modifying the Collins 51J receiver for ssb reception

If you're lucky enough to have one of the 51J-series receivers, here's an easy way to update it for single-sideband reception

One of the most popular surplus receivers is the Collins 51J series, available in limited quantities through MARS and some surplus stores. Designed in the mid 1950s, the stability, readout accuracy, and general excellence of this receiver literally revolutionized receiver design, setting the trend for most of the modern ssb receivers and transceivers. The immediate fallout from the 51J design was the well-known Collins 75A series of amateur-band-only receivers, followed by the present S-line.

The many virtues of the 51J series receivers do not include good ssb reception. An important modification is the inclusion of a product detector and alteration of the automatic gain-control loop to accommodate ssb signals. This article covers these modifications as well as other minor changes that make the 51J into a first-class receiver suitable for amateur service, including general-coverage operation.

Five models of the 51J receiver are available. The 51J-1 is quite rare; probably the quantity made was small. The 51J-2 and 51J-3 are fairly common on the surplus market; differences between the receivers are minor. The military R-388/URR is similar to the 51J-3. The 51J-4 was the latest production model and incorporates mechanical filters in the i-f system. A choice of three filters may be made with a panel switch.

At one time Collins made an adapter (Collins part number 354A-1) for the 51J-2 and 51J-3 that would modify the receivers for inclusion of crystal filters. The adapter is no longer in production.

The first job for the owner of a 51J is to align it correctly and test all the tubes. Complete alignment information is included in the Collins receiver manual and also in the military technical manual, *Radio Receiver R-388/URR*, TM-11-854, sometimes obtainable through MARS or surplus dealers.

receiver sensitivity

A common fault in most 51J receivers I've inspected is that overall gain is low and the receiver seems dead above about 15 MHz. Investigation has shown that receiver gain is reduced because of an uncommonly high bias voltage applied to the rf tubes. Bias is obtained from a voltage divider in the negative side of the high-voltage power supply (**fig. 1**). Normal bias voltage is −1.4 volts and, in the receivers tested, has usually run from −1.6 to −3.0 volts. This high

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negative voltage lowers the gain of the rf stages, leaving the receiver lifeless. Bias voltage is developed across resistor R149, which is 820 ohms, 1/2 watt. In many receivers, this resistor looks to be overheated or measures abnormally high in resistance. The cure is to remove R149 (which is located on a terminal strip on the inside wall of the receiver, near the line cord) and replace it with a 2-watt resistor of the proper resistance, which will develop a voltage drop of 1.4 volts across it. You'll find the value will run between 700 and 1000 ohms, depending upon your receiver.

receiver PTO

On occasion a 51J may be picked up for a song because the PTO (permeability tuned oscillator) "doesn't work." The usual cause of malfunction is a collection of matchstick capacitors in the PTO (C005, C006 and C008), which tend to short circuit after a few years of service. These are 0.01-μF, 400-volt capacitors of a design no longer made. Replacing these capacitors with 0.01-μF, 600-volt disc ceramic capacitors will usually restore the PTO to operation.[1]

the new product detector

Once the 51J has been aligned and is operational, the ssb modification may be added. The circuitry to

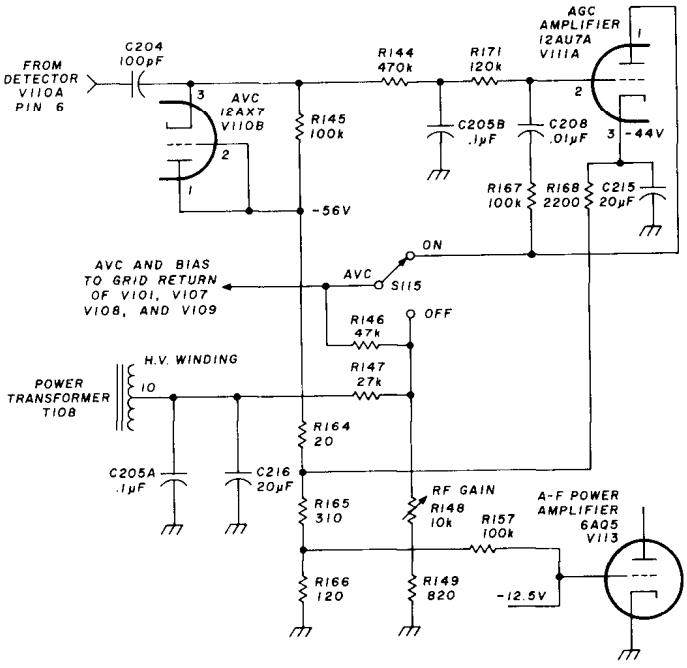

fig. 1. Agc and bias control portion of the 51J receiver. R149 establishes control-bias level. For a negative control voltage V110B and V111A operate below ground. Agc time constant is determined by R144 and C250B. External cathode-to-grid circuit (V111A) should be below 2 megohms after modification to prevent stray "gas current" in the 12AU7 from blocking the agc action. Audio amplifier bias is obtained from the negative source across R166.

