The basic tuning element around which the front end assembly is designed is a standard Mallory S-4 Spiral Inductuner. A stop assembly is arranged to restrict rotation of the spiral tuner to the last one and one quarter clockwise turn of its normal 5- turn rotation. The signal frequency is tuned by L-101 and the input capacity of the 6J4 plus wiring capacities. A double tuned band-pass circuit is used between the 6J4 r-f amplifier and the 6AK5 mixer to provide high image and i-f rejection. The coupling between the two circuits is capacitive and consists of C104, C105, and C106. C105 is adjustable to provide accurate control of bandwidth. The 6J4 R-F stage is operated at maximum gain at all times to produce maximum signal-to-noise ratio. Bias for the 6AK5 mixer is obtained from the local oscillator. This method produces more uniform operation at all frequencies, allows for considerable variation in local oscillator amplitude due to tube aging, A.F.C. pulling, etc., and allows direct grounding of both cathode terminals to minimize cathode lead inductance and produce maximum input resistance which is necessary at these frequencies. The mixer is pentode connected to prevent distortion of the I-F response due to changes in plate resistance which may be caused by variation of local oscillator amplitude, tube aging, etc. A rather unconventional oscillator configuration is used because of the high frequency of operation and the necessity of A.F.C.

The oscillator circuit used is essentially a Colpitts with an unbypassed resistor connected in the cathode to damp tube resonance. The A.F.C. reactance tube is connected directly across the combination of the grid-plate capacity and a 27 ohm carbon resistor. Input resonance in the reactance tube is not damped by the cathode resistor since the grid circuit must return to the cathode. The use of a small resistor (27 ohms) in the grid circuit extends the operating range through 285 mc. A.F.C. may be turned on or off or supplied from an external source by a front-panel control.

The crystal-controlled oscillator, See Figure 16, which is used when fixed-frequency operation of the Clarke receiver is desired, employs an overtone crystal in a cathode-coupled circuit, and three type CK5703 subminiature tubes.

The crystal frequency was chosen so that adequate oscillator injection could be obtained by doubling twice. A test to determine optimum oscillator injection for maximum sensitivity showed that the optimum value of oscillator voltage was between 4 and 5 volts, and that the injection voltage could vary from 3.0 to 6.0 volts with about a 10% loss in sensitivity.

The link coupling and double-tuned coupling circuit employed permits adjustment of the link so that the optimum value of oscillator voltage may be obtained upon installation in the receiver. A high impedance type of voltmeter is employed to read the rectified grid voltage at TP117. Since TP117 is the midpoint of the mixer grid resistor, whatever voltage is observed must be multiplied by two to obtain the correct injection voltage.

The r-f unit is a complete assembly with input and output signals available through coaxial connectors and with power and A.F.C. leads through a small cable.

The i-f amplifier is a separate, completely shielded assembly which is conventional in most respects. Two high-gain stages using 6CB6 tubes are followed by a 6CB6 first limiter and a 6AK5 second limiter. A 6AL5 is used in a balanced phase discriminator.

The discriminator circuit is a conventional balanced phase shift type. In order to obtain balance the secondary is bifilar-wound and link-coupled to the primary. This link is adjusted in production for minimum distortion. For stability a self-resonant choke is connected to the output lead.

Signal level monitoring is provided by sampling the rectified signal current of both limiter grids. The second limiter developes a voltage proportional to the input signal up to about 10 uv. Above this level the voltage on the second limiter is constant, and a voltage proportional to the logarithm of the input exists at the first limiter. These voltages are combined to produce an easily read logarithmic signal strength scale.

A 12AU7 is used as a DC bridge to indicate discriminator output for tuning purposes and as a direct coupled video amplifier. V110 is used as a cathode follower output stage and is direct coupled from the video amplifier. The output is 10-15 volts RMS for ± 125kc deviation.

A conventional two-stage amplifier with built-in loudspeaker is provided for monitoring.

