instances it will be possible to totally eliminate pickup from local stations, thus permitting the DX'er to log distant DX stations on the same channels as his locals! The physical and electrical characteristics of this antenna have been very carefully chosen to provide maximum signal pickup and tuning selectivity without impairing the tuning range. The use of a special low-loss tuning capacitor with linear characteristics eliminates "top-band bunching" and provides easy tuning of stations.

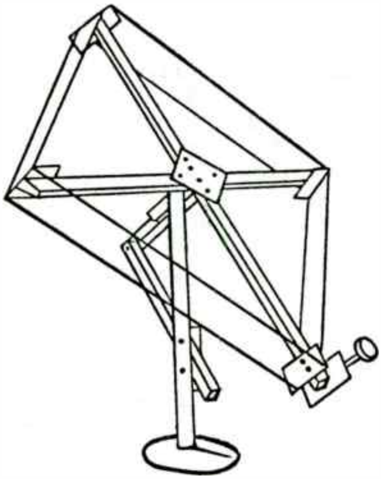
A Field Effect Transistor (FET) amplifier was designed especially for this application. In addition to supplying more than 25 db. of low noise gain, the use of balanced input circuitry and FET's with unusually high input impedence reduces tank loading to an absolute minimum. As a result, both output voltage and tuning sharpness are extremely high compared to ordinary designs. Balanced cross-neutralization provides for unusual stability and permits relatively careless construction practices. The special low-capacity feedline eliminates "vertical effect" without signal losses. The Q-gain control allows the operator to vary the output voltage of the loop over a wide range to meet all possible signal enviornments - from the shadow of a 50,000 watt local to the quietest Monday morning of the DX season.

While this antenna is primarily designed to be used with a balanced FET amplifier, only a few changes are needed to allow operation without the amplifier - the basic antenna design remains unchanged. Omission of the amplifier will reduce signal pickup and tuning sharpness; the ability to null local stations, reject local electrical noise and make direction-finding measurements will not be affected, however.

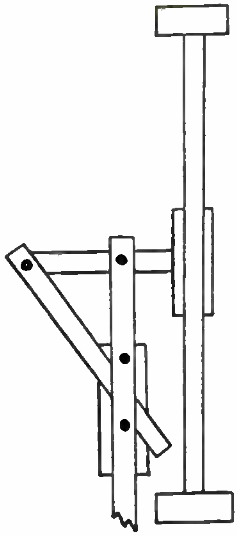
The actual null depth (i.e., how much a local can be reduced) depends on a number of uncontrollable factors, including the nature of the transmitting antenna, the ground between the receiver and transmitter, and the presence of reradiation from local power and telephone lines. Under the best of conditions, the unwanted station can be reduced by more than 80 decibels; in the worst case observed, the null was still 38 db. When a very powerful local station is deeply nulled out, the remaining audio will sound extremely distorted - almost like single sideband; in this case the signal is being picked up as a result of scattering from the overhead ionosphere and no depper null is possible.

When using the loop without the accompanying FET amplifier, the loop is wound with an inductive coupling segment called a link coil, which consists of two turns of slightly smaller diameter wire wound on top of the main or tank winding.

Figure 6



Face View



Side View

III. SELECTIVITY

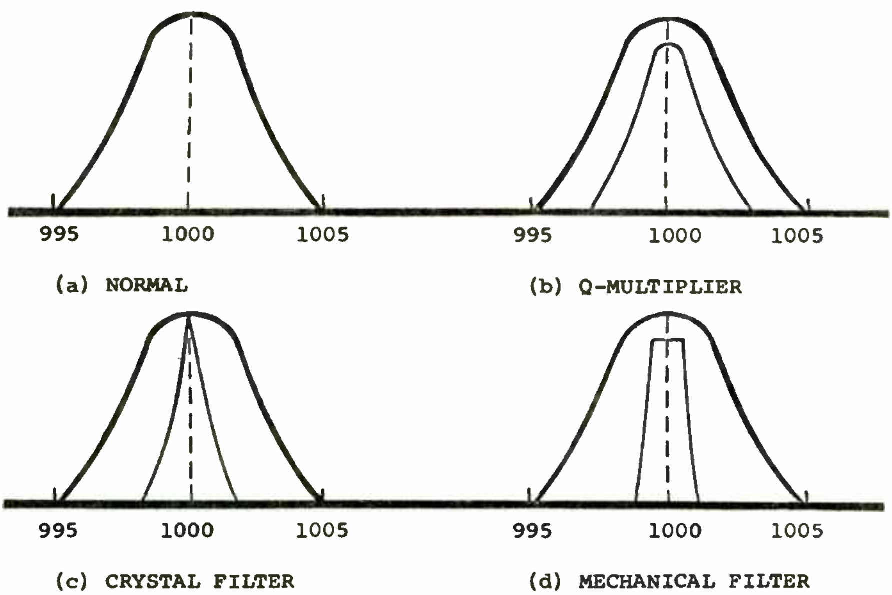
Selectivity, or the ability of the receiver to distinguish between signals on adjacent frequencies, is happily, an aspect of reception which can be significantly improved, although some of the construction involved is by no means simple.

While a certain amount of selectivity is gained through the use of an antenna tuner or loop antenna due to its selective peaking of the signal, the overall increase is still somewhat minimal by comparison with that gained by other methods. One of the simplest and effective ways to increase selectivity is with the addition of an external Q-Multiplier. This piece of equipment will do wonders for the inexpensive sets. In a communications receiver, the installation is quite simple, as the directions for connecting the unit are supplied by the manufacturer. If the DX'er wishes to build a transistorized Q-Multiplier, he is referred to the Radio Amateur's Handbook published by the ARRL for constructional details.

In "All American Fives" or other inexpensive receivers, a separate power supply for the Q-Multiplier must be built. Be forewarned that unless properly shielded, this power supply will cause excessive amounts of noise. It is best to use a metal chassis and ground it well, in addition to using shielded coaxial cable wherever possible, both inside and outside the unit.

The most effective way to improve receiver selectivity is by the use of mechanical filters. The primary function of these devices is to pass a narrow band of frequencies (typically 2.1 kHz) in the IF stages of the receiver; the interference from adjacent channels will be negligible, while the audio quality of the desired signal will remain very readable. This is in contrast to the effect of a crystal filter, which tends to excessively reduce the readability of the audio portion of the signal due to its very sharp peak, and to the Q-Multiplier, which may tend to oscillate when used near strong, adjacent signals. The illustrations which follow (figure 7) depict the comparative effects of: a) The normal signal; b) The signal when a Q-Multiplier is used; c) The signal when a crystal filter is used; and d) The signal when mechanical filters are employed. In the diagrams, only the individual effects of each is considered. The curve representing the normal signal is shown in each diagram only as a means for comparison. Notice how steep the "skirts" of the mechanical filter are, and also take note of the flat passband when mechanical filters are used, as compared to the other modes; this results in very sharp tuning of the signal without the loss of audio, unlike the characteristics of the crystal filter and to a lesser degree, of the Q-Multiplier.

Figure 7



Another major drawback of the budget receiver is its tendency to display an annoying variety of spurious signals when used in an area where one or more strong stations are located nearby. Herein, we shall explore many of the commoner types of spurious signals, their causes, and their cures. Most, but not all, of the spurious responses one is likely to encounter are created within the receiver itself, and are relatively simple to eliminate once the causes are tracked down. Other types are harder to eliminate, yet even so, it's often useful to be able to predict them in advance and know how to attenuate them as much as possible.

The transmitter-originated spurs are of three types. The first type is a harmonic which appears only on a channel that is an even multiple of the originating frequency. Thus, a station operating on 540 kHz may also transmit a small amount of signal on 1080 kHz (2 x 540) and so on. All transmitters radiate a small (although not necessarily audible) quantity of harmonic signal, and the only cure is to utilize a loop antenna to null the offending spur. A second type of transmitter-originated spur is the parasitic radiation. This type of spur is transmitted only by means of a defect within the transmitting equipment. Generally, parasitic radiations appear on both sides of a station's frequency, often on split frequencies. The audio is usually highly distorted and sounds almost like single sideband transmission; however, it's usually impossible to detect a carrier via the BFO method. In most cases, these spurs appear in pairs equidistant from the transmitting frequency, i.e., 743 kHz and 797 kHz from a certain station on 770 kHz. The third type of transmitter-originated spur is commonly known as sideband splash. This is the excessive "thumping" and "banging" heard on either adjacent side of a local station; this radiation can be attributed to overmodulation or to a transmitter that is not properly adjusted or well maintained.

Another category of spurious signals frequently encountered by the DX'er are externally-caused mixing spurs. Defective wiring and old pipes buried in the ground can produce spurious signals and are responsible for many of the spurs experienced in large cities with several powerful local stations. These defective connections or joints, due to corrosion, generally behave somewhat like an old-time crystal detector receiver. The nonlinear properties of this junction cause sum and difference frequencies to be created; the wire or piping then acts like an antenna and radiates these signals on a number of different frequencies. The sum frequency of the two stations involved in the spurious mixing may be one of these frequencies, as may the difference of the two transmitter frequencies. Likewise, these nonlinear junctions may also radiate considerable "signal" on combinations of the difference frequency and the original channel (either of them). For example, given two stations operating on 1060 kHz and 540 kHz, we would have a sum frequency of 1600 kHz and a difference frequency of 520 kHz. The difference frequency of 520 kHz might combine with the original frequency of 1060 kHz to yield a spur on 1580 kHz or with the other original frequency of 540 kHz, yielding a spur on the Longwave band at 20 kHz. Given different sets of originating stations, any of these may appear either in or out of the Medium Wave Broadcast band.

On any of these frequencies where a spurious signal is encountered, there will be a fairly strong audio mixture of the programming of both stations, although one may be stronger than the other. The instant that one of the two stations leaves the air, the spur will disappear, since it is a mixture of the two. The mixing junction may be miles distant and can radiate considerable power on these combination frequencies in some cases. It is important to realize, however, that this junction is actually transmitting just as though a small transmitter had been set up at that precise spot. This means that the signal will be peaked on the antenna tuner at the proper position of the dial for an actual station on that particular frequency, and that it can be nulled with a loop antenna if the null is affected toward the site of the mixing junction, rather than toward either of the originating stations. Of course, if the problem is too severe, the DX'er will have to adopt the same attitude he does toward stations which operate with no silent period - the problem will become one of the hazards of the hobby. Note also, that a longwire used for receiving purposes may cause this spur problem unless all solder joints are very tight and the antenna is completely insulated from everything - trees, leaves, buildings or any structure which it could brush against under adverse weather conditions.

Still another variety of spurious signal is by far the largest and most common, and that is the group of spurs caused by receiver defects. Here are the four common types, the first of which is crossmodulation. Crossmodulation is caused by overloading the receiver with too much signal; this shows up as the transfer of some of the programming from local stations on nearby frequencies to channels 20 kHz or less distant.

A second type of overload spur shows up in the form of "birdies", which are a type of spur often mistaken by novices for heterodynes ("hets") from foreign stations on split frequencies. Heterodynes however, are tones of a single, fixed pitch and variable volume, whereas "birdies" are tones where the actual audio frequency varies as one tunes across it. Oftentimes, programming from a strong local station is heard along with the "birdie."

