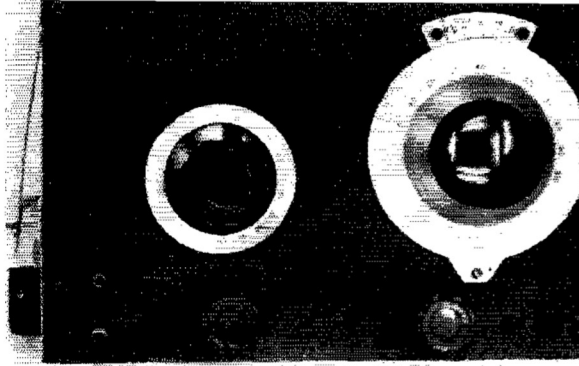


The vernier tuning dial on the right is a now-obsolete National sometimes found in surplus. The straight dial to the left controls the r.f. amplifier tuning. Below are the r.f. and audio gain controls.



Balanced Detector in a T.R.F. Receiver

A Novel Tuner for 40- and 80-Meter C.W. and S.S.B.

BY JAMES R. WHITE, * W2WBI

In this receiver, the principle of the product detector is used to obtain better selectivity and freedom from blocking in a simple t.r.f. receiver.

I GREW to know amateur radio in the early 1930s when the t.r.f. regenerative-detector receiver occupied a position of prominence in nearly every ham shack. The sensitivity of these relatively simple receivers was remarkable and many hams have fond remembrances of rare DX contacts on the then relatively unoccupied bands. Unfortunately, regenerative detectors have inadequate selectivity and are unable to reject overriding strong signals. Moreover, strong signals pull the detector frequency and even block the oscillation. As a consequence, amateurs today generally use superheterodyne receivers, some with two or three separate converter stages, and the simpler early receivers are of little more than historic interest.

Product Detectors

With the introduction of single-sideband techniques to amateur radio in the late 1940s, methods of detection came under new scrutiny. Product detectors soon came into use. These detectors are frequently mixers, mixing the needed local carrier in with the received sidebands, at the same time responding poorly as rectifiers for all signals simultaneously present in the i.f. pass band.

An early paper by Villard, W6QYT,¹ describes the differences between diode or linear detectors and frequency-converter detectors, later dubbed product detectors. In particular, this paper de-

scribes a balanced detector exceptionally well suited for use as an s.s.b. detector in superheterodyne receivers. In this detector, comprised of two frequency-converter tubes as shown in the diagram of Fig. 1, "each tube produces the same amount of audio output from rectification caused by nonlinearity of the control-grid-voltage, plate-current curve. But since the tubes are connected in push-pull as far as their outputs are concerned, these audio signals cancel out.² The local-oscillator voltage, on the other hand, is fed to the two tubes in push-pull, and consequently the audio outputs resulting from the beat between this oscillator and the incoming signal add up in phase at the output transformer." Villard pointed out that in a detector of this sort the only signals effectively detected are those that beat with the local oscillator and that the selectivity is then determined by the audio pass band.

While Villard's detector was originally intended as an s.s.b. detector in superheterodyne receivers, after some recent experimentation it became apparent that such a detector could so effectively reject all signals except those beating with the local oscillator that it could form the