2.2 External Signal Strength Recording

Provision has been made for supplying 10 ma to record variations in signal strength. This signal is the combined plate and screen currents to V104, and it is adjusted to 10 ma with no signal by varying the screen voltage with R150. The signal thus obtained is reverse reading; i.e., 10 ma is obtained with no signal, and minimum current is obtained at maximum signal. The signal strength circuits are connected to channels 13 to 16 inclusive on the oscillograph control panel.

3.0 Subcarrier Amplifier

The subcarrier amplifier provides for separation of up to four audio subcarrier signals from the composite video subcarrier signal. The four subcarrier amplifier units contained in the telemetering receiving station thus provides sixteen subcarrier amplifier (separation) channels. Each channel consists of a cathode follower input stage, filter, a signal amplifier stage, and a cathode follower output stage. The composite subcarrier signal from the receiver is parallel fed to the subcarrier amplifier channels. See Figure 17.

2.0 Model 167-E Clarke Receiver

2.1 General

The Model 167-E special-purpose receiver is designed as terminal equipment for a telemetering system employing a radio link and receiving intelligence in the form of frequency-modulated signals consisting, for example, of one or more frequency-modulated subcarriers. Over the specified tuning range of 180 to 260 mc the antenna input impedance of the 167-E receiver is approximately 75 ohms. The circuit is arranged for single or unbalanced input. The antenna is connected to a SO-239 type jack, located on the rear apron of the chassis. The basic tuning element around which the frontend assembly is designed is a standard Mallory S-4 Spiral Inductuner. A stop assembly is arranged to restrict rotation of the spiral tuner to the last one and one-quarter clockwise turn of its normal 5-turn rotation. The signal frequency is tuned by L101 and the input capacity of the 6J4 plus wiring capacities. A double-tuned band-pass is used between the 6J4 R.F. amplifier and the 6AK5 mixer to provide high image I.F. rejection. The coupling between the two circuits is capacitive and consists of C104, C105, and C106. C105 is adjustable to provide accurate control of bandwidth. The 6J4 R.F. stage is operated at maximum gain at all times to produce maximum signal-to-noise ratio. Bias for the 6AK5 mixer is derived from the local oscillator. This method produces more uniform operation at all frequencies and allows for considerable variation in local oscillator amplitude due to tube aging, A.F.C. pulling, etc. This also allows direct grounding of both cathode terminals to minimize cathode lead inductance and produce maximum input resistance so necessary at these frequencies. The mixer is pentode connected to prevent distortion of I. F. response due to changes in its plate resistance which may be caused by variation of local oscillator amplitude, tube aging, etc. A rather unconventional oscillator configuration is used due to the high frequency of operation and the necessity for A.F.C.

The oscillator circuit used is essentially a Colpitts with an unbypassed resistor connected in the cathode to damp tube resonance. The A.F.C. reactance tube is connected directly across the oscillator. Phase shift is produced in the grid by the series combination of grid-plate capacity and a 27 ohm carbon resistor. Input resonance in the reactance tube is not damped by the cathode resistor since the grid circuit must return to the cathode. The use of a small resistor (27 ohms) in the grid circuit extends the operating range through 285 mc. A.F.C. may be turned on or off or supplied from an external source by a front-panel control.

The R.F. unit is a complete assembly with input and output signals available through coaxial connectors and with power and A.F.C. leads through a small cable.

2.2 I.F. Amplifier

The I.F. amplifier is a separate, completely shielded assembly. It is conventional in most respects. Two high-gain stages using 6CB6 tubes are followed by a 6CB6 first limiter and a 6AK5 second limiter. A 6AL5 is used on a balance phase discriminator.

The discriminator circuit is a conventional balanced phase shift type. In order to obtain balance the secondary is bifilar wound and link coupled to the primary. This link is adjusted in production for minimum distortion. For stability reasons a self-resonant choke L108 is connected to the output lead.

Signal level monitoring is provided by sampling the developed voltage at both limiter grids. The second limiter developes a voltage proportional to the input signal up to about 10 uv. About this level the voltage on the second limiter is constant, and a voltage proportional to the logarithm of the input exists at the first limiter. These voltages are combined to produce an easily read logarithmic signal-strength scale.