A third type of overloading spur is the internal mixing spur, which appears at first observance to be an external mixing spur, since again there are two audios mixed together on sum and difference or combination frequencies. It is important to be able to readily distinguish between internal and external mixing spurs, as the former are cureable, while the latter are not. The primary differences lie in the fact that the external mixing spur acts like a transmitter on the frequency, whereas the internal spur does not. As we have noted previously, the antenna trimmer's position for the peaking of an external mixing spur will be the smae as if there actually were a legitimate station broadcasting on the frequency. With an internal mixing spur, the trimmer control would be peaked at a position suitable to either of the two originating stations involved; therefore, when using a loop antenna, the null will not be in the direction of the faulty junction, but rather in the direction of either of the originating stations. Thus, when the loop is set to null either of the offending stations, the spur should disappear to a degree proportionate to the amount of attenuation effected on the particular station itself when nulled on its own frequency.

The final class of receiver fault to be discussed is the image, which is a kind of special case that results from a basic flaw in all superheterodyne receivers. Images appear like spurs which are located on frequencies differing from the original by a factor of twice the IF frequency of the receiver. Due to the fact that so many receivers have an IF frequency of 455 kHz, we shall deal with that figure in our examples. There are several basic known subtypes in the image family and all are caused by the same problem. While some real quality receivers are advertised as double conversion, they may actually switch out a conversion stage on the Medium Wave Broadcast band, leaving just a single stage of 455 kHz conversion, thus making the receiver prone to all types of images. How many images or types of images, and just how severe the problem is, will vary with different receivers. While not strictly an overload problem, the cures listed subsequently for overload problems will be effective.

Among the commoner images encountered are those appearing 910 kHz removed from the basic frequency (images, since they are not mixing spurs, feature only one station's audio) in <u>either</u> direction; 910 kHz being twice the IF frequency. Examples are: 600 <u>plus</u> 910 = 1510 kHz, and 1600 <u>minus</u> 910 = 690 kHz. There is also an image which appears 910 kHz (2 x IF) lower than <u>twice the station's frequency</u>: 760 x 2 = 1520 minus 910 = 610 kHz.

Occasionally, a type of spur will develope which will combine certain characteristics of both images and mixing spurs. Such a case is observed when a spur appears according to the formula: $F + F_1 - 2F_{if} = F_s$, where F and F_1 are the original frequencies of the stations appearing in the spur, F_{if} is 455 kHz and F_s is the frequency on which the spur appears. For example, stations on 970 kHz and 1010 kHz would fit the formula as follows: 970 + 1010 = 1980; 1980 - 910 = 1070; thus the spur appears on 1070 kHz. This spur, like all images, is caused by faulty receiver design and augmented by other receiver defects.

It is important to note that it is entirely possible for two spurs, or images of either the same, or differing types to appear on the same frequency and although extremely uncommon, it is theoretically possible for others to appear on a given frequency if the reception area has an unusually large number of powerful locals. It thus becomes possible for two spurs or images bearing one audio in common to appear on the same frequency, resulting in a reinforced audio which may seem to be the only audio on the frequency; careful manipulation of the antenna trimmer control, loop, or Q-Multiplier should reveal the depressed audios of the two or more distinct spurs.

In the case of the majority of the afore-mentioned spurs and images caused by receiver overload, there are several solutions to the problem. As has been already mentioned in other sections of this article, it is imperative that weak tubes, especially in the RF and Mixer sections, be replaced regularly with new tubes, as weak tubes in these areas can cause both crossmodulation and internal mixing. If you are using a longwire antenna, try shortening it a bit. Too much antenna will serve to overload the receiver, thus creating in multiple-family dwellings it is probably a waste of time and effort to shield only one TV set unless it is particularly offensive. SCR dimmer noise is found in the form of a loud, raucous hum or buzz occurring approximately every 15 kHz, and while filterable at the source, it is usually impossible tp locate the offending dimmer, since the interference is radiated through the power lines, sometimes over a distance of several blocks. Usually the DX'er is forced to either learn to live with these noises, or to relocate his DX shack to a quieter location.

VI. AUDIO FILTERING

One of the problems confronting DX'ers is how to remove the desired signal from the rest of the audio components in the receiver's pass-band. Although considerable time has been spent in the discussion of removing undesired RF signals and random noise, little has been said regarding the removal of heterodynes, audio tones and other components of the audio spectrum which may be undesirable.

Many DX'ers have found the heterodyne created by two adjacent stations "beating" against each other to be an invaluable aid in determining and recognizing two or more stations within 5 kHz of each other, but this selfsame heterodyne rapidly becomes a nuisance once it has outlived its usefulness as an indicator. Therefore, there is no reason whatsoever that we should not endeavor to eliminate it. This is why the audio filter has become an increasingly popular piece of DX equipment.

Simple audio filters come in two basic varieties: fixed high-pass and fixed low-pass. Although there are several other related types, we will take these two as basic to the DX'ers first understanding of the uses of audio filters in DX'ing. Each of these filters allows a specific portion of the audio signal to pass through unattenuated, hence the designation of low-pass and high-pass. The low-pass filter allows low frequencies to pass through it, while attenuating or reducing the higher frequencies with respect to a given cutoff point. The high-pass filter accomplishes precisely the opposite function. The cutoff frequency for either type is generally a reference figure; the cutoff is not necessarily sharp or precise.

Of primary interest to the DX'er are the simple filters in two general areas of frequency. First, the fixed low-pass filter with a cutoff of about 2 kHz which reduces static, some random noise, and removes higher-pitched "hets", where they arise. Likewise, the fixed high-pass filter with a cutoff in the vicinity of 130 Hz can be extremely useful in reducing or eliminating the lower-pitched hums caused by power lines, improper shielding or other electrical problems. These filters are of the greatest significance because of their relatively easy accessibility and simple installation into a receiver's audio output circuit.

It is possible to attach one filter of each of the types mentioned above together to achieve both effects, as it is likewise possible to use two identical filters in cascade to achieve an even sharper cutoff. The same sharp cutoff effect may be accomplished by re-recording a taped reception two or three times through the same filter.

spurious signals in the presence of powerful locals. Experiment with your antenna so as to arrive at the proper length for your receiver. Better yet, replace your longwire with a good, variable "Q" loop antenna such as the NRC FET Altazimuth Loop; the combination of the loop's sharp tuning and lessened signal level will eliminate most, if not all, receiver-caused spurs. If you absolutely must use an outdoor longwire, build one of the antenna tuners described in Section II of this article. A final precaution which has been previously discussed in another regard, is to have the receiver aligned regularly by a competent and trustworthy technician or "ham". By taking these simple steps, the problems of spurious responses can be significantly reduced.

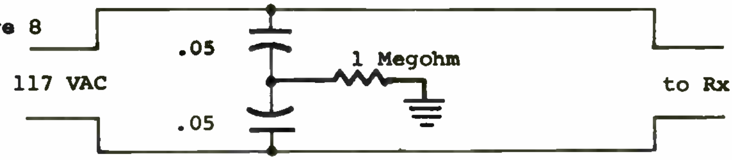
V. NOISE

Noise, or more precisely, the lack thereof, is another contributing factor to the retention of the DX'ers sanity and his hearing. It goes almost without saying, that as we increase the sensitivity to signals, we also increase the sensitivity to noise. It is for this reason that noise-limiting circuits are a requirement for the DX'er.

Many communications receivers are factory-equipped with noise limiters, but generally these are ineffective for the majority of noises that the receiver picks up. There are several commercial noise limiting units, mostly on the order of line filters, which when placed at the source of the noise-making appliance, are supposed to greatly reduce the interference. Of course, sometimes the DX'er will be unable to attach such a device to the offending appliance, especially if he lives in a multiple-family dwelling. He is then limited to attaching the filter to his receiver's power cord, where it accomplishes even less than the minimal amount it would if used at the noise source.

A simple noise limiter for the AC power line which the DX'er can build for himself is shown in the circuit diagram below. It functions as a bypass capacitor bled to ground and is similar to many of the commercially-available units sold in radio repair stores and hardware stores, but is more effective.

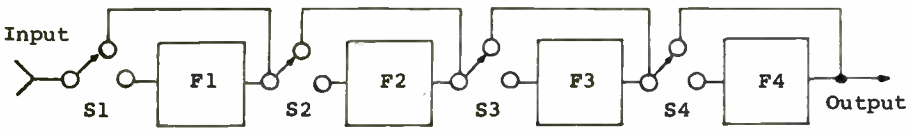
Figure 8



Unfortunately, all noises are not as easy to reduce or eliminate. Two of the more common noises for which there is little cure are those caused by television sets and electronic light dimmers, generally called "SCR dimmers" after the silicon-controlled rectifiers used. Television interference, or TVI, appears as both loud, low-pitched buzzes, and higher-pitched squeals, occurring regularly every seven or eight kiloHertz. TVI can be filtered at the source, but it is a sometimes-difficult procedure and is not always effective. Furthermore, with the huge number of sets which might be causing the noise, Unfortunately, however, many of the lower cutoff values for high-pass, fixed frequency filters are priced rather expensively and one unit may be enough for the first filter network.

Frequently, the varied uses for which the audio filters are employed require a form of coordinated network in order to selectively perform different functions independently. Such a network might include two or three values each of fixed low and high pass filters. The adaptability of such a system is almost unlimited, and nearly every type of noise or undesirable audio component can be reduced or eliminated. Figure 9 depicts such a system consisting of two each of the basic fixed filter types in the form of a block diagram in order to show just how the system is pieced together.

Figure 9

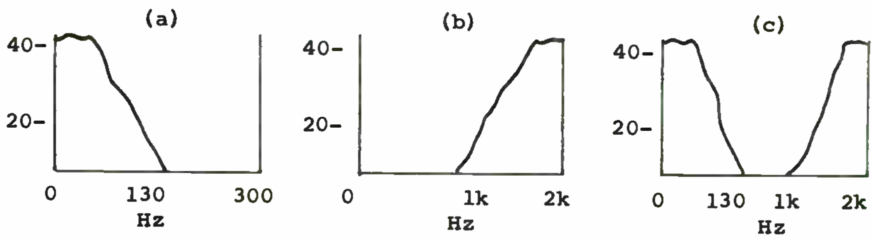


This type of circuit will allow the user the use of any combination of the four filters; with networks consisting of greater numbers of individual filters, one simply continues the same system of wiring. Another type of filter which can be used in an array of this configuration is the fixed-frequency bandpass filter, which cuts out frequencies at both the top and bottom of the frequency range and allows only a central portion of the audio spectrum to be passed.

At this point in the discussion, it becomes necessary to be sure that we have distinguished adequately between the different functions of the filters mentioned. In figure 10a, we see illustrated the effects of a high-pass fixed frequency filter with a cutoff of 130 Hz. This would effectively remove 60 and 120 Hz AC hums, leaving good intelligibility. In figure 10b, seen is the action of a 1000 Hz low-pass audio filter which would remove most heterodynes and still permit good readability. In figure 10c, seen is the action of a bandpass filter having cutoff values similar to our single action filters; when combined, these have the effect of using two single units together, leaving the range of frequencies defined by 130 Hz and 1000 Hz to be passed untouched through the network.

