TWO INTERFERENCE NULLERS

By JACK ALTHOUSE and OTIS VAN HOUTEN

IN COMMUNICATION RECEIVERS (CB, commercial two-way, SWL or amateur) heterodyne interference from undesired signals is a constant problem. Here is a pair of construction projects, both solid-state, and each with its own solution to the problem.

Selectoject

Devised some years ago, this circuit was named for what it does: select, oscillate, or reject. It works in the audio section of the receiver, where it can (a) select a narrow band for amplification, rejecting all others, or (b) reject only a narrow slice of frequencies.

In the *select* mode, shown in Fig. 1, a selected frequency is boosted. The first phase shifter operates only at the desired frequency, while the third shifter (or inverter) works at all frequencies. Because of the feedback loop, the selected frequency is shifted 360° (180° by each inverter) and added to the input. The combined signal at that frequency has a greater amplitude (adjusted by the SELECTIVITY control) than the original. Since all other frequencies are only shifted 180°, they tend to partially cancel out.

In the *reject* mode (shown in Fig. 2) the selected frequency is split into two channels. The second and third shifters give all frequencies a 180° shift, but the first inverter gives the selected frequency an additional 180°. When the two channels are combined, the selected frequency cancels out.

To make the circuit oscillate, it's only necessary to place it in the *select* mode and increase feedback until it equals the input. At this point the unit becomes a perfectly good audio oscillator for testing.

This Selectoject uses FET's, which are ideally suited for phase inverters. Not only are they made in both p- and n-channel types, they are high-impedance devices which will match most existing receiver circuits.

Fig. 3 is the schematic of the Selectoject. To maintain symmetry, you should use matched pairs for R1–R2 and R5–

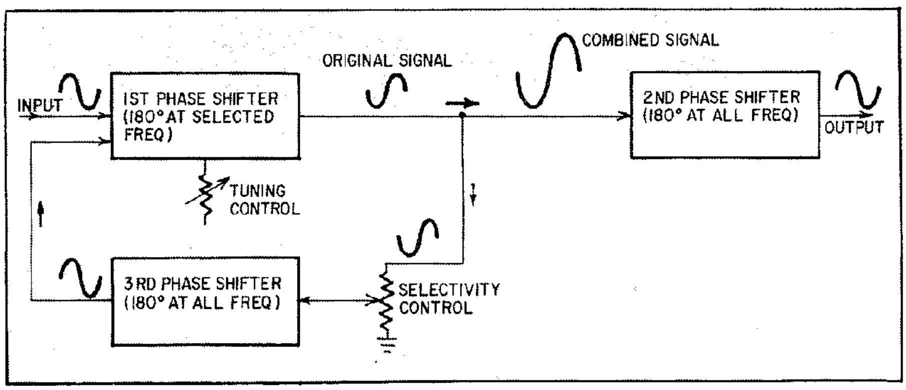


Fig. 1—When operating in the "select" mode, the Selectoject uses positive feedback to increase the amplitude of the desired narrow band of frequencies fed to the output.