2.3 Output and Monitoring

A 12AU7 (V109) is used as a d.c. bridge to indicate discriminator output for tuning purposes and as a direct coupled video amplifier. V110 is used as a cathode follower output stage and is direct coupled from the video amplifier. The output is 10-15 volts RMS for ± 125 kc deviation.

A conventional two-stage amplifier with built-in loudspeaker is provided for monitoring.

2.4 External Signal Strength Recording

Provision has been made for supplying 10 ma to record variations in signal strength. This signal is the combined plate and screen currents to V104, and it is adjusted to 10 ma with no signal by varying the screen voltage with R150. The signal thus obtained is reverse readings; i.e., 10 ma is obtained with no signal, and minimum current is obtained at maximum signal. This current can be recorded on channels 13 to 16 inclusive.

2.5 Alignment Procedure

2.5.1 Align discriminator.

2.5.2 Align I.F. transformers.

2.5.3 Check dial stops and mechanism.

2.5.4 Adjust oscillator

2.5.5 Align R.F. amplifier

2.5.6 Repeat adjustment of local oscillator

2.5.7 Calibrate signal-strength meter

2.6 Discriminator Alignment

In preparation for alignment of the discriminator transformer T105 (at left end of I.F. assembly as receiver is viewed from the front), remove the second limiter 6AK5 tube from the assembly and note the reading of the center frequency or zero center meter. If it is off center, it should be centered by means of the adjustment (R153 potentiometer) on the rear apron of the chassis. Difficulty in readily securing an exact center reading is indicative of a defect in the 6AL5 tube (V108), the 12AU7 tube (V109), or their associated components, and must be corrected before proceeding further. Other steps are as follows:

2.6.1 Remove oscillator tube to prevent mixing at signal generator harmonic frequencies.

2.6.2 Set receiver dial to 200 mcs.

2.6.3 Set signal generator to 21.4 mcs and connect to antenna terminals. If sufficient output indication is not secured, connect to mixer grid instead.

2.6.4 Connect high-resistance voltmeter (Volt Ohmyst type) to second limiter grid return (orange lead from I.F. assembly connected to tie point T-111). The signal-strength meter may be used as an output indicator with equal accuracy.

2.6.5 Set generator to produce approximately 1 volt on VTVM or 5 uv on signal-strength meter.

2.6.6 Connect the VTVM to the discriminator output lead (TP-113).

2.6.7 Detune or back out the bottom or secondary slug of T105 until the VTVM shows a reading of .5 volt.

2.6.8 Peak top of primary slug of T105 to give maximum reading.

2.6.9 Retune bottom or secondary slug to center frequenc or zero reading on the VTVM.

2.6.10 When the visual alignment equipment is available, a sweep generator should be connected to the second limiter grid and the oscilloscope connected to TP-113 or the output connector. Primary and secondary should then be adjusted for maximum output with symmetry around a 21.4 mc center frequency.

2.7 I.F. Alignment

The characteristic of cascaded critical coupled amplifier stages is such as to make alignment difficult; however, the advantages of response stability, gain, and adjacent-channel selectivity make this type of coupling most desirable. Alignment has been kept as simple as possible by using transformers with almost identical characteristics. The primary and secondary Q's have been kept high and, therefore, the mutual coupling low for the required bandwidth. These factors suggest a rather simple alignment procedure with a minimum of equipment. The resonant frequency of the primary or secondary in the absence of the other (no coupling) is very nearly the proper tuning when the circuits are coupled.

If the primary circuit is detuned and the secondary adjusted to maximum output and then the primary tuned to maximum, the overall response will be approximately correct. The procedure is then as follows:

2.7.1 Remove oscillator tube to prevent mixing at a signal generator harmonic frequency.

2.7.2 Set receiver dial to 200 mcs.

2.7.3 Set signal generator to 21.4 mcs and connect to antenna terminals. If sufficient output is not obtained, connect to mixer grid.

2.7.4 Connect high-resistance voltmeter (Volt Ohmyst type) to second limiter grid return (test point TP-111). The signal strength meter may be used as an output indicator with equal accuracy.