"You see, hair acts like a filter to eliminate interfering audio components."

Figure 10



Vertical axis denotes degree of attenuation in decibels.

* *

Please note that all the audio filters discussed this far are installed between the audio output of the receiver and the speaker, phones or tape recorder.

* *

We have covered the simple, fixed filters commonly available and how they can be constructed into effective filtering networks, but there is another way to achieve audio filtering; that being through the use of commercially constructed units available on the surplus market. Although there are companies manufacturing variable audio filters for commercial use (notably General Radio Company), these units are extremely expensive and unless you have a thousand dollars to spend, you may as well forget them. The surplus markets are an excellent source of used audio equipment manufactured within the last two or three decades. Generally, these filters may be obtained at prices ranging from $40 to $120, depending on how much rebuilding or repair is necessary. Their real value lies in the fact that many of these commercial filters are variable in frequency.

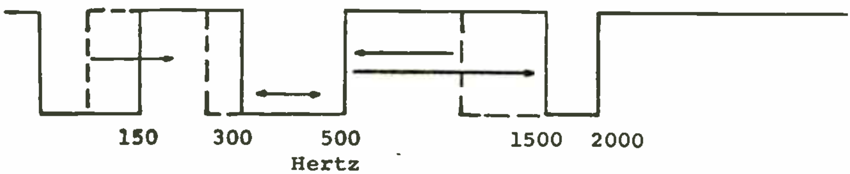
The most readily-attainable type is the Variable Band-Pass Filter, which functions in generally the same manner as the fixed-frequency band-pass already discussed, save that its frequency cutoffs are adjustable. One such filter is the unit manufactured some years ago by Krohn-Hite Instruments of Cambridge, Massachusetts, the nomenclature of which is Model 310-A. This type of filter permits the user to select any given set of cutoff frequencies within the operating range of the filter to define the passband. This ability is invaluable in the DX'ing hobby where no two signal/noise situations are alike, and where noises or interference accompanying an audio signal will vary greatly on many occasions.

Still another type of filter available on the surplus market is known as a Variable Band-Reject Filter. This particular filter's action serves to reject a specific frequency or small group of frequencies within the audio spectrum. In this way, it can be thought of as having a function precisely the reverse of the band-pass filter in terms of end result. The Variable Band-Reject Filter allows for the rejection of audio heterodynes; many of the more sophisicated varities of this unit feature variable bandwidth of the rejection band. These filters can be used to remove test tones, thus uncovering audio underneath. In such a case, the revealed audio would appear as if it were being heard beneath a strong open carrier. Unfortunately, it will be impossible to simultaneously attenuate the harmonics of the basic tone used.

One more piece of valuable equipment in use today by dedicated DX'ers is the Comb Audio Filter, which utilizes IC's (integrated circuits) and can be built by ambitious electronic hobbyists who have an affinity for construction projects.

This comb filter is used for the POST PROCESSING of DX tapes; not "in line" between the receiver and tape recorder.

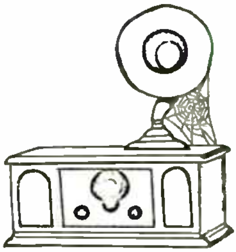
Figure 11



The DX'er is aware that for any particular segment of programming broadcast, there are portions of the intelligence-carrying audio frequency spectrum which contain varying amounts of audio power, be it voice announcements or a certain type of music. The beauty of a comb filter is that it can be adjusted for both passband width and frequency response (see figure 11). The filter can be selectively peaked on the voice frequencies of a male announcer, or female announcer as the case may be; the audio power may be concentrated in the voice frequencies of either announcer and the comb filter can be tuned to accept each, plus reject other frequencies or bands of frequencies of the audio spectrum. The process can be "tailored" to meet ones needs; peaking action is accomplished by manually shifting the "combs" back and forth over the tape: the DX'er tunes a number of potentiometer controls by ear to select the audio portion desired, and listens to the effect on a second, filtered tape recording.

In order to improve the signal to noise ratio, a DX tape may have to be processed through the comb filter numerous times; this technique may require a day or more of tinkering with the comb filter to clean up the tape, however, the time spent is well worthwhile, as a remarkable enhancement in audibility of the DX tape results. When the tape's frequency spectrum is "combed" of undesirable audio elements, the presence of a positive ID of a rare Medium Wave DX station is often revealed. Without comb filtering the ID would tend to remain "hidden" under interfering elements of the audio spectrum.

VII. CONCLUSION



There are, of course, many other improvements which the DX'er can make to increase the sophistication of his budget receiver. Many of these improvements are complicated projects, such as the installation of triple mechanical filters for optimum selectivity which requires an additional IF amplification stage as well; others, although relatively simple, are limited to only a few specific receivers.

The DX'er may later wish to add further accessories, such as an oscilloscope for the detection of SAH's (sub-audible heterodynes) or a frequency meter for the accurate determination of frequency. Perhaps the most widely-known piece of surplus equipment is the BC-453 military receiver, or "Q-5er" as it is known in DX circles, which may be used as an accessory piece of gear to improve the performance of cheaper receivers. Connection instructions for the unit are available from most surplus dealers.

Only the more universally-employed and relatively easy additions and modifications are discussed in this article; it is absolutely certain that if even a few of them are used, they will substantially contribute toward making a budget, or second-hand receiver a more useful piece of DX equipment.

RECEIVER HOT-RODDING HINTS

By Ray Moore

Just as the teen ager can modify an automobile to outperform the most expensive factory built car for a specific purpose,such as drag racing, so can the interested DXer modify a receiver to outperform the factory built set for a specific purpose, such as BCB DXing. For such interested DXers here are some notes and observations.

The Detection Process

The detector is really a mixer in which two frequencies beat against each other to produce a new frequency. In AM reception the carrier beats against the sidebands and the difference frequency is in the audio range. The original and sum frequencies, which are also present at the output of the detector, are filtered out with R/C elements.

An important characteristic of a detector is that it is controlled by the strongest frequency present. If the strongest frequency at the detector is the desired carrier everything else will be demodulated against it and we have a readable signal. If the strongest frequency is a sideband component from another station the output of the detector will be unintelligible.

The carrier of a properly modulated AM signal is from 6 to 20 dB or more stronger than any individual sideband component. This insures the proper relationship at the detector in the absence of interference.

What can we do to present more desired signal and less interference to the detector and thus recover more usable audio? There are three basic things to do

1. Use steep sided, narrow IF filters so that only the band of frequencies that contains the desired carrier and one set of sidebands is accepted.

2. Limit all signals, except the desired carrier, to the level of the desired sidebands.

3. Exalt the carrier within the receiver by increasing its level in relation to the desired sidebands and interference.

IF Filtering

Nelson's article[1] thoroughly covers the use of mechanical filters in the IF strip and is a must for anyone interested in DX receivers. Here are some observations based on much practical experience with mechanical filters.

Use of more than two mechanical filters in an IF strip is a futile exercise because of the limited dynamic range of existing front ends. Ordinary receiver front ends cannot simultaneously handle two signals that differ in strength by more than 50 to 100 dB without blocking, cross modulation or intermodulation. The average receiver will be closer to the 50 dB end, only special military receivers reach 100 dB. Two cascaded mechanical filters, properly shielded and filtered, will have an ultimate rejection between 120 and 140 dB, much more than can be used in practice. A third filter can, at best, make a small improvement in shape factor at the expense of a decrease in the already borderline bandwidth, and increased complexity.

Cascaded mechanical filters should be separated by amplifier stages rather than connected end-to-end. One of the filters should be placed directly at the input to the IF strip to knock down the undesired signals a few notches before they hit the amplifiers. The other filter can be located one or two stages further along. (Figure 1) If the two filters were placed back-to-back at the input to the IF strip your receiver front end would be looking into a unit with a noise figure of 20 dB or more. Many front ends are not quiet enough and have insufficient gain to overcome such a handicap. Secondly, if the filters are separated by amplifier stages you will have less stringent interfilter shielding requirements. Third, if the filters are lumped at the input to the IF strip the three following amplifier stages can generate considerable wideband noise.[7,8]

The center frequencies of cascaded filters must be matched within a few hertz since any mismatch will reduce the combined bandwidth which is already near the minimum that can be used for intelligible audio. The effective bandwidth of a given filter is much greater for SSB than for AM since the carrier is placed at a point 20 or 30 dB down the side of the filter response for SSB. This adds perhaps 500 Hz to the upper audio frequency that is passed compared to that which can be passed for AM where the carrier must be within the passband of the filter.

Don't spend too much time trying to flatten out the passband of your IF strip. Experience has shown that peaks and valleys in the passband or rounding off of the edges, up to 5 or 10 dB, has little effect on the intelligibility of the signal <u>if the exalted carrier technique</u> is used. Even when it isn't, passband ripple is hardly noticed but rounding of the edges (as in Fig. 3A) can be annoying.

An instrument for visually displaying the response curve is helpful in working with IF strips. One of the best and least expensive instruments is the Heath SB-620 Spectrum Analyzer. Set the SB-620 at its minimum sweep width position which will be about 0.7 kHz per division and manually sweep a steady signal across your IF passband, either with a signal generator or by tuning your receiver back and forth across a local BC station. The result is a nice picture of your IF passband down to more than 40 dB. See Figure 3.

<u>Exalting The Carrier</u>

There are a number of ways to exalt the carrier of an AM signal. Some don't work well when the carrier is obscured by noise and QRM and others are very complex. The best and the simplest of the methods which have been tried for BCB DX is to use a Q Multiplier to peak the carrier frequency relative to the other frequencies in the passband. The peak can be moved from one side of the passband to the other so that either the upper or lower

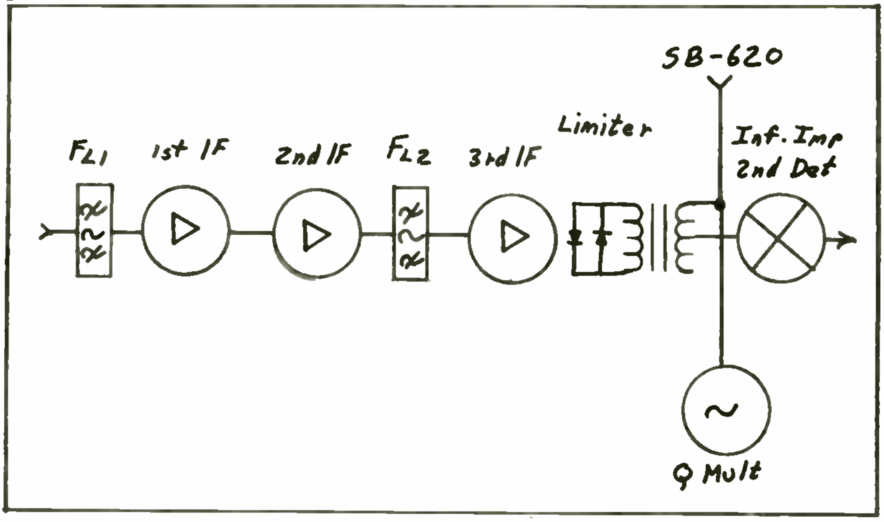


Figure 1 - Ideal IF strip for receiving weak AM signals thru heavy interference.