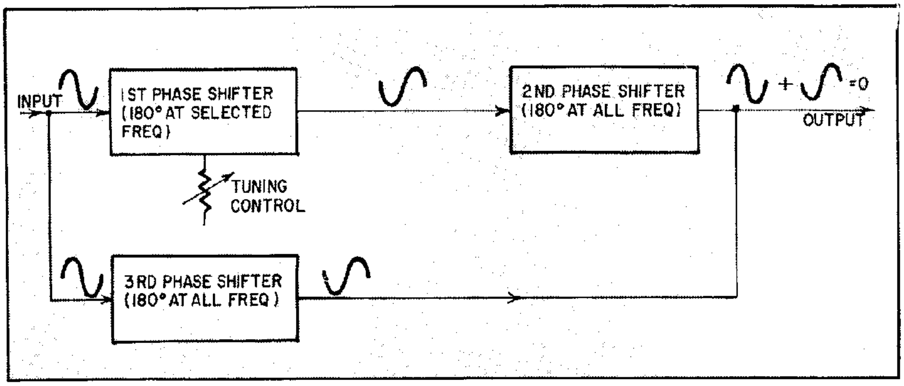
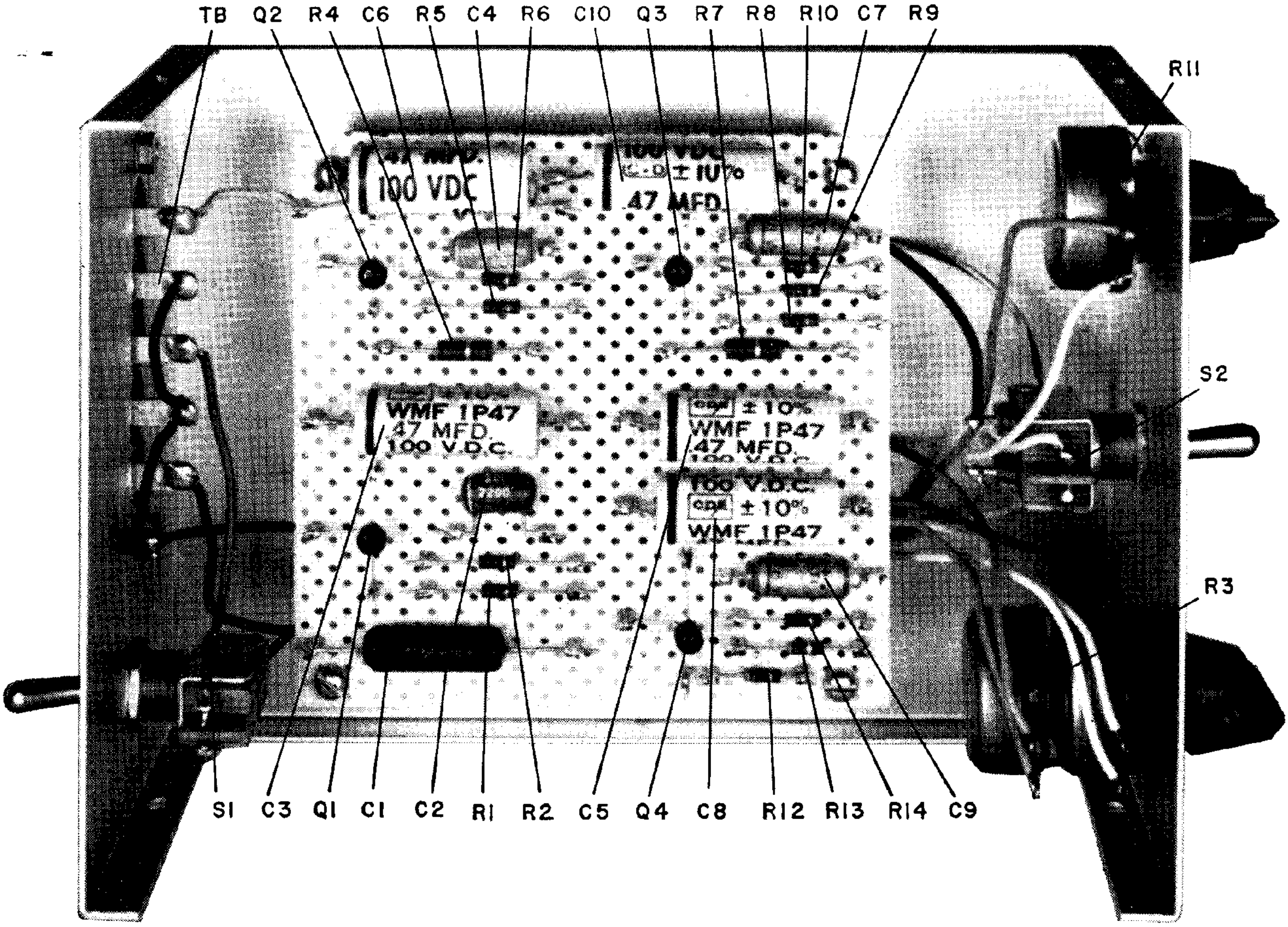


Fig. 2—The Selectoject can also reject a narrow frequency range. This is accomplished by inverting part of the signal so it cancels itself. Other frequencies are unaffected.



