

A VHF-UHF TELEVISION TURRET TUNER

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Summary—A sixteen-position turret type of tuner covering both the very-high-frequency (VHF) and ultra-high-frequency (UHF) television channels has been designed and tested. The measured electrical performance data and field tests of the tuner indicate that it gives excellent performance.

INTRODUCTION

WITH the advent of ultra-high-frequency television and the subsequent allocation of specific UHF channels, the need for a VHF-UHF television tuner becomes apparent. This tuner should ideally make the maximum use of the same components on VHF and UHF, so that there would be a minimum duplication of parts. This design should be one which would give optimum performance and still be easy to fabricate and align. The tuner should also use a 41-megacycle intermediate frequency to take full advantage of the protection from interference which the Federal Communications Commission provided in its channel allocation plan. A sixteen-position turret type of tuner which has been developed accomplishes some of the objectives of the ideal tuner. A careful study of the television channel allocations showed that sixteen positions on the turret would cover channel requirements of almost any receiver location in the United States. This report describes the technical aspects of the television tuner.

GENERAL DESCRIPTION

The tuner covers both the VHF and UHF television channels. Figure 1 is a photograph of the tuner showing the drive assembly and channel indicating system.

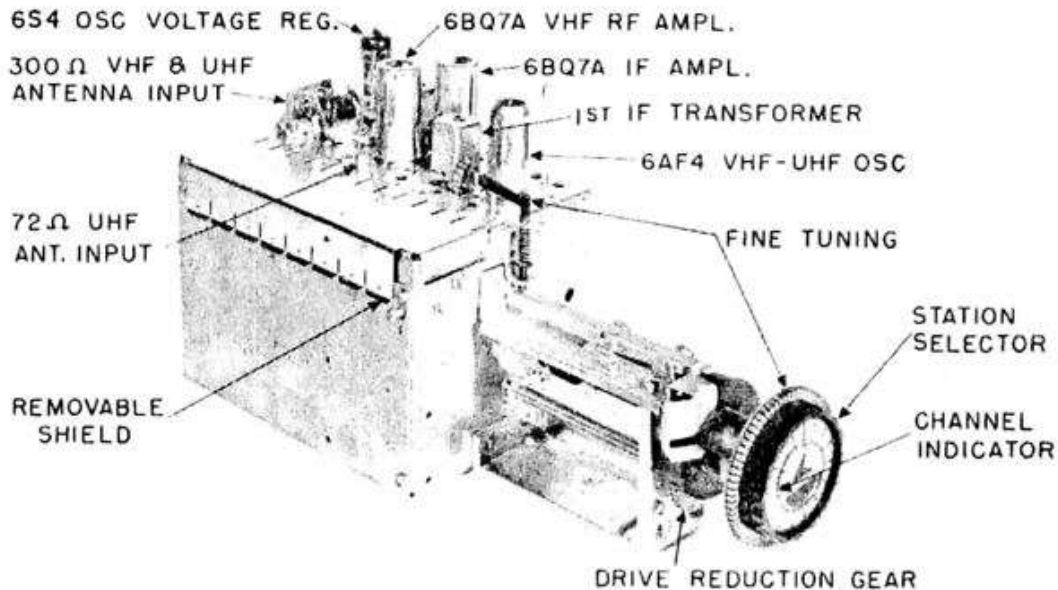


Fig. 1—VHF-UHF tuner.

A 2:1 step down ratio is used for the turret drive system for ease of tuning. Figure 2 shows the turret with its divided shielding compartments, inside the main housing. The tube complement for this tuner consists of a 6BQ7A for the VHF radio-frequency (r-f) amplifier, a 6AF4 for the VHF-UHF oscillator, a 6BQ7A for the intermediate-frequency

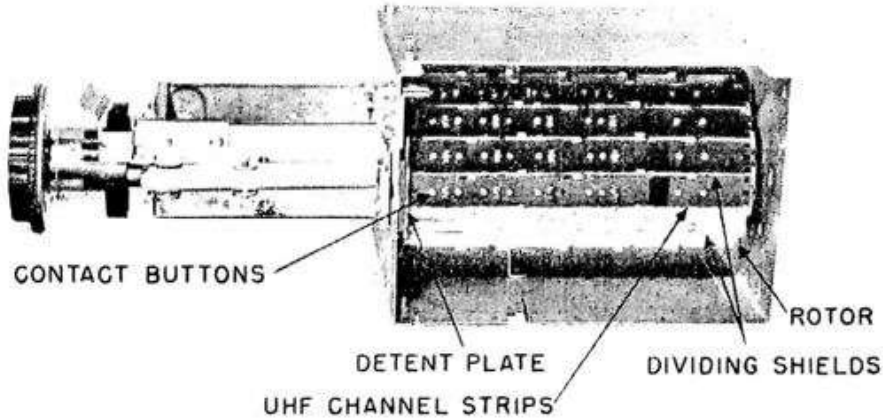


Fig. 2—Turret and housing of VHF-UHF tuner.

(i-f) amplifier, and a 6S4 for the oscillator plate voltage regulator. A 1N82 silicon crystal is used in the mixer circuit for both VHF and UHF. In the VHF range a low-noise r-f amplifier is used before the crystal mixer which, in turn, is followed by another low-noise stage operating on the 41-megacycle intermediate frequency. For the UHF, the arrangement is similar except there is no r-f amplifier ahead of the crystal mixer. Figures 3a and 3b show block diagrams of the tuner operating at VHF and UHF. Figure 4 is a bottom view of the r-f shield showing some of the circuits described.

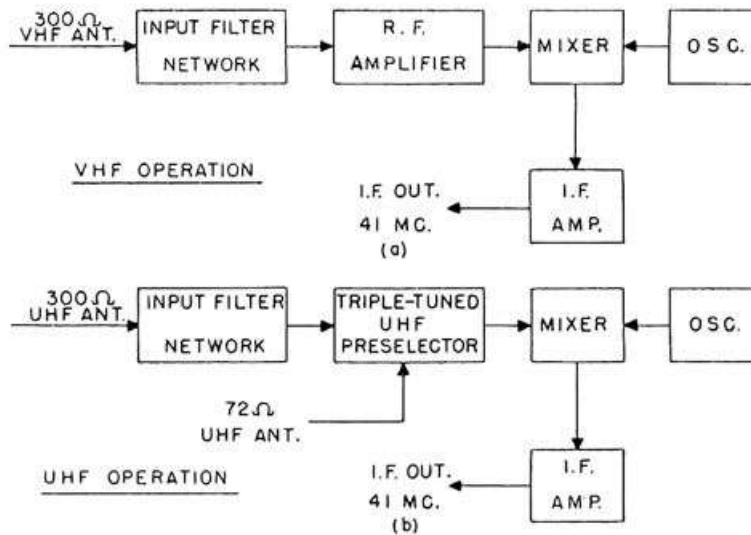


Fig. 3—Block diagram of VHF-UHF tuner.

The antenna input circuit for the VHF portion of the tuner consists essentially of a single-tuned circuit with the 300-ohm balanced antenna input tapped down on this circuit for impedance match. A double-tuned circuit is used between the r-f amplifier and the crystal mixer, with the crystal tapped down on the secondary circuit to obtain the proper circuit loading. Four different channel strips, shown in Figure 5, are used for the VHF range. On UHF, a

triple-tuned preselector is used between the antenna input and the crystal mixer. Both 72-ohm unbalanced and 300-ohm balanced antenna input impedances are available on UHF. Two different channel strips are used to cover the frequency range from 470 to 890 megacycles; these are shown in Figure 6.