2.7.5 Set generator to produce approximately 2 volts on VTVM or 5 uv on signal-strength meter.

2.7.6 If the I.F. amplifier is known to be considerably out of adjustment, it is desirable to peak T101, T102, T103, and T104 to provide adequate gain.

2.7.7 Detune primary by tuning the bottom slug of T104 counterclockwise against the stop.

2.7.8 Increase signal generator output to produce approximately 2 volts on VTVM or 5 uv on the signal-strength meter.

2.7.9 Adjust secondary (top) of T104 for maximum indication.

2.7.10 Adjust primary (bottom) of T104 for maximum indication, keeping signal generator adjusted for 2 volts output indication. DO NOT readjust secondary for maximum, as this will result in improper adjustment.

2.7.11 Repeat steps 2.7.9 and 2.7.10 for T103, T102, and T101. NOTE: It is not necessary that this sequence be followed, as any transformer may be adjusted without affecting the other.

The alignment may be checked by varying the signal generator frequency ±240 kc. The output voltage should be constant ±1 db over this range.

If a sweep generator and an oscilloscope are available, they may be used to check the response; however, the above procedure should first be performed and then the shaping checked or retouched as required in the light of the visual display. For this test, replace the signal generator with the sweep generator and the VTVM with the oscilloscope. Slight retouching of the transformers may give some improvement in response shape.

2.8 Check of Dial Stops

2.8.1 Loosen (4) screws on flexible coupling between dial and tuner.

2.8.2 Rotate knob clockwise to stop position.

2.8.3 Loosen set screws on dial.

2.8.4 Set dial to read "zero" and tighten set screws.

2.8.5 Rotate knob counterclockwise until dial returns to zero.

2.8.6 Set stop nut if necessary.

2.8.7 Rotate tuner shaft clockwise until tuner is stopped by its own mechanism.

2.8.8 Tighten screws on flexible coupling.

2.9 Local Oscillator Adjustment

The only adjustments to be made in the local oscillator are to make the tuning dial read properly. If the dial reading is correct, disregard this section. If a tube has been replaced and an error is noted, it may be corrected by adjustment of C116 (screwdriver adjustment adjacent to oscillator tube). This adjustment should be made with a signal generator of high accuracy with crystal check points spaced 2 to 10 mc and should be made at about 200 mcs. If component parts have been replaced or wiring disturbed, the dial may show an error at the high end (260 mcs.). This is correct by adjusting L105A (a short hairpin loop made of bus wire). Sufficient range may be obtained by adjusting the shape of this hairpin. The 200 mc point should then be rechecked since the adjustments are related.

The modification of the Clarke receiver was planned with a view to making the restoration to variable tuning as simple as possible. The bracket which mounts the coupling coil and the coaxial cable may be removed by taking out two screws, and unsoldering the 1 uuf coupling capacitor from the coupling coil. The free end of the coupling capacitor is then soldered back to the lug of L 105. The original 6J6 oscillator tube which was removed when the crystal oscillator was installed has been taped to its shield and to the top of the R.F. shield in the receiver. Insertion of this tube in the socket restores to operation the tunable oscillator. The three power leads to the crystal oscillator are then unsoldered and the crystal oscillator may be removed from the receiver. If it is not necessary to remove the crystal oscillator completely, variable tuning may be restored merely by changing the connection of the 1 uuf coupling capacitor, inserting the 6J6 tube, and disconnecting the red B+ lead to the crystal oscillator.

In some receivers after the crystal oscillator was installed, the VR150 regulator, V-112, ceased to function, since the three 5703 tubes draw about 8 ma more than the 6J6. When this conditon occured, R165 was adjusted until minimum current necessary to regulate was obtained. This adjustment was of the order of about 10%.

If it is necessary to change tubes, the leads of the replacement 5703 should be cut to .2 inches. A red dot on the socket shows which end the red dot on the tube should face. A seven pin socket is used in order to avoid bending the tube leads. Since there are only five leads on the tube, care should be observed in inserting the tube so that the leads go into the proper holes. Generally, little difficulty should be encountered as the supports and sockets are lined up to minimize error.