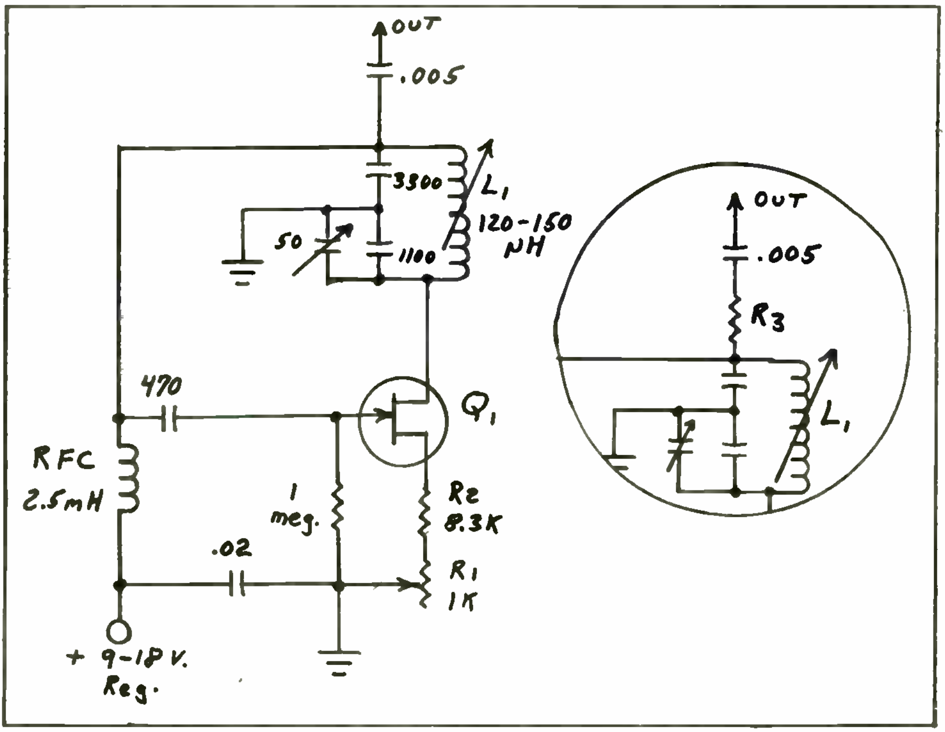


Figure 2 - Peaking type Q multiplier for exalted carrier reception. R2 can vary down to 500 ohms and may have to be determined experimentally. Inset shows R3, discussed in text.

sideband can be received.

The use of the Q multiplier for exalted carrier reception was explained in some detail in the original article in Electronics[2] in 1952 and is good reading for anyone interested in the subject.

One of the little known advantages of exalted carrier reception is that it adds perhaps 200 to 300 Hz to the usable bandwidth of a given IF strip because the carrier can be placed somewhat down the side of the passband and then brought back up with carrier exaltation.

Exalted carrier reception is useful in receivers not equipped with mechanical filters. It provides the usual exalted carrier advantages and, in addition, steepens the side of the passband which has the most QRM. The HQ-150, which has a built-in Q multiplier and a crystal filter, can also provide exalted carrier reception by placing the crystal filter in the medium position, tuning so that the carrier is down the side of the crystal selectivity curve by about 6 dB (one "S" point) and then tuning the Q multiplier peak to the carrier.

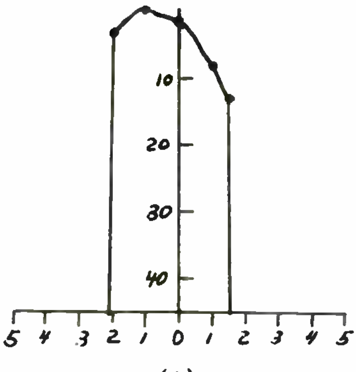
AM reception on the SSB positions of modern receivers is seldom satisfactory because the locally generated carrier is not phase locked to the original carrier. The carrier of an SSB signal is down about 70 dB at the detector, 50 dB at the transmitter and 20 dB in the receiver, thus there is no reaction between the original suppressed carrier and the local carrier.

How much carrier exaltation is desirable? The carrier should be exalted at least 15 to 20 dB relative to the rest of the passband, based on experiment. This coincides well with the SSB recommendation that the local carrier be 14 to 28 dB greater than the signal. Less exaltation does not achieve the characteristic clarity of exalted carrier reception.

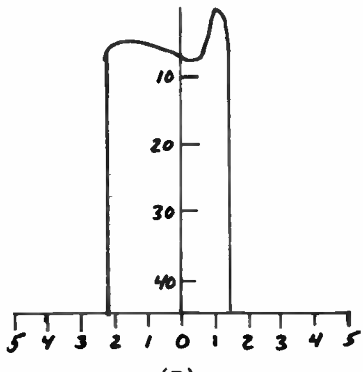
The Q Multiplier

There are no Q multipliers on the market today. You will either have to purchase a used one or build your own. Much of the circuitry can be eliminated if the Q multiplier is for exalted carrier reception. The circuit in Figure 2 provides excellent performance. Q1 can be an HEP-801 or HEP-802 or most any general purpose N-channel FET. L1 can be a BCB loopstick or antenna coil (Miller A-5495-A, for example) with primaries and other extraneous windings removed. The coil winding should be positioned so that it is a couple of inches from any other objects. The unit can be built into a mini-box large enough to give the proper coil clearance. The lead connecting the Q multiplier to the receiver should be coax not more than 10" to 18" long. Retune the transformer to which the connection is made. A switch in the supply voltage lead will turn the unit off and on.

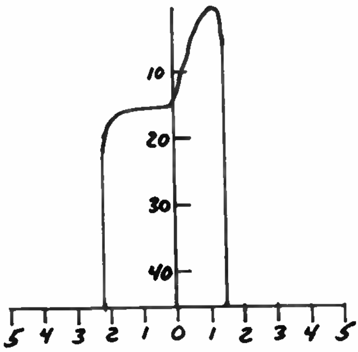
The Q multiplier will superimpose a peak on the receiver passband if the decoupling resistor, R3, shown in the inset in Figure 2, is added. Curve B in Figure 3 results when a 22K resistor is used and C was taken with a 10K resistor. The larger the resistor the narrower the peak and the less its amplitude. With the 22K resistor the peak is so narrow as to make tuning very difficult and it is not high enough to give sufficient carrier



(A)



(B)



(C)

Vertical axes in dB

Horizontal axes 0.7 kHz/Div.

Figure 3 - IF passbands as displayed on SB-620 Spectrum Analyzer. (A) IF strip consisting of three amplifier stages and two Kokusai mechanical filters and two IF transformers. (B) Same IF strip with Q multiplier set for exalted carrier reception, R3 of 22K. (C) Same except R3 is 10K.

exaltation. The 10K resistor is much better. In practice the straight Q multiplier without the resistor does a good job and allows more carrier exaltation. The Heath QF-1 and GD-125 Q multipliers have a 27K decoupling resistor in their broad positions.

Where should the Q multiplier be connected into the IF strip when it is intended for carrier exaltation? The best point is just before the second detector. Figure 4. If your receiver has a diode detector it will either be necessary to change it to the infinite impedance type or move the Q multiplier to the primary of the last IF transformer. The reason for placing the Q multiplier at the end rather than at the beginning of the IF strip is that it is protected from strong, off frequency signals by the mechanical filters and because it must come after the IF limiting which which must be done late in the IF strip.

How To Tune The Exalted Carrier Receiver

Tune to the desired station with the Q multiplier off and determine which sideband has the least interference. Then tune so that the desired sideband is in the receiver passband with the carrier at the extreme edge as evidenced by a 6 to 12 dB (1 or 2 "S" units) drop in the "S" meter reading. With experience the correct point is easily found audibly. The Q multiplier is then switched in and peaked on the carrier. The Q multiplier feedback control should be advanced nearly to the point of oscillation. When properly tuned there is a pronounced sharpening of the clarity of both the background and the desired signal.

When the desired station is very weak it is sometimes better to perform the above set-up on a nearby, stronger station and then tune back to the desired station and peak it with the receiver tuning. leaving the Q multiplier alone.

A slow tuning rate is required when using a large amount of carrier exaltation. Many receivers are deficient here and need some help. Either a mechanical or electronic bandspread capacitor across the oscillator tuning capacitor will do the job.

Receiver drift must be low otherwise you will be chasing the signal across the band. Once set up, the retuning to maintain the carrier on the peak should be done with the receiver tuning rather than the Q multiplier tuning otherwise the position of the peak in relation to the passband will change.

IF Limiting

After we have narrowed the bandwidth to only that required for one sideband and have exalted the carrier we can reduce the amplitude of QRM and QRN to a level equalling that of the desired sideband by limiting. This will insure that the desired carrier will be the strongest component at the detector. The type of limiter described here is particularly effective against short, sharp bursts of sideband energy from a nearby station. It is also effective against short individual static crashes. It will not improve readability in the presence of continuous QRM or QRN although it may save your ears.

The simplest and best IF limiter tried to date is a pair of silicon diodes across the last IF transformer. (Figure 4) The diodes appear as a short across the transformer to any RF voltages above the diode threshold, about 0.6 volts. Below that point the diodes are an open circuit. The 6-60 pF capacitor is a mica trimmer to tune the transformer when the diodes are cut out. The diodes, trimmer and switch should be mounted as compactly as possibile around the bottom of the IF transformer.

Tune-up consists of switching the diodes into the circuit and peaking the transformer, T. Then switch the diodes out and peak again with the 6-60 pF trimmer. Operation of the limiter is best with the AGC off. The RF gain control is advanced until clipping occurs, as determined audibly, and then the AF gain con-

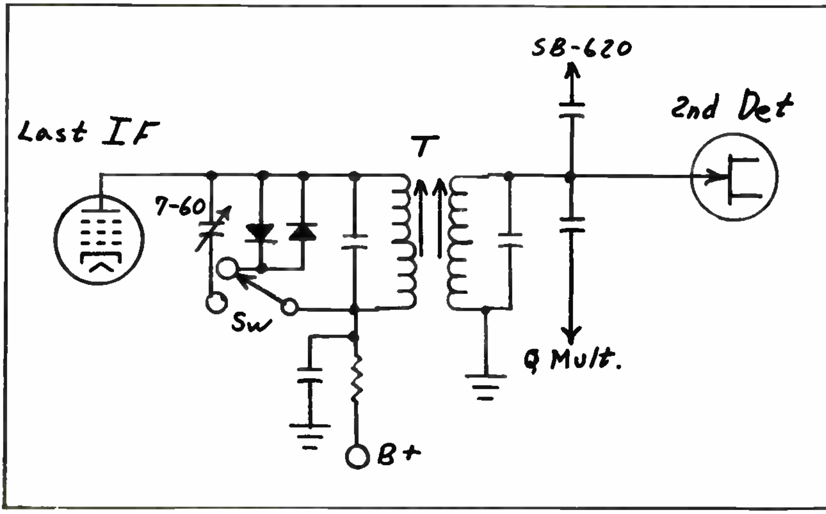


Figure 4 - IF noise limiter connected across last IF transformer. Low leakage silicon diodes such as the 1N457 are recommended.

trol is adjusted for a comfortable listening level.