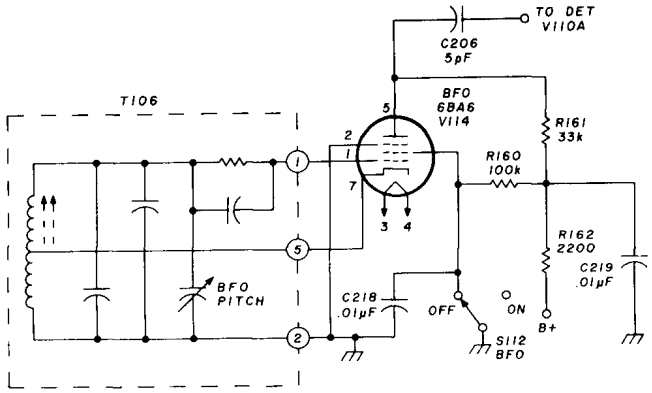

fig. 2. Original 51J BFO circuit. A 6BE6 tube is substituted for the original 6BA6 (V114) to provide a product detector. Tube is turned off by switch S112, which short circuits the screen voltage to ground. (See reference 2 for more details on the tube substitution.)

be modified is shown in **figs. 2, 3,** and **4**. The major alteration is in the beat-frequency oscillator (**fig. 2**), which is changed to perform as a product detector. To make this change, the receiver panel may have to be removed, as a new beat oscillator switch (S112) may be required. A 6BE6* is substituted for the 6BA6 BFO tube, and various circuit changes are made beneath the chassis. The final circuitry, after modification, is shown in **fig. 4**.

The first step is to start work on the BFO tube socket (XV114). Most Collins 51Js are wired with high-quality wire having a thin plastic coating, which can be easily damaged by a soldering iron. I suggest, therefore, that you use a small iron with a long, narrow point and proceed carefully so that you don't inadvertently burn any insulation on adjacent wires. Referring to **fig. 2**, remove the following components: R161 (33k), R160 (100k), R162 (2.2k), C218 (0.01 μF) and C219 (0.01 μF).

Next, capacitor C206 (5 pF) must be carefully disconnected from XV114 pin 5 and reconnected to pin 7. A 10k, 1/2-watt resistor is then connected between pin 7 and the adjacent ground lug. XV114 pin 2 is ungrounded and reconnected to the BFO transformer pin 5 (center pin) through the 220-ohm resistor and 0.01 μF combination.

The next step is to solder the 0.05-μF disc ceramic capacitors in place. One capacitor connects between pin 6 and the nearby socket ground post. The other, in the plate circuit, is attached to an existing terminal stud, which is screwed to the bolt holding the main filter capacitor socket. The 10k, 1-watt resistor is connected between the high-voltage terminal (pin 5 of C217B socket) and the terminal stud. The 47k, 1/2-watt resistor is placed between the stud and pin 5 of socket XV114.

*For additional information on the use of the 6BE6 product detector, see reference 2.

The final modifications at this point are to place the 0.1 μF filament bypass capacitor on the socket and revise the audio and agc circuitry.

audio-stage mods

The remainder of the modified circuitry is shown in **fig. 4**. The plate circuit filter components (two 470-pF capacitors and a 47k, 1/2-watt resistor) are mounted on a two-terminal strip placed under one bolt of coaxial socket J104 (marked **if output**). The 0.05 μF coupling capacitor is connected between this assembly and XV114 pin 5.

The 51J panel must now be removed to get at selector switch S112 (BFO OFF-ON) (**fig. 5**). If not, the switch will have to be replaced with the proper type (dpdt). The **A** section shorts the 6BE6 screen supply for am service. The **B** section switches the audio section of the receiver from the product detector to the diode detector, through limiter tube V112A. The audio takeoff point is XV112A pin 3.

To make the interconnections, three coax cables must be run from switch S112 to the rear of the receiver. For ease of wiring, the small-diameter RG-179/U is suggested. The outer braids of the three cables are grounded to the switch assembly on the panel. The cables are dressed into position and run to the respective termination points, at which place the shields are again grounded.