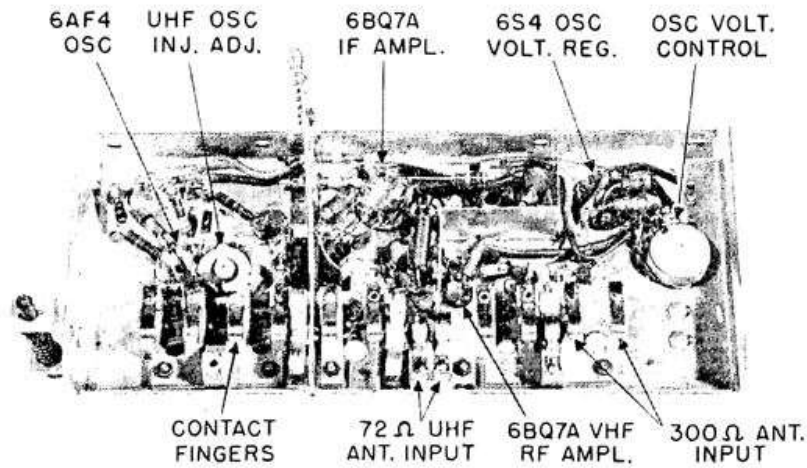


Fig. 4—Bottom view of r-f shelf.

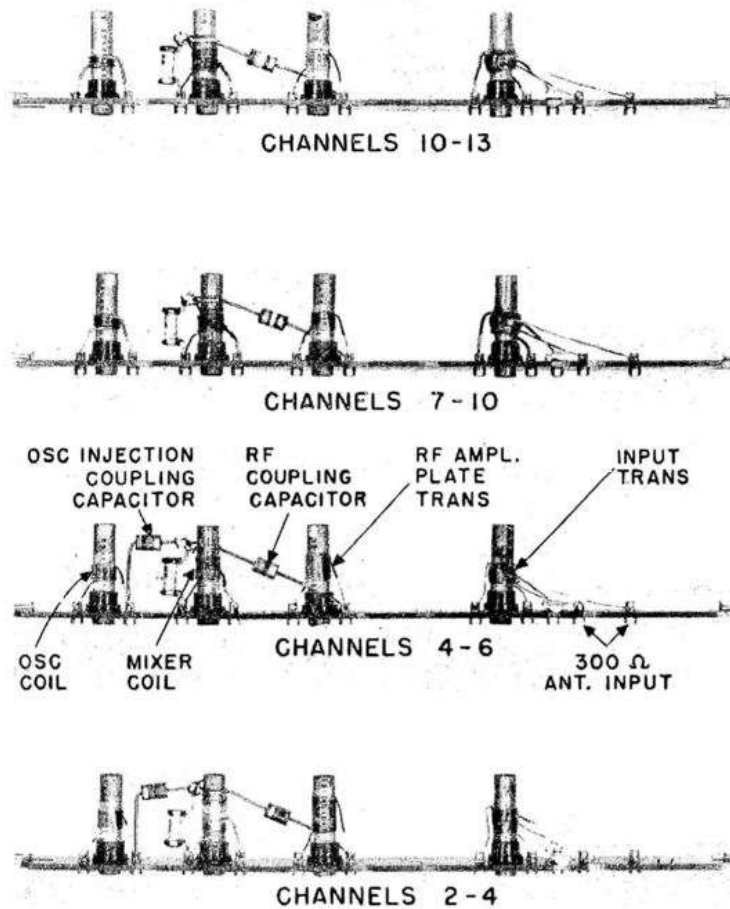


Fig. 5—VHF channel strips.

The only portion of the oscillator circuit which is switched when changing channels on the tuner is the circuit between the grid and plate of the 6AF4 oscillator tube. An incremental change in impedance in the plate side of the

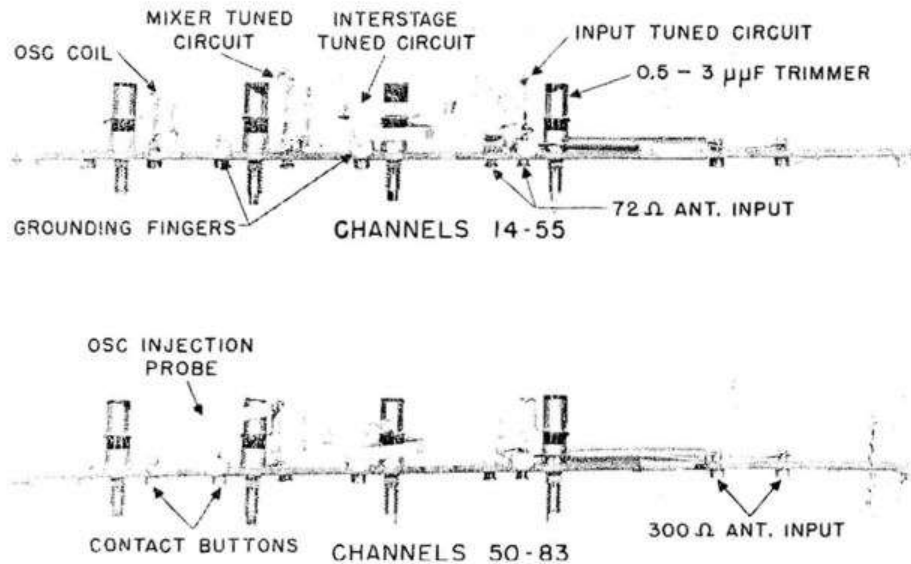


Fig. 6—UHF channel strips.

oscillator circuit provides fine tuning for both VHF and UHF. The oscillator and intermediate-frequency on this tuner have been designed for a picture i-f of 45.75 megacycles and a sound i-f of 41.25 megacycles. The i-f output system of the tuner consists of a link-coupled transformer, with a coaxial cable in the link circuit. The primary of the link-coupled transformer is on the tuner chassis, the secondary being located in the i-f amplifier section on the main chassis. All switching on the tuner is done by means of the silver plate type of contact, which is used on VHF tuners. The contact springs are made of phosphor bronze with a silver overlay.

VHF CIRCUIT DESCRIPTION

Antenna Input Circuit

Figure 7 shows the basic input circuit used in the VHF channel strip. An antenna impedance of 300 ohms is used, since in most receiver locations balanced 300 ohms is most convenient. To obtain a 72-ohm unbalanced input impedance, a 4:1 wide-band-impedance transformer may be used. Referring to Figure 7, C60 and L60 form a variable trap which is made of a section of 300-ohm transmission line and a trimmer capacitor.

This trap is mutually coupled to the input line to attenuate undesired signals between 88 and 108 megacycles (frequency modulation broadcast band). Since the 300-ohm antenna is common to both VHF and UHF, the length of transmission line is so chosen that the UHF resonances fall below 470 megacycles and above 890 megacycles. Two i-f traps tuned to 43.5 megacycles, shown by L1, C1 and L2, C2 in Figure 7, are used to improve the i-f rejection of the tuner. These traps have very low impedance to the signals in the VHF and UHF range.

The antenna input transformer, shown as T6 in Figure 7, is of the single-tuned variety with very tight coupling between the primary and secondary circuits. The primary coil is wound directly over the secondary with a center tap provided as shown. The secondary is inductively tuned with the input capacitance of the amplifier by means of a brass core inside the coil. Since the input impedance of the 6BQ7A r-f amplifier tube decreases with an increase in frequency, the impedance step-up from the antenna to the r-f grid must be varied accordingly for the various channels in order to obtain the best performance. The impedance step-up ratios used are the ratios which give the r-f amplifier a reasonably good noise figure, but not the best possible input standing-wave ratio; however, the impedance match to 300 ohms is quite reasonable.

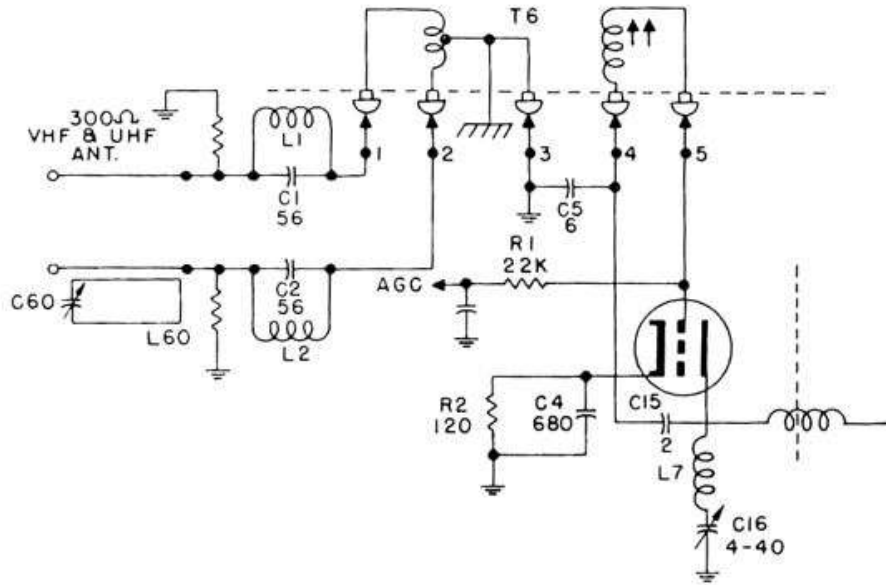


Fig. 7—VHF amplifier circuit.