Audio clippers and limiters are of little value to the AM DX listener. The IF limiter is much superior because

1. the limiter should be ahead of the carrier exaltation point so that noise and QRM can be cut down to the level of the desired sidebands
2. noise and QRM will produce in-band IM products if they are not attenuated ahead of the detector.
3. the IF filter in the detector circuit will stretch and integrate noise pulses if not previously attenuated
4. distortion products of audio clipping and limiting will be largely in-band
5. distortion products of IF limiting are largely out-of-band.

IF limiting is the least explored of the methods of improving AM DX reception. Much experimenting remains to be done. The use of biasing on the diodes to adjust the threshold as an alternative to the above method,which fixes the threshold and adjusts the signal level, should be investigated. Pappenfuss (3) suggests that the limiter would be much more effective if FL1 (Fig. 1) were a Gaussian type filter (two or three IF transformers in series) and the limiter placed just ahead of FL2. Perhaps there are suitable germanium diodes. They have a lower threshold voltage and could be placed nearer the front of the receiver. See Ref. 5.

Receiver Gain and Gain Control Requirements

The Q multiplier operates, not by peaking the desired frequency, but by attenuating all frequencies except the desired one. Therefore, when the Q multiplier is used for exalted carrier reception the sidebands are attenuated up to 20 dB. Add to this the attenuation of a couple of mechanical filters , an IF limiter and an audio filter and you have perhaps 40 dB of attenuation in the signal path of the receiver. Many commercial receivers do not have the reserve gain to handle such a situation. In a homebuilt receiver I have found that a minimum of three IF and three AF stages are required. An RF stage will help but at the expense of signal handling performance.

The receiver should have a manual gain control for each section in order to provide optimum gain distribution for various receiving conditions. If, as is usual, the RF and IF are controlled by a single control they should be separated and a separate control installed for the RF stage. Better yet, remove the RF stage from both the manual and automatic gain controls and install a 2K potentiometer across the primary of the antenna transformer to act as RF gain control. This controls the strength of signals without degrading the RF tube signal handling ability as you do when you change its operating point. Every dB of attenuation ahead of the receiver reduces cross-modulation by 2 dB and IM products by 3 dB while reducing the desired signal by only one dB.

Audio Filters

A low pass filter has limited usefulness in a receiver with adequate IF selectivity unless the filters are lumped at the input to the IF strip in which case the amplifiers can produce a wideband noise that produces a hiss in the receiver output. Some detectors may generate distortion which can be reduced with a LPF.

A high pass audio filter, on the other hand, will sometimes make a marked improvement in the intelligibility of signals which have passed through a narrow filter by eliminating the boominess and muffled sound characteristic of such signals. It has been shown that when the higher audio frequencies have been removed from speech (by the IF filter) that some of the lower frequencies should also be removed to maintain speech naturalness and intelligibility. (4) If the upper frequencies are cut off around 2000 Hz, as they are with a mechanical filter, the lower frequencies below 300 Hz should also be attenuated.

Figure 5 shows a simple method of reducing the low frequency response of a receiver. Experiment with the value of C1 to get the most effective value for your personal hearing characteristics.

Bi-aural Reception

A little known technique is bi-aural reception in which the two sidebands are separated and one sideband is sent to the left earpiece and the other to the right earpiece of a set of phones. The desired signal information is identical on each sideband but the QRM and noise is different on each and the ears and brain separate the signal from the noise so that the signal stands out. There is a sort of stereo effect and you can concentrate on the signal and ignore the noise much as you listen to a conversation in a noisy room.

One way to achieve bi-aural reception is to use two receivers each capable of exalted carrier reception. One receiver is tuned to the upper sideband and the other to the lower and the outputs

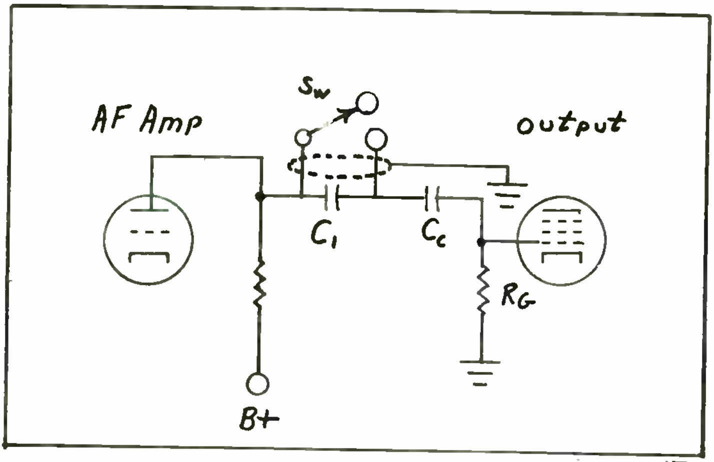


Figure 5.- Simple high-pass audio filter sometimes will make speech crisper and more readable. C1 is added to existing circuit and can be between 200 and 1000 pF.

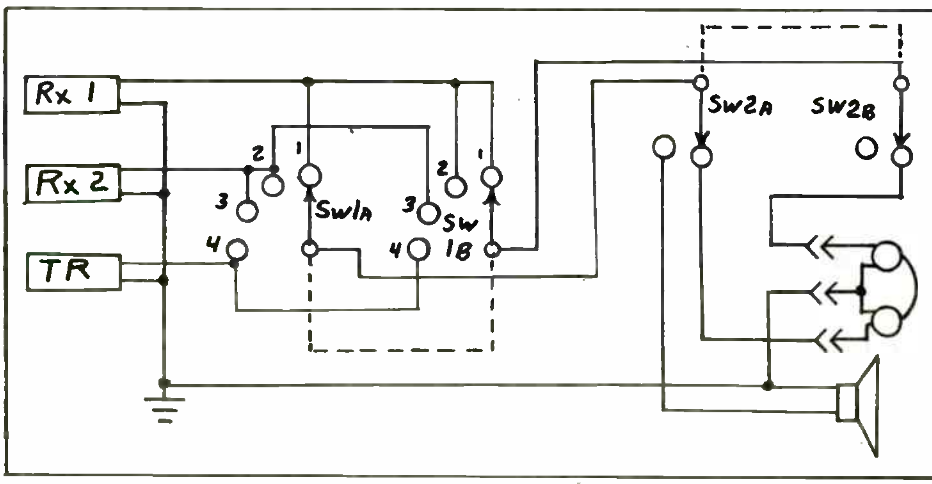


Figure 6 - Switching arrangement feeding either speaker or stereo headphones from two receivers and a tape recorder. Position 2 of SW1 is for binaural reception, one receiver to each ear.

are fed to stereo headphones. I have used an HQ-150 for one sideband and my homebuilt receiver for the other and had really good bi-aural reception. One of the switch positions in Figure 6 is for bi-aural reception.

Headphones

Many DXers believe that the low impedance stereo headphones are the best and most comfortable for DXing. The two earpieces can be paralleled either by rewiring the plug or in an external adaptor. Most modern receivers have low impedance headphone outputs which will accomodate the stereo headphones but older receivers may have a high impedance headphone jack in which case you can wire a headphone jack in parallel with the speaker output terminals.

Putting It All Together

The serious foreign DXer interested in maximum performance needs a second receiver and a tape recorder. He will also want to be able to use either headphones or a speaker. The second receiver is used for checking WWV, listening for SW parallels and general band scanning during lulls in taping or logging the primary station.

Figure 6 is a switching arrangement that allows very flexible use of the equipment. SW2 switches in either a speaker or stereo headphones. Position 1 of SW1 is for listening to receiver 1. Position 2 places receiver 1 on one earpiece and receiver 2 on the other earpiece of the stereo headphones. Position 3 is for receiver 2. Position 4 is for the tape recorder. The switches, jacks and wiring can often be placed in the speaker cabinet.

Reference 6 has some good ideas on the receiving end of DX station design.

1. "Single Sideband Reception on the Broadcast Band With Mechanical Filters," Nelson, NRC DX News, Aug 19, 1967

2. "Flexible Selectivity For Communications Receivers," Villard and Rorden, Electronics, April 1952

3. Single Sideband Principles and Circuits, Pappenfuss, et al, McGraw-Hill, pp 303-304

4. "Cut-Off Frequencies and Audio Quality," Neil, QST, Nov 1950

5. "Noise Limiter For Mobile VHF," Bishop, Electronics, June 1953

6. "Station Design For DX," Part III, Rockwell, QST, Nov 1966

7. "Plagiarize and Hybridize," Pt I, Martin, Radio Communications, March 1971

8. "The Solid State Receiver," Sabin, QST, July 1970

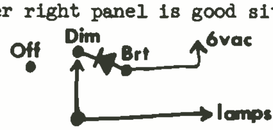
Modifying the Hammarlund HQ-150 Receiver

Bob Foxworth

The HQ-150 receiver is one of the more satisfying MW DX receivers for the money, in my opinion. One can occasionally be found on the surplus ham equipment market in the $130 - 150 range, but unfortunately are offered very infrequently. These receivers can be modified or changed to make them more useful in any one of a cosmetic, mechanical or electronic fashion. Following are most of the modifications I've made to my own unit, in no particular order, and the reader who owns a HQ-150 or a HQ-129X or HQ-140 or other similar unit, can adapt any of these ideas.

Front Panel:

1. Replace present knobs with Daka-Ware skirt knobs for greatly improved appearance; better indication of setting of control (i.e. better visibility).
2. Replace S-meter with Simpson Wide-Vue 200 microamp or similar meter for better pointer action (increased damping for less wild swinging action on jumpy signals), better visibility and panel appearance. Check hole layout.
3. Add jack on panel for IF output directly in front of first IF amp tube. Sig can be taken from copper strap wrapped around tube body, capacitively coupled.
4. Add jack on top left of panel for local osc out, for fqy counter readout.
5. Add S-meter zero and fullscale set controls under standby switch (rotate switch sideways for clearance), moving pots to front deck of chassis from presently inaccessible rear location next to IF can. Drill 2 3/8-inch holes thru panel and chassis. The zeroset changes often in the HQ-150 making frequent resetting desirable. One cure is to substitute a dual-triode bridge circuit here.
6. Add 2 MAPC (Midget Air Padder Cap.) 25pf air trimmers to front chassis deck. Units must have screwdriver slot adjustments, separate mtg holes and tab for ground lead connection. Hammarlund units are still available at some parts stores. These replace the mica compression trimmers under the chassis which set the high-end osc tuning on bands 1 and 2, making the dial track at the 1.3 and 3.2 mc points. Because of longterm circuit drift, aging, and the inability to align exactly with the rx out of the cabinet, the dial calibration will be very hard to get right on. This allows the dial calib. to be set with the rx in normal position on the 2 ranges of interest. Panel layout will have to be watched carefully depending on the exact dimensions of the MAPC the reader uses. Determine shaft centers and drill a 1/8-inch hole thru both panel and chassis with panel attached, to ensure coincidence. Then, completely remove panel. On chassis front deck only, locate and drill the 4 new mounting holes, and enlarge shaft holes to allow the MAPC adjustment slug to fit the hole. 3/8" should do that. Mount the 2 MAPC's using 3 or 4 #4 flatwashers as shims, to keep the MAPC hex head slug from protruding forward enough to hit the panel when it's replaced. Disconnect leads from mica compression trimmers for Osc bands 1 and 2 and move them to the MAPC stators. Band 1 will be the MAPC on the bottom, with chassis inverted. Connect rotor grounding tabs to ground, on the shield bracket for the coils. These devides do not ground thru the screws. Set the alignment by setting the dial on a given freq near 1200 and near 3.0 mc respectively, and turning the MAPC to bring in the signal. See pictorial drawing for illustration of this.
7. AF filter switches can be added, depending on user's application. We suggest the MFJ active filter wired for 200 hz hi-pass, the low-pass wired for say, 5000 hz and a tunable notch filter combined with the 2-watt transistorized output module, replacing the 6V6 output stage. Upper right panel is good site.
8. Dial lamp dimmer. A 3-position switch is put in series with the dial lamp lead and wired: This provides "off", "dim" and "full" settings. The "dim" guarantees your #47 bulbs will last forever, and it's perfectly adequate. Any old silicon power diode works.



