SAVE your SUPER-PRO for SSB

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As a sequel to our experiences in Venezuela[1] modernizing RCA CR-88A receivers, we decided to tackle our BC-794 Super-Pro and see what could be done to bring it up to date. While in the process of thinking about it and planning these receiver changes, we had the opportunity to snap up a good bargain in the form of a kilowatt single sideband transmitter. This made modernization of the BC-794, or purchase of a new receiver, a necessity. We chose the first course of action for economic reasons, as well as for the satisfaction of doing the job ourselves and experiencing the pride of workmanship.

About this time there appeared in "CQ" an article by Geisler[2]. Careful digestion of the meat of this article gave us several good points to consider. However, we were not completely swayed by the author's very exuberant enthusiasm, nor did we "buy" all of his changes as being necessary or desirable. Several points in his wiring diagrams as published were not clear. Furthermore, we had to carry matters further and come up with something good for SSB reception in order to keep up with the trend in modern point-to-point communications techniques.

One of the first requisites for SSB reception is a good product detector. Another one is frequency stability in the hf oscillator. A third is proper AVC action for SSB to permit running the set with the rf gain wide open. Still another is a 3 kc i-f bandpass curve. With these points uppermost in mind as design criteria we planned and made the changes in our BC-794 which are described here.

It should be pointed out that these changes are equally applicable to the other models of the Super-Pro series, such as BC-779, BC-1004, R-129/U, SP-200, SP-210, and SP-400. These changes may also be used as a design basis for modification of any similar type of superheterodyne receiver, if the reader uses a bit of ingenuity in adapting them to his own particular set. This is a real modernization, not merely the substitution of other types of obsolescent tubes in an old set.

(1) Feb. 1957 CQ, "Worthwhile Improvements for that Old Receiver."
(2) Dec. 1957 CQ, "Souping The Super-Pro."

Our first and most logical point of attack on the BC-794 is the installation of a product detector. Removal of the 6SJ7 BFO tube and its octal socket is easily done. Be sure not to cut the leads from the BFO transformer T5 too short in the process. Substitution of a 7-pin miniature socket mounted on a small square of sheet aluminum to fill the old hole is easily accomplished. A 6BE6 tube is used, with its oscillator section acting both as BFO for CW and as a local oscillator for SSB reception. The circuit should be rewired as shown in fig. 1.