R-F Amplifier Circuit

The VHF r-f amplifier is a low-noise driven-grounded-grid stage using a 6BQ7A twin triode. The circuit which is used is shown in Figure 8.

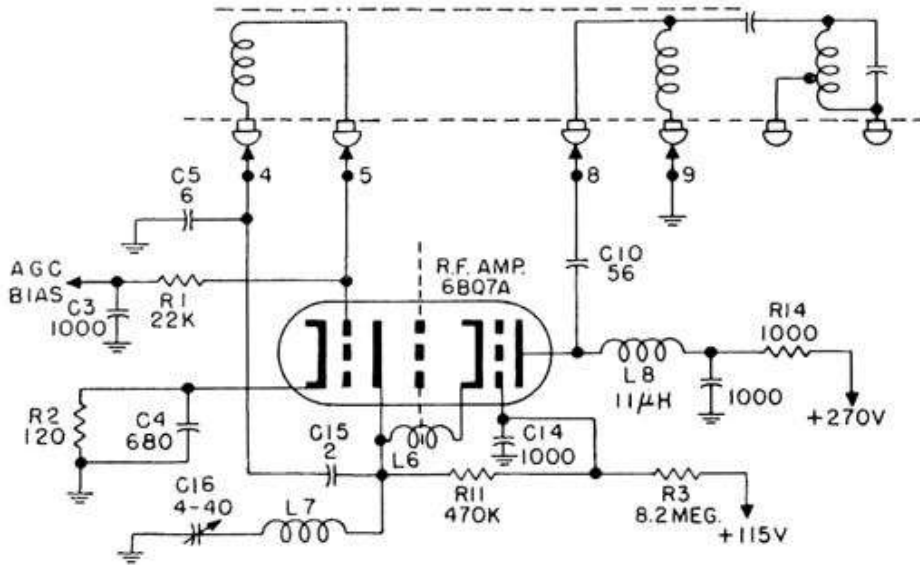


Fig. 8—Radio-frequency amplifier circuit (VHF only).

The relatively high transconductance of this tube, 6400 micromhos per section, permits high gain and reduced equivalent noise resistance. The 6BQ7A also provides low input loading minimizing induced grid noise and aids in obtaining high input circuit gain over all of the VHF channels. The low plate-to-cathode capacitance minimizes direct feed-through of the local oscillator.

A capacity bridge type of neutralization is used to prevent detuning of the input circuit with change in grid bias because of Miller effect and to improve the noise figure of the amplifier. The arms of the capacity bridge are C15,

C_5 , C_{gp} , and C_{gk} , where C_{gp} and C_{gk} are the grid-to-plate and grid-to-cathode capacitances respectively. The requirement for neutralization is:

$$\frac{C_{15}}{C_5} = \frac{C_{gp}}{C_{gk}}$$

The circuit used provides a wide-band type of neutralization which is fairly effective over all the VHF channels. The gain of the r-f amplifier is improved on the upper VHF channels by use of a series inductance between the plate of the first triode section and the cathode of the second section of the 6BQ7A. This inductance is series resonated with the total capacitance from the cathode of the second triode to ground, the inductance being adjusted so that the resonance occurs near the upper end of the high VHF channels. This series circuit further improves the neutralization of the r-f stage on the upper VHF channels by keeping the plate of the first triode section at low impedance so that little r-f voltage is fed back from the plate to the input grid. For the lower VHF channels, the effect of the series resonant circuit is negligible since the inductive reactance is small.

Direct coupling extends the cutoff characteristics, resulting in less cross modulation when automatic-gain-control bias is applied to the first grid. However, for most effective gain control over the wide range of input levels encountered in the field, it is desirable to allow the bias of the second half of the driven-grounded-grid amplifier to vary somewhat with signal level. This is accomplished by tapping the second grid on a d-c voltage divider between the second cathode and a fixed voltage source having a potential slightly less than the cathode potential under minimum bias conditions. In Figure 8, this voltage divider is formed by resistors R3 and R11. Under strong signal conditions, automatic-gain-control bias applied to the first grid increases the plate resistance, resulting in a higher positive potential on the direct-coupled second cathode. The second grid, however, is prevented from following the cathode potential completely, because of the voltage divider connection to the fixed potential source. Therefore, the grid bias developed in the second triode is a function of the ratio of the voltage on the divider and the potential of the fixed source, which have been chosen to maintain a desirable characteristic over a wide range of input levels. For the best noise figure under weak signal conditions, the bias on the first triode should not drop below 1.25 volts. The cathode resistor R2 has been chosen to maintain this condition.

In order to make the VHF and UHF channel strips similar as to the grounding contacts, shunt feeding of the plate-supply voltage to the r-f amplifier stage was necessary. The amplifier plate choke, L8, is so designed that high impedance is maintained over both the lower and upper VHF channels. It was found that in nearly all of the chokes designed, resonances caused the choke impedance to fall off near channel 7 and near channel 13. By using a fluted bakelite coil form to reduce the distributed capacitance of the coil, a choke was made with resonances sufficiently removed in frequency from channels 7 and 13 to give satisfactory performance.

An adjustable i-f trap is provided to increase the i-f rejection of the amplifier, since there is insufficient i-f rejection provided by the r-f circuits alone on channel 2 when 41-megacycle i-f is used. This trap is of the series resonant type, placed between the plate of the first triode of the driven-grounded-grid stage and ground, and is composed of the elements C16 and L7 in Figure 8.

The plate circuit of the r-f amplifier shown in Figure 9 consists of a capacity-coupled double-tuned circuit. The primary on the transformer is tuned with the output capacitance of the plate of the grounded-grid section of the r-f amplifier. The secondary of the transformer is tuned with a 5-micromicrofarad capacitor for all the channel strips. The bandwidth of the coupled circuit is determined by the coupling capacitance and the crystal loading. The amount of loading provided by the crystal depends upon the effective crystal tap point on the secondary of the transformer, and the oscillator injection current to the crystal. The nominal over-all operating bandwidth has been designed such that approximately 4.5 megacycles exist between peaks of the selectivity curves for the over-coupled double-tuned circuits. The tuning of the circuits is accomplished by means of threaded brass cores instead of the powdered iron type since the latter have a tendency to bind or be too abrasive when used with paper base coil forms. Four sets of strips are used to cover the VHF range, with at least a one-channel overlap between strips covering adjacent groups of channels.

Crystal Mixer Circuit

The crystal mixer circuit used for the VHF range is shown in Figure 9. The 1N82 mixer feeds into a 41-megacycle i-f system with an approximate input bandwidth of 8 megacycles, under operating conditions. For the lower VHF

channels, the oscillator injection for the crystal is obtained by capacity coupling with a 1 micromicrofarad capacitor from the grid side of the oscillator circuit to the high side of the mixer tuned circuit. On the upper VHF channels, the oscillator injection is obtained by mutual inductance coupling of the mixer circuit to the oscillator tuned circuit.

The d-c crystal return is through a 100-ohm resistor, R10, which puts a little self bias on the crystal. This generally improves the noise figure of the crystal circuit. This resistance provides a test point TP 1, where a millivoltmeter may be used to measure the amount of oscillator injection. This point is also used to look at the over-all r-f circuit response with a cathode-ray oscilloscope.