9. The chassis can be left loose in the cabinet and pulled forward a half-inch or so to let heat escape and eliminate drift. Handles can be attached to the holes on the edge of the panel, which are spaced for 5-inch rackpanel handles! This helps the user slide the set in and out of the cabinet. They look sharp, too...

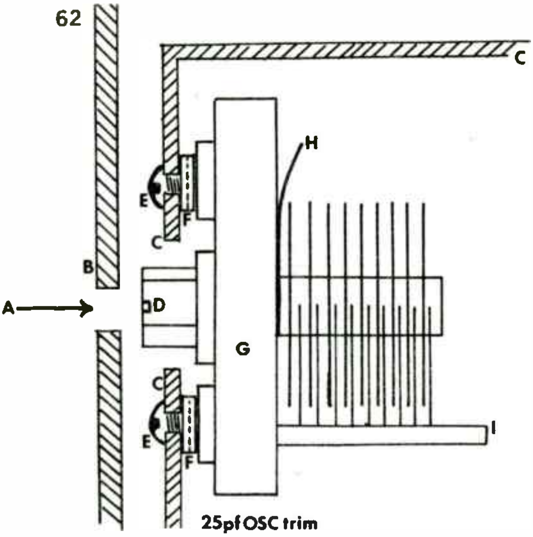
Rear Panel.

10. The A1-A2-G strip can be removed and two SO-239 coax jacks put in the resulting oval hole, flanges outside. Butting faces of the flanges will have to be shaved slightly with a file or grinder, or the hole enlarged about 1/16 inch for a snug fit. This improves shielding and makes cable hookup much easier to do. The user may opt for other types of jacks instead but a buffer plate will then have to be made up. When using single coax inputs (un-bal in) a shorting plug can be inserted in the "low" side. This is a plug with the center wired to the shell.
11. Add a jack for xtal calib in, couple to the "high" side of the Ant in. See prevoius articles, available from NRC reprints, for more on stepp 10 and 11.
12. Add a jack for detector audio out. Couple capacitively to Pin 1 of the 6AL5.
13. Add a jack for speaker level audio out, replacing inconvenient screw lug strip.
14. Add a jack for AVC voltage out, for use in measurements. Connect to AVC buss.
15. Add a jack for mixer video out. See SB-620 review for details, from Reprints.
16. Relocate fusing on rear deck. Add a B+ fuse, as well as mains (AC line) fuse.
17. Add power supply multiplug. This is a jones type socket with all voltages brought to pins and all receiver supply lines brought to pins. A plug wired to connect them (fil. to fils; B+ supply to plates etc) is inserted to make the receiver operative. Advantage: In case of power supply failure inside the set, the strapped plug is removed and an external standby supply with output to a similarly-wired plug is substituted, keeping the receiver in operation, or permitting maintenance/diagnostic tests if poor performance is suspected. Another advantage is that by removing the strapping plug, unauthorized operation of the receiver is prevented. Application of this idea is left to the reader's ingenuity.

Internal.

18. Add mixer trim adjust. This is easy on the HQ-150, electrically, as there is an extra section of the main tuning gang that's brought into use only on bands 1 and 2, and this point (in the mixer circuit) may be accessed and the trimmer so wired that it functions only on bands 1 and 2. This point appears on the bandswitch assembly. Mechanically, the "limiter" switch is removed, as is the shield can around the BFO tube socket. A National PRAD type (that's its number; it's a Precision Right Angle Drive) is mounted so as to drive a 40pf variable with $\frac{1}{4}$-inch shaft, as shown in the illustration. (see next page). As there are no pre-provided mounting points, some research will be needed by the reader to determine just how to mount the unit. In my case I had to drill through the chassis at a point inside the main tuning gang shield to mount a bracket to which the 40pf variable attached. This bracket anchors 4 long threaded bolts which act to secure the body of the PRAD relative to the bracket. The drive to the PRAD is accomplished by running rigid shaft through the busing (formerly occupied by the Limiter switch) and then coupling to a piece of flex shaft, as supplied by Herman H. Smith Co. The PRAD is available from Leeds Radio in New York (57 Warren St.) for about 6 dollars, last time I checked, but it does have a lot of brass gearing in it. Other layouts may suit the reader better, especially if another unit (such as the James Millen right-angle drive) is substituted. An easier approach may be to substitute a varactor diode adjustment, if the reader has the expertise needed to make that approach work. I haven't tried that myself.
19. Add phono jack in coax lead, and 4-pin jones plug in power leads running to Q-mult subchassis for ease in removal when servicing of capacitor gang is needed.
20. Remove stop pin on "tune" shaft of Q-mult subchassis so that device may be tuned through a full 10 khz range, which is not presently possible.
21. Noise blanker subchassis may be mounted on the tuning gang shield, toward the rear of the receiver.

Circuit modifications are beyond the scope of this short paper. Some ideas that may be pursued here are: Addition of mechanical filters or external IF chains, replacing the RF amp with a 6EH7, replacing the mixer with a 7360 beam-deflection type tube, adding a cathode follower isolation stage to the mixer for use with a spectrum analyzer (see the SB-620 review), doing the same with the local oscillator for use with a presettable frequency counter used as a digital readout tuning dial.



Addition of OSC trimmer to front of receiver chassis.

A - Screwdriver adjust access.
B - Receiver panel.
C - Receiver chassis
D - Screw slot in hex head on MAPC
E - 4-40 mounting machine screw (2 req'd per unit)
F - #4 flatwasher shims, use 2 or 3 per hole as needed.
G - Ceramic frame of MAPC.
H - lug for ground connection.
I - Stator (hot) connection, lead runs to osc. coil.

-- SIDE VIEW --

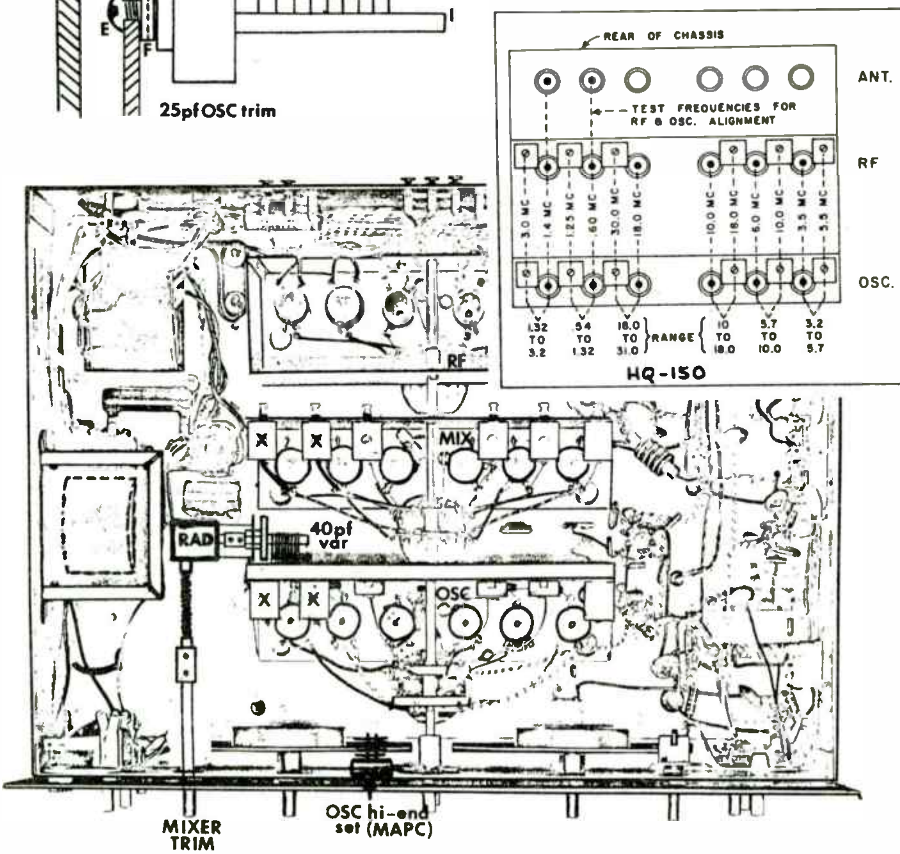
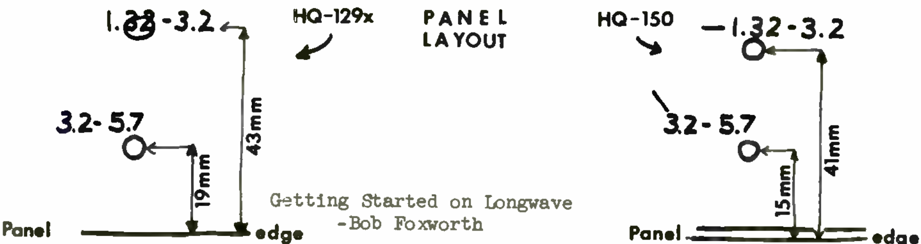


Figure 11. Bottom View of Chassis, Showing Trimmers and Coils

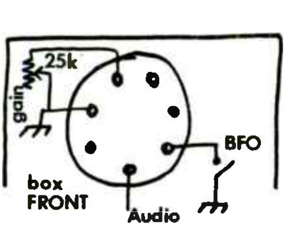
Trimmers marked X are replaced by variables.

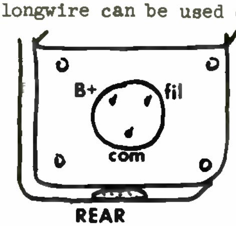
The view of the MAPC on the previous page shows the mounting screws out of phase with the rest of the capacitor body, for purposes of clarity. In the HQ-150 the two MAPC's (depending on size) will likely be mounted with all holes in a vertical line, top to bottom on the chassis. The stator (hot) connections are positioned to be closest to the bandspread tuning shaft. Another point should be made clear. The wires from the osc. coil lug to the compression trimmers are removed, and new wires from the bandswitch lugs (not the coil lugs) are then run to the MAPC's. The idea is to keep the leads as short as possible. Anyone attempting this who is having difficulty may write me, providing it's a HQ-129, 140 or 150. Other sets require different approach. The 1/8-inch hole will be drilled very close to the points on the panel that bear the bandswitch legend, as shown below for the HQ-129x and HQ-150.