Selectoject Parts List

C1—.01 μF, 200 volts
C2, C4—.0022 μF, 100 volts
C3, C5, C6, C8, C10—0.47 μF, 100 volts
C7, C9—10 μF, 10 volts, electrolytic
Q1, Q2, Q3, Q4—2N4360 FET, Fairchild (send post card to Marketing Services, Fairchild Semiconductors, 313 Fairchild Drive, Mountain View, Calif., and request name and address of your nearest Fairchild stocking distributor)
R1, R2—2,200 ohms (matched pair)
R3—dual pot, 500K audio taper
R4, R7—2.2 meg
R5, R6—2,200 ohms (matched pair)
R8—1,000 ohms
R9, R13—220 ohms
R10, R14—2,200 ohms
R11—pot, 1 meg, audio taper
R12—4,700 ohms
All fixed resistors ¼ watt
S1—spst toggle switch
S2—dpdt toggle switch
Miscellaneous—5-terminal strip, 4½ x 4½-in. perforated board, 7 x 5 x 3-in. metal box, terminals and spacers for board.

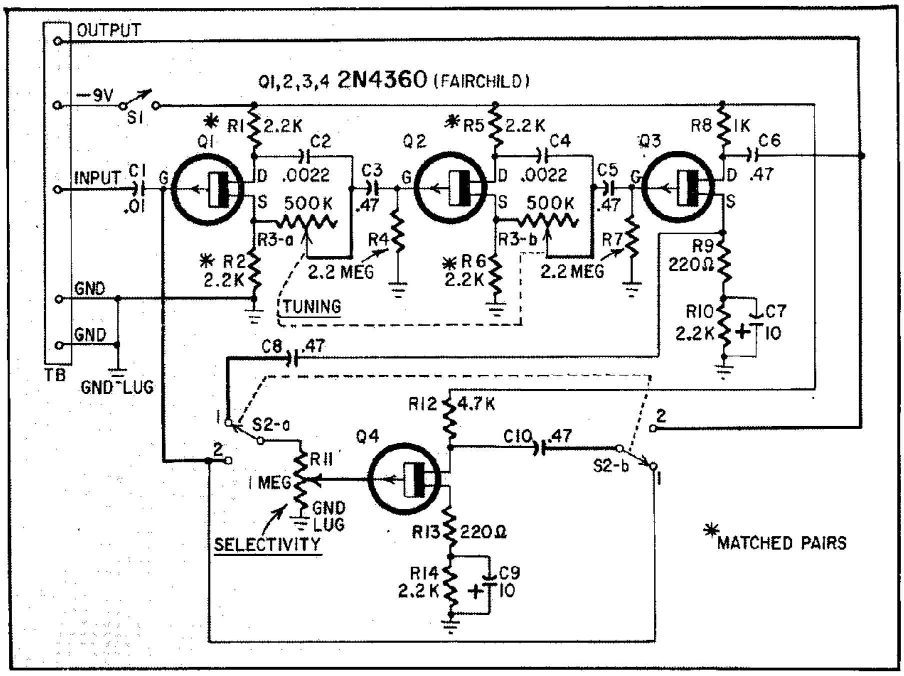


Fig. 3—FET Selectoject circuit is obviously much like the old vacuum-tube version. Heavy lines are those wires which join the perforated board to the case components.

R6. You can buy 1% resistors, or use an ohmmeter to select close pairs from a number of 2,200-ohm units.

The easiest way to build the Selectoject is to mount and wire the components on the 4½ x 4½-inch perforated board as shown in the photo above. But drill mounting holes both in the board and in the 7 x 5 x 3-inch box first. Wires from the board to the panel components are drawn in heavier lines in Fig. 3.

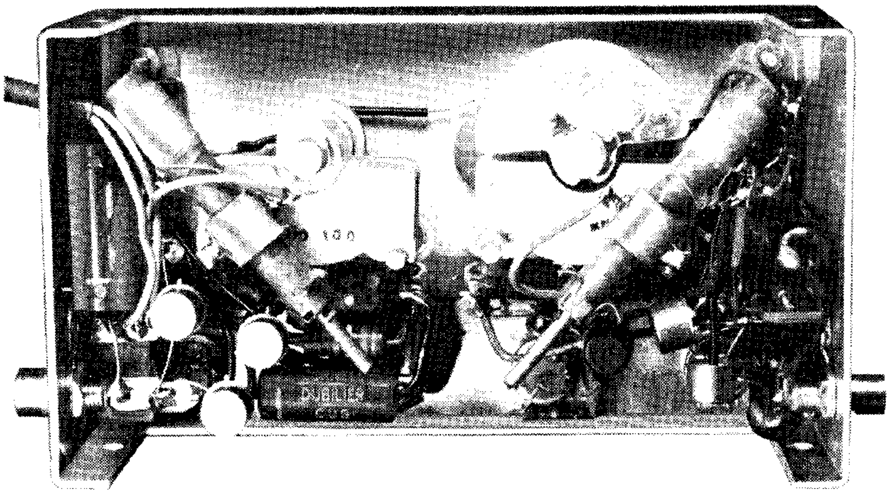
FET lead arrangement is shown in Fig. 4-a, while 4-b shows how to bend the leads for board mounting.

