Updating the SP-600

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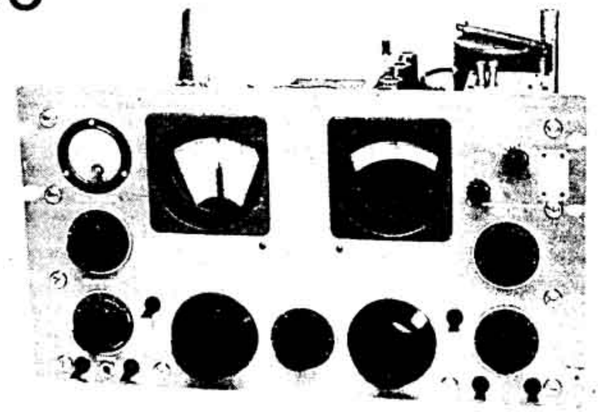

Modified SP-600. The new panel switches are Cutler-Hammer type 8373K27C. A switch mounted in place of the TUNING LOCK cuts the HFO off when an external oscillator is used.

MODIFYING a piece of surplus equipment to get operation up to current standards is a popular amateur pastime. With the sophisticated gear now on the surplus market, a ham can often come up with outstanding performance for a relatively-small monetary investment. This article covers reworking the SP-600 receiver, but the circuits used may be adapted for use with any receiver of similar vintage.

The R-274 receiver series (sold commercially as the SP-600 by Hammarlund and the SX-73 by Hallicrafters[1]) has been released in quantity by the military services to MARS and surplus outlets. These receivers, which were used in intercept, point-to-point and mobile communications by the Army and Air Force, have largely been replaced by the R-390A. As the available supply has increased, the price has dropped to the point where a 274 is an attractive buy as a general-coverage receiver. It is a single-dial type covering 0.54 to 54 MHz in 6 bands, providing a close-to-ideal tuning rate for vhf (with converters, of course).[2] The objectives of the modifications made to the receiver are to improve the ssb, cw performance and to generally make the receiver suitable for amateur service.

Circuit Changes

As originally designed, the SP-600 is a poor performer on ssb. It has a lot of amplification in the i-f stages and a low-gain audio stage. The BFO is amplified, but it is still not unusual to get ten times the voltage out of the i-f that you get from the BFO — the inverse of the ratio needed for linear detection. If the rf gain control is backed off to reduce the i-f output so the detector can operate in a linear manner, there isn't enough audio gain to amplify the detected signal to loudspeaker volume. Obviously, changes are necessary in the levels and gains of the receiver's "rear end" stages.

A product detector was added in place of the original 6AL5 diode detector, V14. Needing a high-transconductance triode for this stage, we chose the 6J4 because it has a 7-pin base and would fit in the 6AL5 socket. Other similar triodes made for TV front ends would work as well. The new detector circuit is shown in Fig. 1.

It was necessary to separate the plate circuits of V11 and V12 — they were originally fed B-plus through a common choke — so that the output of the BFO buffer could be routed to the cathode of the product detector. The output of the i-f driver, V11, is far in excess of what any detector can handle with the available BFO voltage. Raising the BFO level was not the answer, as the increased 455-kHz signal leaked into the i-f, producing lockup. The product detector input was capacitively coupled to the grid of V11, where the i-f level was about right for proper detector operation.

Even with the gain picked up in the product detector, audio output was still insufficient. The first audio amplifier in the SP-600 uses one section of a 12AU7, with the other half of the tube functioning as a cathode follower on the output of the i-f. This output stage was not being used, so a 12AX7 (Fig. 2A) was substituted for the 12AU7, and both halves were wired as audio amplifiers. This combination gave sufficient output to drive the 6V6 final audio stage. With high gain in the audio stages, decoupling of each stage was necessary to prevent oscillation in the audio range.

With a 600-ohm audio output, a transformer is necessary to match 4-ohm speakers. These transformers are not easy to find surplus, and are very expensive new. The author found that the standard public address 70-volt line transformer could be wired to give the proper impedance ratio. The transformer's 8-watt tap is connected to the receiver output, and the 4-ohm speaker to the 8-ohm tap (Fig. 4B).

