

An Anthology Of Technical References For The Hammarlund SP 600 And Its Variants

A collection of wisdom for enthusiasts

Table Of Contents	2
Introduction and Project Origins	4
Safety Section	6
EB5AGV's SP-600 Model Information	8
SP-600 Sequential Model Information	10
SP-600-JX 21A Pictures Photos courtesy of Paolo Viappiani	12
Hammarlund Super-Pro SP-600 Page	13
SP-600 Identification Guide	17
Original Power Supply Schematic With Comments	22
Recapping the Hammarlund SP-600	23
Some General Notes From Other Experienced SP 600 Rebuilders	34
SP-600 Receiver Modifications Bruce Stock	36
Updating the SP-600 By Douglas A. Blakeslee	40
Quick and Dirty SP-600 Audio Modifications	45
Problem Parts	45
455KHz IF buffer output check	46
Nuvista plug in for 1 st RF amplifier	47
Increasing The Lifetime Of V18 (0A2)	49
Simple, inexpensive audio output improvement	50
On Using The 6EH7	51
Cross-Modulation In Receiver R.F. Pentodes	52
Improving Your Receiver With Frame-Grid R.F. Pentode	54
JX-17 IF Gain Mod	61
Adding Collins Disc-Wire Mechanical Filters., Parts 1,2 and 3	63
Synchronous Detection of DSB and ISB Signals	71
TM 11-851 Resistor and Capacitor Parts List	74
Capacitor Summary Tally	76
Cleaning & Lubrication Materials and Helpful Hints	79
Capacitor Color Code Table	81
Capacitor Value Translation Table	82
Test Jigs and Adapters	84
Section 2	
Published John R Leary Hammarlund Articles	85
The John R Leary SP 600 Chronicles	87
Tube Substitution	99
An Experimental SP 600 SS Delayed B+ Power Supply	103
SP-600 Dial & Gear Train Alignment	105
Lead Leakage Filtering Systems	106
A Medium Wave Audio Processor	107
MOSFET 6V6 or 6AQ5	110
SP 600 General Upgrade and Mod List	114
Tube Shield Dissipation Measurements	115

Precision AM Rectifier Circuit	117
Precision AM Rectifier Circuit Version 2	118
Precision AM Rectifier Circuit By Rob Schenck	126
Elliptic Low Pass Audio Filter	130
New MRF581A Transformer Feedback Amplifiers	133
Short Amplified High Performance MW, LW, And SW Vertical Antennas	134
The Best Small Antennas For MW, LW, And SW	135
Revised Simplified complimentary Push-Pull Output Active Amplifier For Active Whip Antennas With Simple IIP2 Adjustment	137
Low Noise Active Antennas AC/DC Power Supplies	138
Receiver noise figure sensitivity and dynamic range - what the numbers mean	141

Project Origins

The inspiration for this project is the Hollow State Newsletter that was started by Skip Arey, Chris Hanson, Dallas Lankford, Ralph Sanserino, and Reid Wheeler which had to be a money losing labor of love. Without their pioneering efforts there most likely would not be the R390 reflector list or what became the Y2K project.

Special mention must be given to Dallas Lankford who well could be the Nicola Tesla [The true inventor of radio] of boat anchor radio experimenting and upgrading. With a lifetime commitment to search for improvements and sharing them with others Dallas has written numerous articles not only posted on his web site but for the NRC, and the HSN as well. His combination of technical expertise combined with a down home writing really draws one to his articles. He maintains a “solid gold” web site at www.Kongsfjord.no

The SP 600 was the culmination of a series of receivers built by Hammarlund starting in 1951.

Generally considered as the best “band cruising” short wave receiver ever made, it continues to be a favorite although the last of the main series of receivers were produced almost 50 years ago.

Although most SP 600 models appear to identical from a brief visual inspection, there were very many circuit modifications to the various models for reasons that may never be known. Some such as the “DX” modification were less than successful. Others may have been made at the request of the procuring agency. Many obscure variations are poorly or not documented. It can be a real challenge or nightmare, depending on ones attitude, to find the exact schematic that matches ones set

In addition, many receivers have down through the years have lost their original badging and others have been “re-manufactured” turning a “J” into a “JX” or some other combination.

Andy Moorer has assembled a chart which gives invaluable information for “de-crypting” the particular chassis one has.

Technical manuals issued range from the pitifully pathetic and almost useless Northern Radio Company Type 159 Model 1 to the encyclopedic TM 11-851. Many manuals fall in between but have flashes of inspiration either in mechanical drawings, sub-assembly pictures, or parts lists. (See Andy Moorer’s comments.)

Hammarlund also made a plug in modules such as the Navistar base replacement for the first RF amplifier tubes. These are generally obscurely documented.

There have been numerous improvements published over the years and as many of these that have been found are included.

Andy Moorer has catalogued over a dozen manuals on the Hammarlund web site. They are available for download.

Some idiotic manual statements by a junior Eddie Einstein such as “g. Plot as abscissa on semi-logarithmic graph paper the plus and minus kilocycle deviations from resonance against their respective 10, 100, or 1,000 times, logarithmic ordinate resonance input.” will be attempted to be translated into “real world” information.

Many tests called for required test equipment that was never seen in the field by the troops such as spectrum analyzers, sweep generators and O’scopes that could be used for bandpass calibration. Do not despair. There are real world work arounds that will give the same or better results with much less difficulty. For example, if one does the audio modification suggested by Chuck Ripple, the receiver will perform better than the original factory specifications.

The anthology is published in PDF format for its universal ability to be read and for a smaller file size that using a .doc file.

This project was initiated to try to consolidate the many upgrade articles that have been published over the years as well as articles published on the internet that would be of use in upgrading SP 600 receivers.

Due to the inconsistencies of different manuals one should consider the downloads available on the Hammarlund website for a collection that would be appropriate to your specific needs. Also much “tweaking” was done to the SP 600 during production runs and often was not well documented..

Due to the relative spaciousness above and below the chassis, the SP 600 series provides great opportunity for performance enhancing modifications or supplemental additional circuits. With replacement of many of the original passive components far better performance can be obtained that were the receivers left the factory.

The goals of this project are to:

1. Retouch the line and schematic drawings used for improved clarity.
2. Add modification projects, repair methods, and suggestions for achieving maximum performance.
3. Include other documents that provide a basis of objective evaluation of ones receiver.

This document would not have been possible without the assistance of many volunteers who assisted drawing, photographing, copying, and researching. We are deeply indebted to the following contributors for their assistance. If we have missed any names please inform the editor so we can correct our oversight.

Jose Gavila, EB5AGV
Dallas Lankford
Norman Dulebohn

Perry Sandeen
James A. (Andy) Moorer
Tom Norris

Les Locklear
Dave Drew, K3DX
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Cecil Acuff
Barry Hauser (sk)

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The lead editor of this project is Perry Sandeen. I am solely responsible for all material, re-pagination and editing of articles used. Much of the material has been graciously provided by dedicated volunteers. But in the end I'm the one responsible for any errors or problems.

Please contact me at sandeenpa@Yahoo.com for any errors, omissions, permissions, or lack of appropriate attribution. Many of the articles and mods were copied from currently open websites. The addition of this material is to ensure it doesn't get lost as sometimes sites disappear without a trace.

Safety Section

With thanks to Joe Foley for material used in the Y2K manual

There is absolutely no substitute for good safety practices!

These radios are at least 50 years old. Even if you got the radio in “full operating condition” from your very best buddy it doesn’t insure that he or people before him knew what they were doing.

If the radio was obtained from an unknown source or is a “builder” this becomes even more important. These radios can bite. I found that out the hard way.

There was one “fix” for leaking power chokes published in the HSN. Instead of replacing the bad choke (it is expensive) the “cure” recommended was to just isolate the choke from the chassis. This, unless permanently displayed on the part, is illegal. Even properly marked, this type of “repair” thinking process is dangerous and stupid. As an example, I bought a SP 600 from an “experienced ham” in California who had used telephone low voltage wiring in his modification circuits, an AGC “Mod” that totally ruined the audio output meter function, a home brew power supply of questionable performance and shoddy workmanship.

Improper touching of the high voltage circuits, while it is very improbable that you will be killed, can cause an involuntary muscle reaction where you jerk against something sharp. This can require the need for some unique and painful stitching at your local trauma center.

Sadly to say, there are far too many incompetent “technicians” who’ve been inside these sets. You have to watch out for yourself.

On to the practical:

Before plugging the receiver into an outlet:

1. The first thing one wants to do is a visual inspection and a smell test. If all the components and wiring look OK and there are no smells of burning or other putrid odors it’s reasonable to go on to the next step.
2. Check that all the fuses are where they should be and are of the right value. There are no spare RF or IF transformers at Rat Shack.
3. Check the power cord. Is it a modern 3 wire type? If not this is the first thing you want to change. You have several choices at this point. One is to gut out the old cord and to insert a salvaged 3 wire computer power cord. All cords are color coded in one of two ways. Black, white and green usually used in North America or brown, blue and green which is used in other parts of the world.

Green is always a chassis to approved electrical service “earthed” ground. This must be physically bonded to the metal chassis.

Black or brown are always the hot lead which should always go to through a fuse to the input power switch. The SP 600 and other receivers ARE NOT wired that way and should be changed.

White or blue go to the return power lead.

There are no exceptions to this rule for receivers wired for 110 volts. 220 volt wiring in other country’s may be different. If 220 volts are used check your local electrical codes.

At the time these radios were in service what is known as a "live front" caps were used extensively. What "live front" means is that when a paperboard type of insulated spacer was removed from the cap front, the wire mounting terminals were exposed. Due to the tight fit it was common practice to tin these wires with solder to keep from having any stray strand(s) from sticking out and allowing easier tightening of the screws. Unfortunately, solder will "cold flow" allowing the terminals to loosen and overheat. Any cap like this is now illegal and should be replaced before powering up. Modern 3 wire plugs as used on power tools will be fine.

Here becomes the first of problems you will face. A properly grounded SP 600 with the originally installed line filter that is perfectly functional may trip the standard USA GFCI protected circuit. It does this if the filter design passes a little more than 5 Ma. to ground and the GFCI trip current is 4 Ma. GFCI protected circuits are a NFPA mandatory electrical code requirement in new or remodeled construction for a number of years in the USA. In most areas requiring electrical inspection, it is law. If the receiver is operated on 220 volts, this current leakage doubles.

You have several choices. One is to use an isolation transformer. A second is to remove the original filter capacitors attached near the power cord entrance. This is not a particularly good plan as the original filter provided some EMI protection. The third choice is to use a modern computer power supply input filter or an equivalent type low leakage filter mounted inside the chassis. They are cheap, readily available from a dead computer PS or major parts suppliers.

Now that the power into the radio has been checked do a visual check on the innards. Look for burn marks, hot spots, bad wiring. Do the resistance checks in the manual at every tube socket and resistor. Check the operation of all switches, if any bind or feel loose this is a good time to fix them. Pay close attention to the Filter Capacitors, they are a popular failure point. They may work fine, explode, or just get very hot. If its an older model and has the some or all of the Black Beauty capacitors one should seriously consider a wholesale replacement before going any further as you are going to have to do it sooner or later as they are now at least leaky and will fail in the near future.

Is it power time? That's your decision.

If you do it's a good idea to bring it up to full voltage on a variable transformer (variac), slowly, while checking for smoke/heat/sparks. One problem with a variac is that the voltage is dependent on the current passing through it. It should always have a voltmeter and ammeter attached to it. Watching the CURRENT as one brings up the voltage is the easiest way to spot a bad power problem BEFORE the smoke and sparks start. It should also be connected to a Ground Fault Circuit Interrupter.

⇒ Danger:	Under no circumstances should you attach power to the receiver without a proven good ground wire attached properly to the frame. Filter leakage is present with the receiver turned off.
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⇒ Danger:	A variac is an adjustable auto-transformer and does not provide any current leakage isolation.
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EB5AGV's SP-600 Model Information

SP-600 J-Model Information		
JX Model	Date added (according to Hammarlund files)	Comments
1-9	9-19-51	
10,11	11-8-51	
12	11-9-51	
13	11-26-51	
14	3-12-52	
14	4-23-52	Name plate to add R-274A/FRR
14	9-29-52	'A' was R-542/FRR
15-17	6-17-52	
18	6-26-52	
19,20	8-27-52	
21-26	2-13-53	
24	10-9-57	Special supplied to NAVSHIPS 91661, R-274B/FRR
27	3-13-53	
28	10-5-53	
28	3-8-54	Name plate added
29	3-12-54	
30-33	12-28-54	
34,35	7-7-56	
36	10-3-57	
37,38	3-28-61	
39	7-21-61	Made for FAA contract FA-2338 same as 21, except has 6 position freq control instead of 7

SP-600 Sequential Model Information

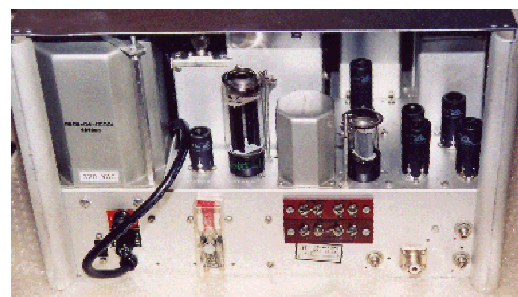
Model	Designation	Comments
1	JX-1	
2	JLX-2	
3	J-3	
4	J-4	R-320A/FRR SIGNAL CORPS 19474-PHILA-50-06
5	J-5	R-483/FRR SIGNAL CORPS 21478-PHILA-50
6	JX-6	R-274B/FRR NAVY NOBSR-52039
7	JX-7	
8	JX-8	
9	JL-9	
10	JX-10	
11	J-11	MADE TO COMPLETE NAVY ORDER ECN-1156
12	JX-12	R-274A/FRR SIGNAL CORPS 3376-PHILA-52
13	J-13	SAME AS 5, NAME PLATE CONTRACT 16838-PHILA-51, SERIAL NUMBERED 52 TO 67 INCLUSIVE
14	JX-14	R-274C/FRR SIGNAL CORPS 1689-PHILA-51-01
15	JLX-15	
16	JL-16	
17	JX-17	AIR MATERIAL COMMAND
18	JX-18	
19	J-19	
20	J-20	R-483A/FRR SIGNAL CORPS 3479-PHILA-52-06
21	JX-21	
22	J-22	
23	JLX-23	
24	JL-24	
25	J-25	
26	JX-26	R-274C/FRR 3376-PHILA-52
27	JLX-27	
28	JX-28	R-620/FRR SIGNAL CORPS 25693-PH-53-61 on contract DA-36-039-SC-49453
29	JX-29	MADE FOR CONTRACT XG-1178
30	JX-30	DIVERSITY
31	VLF-31	
32	JX-32	BLACK WRINKLE FINISH ON FRONT PANEL, FIRST MADE FOR MACKAY RADIO THEIR ORDER # M-41666
33	JLX-33	SAME AS 17, EXCEPT FREQ: .1 TO .4 and 1.35 TO 29.7
34	JL-34	FIRST MADE FOR CIA ORDER XG-1765, FREQ: .1 TO .2 and .54 TO 14.8
35	JX-35	R-274B/FRR ORDER NO BSR-71369, USES 0-10 KC BFO
36		
37	JX-37	
38	VLF-38	SAME AS VLF-31 EXCEPT 25 CYCLE
39	JX-39	FAA CONTRACT FA-2338

PRODUCTION DATE	SUFFIX #	NOTES
Sept. 1951	SP-600-JX-1	Std. Frequency range 540 khz-54 MHz. Also designated R-274A/FRR ("Fixed Radio Receiver") Signal Corps order no. 1689-Phila- 51-01. Note: many early SP-600's were simply designated SP-600-JX
Sept. 1951	SP-600-JLX-2	Frequency range 100-400 kHz, 1.35-29.7 MHz
Sept. 1951	SP-600-J-3	Std. Frequency range, 540 khz-54 MHz. No X-tal frequency control.
Sept. 1951	SP-600-J-4	Std. frequency range, 540 khz-54mhz. No X-tal frequency control. Equipped with 25 to 60 cycle (hertz) power supply. Signal Corps. R-320A/FRC, order no. 21478-Phila-50-06. Also has separate IF gain control located where the X-tal frequency control was normally located. Part of OA-58B/FRC Set.
Sept. 1951	SP-600-JX-6	Std. Frequency range, 540 khz-54 MHz. BFO range 0-10khz. U.S. Navy model R-274B/FRR, order no. Nobsr-52039 19 October, 1954. Navships manual 91661.
Sept. 1951	SP-600-JX-7	Std. frequency range, 540 khz-54mhz.
Sept. 1951	SP-600-JX-8	Std. frequency range, 540 khz-54 Mhz. Manufactured for Welch contract no. XG-479. Believed to be a cover for a CIA contract.
Sept. 1951	SP-600-JL-9	Frequency range, 100-400khz, 1.35-29.7 Mhz. No X-tal frequency control.
Nov. 1951	SP-600-JX-10	Std. frequency range, 540 khz-54 Mhz. Replaces JX-7.
Nov. 1951	SP-600-J-11	Std. frequency range, 540 khz-54mhz. No X-tal frequency control. Note: This model made to complete NAVY order, without the changes per ECN1156 as standard J series. Replaces J-3.
Nov. 9, 1951	SP-600-JX-12	Std. frequency range, 540 khz-54mhz. Signal Corps. R274A/FRR, order no. 3376-Phila-52. Replaces JX-1.
Nov. 26, 1951	SP-600-J-13	Std. frequency range, 540 khz-54mhz. No X-tal frequency control. Signal Corps. order no. 16838-Phila-51. Serial no's. 52 to 67 inclusive. 25 to 60 cycle power supply. Replaces J-5. 16 receivers produced on this order.
April 23, 1952	SP-600-JX-14	Std. frequency range, 540 khz-54mhz. Signal Corps. R274C/FRR, order no. 3376-Phila-52. Also designated previously as R-542/FRR. Replaces JX-10.
June 17, 1952	SP-600-JLX-15	Frequency range, 100-400 kHz, 1.35-29.7 Mhz. Replaces JLX-2.
June 17, 1952	SP-600-JL-16	Frequency range, 100-400 kHz, 1.35-29.7 Mhz. No X-tal frequency control. Replaces JL-9.
June 17, 1952	SP-600-JX-17	Std. frequency range, 540 khz-54mhz. Diversity receiver. Manufactured for Air Material Command. Note: easily identified by 'red metal knobs'. The most common of the SP-600 series receivers.

PRODUCTION DATE	SUFFIX #	NOTES
June 26, 1952	SP-600 JX-18	Std. frequency range, 540 khz-54mhz. Made for 'GAUVREAU' contract. Replaces JX-10.
Aug. 27, 1952	SP-600-J-19	Std. frequency range, 540khz-54 MHz. No X-tal frequency control. Equipped with 25 to 60 cycle power supply. Replaces J-5, J-13.
Aug. 1952	SP-600-J-20	Std. frequency range, 540 khz-54mhz. No X-tal frequency control. Same as J-19. Signal Corps. R-483A/FRR, order no. 3479-Phila-52-05. Equipped with 25 to 60 cycle power supply. Replaces J-19.
Feb. 13, 1953	SP-600-JX-21	Std. frequency range, 540 khz-54mhz. Replaces JX-10.
Feb. 1953	SP-600-J-22	Std. frequency range, 540 khz-54mhz. No X-tal frequency control. Replaces J-11.
Feb. 1953	SP-600-JLX-23	Frequency range, 100-400 kHz, 1.35-29.7 mhz. Replaces JLX-15.
Feb. 1953	SP-600-JL-24	Frequency range, 100-400 khz, 1.35-29.7 mhz. No X-tal frequency control. Replaces JL-16.
Feb. 1953	SP-600-J-25	Std. frequency range, 540 khz-54mhz. No X-tal frequency control. Equipped with 25 to 60 cycle power supply. Replaces J-19.
Feb. 1953	SP-600-JX-26	Std. frequency range, 540khz-54mhz. Signal Corps. R274C/FRR, order no. 3376-Phila-52. Effective upon Signal Corps. approval of TAR#10 dated 2-12-53. Replaces JX-14.
March 13, 1953	SP-600-JLX-27	Special frequency range, 200-400 khz, 540 khz-29.7 mhz.
Oct. 5, 1953	SP-600-JX-28	Std. frequency range, 540 khz-54mhz. Signal Corps. R-620/FRR, order no. 25693-Phila-53-61, contract DA-36-039-SC-49453.
March 12, 1954	SP-600-JX-29	Std. frequency range, 540 khz-54mhz. Made for CIA contract no.XG-1178.
Dec. 28, 1954	SP-600-JX-30	Std. frequency range, 540 khz-54mhz. Diversity receiver. Replaces JX-17 red metal knobs, not very common.
Dec. 1954	SP-600-VLF-31	Special frequency range, 10-540khz; X-tal frequency control (4 position). Very low frequency receiver.
Dec. 1954	SP-600-JX-32	Std. frequency range, 540 khz-54mhz. Black wrinkle finish front panel with white engraved lettering. Made for Mackay Radio, their order no. M-41666, Hammarlund production order no. 2467- 300. Internally the same as JX-21.
Dec. 1954	SP-600-JLX-33	Special frequency range, 100-400 khz, 1.35 - 29.7 mhz.
Aug. 7, 1956	SP-600-JL-34	Special frequency range, 100-200khz, 540 khz-14.8 mhz. Made for CIA. Their order no. XG-1765.
Aug., 1956	SP-600-JX-35	Std. frequency range, 540 khz-54mhz. X-tal frequency control. BFO range 0-10 khz. U. S. Navy R-274B/FRR, order no. NObsr-71369. Navships manual 91661.

PRODUCTION DATE	SUFFIX #	NOTES
Oct. 3, 1957	SP-600-JX-36	Std. frequency range, 540 khz-54mhz. X-tal frequency control. Made for FBI, their order no. FBI-16876, their contract no. J-FBI-3873. Same as JX-21, except for addition of audio input jack on rear of chassis.
Oct. 9, 1957	SP-600-JL-24	(Special) Frequency range, 100-400 khz, 1.35-29.7 mhz. No X-tal frequency control. U.S. Navy R-274B/FRR. Supplied to NAVSHIPS 91661, R-274B/FRR per PL-33910-1. Reason for 'Special' designation not known.
Mar. 28, 1961	SP-600-JX-37	Std. frequency range, 540 khz-54mhz. X-tal frequency control. 25 to 60 cycle power supply. Otherwise, same as JX-21.
March, 1961	SP-600-VLF-38	Special frequency range, 10-540 khz. X-tal frequency control (4 position). Very low frequency receiver. 25 to 60 cycle (hertz) power supply. Same as VLF-31 except for 25 to 60 cycle (hertz) power supply.
July 21, 1961	SP-600-JX-39	Std. frequency range, 540 khz-54 mHz. Made for FAA contract no. FA-2338.
June 1969-1972	SP-600-JX-21A	Std. frequency range, 540 khz-54 mhz. This was the last series of SP-600's manufactured. It had 22 tubes vs. 20 in other models. Also, a separate product detector, LSB,USB,CW,MOD switch. Appearance was different from other SP-600's in that the knobs had no metal skirts, the front panel was engraved with markings for Xtal phasing, selectivity, bfo, audio gain, rf gain. Also is marked JX-21-A on front panel. This is probably the rarest of the SP-600 series.

SP-600-JX 21A Pictures Photos courtesy of Paolo Viappiani



Hammarlund Super-Pro SP-600 Page

From the Hammarlund web site Contributed by James "Andy" Moorer

As noted before, I enjoy restoring these units to good working condition. The difference between these primarily-military units and the commercial shortwave receivers is quite remarkable. These are much easier to repair. They are designed so you can get into every nook and cranny (sometimes with some difficulty) so every part can be repaired.

For more information on Hammarlund and these great receivers, visit the Hammarlund Historian web site.

Many people have asked me what is the difference between the "Diversity" receivers (The SP-600JX 17) and all the other receivers. The diversity receivers look really cool because of the 3 red knobs on the front, but it is probably irrelevant for modern usage. *In fact, the AGC structure, I feel, is not as good as the other receivers. Among other things, they inject the AGC voltage into the 6BE6 first mixer tube. The 6BE6 is not really designed for variable-mu operation. They run the first two RF stages at a relatively high gain all the time. I think this causes the AGC to do weird things.* I feel these receivers overload much more easily on strong signals. But if you like nifty red knobs, this is for you. It is also the most common single model of the SP-600 that was produced. It is a complex enough issue that I put together an entire page just on the diversity receivers: Just click here to see Hammarlund's original description of these receivers.

(repeat of caveat on boatanchor page)

On the other hand, I do need a supply of SP-600 fixer-uppers. I will pay up to \$175 for a SP-600 plus up to \$45 shipping, sight-unseen. If the unit has all the main components (transformers, meter, knobs, etc), you get the full \$175. If it is missing pieces, or some pieces are not repairable, we will negotiate a somewhat lower rate. I pay \$75-\$100 for parts units, depending on how many usable parts they have that I need. Contact me with your tired, dirty old SP-600s.

SP-600 Tidbits

ABOUT THE CASE

The receivers that are pictured in my restored radios are from Premier Metal Products. I would be glad to sell you one for \$272 (my cost with CA state tax) plus about \$25 for shipping, but you can get them cheaper by buying them directly from Premier Metal Products. Go to the Premier Metal Products Web Site. You are looking for the "Trimline Portable Instrument Case". The part number is TIC-101917. It will handle the extra depth of the SP-600 with no problem. Some people complain that there is no ventilation in this cabinet. That is true. For an additional \$100 or so, Premier Metal Products will be happy to give you one with louvers in the sides and top. For a few more bucks, you can get a half-height rear panel as well. The case comes in a range of colors. I tend to prefer the battleship grey myself.

ABOUT WASHING/CLEANING AN OLD RADIO

People ask me frequently about how I get the chassis of the SP-600 so shiny clean. First off, they are more shiny in the pictures than they are in real life. I take my cleaning technique from Dave Medley.. For me, the cleaning is just one part of the restoration process, so I do not clean a radio unless I am ready to completely restore it. My procedure goes as follows:

1. Take everything off that can be easily taken off. Top cover, bottom cover, front panel, all the IF can covers, 3.5 MHz crystal cover, all the tubes, and the sides (they do come off).
2. Make up a gallon of warm, soapy water. I use Simple Green, but just about anything will do. Some people like non-ionizing cleansers, but I don't know how to tell the difference. Take the hose and drench the radio with water. Take a couple of plastic scrub brushes (big and small), a plastic scrubby sponge, an old toothbrush, and maybe a bit of number 600 wet-dry emery paper and get to work! You will have to work the scrubby part of the sponge into all the nooks of the radio. You have to work it all around the tube sockets and behind the coils. Make sure you get into everything. Let the foam go everywhere - pour buckets of water all over the radio. Don't let the radio dry with soap on it - rinse well first. When you are done with the radio, I drop all the small parts into the soapy water and hand-wash them and lay them into a sieve of some kind.

N.B. - if you have a radio with paper parts, like the dial on the drum of the R-388, you may want to remove that first. Take all the paper parts off first.

3. THIS IS THE IMPORTANT PART - Rinse the radio with 3-4 gallons of distilled water (after rinsing with the hose). This prevents any minerals from the tap water from getting in the radio and causing shorts. The stuff is only a buck or two per gallon, so use more than you think you would ever have to. Keep rotating the radio under the water to get it from all angles.
4. Dry the radio carefully. In California, I just leave it out in the sun for a couple of days, rotating it every few hours. Some people put it in the oven(!). It doesn't matter, but it has to get really, really dry. You do not want a single drop of water in the thing when you power it up.

Yes, I do wash the gears and all the parts that are normally lubricated. You are going to re-lube them anyway (if needed - brass gears don't need lubrication). Uh, in case it isn't obvious, don't try to wash the meter. I have inadvertently dunked the meter - it did eventually dry out, but I had to take it all apart first.

ABOUT THE CRYSTALS

I have had a number of questions about the crystals in the FCU (Frequency Control Unit) of the JX models. Getting a crystal is not a difficult process. JAN crystals will be happy to sell you as many as you want, even in the antique HC-11 package, at about \$15 each, custom-cut to your frequency. You do have to get the frequency right. It is not just the frequency of the station you are trying to receive. Here is a reduced version of the chart to figure out the crystal frequency, given the frequency of the desired station:

- .55MHz To 7.4 MHz - add 0.455 MHz to get crystal frequency
- 7.4 MHz to 12.05 MHz - add 3.955 MHz
- 12.05 MHz to 44.05 MHz - Add 3.955 MHz and divide by 3 (3rd harmonic)
- 44.05 MHz to 54 MHz - Add 3.955 MHz and divide by 4 (4th harmonic)

You will also have to specify some other stuff. Use the following:

Case: HC-6/U Resistance at Resonance: 200-1000 ohms (not critical, as high as is
Mode: PARALLEL reasonable)
Parallel capacitance: 40 pf Mode: fundamental, 3rd or 4th harmonic from table above
Precision: 25 ppm (you can get better by paying more)
Signal Level: 2-5 volts.

Go to the JAN Crystals Web Site and click on "Custom Crystal Design Sheet". Fill out the above entries on the sheet. Leave the others blank, or just put "not critical" on them. Last time I did this, the inside sales person was Sue Brick and she was very helpful. It took about 6 weeks to take delivery of the crystals. They all worked perfectly.

Here is a little calculator that will compute the above formula for you:

If you don't get a calculator there, you probably need to download a current Java Virtual Machine. Thank you, Bill Gates. To get this, click [HERE](#) and click on "download it now." If you still don't get a calculator, send me a note. If you do get a calculator after the download, then send an email to Microsoft and ask them to make sure to bundle the most current Java Virtual Machine with their programs and operating systems.

Scanned SP-600 Manuals

One of the most difficult parts of dealing with these old receivers is finding the appropriate manuals. Without schematics and other descriptions, it is a hopeless task trying to repair these things. Fortunately, there are a number of the original manuals still extant. They show up on eBay from time to time, or can be borrowed from old-timers (although the number of such is diminishing every year). Another problem is that most scans of these manuals are of relatively poor quality. I attribute this to the fact that high-quality scans take a lot of disk space, and it takes a fair amount of time to dress them up in Photoshop. I do not have a lot of manuals, but the ones I have, I have scanned in at high resolution. I manually de-screened the half-tone images, since the automatic de-screening doesn't work very well (seems like us DSP types should be able to fix that). Below are some of the manuals I have put together. The first three are from BAMA and are not of high quality. The rest are of very good quality, but are also quite large. The granddaddy of SP-600 manuals is TM11-851, the military manual on the R-274 and related receivers (N.B. - there was a unit made by Hallicrafters that was also called the R-274. That's in TM11-897. I have not scanned it - yet.). It is particularly problematic, since it has six schematics that are 14" by 60". I include scanned versions of these in the original form factor, but also a version that has each schematic as three 11"x17" overlapping sheets, so you can print them out (Kinko's can do this) and tape them together to get the full schematic. This manual only covers units up to serial number 4600 or so and does not cover the diversity receivers. There is a separate manual (see below) specifically for them.

If for some reason you can't manage to download what you want, for \$20 I will send you a CD-ROM with all these .PDF files on it. I prefer PayPal to jamminpower@earthlink.net, but you can just send me a personal check or whatever. Send me an email and give me your mailing address and I'll get a CD right out.