2.10 R.F. Amplifier Alignment

The band pass circuit between the R.F. amplifier and mixer need only be adjusted at the low end of the frequency range as the coupling and band pass are great enough at the high end to take care of all normal variations encountered. To adjust these circuits (C103 and C107) it is necessary only to tune in a signal at about 200 mcs (from a distant transmitter or loosely coupled signal generator) and adjust for maximum reading on the signal-strength meter. It will be noted that variation of C107 will affect the local oscillator frequency, and the dial should be adjusted to keep the signal in tune. The input circuit is sufficiently broad not to require adjustment. C105 should be adjusted only with visual equipment. The sweep generator should be connected to the antenna terminals and an oscilloscope to TP-117. The coupling should then be adjusted until a slightly overcoupled shape is observed.

2.11 Signal Strength Meter Calibration

This requires a signal generator with a 75 ohm output impedance and calibrated from 1 uv to 10 mv. Connect signal generator to antenna terminals and set to 215 mcs and 10 mv. across the output line. Tune receiver and set control in rear labeled "10 mv adjust" to read properly on signal-strength meter. The scale should be checked, but if considerable inaccuracy is noted, V104 should be replaced. If high accuracy is required, the calibration curve must be used.

3.0 Subcarrier Amplifier

3.1 General

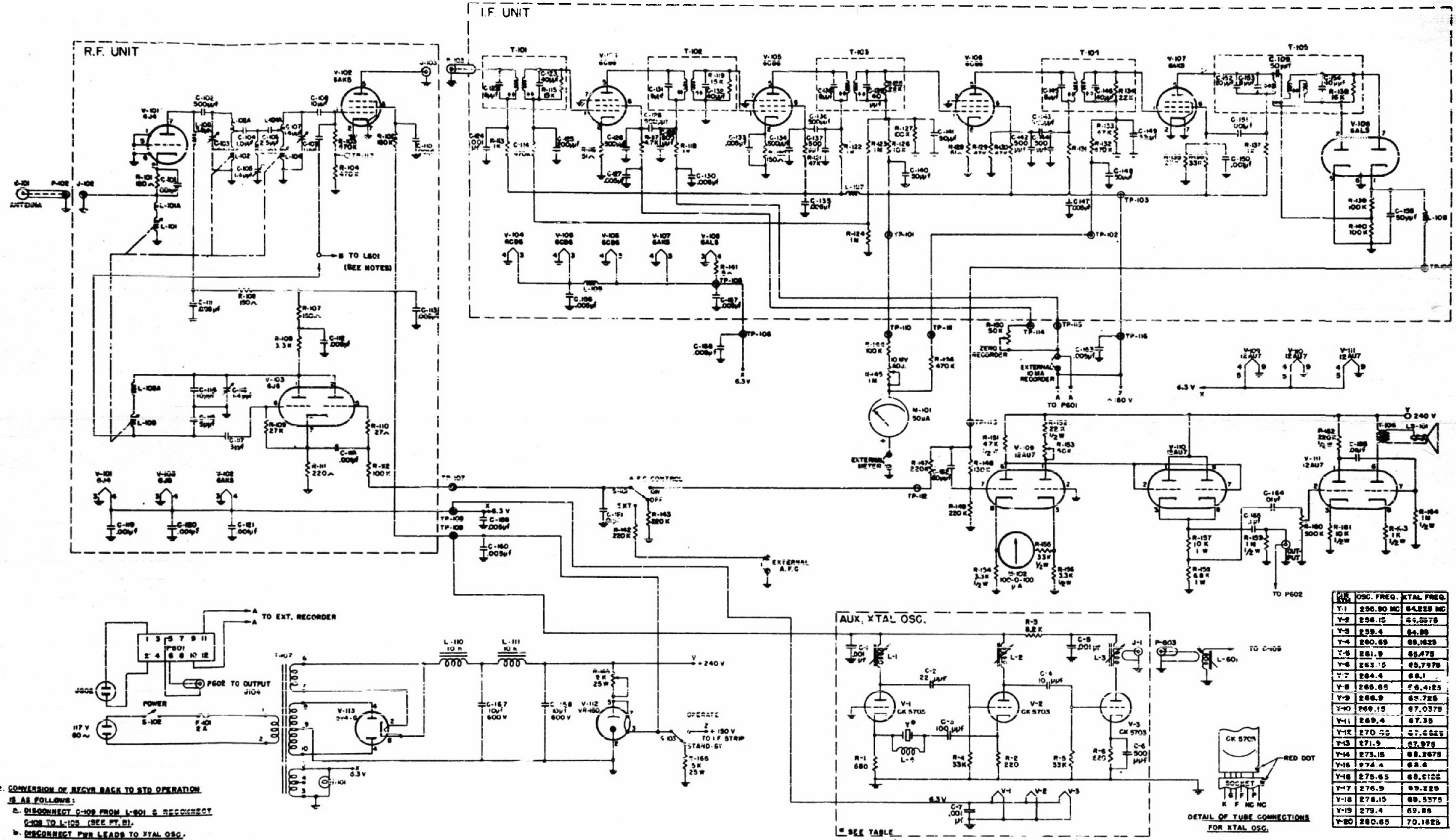
The output from the Clarke FM receiver is fed into a subcarrier amplifier. Each amplifier has circuits for individually amplifying and separating four different subcarriers from the FM/FM composite telemetering signal coming from the receiver. In this station only the first three channels are used, the fourth is a spare.