With a general-coverage receiver it is desirable to be able to copy a-m, so a diode detector was included. To keep the output level in the same range as the product detector, this stage was also fed from the grid of V11. Reed relay K_1, operated by the MOD/CW switch, connects the appropriate detector to the first audio amplifier.

With proper levels, it should have been possible to use the agc for ssb and cw operation. The agc system in the SP-600 was not designed for

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[1] The SP-600 and SX-73 both carry the R-274 military nomenclature, but the two have many differences in circuitry and mechanical construction. The modifications described in this article cannot be used directly in the SX-73 without changes in its BFO and i-f levels.

[2] See *ARRL VHF Manual*, pp. 38-40.

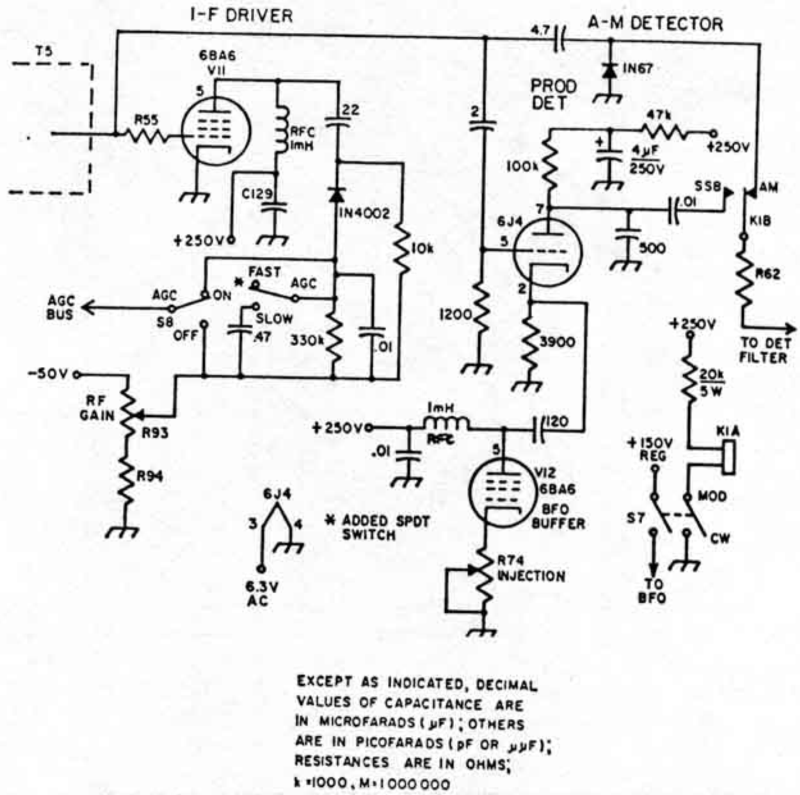


Fig. 1—Modification to the detector and agc sections. Original components are marked with instruction book reference numbers. Resistors are ½-watt composition, except as indicated. Capacitors are paper or ceramic, except those with polarity indicated, which are electrolytic. K_1 is a miniature reed relay, 2500-ohm coil (Magnecraft W104MX-4).

this sort of service, however, and a rework was required. The original circuit had too slow an attack time and too fast a decay. Even manual control with the rf gain control was difficult because of the long time constant on the gain control line, caused by C137. This 2-µF capacitor is switched in when the BFO is turned on. It charges and discharges so slowly that the manual gain control has a time lag that is most annoying when operating.