Getting Started on Longwave
-Bob Foxworth

DXing broadcast stations on Longwave requires a receiver tuning down to 150 khz, plus a good location and good cx. This makes selection and purchase of a suitable receiver an ambitious goal. A temporary expedient that costs little can be made by obtaining a BC-453 Command series surplus receiver. This additionally allows the DXer to DX the beacon band, and to use the set as a selective IF amplifier by tuning in the main receiver's IF signal. The 453 popularly known to hams as the Q-5'er, tunes 190 to 550 khz, allowing reception of the TA freqs of 200, 209, 218, 236 and 251, all of which have been heard here. There are other freqs, too. One can also tune 520, 525 and 529 all of which are broadcast freqs unavailable on the ordinary communications receiver. A surplus, used BC-453A can be found at a hamfest or flea-market from time to time for 5 to 10 bucks. G&G Radio in New York City and Fair Radio Sales in Lima, Ohio have consistently advertised these units in "like-new" condition for prices around $20 or so. The R-11 costs less but has no tuning dial so isn't discussed here. Occasional articles in the ham radio press deal with converting these units. The hardest part of the job is rewiring the filaments (and then substituting 6v. filament tubes for the 12v units in place). We suggest you forget that. Leave the tubes and the filament wiring alone, and get a 24volt transformer to power the filament buss. I use a Triad F-45X rated at 1 amp and it doesn't even get warm. You'll also need about 200 to 225 volts DC at around 25 ma for the plate supply. The power supply in the back of the RCA Tube Handbook is used, with excellent results, but you might be able to rob power from some other piece of gear. You'll need a splined shaft tuning knob which is sold at some surplus places, or you can epoxy a piece of 1/4-inch shaft to the spline (which originally went with a control cable) and put a knob on that. Finally, you'll have to access the connections in the box in the front of the set for a gain control, BFO off-on switch and 600 ohm audio out. This will drive headphones, or a speaker if a line-to-voice coil transformer (e.g. Stancor A-3883 or similar) is used. A longwire can be used on the antenna binding post.





References: BC-455 Unconverted, QST, June, 1966. Surplus, CQ, Dec. 1970 p.77. BC-453 series Receivers, 73, June 1966. Copies of all are available from author for $1 postpaid. B. Foxworth, GPO Box 2111, New York 10001.

Selectivity Devices

AND HOW TO USE THEM

Ronald F. Schatz

Selectivity - without it your receiver would pick up every station on the band at the same time, and that wouldn't be nice. When we speak of selectivity we mean a receiver's capacity to pick up only the station you want to hear - and no others. Toward this end both standard and special circuits are employed in receivers.

One may not think of it in such a manner. but the basic selectivity device found in all receivers is the RESONANT CIRCUIT, and without it radio as we know it today would be an impossibility. The resonant circuit is nothing more than a coil and a capacitor connected together. When connected in series (Figure 1) only one particular frequency can pass through them; when connected in parallel (Figure 2) only one frequency cannot get through the circuit - just the opposite effect. Here is how it works:

Figure 1

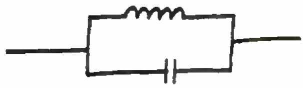


Figure 2

Most readers know that the purpose of that colour-banded device known as a RESISTOR is to impede the flow of current through it; the higher the resistance, the more "open" the circuit is. Coils and capacitors have a similar effect on current flow - as follows:

A COIL is so constructed in order to concentrate a magnetic field in its area. This magnetic field is slow to change, so that it permits DC to pass through the coil with no problems but not AC, since the latter changes so many times per second. The higher the frequency of the current, the more "resistance" the coil offers to it. This type of "resistance" in coils is called INDUCTIVE REACTANCE. Like resistance, it is measured in OHMS (symbol = $j\Omega$).

A CAPACITOR consists of two metal plates insulated from each other but still close enough together to permit the existance of a strong electrostatic charge between them. In this case it is the DC that can't pass through the capacitor, while AC can. The higher the AC frequency, the easier time it has crossing the electrostatic field. This property is called CAPACITIVE REACTANCE, also measured in OHMS (symbol = $-j\Omega$).

As can be determined by their respective symbols, inductive reactance and capacitive reactance are similar but opposite in nature. In a circuit, one value subtracts from the other, so that if both reactances happen to be equal (and opposite), the result is no reactance at all. In the case of Figure 1 above, the only frequency that can pass through the circuit is the one for which the reactances of both the coil and the capacitor are equal, and we say the circuit is "resonant" at that particular frequency.

Frequencies very close to the particular frequency of a resonant circuit also pass through, since the reactance, though present, is very low. The further removed the "off" frequency is from the resonant frequency of the circuit, the more reactance it faces. A RESONANCE CURVE is a graphic illustration of what frequencies pass through a given resonant circuit and how well they do so (Figure 3).

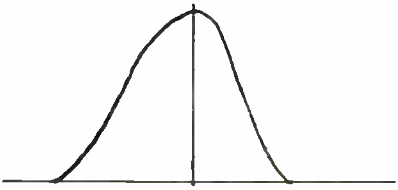


Figure 3

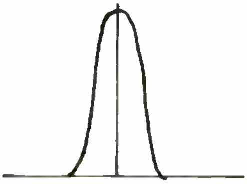


Figure 4

It is now obvious to many readers that the quality of a resonant circuit is to be judged by its ability to reject those "off" frequencies and their unwanted signals, so that a curve like that shown in Figure 4 is preferable to the one in Figure 3. This "quality" is recognised in electronics, where it is abbreviated "Q". Correct - Q as in "Q-Multiplier"!

Low selectivity in a resonant circuit is due to the presence of RESISTANCE, which dampens the circuit's ability to resonate, or "ring", at the resonant frequency. Q then becomes the ratio of reactance over resistance present in a circuit (Q = X/R), so that high Q turns out to be a desirable thing.

Selectivity can be improved by passing a signal through more than one resonant circuit or by sending it through the same circuit again. Receivers of earlier days were limited by component size in the amount of resonant circuits they could contain, so their selectivity left much to be desired (E.g., a super-local taking up much of the band). The "regenerative" receiver tried to overcome the problem by returning the signal for a "recycling job" through the same circuits again. Today smaller and better-quality components give high values of selectivity to the cheapest receivers, so that manufacturers now must avoid designs that are too selective for general use.

Too selective? Yes, since the sidebands that carry a signal's voice and music are, themselves, "off" frequencies. The higher the pitch of the modulating sound, the further removed are the sidebands from the resonant (carrier) frequency, so that too much selectivity will cut out the higher frequencies, leaving audio that sounds muffled and bassy. Perfect selectivity would permit only the carrier to come through the receiver and none of the audio - and no ID for logging and copying the station.

So the dilemma is one of the soldier throwing a grenade; if it lands to close he too will get the shrapnel. A compromise is to be found that will eliminate as much of the interfering signal as possible without hurting the intelligibility of the desired signal. The rule to follow is this:

USE NO MORE SELECTIVITY THAN IS NECESSARY FOR CLEAR AND PLEASANT COPY OF A SIGNAL.

Many inexperienced DX'ers habitually keep their crystal filters on position 4 and their Q-Multipliers near the point of oscillation at all times, deeply affected by the charisma of selectivity, they almost ignore the fact that they can't make out the audio they need for logging the signals they receive.

Now we are ready to discuss selectivity devices other than simple resonant circuits. These devices can be divided into two major classifications: The first group eliminates all signals except the desired one and its audio. Included here are the Q-Multiplier (peaking type), crystal filter, mechanical filter, and ceramic filter.

The second group of selectivity devices pass everything except the one interfering signal it is desired to eliminate. These are the nulling Q-Multiplier and the various notch filters employing differential circuits. These devices have the advantage of better audio quality than those in group one, but they are often helpless when there is more than one interfering signal present.

THE Q-MULTIPLIER

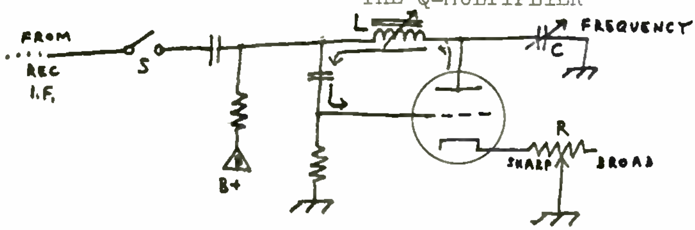


Figure 5

The Q-Multiplier is little more than a glorified resonant circuit. It is a parallel circuit that grounds everything in the normal signal path of the receiver except for that part which falls in its particular resonance curve, the latter being permitted to reach the speaker. The Q of the circuit can be controlled over a wide range to determine just how much of the band is to be diverted away from the latter stages of the receiver and short-circuited to ground.

In Figure 5 the resonant circuit consists of the coil (L) and the combined effect of all the capacitors in the circuit (this includes the interelectrode capacitance in the vacuum tube). The variable capacitor (C) permits shifting the frequency several kHz on either side of a center frequency - the IF of the receiver. C is a front-panel control, generally marked "frequency"; L can also be varied, but is left alone except during receiver alignment. The potentiometer marked "R" is also a front-panel control, usually labeled "selectivity (sharp-broad)". A DP switch (S) is always present in some form for the purpose of turning the Q-Multiplier on or off.

The arrows show the feedback (recycling) path in the circuit. This regeneration is responsible for the very high Q that makes the device useful to the DX'er. R controls the electron flow in the tube, and that literally controls the amount of damping resistance present between the electrodes of the tube and, therefore, in the resonant circuit of which it is a part. Too little resistance, however, will permit the feedback to sustain itself and convert the Q-Multiplier into a poor-quality BFO. This is what happens when the selectivity control is turned too high - a "strong open carrier" appears on the scene. Strong signals from the IF strip entering the Q-Multiplier can <u>also</u> cause it to break into oscillation if the selectivity control is set near the critical point.

In summary, the Q-Multiplier functions by removing everything from the receiver except for what falls within the resonance curve of the device. Its high Q is the result of regenerative feedback.

Most DX'ers like to leave the Q-Multiplier frequency control in mid position at all times, but better audio for a given amount of selectivity often results by tuning that control off to the side opposite to that of the interfering signal.

THE CRYSTAL FILTER

A crystal is a high-Q resonant circuit combined into a small piece of quartz rock. So high is the Q of this rock that crystal-filter circuits must be provided with resistors to dampen its effects.

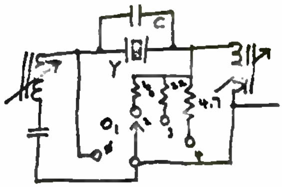


Figure 6

Figure 6 is a typical crystal-filter circuit, such as found in many Collins receivers. This one has 5 positions, marked 0, 1, 2, 3, and 4. Position 0 bypasses the filter completely, thus eliminating the crystal from the signal path. Position 1 has infinite resistance (no connexion) giving the widest possible selectivity with the crystal. Positions 2, 3, and 4 have resistors of 100kΩ, 22kΩ, and 4.7kΩ each respectively, and respectively sharper selectivity down the line. A short circuit across the resistance path would result in the sharpest selectivity, but it would be much too sharp to have practical use.