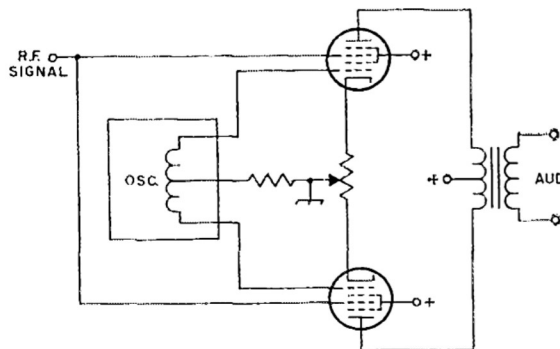
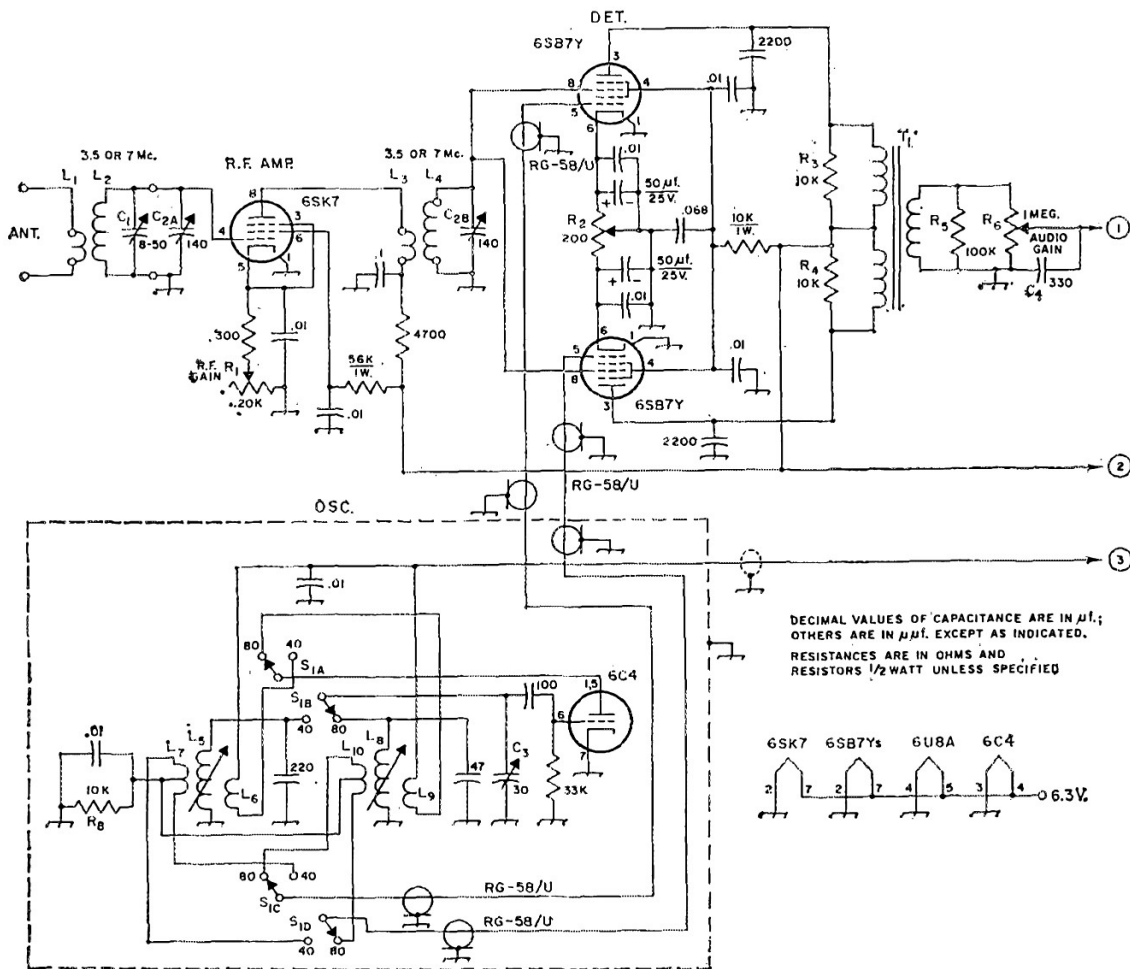


Fig. 1—Balanced detector circuit described by W6QYT.

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¹ Villard, "Selectivity in S.S.S.C. Reception," *QST*, April, 1948.

² The signal grids being in parallel.



basis for an s.s.b. and c.w. receiver that has *no r.f. selectivity whatsoever* ahead of the detector. At this point, a simple t.r.f. receiver, differing only in the detector from the receivers of the 1930s, was built. Experience with this simple receiver has been so favorable that it was felt that others might be interested.