Also, I learned that there are a number of readers that have no good way to get a printed copy of these manuals. As a service to my readers, I will print out and comb-bind a copy of any of these manuals for you for \$15 each (postage to US included - more for foreign). The one exception is the big one - TM11-851. I have to charge you \$45 for that one because of the size (200+ pages) and the difficulty of printing out the schematics. I print them as 3 11x17 sheets for each of the 6 schematics.

ABOUT ISSUE-7

I list below the original SP-600 manuals, Issues 1 through 6. 1, 2, and 3 are pretty similar, but 4, 5, and 6 are quite different. Without explaining it, they describe various different models. For instance, the schematics in Issue-6 correspond to the JX-14 model. Well, there is also an Issue-7. But don't get your hopes up - it is a reprint of Issue-6. It was reprinted in 1966 (a decade after Issue-6). It does not have any additional information in it that wasn't already published in Issue-6. That being the case, I did not bother to scan it in.

Also, I am always searching for originals of Hammarlund manuals - even the ones I have already scanned below. I have noticed that there are often different versions of the manuals, even though they are called the same thing. For instance, I know that there are two different versions of the JX-17 manuals. I only have one of them. And there are two manuals that are earlier than Issue-1 that are just called SP-600J and SP-600JX manuals. If you have any of these original manuals, please let me buy or at least borrow them for scanning.

Download 6MB (Watch this spot!)

Issue-1 From BAMA. This is the oldest of the Hammarlund-issued SP-600 manuals and it shows it
Download 10MB (Watch this spot!)

Issue-2 From BAMA. This one actually is reasonable, but the schematic doesn't have component values on it. A real pain. Download 5MB (Watch this spot!)

Issue-3 From BAMA. This is the first one that is particularly useful. It does describe one class of the first few thousand of these that were built. These are the ones that have the linear E13, as opposed to the rectangular block E13. This may seem like a technicality until you get one with the block E13 on your bench. Download 80MB (Watch this spot!)

Issue-4 My scan. This is the first manual that shows clearly the rectangular block version of E13. It actually has two separate sets of schematics and wiring diagram. One has the linear E13 and the other has the block E13. Also, the block E13 version has R72 and R73 going to the screen supply of V1, V2, V3, and V5. This is the infamous "7-wire" RF deck and is not compatible with any other RF deck. You can NOT swap this RF deck with any other unit. This form of screen supply was quickly abandoned, but R72 and R73 were retained in later units for the screen supply of the IF strip.
(Watch this spot!) (Watch this spot!)

Issue-5 Sorry. Not there yet. Download 89MB (Watch this spot!)

Issue-6 This one represents most of the later models except for the diversity receivers. I also included annotated versions of the wiring diagrams where I put the component values next to the part numbers. Download 94MB (Watch this spot!)

SP600-JX-17 This one documents the "diversity" receivers. This is the most common unit that was made. There are significant differences from the other models. The 3.5 Mhz oscillator is a tuned-plate type rather than a tuned-grid type. The FCU has two boards in it and a torroidal transformer (which is generally broken into small pieces) with an RF connector on the back that serves as both input and output. It has two or three extra RF connectors on the back. (N.B. the units that have the third RF connector on the back are undocumented as far as I can tell. The third connector seems to be the output of the driver/2nd mixer stage before the IF strip, but I'm not sure yet). Download 12M
(Watch this spot!)

AN16-45-436 This is another Air Force manual on the SP-600 (see below). This one is specifically the illustrated parts breakdown for the JX17 "Diversity" receiver. It is especially useful because it shows the location of every part and it specifically identifies the hardware. This is an important companion to the above manual. Note that it is NOT for any other receiver than the diversity receivers. Thanks to Brian Hill for the scan. I have one remaining question for the viewing audience: did the Air Force make other manuals for the JX17? Did they make an operating manual? A maintenance manual with schematics? Does anyone have copies of these that I could scan (if they exist)? Download 390M (Watch this spot!)

TM11-851 The granddaddy of all SP-600 manuals. 195 pages of text. Six large (14"x60") fold-out schematic sets. There is information here that you can't find anywhere else. For instance, it has a table of the DC resistance of every coil and transformer in the receiver. Very useful. It has a lot of detail about the differences among the various models. I have included versions of the fold-out schematics that can be printed on 11x17 paper and taped together.

Download Part 1 72M

Download Part 2 53M

Download Part 3 39M

Download Part 4 120M

Download Part 5 90M

(Watch this spot!)

TM11-851 This is the same as above, but broken up into five pieces for easier download. Each piece has a (redundant) copy of the last page of the previous piece so it is easy to make sure you got them all. Download 25M (Watch this spot!)

AN16-45-221 This is the first of four Air Force manuals on the SP-600. They have two sets of numbers - one starts with "AN" and the other starts with "T.O." This one is the operating instructions. Download 25M (Watch this spot!)

AN16-45-222 Air Force manual. Service Instructions. This has schematics and wiring diagrams. It has one of the most cogent and detailed descriptions of how the receiver works that you will find anywhere. Download 22M (Watch this spot!)

AN16-45-223 Air Force Manual. Overhaul Instructions. This is less useful than you might think it would be. It does have one useful part, which is the instructions for reassembling the gear train. If you have ever taken it apart, for instance, to fix a sticky or stuck tuning system, you will appreciate reading through that section. It does not have any schematics or wiring diagrams. It also has a lot of less useful information, such as how to apply the fungus-resistant coating for tropical operation. Download 44M (Watch this spot!)

AN16-45-224 Air Force Manual. Illustrated Parts Breakdown. When you are about halfway through rebuilding one of these units, you will really, really want a copy of this manual. It has the size of every single nut, bolt, and washer in the system. It is not so helpful with the electrical parts, but it has all the mechanical parts in nauseating detail. I took a lot of care with the scanning to make sure that every single bit is clearly visible in the illustrations. Again, all the half-tone images were manually de-screened for clear viewing.

SP-600 Identification Guide

James A. Moorer October 4, 2004

Most of the information here comes from my own SP-600 restorations.

(<http://www.jamminpower.com/main/sp600.jsp>) and from the Hammarlund Information web site (<http://www.hammarlund.info/sp600.html>). This will not get you to the exact Hammarlund model, except in a few cases. It will get you to the schematics and documentation for all the standard Hammarlund models.

There appear to be 5 basic “body plans” for the SP-600. Since there were at least 40 different model numbers, several model numbers will share basically the same body plan. To confuse us more, the Signal Corps had not only its own labeling scheme (R-274X), but its own set of serial numbers. There is no record of the correspondence between Hammarlund’s serial numbers and the Signal Corps signal numbers that I have ever seen. To make things more confusing, the Navy commissioned the R-274B which used more than one body plan.

The best I can do in identifying the different models of the SP-600 is to figure out which basic body plan the particular unit is.

The most common model of the SP-600 is the JX-17, the “diversity” receiver. Since this unit is easily recognizable by the cool-looking red knobs, there is no difficulty identifying it. Even if the knobs are missing, it is easily identified by the extra switch on front that selects the AGC time constant. Even if the front panel and all the controls are missing, it is recognizable by the fact that it has 3 (or 4) RF connectors on the back panel. If all else fails, one can peek under the can that houses the 3.5 MHz crystal for the second mixer and see if it has more than one RF choke. That is yet another sign that it is a JX-17. You can see a picture of one here:

<http://www.jamminpower.com/eBay/SP-600/SP-600.4.html>

The JX-21A is equally easy to identify, since it has the AM, LSB, USB selector in the bottom right of the front panel.

Generally, the 4 body plans are as follows (in no particular order):

1. The “original” SP-600, including the JX and the JX-1. Has a 6-wire RF deck, R72 and R73 are bleeder resistors, no AGC voltage goes to V6 or V7, and V7 gets a - 10V bias.
2. The “direction-finder” SP-600. It has the 6-wire RF deck, R72 and R73 are power resistors that supply the screen voltage for the IF section. The AGC voltage goes to both V6 and V7. E13 is a block that has the “DF/N” screw terminals. This model includes the JX-26 and maybe others.
3. The “7-wire” SP-600. This is a unique model, the JX-14. It has the 7-wire RF desk, R72 and R73 are power resistors that supply the screen voltage for the RF section.
4. An early SP-600. 6-wire RF deck, R72 and R73 are bleeder resistors, not voltage dividers, no AGC voltage goes to V6 (2nd mixer) or V7 (gate), and V7 has 0-Volts on the grid bias. This includes the JX-6, and probably others. At least one model of the R-274B has this body plan.

About serial numbers: Hammarlund just numbered the SP-600s consecutively, so there is no clear correspondence between serial number and model number that we know of. Model numbers tended to follow order numbers.

Each time Hammarlund got a contract from the military, they would assign it a new model number. As far as I can tell, many of the model numbers are essentially identical. Similarly, the Signal Corps numbered their units consecutively, even though a particular model (R-274C, for instance) was involved in several contracts, several model numbers, and all sorts of SP-600 serial numbers. So, with this preparation, here is my suggested identification method (assuming that it is missing the ID plate on the top of the RF deck. It is also possible that somebody switched RF deck top covers on you, which can lead to endless confusion). The following is in the order that I would use, and not in either model number or date of manufacture number.

Does it have the 7-wire RF deck? (Body Plan 3)

Most of the SP-600s have 6 wires going to the RF deck. They are all connected through the circuit board on the top of T1. T1 is located in the little metal shield that is screwed to the right side of the RF unit. It has a cover that is held down by two cap nuts. T1 consists of two tunable inductors, L33 and L34. Sometimes the cover has the designations of the inductors printed on the top. The first step in removing the RF deck is to unsolder the wires from the RF deck. Count the number of wires coming from the RF deck through the square hole behind T1.

If it has a 7-wire RF deck it is an R-274C with a (Signal Corps) serial number of 487 through 1569. This is also known as SP-600JX-14. Note that other R-274C models (JX- 7, JX-10, and JX-26) do not have the 7-wire RF deck. I have personally worked on JX-14s with Hammarlund serial numbers from 8000 to over 10,000. The schematics of this model (with the 7-wire RF deck) are in Issue-4 of the Hammarlund manual (October, 1952, Figure 13, pp 33-34). Note that Issue-4 has two sets of schematics – the R-274C is in the first set, not in the supplement. It is also shown in Figure 101 of TM11-851.

Curiously, the 7-wire RF deck is shown as Figure 15 (p37) in the Hammarlund SP-600 manuals, Issue-5, Issue-6, and Issue-7, even though the schematics show the direction finder model (the JX-26).

The 7-wire RF deck will also have R72 and R73, which are two large, power resistors, bolted to the side of the chassis near the power transformer. They will be quite obvious. R72 is 7500 ohms at 20 watts. R73 is 10K ohms also at 20 watts. These two divide the regulated 150 volts down to about 85 volts for the screen supply of the two RF amplifier stages (V1 and V2). Note that other models use R72 and R73 for the screen supply of the IF strip.

Editorial comment: There is some point in regulating the screen supply. If you connect it to the plate supply, there is some chance that it will wave up and down as the plate voltage changes. This makes some feedback into the grid circuit, which does all sorts of nasty things, especially at high frequencies. The RF stages, however, never have much AC voltage on the plates, so there won't be much difference whether you stabilize the screen voltages of the RF stages or not. Other models use R72 and R73 to stabilize the screen voltages of the IF stages, which makes somewhat more sense. The AC (signal) voltage on the last IF stages can be several volts in amplitude. Any feedback into the grid circuitry can drive the circuit unstable. Of course, the IF system operates at a relatively low frequency (455 kHz), so it probably doesn't make much difference there either.

Is It Set Up For Direction Finding? (Body Plan 2)

The terminal strip E13 has several different configurations. The basic configuration is just a linear strip, as was so common in that era. The other configuration is just a bakelite block with studs. There are several different configurations of E13 blocks. The easiest one to identify is the "direction finder" version.

This was known as the late versions of the R-274C (Signal Corps serial number 1570 and higher), also as the JX-26 and maybe others.

The direction finder version of E13 has two screw terminals on the top and a single wire that may be moved from one to the next. Sometimes, one is identified by the letters “DF”. Sometimes the cover to the top of the RF cage has a note on it describing the use of the jumper. As often as not, the cover is either missing or is not appropriate to the receiver it comes with, so you should always check E13.

The schematics of the model with the direction finding modification may be found in Figure 102 of TM11-851, but also in the supplement to Issue-4 of the Hammarlund manual (October, 1952, Figure 13, pp33-34, *second* set). As noted above, Issue-4 has two sets of schematics – this is the second set. Figure 1 shows E13 for the direction finder version of the R-274C. The schematics for the DF model are also shown in Issue- 5, Issue-6 and Issue-7, but you have to be careful since in those manuals, Figure 15 is *not* the RF deck of the DF model(!) – it is the 7-wire RF deck.

Editorial comment: This modification allows the operator to choose the amount of AGC voltage supplied to the 1st and 2nd RF stages. In the “DF” position, the RF stages are run at a high gain, regardless of the strength of the incoming signal. This has the effect for medium-strength signals of reducing the input noise floor a bit, since the gain of the 1st RF stage determines the ultimate noise floor of the receiver. Unfortunately, it also causes increased intermodulation distortion and imaging for stronger stations. For normal, general-purpose listening, the jumper should be set to the “normal” (*i.e.*, *not* DF) setting. Note that even in the normal setting, the AGC supplied to the RF amplifiers is less than some other models.

Is it the Early SP-600? (Body Plan 4)

This one has the 6-wire RF deck, R72 and R73 are bleeder resistors on E16-6, there are no big power resistors over by the power entrance (and power transformer), no AGC voltage goes to V6 and V7, and V7 has 0-volts bias, which means that E17-1 and E17-3 are unconnected, like the 7-wire deck has as well. This is one model of the R-274B and is also called the JX-6. It is also the R-274C, Signal Corps serial numbers 1-486. The schematic for this is shown in TM11-851 as Figure 100. There are pictures of this model here: <http://www.jamminpower.com/eBay/SP-600/SP-600.6.html>.

Editorial comment: I happen to like this model more than all the others. The zero-volt bias on V7 gives a lot of gain on the lower three bands. This is lost on bands 1 and 2, since the atmospheric noise will swamp low-level signals, but on the upper part of band 3, the extra gain can help a bit. It does make a conspicuous difference in the gain between the lower three bands and the higher three bands. All the SP-600s are weaker on the upper bands, but in this one, the difference is even more.

Note that my name for it (“early”) is not strictly true – although the design is early, the pictures at the URL above are for a JX-6 with Hammarlund serial number 15182.

Is It The “Original” SP-600? (Body Plan 1)

You have to identify this one largely by things that are not there. The large, power resistors, R72 and R73 that would be by the power entrance and power transformer will be missing. Instead, there will be two small resistors, R72 and R73, that serve as bleeders for the power supply. They will be found on E16-6. On other models, 16-6 will be void (nothing connected to it). It will have a 6-wire RF deck. If the radio can be powered up, you will find that Pin 1 of V7 (the 6BA6/gate grid pin) will be a constant -11 volts. This is supplied through R-34 (E17-1 to E17-3). It is 100K. On other models, pin 1 of V7 will either be zero, or it will vary as you turn the RF gain. This is the R-274A. The schematics are shown in TM11-851 Figure 99. It is also shown in the Air Force manual AN-16-45-222.

It is also shown in the Hammarlund manual Issue-3. It is also shown in Issue-1 and Issue-2, but the labeling of some of the figures is not as complete as in Issue-3. Some pictures of one of these may be found here: <http://www.jamminpower.com/eBay/SP-600/SP-600-3.html>

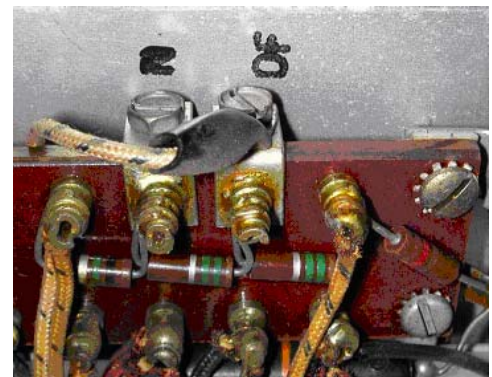
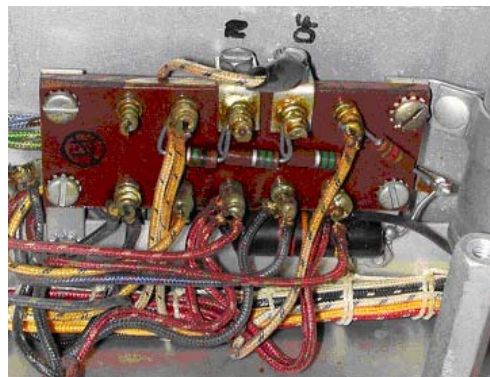
Note that on the DF model, R53 (10K) goes between E17-1 and E17-3. On the 7-wire RF deck, there is nothing on E17-1 and E17-3.

Note that in the Air Force manual AN-16-45-222, Figure 7-4 shows that the wires going to E13-2 and E13-3 are reversed from in other models(!). This is especially confusing. I ran across one of these – it was a JX (no model number). I believe what happened was that some number of them were made with the colors of the wires coming out of the FCU swapped, so they had to swap them on E13 to make them work. Unfortunately, this means that on E13-2, all the wires are red-white *except* the one from the FCU. Normally, all the wires on E13-2 are red-white. Note that in Issue-3, the same wires are not shown as swapped.

Summary: Here is the basic decision matrix as best I can figure it:

	Body Plan 1	Body Plan 2 “DF”	Body Plan 3	Body Plan 4
RF-Deck?	6-Wire	6-Wire	7-Wire	6-Wire
R72/R73 Power?	no	yes	yes	no
E13	Strip	Block, DF/N jumpers	Strip	Strip
E16-6	R72/R73	NC	NC	R72/R73
E17-1, E17-3	R-34 (100K)	R-53 (10K)	NC	NC
Hammarlund Model	JX, JX-1	JX-26	JX-14	JX-6
Signal Corps Model	R-274A	R-274C, #1570 and up, R-274B (later)	R-274C, #487-1569	R-274B (early), R-274C, #1-486
Hammarlund Manual	Issues-1, 2, and 3	Issue-4, second set, plus Issues 5, 6, and 7	Issue-4, first set	None
Military Manual	TM 11-851, Figure 99. AN-16-45-222	TM 11-851, Figure 102	TM 11-851, Figure 101	TM 11-851, Figure 100

Figure 1 – Terminal strip E13 for the “direction finder” modification to the R-274C. These are found on the JX14 and the JX26. This changes the AGC voltage supplied



to the 1st and 2nd RF stages. In the “DF” position, the first two RF stages are run at a relatively high gain, regardless of the strength of the incoming signal.

If anybody has any other observations, please let me know. Email: jamminpower@earthlink.net

Original Power Supply Schematic With Comments

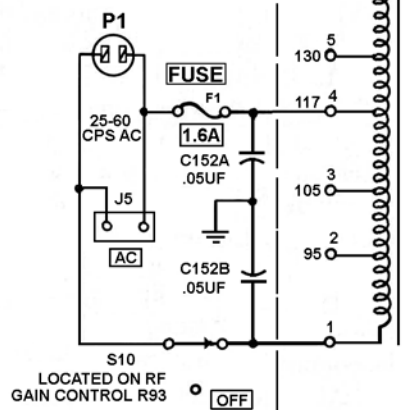
DANGER!

THE AC INPUT WIRING CIRCUIT SHOWN IS THE ORIGINAL, WHICH IF NOT UPGRADED TO MODERN STANDARDS, POSES SEVERAL SHOCK HAZARDS. A POLARIZED 3 WIRE PLUG SHOULD BE INSTALLED. THE HOT WIRE SHOULD BE ROUTED TO THE INPUT OF THE FUSE. THE OUTPUT OF THE FUSE SHOULD GO TO THE INPUT OF THE POWER SWITCH.

BOTH INPUT CAPACITORS SHOULD BE REMOVED AND REPLACED WITH A COMPUTER TYPE INPUT FILTER OR EQUIVALENT FOR RF FILTERING.

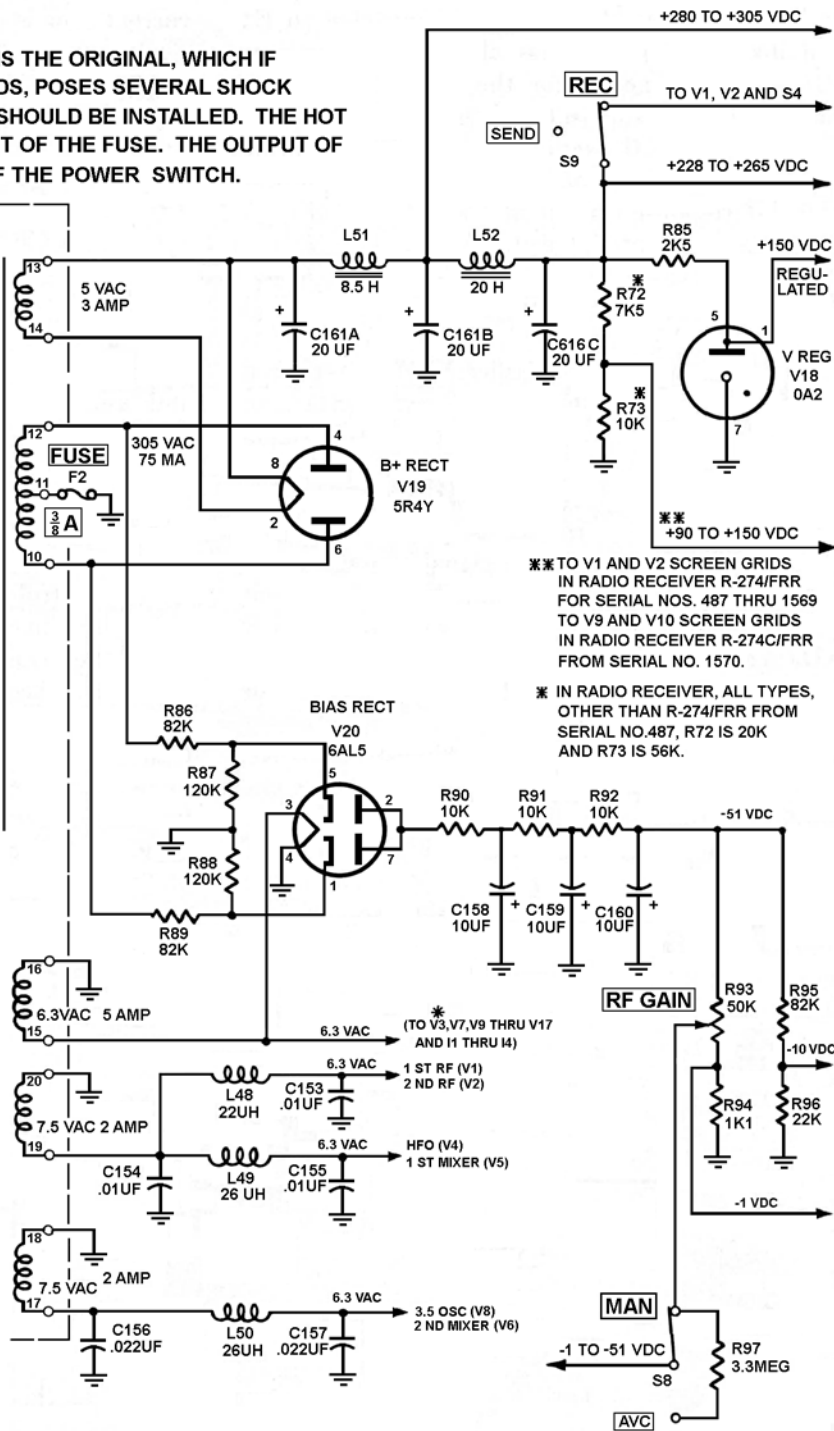
J5 SHOULD BE REMOVED.

A SUITABLE GREEN WIRE GROUND MUST BE ATTACHED TO THE FRAME.



NOTES:

1. IN RADIO RECEIVER R274C/FRR FROM SERIAL NO. 487, F1 IS 1.6 AMP, AND C152A AND C152B ARE REPLACED BY C152 AND 168, EACH .01UF.
2. FOR RADIO RECEIVER, ALL TYPES, EXCEPT FOR R-483/FRR AND R483A/FRR, LINE SOURCE FREQUENCY USED IS 50-60 CPS.
- 3.*V3 USED IN RADIO RECEIVERS R274A/FRR AND R-274C/FRR ONLY.
4. FOR RADIO RECEIVER, ALL TYPES, OTHER THAN R-483A/FRR AND R-274C/FRR FUSE RATINGS APPLICABLE ARE NOT DESIGNATED AS SHOWN.
5. UNLESS OTHERWISE SHOWN; RESISTORS ARE IN OHMS.



** TO V1 AND V2 SCREEN GRIDS IN RADIO RECEIVER R-274/FRR FOR SERIAL NOS. 487 THRU 1569 TO V9 AND V10 SCREEN GRIDS IN RADIO RECEIVER R-274C/FRR FROM SERIAL NO. 1570.

* IN RADIO RECEIVER, ALL TYPES, OTHER THAN R-274/FRR FROM SERIAL NO.487, R72 IS 20K AND R73 IS 56K.

TM851-40

Figure 50. Radio Receiver, all types, schematic diagram of the power supply.

Recapping the Hammarlund SP-600

by Paul R. "Ray" Vasek - W2ECw2ec at arrl.net Used here with permission.

Edited, re-paginated and additional material from the R390 Reflector list added by Perry Sandeen May 2009

(changes made to this article in Sept. 2004 include more pictures, and some text additions)

Recently I had the good fortune to obtain a relatively clean SP-600. Although a ham for over forty years, this was my first SP-600 and I was completely unfamiliar with it except for what I'd read in magazines or e-mail reflectors. The problem area mentioned most often was the BBOD, or Black Beauty of Death.

While waiting for delivery of my radio, I tried to gather whatever information I could in anticipation of a major recapping. While I received lots of good advice and ideas, I didn't come up with a really concise description of just how many and what kind of caps I should plan on replacing, nor the effort that would be involved. I decided that I would try to keep a detailed log of what I did and the order it which it was done, with the intent of providing some detailed information to help make the recapping process easier for others facing an SP-600 for the first time.

Keep in mind that this is the first, and only, SP-600 I have worked with. I do not pretend to be an expert on them, I am only relating the experiences I have had while working on this one particular radio. Additionally, there are many different models of the SP-600 and there may be various minor differences in the electrical configurations. Some differences may even appear within the same model, for example, my radio is an SP-600 JX-6, and one person who used my data while doing his SP-600 JX-6 was not able to locate a few of the capacitors I identified. So use this as a general guide only and be prepared for things to be a little different than I spell out, especially if your model is not a JX-6. However, a look at the schematics for several different models shows the same basic design to be followed throughout the series. Also, this is not a history of the various SP-600 models or an attempt to define the "best" capacitor to use. I'll leave that to those who are more familiar with the SP-600.

First off, many may ask, as I did, just what is a BBOD and what goes wrong with them?

The BBOD is a tubular capacitor, dark gray or black in color with numerous colored bands to identify its value and rating. It looks like a very large old style carbon resistor that might be in the 5 watt class, roughly 3/4" to 1" long and 3/8" to 5/16" in diameter. The name Black Beauty probably comes from the appearance of those caps most often encountered, a body molded of a shiny black material, and the Death moniker comes from the fact that almost every BBOD you encounter will fail, having very poor (high) leakage characteristics. (Later word has it that Black Beauty actually appears to be a real name, a trademark so to speak.) A large number will even have major cracks in them exposing the insides of the capacitor to the air. Some will be almost completely split in half.

These splits usually occur along the length of the capacitor. Don't mistake the sealed seam of the capacitor for a split. When you see a split, you'll know it! Figure 1 shows a pair of capacitors that appear to be in good solid shape with the colored bands plainly seen. Figure 2 shows another pair with splits running the length of the capacitor. While the split capacitors were obviously bad, a test of the "good looking" capacitors showed they were in as poor shape leakage wise as the split caps. The net is, when it comes to BBODs, just perform a wholesale replacement while you have the radio on the bench.



Figure 1

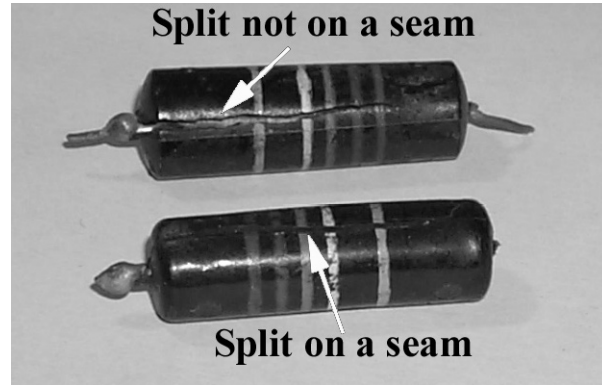


Figure 2

One thing you should be aware of. There are some lucky people out there who will not have to endure the recapping procedure. At some point late in the SP-600 life cycle, at about s/n 17,500, it was apparently recognized that the BBODs were experiencing a high failure rate after years of service. The specifications were then changed and ceramic disk capacitors were used in place of the BBODs. I've not seen any reference to similar failures in the ceramic disk equipped SP-600s. So before you start worrying about doing a recapping, check and see if you are one of the few lucky owners of an SP-600 with factory original ceramic disks!

Now that we have decided we should replace all the BBODs, just how many do we need and what types and values are they?

In my JX-6, I found I had thirty-eight BBODs with a value of .01mfd and sixteen BBODs with a value of .022mfd. A check of some later models show a factory change was made to substitute the .022mfd caps with .01mfd caps. This is supported by a military work order authorizing the change, although I can't reference that MWO number off hand. The consensus is there is no need to get two different values, you can replace all fifty-four caps with .01mfd, although I used both .01 and .022 as called for since I already had them available. There are fifty one caps used for bypass and three used for coupling. In my case I used what I had in my parts bin, .01 or .022 ceramic disks at 1000V for bypass and .01 mylars at 630v for coupling.

Prior to starting the actual recapping, I traced out the schematic locating all the caps as per the parts list.

Then I used the various pictures from the manual to try and locate visually the area where I anticipated the cap should be. I then performed a detailed resistance check of the whole radio based on the manual's resistance chart and found that all values but one were well within 10%, in fact most were within 5%, so I have not yet replaced any resistors. The one area that was out of spec was the cathode of the 6V6. This was supposed to be 380 ohms but read 1.45 ohms. This turned out to be a failed bathtub cap, a large 10mfd x 100v cap for cathode bypass. I replaced this with a standard 10mfd x 250v cap I had spare. With the new cap the resistance was dead on at 380 ohms. Someday maybe I'll mount the new cap in the old can so it looks "original". Finally, after a good visual inspection of the radio, I brought power up on the radio slowly (temporarily swapping the rectifier for a solid state rectifier set and using a variac) prior to making any changes at all, in order to be able to make a before and after comparison.

Once the radio was fully powered up, I found that it had very weak and distorted audio, capable of picking up only a few of the very strong local AM broadcast stations. The bands above 1.34mc appeared dead. At that point I began to make actual changes to the radio.

From this point on I'll summarize the steps I went through for the re-capping. I did it by trial and error, particularly the error phase, so maybe this will help get you in the right frame of mind for what might at first glance appear to be a daunting task.