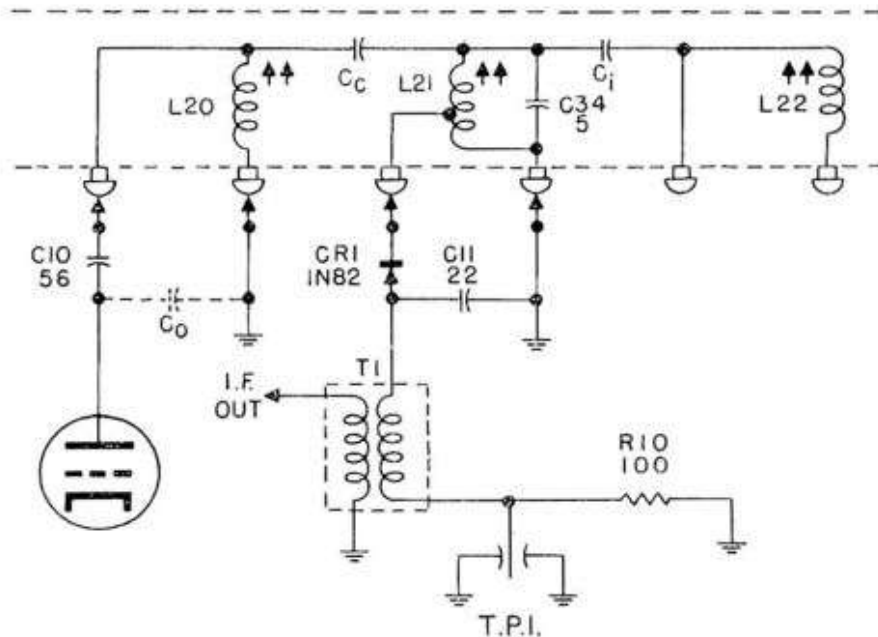


Fig. 9—VHF crystal mixer circuit.

Since the low-noise r-f amplifier is used ahead of the crystal mixer circuit, the noise figure of the mixer stage is not so important on VHF as on UHF where no r-f amplifier is used.

VHF Oscillator Circuit

The oscillator circuit used in the tuner is of the Colpitts type, with the tuning between the various channel strips accomplished by switching in various amounts of grid to plate inductance. The schematic diagram of the circuit is shown in Figure 10.

Fine tuning for the VHF range is accomplished by changing the effective capacitance from plate to ground by means of a brass core inserted into a low inductance sleeve in series with the plate circuit of the oscillator. The inductive reactance used in the plate-to-grid circuit on VHF causes the plate of the oscillator tube to assume very nearly an r-f voltage maximum. The fine-tuning element is therefore quite sensitive to capacitive changes. The ratio of the inductance change of the fine-tuning element to the total circuit inductance is quite small, so that the capacitive change masks any change in frequency which is due to the change in inductance.

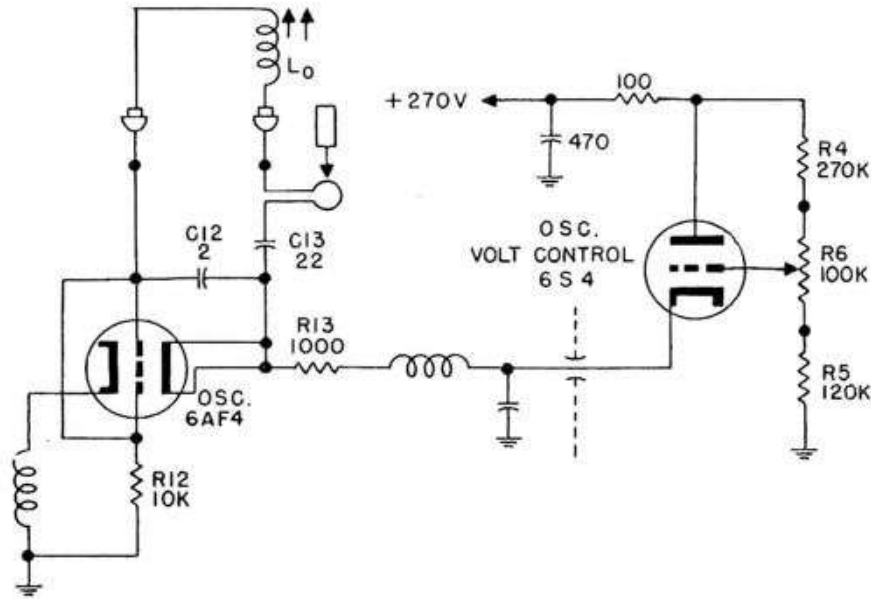


Fig. 10—VHF oscillator circuit.

To decrease the strength of oscillation on the VHF channels, a resistor, R13, is used in series with the plate choke L1. The inductance of L1 is made low enough to further decrease the strength of oscillation, particularly on the upper VHF channels. To allow for the variation in electrical characteristics of different 6AF4 tubes, a voltage-control tube has been used. The 6S4 tube shown in series with the plate-supply system of the 6AF4 in Figure 10 controls the voltage at the plate of the oscillator tube, the voltage being set by means of the grid potential chosen. The plate voltage of the 6AF4 is set so that a maximum cathode current of 28 milliamperes is obtained when the tube is not oscillating. The variation in 6AF4's is such that the voltage required at the plate of the tube to set this condition is between 85 and 115 volts. Since the cathode of the 6S4 stays near grid potential and is a low impedance, the cathode voltage, and therefore the oscillator plate voltage, stays constant with changes in the current drawn by the oscillator tube.

UHF CIRCUIT DESCRIPTION

Antenna Input Circuit

On UHF, an input circuit impedance of 300 or 72 ohms may be used. The 300-ohm input is the same as that used for VHF, but the 72-ohm input is made separate so that a separate UHF antenna may be used. The circuit diagram of the basic input circuit used for the UHF strips is shown in Figure 11.

The 88-108 megacycle trap composed of elements C60 and L60 has resonances outside the UHF range, and therefore does not deteriorate the UHF performance. Similarly, the 43.5 megacycle i-f traps are designed so that the first resonance after 43.5 megacycles occurs above 950 megacycles. Since the 300-ohm antenna-coupling coil does not have a grounded center tap, two static drain resistors, R18 and R19, have been used. The 300-ohm input coupling loops consist of one- or two-turn self-supporting coils made small enough to fit inside the input coil L3. All of the UHF circuits on the strips are capacity tuned using Erie type 535 0.5-3.0 micromicrofarad trimmer capacitors. The 72-ohm UHF input consists of a tap on the input coil, the tap point being set to give the proper input loading under operating conditions.

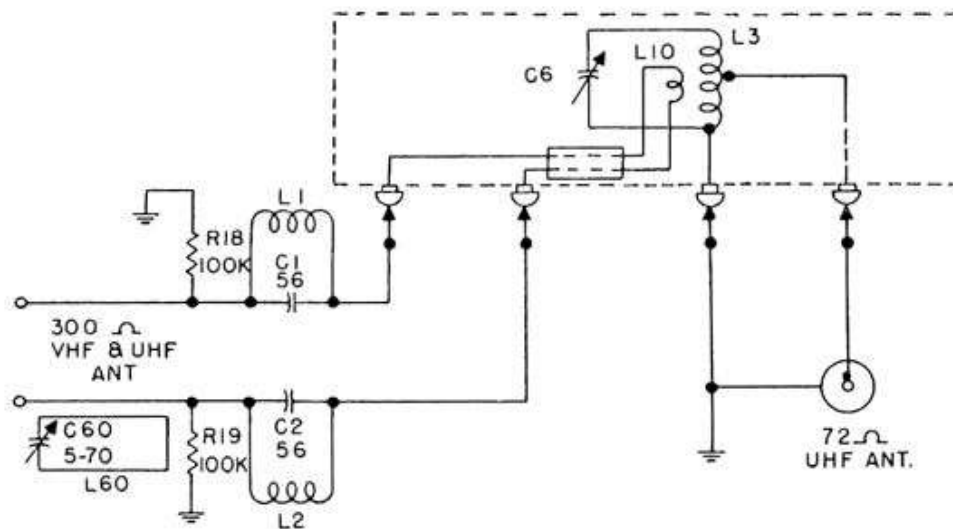


Fig. 11—UHF antenna input circuit.