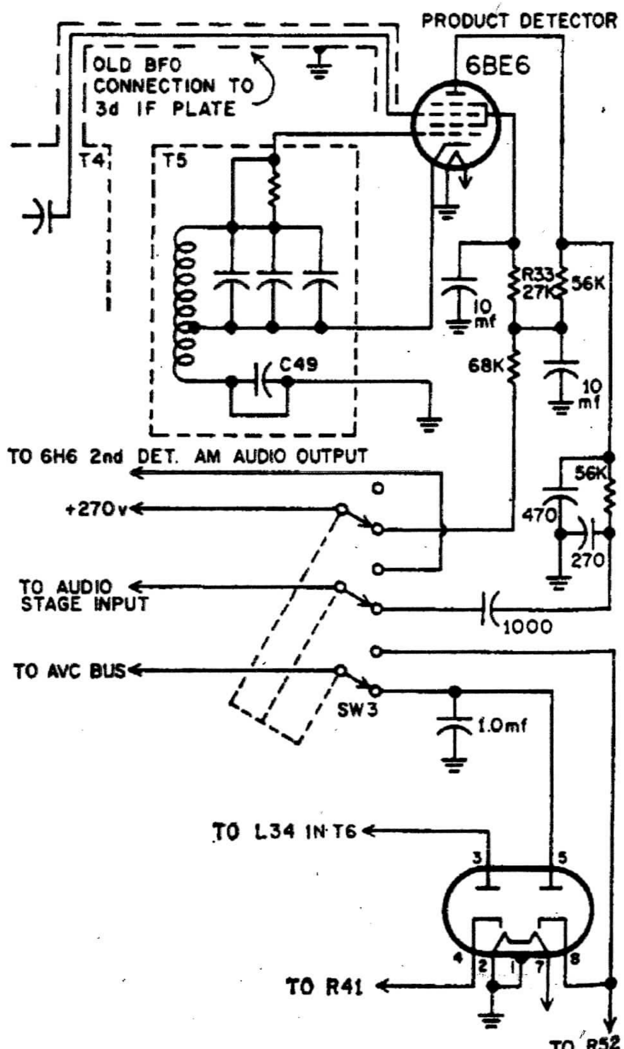


Fig. 1

The value of the screen dropping resistor R33 was found to be quite critical. A strong local oscillator signal is an absolute necessity to avoid the overloading of the detector by strong SSB signals which would produce distortion. R33 was experimentally adjusted in value until all traces of distortion disappeared, and concurrently for the greatest audio output from the detector. It is necessary to remove the shield can from transformer T5 to gain access to C49, the old plate voltage blocking capacitor, and to short out C49 in order to provide a dc return for the cathode of the 6BE6. This is not a difficult operation, but is time-consuming and requires care. In re-assembling the transformer into the can, be sure that there are no internal shorts to the can.

Concurrently with the above, switch SW3 should be replaced with a small 3-pole 2-position rotary switch.

This is necessary to provide an added pole for switching the audio input from the output of the 6H6 AM detector to the output of the 6BE6 SSB detector. Getting the new switch into place is a bit of a squeeze play. We used a Centralab PA-1007. A little bending of an interfering chassis bracket was necessary to make the fit. The new switch SW3 is wired as shown in fig. 1. One pole turns on the 6BE6 plate and screen voltage, another pole throws the audio from the AM to the SSB detector, and the third pole cuts in the special SSB "hanging" avc circuit to be described.

One half of the 6H6 avc diode rectifier, V12, comprising pins 5 and 8, formerly connected in parallel with the other half, is cut free and wired as shown in fig. 1. This section is reverse-connected so that the 1 mfd capacitor which we added to the avc circuit can charge up through the diode, but cannot discharge back through the diode. The 2 megohm avc resistor R19, which is mounted on the back of the AVC-MANUAL switch SW4, should be changed to 10 megohms to provide a slow discharge rate for the 1 mfd capacitor. This provides a fast attack-slow release avc action which permits the avc to ride along on the peaks of the SSB signal. It releases and restores receiver gain quickly enough, however, so that a weak signal in a round table contact is not missed.

The 3-volt bias should be removed from R41 and the 6H6 avc rectifier by moving the two bias lines from terminal 9 of strip E-24 to a convenient ground lug[2]. The avc lines to the 1st rf stage and the mixer should be removed from their terminals on strip E-24 and grounded also, allowing these two stages to operate "wide open"[2].

The product detector is coupled to the 3rd i-f plate transformer T4 by means of the old bfo connection, which is the shielded lead. No change is made here, and this connection works fine.

This is a good point at which to stop work and turn on the receiver and check out all that has been done so far. The local oscillator portion of the 6BE6 may be roughly retuned at this time. Now tune in an SSB signal and try out the new product detector and avc circuit. Run the rf gain wide open, and see how neatly the receiver handles the signals. Gone is the old four-way struggle of rf gain vs. audio gain vs bfo setting vs. tuning. Just sit back and listen to that smooth SSB operation!

While gloating over your work thus far, you will still be dismayed by the frequency drift inherent in all of the Super-Pro series. Well, let's do something about that. Let's do the best we can with what we have and make a practical approach to the problem. Admittedly, we cannot satisfy the "ivory tower" perfectionist and build a long-term stability of one part in ten million into this set and still make it tunable. This is not needed for day to day amateur operations anyway. What we do need and what we can do is to obtain a short-term stability such that during SSB contacts, the other fellow's voice does not grow higher and higher in pitch like an excited Donald Duck and gradually drift out of the i-f passband. The signals will really "stay put", after the changes to be described here.