At the end of the article is a list of caps along with a description of where it is located. This location is often identified as being at the "cold" end of a component. "Cold" refers to the connection point closest to ground. I've also indicated whether the cap at that position is used for bypass or coupling. Again, I chose to use ceramic disks at 1000v (as I had them handy) in the bypass locations and mylar film at 630v (again because that's what I had available) for coupling caps. I had a note from a couple people who indicated they had the models that came factory equipped with ceramic disks and that not only were the caps changed to ceramics, but the values were all .01mfd, i.e. the .022mfd had been changed to .01mfd. This supports the MWO mentioned previously.

My final summary of caps replaced is sixteen of the .022mfd, of which four were split wide open and thirty eight of the .01mfd, of which fifteen were split wide open, plus the one shorted 10mfd in the 6V6 cathode circuit.

Re-capping an SP-600: Refer to figures 3 and 4 at the end of the article.

In order to make this project appear more manageable I identified seven unique sections for recapping. Except for the underchassis, each section represents an area that requires disassembly of some sort to get to the cap(s) that need replacing. Some areas may contain as few as just one cap to be replaced. I have not provided complete instructions, just tips. Some things may seem strange but if you are looking at the radio while reading these instructions it should become clear how to proceed.

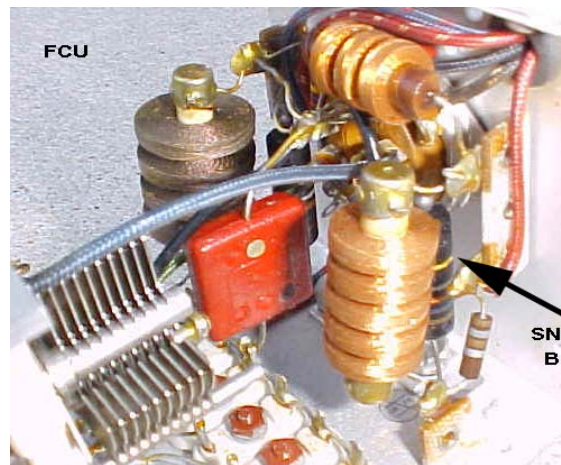
The sections are:

- | | |
|--------------------------------------|---|
| (1) RF Deck (Fig 3) | (5) T9 (HFO oscillator section) (Fig 4), |
| (2) T1 Pod (Fig 3), | (6) Xtal Frequency Control Unit (Not on plain J models) (Fig 3) |
| (3) IF transformers (Fig 3), | (7) Underchassis (fig 4) |
| (4) Band switch turret coils (Fig 4) | |

A. First Steps: This should be the removal of the Xtal Frequency Control Unit (FCU) (this assumes you have an SP-600 with the XFCU) as this makes access to the RF deck and especially the T1 pod is much simpler. Refer to figure 3. Removal of the right side panel makes access to T-1 much easier.

1. Remove the Xtal selection knob and shaft by loosening the various couplers attached to the shaft between the front panel and the FCU and slide it out through the front panel.
2. Loosen the coupler on the Delta Freq control shaft and slid it towards the FCU so the coupler is completely on the long shaft from the FCU.

3. Remove the bracket from the bottom of the FCU that goes to the long spacer near the power transformer. One end is held by a nut at the power transformer. The other end of the bracket is slotted and just slides into a groove on one of the supports for the FCU, so there is nothing to loosen on that end.
4. Unsolder the cap that comes from the FCU to the switch on the front panel.
5. Flip the radio over; locate where the wire harness from the FCU passes through the chassis. Unsolder the wires from their respective terminals. Make notes and keep track of where they attached -- they are color-coded.
6. Remove the four screws that secure the Power Supply filter assembly to its set of spacers and carefully lower the filter assembly, there is no need to unsolder anything here, just support it carefully.
7. With the filter out of the way you can get to the four screws that secure the spacers for the FCU, remove these screws while supporting the FCU so it doesn't fall.
8. Reposition the PS filter assembly and put back in a couple screws to temporarily hold it in place.
9. Flip the radio back over and carefully lift the FCU out, be careful of the long shaft so it doesn't bend and damage the Delta Freq capacitor when removing the FCU.
10. Remove the twelve screws from the FCU cover and open it up. There are two BBODs that need replacing in here. Reassemble the FCU and set it aside, don't reinstall yet!

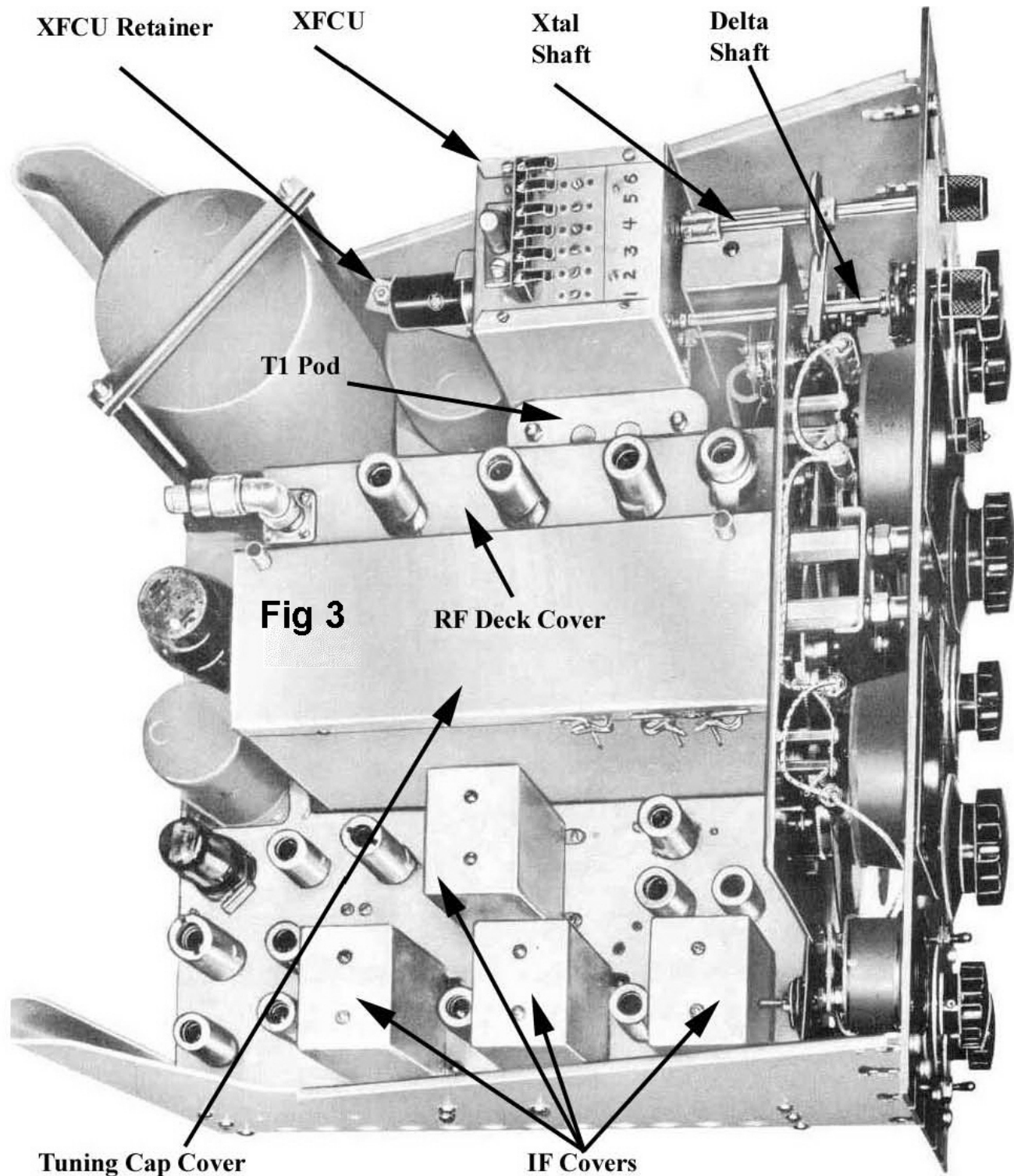


11.

FCU

B. RF deck - refer to figure 3

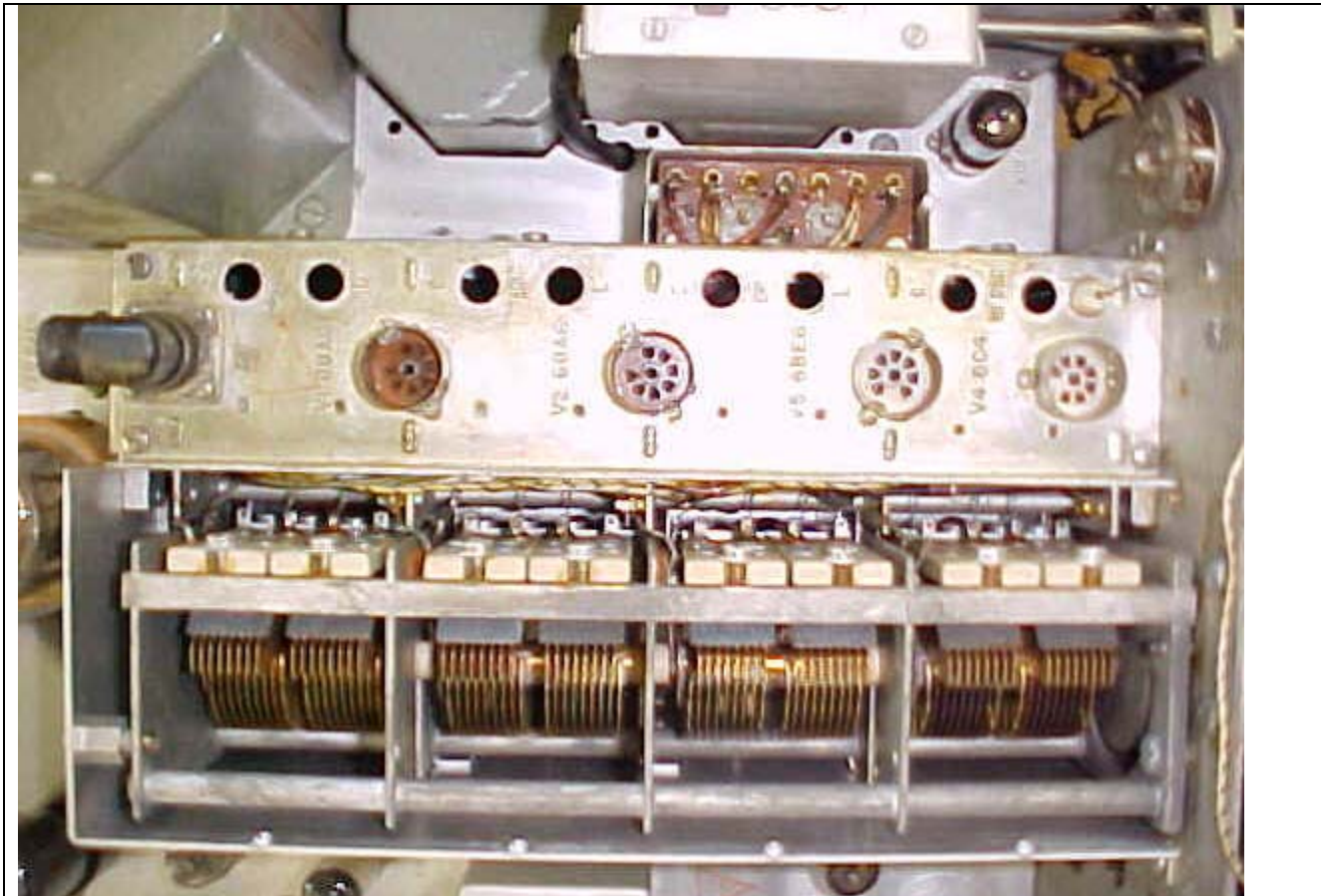
1. First remove the cover over the tuning caps (9 screws), then remove the screws (8) from the RF deck itself.
2. Remove the cover from the T1 pod (two nuts)
3. Unsolder the wires from the RF deck to the T1 pod (6 wires); keep track of them by the color code.
4. Unsolder the wires from the RF deck to each tuning capacitor (total of 12 wires, three for each tuner cap section)
5. Unsolder the ground straps from each tuner cap to the RF deck (4 straps)



1. Remove the cover over the bandswitch turret assembly underneath the chassis.
2. **IMPORTANT!!!** Before removing the RF deck, do one of the following:

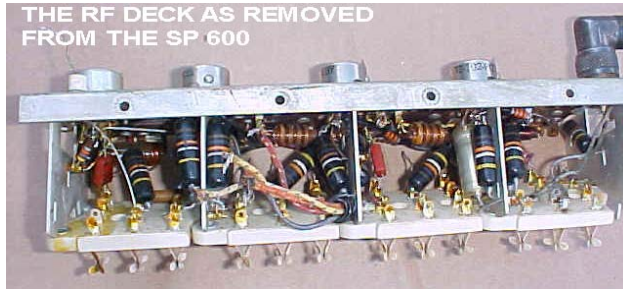
Option A. Position the band switch 1/2 way between bands so no band switch coils are engaged in the fingers of the RF deck. I found this a little hard to gauge.

Option B. Completely remove a set of coils for one band, then turn the band switch to this position. Since you'll have to take a set of coils out anyway to replace some BBODs, I chose this option, removing the entire set of coils for the .54 to 1.35 band, then turning the band switch to select this band. When removing a coil, be careful you don't put stress on the ceramic and crack it. The retainer clips come out pretty easily, and will go back about as easy as long as you're careful. Use of a curved hemostat or rt. angle small needle-nose pliers to grab them is helpful.



Top view of receiver with the RF deck cover removed

1. Once the band switch is positioned so no coils are engaging the RF deck fingers, you can carefully remove the RF deck by pulling upwards. BE CAREFUL as it's a tight fit and you don't want to damage the ceramic plates for the fingers at each end of the RF deck.
2. After the RF deck is out, you can replace the BBODs. They are obvious. There were a total of 22 on my RF deck, all .01mfd. It would be advisable to check all resistors in the RF deck, leaky BBOD's will cause many of them to overheat and increase in value. Now's the time to replace any that are more than about 10% from nominal value.
3. When all the BBODs are replaced, double check your work, you don't want to have to remove that deck again to repair a cold solder joint or short!
4. Set the RF deck aside for the moment.



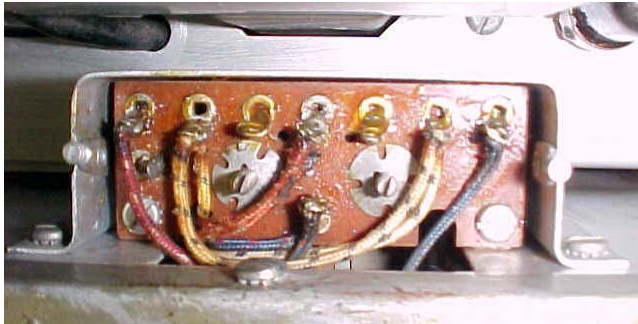
RF Deck before



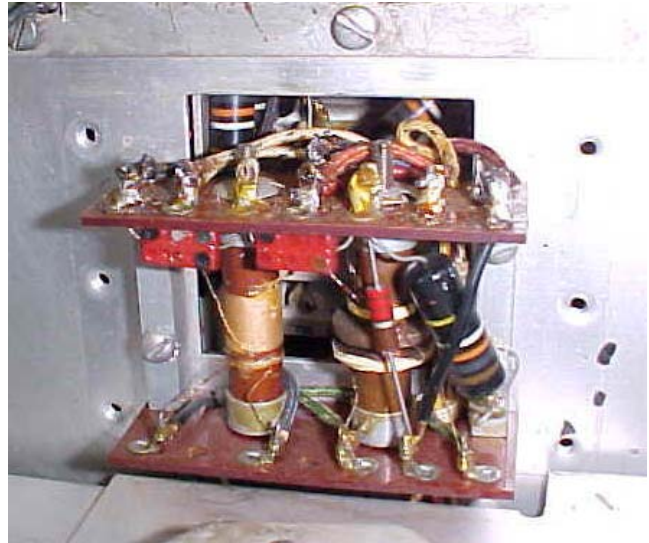
RF Deck after

C. T1 Pod - Refer to figure 3.

1. The top cover should already be off. Complete the disassembly by removing the side cover (6 screws). This is why we left the FCU out, these screws are pretty difficult to get to with the FCU installed.
2. There is only one BBOD to replace in the T1 pod.
3. Reassemble the T1 pod side cover.



T1 pod top view. There is one model that has seven wires and isn't compatible with any other models.



T1 pod – cover removed

D. RF deck, FCU and side panel re-installation - Refer to figure 3.

4. Carefully re-install the RF deck. Watch the ceramic plates. Resolder each of the 12 wires to the tuning caps, resolder the tuning cap ground straps and resolder the wires to the T1 pod.
5. Once the RF deck and T1 pod cover is reinstalled and secure, re-install the FCU using the reverse procedure of the removal instructions. Be careful not to damage the protruding shafts. Replace the side panel if it was removed.

E. Checkpoint

When everything is back together, you may want to make a test to see how it's working. This is assuming you had already done a resistance and power check originally and were satisfied as to its previous operating condition. This test will at least see if there has been any improvement or if something has now gone completely dead. Make sure you aren't testing on the band that you removed the turret coils from. You don't need to re-insert the coils for the band you removed just yet.

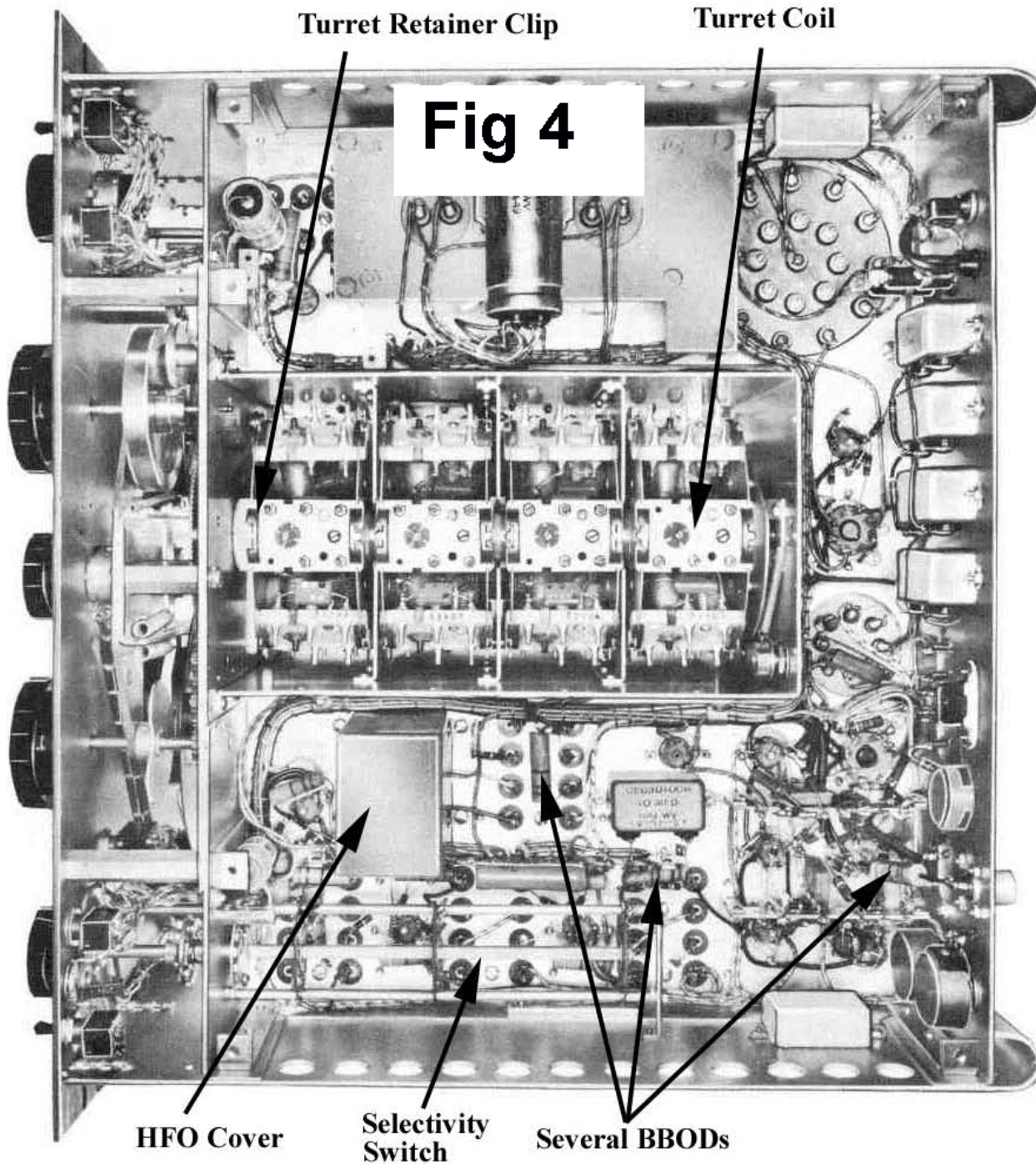


figure 4

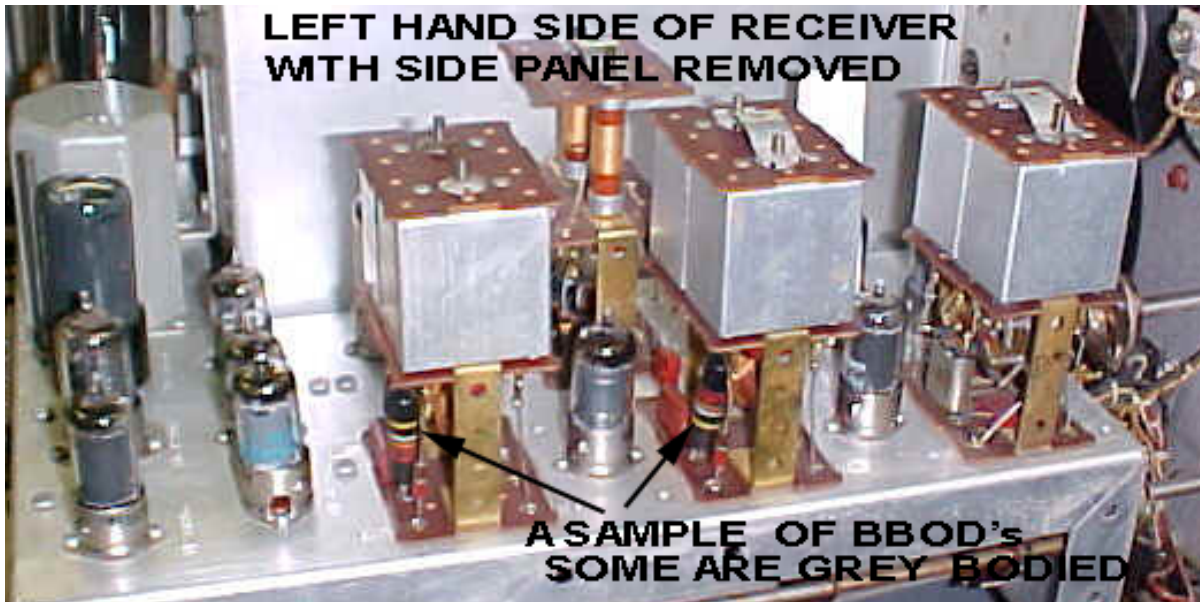
F. Turret Coils - Refer to figure 4.

As long as you have one set out (if you chose to use this method) you may as well replace the BBODs on these now. They are easy to see as you rotate the band switch so you only need to remove the coils that contain the BBODs, there are 6 coils, three at the .54-1.35 band switch position and 3 at the 1.35-3.45 band switch position. The coils for the other bands, at least in my radio, did not use BBODs.

After replacing the BBODs and reinstalling the coils you may want to run another test to see what progress is being made.

G. IF Transformers - Refer to figure 3, and below. Again, removal of the left side panel makes access to the IF cans and under the selectivity switch much easier.

1. These are easy to do as the covers come off quite nicely and once off, with the tubes out, it's easy to get to the caps. It's not necessary to remove the cover for the Crystal (T3) IF unit as it turns out, on my radio at least, the BBODs were on the terminals on the bottom of the chassis, not in the IF can itself.
2. Again, after replacing the caps you can run another test to see that at least nothing has degraded.
3. Once satisfied, recover the IF transformer assemblies. Make sure the ground straps are still on top of the adjustment posts.



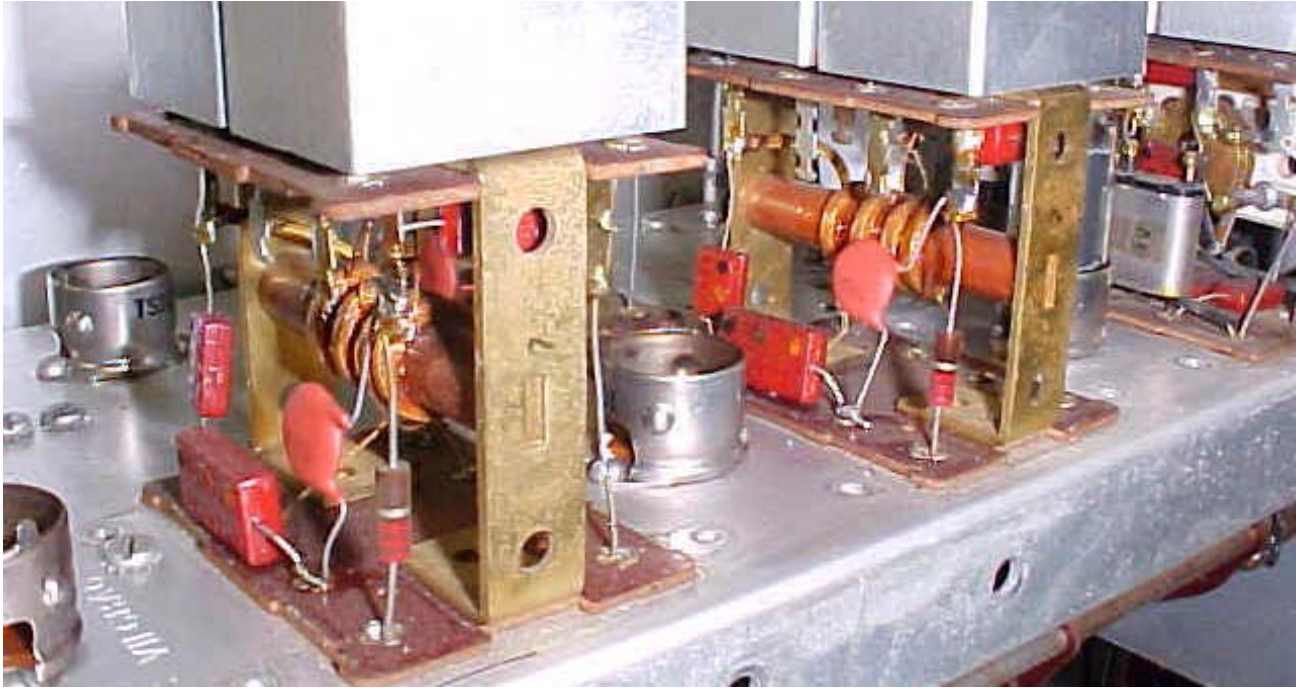
H. T9 HFO assembly. Refer to figure 4.

1. This is under a metal shield next to the selectivity switch assembly. You'll need to remove the four screws and lift the shield off, be careful of the phenolic locator board inside the shield, it's used to keep the circuit board upright so it doesn't vibrate and short out against the shield. Make sure it's installed correctly during reassembly.
2. Replace the BBODs (one of these was in a pretty awkward place, probably one of the hardest to replace).
3. Test the radio, then set the phenolic board and reassemble the cover.

I. Underchassis - Refer to figure 4.

This is the final step and relatively straight forward as it's easy to spot all the BBODs.

The ones under the selectivity switch were the most difficult to replace, however I found the following to be quite helpful. Unfasten the selectivity switch from the front panel and the rear bracket of the switch from the chassis. This allows the switch to be moved around somewhat based on the flexibility of the wires attached to the switch. This provided me with enough room to get under the switch and swap out the BBODs. Just be careful not to flex the switch assembly too much and break a wire, or worse, a switch wafer. That much stress shouldn't be needed as you only need a few tenths of an inch more clearance to get to the BBODs. You may find it easier if the side panel is removed.



IF Transformers after re-capping

Well, that's the summary. I'm sure I left out some little, but obvious steps, the idea is just to show how the job could be broken down into manageable steps. Once I had completed the ground work of tracing out the schematic and identifying the locations on the figures I spent two evenings performing this operation. One evening to do the FCU/RF deck and T1 pod, and the second evening doing the remainder. In conjunction with this I was having several conversations with chaps on 29.0mc AM as the band has been open evenings quite a bit. So figure two pleasant evenings for this, you could probably do it in one evening if you didn't spend time trying to ham it up as well! As for the results: After the recapping was complete, I fired up the receiver and, without doing any form of alignment or having the need to perform any troubleshooting other than the one original bad resistance check, the radio went from virtually very weak audio and picking up only distorted AM signals from a couple local AM broadcast stations to a completely functioning and beautiful sounding radio. It's amazing what just replacing those caps does. The dial accuracy is fantastic, I dialed up both 10.0mc and 15.0mc and WWV was right there.

Eventually I did perform an alignment but it made very little improvement over what was accomplished by the simple task of performing this recap. Believe me, the two evenings spent replacing everything was far, far better time spent than trying to troubleshoot problems one by one in an attempt to avoid replacing a cap or two that might not need it.

Hope someone finds this useful and if anyone has any additional suggestion, tips or corrections, hop in!

I recommend that you have a copy of an SP-600 manual when attempting these changes.

I made good use of the wealth of material available from the BAMA ftp site <ftp://bama.sbc.edu/> and the R-390/SP-600 CD-Rom from Jeff Adams jadams@mcqassociates.com. Both contain very good photographs of the chassis with parts clearly labeled which you'll find useful in identifying the location of the various components mentioned in the following cross reference.

BBOD Replacement Capacitor Cross-Reference list for the SP-600

C = used as Coupling cap, B = used as Bypass cap .01 mfd caps

Symbol	Location	Symbol	Location
B C3	T10	B C105	V7 pin 6
B C5	T11	B C66	V5 pin 2
B C19	V1 pin 1 cold end R1	B C68	V5 pin 6
B C20	V1 pin 6	B C70	T1
B C21	V1 pin 6 junction of R3/R4	B C71	V4 pin 1 cold end R29
B C22	V1 pin 5 cold end L7	B C72	V4 pin 1 cold end R30
B C23	V1 pin 6 cold end R4	B C73	V5 pin 6 cold end R28
C C24	V1 pin 5	C C74	V4 pin 1
B C27	T16	B C115	V9 pin 1 cold end R43
B C29	T17	B C116	V9 pin 6
B C40	V2 pin 1 cold end R13	B C121	V10 pin 1 cold end R51
B C41	V2 pin 1 cold end R12	B C122	V10 pin 6
B C42	V2 pin 6	B C127	V11 pin 1 cold end R56
B C43	V2 pin 5 cold end R15	B C135	V12 pin 6
C C44	V2 pin 5	B C153	L48 (power supply area)
B C47	T22	B C154	L49 (power supply area)
B C49	T23	B C155	L49 (power supply area)
B C61	V3 pin 8 hot end R25	B C165	V1 pin 5 cold end R6
B C64	V3 pin 5	B C166	V2 pin 6 cold end R14

.022 mfd caps (can use .01mfd as well)

Symbol	Location	Symbol	Location
B C98	T2	B C123	T5
B C102	Off single conv. Switch*	B C136	V13 pin 5 cold end R76
B C103	T9 (HFO can)	B C146	V16 pin 6
B C104	T9 (HFO can)	B C148	V16 pin 1 cold end R81
B C106	V6 pin 6	B C156	L50 (power supply area)
B C108	T3 (underneath chassis)	B C157	L50 (power supply area)
B C109	T3 (underneath chassis)	B C162	V14 pin 5
B C118	T4	B C167	Between V18 pin 1 and T1

*** Absolutely Critical. See following notes.**

Editors Note: These part numbers are valid for this model (mostly). One needs to verify each individual radio as Hammarlund made numerous chassis, schematic and parts modifications even within a specific J or JX designation. Please see Andy Moores's article on chassis identification.