The battery isn't shown in the schematic, for you may want to power your unit from an external source. There is room in the box, however, to mount a

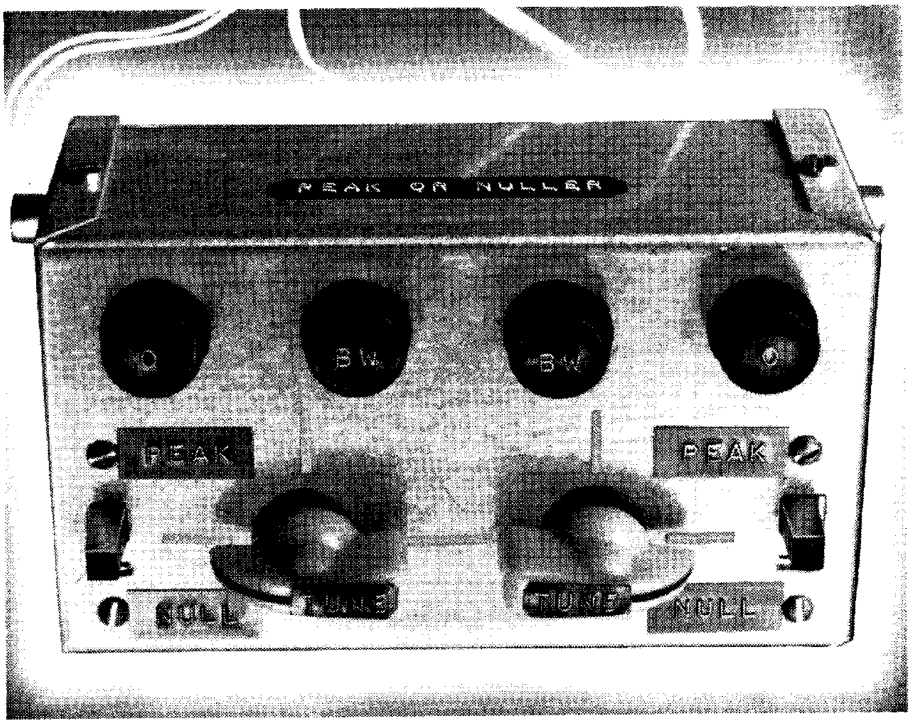
9-volt transistor battery. As the Selectoject draws only about 4 mA, a zinc-carbon type (NEDA 1604) should last about 48 hours. A mercury battery (NEDA 1604M) will be good for two or three times that.

This device is made to work into a high-impedance receiver audio section, and should be connected as shown in Fig. 5.

In practice, you'll find it easiest to reject a single heterodyne with the TUNING control. SELECTIVITY controls the amount of null or boost. If an interfering signal produces a fundamental and harmonics, you'll probably get best results in the *select* mode, tuning for best signal-to-noise ratio.



One author built two Q multipliers in a single case, to have double nulling capability.



Front view of the completed twin Q multiplier (Peak or Nuller) receiver accessory.

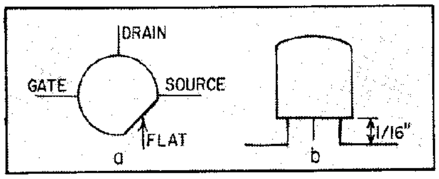


Fig. 4-a—You'll find the FET lead coding easy to make out, but there's one thing you won't believe. It makes no difference if drain and source leads are interchanged! b—To facilitate mounting on the perforated board, bend FET leads like this.

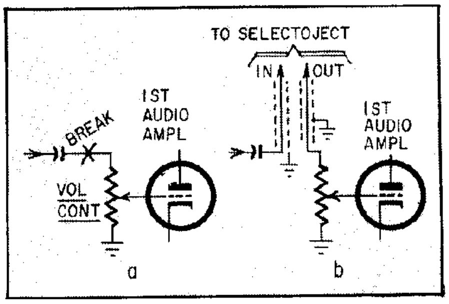


Fig. 5—Follow these steps to connect Selectoject to audio section of receiver.