UHF Preselector Circuit

The UHF preselector consists of a triple-tuned circuit using high-Q tuning coils as shown in Figure 6. The coils are self-supporting and are wound with silver-plated strap stock 0.093 inch wide and .010 inch thick. The input and output coils are the ordinary cylindrical type with an inside coil diameter of 0/203 inch. The interstage coupling coil is shaped in the form of a racetrack to obtain the required coupling to the input and output coils. The circuit diagram of the UHF strip with the associated crystal mixer circuit is shown in Figure 12.

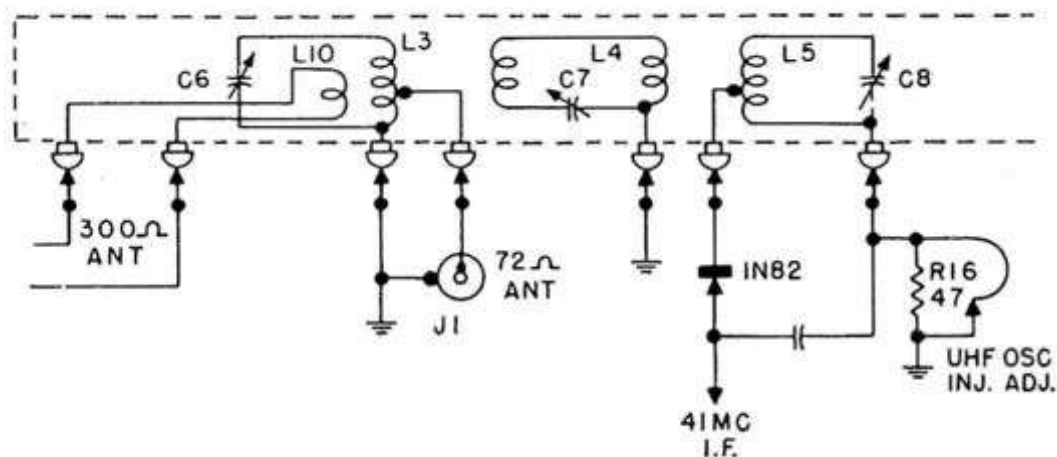


Fig. 12—UHF preselector circuit.

The three tuned circuits on the strip are predominately inductively coupled by proximity and by the coupling loop formed by grounding contacts and the shielding trough in which the strip rests. By proper adjustment of the center-to-center distance between the input and mixer coils and the length of the race-track shaped coupling coil, the bandwidth of the preselector circuit across the UHF range can be made substantially constant. The tap on the crystal mixer circuit is made high enough to give the over-all r-f response a reasonably flat amplitude characteristic over a 4.5-megacycle frequency range when local oscillator injection is applied to the crystal.

The r-f selectivity curve varies with frequency. It is triple-peaked at the low end of the UHF range, double-peaked at midband, and flat-top to round nosed at the upper end of the frequency range. The efficiency of the triple-tuned preselector is quite high, due to the high Q of the tuned circuits. The insertion loss of the preselector is in the order of 1 decibel over the UHF range. Additional grounding fingers have been used between the rotor and the r-f shelf to decrease the direct coupling between the antenna and the mixer circuit of the preselector. This improves the rejection for the image frequency and also reduces the spurious responses due to the resonance of the rotor and the main housing.

The 1N82 crystal diode which is used for the UHF mixer had the most satisfactory oscillator current injection and noise figure characteristics at the high end of the UHF range among all the crystal mixers tested. The oscillator injection to the crystal mixer circuit on the UHF range of the tuner is obtained by means of an adjustable inductance from the ground side of the mixer circuit on the strip to a ground point on the r-f shelf. A 47-ohm resistor, R16, shown in Figure 12, is used to decrease the oscillator injection between 470 and 600 megacycles. A coupling probe on the high side of the mixer circuit on the 50-88 channel strip is used to increase oscillator injection at the upper end of the range.

UHF Oscillator Circuit

The UHF oscillator circuit is the same as that used for the VHF range except that the tuning between channels is accomplished by switching in a variable capacitance in series with an inductance. An oscillator frequency range of 480 to 970 megacycles is covered in the two UHF strips using different oscillator tank, circuit inductances in series with the 0.5 to 3.0 micromicrofarad trimmer capacitor. The fine tuning for the UHF range is accomplished by changing the effective inductance in the grid-to-plate circuit of the oscillator. The fine tuning element consists of a low inductance, one-turn coil in the shape of a slit cylinder into which is inserted a brass core which changes the effective inductance of the one-turn coil. In this case, the plate of the oscillator tube is very nearly a voltage node, and the ratio of the fine tuning inductance change to the total circuit inductance is much higher than on VHF. The inductive change, therefore, predominates over any shift in frequency due to the capacitive change. To compensate for the oscillator frequency drift at the low end of the UHF range, a negative temperature coefficient capacitor is used for the plate blocking capacitor C12. At the high end of the UHF range, a small piece of bimetallic strip is used near the oscillator trimmer capacitor to compensate for oscillator frequency drift caused by the circuit components and the oscillator tube.

Low Noise I-F Amplifier

The noise figure of the tuner at UHF depends primarily on the noise contributed by the crystal mixer and by the first i-f amplifier following the mixer circuit. Therefore, a low-noise, driven-grounded grid stage is used for the first i-f amplifier. A schematic diagram of the circuit used is shown by Figure 13.

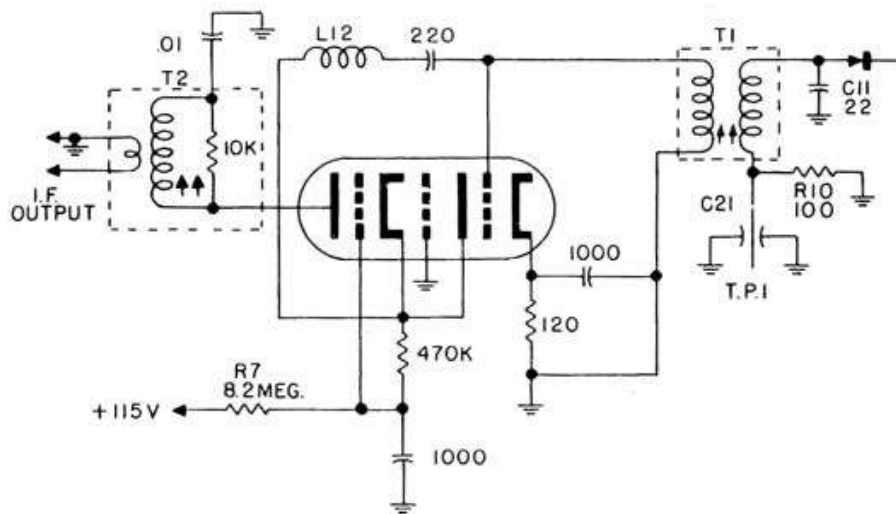


Fig. 13—Low-noise i-f amplifier.

The input transformer T1 is designed so that enough loading is provided by the crystal diode to give a 3-decibel bandwidth of approximately 8 megacycles. The 22 micromicrofarad capacitor C11, which is used for the crystal r-f bypass and the input capacitance of the tube, provides the capacitance required to tune this circuit to 43.5 megacycles.