Following an excellent lead previously published[2], we replaced the hf oscillator and mixer stages with 12AX7 dual high-mu triodes, wired as shown in fig. 2. The octal sockets are removed, and replaced with noval miniature sockets mounted on small sheet aluminum plates. The noval sockets should be oriented so that short, direct rf leads are obtained. Tube shields are used, and should be in place before any subsequent re-alignment is attempted. Next, remove the top cover of the main tuning capacitor, and connect a 3.3 mmfd type N750 negative co-efficient capacitor across the oscillator tuning capacitor. The former 6L7 and 6J7 grid leads should be extended and run through holes in the chassis drilled adjacent to the grid pins. Rubber grommets should be used in the holes. We chose miniature tubes for this modification in the interests of modernization.

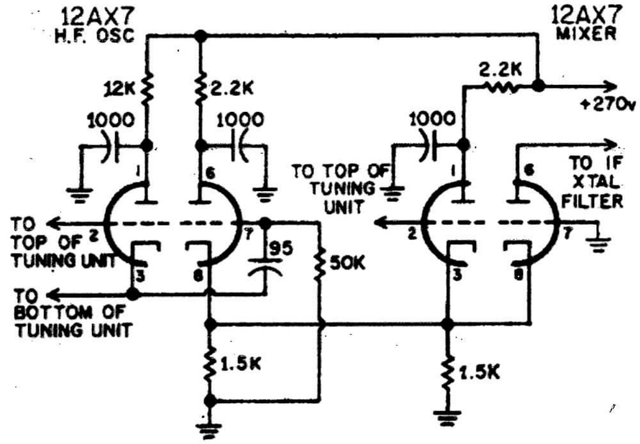


Fig. 2

The important thing is the result of the modification, which is an excellent short-term frequency stability. This is due to the isolation between the oscillator triode section and the remainder of the set afforded by the cathode coupling scheme used.

The next improvement to be made is in the rf stages. We removed the old 6K7's and their octal sockets, and replaced them with 7-pin miniature sockets and 6BA6 tubes. This change greatly increased rf gain and sensitivity. No changes in circuit or components were made, and therefore no diagram is shown here for this change. Here again the grid leads are extended through grommetted holes in the chassis. Tubes are shielded, and the tube shields should be in place before any re-alignment is done. A word of caution is necessary here. If oscillation of either 6BA6 stage is noted in the 20 to 40 mc range, the grounding of the filament, cathode and suppressor pins is not effective. Do not rely on connecting all those pins together and running one common ground lead to the nearest ground lug. Drill a new hole in the chassis adjacent to each pin, and ground each pin separately by a very short connection. We experienced this trouble at the high frequency end of this band, and it took us some time to find the source and apply the cure.

We might say in passing that we tried several other tube types in the 1st rf stage. We tried a 6BZ6, a 6CB6, and a 6DC6, but each of these produced overloading and cross-modulation from strong local signals on the high frequency end of the broadcast band, even with the avc re-applied to the stage. The same was true of the 6BK7A, 6BQ7A, and 6BZ7 dual triodes which we naturally tried as a result of our previous work with the CR-88A[1].