The purpose of capacitor "C" in Figure 6 is to neutralise the capacitance of the crystal holder (Y). It is called a "phasing capacitor".

Better crystal filters employ two or more crystals differing slightly in resonance frequency to give a combined resonance curve (bandpass) with a flat top and steep sides. Today this arrangement has largely been replaced by mechanical filters.

THE MECHANICAL FILTER

This is not a circuit but a component. A typical mechanical filter consists of, say, 7 cylindrical discs tightly suspended between two TRANSDUCERS (devices which convert electrical energy to mechanical energy and vice versa). Each metal disc resonates at an ultrasonic frequency near that of the receiver IF in a manner that all the discs cover the desired bandpass. For example: If we desire a 7-element filter to have a bandpass 2.1 kHz wide centered on 455 kHz, we would want seven discs to resonate respectively on the frequencies of 454.1, 454.4, 454.7, 455.0, 455.3, 455.6, and 455.9 kHz. As each disc has a very high Q the resulting "curve" would approach the rectangular shape that offers the best possible selectivity/intelligibility ratio. This is how a mechanical filter can offer excellent selectivity without "muffling" the audio.

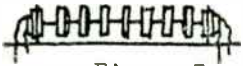


Figure 7

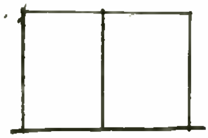


Figure 8

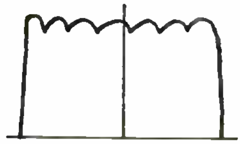


Figure 9

Figure 7 is a sketch of a mechanical filter with its cover removed. Figure 8 is the ideal hi-Q bandpass. Figure 9 is the bandpass of a 7-element mechanical filter; note how it approaches the ideal bandpass in shape.

The shape of the mechanical filter output can be improved by placing several in series, although their high cost tends to discourage this practice.

When one tunes a receiver equipped with mechanical filters stations do not fade up to a peak then fade out, rather they appear sharply, remain steady as one tunes, then suddenly disappear off the opposite end. This "sharp edge" can be used to advantage (as illustrated in Figure 10) by placing the carrier of the desired signal just within it - so that the interfering signal falls on the "wrong side". For all practical purposes this tantamount to single-sideband reception!

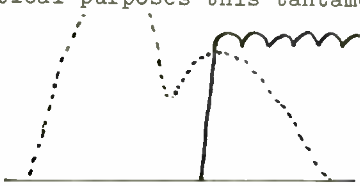


Figure 10

Comprehensive literature on mechanical filters is available from the National Radio Club in the form of reprints.

THE CERAMIC FILTER

This is a little red component measuring a centimeter square and costing about 47¢US each. It uses a small piece of china as a resonating element. As china has less Q than metal this device has a rather wide, "unselective" resonance curve.

Ceramic filters are not supposed to be sharply selective items; they are meant chiefly to replace IF transformers in solid-state receivers with the advantages of lower cost and simpler alignment. So if you read about ceramic filters in a receiver advertisement, don't jump for joy.

NOTCH FILTERS

These devices take a "slice" out of the bandpass in order to remove an interfering signal, heterodyne, etc. Figure 11 illustrates a notch falling in a typical bandpass. When not in use the notch is "stored" outside the bandpass rather than turned off. In some receivers, such as Hammarlund's, the notch is known as a "slot".

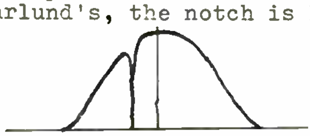


Figure 11

There are two common methods of forming the notch. A modification to a Q-Multiplier can give a receiver a "negative" passband, with a sharp hole in place of the usual sharp, selective peak. Bridged "T"s and other balanced passive circuits create the notch through phase comparison and cancellation.

THE Q-MULTIPLIER NOTCH FILTER

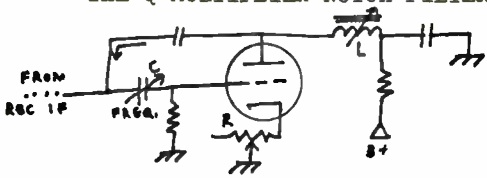


Figure 12

The circuit in Figure 12 resembles the one in Figure 5, but this time the resonant circuit is series rather than parallel. Where the normal Q-Multiplier takes everything else but a sharp peak from the receiver, this one does just the opposite - stealing the peak and leaving the rest. Potentiometer "R" now becomes a "notch depth" control, which is adjusted to give the strongest possible null on a signal - usually a superlocal - then is left alone. The job of capacitor "C" is to move the null around the passband, placing it over any interfering carrier. When the null is not needed this "notch frequency" control is turned to its far side, "storing" the notch on the side of the bandpass until it is needed again.

PHASE-DIFFERENTIAL NOTCH FILTERS

These devices form the notch by varying the differing phases of two otherwise identical signals so that they "destroy" each other at a given frequency in the passband. There are many possible circuit combinations that can accomplish this; the one illustrated is from one of the Collins receivers.

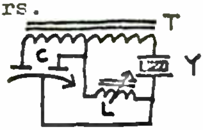


Figure 13

Perhaps an explanation of the term "phase" is in order: Picture two pendulums side by side. If both pendulums swing from the left, to the right, to the left together - in unison - then they are said to be "in phase". If one swings to the left while the other swings to the right, then they are said to be "out of phase". Two or more AC signals can be compared in this manner: Two signals that are "in phase" will reinforce each other; two that are "180° out of phase" will subtract, possibly cancelling each other out. A "phase shift" occurs in the presence of reactance; in a pure reactance this shift is 90°, but resistance reduces the amount of the shift to any value between 0° and 90°. The direction of the phase shift depends upon whether the reactance is inductive or capacitive.

Capacitor "C" in Figure 13 possesses one rotor (the moving part) and two stators; it is called a "differential capacitor". This capacitor receives two signals off of transformer "T"; they are equal in strength, of the same IF frequency, but are 90° out of phase. The capacitor and the lower half of T form one side of a balanced circuit, with crystal "Y" and its adjacent circuitry forming the other.

Before we go on, we must mention that a crystal in its holder possesses two resonant frequencies, there being a series resonant frequency slightly higher than a parallel frequency. The crystal holder in itself is a capacitor, thus it possesses reactance and everything that goes with it. Furthermore, either crystal frequency is variable within close limits, so that one may be shifted relative to the other.

A notch filter of this particular design is invariably an integral part of a crystal filter. In the case of Figure 13 the sharp notch is moved around the bandpass by varying the crystal's parallel resonant frequency and phase by rotating capacitor C. This is the "phasing" control found on many better receivers.

This type of notch filter, often termed the "T" notch for the shape of its circuitry, actually has two notches, one on each side of the center frequency. When not in use the phasing control is kept at center position, which stores the two notches at the far ends of the bandpass. Rotating the control either to the right or to the left moves one of the respective notches toward the center - to be placed over the interfering signal.

Most DX'ers prefer the T-notch filter to the Q-Multiplier notch filter for its simplicity, stability, and ease of use.

Notch filters are extremely useful devices, especially for DX'ers working "splits". Not only will the notch remove an unwanted heterodyne but, by removing the carrier of an interfering station, it will render the audio from that station unintelligible. It also has an indirect tendancy to exault the carrier of the wanted station, giving dominance to a normally relatively weak signal lost in the shadows of powerful sideband splash. Unfortunately the notch can only act on one frequency at a time, so it may not help much if there is more than one interfering signal present.

There are other selectivity devices available to the DX'er, but the more common ones were mentioned in this article. Learn to use the device in your receiver - correctly. Above all, don't overuse it!

-30-

The HQ-145 Communications Receiver

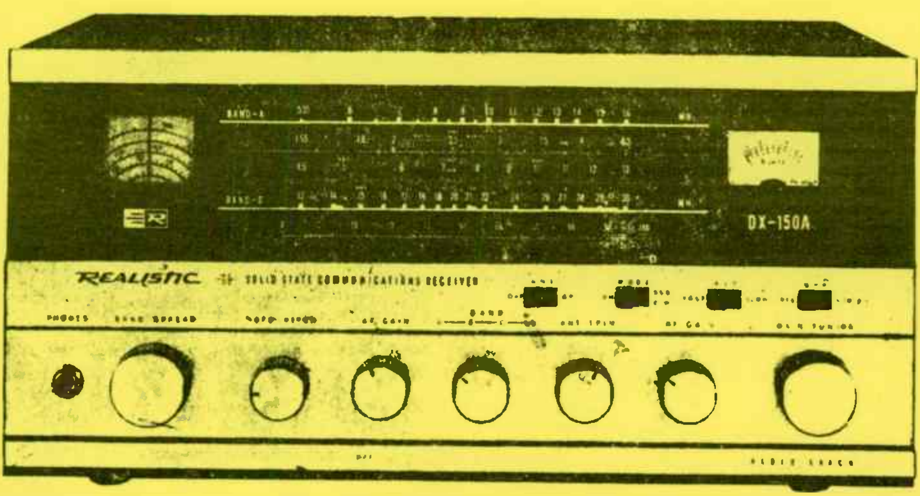
Cont'd from pg. 3

est electronics store and buy replacements with similar voltage ratings. Type won't matter for these-they are just bypass capacitors.
Handles: put them on this 50 pound monster and you too can have a portable receiver.
Tape Jack: very handy and easily installed by running a piece of shielded audio cable to the hot side of the volume control (side with the wire from the detector) and the shield to ground.

What I didn't do and hope to get around to some day.... the old 6K8 in the 129X performs as well as other newer conventional mixers at freqs below 10 mHz. The key word here is conventional mixers-the double balanced diode mixers now being sold are theoretically capable of handling the strongest signals that you will ever encounter on the BCB! That means an end to desensitization, gain compression, intermodulation distortion, and any other strong signal problems that you have from that 50 kw at 2 miles. It's really too much trouble to tear apart an old receiver for this-I think I'll wait and try a homebrew. Frequency readout at the top of the BCB is another problem with most receivers. While you can read the dial to at least 5 kHz and probably be within a kHz or two, that won't help you any when you want to put the carrier from a station that is not producing any audio right on the edge of the passband. About the only answer is some sort of digital frequency readout; believe me when I say that you don't want to try bandspreading with the variable in the set or adding a vernier via varicaps. I have tried both and they are more trouble and less worthwhile than a counter. One other unsolved problem was the noise limiter. With semicinductor diodes it eill clip at too low a level, with resultant distortion of the audio. I hope to add one of the circuits that automatically adjusts itself to the level of the received carrier and clips everything above that. Unless you have a noise problem due to certain electrical equipment the fancy noise blankers available will not do you the least bit of good. Also the limiter type of setup is effective against atmospheric noise and bursts of sideband slop, neither of which can be said for the blanker.

I will attempt to answer any questions, solve problems, etc. References include Foxworth in the NRC Receiver Reference Manual, Stueber and Noe from CQ for May 1959, and Stueber from CQ for April 1963.

* *



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