TM 11-831 can be invaluable in these situations as it has both pictures as well as schematic changes noted.

Fig-5.jpg I deleted this picture of the SP 600 with parts callouts as it was specific to Ray's receiver. Having a copy to TM11-851 should provide the bottom view specific to the model you are re-capping. Editor

Some General Notes From Other Experienced SP 600 Rebuilders

The model or "suffix" number has nothing to do with it may or may not have black tubular capacitors. The serial number is the key indicator. Any SP-600 with a serial number of 175XX or higher came from Hammarlund with ceramic disc capacitors. All SP-600's were built with consecutive serial numbers independent of model/suffix number.

Reference note from Les Locklear: Parts were subbed during production runs. Don't trust nameplate for what parts are actually inside. Also the avc chain mica caps are usually bad at this point due to age, etc. replace any caps and resistors in that avc chain, as they are usually suspect.

This from Andy Moorer who has restored many, many SP-600s is to shotgun replace the screen and plate de-coupling resistors in the first two IF stages as those tend to drift and to be under-specified for power. [Also RF amp stages] I think they're all spec'ed at 1/2 watt (Some manuals show 1/3 watt), but the modern 1-watters are mostly physically smaller, so fit in there nicely.

When I bought my SP-600, the plate de-coupling resistor on the second RF amp was burned through, so no B+ on the second RF amp, thus really dead reception. I had to pull the RF deck for that reason and while there, of course, I replaced all the BBODs with, in my case, OD's. **I replaced the burned out resistor and others out of spec, but wish now that I had shotgunned all the other resistors in the first two RF stages. (Use 1 W metal films).**

I have restored several JX-26 units- some of them had ceramics but most of them have the dread BBOD's.

I agree - do not even power it up until you replace at least C102. If that one shorts, it takes one or both of the big chokes with it (L51, L52). (Begg the question: why no B + fuse?)

AGC Characteristics

Well, some of them have slightly different schematics, the best of the bunch imho is the JX-14 and it's successors. It had the better avc characteristics of all of the various SP-600's. Les Locklear

Editors Note: Please read Andy Morrer's differing opinion about the JX 17 model.

Also check Chuck Ripple's audio improvement source if you are planning a major part replacement program.

About replacing the paper caps in an SP-600:

I've used .022 uF/600V Sprague type 715 Orange Drops, and I've used 02 uF/1000V ceramics. The ceramics work better (the IF leakage into the RF at 910 and 1365 Kc is definitely better with the ceramics, particularly if you keep the leads as short as possible). Hammarlund specified ceramics for many of these caps in 1955, then apparently went on building radios for years with all paper caps. They must have had a big inventory of the paper caps they needed to use up. . . .

Note: these are all bypass caps on the DC supplies -- none are audio coupling caps, where ceramic would be a poor choice. There are only two audio coupling caps -- C143 & C149, both 5100 pF mica. You can change them to .005 or .01 uF Orange Drops if you want, and will realize some improvement in the audio.

One thing to make sure of is that you get EVERY SINGLE paper cap out of the radio. Some are hiding in the RF box, some in the IF cans, some in the turret assembly, and some beneath wiring and switches under the chassis. There are about 51 in all.

You don't need to worry about the values (some of the original caps are .01, some are .022, and it varies from radio to radio). Use all .02 or .022 and you'll be fine.

Best regards, Don

Products From Andy Moorer

I am offering some CD-ROMs for sale, mostly as a convenience for my public. If you are having trouble downloading these manuals, I will make you a CD-ROM of the ones you want. All CD-ROMs are \$20 each. I don't have a web mall, so just email me with your mailing address. I take PayPal, money order, cashier's check, personal check, wampum, stamps, old radios or radio parts, or anything interesting and/or nifty that you think I'll go for. Also, I understand that some folks don't have any good way to print out these PDF files. As a service, I will sell you a printed copy of any manual or paper on this web site for \$15 (with a few exceptions - TM11-851 is \$45, for instance).

SP-600 CD-ROM. This includes all the PDF files on this web site that pertain to the Hammarlund Super-Pro SP-600.

R-390 CD-ROM. All the PDF files pertaining to the R-390 family of receivers.

PRINTED MANUALS. All the BC-348 manuals, the R-5007 manual, all the SP-600 manuals (except TM11-851), I will sell you a printed copy, comb-bound, for \$15 each, postage in US included. The schematics are as 11x17 fold-outs.

PRINTED TM11-851. Sorry - I have to charge \$45 for this one due to the size and the difficulty of printing the schematics.

Editors Note: Having produced tutorials by desk top publishing, these manuals are a bargain. I was fortunate to get an original TM11-851 when I bought a couple of SP 600's. I wouldn't copy it for anyone at twice the price and I've never seen one come up for auction on ebay.

Hammarlund SP-600 Receiver Modifications

From The Hammarlund Historian

This section is provided thru the graciousness of Bruce Stock, AB7YD, and is used here with his permission.

The following modifications were produced in order to improve what the author feels are several shortcomings in the SP-600 receiver. My goal was to minimize the impact of the changes to the SP-600 to the point where they could be easily reversible if some future custodian of the receiver wanted to do so.

The areas where I feel the SP-600 needs help are the following:

1. The RF signal level meter is very non-linear and is not calibrated with S-units. It is useful only as a tuning indicator.
2. The AGC employs a large amount of delay, which is partially responsible for the non-linearity of the S-meter.
3. SSB detection with the existing circuitry is very poor, and the existing AGC is not suited for SSB reception.

In making the following modifications, I removed as little as possible from the SP-600 and left all original wiring in place. New wiring was done with a single color of easily recognizable modern wire for ease of identification by any future restorer.

These modifications are for an SP-600 JX1, so there may be minor circuit differences if you are working with a later model receiver. Since this will not be a “cookbook” set of instructions, you will have to know enough about your particular model to make your own decisions about the best way to incorporate each particular change.

I. The AGC modifications. It is best to start with the AGC modifications, because both the S-meter and product detector changes depend on them. There are three problem areas I wanted to address with the AGC changes. First, the bias applied to pin 5 of V14, the AGC detector, causes the receiver to remain at maximum sensitivity until quite strong signals are received. At that point the developed AGC voltage finally overcomes the bias and is fed back to reduce the gain of the appropriate stages. In my receiver, dropping the value of R66 in the AGC delay divider below a value of 4.7k caused some distortion to AM broadcast stations. So I settled on changing R66 to 4.7k, which reduces the amount of delayed AGC significantly.

A second problem with the AGC is that the existing filtering is insufficient to remove some of the variations due to audio modulation on the incoming carrier. This is easily corrected by adding a .002 ufd capacitor in parallel with C140. Note that instead of replacing C140 with a .003, I have left the original in place to make restoration easier.

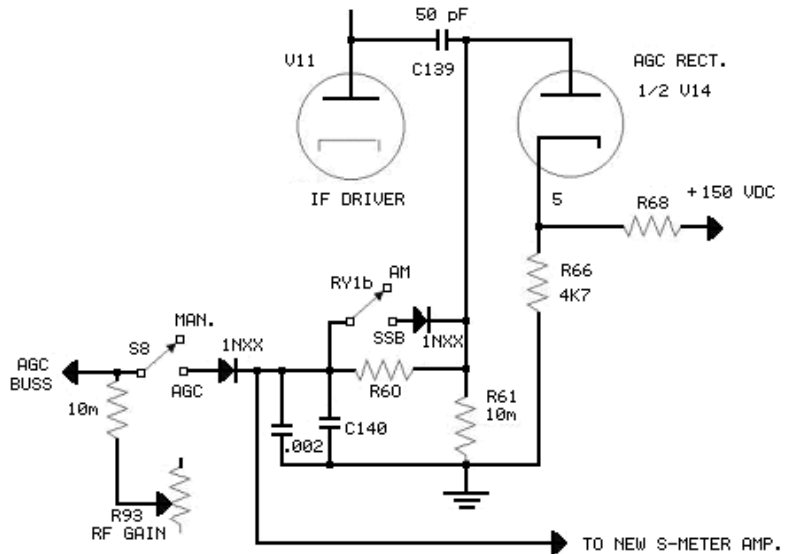
Finally, some further reconfiguration of the AGC circuit is required to smooth a few further kinks in the AGC action. The final circuit is shown below. Wherever component parts list numbers are used, the original part is unchanged. Wherever part values are given, it is for a newly added part. If both are given, it means an existing part has been changed in value.

The 10 megohm resistors were added to provide for a slow discharge time constant which will be more effective on SSB reception.

The 1nxx diode on the left ensures that when the RF gain control is reduced, thereby pulling the AGC line strongly negative, the new S-meter will not be pulled upscale. Instead, it will fall toward zero as the output of the AGC detector drops

Note that R97 (3.3meg) is removed and S8, the AGC/Manual switch, has been rewired. The other half of S8 going to the old RF/AF meter switch is no longer used, so the wires can be disconnected and taped.

Also, note that C139 is changed in value from 7 to 50 pf.



This provides a stronger drive for the fast-attack AGC mod that will be added with the product detector. The right most 1nxx diode and relay contacts are not to be added until the product detector is installed. They are shown here only for clarity as to where in the circuit they are installed.

All the semiconductor diodes added for this project are garden-variety types, so I have used the 1nxx designator. Use whatever you have.

II. The S-meter. The only hard part of the S-meter modification is making a new meter scale for the existing meter. I'll describe the steps I took, and let you decide how best to proceed depending on your circumstances. First I removed the S-Meter dial face from my HQ-170 receiver and used a flatbed scanner to scan into my computer. There I cleaned up the image and prepared it to be printed out. I used my printer's scaling options to get the printed dial scale to approximate size. At this point I removed the dial scale from the SP-600 meter and superimposed the two, with a strong light behind to see how close to the needed size I was.

If you look at the original scale, you will see that the existing RF level meter swings through an arc of only about 60 degrees. There is plenty of leeway in the existing meter mechanism to accommodate about 80 degrees of swing, and I printed out the final version of my new scale to take advantage of this.

Since the meter scale is illuminated from the rear, a transparent plastic blank, identical in size to the original meter face was constructed. I used clear plastic from the lid of a small plastic box, then overlaid the original meter face and scribed the outline and screw holes. I used a router bit at low speed on a Dremel tool to remove most of the excess plastic, and finally used a file to bring the dimensions down to the size of the original scale. The paper scale was finally glued to this new transparent blank, yielding a nice looking, and translucent dial face. You may want to make several test alignments of the scale, the blank, and the meter movement to be sure you have it right before you finally glue the paper in place.

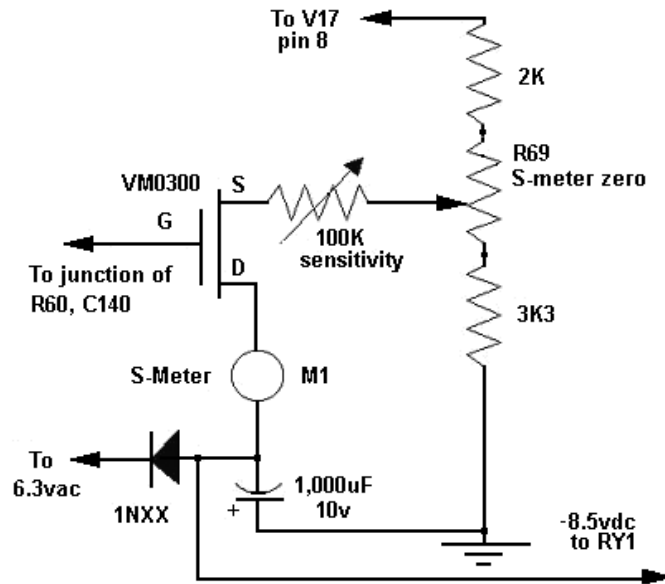
The original meter mechanical zero was uncoupled in order to be able to set the needle as far to the left as possible without physically contacting the meter pole piece. Finally, the original needle bumper strips were repositioned to allow the new wider needle swing, and the meter was reassembled and remounted on the front panel. All the leads to the original meter were removed and taped.

Note that when you remove the original wires from the upper end of the S-meter zero pot (R69), you must ground them. This is necessary to provide the correct DC return path for the audio detector.

The new S-meter amplifier circuit was built up on a small board that was conveniently mounted on the bracket that holds the rear of the selectivity switch. The circuit for the new S-meter amplifier is shown below.

The circuit uses a VM0300 P-channel, enhancement-mode, FET. The transistor is available from Active Electronics, Inc, and no doubt other parts suppliers as well. There is nothing unique about this part, and it is likely that any similar P-channel enhancement mode FET will work as well. The original S-meter zero pot is used to bias the FET to the point where it is just turning on with no signal input to the receiver.

The cathode bias of the audio output tube is used to generate the needed positive voltage supply.¹



¹Ed Note: Since the cathode bias V17 exists only when the tube is inserted and properly operating, one might want to generate the positive voltage from a rectified filament supply to prevent circuit damage if the audio output tube is removed or becomes defective during operation.

A negative 8.5 volt supply for the drain is obtained by half-wave rectifying the receiver filament voltage. This supply is also used to power the relay I used to switch the new product detector into the audio amplifier.

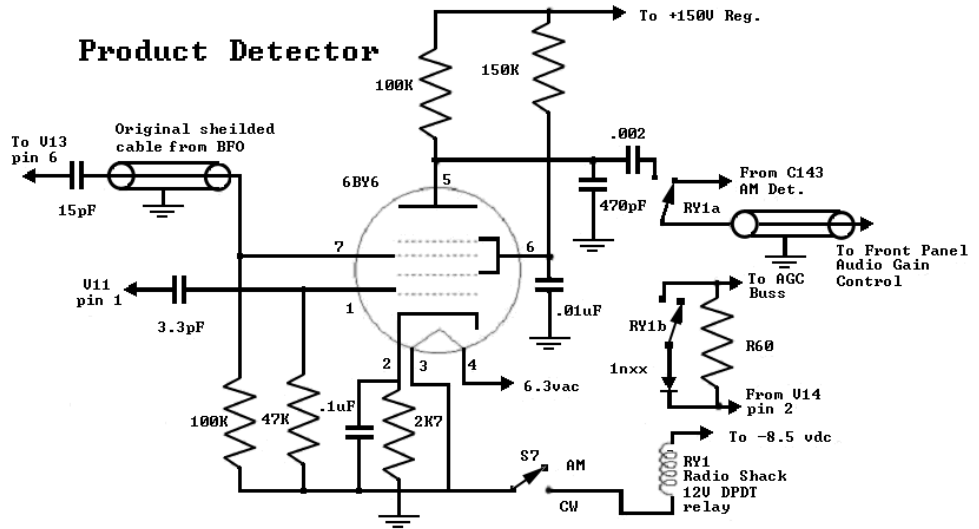
The meter zero pot is adjusted so that the meter needle just rises off the low end of the scale. The sensitivity pot is adjusted so that the strongest received signals will just cause the meter to peg on the right hand side.

III. The Product Detector. The product detector uses the circuit from the SX-101A receiver. I've installed it in several other receivers, with very good results in all cases. Since V12, the BFO buffer, will not be required, it is not necessary to drill any new holes for the product detector tube.

Begin by clearing the unneeded components from the V12 socket. In my receiver, several parts which feed both V12 and V11 were terminated on V12. They must be moved over to V11 first, so that it will continue to operate properly. The BFO injection pot is no longer needed.

To switch from AM to SSB, the audio amplifier input must be switched from the output of the AM detector to the output of the product detector. You can do this by running shielded leads to the front panel Mod/CW switch, S7, but I chose to use a Radio Shack 12vdc DPDT relay instead. The relay is mounted near the AM and product detector location, so long shielded leads are not necessary. S7 now energizes the relay, which switches the audio amplifier over to the product detector output. It also completes the circuit for a diode I placed across R60, to give a faster attack AGC characteristic on SSB (refer back to the AGC schematic for a better view of the diode location). The product detector circuit is shown below.

Originally, S7 also had a second set of contacts used to switch in C137, a .22 ufd. capacitor, to slow the AGC time constant for CW/SSB reception. I preferred the flexibility of having the AGC time constant independently selectable from the AM/SSB mode.



Sometimes I want long AGC time constants on AM when there is rapid fading or controlled-carrier modulation. For this reason, I removed the original RF/AF meter switch and replaced it with a SPST switch that connects a .1-uf disc ceramic capacitor to ground from the AGC buss. This gives an adequately long time constant for SSB or fast fading AM conditions. The new switch becomes the FAST/SLOW AGC selection.

When the new product detector is connected to the V13 BFO, it will change the center frequency of the BFO somewhat. Be sure to readjust the BFO center frequency, by adjusting L44, to coincide with the center of the receiver pass band.

You will select upper or lower sideband by setting the front panel BFO frequency knob to between 1 and 1.5 khz above or below, respectively.

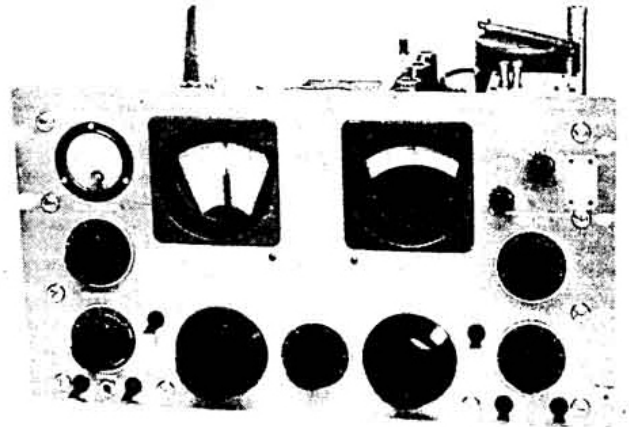
Updating the SP-600

BY Douglas A. Blakeslee, W1KLLK

Adapted from a QST article of Aug. 1970 by Perry A. Sandeen June 2009

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) has been released in quantity by the military services to MARS and surplus outlets.



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.

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 R274 is an attractive buy as a general coverage receiver. It is a single-dial type covering 0.54 to 54 MHz in 6 bauds, providing a close-to ideal tuning rate for vhf (with converters, of course)! 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 audio to loudspeaker volume. Obviously, changes are necessary in the levels and audio gains of the receiver's "rear end" stage.

A product detector was added in place of the original 6AL5 diode detector, V14. Needing a high-transconductance triode for this circuit we chose the 6EJ4 as 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.

With a general-coverage receiver it is desirable to be able to copy a-m, so a diode detector was included. To keep the impute level in the same range as the product detector, this stage was also fed from the grid of V11. Reed relay K₁, 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 age for ssb and cw operation. The age system in the SP-600 was not designed for 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-uF capacitor is switched in when the BFO is turned on. It charges and discharges so slowly that. the manual gain control has a trine lag that is most annoying when operating.

The age circuit was rebuilt completely. The 6AL5 that was removed to make room for the product detector also had served as the age rectifier, so a silicon diode was used in its place. A front-panel switch was added to select a fast or slow age discharge time constant. The series resistors were removed from the age line to improve the attack time. With the components shown in Fig. 1, age action will start at about 1μVolt. The rf gain circuit was modified so that manual gain could be used either with age or alone. The original switch S₈₁ continues to select manual or automatic gain control. With four 6BA6 stages being controlled, age action very smooth.

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 a solid state rectifier will raise the B- plus voltage, which is not desirable. The lead from capacitor C161A is removed from the input slide of choke L51 and connected to the input of choke L52. Effectively, this changed 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.

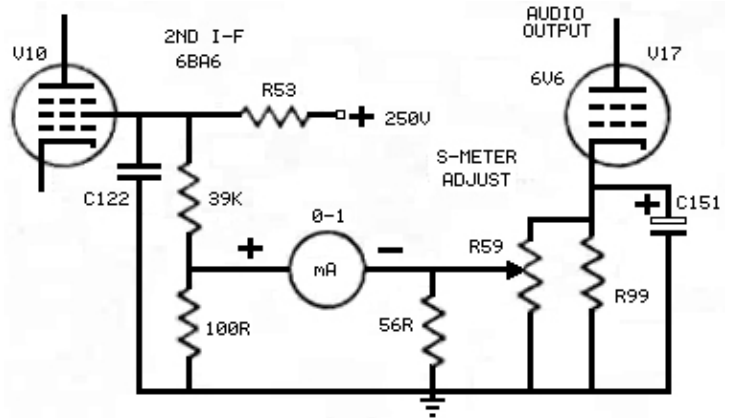
Making the Modifications.

~~The~~ Some 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 aide of any prospective purchase 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 5-1ug terminal strips should be added under one of the mounting screws of the phono-input strip for the extra audio stage, one end of C129 for the age circuit, and on one end of the new tube socket at V14 for the product detector. The old age filter components, when removed from V16, 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 he 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, S 11, 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 uF 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 in the rf amplifier/mixer sub-assembly, which is a four job to take out and replace. This deck is impossible to troubleshoot, also, as you can't get to the bottom side while it is "hot." With the last capacitor failure, the author replaced all 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 a 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.

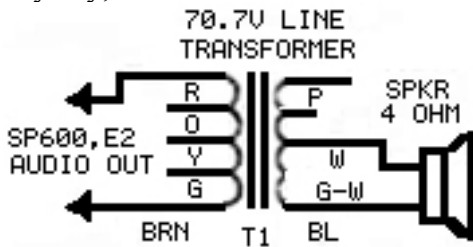
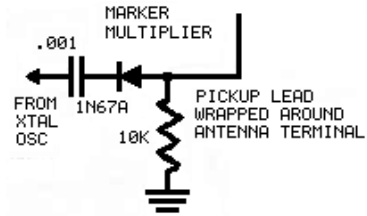
For those unlucky enough to have to remove the rf deck, a little explanation is in order, as the instruction book isn't any help. The best procedure is first to take all the screws out of the rf deck itself and the tuning capacitor cover. Remove the cover and the top of the mixer coil housing, which is on the side of the tuning unit sub-chassis. Unsolder all seven power leads (**all other models have 6 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 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 and gently slip the rf deck back in place, and rotate the band switch to a band setting. Then, re-solder 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 r.f. 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 mounting screws, loosen the shaft coupling *and* 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.

Oscillator

Two objections to the SP-600 are its lack of calibration accuracy and its rate of tuning in 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 subassemblies BUT, if you have to get to the BFO can, you have to take the xtal oscillator out anyway,



PRIMARY		SECONDARY	
Color	Watts	Color	Tap
Red	8	Purple	16Ω
Orange	4	White	8Ω
Yellow	2	Grn/Wh	4Ω
Green	1		
Brown	Common	Black	Common

Quick and Dirty SP-600 Audio Modifications

by Chuck Rippel, WA4HHG

Changes:

From	To
C141 Ceramic 100pf. \pm 10% 500 vdcw	100 pF, polystyrene
C142 Ceramic 100pf. \pm 10% 500 vdcw	100 pF, polystyrene
C143 5100pf	0.01 uF, polystyrene
C148 BBOD Paper, 22,000pf. \pm 20% 400 vdcw	0.01 uF, polyester
C149 5100pf	10 uF, electrolytic.
C151 Electrolytic, 10uf. 100 vdcw	20-30 uF, electrolytic

Add: a .01 uF, 630 V mylar capacitor off the bottom of the primary of the output transformer to ground.

Change to metal film types:	R81 100K ohm \pm 10%, ½ W
R62 100K ohm \pm 10%, ½ W	R82 10K ohm \pm 5%, ½ W
R63 27K ohm \pm 10%, ½ W	R83 1K ohm \pm 10%, ½ W
R64 47K ohm \pm 10%, ½ W	R98 470K ohm \pm 10%, ½ W
R65 22K ohm \pm 5%, ½ W	R99 360 ohm \pm 5%, 1 W

Problem Parts

I agree - do not even power it up until you replace at least **C102**. If that one shorts, it takes one or both of the big chokes with it (L51, L52). (Begg the question: why no B + fuse?)

455 KHz IF buffer output check

After receiving a number of requests, herewith the information to determine whether an SP-600 needs its 455 kHz IF output buffer amplifier modified, and if so, how to do it.

First, I may not have made it entirely clear in my previous post what the problem is -- on units that have the problem, it isn't in the IF itself, it is in the buffer stage that drives the 455 kHz output jack on the rear panel. The harmonics of the 455 kHz IF signal that are generated in the overloaded buffer amp are then received by the radio as spurious signals.

There were (at least) three IF output schemes used by Hammarlund. The older ones give very high output (10V or more p-p) with lots of harmonics (clipping on the negative swing), and the newest one gives a very clean 1 or 2V p-p.

In the oldest version the buffer amplifier -- a cathode follower (V16a) -- is fed straight (through C145) from the tied plates of the IF Driver (V11) and BFO Buffer (V12).

The newest version uses an additional connection inside T5 to feed the follower (through C145 and some shielded cable) from the top of the secondary. This has two advantages -- it reduces the feed level by the gain of the IF Driver (V11), and it picks off the IF output feed before the BFO injection. The newest version also uses a tapped coil (L53) as an autotransformer on the output (the cathode of V16a feeds the top of L53 through C147, and the IF output jack connects to a tap a ways down on L53).

The middle version has the old-style feed plus L53. I believe this is the most common configuration.

If one has an old-style or middle-style unit I highly recommend changing it, because the distortion in the follower due to the high signal level radiates harmonics of 455 and causes spurious signals.

To change it, one can go into T5 and add the connection for C145. In this case (assuming one already has L53, or adds it) you end up with exactly what Hammarlund built later. Or, you can take the feed without going into T5 by putting C145 on the junction of R55/R56 (the output of T5). I prefer the second method, because it comes out at a bit lower level and does not unbalance the load on the secondary of T5. In either case you need to feed the signal from T5/V11 through shielded cable, grounded at both ends, to the grid of the follower (V16a). C145 goes at the T5/V11 end of the coax to minimize the capacitive loading on T5 (the capacitance of the shielded cable ends up in series with C145). You don't need to try to chase down an appropriate coil to use for L53 -- the follower can just drive the IF output directly. If you want, you can use a resistive voltage divider in place of L53 to lower the signal level some more.

Alternatively, if you don't use the 455 kHz output, you can reduce spurious responses even a bit further by disconnecting C145 from the tied plates of V11 and V12 and connecting it to ground instead.

Best regards, Don

Nuvista plug in for 1st RF amplifier

ENGINEERING TECHNICAL BULLETIN No. 107 Field Handbook No. 90-2807-1 STOCK NUMBER: 5960-HOO-9058 March 1965

Improving the Noise level of the SP-600 Receiver using a Nuvistaplug

Introduction:

The Nuvistaplug, a new device made by Raytronics J has been found to significantly improve the noise figure of the SP.600 when substituted for the first RF amplifier. The purpose of this Technical Bulletin is to explain the advantages of the Nuvistaplug and describe the substitution procedure.

Technical Discussion:

Noise figure (the ratio of noise generated in a practical receiver compared to the noise generated in an "ideal" receiver and expressed (in db) is an important consideration in determining the effectiveness of a receiver. It is generally true that the noise figure of a receiver is established in the first RF stage. This is because the signal and noise present at the first stage are amplified to such a level that the noise contributed by, succeeding stages amounts to very little.

It is therefore desirable to keep the first stage as free from internally generated noise as possible. Pentode tubes have long been used instead of triode tubes as first RF amplifiers (in most receivers) because of their more desirable amplification characteristics. However, the pentode, because of its physical construction, is more noisy than the triode.

By combining the miniature, low noise, high amplification triodes (RCA Nuvistor Type 6DS4) in a cascade arrangement, the Nuvistaplug is able to take advantage of the triode's low noise while retaining, essentially, the desirable amplification characteristics of the pentode it replaces (See Schematic, Figure 1). No circuit changes are necessary when the Nuvistaplug is used, and only slight compensating adjustments are needed in most cases.

Tests show that the noise figure of the SP- 600 can be improved 2 to 6 db or more at most frequencies. It should be pointed out that improving the noise figure by 3 db is equivalent to doubling the signal strength at the transmitting antenna, all other conditions remaining. equal. The Nuvistaplug cannot, of course, improve conditions resulting from noise external to the receiver.

Substitution Procedure:

The procedure for substitution of the Nuvistaplug in the SP-600 is as follows:

1. Connect a resistor (approximately 600n) across the audio output of the SP-60D receiver and connect an audio voltmeter across the resistor.
2. Connect a variable amplitude CW source to the SP- 600 antenna connector. The source frequency should be in the middle of the MOST frequently used range of frequencies -- in other words, if the receiver is used most of the time between 5 and 25 Mc., set the signal generator at about 15 Mc.
3. Replace the VI tube 6BA6 in the first RF amplifier stage with the Nuvistaplug Model 675 (6DS4).
4. Set the MOD-CW switch to CW and the AVC-MANUAL switch to MANUAL; set the RF gain for best sensitivity. Tune the receiver until the CW source is heard.
5. Adjust the CW signal generator amplitude so that the audio tone output is in the noise level of the internally generated white noise of the receiver. The audio gain should be high enough for easy listening, but the tone should be audible, (the noise will be much stronger).

6. Adjust the trimmers for the antenna and the first RF stage while listening to the tone output (See Figure 2). Each time an improvement is made, decrease the amplitude of the CW generator output so that the audio tone is barely heard under the internally generated white noise of the receiver. In most cases the two trimmer capacitors marked "C" need to be readjusted, but the two trimmer inductors marked "LU" do not need readjustment.

7. The substitution and realignment are now complete. The manufacturers of the Nuvistaplug point out that two effects may be immediately noticeable after installation of the Nuvistaplug. One is the lowering of the background noise normally heard through the speaker, and the other is a reduced S-meter reading. Both are due to the fact that the Nuvistaplug frequently has a lower amplification factor than the tube it replaces. However, the important fact remains that the noise is reduced in relation to the signal.