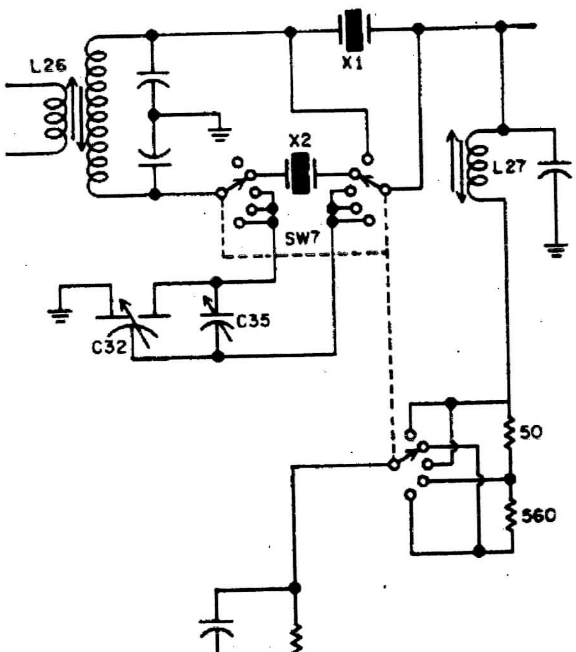


Fig. 3

Reasoning that a strong local amateur signal would cause the same effects, we chose the remote cut-off 6BA6, and there is no trouble from overloading nor cross-modulation even from 50 kw WTOP nearby, and with the 6BA6 1st rf. stage running "wide open."

After re-alignment of the rf portion of the set, we then proceeded to the installation of a 3 kc band-pass crystal filter, whose complete circuit is shown in fig. 3. We wished to do this without destroying the usefulness of the receiver for short-wave listening or cw reception, and if possible, without spoiling the front panel appearance. A half-lattice crystal filter was chosen as being the most practical type from the standpoint of available space and a minimum of circuit changes.

First it is necessary to remove the top and side covers of the existing crystal filter. Access to the side is facilitated by temporary removal of the chassis support bracket. The 465 kc crystal and the old 6-position switch should be removed and added to your junk box. The switch can be removed without taking off the front panel by using a thin open-end wrench to turn the locking nut behind the panel. A new switch with 3 poles and 5 positions on a single wafer was installed. Getting the old one out and installing the new one is a tight fit, but it can be done. A small, thin switch with but a single wafer is a necessity to fit in the small space. We used a Centralab type PA-2007. The switch should be lined up so that its five positions correspond to the OFF-1-2-3-4 markings on the front panel. The last figure, 5, is not used. The new crystal filter switch positions are:

OFF-OFF
1—3 kc Bandpass
2—Broad CW
3—Medium CW
4—Sharp CW

A half-lattice filter has the simplified schematic and response curve shown in fig. 4. Crystal X1 is a surplus type FT-241-A for channel 334, whose fundamental frequency is 463.88 kc. Crystal X2 is a companion unit for channel 336, whose fundamental frequency is 466.66 kc. These are the 72nd harmonic crystals which are readily available from surplus crystal suppliers at a cost of about 55¢ each. The separation between this pair is 2.78 kc, which is just about right for a nominal 3 kc filter. Following through the circuit in fig. 3 will show that X1 is used for both cw and SSB, but that X2 is in the circuit only for SSB. Neither crystal is in the circuit when the switch is in the OFF position. On cw positions 2, 3, and 4 the crystal phasing capacitor is connected in the circuit to provide for moving the rejection notch from one side of the received signal to the other for phasing out heterodynes. For SSB, a small (1 or 2 mmfd) capacitor may be added in parallel with X2, to cause rejection notches to appear in the skirts of the pass band, if desired.

The values of the secondary loading resistors are changed to 50 and 560 ohms. We chose 560 ohms experimentally because it seemed to give a sharp enough filter without too much of the characteristic crystal "ringing" effect which we found could become objectionable when using the 3 kc position on voice. If the reader wishes to increase the value of this resistor above 560 ohms, it may be done if the "ringing" effect is not considered objectionable.

Crystals X1 and X2 were placed in the space formerly occupied by the old 465 kc crystal, and were connected by merely soldering the leads to the tips of the holder pins. This must be done very quickly and carefully, without excess heat. The pin should be firmly grasped with pliers near the holder while soldering, to minimize the heat travelling back up the pin and causing damage to the crystal and its very delicate connecting wires.

At this point in the operation, replace the 6SK7 avc amplifier and the 6SK7 2nd i-f tube with 6SG7's, and substitute a 6AC7 for the 3rd i-f 6SK7. Then it is wise to thoroughly check over all that has been done to date, to make sure there are no omissions nor errors in wiring. Replace the crystal filter shield covers.