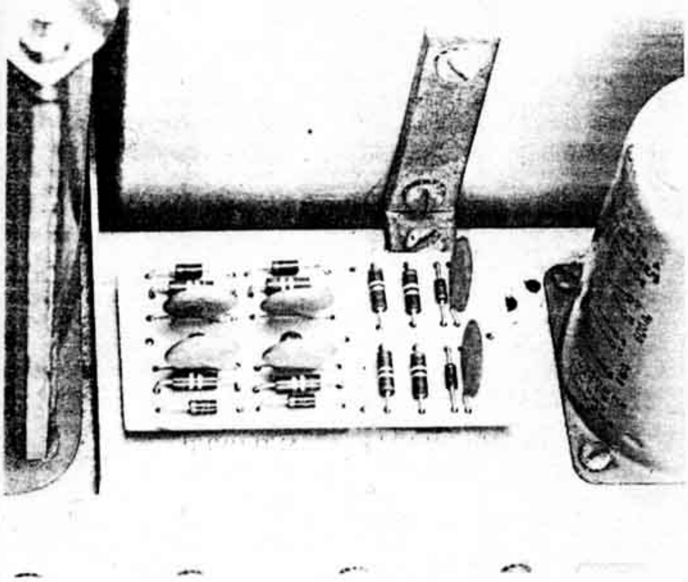
The agc circuit was rebuilt completely. The 6AL5 that was removed to make room for the product detector also had served as the agc rectifier, so a silicon diode was used in its place. A front-panel switch was added to select a fast or slow agc discharge time constant. The series resistors were removed from the agc line to improve the attack time. The rf gain circuit was modified so that manual gain could be used either with agc or alone. The original switch, S8, continues to select manual or automatic gain control. With the components shown in Fig. 1, agc action will start at about 1-µV signal input. With four 6BA6 stages being controlled, agc action is very smooth.

The old detector also provided operating voltage to the S meter, so a modified S-meter circuit was added. See Fig. 3. The new metering arrangement indicates the voltage swings produced on the screen of an i-f tube by the agc control voltage applied to the grid of the stage. The original meter zero control, R69, is rewired but still performs the zeroing function.

The rectifier tubes in the power supply were replaced with the silicon diode assembly detailed in Fig. 2B. Purchasing one of the commercial silicon replacements for the 5R4 would save the work of making up this assembly. Using solid-state rectifiers will raise the B-plus voltage, which is not desirable. The lead from capacitor C161A was removed from the input side of choke L51 and connected to the input of choke L52. Effectively, this changes the power supply from capacitor input to choke input, reducing the B-plus voltage to about the same point it was before the silicon rectifiers were added.

Making the Modifications

The military versions of the SP-600 were given a liberal spraying with moisture-fungus proofing (MFP) during manufacture, which coats all the solder connections and makes it difficult to remove and add parts. It also covers the wiring, which after a few years of being heated and cooled, converts the once-flexible insulation into a hard substance that cracks easily. If the wiring in your receiver has reached this advanced state of deterioration, be very careful as you work on the unit. During the modifications described in this article, the insulation on several leads cracked and fell off, making an arduous extra job of rewiring. This SP-600 was in poor condition when purchased, but the units that have come through MARS channels are in much better shape. Look over the bottom side of any prospective purchase



The solid-state rectifier assembly, made up on an etched board, is mounted between the power and audio output transformers

before handing over your money. A better unit should not have the problems with wire and component failure that the author experienced.

The best way to make the changes to the detector and audio amplifier stages is to cut the unused parts away from tube sockets V14 and V16 then carefully disconnect the filament connections and remove these sockets. Bolt in two new tube sockets — starting with a new socket makes rewiring so much easier! Reconnect the filaments and add the other parts shown in Fig. 1.

Additional wiring points are needed, so 5-lug terminal strips should be added under one of the mounting screws of the phono-input strip for the extra audio stage, on one end of C129 for the agc circuit, and on one end of the new tube socket at V14 for the product detector. The old agc filter components, when removed from E16, leave a number of free terminals which can be used for the plate circuit components associated with V11 and V12. The reed relay, K1, should be cemented to the top of C128, the only open space in the area.

To make some of the wiring changes on the switches, it is necessary to remove the front panel. All of the switches on our unit were on their last legs, so we changed the lot while the panel was off. The meter range switch, S11, is a momentary type. It wasn't being used, so this switch was replaced by a standard spst type which selects a fast or slow agc time constant. The S meter itself was broken beyond repair, so it was replaced by a surplus 0-1 mA unit.