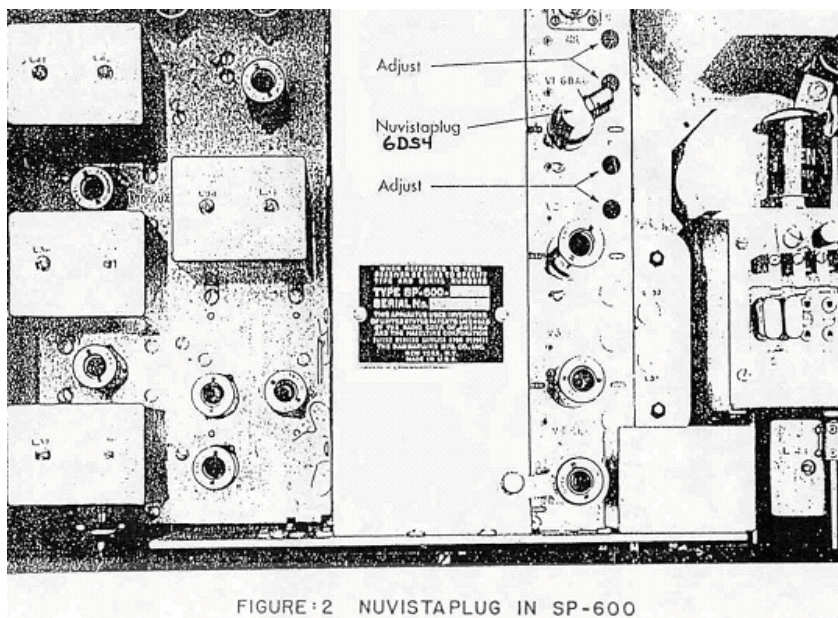
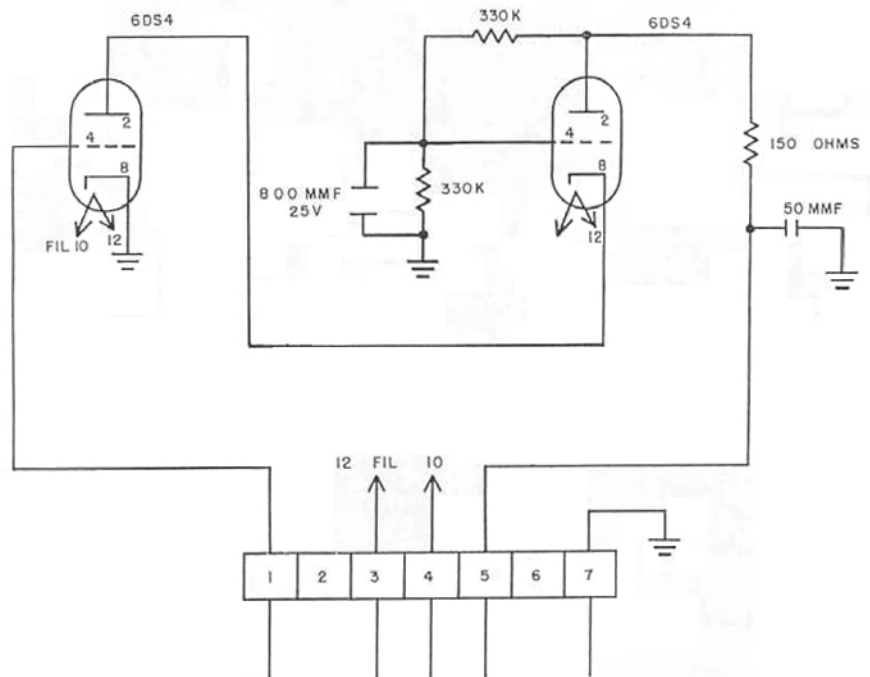


FIGURE 2 NUVISTAPLUG IN SP-600

Increasing The Lifetime Of V18 (0A2)

Intrigued by the worn-out appearance of V18 in my SP-600-JX I decided to exploit the design margins of this 1950 vintage beauty.

Warning! Do not simply assume the following as suitable without adaptation for your beloved SP-600. Please do your own measurements, calculations and draw your conclusions. Tolerances of component values, esp. 0A2 voltage ratings can be considerable!

Varying various controls (Rf Gain, CW/MOD, Send/Rec) show that the regulated section draws 13.6-14.8mA at 147.3-150.5V. The B+ voltage varied from 230V to 256V, and the current through R85 (2.56k Ohm measured) 32.3-41.2mA accordingly. This results in a current draw for the 0A2 of 18.7-26.4mA which seems unnecessarily high for today's standards of mains supply (urban areas at least).

Assuming a minimum B+ voltage of 215V due to low mains voltage, minimum current for 0A2 of 5mA (according to datasheet), and maximum (to stay on the safe side) regulated voltage of 150V, the maximum value for R85 would be

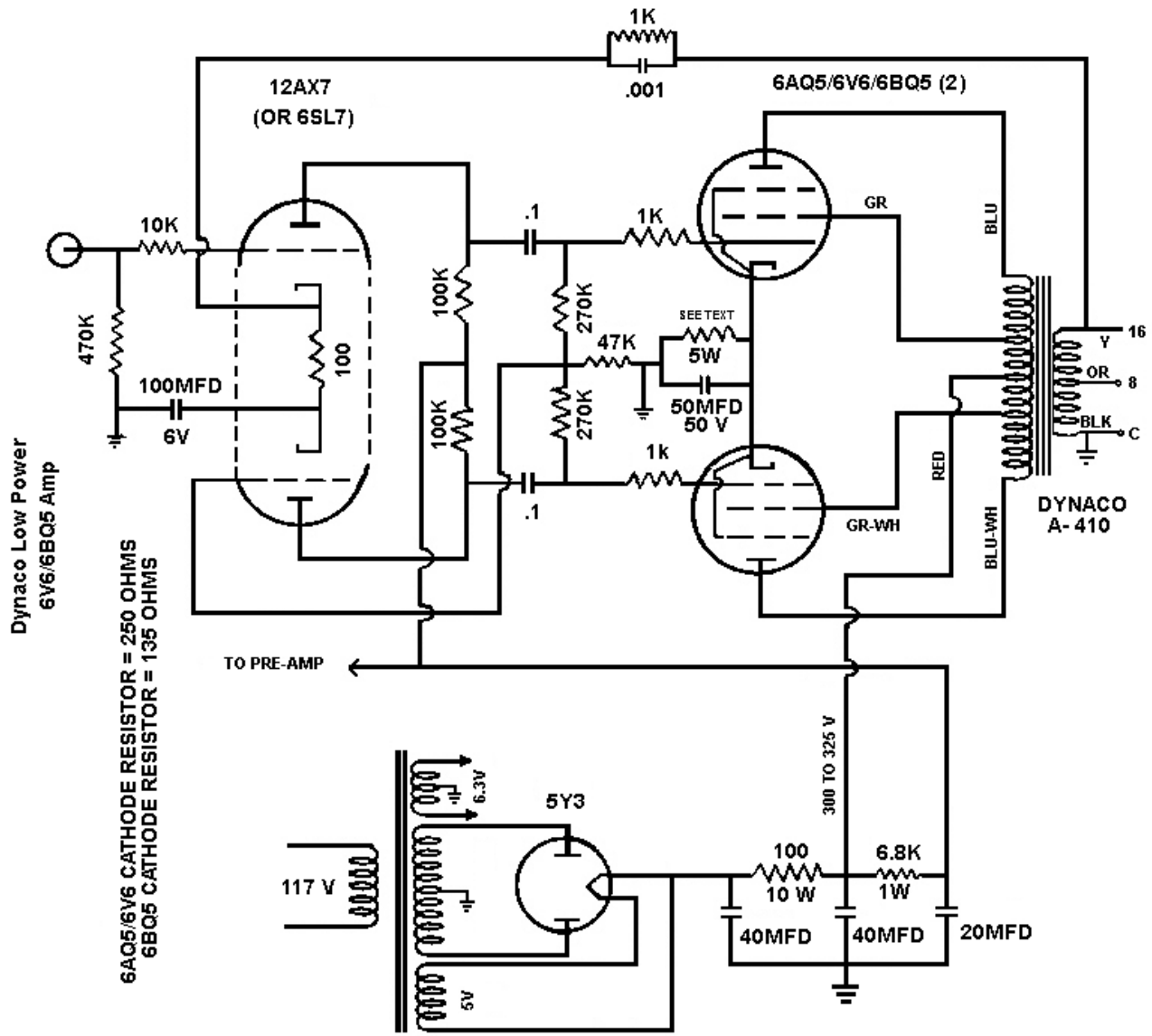
$$(215-150)V / (15+5)mA = 3.25k\Omega.$$

Adding a 2W/470 Ohm carbon resistor in series to R85 reduces the current through V18 up to 4.5mA. This may not seem much, but will reduce the dissipated power by approx. 17%. Considering the exponential behavior in speed with increasing temperature of many physical processes (Arrhenius' Hypothesis), a doubled lifetime is quite probable...

As an unexpected plus I found an improvement in voltage regulation: 146.6-149.4V soon after power on, and further decreasing to 146.6-148.6V two hours later. Enjoy!

Gottfried Ira ira@atnet.at

A Simple, Inexpensive High Quality Audio Output Replacement For the SP 600



A simple improved audio output circuit. The Hammond output transformer is available at Antique Radio Supply, Triode Electronics as well as others.

On Using The 6EH7

Technical Editor, *QST*

I have just read K3CFA's "Improving Your Receiver with a Frame-Grid R.F. Pentode" (February 1966 *QST*). I tried the EF184/ for that purpose when it appeared in Europe several years ago, but since then have found the EF183/6EH7 a better choice due to its remote cutoff and its lesser "nervousness."

The use of an unbypassed cathode resistor is advantageous as regards the variations in input capacitance and resistance where wide bands are concerned, but is far from improving the stability.

Comparative trials have proved to me that the best stability is obtained with the two cathode leads duly bypassed. The diagram is shown in Fig. 1.

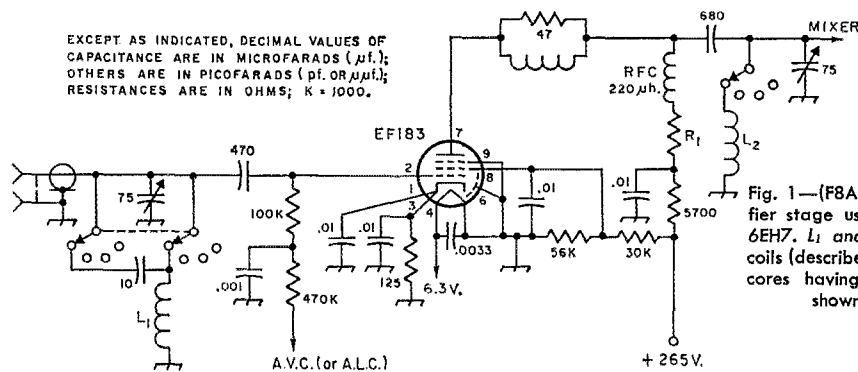


Fig. 1—(F8AJ) The r.f. amplifier stage using the EF183/6EH7. L_1 and L_2 are toroidal coils (described in letter) using cores having the dimensions shown in Fig. 2.

July 1966

49

Careful shielding of the following mixer tube has an important effect on the stability of the r.f. amplifier. A good way to control stability is the use of a swamping resistor, R_1 in series with the anode 220 μ h. choke (the idea was borrowed from the Collins KWM-2 designs). A resistor as high as 1K ohms may be required at the beginning to stop oscillation. In proportion as the stability is increased by shielding and bypassing, R_1 may be reduced in value,

Of course, u. high-transconductance tube deserves high-Q coils. If you have succeeded in putting an EF183/6EH7 in your old receiver without instability, don't have too much pride in your ability until you have a look at the coils.

I am using toroidal coils wound on powdered-iron cores; several cores from the local surplus shop were tried, and best results were obtained with small cores of unknown origin having the dimensions shown in Fig. 2.

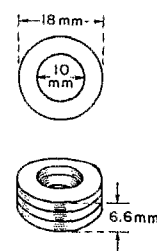


Fig. 2—(F8AJ) Core dimensions. Permeability of the iron measured about 10 as judged by increase in coil inductance compared with air core.

With 49 turns of No. 23 enameled d.e.c. (one layer) the measured inductance is 19.1 μ h. The theoretical inductance of the same coil without iron should be about 1.9 μ h which indicates a permeability of about 10

Antenna coupling, though apparently unorthodox, proved very convenient with 50-75.ohm lines, The value of the coupling capacitor has to be adjusted and switched with each band. The value in Fig. 1 is for :3.5 Mc.

Aymon Claudet, F8.AJ7 Allie de bois 95 Orley France.

Cross-Modulation In Receiver R.F. Pentodes

Technical Editor. *QST*. June 1966.

A number of correspondents have questioned the author about the cross-modulation characteristics of the 6EH7 frame-grid r.f. amplifier which was mentioned in his February 1966 *QST* article.

Cross-modulation occurs when a strong adjacent-channel signal modulates the desired, but relatively weak, signal in the operating channel. This modulation process occurs when the signal amplitudes exceed the linear operating capability of the r.f. amplifier. The remote-out off tube was developed to operate as a linear amplifier with large signal amplitudes. This tube type utilizes a grid structure which will maintain linear control of the plate current when a large grid bias is used (cathode bias plus a.g.c.). The design of the a.g.c. detector circuit is very important for receivers which are to have a minimum of cross-modulation.

The ability of a r.f. amplifier to handle large signal amplitudes without producing cross modulation is synonymous with its ability to have useful transconductance when the grid bias is great enough to handle the large signal amplitude. The term useful transconductance implies that the tube is still functioning as an amplifier - it is not cut off. A cross-modulation figure of merit for r.f. amplifiers could simply be the product of the minimum transconductance and the corresponding large bias voltage as given in the tube data sheets. If a comparison is to be made among tubes which have different values of maximum transconductance, it will be necessary to specify a standard value for the minimum transconductance. If a small standard value, such as 10 micromhos, is used for the transconductance the best figure of merit is obtained with the tube which has the largest grid bias at that transconductance. The control-grid bias necessary to maintain this minimum g_m may be determined from the operating curves in the data sheets. It might be necessary to extrapolate the curves for any particular tube to determine the standard minimum g_m value. It will also be necessary to specify the circuit configuration for the screen grid, since the voltage on the screen grid competes with the bias on the control grid to maintain the g_m .

The best screen-grid circuit for low cross-modulation performance consists of a series dropping resistor between the screen grid of the r.f. amplifier and the full B+ voltage which is available in the receiver.

Several remote-cutoff pentodes have good reputations for low cross-modulation. The 6SK7 and the 6BA6 are good examples. The 6SK7 data sheets show that this tube will have a g_m of 10 micromhos with a grid bias of - 50 volts and a screen-grid voltage which is derived from a 39K series resistor tied into the plate supply of +250 volts.

The 6BA6 data sheets show that this tube will have a g_m of 10 micromhos with a grid bias of - 55 volts and a 33K screen-grid series resistor. The 6EH7 data sheets show a g_m of 10 micromhos with a grid bias of - 27 volts and a 22K screen-grid dropping resistor. **For the 6EH7 in the author's earlier article, the series screen-grid resistor should be 39K ohms when the B+ is 250 volts. There should not be a resistor from screen grid to ground as shown in the article.**

Several other factors must be kept in mind when considering the cross-modulation characteristics of r.f. amplifiers: The cathode bypass capacitor must be a bypass of r.f. frequencies but not audio frequencies. The selectivity ahead of the control grid of the r.f. amplifier must be as high as possible; two or three tuned circuits would be a great help. The a.g.c. detector circuit must respond fast enough to work with s.s.b. and c.w. as well as provide sufficient bias to protect the r.f. amplifier from adjacent-channel cross-modulation.

The selectivity ahead of the control grid usually is determined by only one tuned circuit. The Hammarlund PRO-310 general-coverage receiver used two tuned circuits ahead of the r.f. grid with excellent results. Those receivers which have two r.f. amplifiers, such as the NG-183D and the SP600 line, would benefit by cascading the first two tuned circuits and using only one r.f. amplifier.

The fast-attack, slow-release, delayed a.g.c. detector shown in Fig. 1 is recommended for c.w. and s.s.b. as well as a.m. signals. It responds to adjacent-channel signals by virtue of being tied into the primary of the last i.f. amplifier. It provides a constant load on the i.f. transformer since the delay voltage operates on the a.g.c. bus and not on the a.g.c. detector diode.

The small coupling capacitor should be increased until the strongest local a.m. signal is not distorted. If this capacitor is advanced too far, the audio volume level will be reduced.

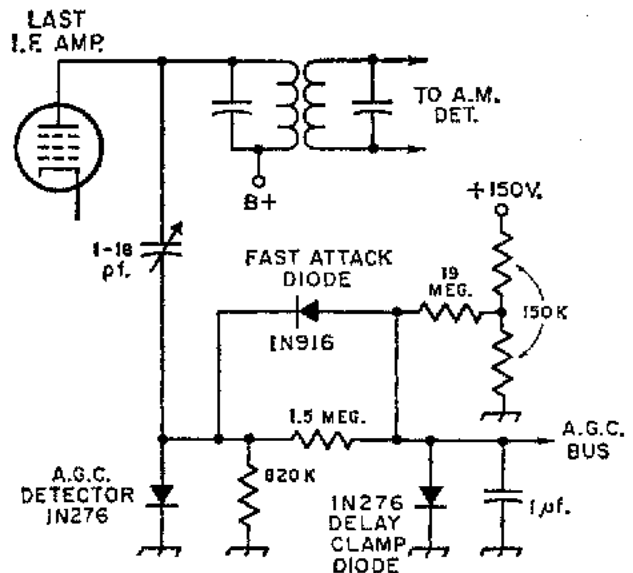


Fig. 1

It should be noted that the remote-cutoff r.f. pentode that has best cross-modulation characteristics does not have the best low-noise, high-sensitivity figure of merit. However, the author finds the 6EH7 to be very adequate on cross-modulation when used with the a.g.c. detector in Fig. 1 and a series screen-grid resistor. The 6EH7 is superior for high sensitivity and low noise, as discussed in the earlier article.

Joel Balough, K3CFA, P.O. Box 327, Lemont PN 16851.

June 1966

Improving Your Receiver With Frame-Grid R.F. Pentodes

BY JOEL BALOGH W3CFA *QST* February 1966

The many requests for information on the use of the EF 183/6EH7 variable-mu frame-grid pentode mentioned by the author as an r.f. amplifier in an earlier *QST* article¹ have forced the following conclusion: there still exists that breed of radio amateur who would rather rebuild his present equipment than trade it in on a new model to obtain the best possible performance. This article is dedicated to that breed.

A knowledgeable reader of this article may correctly point out that atmospheric and manmade noise levels, will normally exceed the low noise levels in the author's receivers. But that is how it should be. A quick method of checking receiver performance is to disconnect the antenna and note what happens to the audio-output noise level. It should drop when the r.f. gain is wide open and the receiver is set at its upper frequency limit. It should also be possible to peak up the antenna noise with the antenna trimmer control. If these two checks are marginal, then pull out the r.f. amplifier tube to cause a drop in noise. If the noise still doesn't drop you know that the mixer or converter stage is contributing more noise than the r.f. amplifier or the atmospheric and man-made noise, levels coming in from the antenna. Improving the receiver is now up to you.

Many articles, on receiver improvements have appeared in the amateur magazines and sections in the ARRL *Handbook* on this subject, so no attempt will be made to give credit to all reference material used in this article.

Some credit is due the old HQ-120X receiver which has served as a guinea pig during the past decade of rebuilding and experimentation. This particular receiver (a Navy version of the HQ-120X went through the Second World War and was salvaged from a junk heap around 1951. The first attempts to improve it, were started when W1NXY² discussed some changes in the postwar HQ-120 receiver.

This consisted of changing the mixer stage to obtain lower noise operation. Revisions in the r.f. stage were already underway when W5UZ³ discussed this and other areas of the same receiver. Not all of the work through the years on the guinea pig resulted in improvements -- the cathode-coupled triodes and cascaded triodes were tried out as r.f. amplifiers were rejected for reasons discussed later on.

A 6BZ6 pentode was used for several years as a r.f. stage, but it was unstable above 20 Mc. The present 6EH7 has been used as an amplifier in the guinea pig since early 1962, and it will continue in that role until a better tube is invented. This article not only discusses how to use the 6EH7 to obtain better performance, but it also discusses the principles used by the author to evaluate new tubes as they are introduced on the market.

The following list presents most of the factors which should be kept in mind when planning receiver front-end improvements:

- 1) R.f. stages which were originally designed to operate with remote-cutoff pentodes should be rebuilt with better remote-cutoff pentodes and not sharp-cutoff pentodes or any triodes.
- 2) The transconductance of the new pentode should be higher than that of the old pentode.
- 3) The cathode current of the new tube should not exceed 20 milli-amperes,

- 4) The grid-to-plate capacitance of the new pentode should be equal to, or less than, that of the old pentode.
- 5) The sum of the pentode's shotnoise and partition noise should be as small as possible.
- 6) The dynamic plate resistance of the new pentode should not be less than .5 megohm.
- 7) The cost and availability of the new tube must be such that the average receiver can readily be modified.
- 8) The heater voltage, must match that of the old tube.

The factors given above are not all independent, so a compromise must usually be reached when considering an assortment of tubes. Various methods of weighing the importance of these factors are discussed in the following sections of this article.

Pentode versus Triode

A number of articles have appeared on the subject of receiver improvement using triodes to replace pentodes, but it is this author's experience and opinion that the resulting loss in r.f. gain and selectivity do not justify the reduction in tube noise. The loss in gain and r.f. selectivity is a result of the low dynamic plate resistance of the triode which swamps the Q of the resonate r.f. plate circuit. These plate circuits were originally designed to yield the desired Q when operated with the high plate resistance of pentodes. The dynamic plate resistance is parallel with the plate circuit when considering the equivalent circuit of the tube, plus the plate circuit. For this reason a plate resistance which is below .5 megohm is not desirable.

High. Transconductance

If there had to be just one criterion for evaluating receiver pentodes, it would be for higher transconductance. This primary characteristic determines the obtainable gain as well as the shot noise and partition noise. But in any practical application, higher gain can be utilized only if the stage is stable, and this is primarily a function of the tube's grid-to-plate capacitance. Thus, higher transconductance can be handled only if the C_{gp} is about equal to that of the old tube. Also, in practical applications, higher gain presupposes the end result of detecting weaker r.f. signals, but the minimum detectable signal is determined by the combined atmosphere, man-made and tube noise present at the front end of the receiver. We cannot do anything in the receiver to change the atmospheric and man-made noise levels. The tube noise of a pentode is usually considered to be the sum of the shot noise and the partition noise. The shot noise is reduced by higher values of transconductance. The partition noise is reduced by a combination of higher transconductance and a smaller ratio of screen current to cathode current. Some sharp-cutoff pentodes are on the market (the 7788 is one example) which yield low shot and partition noise by having both high transconductance and a low ratio of screen-to-cathode currents.

But such tubes, even if a remote-cutoff version were available, would not be usable for improving a communications receiver because the total cathode current (45 ma. for the 7788) might cause heating in the Litz wire of the coils in the receiver. For this reason, an upper limit on the total cathode current was set at 20 ma. The price of the 7788 would also be a disadvantage for this particular tube.

Evaluating New Tubes

The data on the new tubes which are introduced on the market, seldom include specific mention of shot and partition noise, so recourse must be taken to compute this information from the data which are furnished. Shot and partition noise is usually spoken of in terms of the equivalent resistors which would give rise to the observed noise voltages. This analogy arises from the observable noise voltage which is present across the terminals of any resistor due to the random motion of the electrons which are present in the resistance material. This has the classical name of Johnson Noise. The equations which are in use for computing the values of these equivalent resistors are usually approximations instead of precise equations. This makes the computation easier. But it also result in a variety of approximation equations. The author here prefers to use two different approximations, one from the *MIT* reference⁴ and the other from the *Radiotron* reference⁵. The results of both equations are then used to establish a ball-park figure for the equivalent noise resistance of the tube in question. The equations appear below:

$$(MIT) R_{eq} = R_{SHOT} + R_{PARTITION} = \frac{2.5}{gm} + \frac{20I_{sg}}{gm I_K} \text{ ohms}$$

$$(Radiotron) R_{eq} = \frac{I_p}{I_K} \left(\frac{2.5}{gm} + \dots \right) \text{ ohms}$$

where gm = transconductance in mhos
 I_K = cathode current in all peres
 I_p = plate current in amperes
 I_{sg} = screen grid current in amperes

A selection of both sharp and remote-cutoff pentodes is listed in Table 1 to show the results of the two equations. Keep in mind that a high gain (high- Transconductance) pentode is desired which has the lowest possible equivalent noise resistance. The other columns in Table 1 are discussed elsewhere. The information on the sharp-cutoff tubes is provided as reference material for use when selecting a low-noise mixer stage. The reader can observe that the 6EH7 has the lowest computed equivalent noise resistance of the remote-cutoff pentodes listed in Table 1.

Ratio of Transconductance -to- C_{cg}

As mentioned previously, a high-transconductance pentode will have merit as a r.f. amplifier only if the grid-to-plate capacitance is low enough to give stable operation. The 6EH7 does not have the lowest C_{cgs} , as shown in Table 1, but it does have the highest gm . The obvious way to get a relative comparison between r.f. pentodes, is to look at their ratios of gm/C_{gp} . This is tabulated in one of the columns of Table 1. Again, the 6EH7 shows up as the best tube when the criterion is for the highest gm -to- C_{gp} ratio.

Ratio of gm/C_{gp} -to- R_{eq}

For the case where a new tube may not have the lowest R_{eq} . but does show the highest gm/C_{gp} ratio (or vice versa), a relative comparison based on the ratio of gm/C_{gp} -to- R_{eq} . would be helpful. This latter ratio is tabulated in the last column of Table 1. The lowest value of the two approximated R_{eq} 's was used for computing this ratio. Again, the 6EH7 is the best available tube for use as a gain-controlled r.f. amplifier when the criterion is for the highest gm/C_{gp} -to- R_{eq} ratio.

Selecting a Mixer Tube

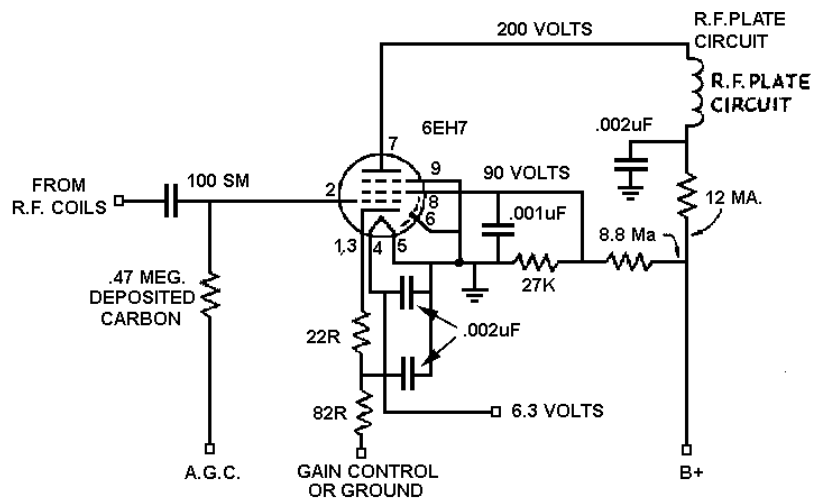
With a few exceptions, most of the comments on selecting an d. tube apply to the task of selecting a mixer tube. Since the plate and grid circuits are not tuned to the same frequency, feedback by way of C_{gp} should not produce instability. Some mixers are desired which have a broad-band response (such as in converters), so a lower value of dynamic plate resistance can be tolerated. This lower value cannot be tolerated, though, if the mixer is in a communications type receiver where high Q i.f. transformers follow the mixer stage. The 6EJ7 sharp-cutoff pentode (Table 1) is a good candidate for mixer service. The author uses four of them in this role, in four different receiving systems. The 6EJ7s have also been put to use as Lf. amplifier's in an f.m. tuner and a pre-i.f. noise-silencer.

A R.F. Amplifier Circuit

The 6EH7 has been used as a r.f. amplifier by the author in the HQ-120X receiver as well as an Eddystone 888A ham-band receiver and an RME DB-20 pre-selector.

The circuit shown in Fig. 1 represents an r.f. amplifier which can be adapted for use in any receiver covering all, or parts, of the 0.55-Mc. to 30-Mc. range.

The unspecified plate and screen-dropping resistors must be selected on the basis of the available supply voltages and the required plate and screen circuit currents.



For the 6EH7 in the author's earlier article, the series screen-grid resistor should be 39K ohms when the B+ is 250 volts. There should *not* be a resistor from screen grid to ground as shown in the article. (QST June '66)

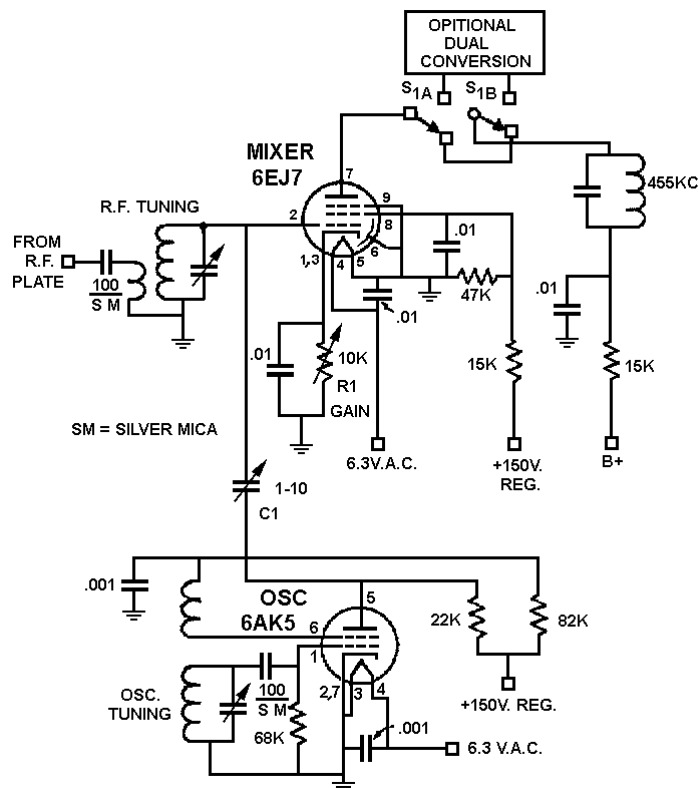
Please note the specified values of cathode and screen bypass capacitors. These values were selected to form series-resonant circuits where the inductance is in the form of the capacitor leads. Do not use larger values of bypass capacitors unless the amplifier is for use only on lower frequencies. A 0.01mfd bypass can be used at 7 Mc. and lower, while a 0.1 mfd bypass can be used at 2-Mc. and lower. The unbypassed 22-ohm cathode resistor is used to compensate for variations in input capacitance and resistance which otherwise would occur when cathode or grid voltages are changed. Pin 6 is used to ground the tube's internal shield. An external shield is also recommended. The heat-dissipating style such as IERC's TR.-6-6020B will assure longer tube life. Something not shown in Fig. 1, but which is always used by the author, is a shield partition which straddles the tube socket. A piece of 1/32-inch sheet brass, which is about 3 inches square, is installed to pass between Pins 1 and 9 and between Pins 5 and 6. Pins 5, 6, and 9, the center post of the socket, and the grounded ends of the bypass capacitors, are then soldered to this brass plate.

Of course, the r.f. circuits will have to be realigned after the new tube is installed.