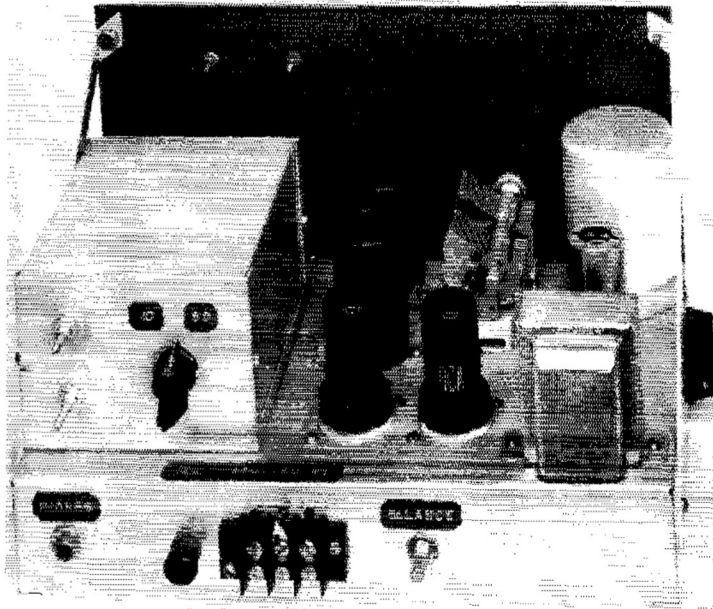
Receiver Circuit

The circuit diagram of the receiver is shown in Fig. 2. The 6SK7 r.f. stage is conventional in every respect. It is gang-tuned with the detector grid circuit by C_2 . Both circuits use plug-in coils to permit band changing. While these circuits provide some small r.f. selectivity along with gain, the selectivity is unnecessary and, in fact, it is helpful to stagger-tune these circuits slightly, thus creating a broad-banding effect that annihilates the r.f. selectivity. The receiver is tuned exclusively by varying the frequency of the local oscillator, and C_2 is adjusted solely for peaking-up incoming signals. C_2 need not be re-adjusted, after peaking for oscillator frequency

changes of at least ± 50 kc. The r.f. and detector tuned circuits are made to track by adjustment of ceramic trimmers (C_1) mounted inside each r.f.-stage coil form.

The balanced detector is similar to Villard's except that 6SB7Ys are employed in the frequency-conversion circuitry. These tubes permit a much higher conversion gain than obtainable with the 6L7s used by Villard. 6SA7s have been tested and also work well in this circuit. The balancing adjustment for this detector is easily made by coupling an amplitude-modulated signal into the detector grids and, with the local oscillator disconnected or detuned to a frequency where it does not beat with the signal, adjusting the cathode-balancing potentiometer, R_2 , for no audible detection of the signal modulation in the headphones. This condition occurs roughly at the center of the potentiometer range. Once the adjustment has been made it need not be repeated unless the detector tubes change characteristics.

The oscillator circuit is also conventional except that a push-pull output signal is obtained from the center-tapped coupling coils, L_7 and L_{10} .



In this view of the receiver, the oscillator is enclosed in the aluminum box to the left. The band switch is mounted on the rear wall of this box. The plug-in r.f. stage coil is enclosed in the shield can in the upper right-hand corner. Audio and detector components are to the rear.

tectors are in the center rear, the 6SK7 r.f. stage is adjacent to the front panel, and the 6U8A are on the far right. The plug-in coil for the r.f. grid circuit is shielded in the removable aluminum can on the right. The detector plug-in grid coil is unshielded. The band-changing switch S_1 is at the rear of the oscillator box, beside the adjustment screws for the permeability-trimmed oscillator coils.

The receiver requires a power supply of 225 to 250 volts at 30 ma., 150 volts at 8 ma. (regulated by a VR tube) and 6.3 volts at 1.5 amperes.

Adjustment

The receiver is most conveniently adjusted for operation with the aid of a signal generator with modulated output. If the generator is not available, the alignment can be done by listening on the ham bands. The principal adjustments required are (1) the setting of the oscillator permeability-trimmed coils to center up the 40- and 80-meter bands on the dial, (2) the adjustment of the r.f. trimmer capacitors to secure rough tracking of the r.f. and detector tuned circuits, and (3) the adjustment of the detector balancing potentiometer. This latter adjustment, with the aid of a modulated oscillator, has been previously mentioned; it can also be made by tuning in a

very strong a.m. signal, using C_2 . With the oscillator tuned to a different frequency, the potentiometer is adjusted for minimum detection of the a.m. signal.

This receiver tunes in much the same manner as a superheterodyne receiver with a fairly broad

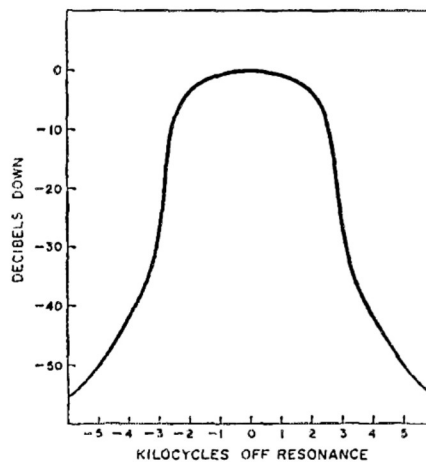


Fig. 4—Frequency characteristic of the filter of Fig. 3.