Q multiplier

Another way of getting rid of heterodyne interference in a receiver is by varying the Q of the i.f. circuit. For instance, the Colpitts oscillator of Fig. 6, when connected in a receiver i.f. stage, will vary the selectivity depending on the position of R3.

With R3 set for zero resistance, maximum positive feedback occurs and the circuit oscillates at a frequency determined by L, C1, C2 and C5. Under this condition, the Q of the LC tank is almost infinite, producing high gain around the selected frequency. The effect in the receiver is the same as rejecting all other frequencies. By adding a third transistor, the circuit can null out a narrow frequency range.

The frequency of the *peak* or *null* can be varied over a 25-kHz range centered on 455 kHz. *Peak* bandwidth is adjustable from 1 to 20 kHz, while *null* bandwidth can be widened to eliminate most typical voice signals. The entire circuit can, depending on control settings, provide voltage gains from 5 to 10.

Refer to Fig. 7 for circuit function. The input is isolated from the receiver by R1, and the output is similarly isolated by its connection to the feedback-stage (Q2) emitter. This makes cable connections to the receiver uncritical.

In the *peak* mode, the i.f. input signal is applied to a voltage divider consisting of R1 in series with the parallel combination of R2, the input impedance of Q1, and the resonant impedance of the tank. At the tank's resonant frequency (f_R) the input impedance of Q1 is high due to the bootstrap feedback connection through R3. But at frequencies other than f_R, circuit impedance is much less, as is developed voltage.

Emitter follower Q2 isolates the input and output stages, and the output is taken from the collector circuit of Q3.

In the *null* mode, the signal from output amplifier Q3 is fed back to the input tank. This negative feedback

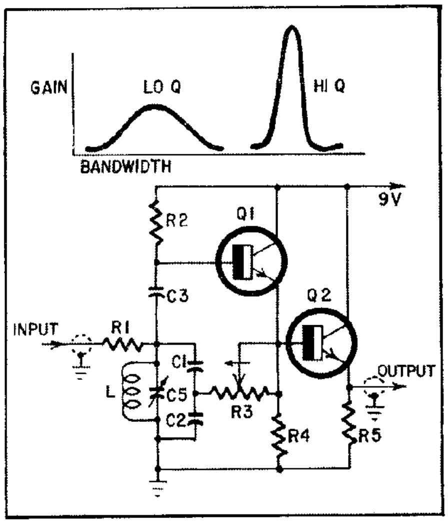


Fig. 6—A Colpitts oscillator can be used as a Q multiplier in a receiver i.f. stage.

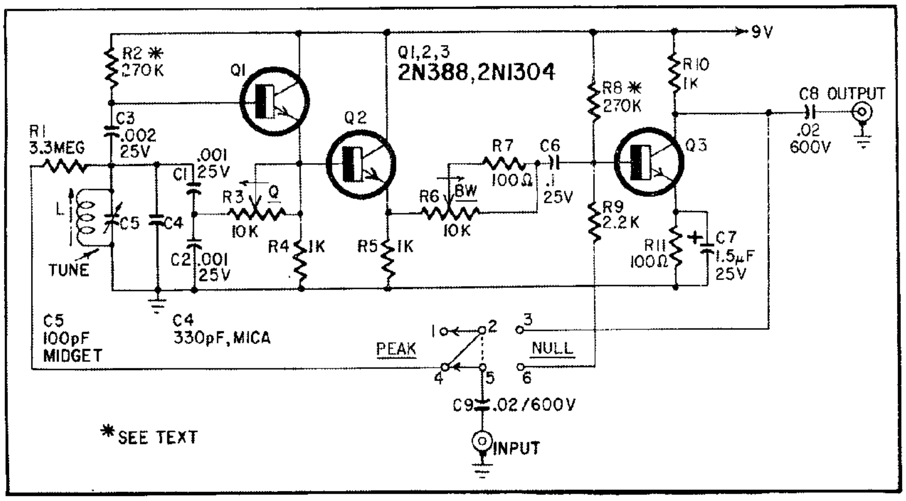


Fig. 7—Complete schematic of the solid-state Q multiplier. For greater flexibility in interference rejection, you may want to build two and put them in series. You'll then be able to cut through much hash by nulling out two signals, and copy cleaner signals.

causes gain to be very low at f_R, producing a notch (or null) in the i.f. response curve.