A Mixer Circuit Using the 6EJ7 Pentode

The mixer circuit which was used in the HQ-120X appears in Fig. 2. A separate local oscillator using a 6AK5 was installed on a sub-chassis underneath the main chassis. The 9-pin socket for the 6EJ7 was mounted on an adaptor plate which replaced the old 8-pin socket. The variable cathode resistor and the trimmer capacitor between the oscillator plate and the mixer grid are adjusted so that the mixer has high gain while remaining stable over the entire frequency range. Too much oscillator injection or too little mixer bias will produce "birdies." A triode local oscillator should *not* be used if pulling of the oscillator frequency is to be avoided on the higher frequency bands.

This is the mixer circuit John Leary used in his SP 600's for the 2nd mixer with the exception of making C₁ a fixed value of 10pf. (He didn't use the 6AK5 circuit.)



Note: On some receivers John used a variable pot that could be adjusted from the front panel. It is unclear whether an adjustable pot was located by the mixer tube and adjusted for optimal performance as stated in this article.

Dual Conversion for the HQ-120X Receiver

The image rejection of this receiver was not very good when operating above 10 Mc. because of its relatively low i.f. of 455 kc. A subchassis was installed under the main chassis of the HQ-120X which provided dual-conversion capabilities above 10 Mc. A three pole, double throw wafer switch was mounted behind the front panel with its shaft coming out just to the left of the sensitivity control and below the send-receive switch.

The schematic of this dual-conversion unit is shown in Fig. 3. It uses a 6U8A triode-pentode, with the triode serving as a crystal-controlled oscillator and the pentode as the mixer. The frequency of this crystal can be between 1855 kc. and 2055 kc. The 1965-kc. unit was obtained from one of the surplus crystal companies. The cathode resistor of the pentode might have to be adjusted a little to obtain stable mixer operation. Of course, the first local-oscillator circuits had to be realigned when the dual-conversion feature was incorporated in the receiver. The fixed-padder capacitors which were in series with the oscillator coils, for the two bands above 10 Mc., were replaced with Arco 307, 350-1180 pf., variable padder capacitors. A signal generator which provided marker signals every 1 Mc., as well as a variable-frequency signal, was useful for the realignment work.

Changing the HQ-120X over to dual conversion entailed a lot of work, but the elimination of the image problem was well worth it. The elimination of the images was especially rewarding when using this receiver as a tunable i.f. in the 14-Mc. to 18-Mc. range, which is the output frequency of the 2-meter converter used by the author.

The noise present at the image frequency tended to degrade the performance of the converter by approximately 3 db. when the 455-kc. i.f. was used at 14 Mc.

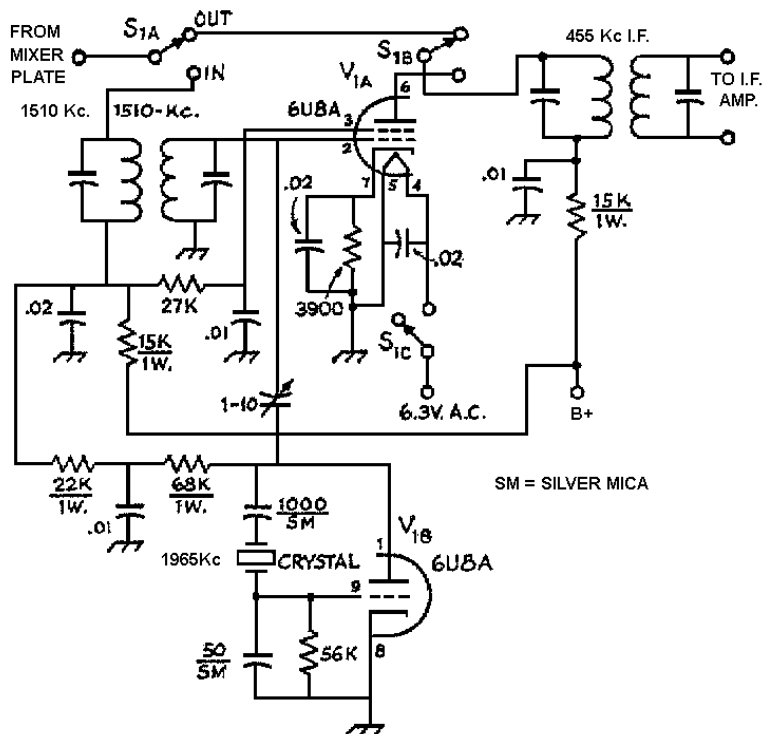


fig. 3- (Right) Circuit diagram of the dual-conversion unit for the HQ-120X receiver.

Actual Results

Some reasonable questions come up every time the subject of receiver improvements is discussed. How can I check my present receiver's performance? What improvements can be obtained with these frame-grid tubes? The first question was answered in the introduction to this article.

The noise figure which can be expected with the 6EHF at 30 Mc. is approximately 5 db. The improved HQ-120X was able to copy a c.w. 0.03-microvolt signal from a 50-ohm calibrated signal generator at 30 Mc. *before* the dual conversion was installed, This 0.03 microvolt level was where the c.w. signal dropped into the noise.

The narrow-band crystal filter was in use during the c.w. test. An a.m. signal, modulated 40 percent with 400 c.p.s., dropped into the noise at .06 microvolts without a crystal filter. The S-meter circuit in the receiver was rebuilt and calibrated for use at 15 Mc. with the 2-meter converter.

Table II shows the a.m. test-signal levels present at the antenna jack of the HQ120X from a 50-ohm generator operating at 15 Mc., which produced the various S-meter readings. These measurements were obtained *before* the dual conversion was installed.

Table II - S-Meter Readings at 15 Mc.

S-Units	Input μ v. 50-Ohm Source.
9	50
8	25
7	10
6	3.5
5	1.2
4	0.5
3	0.2
2	0.1
1.5	0.05
1	noise

The Eddystone 888A ham-band receiver, modified by the author, was checked with the calibrated signal generator on c.w. at 29.5 Mc. The signal dropped into the noise at 0.01 microvolt. The Eddystone has dual conversion, a 1-kc. i.f. bandwidth and an 80-e.p.s. audio filter for use on c.w.

Table I - Tabulation of Pentode Tube Data.

Tube Type	Plate Voltage	Screen Voltage	Cathode	Plate	Screen	g_m μmhos	C_{gp} pf.	R_p Meg-Ohms	Equivalent Noise Resistance		Ratio $\frac{g_m}{C_{gp} 10^{12}}$	$\frac{g_m}{C_{gp} 10^9}$ R_{cq}
			Current ma.	Current ma.	Current ma.				MIT ohms	Radio-tron ohms		
6SG7	250	100	11.0	9.0	2.0	1,850	.004	1	3320	10,680	.463	.139
6SK7	250	100	11.8	9.2	2.5	2,000	.003	0.8	3450	11,100	.666	.139
6BJ6	250	100	12.5	9.2	3.4	4,400	.0035	1.3	2160	4,260	1.03	.477
6SG7	250	150	12.6	9.2	3.4	4,000	.003	1	1980	3,100	1.33	.674
6BA6	250	100	15.2	11.0	4.2	4,400	.0035	1	1820	3,520	1.25	.685
6DC6	200	150	12.0	9.0	3.0	5,500	.02	0.5	1370	1,830	.275	.202
6BZ6	125	125	17.6	14.0	3.6	8,000	.015	0.26	822	1,140	.533	.648
6JH6	125	125	17.6	14.0	3.6	8,000	.015	0.26	822	1,140	.533	.648
6HR6	200	115	17.5	13.2	4.3	8,500	.006	0.5	875	1,400	1.42	1.62
6BH6	250	150	10.3	7.4	2.9	4,600	.0035	1.4	1770	2,330	1.31	.739
6SH7	250	150	14.9	10.8	4.1	4,600	.003	0.9	1630	2,850	1.63	1.00
6AK5	180	120	10.1	7.7	2.4	5,100	.02	0.5	1420	1,880	.255	.180
6AU6	250	150	14.9	10.6	4.3	6,200	.0035	1	1590	2,660	1.48	.930
6BC5	250	150	9.8	7.5	2.1	6,700	.02	0.8	1210	1,360	.285	.236
6CB6A	125	125	18.7	13.0	3.7	8,000	.015	0.28	867	1,150	.533	.616
6DE6	125	125	19.7	15.5	4.2	8,000	.015	0.25	847	1,280	.320	.378
6AC7	300	150	12.5	10.0	2.5	9,000	.015	1.0	722	720	.600	.838
6HA6	300	150	12.5	10.0	2.5	9,000	.03	0.5	722	716	.300	.419
6HS6	150	75	11.6	8.8	2.8	9,500	.006	0.5	769	668	1.58	2.37
6FS5	275	135	9.2	9.0	0.17	10,000	.03	0.24	287	278	.333	1.20
6EW6	125	125	14.2	11.0	3.2	14,000	.04	0.2	503	392	.350	.893
6EJ7	200	200	14.1	10.0	4.1	15,600	.0055	0.51	582	352	2.84	8.07
6688	180	150	14.4	11.5	2.9	15,900	.018	0.09	410	308	.884	2.87
7788	185	165	40.0	35.0	5.0	50,000	.035	---	100	79	1.43	18.1

Tubes listed above in the top section are remote or semi-remote cutoff. The tubes listed in the bottom section are sharp cut-off types.

Note: It may be possible to use a 7788 in the RF section as the plate voltages to the RF amplifier tubes use a shunt feed. Also check out the 6EH7 as a remote cut off tube for front end use.

JX-17 IF Gain Mod

TECHNICAL ORDER WASHINGTON 3IRZ-4-I8-50Z I MAY 1956

MODIFICATION OF HAMMARLUND COMMUNICATION RECEIVER MODEL SP-600-JX-17 TO INCREASE OPERATIONAL EFFICIENCY

To increase the operational efficiency of Hammarlund Communication Receiver, ModeISP-600-JX-17, by:

- a. Addition of an "IF Gain" label and card holder to the front panel to provide operational and maintenance information.
- b. Addition of an IF Gain control for thresh-hold adjustment of overall receiver gain to provide necessary balance in receiver gain for use in diversity service.

£.. Addition of a series resistor to reduce voltage to dial lamps, thus increasing dial lamp life.

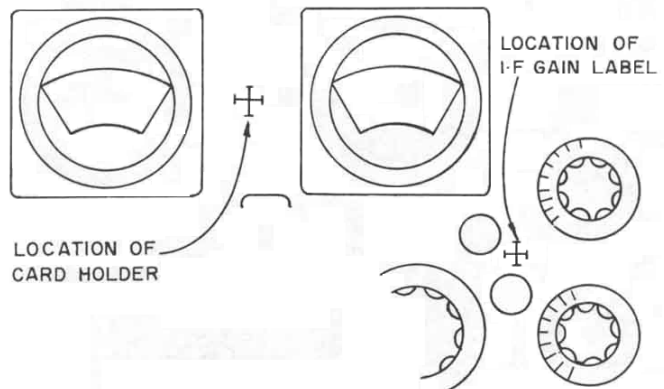
a. Turn off all power to the receiver.

b... Addition of IF Gain label and card-holder to the front panel (see Figure 1).

(1) Remove bottom plates from receiver and tuning unit.

(2) Remove dial lock knob and assembly, retaining the knob. washer for later use with new IF Gain control nut and lock.

Support the dial lock assembly while removing panel nut and lockwasher to avoid damage to the dial needle.



(3) Place the receiver on its back with the front panel up, in horizontal position.

(4) Clean the panel surfaces between dial escutcheons and around lettering of dial tuning lock, using an approved cleaning solvent such as trichlorethylene

(5) Apply a coating of toluol, supplied in capsule form in the kit, to rear surfaces of IF Gain label and card holder.

(6) Wait about 30 seconds or until surfaces are tacky, then place the IF Gain label centered over the dial tuning lock lettering, and the card holder centered between the dial escutcheons. Apply even pressure to both labels and allow the adhesive material to harden.

c. Installation of IF Gain control.

(1) With receiver's bottom up; feed free end of the new IF Gain control cable through the grommet in front skirt of chassis and install the IF Gain control on the front panel, using the hole from which tuning lock was removed.

(2) With the terminals of the new IF Gain control facing upward. toward bottom of receiver, secure the control using the lockwasher and nut previously removed from the tuning lock.

(3) Install tuning lock knob on the IF Gain control shaft.

(4) Dress the new cable. along with the receiver cable, towards the side of the tuning unit and then upward and through the slot at the front bottom corner of the tuning unit shield.

(5) Dress the cable across the inside front of the tuning unit shield and through the slot in the opposite corner of the shield.'

(6) Leave just enough slack in cable inside the tuning unit shield to clear below the screw head in the center of the shield's front.

(7) Dress cable downward along front corner of tuning unit shield; then around the front of chassis with the receiver cable and then along the side of the chassis until it is opposite to the front of socket for tube V9.

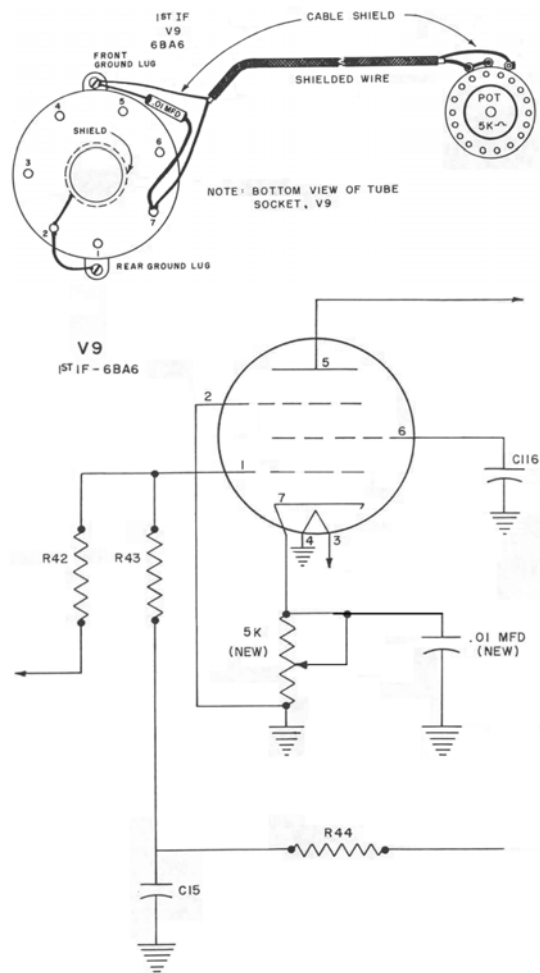
(8) Replace tuning unit bottom Cover.

(9) Unsolder and remove wire connections between pin 7 and center shield of socket for tube V9 and the chassis.

Connect pin Z and center shield of socket for tube V9 to the rear ground lug of this socket (see Figure 2).

(11) Connect the center conductor of new cable together with one lead of new 0.01 mfd capacitor to pin 7 of socket for tube V9 (see Figure 2)

(12) Connect other lead of the new capacitor and cable ground lug of the socket for tube V9 shield to the front



Collins Disc-Wire Mechanical Filters., Parts 1,2 and 3

Dallas Lankford [HSN Issue # 15, pgs 2-8]

Collins disc-wire mechanical filters for communications purposes are available in the frequency range of 60 - 500 kHz with bandwidths of 0.2 to 16 kHz. Most of those filters operate at or near 455 kHz. The filters come in three varieties: symmetric, USB, and LSB. The vast majority of such filters which are generally available on the used and surplus market are symmetric filters. For tube type applications, source and load terminations of 100 K ohms or more (≥ 100 K) are required. So our discussions will be restricted to disc-wire, symmetric, 455 kHz center frequency, ≥ 100 K termination, Collins mechanical filters. Listed below are some common mechanical filters of those kinds, and their specifications.

TYPE	PART NUMBER	PASS BAND (kHz/dB)	STOP BAND (kHz/db)	RES.CAP. (pf)
F455-N-20	526-9163-002	2.0/6	4.0/60	110
F455-N-40	526-9160-002	4.0/6	8.0/60	110
F455-N-80	526-9161-002	8.0/6	16.0/60	110
F455-N-160	526-9162-002	16.0/6	32.0/60	80
F455-FA-05	526-9494-000	0.5/6	3.0/60	130
F455-FA-09	526-9446-000	0.9/6	4.0/60	130
F455-FA-15	526-9495-000	1.5/6	3.5/60	130
F455-FA-21	526-9427-000	2.1/6	5.3/60	130
F455-FA-27	526-9500-000	2.9/6	6.2/60	130
F455-FA-31	526-9496-000	3.1/6	6.5/60	130
F455-FA-40	526-9497-000	4.0/6	8.5/60	130
F455-FA-60	526-9498-000	6.0/6	12.6/60	130
F455-FC-60	526-9522-001	6.0/3.5	25.0/60	130
F455-Y-05	526-9521-010	0.5/6	3.0/60	130
F455-Y-21	526-9337-000	2.1/6	5.3/60	130
F455-Y-31	526-9338-000	3.1/6	6.5/60	130
F455-Y-40	526-9339-000	4.0/6	8.5/60	130
F455-Y-60	526-9340-000	6.0/6	12.6/60	130
F455-Y-80	526-9341-000	8.0/6	18.5/60	130
F455-Y-160	526-9343-000	16.0/6	27.5/60	130

N filters are used in R-390A's, and are perhaps the most common on the used and surplus market. The last three digits of the part numbers of the N filters may be different from the numbers given above. Part numbers, pass bands, stop bands, and resonating capacitors values for the N filters are inferred from measurements, the 1970 NAVSHIPS manual drawings and parts list, and individual filters markings. N filters have a metal case with flange. mount. Measured skirt attenuation is typically well in excess of 100 dB.

FA filters originated in the early 1960's as an "inexpensive" ham and experimenter filter, although some now sell in the \$200 range for a new filter. FA filters have a plastic case, and it is important that the two ground lugs have a common signal ground. Measured skirt attenuation is typically well in excess of 100 dB.

Y filters are seldom seen on the used and surplus market, and are included mainly for completeness. The Y case is a metal cylinder, similar to the N case, but slightly smaller, and with no flange.

Data for the FA and Y filters above is taken from various Collins publications. There is also a series of FB filters which are identical to the FA filters above, except that the FB filters have measured pass band and stop band values marked on each filter. Pass band and stop band values may vary from filter to filter.

The FA and Y values above are minimum pass band and maximum stop band values respectively. For example, an individual F455-FA-21 filter might typically have a 2.4/6 pass band and 4.6/60 stop band. Collins mechanical filters are very reliable, with a mean time before failure on the order of 2000 years based on field measurements. Insertion loss for the FA and Y filters is specified as 25 and 20 dB maximum respectively, but are typically much less, about 8 dB. I have no information about N filter insertion loss, but it is probably similar to FA and Y filter insertion loss.

There are several ways to improve the less expensive models. Since all have a 455 kHz IF at some point, all can be fitted with a 455 kHz mechanical filter. Chuck Hutton (DX News IDX Editor) has modified his HQ-120X with two Collins 2.1 kHz mechanical filters and reports that it outperforms his R-390A. Mechanical filters are not cheap (\$25-\$150 or more), but installing one or two mechanical filters in most of the Hammarlund receivers is probably the easiest way to get a state of the art receiver for the BCB or tropical bands. The center frequency of Hammarlund crystal filters is generally not exactly 455 kHz, but typically 2 to 4 kHz lower. This means that if you add a mechanical filter to one of the Hammarlund receivers with a crystal filter, then the crystal filter may not be used unless you change the crystal. My article "180 + Collins F455FA40 mechanical filter ~ super 180" describes one method of adding a mechanical filter to the HQ-180(A). It should still be available from the National Radio Club through their reprints service.

Recall that in Part 2 I discussed the two general kinds of mechanical filter circuits which are used when AVC is needed at the output, namely series and parallel AVC. In Part 3, I will present some applications of those two general approaches, using suggested before and after circuits for some common tube type communications receivers. Let me begin with a description of an HQ-180(A) mod which I have done to my own '180.

The format I will use to display schematics is illustrated in **Figure 1**, a small section of a late model HQ-180A schematic. The figure labels are not (usually) the same as '180 labels, which are listed in the column under "HQ-180(A)." To avoid ambiguity and confusion, when I refer to the labels from a receiver schematic I will enclose them in parentheses. For example, C3 in **Figure 1** is (C134) on a '180 schematic. I have also deleted some details from the original schematics to conserve space and simplify schematics. For example, the original '180 schematic indicated that a shielded cable connected the junction of C2, L2, and R1 to C3. However, in all cases there should be (to R9) enough details for you to associate the figures from this article with actual receiver schematics. Sometimes additional information will be given in the text.

For example, **Figure 1** contains the caption "(P: see text)" beside one of the arrowheads. It would have been awkward or unsightly to attach the AVC label "(to junction of R14, R15, R18, and C20)" at that point, and it is much simpler to refer to that point as point P. The parallel LC tuned circuits L1-C1 and L2-C2 are both part of transformer T1, and I have omitted some of the shielding (dashed line) which should entirely enclose them.

The question marks beside L1 and L2 in column 2 of **Figure 1** indicate that the inductances of those two inductors is not given on the '180 schematic. Also, only late model '180's have CS (C158) and very early model '180's do not have R1 (R10?). The voltage ratings of components from a receiver schematic are not given because you can determine them from the original schematic or parts list. Voltage ratings of added components in modifications, such as in **Figure 2**, are generally given, except for half watt resistors whose ratings are omitted.

The mechanical filter type (second column entry beside MF 1) and resonating capacitors (second column entry beside C3 and C4) are not specified. Any FA, FB, or N series mechanical filter is suitable for any of these modifications. The values of the resonating capacitors Ct for each filter have already been given in the first table.

If you have an older '180 which does not have R1 (R107), it is not necessary to add a 100 K resistor. I removed R1 (R10?) from my '180 to determine if there was any noticeable difference, but could detect none.

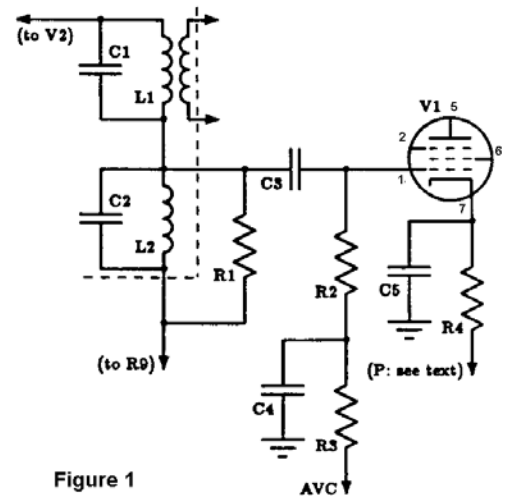


Figure 1

Figure 1	HQ-180(A)
C1	22
C2	90
C3	2
C4	0.01
C5	0.01
L1	?
L2	?
R1	100 K
R2	22 K
R3	100 K
R4	2200
V1	6BA6

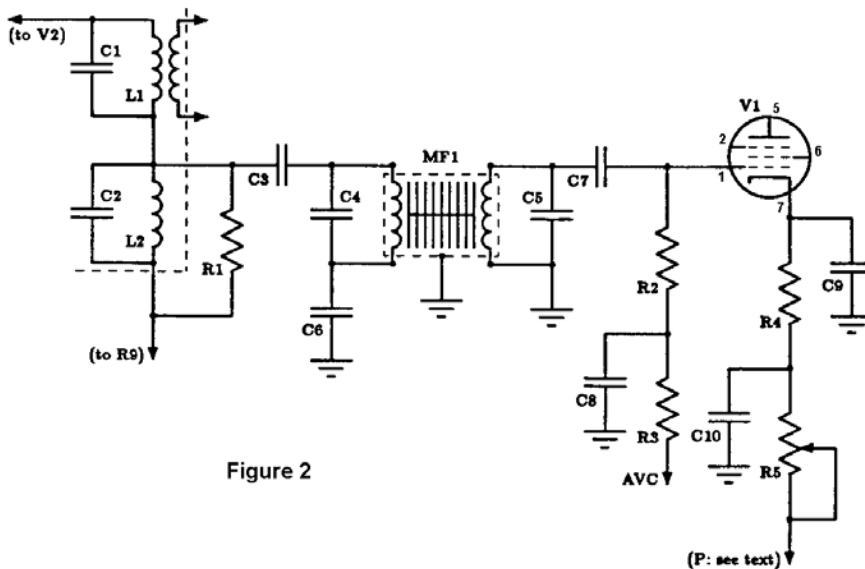


Figure 2

Figure 2	HQ-180A
C1	22
C2	90
C3	.01, 1 KV
C4	Ct (see text)
C5	Ct (see text)
C6	.01, 1 KV
C7	.01, 1 KV
C8	0.01
C9	0.01
C10	.01, 1 KV
L1	?
L2	?
MF1	see text
R1	100 K
R2	100 K
R3	100 K
R4	180
R5	2500, 2 W
V1	6BA6

Look back at **Figure 1** and notice the difference between the original V1 cathode circuit and the modification in Figure 2. All mechanical filters introduce some signal loss, called insertion loss, typically on the order of 6 - 8 db or about 1 S-unit. Insertion loss is usually inconsequential, but if you are a perfectionist like me, then you will want to try to restore S-meter readings to their original values.

In many modifications there are easy ways to do this, and the modified cathode circuit of **Figure 2** illustrates one such method.

Notice that R4 of **Figure 1** has been replaced by R4, R5, and C10 of **Figure 2**. For reasons which I will discuss later, you should not replace R4 of **Figure 1** by a 2500 ohm 2 watt variable resistor in an attempt to simplify the cathode modification.

The AVC feed for V1 of **Figures 1 and 2** is parallel. Because R3-C4 of Figure 1 [R3-C8 of Figure 2] is part of the '180 time constant circuit, they should not be changed [and have not been changed]. The load resistor R2 has been changed from 22 K in **Figure 1** to 100 K in **Figure 2**. Collins recommends load resistors of at least 50 K for FA, FB, and N filters. You may use any value in the 50 K - 500 K range.

The filter input circuit is not the same as recommended by Collins, partly because L1-C1 and L2-C2 are switched by the '180 depending on the band, making it difficult to design and construct an alternate circuit. Also, it makes no sense to unnecessarily remove parts while modifying a receiver.

So the input circuit takes advantage of the existing 455 kHz IF transformer L2-C2, and is typical of many modifications except for that R1 will usually not be present. **Figure 3** is a small piece of a **SP-600** schematic showing the 455 kHz gate V1 (V7), the 3.955 MHz to 455 kHz converter V2 (V6), and part of T3, the 455 kHz IF transformer which includes a multi position 455 kHz crystal filter.

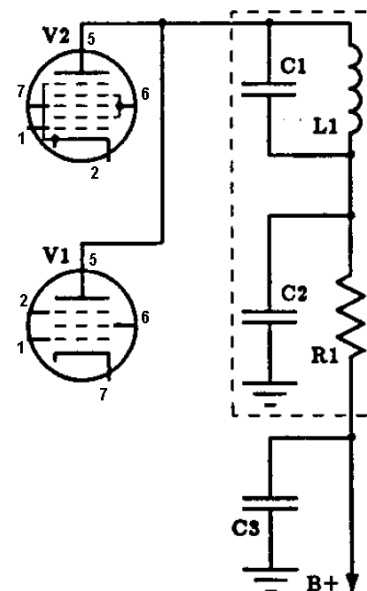


Figure 3

Figure 3		SP-600
C1	220	C107
C2	0,022	C108
C3	0,022	C109
L1	?	L36
R1	2200	R41
V1	6BA6	V7
V2	6BE6	V6

In contrast to the '180 modification which provides mechanical filter selectivity only for the low bands, bands 1 - 4, the modification of the **SP-600** in **Figure 4** provides mechanical filter selectivity for all bands.

Assuming there is ample space inside the **SP-600** chassis near V13, the **Figure 4** modification should be especially easy. It only requires disconnecting the B+ line at the junction of C3 and R1 in Figure 3 (never having seen a **SP-600**, I am not sure where C10 attaches to the B+ line...,you may be able to use C10 in place of C2 if it attaches appropriately), and disconnecting the wire which joins the junction of V1 and V2 pins 5 and the junction of LI-C1 of Figure 3. The modification in **Figure 4** requires a mechanical filter of your choice (I like the N series), a 10 mH, 100 mA choke (you can cannibalize a nice 12 mH choke from an R-390A IF sub-chassis), a 2200 ohm half watt resistor,

five.01 1 KV disc ceramic capacitors, two filter resonating capacitors Ct [C3 and C4], some stranded pieces of hookup wire, perhaps a few short pieces of coax, a little aluminum metal or printed circuit board work to fabricate a mounting arrangement for the filter, and you are in business.

A similar modification could also be done to the '180 because it uses a similar conversion scheme [following V1 of **Figure 1**]. The only differences are the '180 high IF is a 3.035 MHz [which does not affect the modification, the bypass capacitor C9 and dropping resistor R2 of Figure 4 are outside the '180 IF transformer, and the '180 has no bypass capacitor corresponding to C10 in **Figure 4**. The main reason I did not do a style modification on my '180 is because I wanted a mechanical filter immediately following the first mixer for best BCB performance.

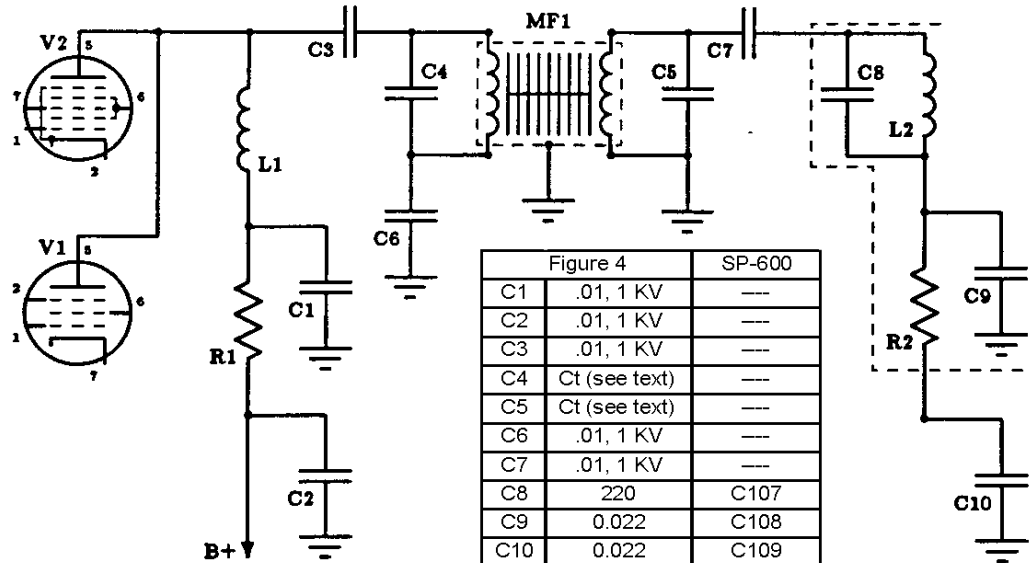


Figure 4

Figure 4	SP-600
C1	.01, 1 KV
C2	.01, 1 KV
C3	.01, 1 KV
C4	Ct (see text)
C5	Ct (see text)
C6	.01, 1 KV
C7	.01, 1 KV
C8	220
C9	0.022
C10	0.022
L1	10 mH, 100 ma
L2	?
MF1	see text
R1	2200
R2	2200
V1	6BA6
V2	6BE6

Figure 5 is another part of a SP-600 schematic where a mechanical filter can be inserted, and Figure 6 below shows the modification which is similar to the '180 modification in Figure 2. Figure 6 also illustrates the series AVC circuit discussed in Par 2 (HSN 12).