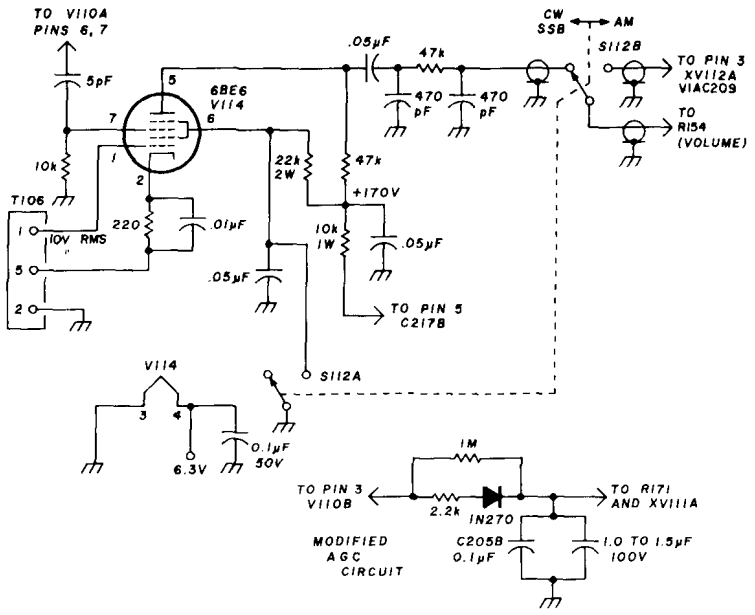

fig. 4. Revised product detector and agc circuit. Caps are ceramic except for the time-constant cap, which is Mylar (see text). BFO injection, measured at pin 1 XV114 socket, should not be more than 10V rms. Oscillator voltage can be set by varying the 22k, 2W screen resistor. Signal injection level is set by the value of the resistance between XV114 pin 7 to ground.

agc mods

To complete this step, capacitor C205A-B-C should be temporarily unbolted from the chassis and moved out of the way.

The agc loop in the receiver is designed to adjust the rf and i-f gain automatically for a-m signals. It must be modified for ssb reception. Pappenfus *et al*[3] recommends an attack time of about 0.002 second and a release time of 0.2 to 2 seconds. This time constant can be closely approximated within the limitations imposed by the 51J circuitry. The agc circuit is shown in **fig. 1**. The agc time constant, as the receiver stands, is about 0.06 second, determined by capacitor C205B and resistor R144.

It's theoretically possible to increase the time constant by increasing R144; however, there's an upper limit to the value of this resistance, as pointed out by my friend and colleague, W6PO, who reminded me that oxide cathode tubes such as the 12AU7 are restricted as to the maximum value of grid resistance, which should run less than two megohms.

The reason for this restriction is that a combination

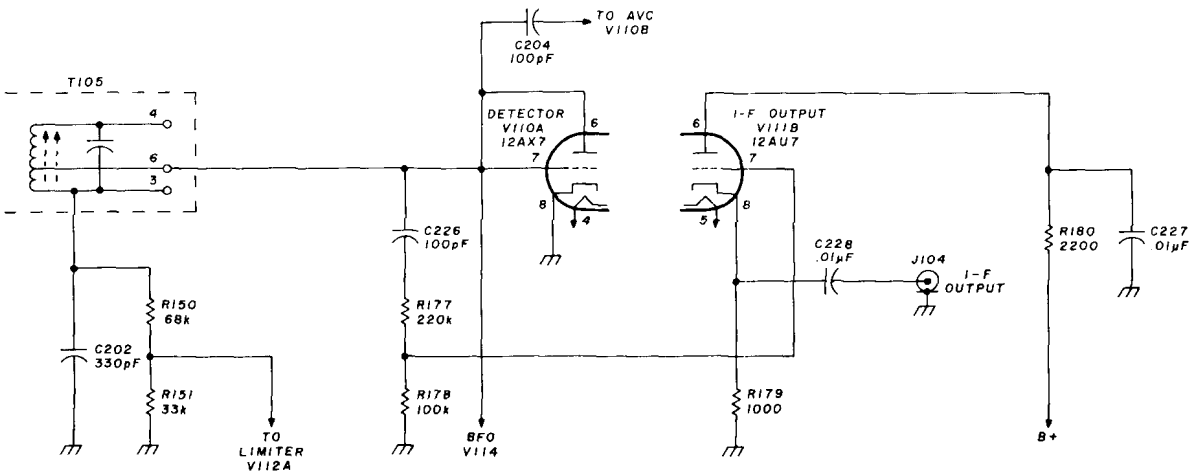

fig. 3. Detector and i-f output amplifier schematic. V110A is connected as a diode detector. Audio is recovered across R151.

of the Edison effect and the migration of oxide from the cathode to the grid as the tube ages can lead to grid emission. An electron flow caused by grid emission (even if only a microampere or so) can seriously disrupt the bias level when the grid resistor is an unreasonably high value. One microampere, for example, flowing through a 2-megohm resistor produces a 2-volt drop, enough to alter the operating characteristics of the 12AU7 agc amplifier tube. The flow of grid current can block the agc line, rendering the receiver inoperative. W6PO recommended that not more than 2 megohms, and preferably less, be used in the agc time constant circuit.