The 0.01-μF paper bypass capacitors in our SP-600 failed at an alarming rate. Before the modifications were attempted, three had failed and one went while we were working on the set. Three of these four capacitors were located up in the rf amplifier/mixer subassembly, which it is a four-hour job to take out and replace. This deck is impossible to troubleshoot, also, as you cannot get to the bottom side while it is "hot." With the last capacitor failure, the author changed the bypasses in this section, and then all the rest in other parts of the receiver for good measure. (After a while a fellow gets a little tired of a smoking receiver.) The input coax fitting was changed to an SO-239 from the original two-pin receptacle provided.

While the rf deck was apart, the sliding contacts on the main tuning capacitor were given a good shot of contact cleaner. Before modification the receiver had a tendency to jump frequency about one kilohertz every few minutes. The cleaning job solved the problem. The work was done all at once, so it wasn't possible to determine the exact culprits.

For those unlucky enough to have to remove the rf deck, a little explanation is in order, as the instruction book isn't any help. The best procedure is first to take all the screws out of the rf deck itself and the tuning-capacitor cover. Remove the cover and the top of the mixer coil housing, which is on the side of the tuning unit subchassis. Unsolder all seven power leads that go from the mixer coils to the rf deck, making a note of the color code and terminal connections so these leads can be reconnected later. Using a 150-watt iron with a long-nose tip, unsolder all of the leads coming from the main tuning capacitor sections to the rf deck. There are four

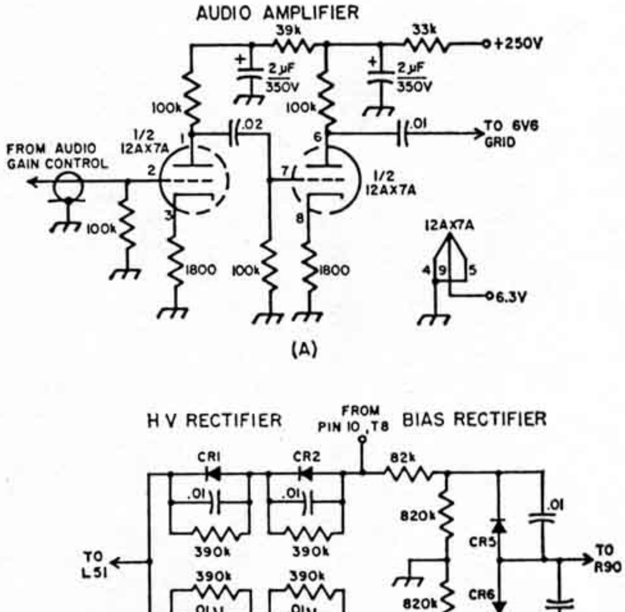


Fig. 2—Additions to the (A) audio amplifier and (B) power supply. Resistors are ½-watt composition, and capacitors are ceramic, except those with polarity indicated, which are electrolytic. Diodes CR_1-CR_6 are 800-volt PIV, 500-mA silicons.

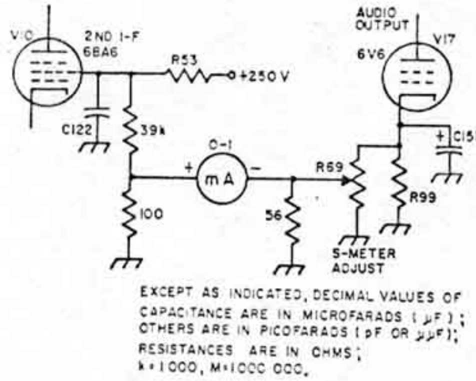
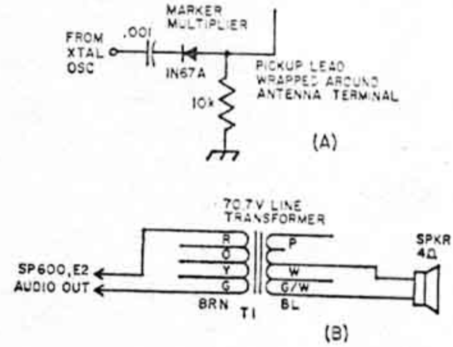


Fig. 3—Circuit of the S meter. Parts marked with reference numbers are original components in the receiver. Resistors are ½-watt composition.