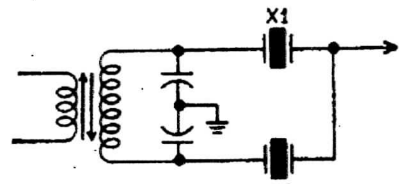
The only stages now being supplied with avc voltage are the 2nd rf and the 1st and 2nd i-f. The 1st rf and the mixer are running with no avc, and the 3 volts bias is still being applied to the 6SG7 avc amplifier. Re-connection of the 6AC7 to the 3 volts bias is necessary, and it is done by disconnecting the old bias lead from the end of R22 (10,000 ohms), and running a new lead from R22 to terminal 9 of strip E24. No 1500 ohm resistor from R22 to ground is used here. [2]

The modifications are now completed. With the crystal switch in the OFF position, and the bandwidth control at 3, the i-f stages should be realigned to 465.27 kc, which is the mid-frequency of the 3 kc passband. This alignment was done with the help of our LM frequency meter as a signal generator. An accurate signal generator is a necessity for plotting the response curves of the filter in the SSB and cw positions. L26 should be peaked up on the mid-frequency also. Now turn the crystal switch to position 3 or 4 and perform the adjustments of L27 and trimmer C35 to obtain the proper rejection curves for the right and left positions of the phasing capacitor C32. The shapes of these rejection curves are shown in fig. 5. These adjustments can best be made with the use of a sweeping oscillator and an oscilloscope so that one can actually see the changes in shape as adjustments are varied, but we used our LM, and a VTVM on the output of the avc amplifier, and used the longer method of plotting results and then making changes.

The shape of the response curve of the 3 kc filter should also be checked. The bandwidth control should be set at 6 or higher for this. Any inequality in the two peaks at the frequencies of X1 and X2 can be evened out by shifting an i-f transformer slightly to one side or the other of the center frequency. There will be a slight dip in the center of the curve, possibly as much as 16%. This is satisfactory and normal, so don't worry about it.

The receiver has enough gain to compensate for the insertion loss of the 3 kc filter when receiving on position 1. It also has sufficient gain to make up for the fact that the cw crystal frequency, 463.88 kc, is 1.39 kc off from the i-f alignment frequency of 465.27 kc. It will be noted that as you swing the crystal switch from position 2 to position 4, a drop in S-meter reading and in gain occurs. This is due to the slight mis-alignment for cw just mentioned. It is not serious, however, and it does not handicap cw reception at all. After all, we have designed for the SSB requirement as our primary objective, and we should not handicap our 3 kc filter by an off-center frequency alignment for the i-f stages.

Now a word about operation of the receiver is in order. For reception of am or cw, the single crystal filter of positions 2, 3, and 4 may be used, and the phasing control adjusted for reduction of heterodyne interference exactly as before. Or, for short-wave broadcast reception, the switch may be left in the OFF position, and the bandwidth control adjusted to suit the listener's tastes.



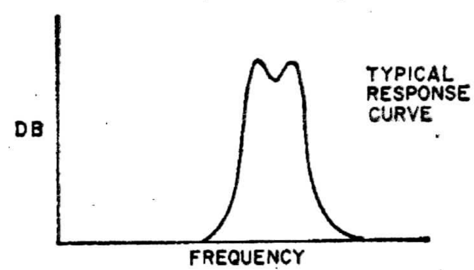


Fig. 4

For SSB reception, we first adjust the local oscillator transformer T5 for zero beat at 465.27 kc, with the bfo knob at zero center. It will then be found that the local oscillator will be at zero beat at 463.88 kc with the knob at about 1.0 on one side of center, and at zero beat on 466.66 kc at about 1.0 on the other side of center. Which side it is, is immaterial. Thus one is able to set the local oscillator to one side or the other of the crystal filter passband, to demodulate whichever sideband is in use by the transmitting station. The actual set-