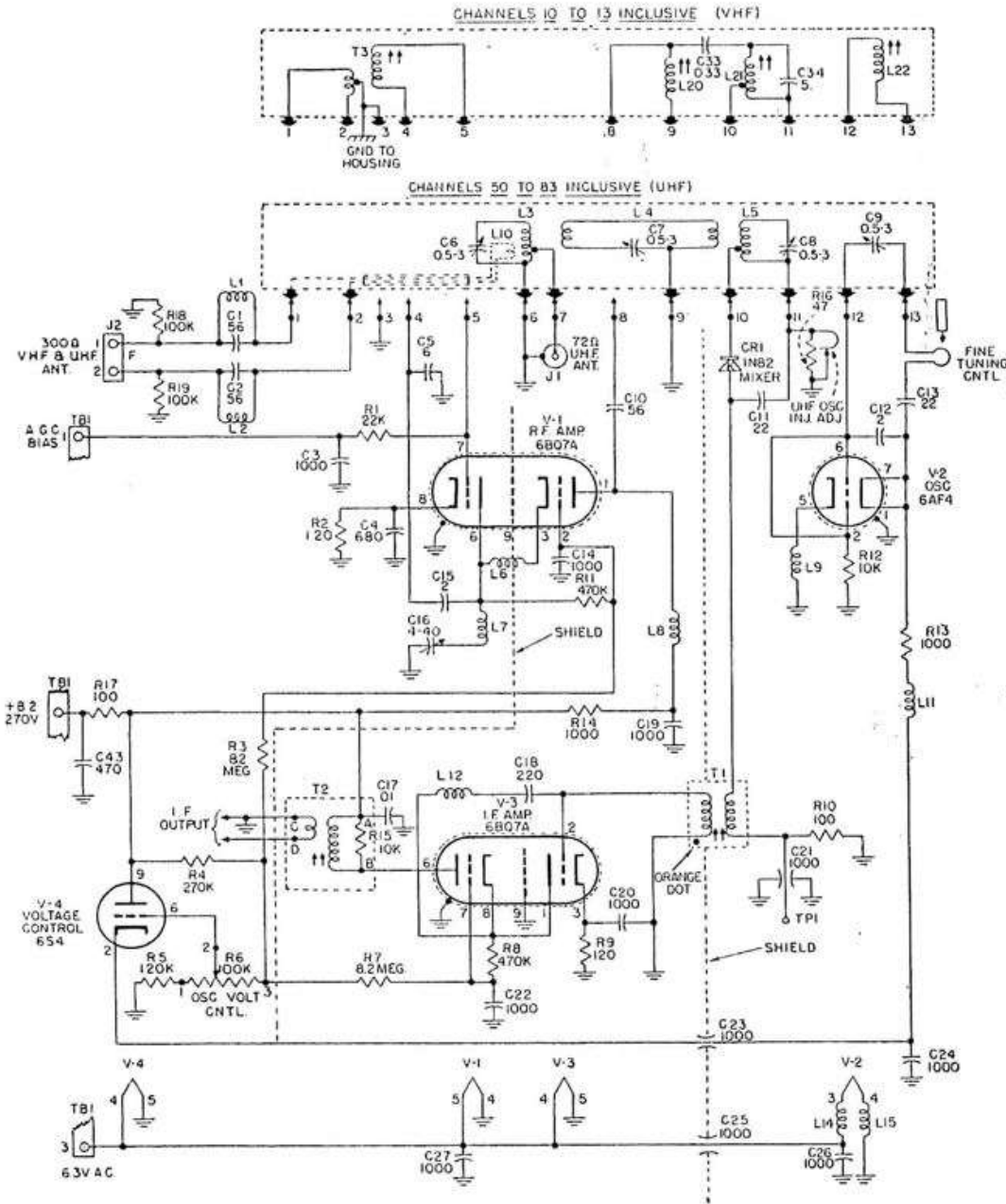


Fig. 14—Schematic diagram of tuner.

The neutralization of the grid-to-plate capacitance is accomplished by means of a shunt inductance, L12, from grid to plate which resonates with this capacitance. The output transformer of the amplifier is of the link-coupled type so that a low-impedance circuit can be used between the tuner and the i-f amplifier on the main chassis. The complete circuit diagram of the VHF-UHF tuner, with the various channel strips, is shown in Figure 14.

VHF PERFORMANCE

Noise Figure

The noise figure of the tuner on VHF depends primarily on the driven-grounded-grid r-f amplifier, although some noise is contributed by the crystal mixer and the low-noise i-f amplifier following the crystal mixer. The antenna input circuit has been designed with the signal to noise ratio as the criterion; therefore, the coupling of the antenna transformer has been increased beyond the value which would give maximum gain. (See Wm. A. Harris, "Some Notes on Noise Theory and Its Application to Input Circuit Design," *RCA Review*, Vol. IX, No. 3, pp. 406-418, September, 1948.) The neutralization of the grid-to-plate capacitance of the first triode section of the driven-grounded-grid r-f amplifier also improves the noise figure. The measured noise figures for the VHF channels are given in Table I along with other performance characteristics of the tuner. These measurements were taken using a balanced type of noise diode with a source impedance of 300 ohms.

Gain

The VHF voltage gain of the tuner from the antenna terminals to the grid of the first i-f tube on the main chassis is shown in Table I.

The gain on channel 13 is somewhat higher than that on the other upper VHF channels; this is due to the peaking caused by the inductance L61, in Figure 8, resonating with the total input capacitance of the cathode of the second triode section of the r-f amplifier tube.

Input Standing-Wave Ratio

The voltage-standing-wave ratio of the VHF antenna input circuit was measured by the long-line method. The ratio could be improved by decreasing the coupling between the primary and secondary windings of the input transformer, but the input circuit bandwidth would then be too narrow on some of the lower VHF channels. On the upper VHF channels, a decrease in coupling would result in a poorer over-all noise figure for the r-f amplifier, even though the input circuit gain and bandwidth would be improved.

Undesired Responses

The image and i-f rejections for the VHF channels shown in Table I were measured with zero automatic-gain-control bias. The other undesired responses are more than 80 decibels below the desired signal. For cross-modulation to exist under weak signal (50-microvolt desired signal) conditions, the undesired signal must be at least 80 decibels greater than the desired signal to produce perceptible interference. This is under the conditions where the most cross-modulation exists, e.g., the undesired signal is within the r-f pass-band but outside the i-f pass-band. Under strong signal conditions (50-millivolt desired signal), the undesired signal must be at least 40 decibels greater than the desired signal to produce appreciable cross-modulation. For other frequencies, this ratio of strength of the undesired to desired signals would have to be greater to produce interference.

The use of a 41-megacycle intermediate-frequency gives the possibility of self-generated interference on channel 6 (82-88 megacycles) due to the second harmonic of the i-f generated in the first detector, or generated in the second detector and fed back overall through the i-f amplifier. The over-all feedback can be reduced by proper shielding and filtering, in the i-f amplifier. Both the first detector and the feedback harmonic interferences increase as the detectors are operated at higher signal levels; therefore, these types of interference can be reduced somewhat *by* operating the r-f and i-f amplifiers at lower signal levels by use of higher automatic-gain-control bias under strong signal conditions. Also, they can be reduced by tuning the 88-108 megacycle trap in the VHF antenna circuit to the sound carrier of channel 6 (87.75 megacycles).

Oscillator Radiation

The VHF oscillator radiation data is also shown in Table I. These measurements were taken with a Stoddart NMA-5 field intensity meter at a standard Institute of Radio Engineers radiation test site. The data shown is given for two cases: first, without an auxiliary shield covering the oscillator tube and the fine tuning plunger; and second, with the shield. With the shield, the oscillator radiation is well within the Radio and Television Manufacturers Association's

Table I—Typical VHF Tuner Operating Characteristics

| Channel Number | Noise Figure (Decibels) | Voltage Gain | Image Rejection (Decibels) | I.F. Rejection | | Input V.S.W.R. | Oscillator | Radiation |
|----------------|-------------------------|--------------|----------------------------|---------------------|----------------------|----------------|---|--|
| | | | | 43.5 Mc. (Decibels) | 45.75 Mc. (Decibels) | | Without Shield Max $\mu\text{v}/\text{m}$ at 100' | With Shield Max $\mu\text{v}/\text{m}$ at 100' |
| 2 | 3.7 | 80 | 59.1 | 80 | 66 | 2.36 | 30.0 | < 5 |
| 3 | 4.0 | 83 | 60.0 | 90 | 72 | 2.48 | | |
| 4 | 4.5 | 77 | 59.5 | 90 | 79 | 2.06 | 32.1 | < 5 |
| 5 | 4.6 | 95 | 57.3 | 90 | 88 | 2.82 | | |
| 6 | 5.1 | 95 | 57.4 | 90 | 90 | 2.25 | 48.1 | < 5 |
| 7 | 6.7 | 67 | 75.2 | 90 | 90 | 1.83 | 165.0 | 25.0 |
| 8 | 6.9 | 55 | 78.0 | 90 | 90 | 1.59 | | |
| 9 | 6.6 | 55 | 75.9 | 90 | 90 | 1.66 | | |
| 10 | 6.7 | 54 | 78.5 | 90 | 90 | 1.85 | 101.5 | 23.7 |
| 11 | 6.6 | 50 | 70.7 | 90 | 90 | 2.62 | | |
| 12 | 6.6 | 51 | 78.8 | 90 | 90 | 2.73 | | |
| 13 | 6.4 | 83 | 72.5 | 90 | 90 | 2.11 | 123.2 | 30.5 |

recommended limits for oscillator radiation of 50 microvolts per meter on the lower VHF channels and 150 microvolts per meter for the upper VHF channels. Without the shield, the oscillator radiation on channel 7 is just above the recommended limit.