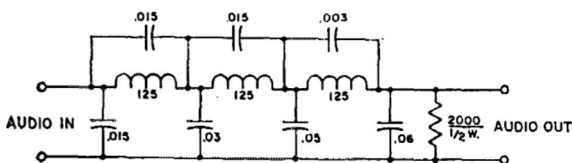
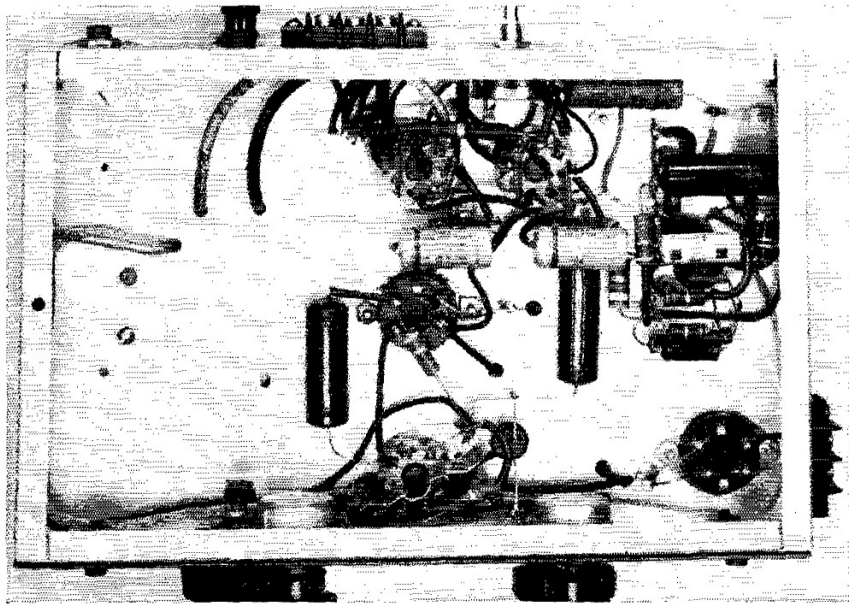


Fig. 3—Simple audio filter for better selectivity. Capacitances are in $\mu\text{f.}$, inductance in millihenrys and resistances in ohms.

i.f. pass band and a good product detector. Each c.w. carrier will produce two audio signals, one on each side of zero beat. By the use of a peaked audio filter, such as the Selectoject, following the receiver, these two signals can each be made to occupy a band a few hundred cycles wide. Single-sideband signals are received when the local oscillator frequency coincides with the needed carrier injection frequency. Double sideband signals are also receivable. A.m. signals are receivable but



Bottom view of the balanced-detector receiver.

only when the local oscillator frequency coincides precisely with the a.m. carrier. When the frequency deviates even slightly, the a.m. modulation flutters at the difference frequency sufficiently to render proper reception difficult.

More Selectivity

A rather simple audio filter following the receiver, such as that shown in Fig. 3, adapted from a design in the 1949 ARRL *Handbook*, produces the over-all selectivity characteristic of Fig. 4. This particular filter, although it attenuates more than might be desired, has proven to be very effective in receiving s.s.b. signals.

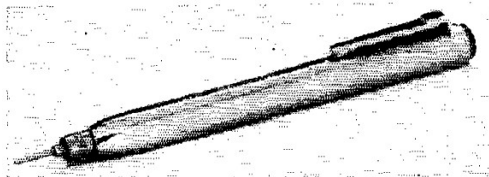
There is, of course, no discernible pulling of the oscillator by the received signal. Moreover, the modulation on strong signals adjacent to those which are being detected does not "ride through." Under the worst circumstances, when a *very strong* modulated signal is present adjacent to a weak signal being received in the broad r.f. pass band, a slight background hash can be heard.

When provided with a 25- or 30-foot antenna, the sensitivity of the receiver is more than adequate for reception of 40- and 80-meter signals. Since relatively few stages are used, however, the receiver does not have the gain of a multistage superheterodyne receiver. QST

• New Apparatus

Transistorized Signal

THE interesting gadget shown in the photograph is called the "Mosquito" and is manufactured by the Don Bosco Electronics, Inc., Hanover, New Jersey. It's a transistor oscillator powered by a single 1½-volt penlight cell. The oscillator runs at about 2000 cycles but, since the wave shape is square, it puts out harmonics well up into the r.f. range. It can be used as a test-signal source



for both transistor or vacuum-tube equipment and is useful at audio, intermediate and radio frequencies. Only 5½ inches long, ½ inch in diameter and weighing but 1 ounce, the chrome-plated "Mosquito" is in the shape of a mechanical pen or pencil, and even has a clip, which doubles as the on-off switch, for attaching it to the inside of a pocket. The injector is turned on by moving the clip holder down and is put into operation by touching the tip to the circuit under test. For some applications, it is necessary to ground the shell to the equipment. The device can also be inductively coupled to magnetic devices by placing it a few inches away from the unit under test. We connected the "Mosquito" to the terminals of a vacuum-tube communications receiver and the harmonics were still loud and clear at 30 Mc. — E. L. C.