[Continued on page 104]

ting of the local oscillator should be about 250 to 300 cycles out beyond the crystal filter frequencies, for increased rejection of unwanted sideband products and for most efficient use of the crystal filter passband. This is shown graphically in fig. 6, which shows the relationships of local oscillator settings, crystal frequencies, and overall passband. A picture at this point is worth more than a thousand words. For 3 kc

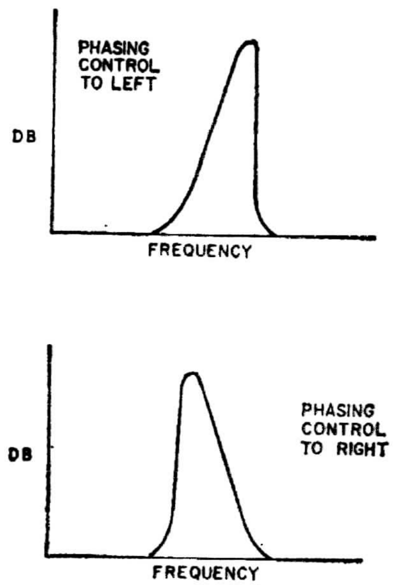


Fig. 5

filter SSB reception, the bandwidth control should be set at 6 or higher, inasmuch as the variable selectivity i-f transformers are after the crystal filter in the i-f chain, and the filter is the controlling factor in bandwidth. We do not wish to compress the filter response curve by setting the bandwidth control at a narrow selectivity position. Nor did we wish to eliminate the bandwidth control entirely, as it does have its value, for certain uses. SSB may also be received with the crystal switch in the OFF position, and best results are then obtained with the bandwidth control set from 4 to 6 depending on interference conditions.

The 3 kc filter can be very useful for AM reception as well as for SSB. If one tunes the AM signal right on the nose, it will be noted that the audio sounds very bass with the high frequency sidebands on both sides cut off. Tuning to one sideband or the other, depending on interference conditions, and thus making good use of the 3 kc passband of the filter, is a great help in reducing interference in AM reception. By experimentally tuning across an AM signal which is not fading, and watching the S-meter, one can get a very good mental picture of what the 3 kc filter does for AM reception as well as for SSB. Refer again to fig. 5 to see the relationship of passband and crystal frequencies.

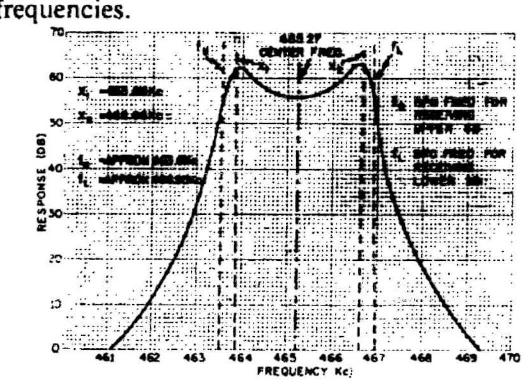


Fig. 6

Operation of this receiver on SSB, our primary objective, is now very simple and straightforward. There is no more fussing with rf and audio gain controls. Just set the rf gain at maximum, the audio gain at a comfortable level, and turn on the product detector and sit back and tune in the SSB signals. The avc does the work—it takes care of the strong ones, and there is plenty of gain for the weak ones, "down in the mud." If the going gets rough due to overpopulation of the band, cut in the 3 kc filter. And with the new hf oscillator and mixer the signals stay in tune during contacts. To switch to receive the other sideband, just rotate the old bfo control to a bit over 1.0 on the other side, and there you are—it's as simple as that. Your old Super-Pro has been lifted out of the trade-in class, and you don't have to hand out the cash for a new receiver. SSB reception is now a pleasure instead of a headache! See you on SSB, fellows! 73, Paul, W3JHR