Oscillator Stability

The oscillator frequency drift for a lower and an upper VHF channel is shown in Figure 15. The warm-up drift of the oscillator on other VHF channels is similar. The initial reading in all cases was taken one half minute after the power for the tuner was turned on.

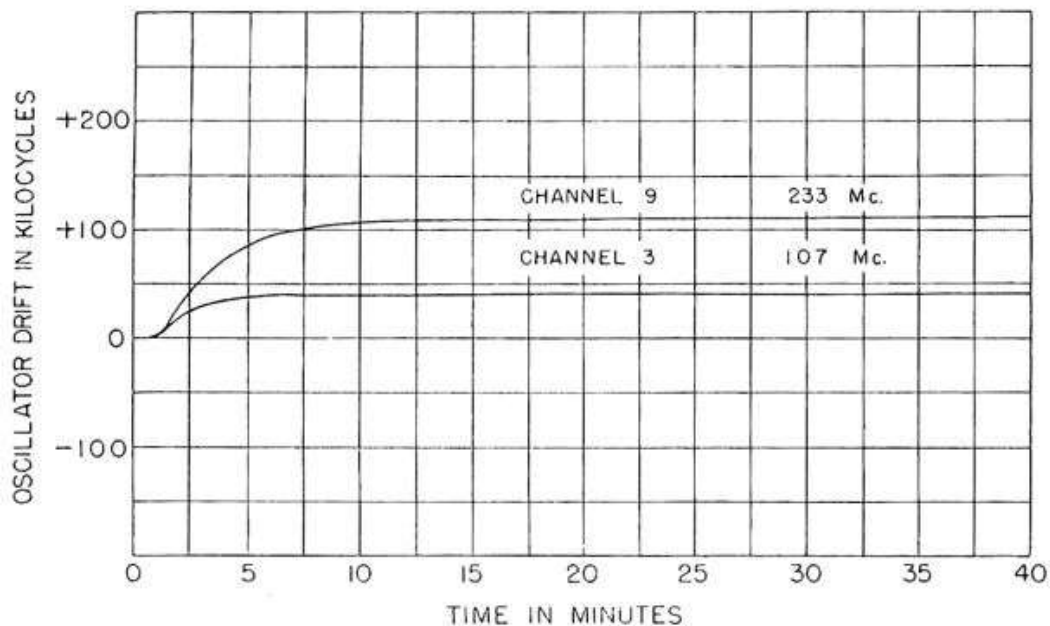


Fig. 15—VHF oscillator frequency drift.

UHF PERFORMANCE

Noise Figure

When operating on UHF, the noise figure of the tuner depends primarily upon the crystal mixer and the low-noise i-f amplifier following the mixer. With the 1N82 silicon crystal used as the mixer, the maximum noise figure variation among crystals is approximately ± 2.5 decibels, with an average noise figure of 13.2 decibels at 500 megacycles. The noise figure of the tuner for various frequencies in the UHF range is shown in Table II. These measurements were made using a "Mega-Node Sr." noise diode, a 50 to 72 ohm coaxial line transformer, and a 75 to 300 ohm UHF balun. The noise figure measurements were essentially the same when 72 or 300 ohm antenna inputs were used.

Gain

The over-all voltage gain between the antenna terminals and the grid of the first i-f tube, when operating on UHF, is considerably less than that obtained on VHF due to the absence of the r-f amplifier.

Input Standing-Wave Ratio

The voltage standing wave ratios of the UHF antenna input circuit for both 300 and 72 ohm input impedances are given in Table II. The values shown are the average values over a 4.5-megacycle frequency range. The long-line method of measuring standing-wave ratio was employed for these measurements, using approximately 130 feet of low-loss 75-ohm coaxial cable.

Table II—Typical UHF Tuner Operating Characteristics

| Channel Number | Center Freq. (Mc.) | Noise Figure (Decibels) | Voltage Gain | Input 300Ω | V.S. W.R. 72 Ω | RF Band width (Mc.) | Image Rejection (Decibels) | I.F. | Rejection | Oscillator | Radiation |
|----------------|--------------------|-------------------------|--------------|------------|----------------|---------------------|----------------------------|---------------|--------------|------------------|------------------|
| | | | | | | | | (Decibels) | (Decibels) | Without Shield | With Shield |
| | | | | | | | | 300 Ohm Input | 72 Ohm Input | Max μv/m at 100' | Max μv/m at 100' |
| 14 | 473 | 12.5 | | 1.41 | 1.18 | 9 | 47.2 | 90 | 59.8 | | |
| 19 | 503 | 13.0 | 10.0 | 1.34 | 1.22 | 9 | 46.0 | 90 | 60.6 | 1530 | 161 |
| 27 | 551 | 12.2 | | 1.33 | 1.16 | 11 | 47.6 | 90 | 60.6 | | |
| 35 | 599 | 13.6 | | 1.34 | 1.27 | 11 | 36.5 | 90 | 60.1 | 1495 | 414 |
| 44 | 653 | 13.1 | | 1.63 | 1.22 | 11 | 38.7 | 90 | 60.2 | | |
| 52 | 701 | 15.6 | 7.8 | 1.70 | 1.25 | 9 | 50.9 | 90 | 62.2 | 2008 | 559 |
| 60 | 749 | 15.6 | | 1.83 | 1.31 | 6 | 42.8 | 90 | 62.4 | | |
| 69 | 803 | 16.2 | 8.7 | 1.74 | 1.17 | 8 | 42.9 | 90 | 63.0 | 1092 | 218 |
| 77 | 851 | 15.4 | | 1.71 | 1.36 | 9 | 58.4 | 90 | 65.0 | | |
| 83 | 887 | 16.4 | 5.3 | 1.20 | 1.22 | 8 | 50.3 | 90 | 62.1 | 2880 | 212 |

Preselector Bandwidth and Selectivity

The approximate r-f bandwidth of the triple-tuned UHF preselector is shown in Table II. The bandwidth has been measured with oscillator injection in the crystal mixer. The over-all r-f selectivity curve is shown in Figure 16 for a center frequency of 500 megacycles. For other frequencies in the UHF range, the response curves are similar to that shown.