As shown in Figure 17 the input lead supplies the composite signal through individual 500K gain controls, R501 through R504, to each of four cathode followers, V501 through V504. These tubes are mounted on the chassis immediately behind the front panel. The output circuits of these cathode followers connect through plug-in band pass filters to amplifier-cathode follower output tubes V502, V503, V505 and V506. These filters are mounted in individual cases and are plugged into four receptacles on the chassis. Heater voltage and 250 volts plate voltage are supplied by a separate regulated power supply. Connections are made through a 12 pin connector mounted at the rear of the chassis.

The meter M501 on the front panel can be connected by means of switch SW501, mounted immediately below it, to measure plate current to the various tubes.

In operation, the first cathode followers in the four channels serve principally to isolate the individual filter loads from the receiver output circuit and from each other. As the impedance of each filter is 510 ohms, four such filters in parallel would present a very low impedance load to the receiver output circuit, and would produce a very bad impedance mismatch. A further purpose in isolating the filter input circuits is to prevent the return of reflections from the filters to the receiver output circuit. The output signal from the filter drives the output tube. In the output tubes, which are 12AT7 twin triodes, the first triode is used as a linear amplifier to drive the second section which functions as a cathode follower output coupling means.

NOTE: Mounted above the gain control of each of th[illegible] channels is a white designation [illegible] frequency is to be written in pencil on this plate when the filter is installed or replaced.



CIR. SYM.	OSC. FREQ.	XTAL FREQ.
Y-1	256.90 MC	64.225 MC
Y-2	258.15	64.5375
Y-3	259.4	64.85
Y-4	260.65	65.1625
Y-5	261.9	65.475
Y-6	263.15	65.7875
Y-7	264.4	66.1
Y-8	265.65	66.4125
Y-9	266.9	66.725
Y-10	268.15	67.0375
Y-11	269.4	67.35
Y-12	270.65	67.6625
Y-13	271.9	67.975
Y-14	273.15	68.2875
Y-15	274.4	68.6
Y-16	275.65	68.9125
Y-17	276.9	69.225
Y-18	278.15	69.5375
Y-19	279.4	69.85
Y-20	280.65	70.1625

NOTES:

1. SCHEMATIC COVERS MODIFICATION OF STD. CLARKE RECVR BY ADDITION OF AUX. XTAL OSC. & REMOVAL OF 6J6 OSC. TUBE
2. CONVERSION OF RECVR BACK TO STD OPERATION IS AS FOLLOWS:
   a. DISCONNECT C-109 FROM L-601 & RECONNECT C-109 TO L-105 (SEE PT. B).
   b. DISCONNECT PWR LEADS TO XTAL OSC.
   c. INSERT 6J6 OSC TUBE.

Figure 16 - Schematic, Modified Clarke Receiver with Crystal Controlled Oscillator