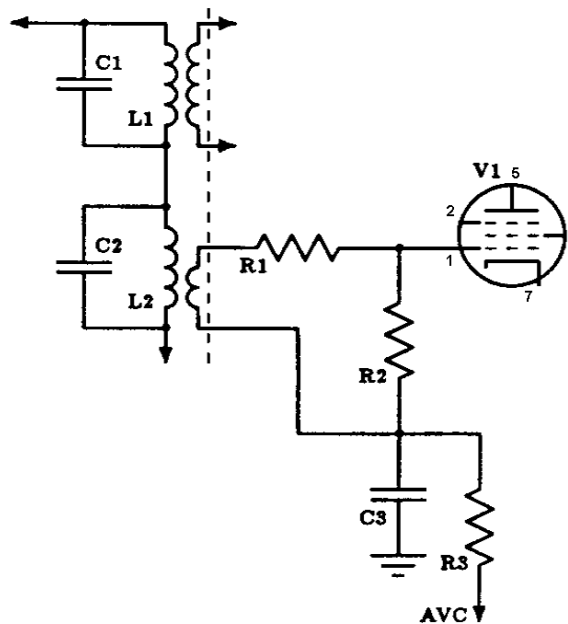


Figure 5	SP-600
C1	55
C2	220
C3	0.01
L1	7
L2	7
R1	1500
R2	510
R3	10 K
V1	6BA6

It requires a bit more "surgery" than the Figure 4 modification,

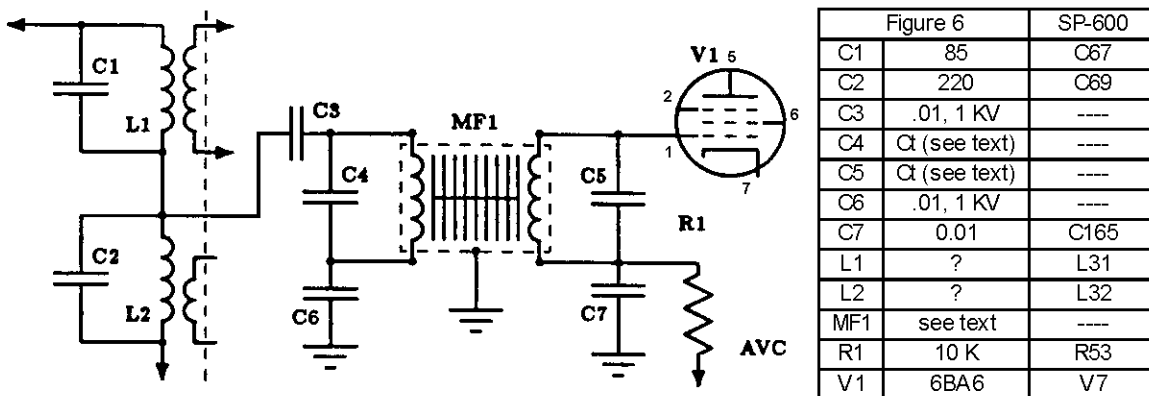
but has the advantage (or disadvantage, depending on your point of view) of placing the mechanical filter immediately after the first mixer.

Similar to the '180 modification, the Figure 6 modification provides mechanical filter selectivity only for the low bands, bands 1 - 3. I have not done the Figure 6 modification, so I do not know how difficult it may be to access the junction of L1-C1 and L2-C2. I would appreciate receiving a letter from any reader who does this modification concerning the difficulty or ease of accessing the junction of L1-C1 and L2-C2, and any other points about this modification so that I can include additional information in future revisions.

Notice, too, that both R1 and R2 should be removed, and there should be no components connected to the output link coupling of L2 (L32). The **Figure 6** modification is different from the '180 modification in another important way. In both cases, signal loss is intentionally introduced before the "gate" [V1 (V17) of Figure 1 and V1 (V7) of **Figure 5**] because an IF amplifier [which the "gate" essentially is] has more gain than a converter [which is used in place of the "gate" for the high bands signal path]. But the methods of introducing signal loss are different, cf. **Figures 1 and 5**.

Having no direct experience with a **SP-600**, I do not, know what effect the mechanical filter, modification in **Figure 6** will have on mechanical filter insertion loss or gain for the low bands signal path. In other words, I cannot predict whether the sum of the mechanical filter insertion loss plus the gain from eliminating the impedance mismatch at the grid of V1 (V7) in **Figure 5** will be positive or negative. In the best of all possibilities, the loss and gain would exactly cancel, requiring no further circuit changes. If the net effect is a loss, I will describe a simple solution later which is also applicable to the modification in **Figure 4**. If the net effect is a gain, then gain reduction should be applied to the gate, and I will describe a simple solution later which uses a circuit borrowed from the '180.

Perhaps it is appropriate here to give an important *****WARNING*****: impedance mismatching should never be used at either the input or output of a mechanical filter because it may [and usually will] cause all kinds of anomalous performance, including greatly increased insertion loss, possible spurious responses such as harmonic and inter-modulation distortion, *greatly* increased pass band ripple, and greatly reduced stop band rejection.



If the thought of removing and opening up T2 to find the junction of L1-C1 and L2-C2 blows your mind, not to mention the potential problem of rewiring T2 to bring a lead from the junction to a lug on the base of T2 so that you can access the junction, then you might like to consider an alternate approach in Figure 7.

As I have indicated above, the problem with connecting a mechanical filter between the grid of V1 and the junction of R1 and R2 of **Figure 5** is the resulting impedance mismatch which would probably cause all sorts of anomalous filter performance. But did you know that FA and FB (and probably N) series mechanical filters can be tuned in two ways - parallel and series?

The parallel tuning is generally found in most production circuits, and in fact I have never seen the series tuning used in practice (it is mentioned briefly in Collins data sheets for the FA and FB series filters) . Parallel tuning is used for loads of 100 K ohms or more, which is perfect for tube plates and grids, and for high impedance parallel L-C circuits such as in the previous examples.

Series tuning is used for loads of 500 ohms or less, which would seem ideal for the 510 ohm load presented by R2 of **Figure 5**. Never having tried it, I can make no promises for the modification of **Figure 7**. If anyone checks it out, please drop me a line.

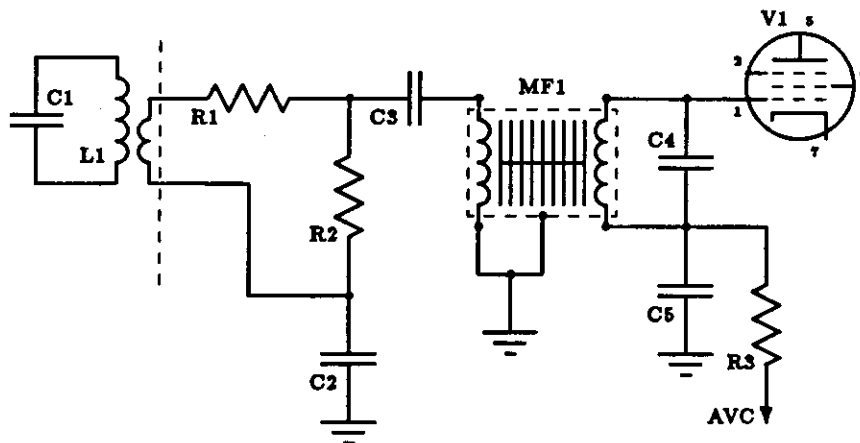


Figure 7

SP-600

As I said above, for the **SP-600** there is a simple way to compensate for any reasonable (5-10 dB) insertion loss introduced by a mechanical filter. **Figure 8** shows the method: unsolder the wire at the junction of R1 (R95) and R2 (R96), remove R2 (R96), and replace it with a 25 K, 2 W variable.

The R1-R2 circuit is a voltage divider which provides about -10 VDC for the grid of V11, thus substantially reducing the gain of V11. This is the same principle used for AVC, except that the AVC voltage varies depending on signal level. Just as a guess, the modification in **Figure 8b** may permit an additional 20 dB gain from V11, which is much more than should be needed.

C1	220	C69
C2	.01, 1 KV	----
C3	a (see text)	----
C4	a (see text)	----
C5	0.01	C165
L1	?	L32
MF1	see text	----
R1	1500	R33
R2	510	R32
R3	10 K	R53
V1	6BA6	V7

The 25 K, 2 W variable resistor can be mounted almost anywhere you please as long as you don't run the connecting wire near RF, mixer, oscillator, and IF stages which precede V11 in the signal path. Because variable resistors are notorious for promoting anomalous performance as they age, the best approach is to replace R2 with two fixed resistors soldered in place.

The final circuit in this collection of **SP-600** mechanical filter modifications is a gain reduction method for the "gate." **Figure 9a** shows the original V1 (V7) cathode circuit, which is similar to the method used in older '180's. Look back at Figure 2 and you will see that the circuit of Figure 9b is essentially the same as the one which works well in my '180 modification. The circuit in Figure 9b should allow up to 20 dB of gain reduction, i.e., about 3 S-units. Like the modification of Figure 8b, the best approach is to replace R1 and R2 in **Figure 9b** by a fixed resistor after the required value (180 ohms plus the experimentally determined value of R2) has been determined. The bypass capacitor C2 is desirable to minimize stray signal paths while both R1 and R2 are in use because it will probably be necessary to mount R2 some distance away from pin 7 of V1 (V7).

At this point it is perhaps appropriate to say that the **Figure 9b** modification is intended for use only with the **Figure 6** or **Figure 7** modification, while the **Figure 8b** modification is intended for use only with the **Figure 4** modification.

There are several points to consider before you rush off and add a mechanical filter to your **SP-600**. First, which filter series and what band width will you choose? If you never listen casually, and only DX, then I suppose a 2 kHz band width filter is the logical choice. But I presume you have considered that a 2 kHz bandwidth significantly reduces fidelity.

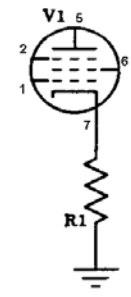
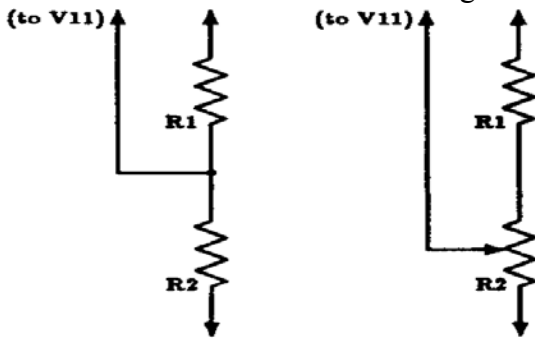


Figure 8a		SP-600
R1	82 K	R95
R2	22 K	R96

Figure 8b		SP-600
R1	82 K	R-95
R2	25 K, 2 W	----

Figure 9a		SP-600
R1	390	R112
V1	6BA6	V7

A good compromise is a 4 kHz filter, which I used for my '180 modification, but I missed the wider band widths enough to have caused me to begin preparations for a switched mechanical filter arrangement for my '180. That is not as difficult as you might think, because an R-390A IF sub-chassis contains all the parts necessary for such a construction project. Second, you will not be able to use the **SP-600** crystal filter narrow bandwidths (1.3, 0.5, and 0.2 kHz) unless its center frequency just happens to be very nearly 455 kHz. To avoid an unpleasant surprise later, measure the crystal filter center frequency before you start. An off-frequency crystal filter will not stop the determined experimenter, who will trade crystals until the center frequency is acceptable. An R-390A IF sub-chassis contains a crystal filter with a 455 kHz crystal which may suffice. Third, where and how will you mount the mechanical filter and its associated components?

In my experience it takes about the same amount of work to develop a satisfactory mounting arrangement for both the F/A, F/B and N series filters.

In both cases be sure that a grounded metal shield is placed between the input and output terminals (including all associated components such as Ct's and leads. If it is not possible to isolate parts of the leads, double shielded cable may be required to avoid degrading filter stop band performance. Fourth, if you do the modification in Figure 6, give some thought to opening up transformer T2 for access to the junction of LI-C1 and L2-C2. Assuming T1 has a "quick release" shield style and there is enough nearby empty space, it may be possible to modify T1 in situ, without removing the entire transformer assembly from the chassis. But do not hesitate to remove the entire transformer assembly if it is necessary.

The HQ-150 is another receiver in the Hammarlund line which can be fitted with a mechanical filter. Figure 10a shows part of the first IF transformer (T1) and the Ave and input to V1 (V4). The '150 modification in Figure 10b is similar to the Figure 6 modification in that you will have to remove the IF transformer shield and rewire the output. I have not done this modification, but reports of a similar modification to a HQ129 indicate that the increased signal level due to modifying L1 approximately compensates for mechanical filter insertion loss which should make additional modifications unnecessary. However, if a net signal level gain is experienced after adding a mechanical filter, the gain-reduction modification in Figure 9b may be used at the cathode of V1 (V4) in Figure 10b. And, if a net signal loss is experienced, the inductor in T3 can be modified like L1 of Figure 10b. Apparently it may require modifications to both T1 and T3, and, in addition, a gain-reduction modification to the cathode of V1 (V4) to restore the '150 gain distribution.

Synchronous Detection of DSB and ISB Signals

By Peter C. McNulty, WA1SOV May 2, 1999

Background

A Synchronous Detector designed with the use of an LM311 and an Analog Devices AD607. This is a very basic design. It functions as a product detector and when JMP2 is closed and JMP 1 is open, it functions fully synchronously locking to the 455 KHz I.F. provided at the input. The 455 KHz input should be pre-filtered to remove unnecessary noise from the signal so as to improve locking performance. This circuit has been tested with a Hammarlund SP-600, and it functions quite well with the I.F. out of this receiver connected to J1 of this circuit. Most of the testing has been done with the SP-600 in its 8 KHz position however, any of the passband selections work fine. The narrower the bandwidth selection the better rejection there is against unwanted adjacent channel interference. Additional I.F. selectivity can be had by filtering just the signal provided to U1 and not the I.F. sent to U2. This is not shown below but can easily be implemented. Further improvement could be had, by regenerating the carrier with a Phase Locked Loop such as the NE564. This is necessary for use on signals with marginal carrier signal or suppressed carrier. The loop filter designed for use with such a PLL would provide much greater rejection of unwanted adjacent channel noise. This is an experimental breadboard and is by no means a polished performer. It does afford the experimenter the opportunity to play with a configuration that can provide synchronous detection. Have Fun!

Theory of Operation

The signal applied to J1 is between 1 to 2 volts, rms and is hard limited by U1, LM311. The limiting is necessary to remove amplitude variations of the signal due to the modulation components present. It is only the carrier we want the Phase Locked Loop in U2 to lock-up to. U1 is configured as a zero crossing detector. R1 & R2 bias the input signal to half of VCC. R3 & R4 provide the reference voltage to the comparator, which will determine the switching point of the comparator. The output of U1 is pulled up to VCC so it provides an output which swings between VCC and ground (+4.5v). It is not recommended to apply greater than 4.5 volts to this circuit because of limitations in U2. Nominally the AD607 runs at as little as 3 volts and under no circumstances wants to run above 5 volts. 4.5 volts is fairly standard and can be gotten from a wall transformer or 3 AA batteries. The output signal of U1 is sent through a trim pot which will limit the amplitude of the PLL reference signal to about 0.5 volts at the FDIN input at pin 1 of U2. This signal is also biased at one half of VCC with R10 & R11. The selection of C3 and these resistors is such to minimize any phase distortion caused by the input coupling of these components.

The input signal from J1 is also sent through a resistor network, which conditions the signal for suitability at the input of the product detector in the AD607. These detectors are basically doubly balanced mixers and the local oscillator differs for the two detectors by 90 degrees. The PLL in the AD607 basically takes the reference signal that was limited in U1 and provides a new signal, which is in phase and in quadrature to that reference signal for application to the product detectors as shown in the U2 block. The PLL also has a loop filter, which is optimized for 455 KHz, however I did not notice much difference in performance when this time constant was lowered by an order of magnitude. So I wouldn't be too concerned about this when running I.F.s below 2 MHz.

The detected baseband signal is present at pin 18 of U2 (IOUT), and Pin 17 (QOUT) along with other mixing components. These other components should be filtered and R13, C9, R14, & C8 are selected to filter the outputs with a minimum of phase distortion. If you are going to only utilize this detector as a DSB Detector, then the Quadrature output available is not necessary, and it need not be used for anything. Just pass the In-phase output to an audio amplifier auxiliary input for amplification.

Independent Sideband Synchronous Detection

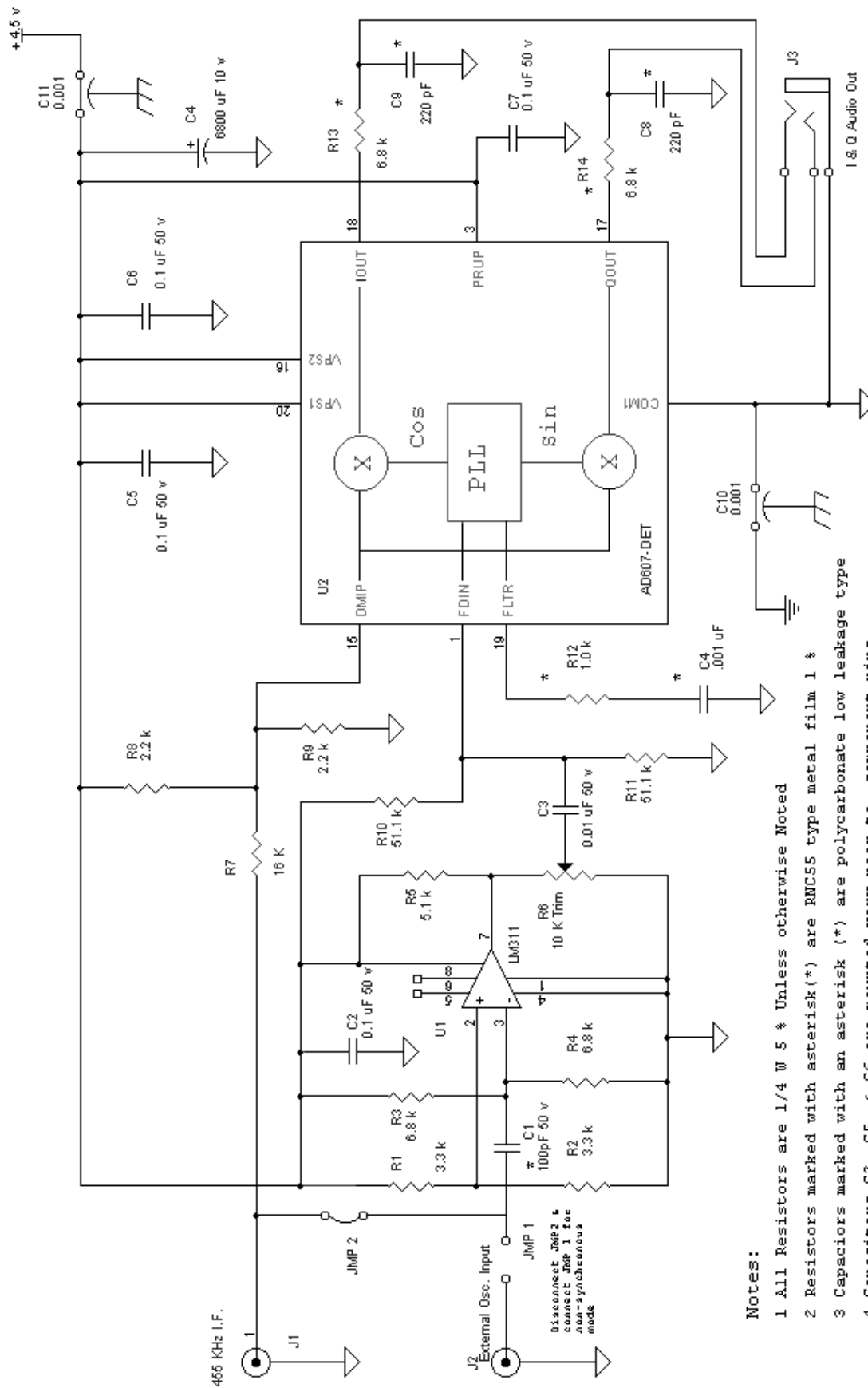
This circuit has been used to provide a source for detection of independent, upper, and lower sideband signals. Unless there is a carrier present with these signals, it cannot operate in the synchronous mode as configured. An independent sideband (ISB) signal can be detected with this detector by utilizing both outputs (IOUT, & QOUT) and passing them to a phase demodulation network. The principle is very much like phasing sideband modulation, but in reverse. The ISB performance of the detector when locked to a carrier was somewhat disappointing. For some reason that I have not discovered yet, the detector will not demodulate ISB when locked to the incoming carrier. It will however demodulate ISB perfectly when a non-phase locked oscillator running near 455 KHz is applied to J2 and the jumper at JMP 2 is removed and JMP is shorted. For ISB detection an external audio phasing network is necessary.

For this to happen it is necessary to utilize wideband audio phase shift networks known as Allpass Filters coupled with doubly balanced mixers. This network is much like the DOME networks originally designed in the 50's. An Allpass Filter design (see <http://home.worldnet.att.net/~walsov/technical/allpass/allpass.html>) can be used or a Digital Signal Processor (DSP) implementing a FIR filter can be employed. The latter was how I have debugged this design. The concept is pretty simple. If you realize that the IOUT signal contains both sidebands of the signal in phase with each other, and that the QOUT signal contains the sum of upper and lower sidebands 90 degrees out of phase with the IOUT, then with additional phase delay the upper and lower sidebands can be demodulated independently. The IOUT channel gets passed through one Allpass filter, which alters the phase of the signal, by +45 degrees. The QOUT signal is passed through another Allpass filter, which alters the phase of this signal, by -45 degrees. This leaves a net difference of 180 degrees between the IOUT and QOUT Phase processed signals. Adding the IOUT and the QOUT phase processed signals yields a cancellation of the lower sideband. However, the upper sideband remains at the output of this summation and at twice its original amplitude. Now the same two signal are also subtracted from each other in another network to obtain the lower sideband. The lower sideband is also at twice its original amplitude. Thus the lower sideband appears on one channel and the upper sideband would appear on the other channel when applied to the input of a Stereo amplifier. In order for this to work with any degree of opposite sideband rejection close attention to phase accuracy and amplitude matching are paramount. I have obtained without any special optimization of these circuits when using a DSP running a 256 point FIR Filter, opposite sideband rejections of 30 dB. Better can be obtained though through rigorous optimization. Stay tuned!

The signal demodulated does not have to be synchronous to detect signals independently. The system can be used with an external function generator, which is not phase coherent (free running) with the signal. It will function as an independent sideband product detector and Upper and Lower Sideband can be discerned well with this mode.

I hope this article has stirred some interest in this type of detection. Additionally, CQUAM AM Stereo can be demodulated with the I and Q outputs of this detector by simply summing to obtain one channel and differencing to obtain the opposite stereo channel. This does not require the Allpass phasing network described above. Jerry, WA2FNQ transmits the old QAM Stereo signal that can be demodulated using this technique. There are more developments in the works so check back often.

Stay Tuned!



Notes:

- 1 All Resistors are 1/4 W 5 % Unless otherwise Noted
- 2 Resistors marked with asterisk(*) are RMC55 type metal film 1 %
- 3 Capacitors marked with an asterisk (*) are polycarbonate low leakage type
- 4 Capacitors C2, C5, & C6 are mounted very near to component pins
- 5 All interconnects should be kept as close as possible and circuitry should be layed out on a ground plane, and placed in a fully enclosed metal box with appropriate feedthrough power bypasses.

Title		P. McMulty (WALSOV)	
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Date:	3/22/1999	Sheet	of

**TM 11-851 Resistor and Capacitor Parts List
For R-274A-C, R-320A and R-483 and R-483A (JX-17???)**

Note: that there are minor variations in components and wiring in different models except for the BBOD's. Attempt to verify your exact model. Do not necessarily trust the tags. Refer to Andy Moorer's ID list for a double check.

Capacitors

Ref. Desig.		Ref. Desig.	
		C40	.01 BBOD
		C41	.01 BBOD
		C42	.01 BBOD
C1		C43	.01 BBOD
C2		C44	.01 BBOD
C3	.01 BBOD	C45	
C4		C45A	Mica, 100pf. ± 2% 500 vdcw
C5	.01 BBOD	C46	
C6	Mica, 20pf ± 5% 500 vdcw	C46	
C7		C47	.01 BBOD
C8	Mica, 2400pf. ± 5% 500 vdcw	C47	
C9	Mica, 33pf. ± 5% 500 vdcw	C48	
C10		C49	.01 BBOD
C11	Mica, 1500pf. ± 2% 500 vdcw	C50	Mica, 20pf ± 5% 500 vdcw
C12	Ceramic 7pf. ± 1pf 500	C51	
C13		C52	Mica, 2400pf. ± 5% 500 vdcw
C14	Mica, 1000pf. ± 2% 500 vdcw	C53	Mica, 33pf. ± 5% 500 vdcw
C15	Ceramic 15pf. ± 5% 500 vdcw	C54	
C15A	Ceramic 15pf. ± 5% 500 vdcw	C55	Mica, 1500pf. ± 2% 500 vdcw
C16		C56	
C17	Mica, 1500pf. ± 2% 500 vdcw	C57	Mica, 85pf. ± 2% 500 vdcw
C18	Mica, 100pf. ± 2% 500 vdcw	C57A	Mica, 100pf. ± 2% 500 vdcw
C19	.01 BBOD	C58	
C20	Mica, 20pf ± 5% 500 vdcw	C59	Mica, 51pf. ± 2% 500 vdcw
C20A	.01 BBOD	C59A	
C21	.01 BBOD	C60	Ceramic 12pf. ± 5% 500 vdcw
C22	.01 BBOD	C60A	
C23	.01 BBOD	C61	.01 BBOD
C24	.01 BBOD	C62	Mica, 2200pf. ± 5% 500 vdcw
C25	Mica, 100pf. ± 2% 500 vdcw	C62A	.01 BBOD
C26		C63	Mica, 39pf. ± 5% 500 vdcw
C27	.01 BBOD	C63A	.01 BBOD
C28		C64	.01 BBOD
C29	.01 BBOD	C65	
C30	Mica, 20pf ± 5% 500 vdcw	C66	.01 BBOD
C31		C67	Mica, 85pf. ± 2% 500 vdcw
C32	Mica, 2400pf. ± 5% 500 vdcw	C68	.01 BBOD
C33	Mica, 33pf. ± 5% 500 vdcw	C69	Mica, 220pf. ± 2% 500 vdcw
C34		C70	.01 BBOD
C35	Mica, 1500pf. ± 2% 500 vdcw	C71	.01 BBOD
C36	Mica, 85pf. ± 2% 500 vdcw	C72	.01 BBOD
C37	Mica, 100pf. ± 2% 500 vdcw	C73	.01 BBOD
C37A		C74	.01 BBOD
C38			
C39	Mica, 51pf. ± 2% 500 vdcw		

C75	Mica, 100pf. ± 2% 500 vdcw	C119	Mica, 300pf. ± 2% 500 vdcw
C76		C120	Mica, 1300pf. ± 2% 500 vdcw
C77		C121	.01 BBOD
C78	Mica, 404pf. ± 1% 500 vdcw	C122	.01 BBOD
C79	Ceramic, 5pf. ± .25pf 500 vdcw	C123	BBOD Paper, 22,000pf. 400 vdcw
C80	Ceramic, 5pf. ± .25pf 500 vdcw	C124	Mica, 220pf. ± 2% 500 vdcw
C81		C125	Mica, 300pf. ± 2% 500 vdcw
C82	Mica, 820pf. ± 2% 500 vdcw	C126	Mica, 1300pf. ± 2% 500 vdcw
C83	Mica, 10pf ± 10% 500 vdcw	C127	.01 BBOD
C84		C128	Electrolytic, 10uf. 100 vdcw
C85	Mica, 1200pf. ± 2% 500 vdcw	C129	
C86		C129A	BBOD Paper, 2 sects.50,000pf.
C87	Mica, 120pf. ± 2% 500 vdcw	C129B	Uses 1/2 of above
C88	Ceramic 12pf. ± 5% 500 vdcw	C130	Ceramic 27pf. ± 5% 500 vdcw
C89	Mica, 190pf. ± 1% 500 vdcw	C131	Mica, 430pf. ± 2% 500 vdcw
C90		C132	Mica, 2400pf. ± 5% 500 vdcw
C91	Mica, 91pf. ± 2% 500 vdcw	C133	Mica, 430pf. ± 2% 500 vdcw
C91A	Mica, 100pf. ± 2% 500 vdcw	C134	
C92	Ceramic, 51pf. ± 1% 500 vdcw	C135	.01 BBOD
C93	Mica, 379pf. ± 2% 500 vdcw	C136	BBOD Paper, 22,000pf. 400 vdcw
C94		C137	BBOD Paper, 25,000pf. 600 vdcw
C95	Mica, 42pf. ± 1% 500 vdcw	C138	Ceramic 7pf. ± 1pf 500 vdcw
C95A	Mica, 51pf. ± 2% 500 vdcw	C138A	Ceramic, 51pf. ± 1% 500 vdcw
C96	Mica, 610pf. ± 1% 500 vdcw	C139	Ceramic 15pf. ± 5% 500 vdcw
C97	Mica, 65pf. ± 2 pf. 500 vdcw	C139A	Mica, 51pf. ± 1% 500 vdcw
C98	BBOD Paper, 22,000pf. 400 vdcw	C140	Mica, 430pf. ± 2% 500 vdcw
C99	Mica, 51pf. ± 2% 500 vdcw	C141	Ceramic 100pf. ± 10% 500 vdcw
C99A		C142	Ceramic 100pf. ± 10% 500 vdcw
C100	.01 BBOD	C143	
C101		C144	BBOD Paper, 50,000pf. 600 vdcw
C102	BBOD , .022 uf. 400 vdcw	C145	Ceramic 7pf. ± 1pf 500 vdcw
C103	BBOD Paper, 22,000pf. 400 vdcw	C145A	Ceramic 15pf. ± 5% 500 vdcw
C104	BBOD Paper, 22,000pf. 400 vdcw	C146	BBOD Paper, 22,000pf. 400 vdcw
C105	.01 BBOD	C147	
C106	BBOD Paper, 22,000pf. 400 vdcw	C148	BBOD Paper, 22,000pf. 400 vdcw
C107	Mica, 220pf. ± 2% 500 vdcw	C149	
C108	BBOD Paper, 22,000pf. 400 vdcw	C150	
C109	BBOD Paper, 22,000pf. 400 vdcw	C151	Electrolytic, 10uf. 100 vdcw
C110	Mica, 100pf. ± 2% 500 vdcw	C152	Mica, 10,000pf. Power Line Filter
C111		C152A	BBOD, 2 sects. Power Line Filter
C112	Mica, 100pf. ± 2% 500 vdcw	C152B	Uses 1/2 Power Line Filter
C112		C153	.01 BBOD
C113	Mica, 100pf. ± 2% 500 vdcw	C154	.01 BBOD
C114	Mica, 270pf. ± 2% 500 vdcw	C155	.01 BBOD
C115	BBOD	C156	BBOD Paper, 22,000pf. 400 vdcw
C116	.01 BBOD	C157	BBOD Paper, 22,000pf. 400 vdcw
C117	Mica, 220pf. ± 2% 500 vdcw	C158	Electrolytic, 10uf. 100 vdcw
C118	BBOD Paper, 22,000pf. 400 vdcw	C159	Electrolytic, 10uf. 100 vdcw