Construction requirements aren't critical, with two exceptions: R2 and R8, nominally 270 K, should be chosen to drop half the supply voltage to the respective bases of Q1 and Q3. The transistors may be npn's like the 2N388, 2N365A or 2N1304. Specifications should be at least the following: f_{ab} 5+ MHz, E_{ce} 20+ volts, P_c 100+ mW, h_{fe} 100+.

As shown in the photo, you can build the Q multiplier with point-to-point wiring in a small box. (The model shown is actually two separate Q multipliers in series, which permits more effective deheterodyning.) Or you may prefer a perforated board. Be sure the tank circuit components are rigidly mounted in a box with tight corners, for proper shielding.

Signal connections are shown in Fig. 8. Remove the agc connection to the i.f. transformer, and ground the bottom of the winding. Then add a 470K resistor from the last i.f. grid to the agc line just disconnected. Use shielded cable to connect the Q multiplier to the *in* and *out* points shown in Fig. 8.

If you wish, you may use a 9-volt battery to power the system (as mentioned above). To avoid the nuisance of changing batteries, you can alternatively steal the approximately 20 mA needed (for the twin version) from the receiver audio output stage, as illustrated in Fig. 9. Dc cathode voltage should be in the range of 8–13. The effective power-circuit resistance of the twin Q multiplier is about 450 ohms, so you can substitute the circuit for an existing output-stage cathode resistor in the range of 400–500 ohms. If your receiver uses another value, you'll have to shunt it with an added resistor to equalize the load. Be sure to use a cathode bypass electrolytic of about 50 to 100 μF at 25 volts—add one if not already present.

Q Multiplier Parts List

- C1, C2—.001 μF, 25 volts
- C3—.002 μF, 25 volts
- C4—330 pF, mica
- C5—100 pF, midget variable
- C6—0.1 μF, 25 volts
- C7—1.5 μF, 25 volts, electrolytic
- C8, C9—.02 μF, 600 volts
- L—40 to 300 μH variable (J. W. Miller 2002, or equivalent)
- Q1, Q2, Q3—2N1304 (see text) or equivalent
- R1—3.3 meg
- R2, R8—270K (see text)
- R3, R6—pot, 10K linear taper
- R4, R5, R10—1,000 ohms
- R7, R11—100 ohms
- R9—2,200 ohms
- **All fixed resistors ½ watt**
- Miscellaneous—input and output phono jacks, aluminum case, tie strips, shielded cable.

To align the circuit, apply a 455-kHz signal to the input jack. With C5 (the TUNE control) in the middle of its range and the switch set to PEAK, adjust L for maximum output. Be sure the Q and BW controls are at midrotation, with Q set just below oscillation point.

In operation, the TUNE control adjusts the position or frequency of the peak or null. The bandwidth control sharpens or broadens, and the Q control adjusts the height or depth of the peak or null. For initial adjustment, tune in a signal on the receiver with the switch in the NULL position and the TUNE control detuned. Turn the bandwidth control to maximum clockwise position and rotate the Q control until you hear a squeal in the speaker—indicating oscillation. Now turn the Q control counterclockwise until oscillation just stops. The Q control is now properly adjusted.

So there you are—take your choice, get out that soldering tool, and start your way toward slicing out interference! END

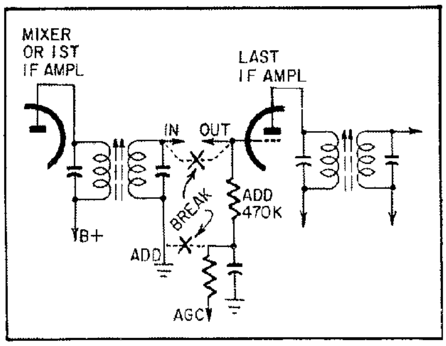


Fig. 8—Q multiplier connection to receiver.

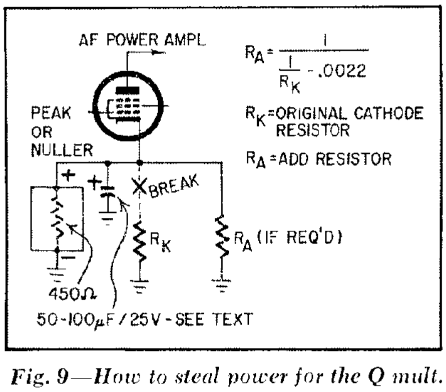


Fig. 9—How to steal power for the Q mult.