PRIMARY		SECONDARY	
COLOR	WATTS	COLOR	TAP
RED	8	PURPLE	16 Ω
ORANGE	4	WHITE	8 Ω
YELLOW	2	GREEN / WHITE	4 Ω
GREEN	1		
BROWN	COMMON	BLACK	COMMON

Fig. 4—(A) Diode multiplier for the crystal oscillator. (B) Connection of a line transformer to match 600 to 4 ohms. T_1 is a public address 8-watt speaker transformer (Knight 54 A 1422 or Inglot T-8). Note that not all manufacturers use the line-transformer color code shown.

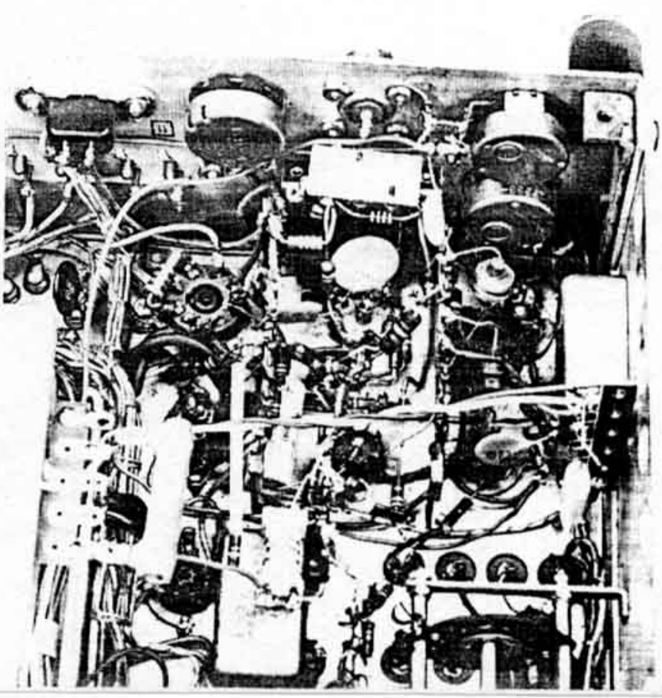
leads per section. When all these leads are loose, pull up on the deck and lift it out. To replace it, turn the band switch to a position half way between two-band settings, gently slip the rf deck back in place, and rotate the band switch to a band setting. Then, resolder all leads.

Another problem area was the BFO. The pitch control caused severe electrical noise in the receiver when it was rotated. This condition got steadily worse until the BFO would stop oscillating at certain pitch settings, and then it quit working entirely. Everything external to the BFO can was checked and found to be OK. So, the author was left with the task of removing the BFO can assembly to see what had gone wrong. This job is even worse, if possible, than taking out the rf deck. The instruction book isn't any help here either. You must first remove the mounting plate holding the filter chokes. Drop this whole assembly down, which will give access to the mounting bolts that secure the crystal oscillator assembly. Unsolder the five power leads from the crystal oscillator, remove the mountings screws, loosen the two shaft couplings on the front panel controls, and pull the assembly out. Then remove all leads and the two mounting screws from the bottom of the BFO can, loosen the shaft coupling and slide it forward, and then pull the can out.