C160	Electrolytic, 10uf. 100 vdcw	C167	BBOD Paper, 22,000pf. 400 vdcw
C161A	Electrolytic, 20uf. 450 vdcw	C168	Mica, 10,000pf. \pm 5% 500 vdcw
C161B	Electrolytic, 20uf. 450 vdcw	C169	Mica, 10,000pf. \pm 5% 500 vdcw
C161C	Electrolytic, 20uf. 450 vdcw		
C162	BBOD Paper, 22,000pf. 400 vdcw	C171	C170 to C261 Not used
C163	BBOD Paper, 25,000pf. 600 vdcw	C262	.01 BBOD
C164	Mica, 430pf. \pm 2% 500 vdcw	C263	.01 BBOD
C165	.01 BBOD	C264	.01 BBOD
C166	.01 BBOD		

Resistors

Ref. Desig.		Ref. Desig.	
R1	510K ohm \pm 10%, 1/2 W	R36	22K ohm \pm 5%, 1/2 W
R2	10K ohm \pm 5%, 1/2 W	R37	2K2 ohm \pm 10%, 1/2 W
R3	33K ohm \pm 5%, 1/2 W	R38	100K ohm \pm 10%, 1/2 W
R4	1K ohm \pm 10%, 1/2 W	R39	33K ohm \pm 5%, 1/2 W
R5	510 ohm \pm 5%, 1/2 W	R40	20K ohm \pm 5%, 1/2 W
R6	1K ohm \pm 10%, 1/2 W	R41	2K2 ohm \pm 10%, 1/2 W
R7	51 ohm \pm 5%, 1/2 W	R48	33K ohm \pm 5%, 1/2 W
R8	51 ohm \pm 5%, 1/2 W	R49	2K2 ohm \pm 10%, 1/2 W
R9	24 ohm \pm 5%, 1/2 W	R50	10 ohm \pm 10%, 1/2 W
R10	22 ohm \pm 10%, 1/2 W	R51	100K ohm \pm 10%, 1/2 W
R11	22 ohm \pm 10%, 1/2 W	R52	10K ohm \pm 5%, 1/2 W
R12	10K ohm \pm 5%, 1/2 W	R53	33K ohm \pm 5%, 1/2 W
R13	510K ohm \pm 10%, 1/2 W	R54	2K2 ohm \pm 10%, 1/2 W
R14	33K ohm \pm 5%, 1/2 W	R55	10 ohm \pm 10%, 1/2 W
R15	510 ohm \pm 5%, 1/2 W	R56	100K ohm \pm 10%, 1/2 W
R16	1K ohm \pm 10%, 1/2 W	R57	10K ohm \pm 5%, 1/2 W
R17	51 ohm \pm 5%, 1/2 W	R58	2K2 ohm \pm 10%, 1/2 W
R18	51 ohm \pm 5%, 1/2 W	R59	2K2 ohm \pm 10%, 1 W
R19	24 ohm \pm 5%, 1/2 W	R60	1meg ohm \pm 10%, 1/2 W
R20	22 ohm \pm 10%, 1/2 W	R61	1meg ohm \pm 10%, 1/2 W
R21	22 ohm \pm 10%, 1/2 W	R62	100K ohm \pm 10%, 1/2 W
R22	47K ohm \pm 10%, 1/2 W	R62A	47K ohm \pm 10%, 1/2 W
R23	47K ohm \pm 10%, 1/2 W	R63	27K ohm \pm 10%, 1/2 W
R24	180 ohm \pm 5%, 1/2 W	R64	
R25	180 ohm \pm 5%, 1/2 W	R65	22K ohm \pm 5%, 1/2 W
R26	510K ohm \pm 10%, 1/2 W	R65A	47K ohm \pm 10%, 1/2 W
R27	150 ohm \pm 5%, 1/2 W	R66	18K ohm \pm 10%, 1/2 W
R28	6K8 ohm \pm 10%, 1/2 W	R67	100K ohm \pm 10%, 1/2 W
R29	1K ohm \pm 10%, 1/2 W	R68	100K ohm \pm 10%, 1/2 W
R30	1K ohm \pm 10%, 1/2 W	R69	WW, Variable 1K \pm 10%, 2 W
R31	2K2 ohm \pm 10%, 1/2 W	R70	10K ohm \pm 5%, 1/2 W
R32	510 ohm \pm 5%, 1/2 W	R71	
R33	1K5 ohm \pm 10%, 1/2 W	R72*	WW, 7K5 ohm \pm 10%, 20 W
R34	100K ohm \pm 10%, 1/2 W	R73	56K ohm \pm 5%, 1/2 W
R35	100K ohm \pm 10%, 1/2 W	R74	WW, Variable 1K \pm 10%, 2 W
		R75	100K ohm \pm 10%, 1/2 W
		R76	100K ohm \pm 10%, 1/2 W

R77	47K ohm ± 10%, ½ W	R98	470K ohm ± 10%, ½ W
R78	470K ohm ± 10%, ½ W	R99	360 ohm ± 5%, 1 W
R79	680 ohm ± 10%, ½ W	R100	100K ohm ± 10%, ½ W
R80	2K2 ohm ± 10%, ½ W	R101	Variable 25K ohm ± 10%, 2 W
R81	100K ohm ± 10%, ½ W	R102	1K ohm ± 10%, ½ W
R82	10K ohm ± 5%, ½ W	R103	510 ohm ± 5%, ½ W
R83	1K ohm ± 10%, ½ W	R104	510 ohm ± 5%, ½ W
R84	Variable 500K ohm ± 10%, 2 W	R105	510 ohm ± 5%, ½ W
R85	WW, 2K5 ohm ± 5%, 12 W	R106	510 ohm ± 5%, ½ W
R86	82K ohm ± 5%, ½ W	R107	510 ohm ± 5%, ½ W
R87	120K ohm ± 5%, ½ W	R108	510 ohm ± 5%, ½ W
R88	120K ohm ± 5%, ½ W	R109	510 ohm ± 5%, ½ W
R89	82K ohm ± 5%, ½ W	R110	510 ohm ± 5%, ½ W
R90	10K ohm ± 5%, ½ W	R111	100K ohm ± 10%, ½ W
R91	10K ohm ± 5%, ½ W	R112	390 ohm ± 10%, ½ W
R92	10K ohm ± 5%, ½ W	R113	330K ohm ± 5%, ½ W
R93	Variable 50K ohm ± 10%, 2 W	R114	1K ohm ± 10%, ½ W
R94	1K1 ohm ± 5%, ½ W	R115	1.5meg ohm ± 10%, ½ W
R95	82K ohm ± 5%, ½ W	R116	1.5meg ohm ± 10%, ½ W
R96	22K ohm ± 5%, ½ W		
R97	3.3meg ohm ± 10%, ½ W		

1	360 ohm ± 5%, 1 W	1	Comp., Variable 500K ohm ± 10%, 2 W
1	Comp., 2K2 ohm ± 10%, 1 W	1	WW, Variable 1K ohm ± 10%, 2 W
1	Comp., Variable 25K ohm ± 10%, 2 W	1	WW, 2K5 ohm ± 5%, 12 W
1	Comp., Variable 50K ohm ± 10%, 2 W	1	WW, Variable 1K ohm ± 10%, 2 W

Capacitor Summary Tally

Quan	Description	Quan	Description
44	01 BBOD	1	BBOD Paper, 250,000pf. \pm 20% 600 vdcw
16	BBOD Paper, 22,000pf. \pm 20% 400 vdcw	2	BBOD Paper, 2 sects.50,000pf. + 20 -10% 600 vdcw Power Line Filter
1	BBOD Paper, 50,000pf. \pm 20% 600 vdcw	1	BBOD Paper, 250,000pf. \pm 10% 600 vdcw
3	Mica, 20pf \pm 5% 500 vdcw	2	Ceramic, 5pf. \pm .25pf 500 vdcw
1	Mica, 10pf \pm 10% 500 vdcw	3	Ceramic 7pf. \pm 1pf 500
3	Mica, 33pf. \pm 5% 500 vdcw	2	Ceramic 12pf. \pm 5% 500 vdcw
1	Mica, 20pf \pm 5% 500 vdcw	4	Ceramic 15pf. \pm 5% 500 vdcw
1	Mica, 39pf. \pm 5% 500 vdcw	1	Ceramic 12pf. \pm 5% 500 vdcw
1	Mica, 42pf. \pm 1% 500 vdcw	1	Ceramic 27pf. \pm 5% 500 vdcw
5	Mica, 51pf. \pm 2% 500 vdcw	2	Ceramic, 51pf. \pm 1% 500 vdcw
1	Mica, 65pf. \pm 2 pf. 500 vdcw	2	Ceramic 100pf. \pm 10% 500 vdcw
3	Mica, 85pf. \pm 2% 500 vdcw	4	Mica, 430pf. \pm 2% 500 vdcw
1	Mica, 91pf. \pm 2% 500 vdcw	1	Mica, 610pf. \pm 1% 500 vdcw
10	Mica, 100pf. \pm 2% 500 vdcw	1	Mica, 820pf. \pm 2% 500 vdcw
1	Mica, 120pf. \pm 2% 500 vdcw	1	Mica, 1000pf. \pm 2% 500 vdcw
1	Mica, 190pf. \pm 1% 500 vdcw	1	Mica, 1200pf. \pm 2% 500 vdcw
4	Mica, 220pf. \pm 2% 500 vdcw	2	Mica, 1300pf. \pm 2% 500 vdcw
1	Mica, 270pf. \pm 2% 500 vdcw	3	Mica, 1500pf. \pm 2% 500 vdcw
2	Mica, 300pf. \pm 2% 500 vdcw	5	Mica, 2400pf. \pm 5% 500 vdcw
1	Mica, 379pf. \pm 2% 500 vdcw	3	Mica, 10,000pf. \pm 5% 500 vdcw
1	Mica, 404pf. \pm 1% 500 vdcw	1	Electrolytic, 20uf. 450 vdcw (3X)
		5	Electrolytic, 10uf. 100 vdcw

Cleaning & Lubrication Materials and Helpful Hints

Walter Wilson et all

G5S-6 ProGold G5 Spray (200mL) \$ 13.29

Simple Green

Mobil 1 10W30or 30W Mix 50/50 W/MMO

Mobil 1 synthetic gear oil 90 weight

WD 40 Spray & liquid

Caig Laboratories, DeOxit®

Nevr-Dull 5 oz can \$ 3.67

Marvel Mystery Oil (Use 50/50 with Mobile 1.) 16 oz \$ 2.04

Phil Wood Waterproof Grease 3 oz. \$ 2.99

Tri-Flow Drip Bottle - 2 oz. \$ 2.69

Tri-Flow Aerosol Can - 12 ounce \$ 8.29

Mineral oil

GoJo hand cleaner (the kind without pumice)

GoJo hand cleaner (with pumice) for corroded aluminum IF cans

Naphtha

Something a little stronger - Goof Off

I will pass along a mix that was passed on to me. 409 - 50% and Ammonia - 50%

Redline Synthetic hi-pressure bearing grease

Windex-on the chassis

Sewing Machine Oil

General Tips

In most cases I replace the chassis hardware (screws) with new stainless ones. I buy these by the box full!

All the metal pieces that have been removed are cleaned with GoJo hand cleaner (the kind without pumice)

At this point I will mention that on some very old pieces (75A1, SX28), the IF cans often dull and develop a rough oxidized finish. These can be restored by rubbing with hand cleaner again, but the kind with pumice. Wash them down with soap and water when your done and they will be smooth again and look like new! I don't use the pumice cleaner on anything else except my hands!

I usually use only Windex on the chassis. I work it into the crooks and crannies with Q-tips and an old toothbrush. I cut up old T-shirts into little squares and use them as swabs. Slowly but surely I wipe away all the dirt.

Something a little stronger - Goof Off did the trick. It will eat at the silk screen on the chassis if you rub it very hard so try to avoid the silkscreen.

I have never installed an overlay on a dial drum. I just wipe these down with Windex also. I do this many times and gradually the old oxidized surface comes off. You have to know when to stop! It will not look as nice as an overlay, but it is original! Obviously if you go too far, you will need to install an overlay

On the subject of what to lubricate the contact surfaces with, I concluded that silver conductive grease is the thing to use. I found some at a local hardware store, ~ \$15 for a tiny syringe full! Its a bit pricey but seems to work quite well.

Aluminum RF cans sometimes become ingrained with dirt, which can be difficult to shift. Solvo Autosol Paste (available from car accessory shops) is good for cleaning these. Take great care not to let it get inside the cans or under the chassis.

I will pass along a mix that was passed on to me. 409 - 50% and Ammonia - 50%.

For the tiny little bearings in the rotary switches, I use teflon lube in a hypodermic type applicator (Do not get teflon on the switch contacts!).

When do I use DeoxIT (R5 Power Booster) vs ProGold vs PreservIT.

DeoxIT (R5 Power Booster). General purpose, for all metal surfaces. Use on non-critical metal surfaces with severe oxidation and corrosion on the metal surface. If there is a discoloration of the metal - it is severe. Use DeoxIT to dissolve the contamination. DeoxIT will also lubricate and protect the surface. For reference, DeoxIT has approximately 20% cleaning action.

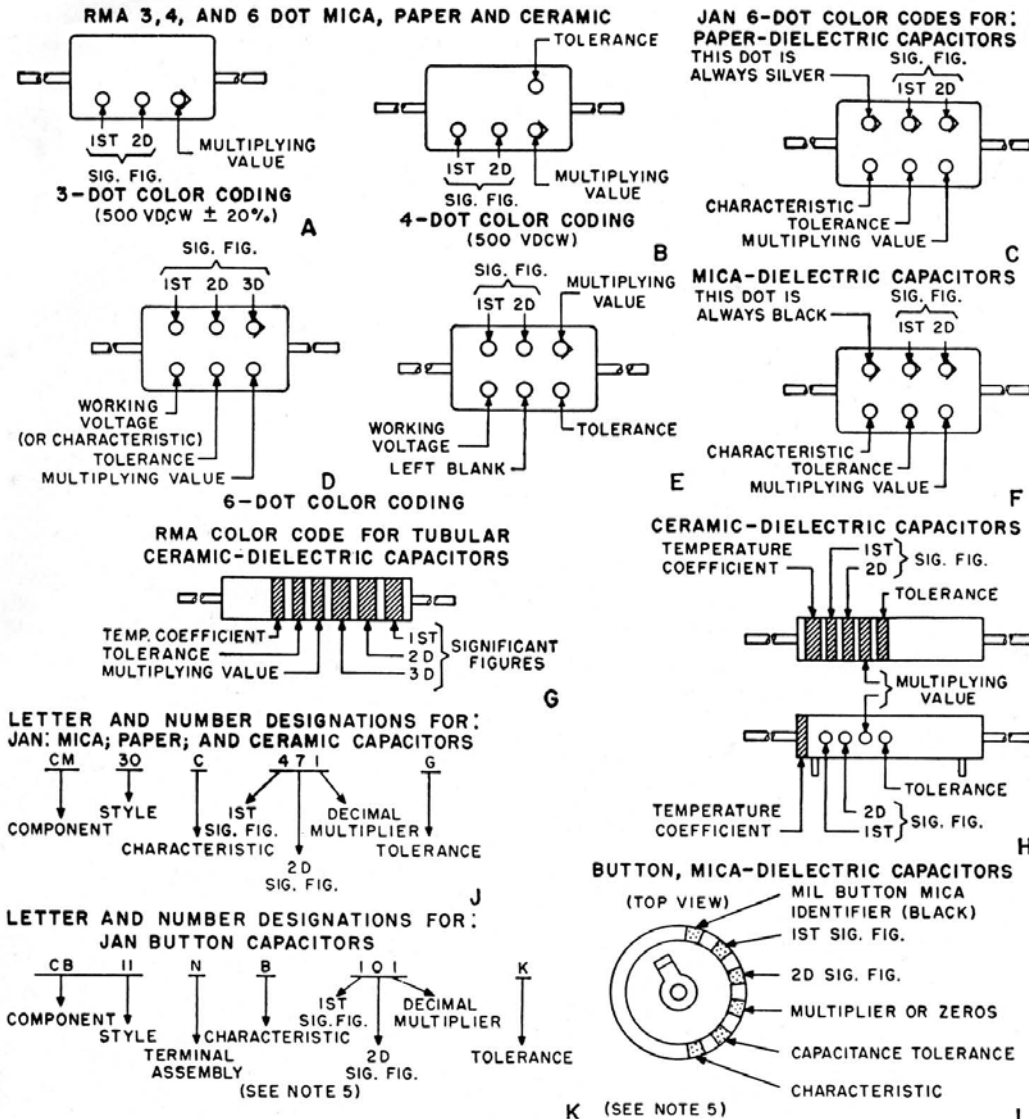
NOTE:

The R5 Power Booster concentrate (100% solution) is identical to the DeoxIT concentrate (100%). So all references to R5 Power Booster and DeoxIT concentrates will be the same. In 5% solutions, R5 Power Booster utilizes Dupont Vertrel solvents which are nonflammable and fast evaporating. DeoxIT 5% solutions use OMS (odorless mineral spirits which flammable, slower to evaporate and more cost effective.

ProGold. Plated surfaces (gold and other precious metals). Recommended for critical applications where only slight cleaning action is necessary. For reference, ProGold has approximately 0.5% cleaning action. If the surface looks clean, then applying DeoxIT first is usually not necessary. If there are small amounts of oxidation on the surface, ProGold will be able to dissolve this. ProGold should be applied after DeoxIT when it is a plated metal surface except where noted with PreservIT below. The more critical the connection/part, especially low current applications, ProGold should be the final step.

PreservIT. All metal surfaces. Seals and protects. Recommended after DeoxIT for best protection and NEW metal surfaces, usually in the manufacturing process. It is also ideal where high degrees of pollution (sulfur, salts, acids, etc.) are present. PreservIT should be applied to a clean surface - after using DeoxIT or other cleaning method. For reference, PreservIT has 0% cleaning action.

CAPACITOR COLOR AND LETTER CODES



- STANDARDS -					JAN MICA-CM		JAN PAPER-CM		JAN CERAMIC-CC					
COLOR	SIG. FIG.	DECIMAL MULTIPLIER	% TOL.	VDCW	LETTER TOL.	CHARACTERISTIC	LETTER TOL.	CHARACTERISTIC	DEC. MULT.	%	LETTER DESIGNATION	UUF	LETTER DESIGNATION	CHARACTERISTIC
BLACK	0	1	±20	500	M	A	M	A	1	±20	M	±2.0	G	C
BROWN	1	10	±1	100	-	B	-	E	10	±1	F	-	-	H
RED	2	100	±2	200	G	C	-	H	100	±2	G	-	-	L
ORANGE	3	1,000	±3	300	-	D	N*	J	1,000	-	-	-	-	P
YELLOW	4	10,000	±4	400	-	E	-	P	-	-	-	-	-	R
GREEN	5	100,000	±5	500	-	F	-	R	-	±5	J	±0.5	D	S
BLUE	6	1,000,000	±6	600	-	G	-	S	-	-	-	-	-	T
VIOLET	7	10,000,000	±7	700	-	-	-	T	-	-	-	-	-	U
GRAY	8	100,000,000	±8	800	-	-	-	-	0.01	-	-	±0.25	C	B
WHITE	9	1,000,000,000	±9	900	-	-	-	-	0.1	±10	K	±1.0	F	SL
GOLD	-	0.1	±5	1,000	J	-	-	-	-	-	-	-	-	A
SILVER	-	0.01	±10	2,000	K	-	-	-	-	-	-	-	-	-
NO COLOR	-	-	±20	500	-	-	-	-	-	-	-	-	-	-

* THE TOLERANCE OF THIS CAPACITOR IS ±30%, NOT ±2%

NOTES

- JAN: JOINT ARMY-NAVY
- RMA: RADIO MANUFACTURERS ASSOCIATION
- 1. THESE COLOR AND LETTER CODES GIVE CAPACITANCES IN MICROMICROFARADS
- 2. THIS TABLE IS ADAPTED FOR JAN AND RMA COLOR AND JAN LETTER TYPE DESIGNATIONS
- 3. CERAMIC AND MICA CAPACITORS, BOTH JAN AND RMA, ARE GENERALLY 500 VDCW
- 4. BUTTON CAPACITORS ARE GENERALLY 300 VDCW
- 5. READ BUTTON CAPACITOR TOLERANCE UNDER CERAMICS OF MORE THAN 10 UUF
- 6. CHARACTERISTICS ARE AVAILABLE IN JAN CAPACITOR SPECIFICATION MANUALS
- 7. THE COMPONENTS USED ABOVE FOR JAN LETTER TYPE DESIGNATIONS ARE:
 CC CERAMIC; CM MICA MOULDED; CW PAPER MOULDED

Capacitor Value Translation Table

Older and European schematics often use a different conventions for specifying capacitor valises. This table provides an easy method to compare conventions. This table was adapted from one posted by Just Radios of Canada. A good source for inexpensive tube (valve) equipment parts.

To use this table, just read across. For example, 1uF is same 1,000nF or 1,000,000pF.

uF/ MFD	nF	pF/ MMFD	uF/ MFD	nF	pF/ MMFD
1uF / MFD	1000nF	1000000pF(MMFD)	0.0082uF / MFD	8.2nF	8200pF (MMFD)
0.82uF / MFD	820nF	820000pF (MMFD)	0.008uF / MFD	8nF	8000pF (MMFD)
0.8uF / MFD	800nF	800000pF (MMFD)	0.007uF / MFD	7nF	7000pF (MMFD)
0.7uF / MFD	700nF	700000pF (MMFD)	0.0068uF / MFD	6.8nF	6800pF (MMFD)
0.68uF / MFD	680nF	680000pF (MMFD)	0.006uF / MFD	6nF	6000pF (MMFD)
0.6uF / MFD	600nF	600000pF (MMFD)	0.0056uF / MFD	5.6nF	5600pF (MMFD)
0.56uF / MFD	560nF	560000pF (MMFD)	0.005uF / MFD	5nF	5000pF (MMFD)
0.5uF / MFD	500nF	500000pF (MMFD)	0.0047uF / MFD	4.7nF	4700pF (MMFD)
0.47uF / MFD	470nF	470000pF (MMFD)	0.004uF / MFD	4nF	4000pF (MMFD)
0.4uF / MFD	400nF	400000pF (MMFD)	0.0039uF / MFD	3.9nF	3900pF (MMFD)
0.39uF / MFD	390nF	390000pF (MMFD)	0.0033uF / MFD	3.3nF	3300pF (MMFD)
0.33uF / MFD	330nF	330000pF (MMFD)	0.003uF / MFD	3nF	3000pF (MMFD)
0.3uF / MFD	300nF	300000pF (MMFD)	0.0027uF / MFD	2.7nF	2700pF (MMFD)
0.27uF / MFD	270nF	270000pF (MMFD)	0.0025uF / MFD	2.5nF	2500pF (MMFD)
0.25uF / MFD	250nF	250000pF (MMFD)	0.0022uF / MFD	2.2nF	2200pF (MMFD)
0.22uF / MFD	220nF	220000pF (MMFD)	0.002uF / MFD	2nF	2000pF (MMFD)
0.2uF / MFD	200nF	200000pF (MMFD)	0.0018uF / MFD	1.8nF	1800pF (MMFD)
0.18uF / MFD	180nF	180000pF (MMFD)	0.0015uF / MFD	1.5nF	1500pF (MMFD)
0.15uF / MFD	150nF	150000pF (MMFD)	0.0012uF / MFD	1.2nF	1200pF (MMFD)
0.12uF / MFD	120nF	120000pF (MMFD)	0.001uF / MFD	1nF	1000pF (MMFD)
0.1uF / MFD	100nF	100000pF (MMFD)	0.00082uF / MFD	0.82nF	820pF (MMFD)
0.082uF / MFD	82nF	82000pF (MMFD)	0.0008uF / MFD	0.8nF	800pF (MMFD)
0.08uF / MFD	80nF	80000pF (MMFD)	0.0007uF / MFD	0.7nF	700pF (MMFD)
0.07uF / MFD	70nF	70000pF (MMFD)	0.00068uF / MFD	0.68nF	680pF (MMFD)
0.068uF / MFD	68nF	68000pF (MMFD)	0.0006uF / MFD	0.6nF	600pF (MMFD)
0.06uF / MFD	60nF	60000pF (MMFD)	0.00056uF / MFD	0.56nF	560pF (MMFD)
0.056uF / MFD	56nF	56000pF (MMFD)	0.0005uF / MFD	0.5nF	500pF (MMFD)
0.05uF / MFD	50nF	50000pF (MMFD)	0.00047uF / MFD	0.47nF	470pF (MMFD)
0.047uF / MFD	47nF	47000pF (MMFD)	0.0004uF / MFD	0.4nF	400pF (MMFD)
0.04uF / MFD	40nF	40000pF (MMFD)	0.00039uF / MFD	0.39nF	390pF (MMFD)
0.039uF / MFD	39nF	39000pF (MMFD)	0.00033uF / MFD	0.33nF	330pF (MMFD)
0.033uF / MFD	33nF	33000pF (MMFD)	0.0003uF / MFD	0.3nF	300pF (MMFD)
0.03uF / MFD	30nF	30000pF (MMFD)	0.00027uF / MFD	0.27nF	270pF (MMFD)
0.027uF / MFD	27nF	27000pF (MMFD)	0.00025uF / MFD	0.25nF	250pF (MMFD)
0.025uF / MFD	25nF	25000pF (MMFD)	0.00022uF / MFD	0.22nF	220pF (MMFD)
0.022uF / MFD	22nF	22000pF (MMFD)	0.0002uF / MFD	0.2nF	200pF (MMFD)
0.02uF / MFD	20nF	20000pF (MMFD)	0.00018uF / MFD	0.18nF	180pF (MMFD)
0.018uF / MFD	18nF	18000pF (MMFD)	0.00015uF / MFD	0.15nF	150pF (MMFD)
0.015uF / MFD	15nF	15000pF (MMFD)	0.00012uF / MFD	0.12nF	120pF (MMFD)
0.012uF / MFD	12nF	12000pF (MMFD)	0.0001uF / MFD	0.1nF	100pF (MMFD)
0.01uF / MFD	10nF	10000pF (MMFD)	0.000082uF / MFD	0.082nF	82pF (MMFD)
			0.00008uF / MFD	0.08nF	80pF (MMFD)

0.00007uF / MFD	0.07nF	70pF (MMFD)	0.0000082uF / MFD	0.0082nF	8.2pF (MMFD)
0.000068uF / MFD	0.068nF	68pF (MMFD)	0.000008uF / MFD	0.008nF	8pF (MMFD)
0.00006uF / MFD	0.06nF	60pF (MMFD)	0.000007uF / MFD	0.007nF	7pF (MMFD)
0.000056uF / MFD	0.056nF	56pF (MMFD)	0.0000068uF / MFD	0.0068nF	6.8pF (MMFD)
0.00005uF / MFD	0.05nF	50pF (MMFD)	0.000006uF / MFD	0.006nF	6pF (MMFD)
0.000047uF / MFD	0.047nF	47pF (MMFD)	0.0000056uF / MFD	0.0056nF	5.6pF (MMFD)
0.00004uF / MFD	0.04nF	40pF (MMFD)	0.000005uF / MFD	0.005nF	5pF (MMFD)
0.000039uF / MFD	0.039nF	39pF (MMFD)	0.0000047uF / MFD	0.0047nF	4.7pF (MMFD)
0.000033uF / MFD	0.033nF	33pF (MMFD)	0.000004uF / MFD	0.004nF	4pF (MMFD)
0.00003uF / MFD	0.03nF	30pF (MMFD)	0.0000039uF / MFD	0.0039nF	3.9pF (MMFD)
0.000027uF / MFD	0.027nF	27pF (MMFD)	0.0000033uF / MFD	0.0033nF	3.3pF (MMFD)
0.000025uF / MFD	0.025nF	25pF (MMFD)	0.000003uF / MFD	0.003nF	3pF (MMFD)
0.000022uF / MFD	0.022nF	22pF (MMFD)	0.0000027uF / MFD	0.0027nF	2.7pF (MMFD)
0.00002uF / MFD	0.02nF	20pF (MMFD)	0.0000025uF / MFD	0.0025nF	2.5pF (MMFD)
0.000018uF / MFD	0.018nF	18pF (MMFD)	0.0000022uF / MFD	0.0022nF	2.2pF (MMFD)
0.000015uF / MFD	0.015nF	15pF (MMFD)	0.000002uF / MFD	0.002nF	2pF (MMFD)
0.000012uF / MFD	0.012nF	12pF (MMFD)	0.0000018uF / MFD	0.0018nF	1.8pF (MMFD)
0.00001uF / MFD	0.01nF	10pF (MMFD)	0.0000015uF / MFD	0.0015nF	1.5pF (MMFD)
			0.0000012uF / MFD	0.0012nF	1.2pF (MMFD)
			0.000001uF / MFD	0.001nF	1pF (MMFD)

Test Jigs and Adapters

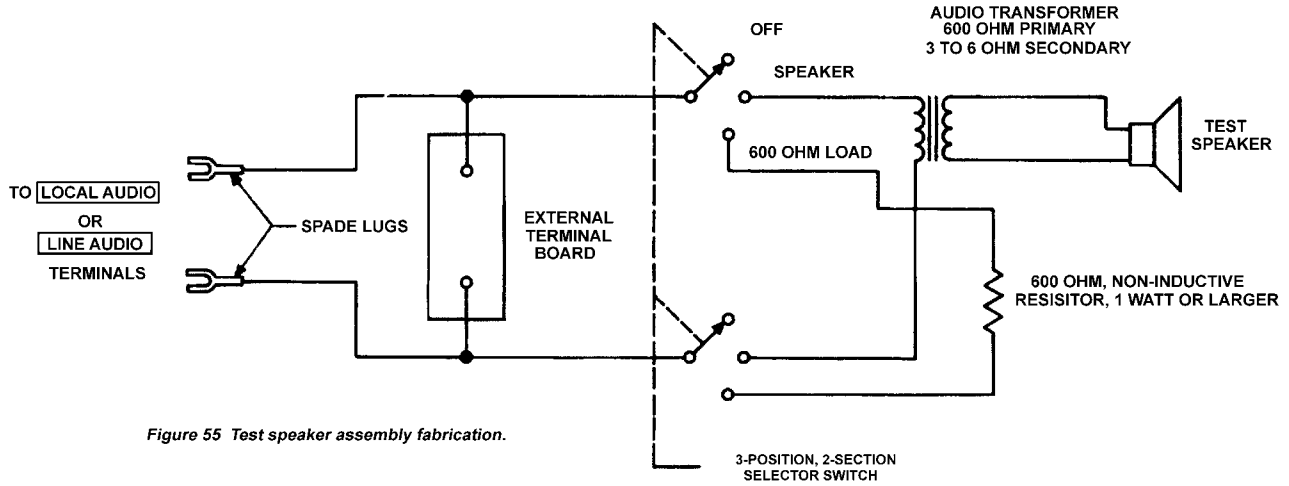


Figure 55 Test speaker assembly fabrication.