To achieve the desired results capacitor C205B (0.1 μF), which is part of the timing circuit, must be increased to at least 1 μF. The use of a low leakage, *Mylar* capacitor at this point is recommended. The capacitor can be placed directly from the center terminal of C205B to an adjacent ground lug. The resistive portion of the timing circuit is made up of a germanium diode and two resistors. The attack time is set by the 2.2k, 1/2-watt resistor and the release time by the 1 megohm, 1/2-watt resistor. The 1N270 diode disconnects the attack resistor during the discharge portion of the agc cycle. This tiny network is made up and then placed between pin 3 of socket XV110B and the adjacent terminal of capacitor C205B (**fig. 4**).

testing

After the wiring is checked, the receiver should be tested on a-m to make sure that all original circuits are working. When the BFO switch is turned on, the BFO may be adjusted for good ssb reception. Once satisfied the receiver is working properly, you can check out ssb operation.

The first step is to check for BFO harmonics. With the antenna off, tune the receiver to 1 MHz, 1.5 MHz, and 2 MHz. The BFO harmonics should be heard weakly at the lower frequency and should be in the receiver noise level above 3 MHz. If the harmonics are loud enough to be troublesome, the BFO level should be reduced by increasing the value of the 22k, 2-watt screen resistor on the 6BE6. Once the BFO harmonics have been reduced to your satisfaction (about 2 or less divisions on the S meter at 2 MHz), you can check the product detector for signal overload.

With the constants shown, the signal from the product detector will be somewhat less than that from the a-m detector. The receiver has ample audio gain, so this presents no difficulty. You should be able to tune in a needle-banging ssb signal and receive it crisp and clean. If audio distortion shows up as a growl on speech, this indicates that the product detector is being driven too hard by the i-f signal. The remedy is to reduce the value of the 10k, 1/2-watt resistor in the rf input leg of the 6BE6 XV114 pin 7. In some cases, this resistor value will be as low as 1.2k for low intermodulation distortion.

The 51J receivers vary a bit from one production run to another, and changes in harness layout affect the oscillator level injection, oscillator harmonics, and intermodulation distortion. However, the values

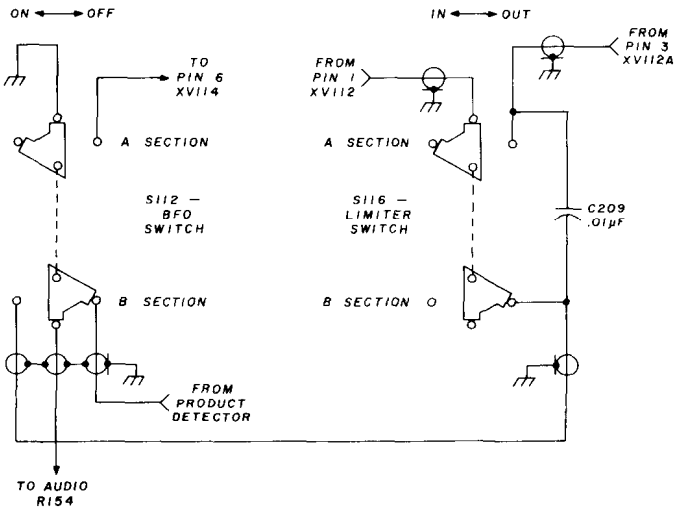

fig. 5. Many 51Js can be wired in this fashion for proper switching. If S112 and S116 are single-pole switches, they must be replaced with double-pole, 2-position, shorting switches. Note that section B of S116 is used only as a tie point for C209.

given in the schematic are representative and are a good place to start from.

parting thoughts

One baffling 51J receiver, after modification, overloaded on even the weakest ssb signal. A painstaking check revealed that some previous owner, anxious of wringing every decibel of gain out of the receiver, had changed the detector tap on transformer T105 from pin 6 to pin 4 (**fig. 3**). This upset the gain level of the receiver so that overload was inevitable. Changing the modification back to the original circuitry cured the trouble.

The modified 51J, especially if equipped with mechanical filters and a reduction tuning knob, is the equal of the best of today's ssb receivers. How many items of equipment, designed in the mid-1950s can equal that?

references

1. William I. Orr, W6SAI, "Collins 51J PTO Restoration," *ham radio*, December, 1969, page 36.
2. Lee, "The Single-Tube Pocket Detector," *CQ*, April, 1961, and Scherer, "More on Updated Improvements for the 51J Receivers," *CQ*, December, 1968.
3. Pappenfus, Bruene, and Schoenike, *Single Sideband Principles and Circuits*, McGraw-Hill Book Company, New York, 1964.

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