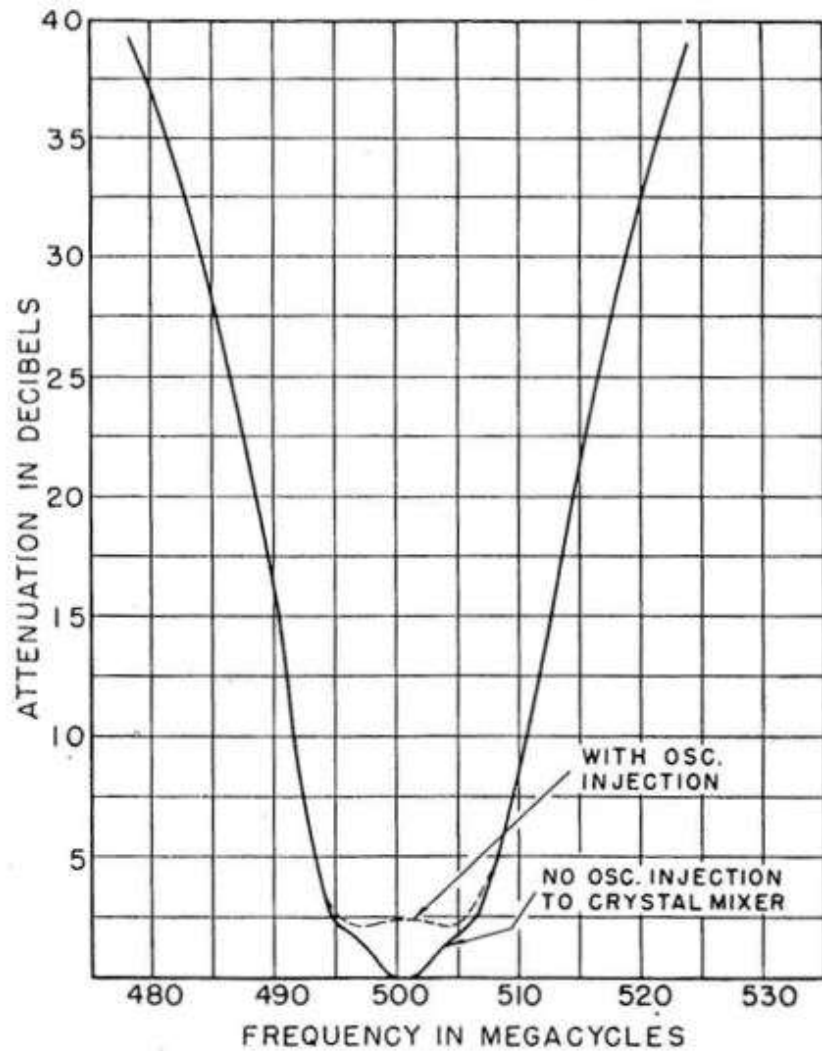


Fig. 16—UHF preselector sensitivity at 500 megacycles.

Undesired Responses

The image and r-f rejections of the tuner when operating in UHF range are given in Table II. The decrease in image rejection for channels 35 and 44 is due to a 700-megacycle resonance in the crystal mixer circuit. The 300-ohm input gives more i-f rejection than the 72-ohm input due to the extra trap circuit in the antenna. Other undesired responses below 980 megacycles are more than 60 decibels below the desired signal level. Figure 17 shows the various responses when the tuner is tuned to 500 megacycles.

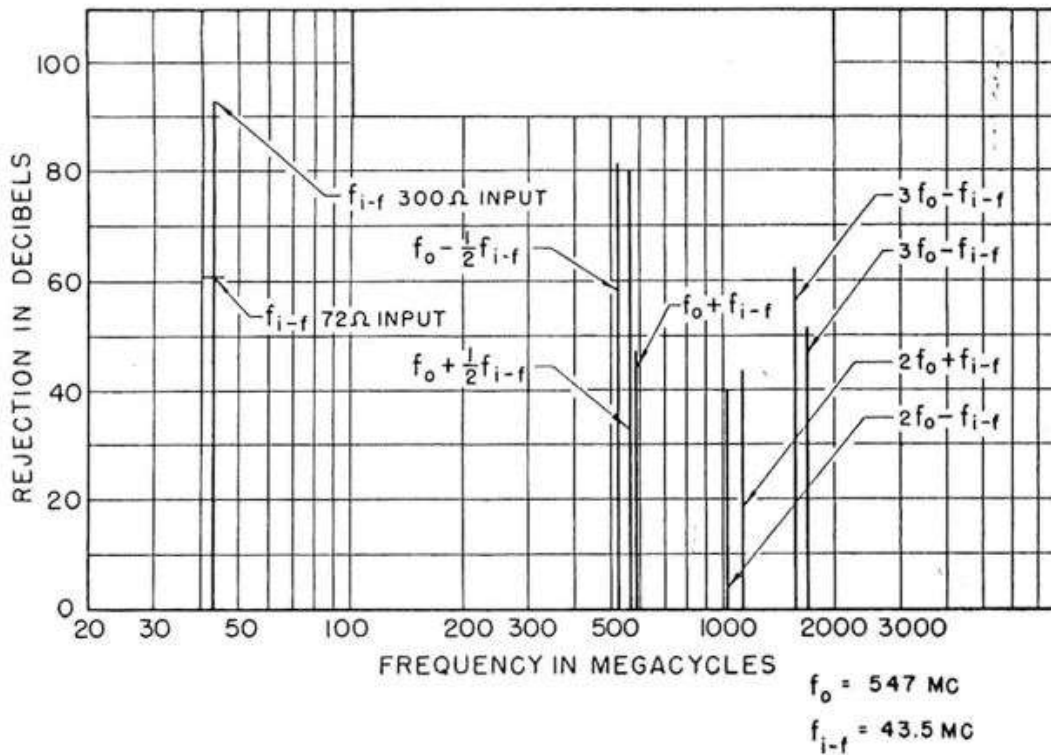


Fig. 17—Rejection of undesired signals for a desired signal of 500 megacycles.

Oscillator Radiation

The UHF oscillator radiation data is shown in Table II. The measurements were taken with a Stoddart NM-50A field intensity meter at a standard Institute of Radio Engineers radiation test site. In order to reduce the antenna radiation, the oscillator compartment was isolated from the antenna by use of several small grounding fingers which contact the rotor at various points on its periphery. The data shown is given for two cases: first, without an auxiliary shield covering the oscillator tube and the fine tuning plunger; and second, with the shield in place. The shield is seen to reduce the chassis radiation from 3 to 13 times.

Oscillator Stability

The oscillator frequency drift for various frequencies in the UHF range is shown in Figure 18. The initial reading in all cases was taken one half minute after the power for the tuner was turned on. For the strip covering channels 50-83, the compensation is not sufficient for frequencies above 800 megacycles. To add compensation above 830 megacycles, a 1/8 x 1/2 x 0.005-inch piece of bimetel was used near the oscillator trimmer capacitor in the strip.

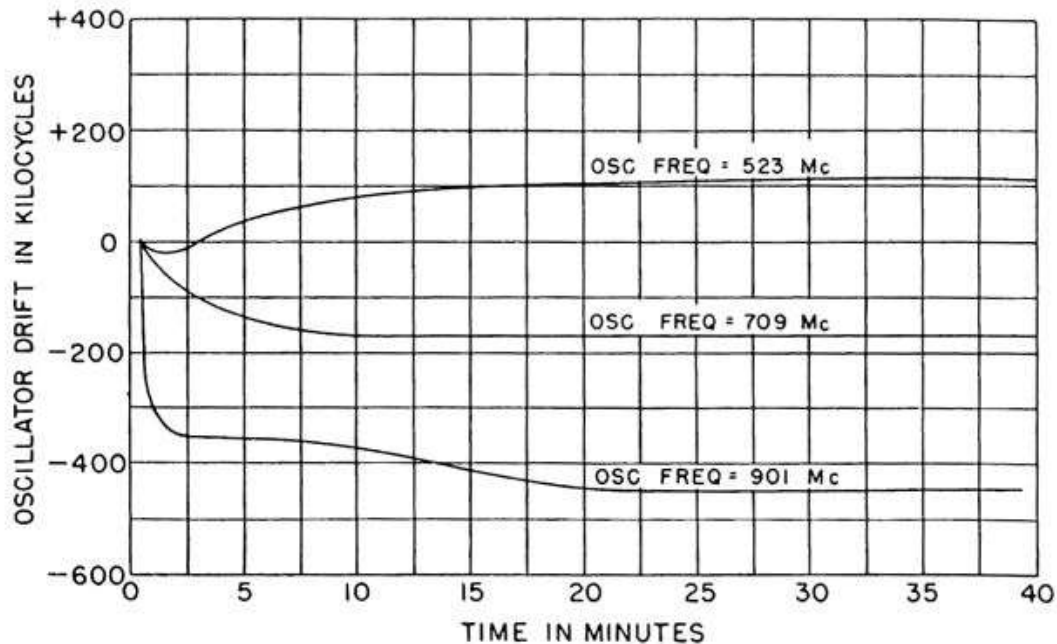


Fig. 18—UHF oscillator frequency drift.

Field Tests

Field tests of the tuner on the VHF channels indicate that it performs as well or better than most current tuners under normal operating conditions. The low noise figure on the VHF channels results in a better picture in weak signal locations. The tuner was extensively field tested for UHF operation in various locations such as Portland, Oregon (channel 27), Harrisburg (channel 55), Reading (channels 33 and 61), and York (channel 43). These tests indicated this tuner on a "B" line chassis (3 i-f stage set) performed very well. The low noise figure on UHF results in a picture with less snow than other receivers tested in moderately weak areas. The resetability on UHF is very good, the tuning on UHF being very similar to that on the VHF channels.

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