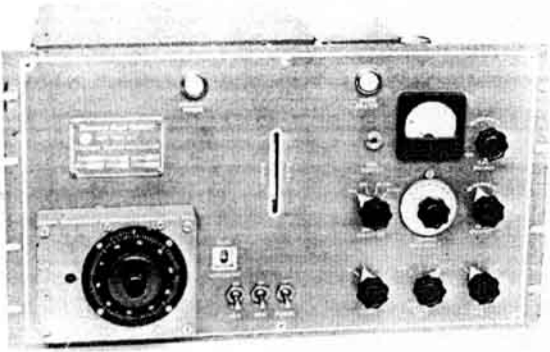
The problem in this unit was that the coil form on the pitch control had broken loose and had rotated until the leads had broken. This was caused by the bottom tab on the spring mounting plate having broken, allowing the coil to be pulled forward until it broke loose from its mount. It is not a good idea to try to solder this spring, as heat will destroy the spring temper. A piece of heavy wire was put in the tab hole and the spring cemented to it. Both coil forms were given a coat of cement around their bases to insure that neither would break loose again.

Oscillators

Two objections to the SP-600 are its lack of calibration accuracy and its rate of tuning on the high hf bands. There isn't much that can be done about the calibration accuracy of the receiver itself, but the crystal oscillator used for fixed-frequency operation of the receiver can be modified to a secondary frequency standard and band-edge marker. The small changes necessary to accomplish this can be made without having to remove the subassembly. But, if you have to get to the BFO can, you have to take the xtal oscillator out anyway.



Underside of the receiver showing the area of modification. The product detector, diode detector, and audio amplifier are at the center. The relay which selects the detectors is cemented on top of the large "bathtub" capacitor (lower center), and the terminal strip mounted vertically on the right holds the agc rectifier and filter components.



A surplus Northern Radio 115 VFO can provide better stability and bandspread when used with the SP-600 (see text).

The connection to the HFO (high frequency oscillator) is no longer needed, so it is removed and a diode multiplier (Fig. 4A) connected to the crystal oscillator output pin. This terminal has B plus on it, so make your connections with the receiver turned off. The output lead from the multiplier is run over to the receiver antenna jack. The switch in the oscillator subassembly originally turned the receiver HFO on and off. This power lead, coming to terminal 2 of E13, just below capacitor C161, is cut loose and taped. The HFO can be made operational at all times by jumpering terminals 2 and 3 on E13, or if operation with an external oscillator is contemplated, an HFO switch which shorts terminals 2 and 3 can be mounted on the front panel in place of the dial lock shaft.

The author used 1- and 10-MHz crystals which gave useful markers over the entire receiver tuning range. The crystal frequency control is used to bring the crystals into zero beat with WWV, and the crystal selector switch turns the oscillator on and off, as well as selecting the desired crystal.

A popular trick to improve the tuning rate of this receiver is to use an external hf oscillator. The input to the HFO used by the crystal oscillator can be run to a jack and used for external oscillator input. Connected as described above, a rear-deck switch is wired to disable the receiver HFO. There is one highly-stable master oscillator designed for use with the SP-600, the Northern Radio Model 115, which is available on the surplus market. This unit has an oven-heated master oscillator with multiplier circuits giving output on any desired frequency from 2 to 30 MHz. It also has a 455-kHz oscillator for use as an extra-stable BFO. Of course, any home-built oscillator with a good tuning rate will do the job.[3] When using an external oscillator, the main tuning dial functions as a preselector.

A BC-221 frequency meter was tried as an external HFO, and it worked out well, improving the tuning rate and stability. The SP-600 is single conversion below 7.4 MHz and double conversion above this frequency, so the external HFO should be set 455 kHz above the desired frequency when tuning below 7.4 MHz, and 3955 kHz above when using the higher ranges.

Results

After all the modifications had been made, the receiver was given a complete realignment. The front end was originally aligned for 100-ohm input impedance, so the input trimmers must be reset for 50 ohms. Realigned, the leakage signal of our signal generator, less than 0.1 μV, could easily be found without prior knowledge of the exact frequency. The high gain in the two rf stages does mean cross modulation at the first mixer on very strong signals. The rf selectivity of the 600 is much better than found in an average receiver, so you don't have to tune very far away from a strong signal to have it stop bothering you. Overall, these changes and repairs have given the receiver a new lease on life, and made it a pleasure to use. QST

[3] The general purpose VFO described in the 1969 and 1970 editions of *The Radio Amateur's Handbook*, page 191, can be used with appropriate coil changes.