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SPECIFICATIONS, THEORY OF OPERATION AND MODULE DESCRIPTION OF VLRB-1 PROTOTYPE RECEIVER

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I. SPECIFICATIONS OF TMC MODEL VLRB-1

Frequency Range:	30 to 600 kcs continuously in tuning ranges of 30 to 55, 55 to 100, 100 to 180, 180 to 330, and 330 to 600 kcs.
Modes of Reception:	AM, AME, CW, FSK and FAX over the entire frequency range of 30 to 600 kcs.
Frequency Stability:	0.01% of the operating frequency after warm-up.
Input Impedance:	50 ohms nominal.
Sensitivity:	With a bandwidth of 500 cycles, a 0.3 microvolt signal at the antenna terminals will produce a 15 db signal to noise ratio at the output of the audio amplifier.
Tuning:	Continuous tuned with magnetic cores to give stable smooth tuning.
RF Bandwidth:	The RF bandwidth is a minimum of 2 kc on the lower band at 30 kc. On other bands starting at 55 kc, at least 8 kc bandwidth.
IF Bandpass:	0.5, 2, 4, and 8 kc at 3 db points, selectable from the front panel.
IF Noise Silencer:	A highly effective IF type noise silencer is included to remove impulse noise.
IF Output:	.001 volt across 50 ohms.
Image Ratio: (in accordance with CCIR specifications)	HFO image is at least 80 db down when referenced to 0.3 microvolt input signal.
AGC Characteristics:	With a 100 db variation in the input signal, the output remains constant within + 1 db.
Audio Distortion:	On standard two tone test audio distortion will be at least 40 db down.

I. SPECIFICATIONS OF TMC MODEL VLRB-1 (Continued)

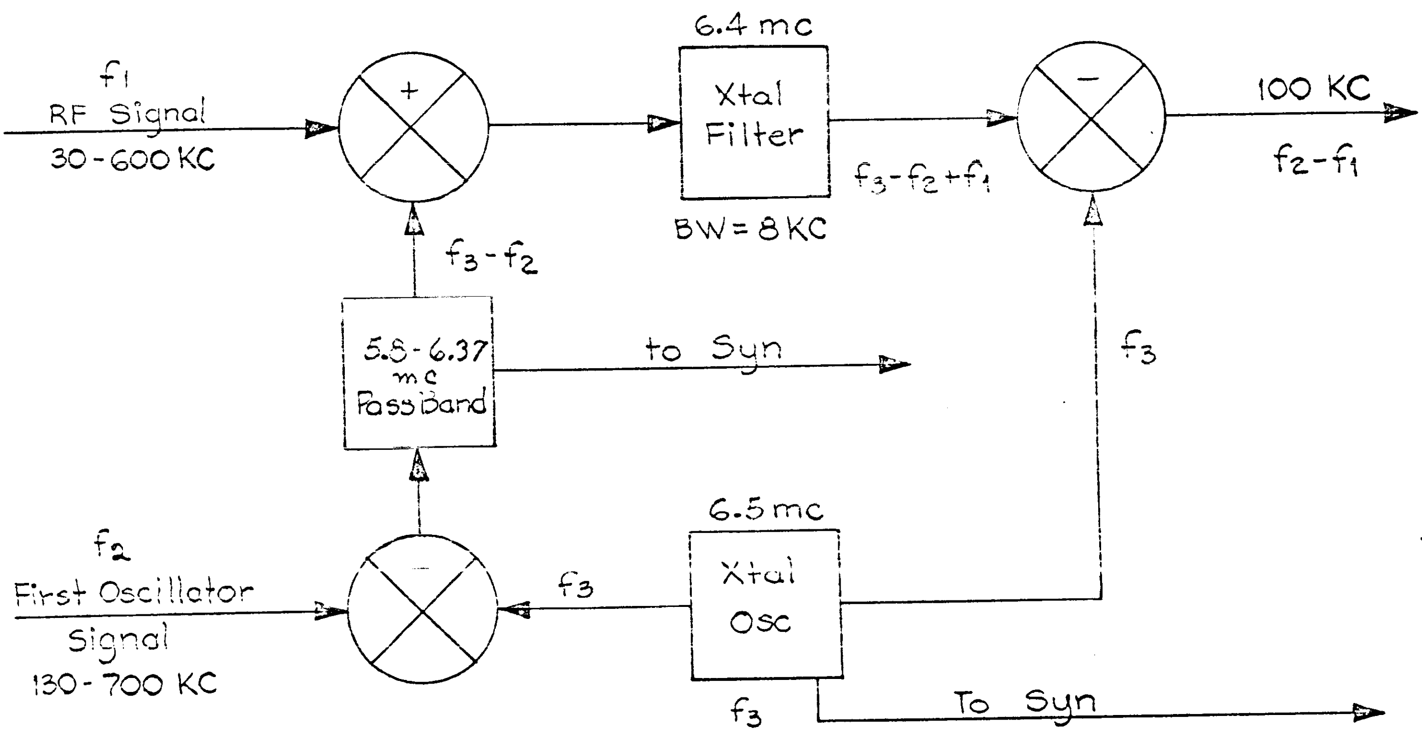
Audio Output:	1. 0 dbm output into a 600 ohm balanced center tapped line. 2. 4 ohm output to drive a speaker, 1/2 watt average power output. 3. Headphone monitor.
Hum Level:	Power Supply hum at least 50 db below full audio output.
Environmental Conditions:	Designed to operate in any ambient temperature of 0°C to 50°C, and any value of humidity up to 90%.
Installation Data:	The unit is approximately 7" high X 19" wide X 16" deep, and weighs approximately 15 lbs.
Power Supply:	115/230v, 47-400 cycle, single phase primary power, approximately 15 watts.
Components and Construction:	All equipment is manufactured in accordance with JAN/MIL specifications wherever practicable.
Options/Accessories:	(All priced separately) Synthesizer, TMC Model LFSB-1, with Frequency Standard, TMC Model CSS-2, for 1 part in 10^9 stability per day. An electronically switched battery supply is available for operation of the receiver by itself or to provide power to the receiver, synthesizer and frequency standard in the event of main power failure. Model BPSA-1 will furnish power to the unit for at least 6 hours. Single sideband converter, TMC Model LFCA-1, with simultaneous outputs of upper and lower sideband channels.

II. THEORY OF OPERATION

The receiver is a superheterodyne type having a double conversion number scheme. This receiver provides continuous coverage from 30 to 600 kc using 5 RF bands covering the frequency range as shown in the following chart:

Band	RF Frequency Change (KC)	First OSC Frequency Coverage (KC)	RF Frequency Ratio	RF Minimum Bandwidth (KC)
1	30 - 55	130 - 155	1.83	2
2	55 - 100	155 - 200	1.82	8
3	100 - 180	200 - 280	1.80	8
4	180 - 330	280 - 430	1.83	8
5	330 - 600	430 - 700	1.82	8

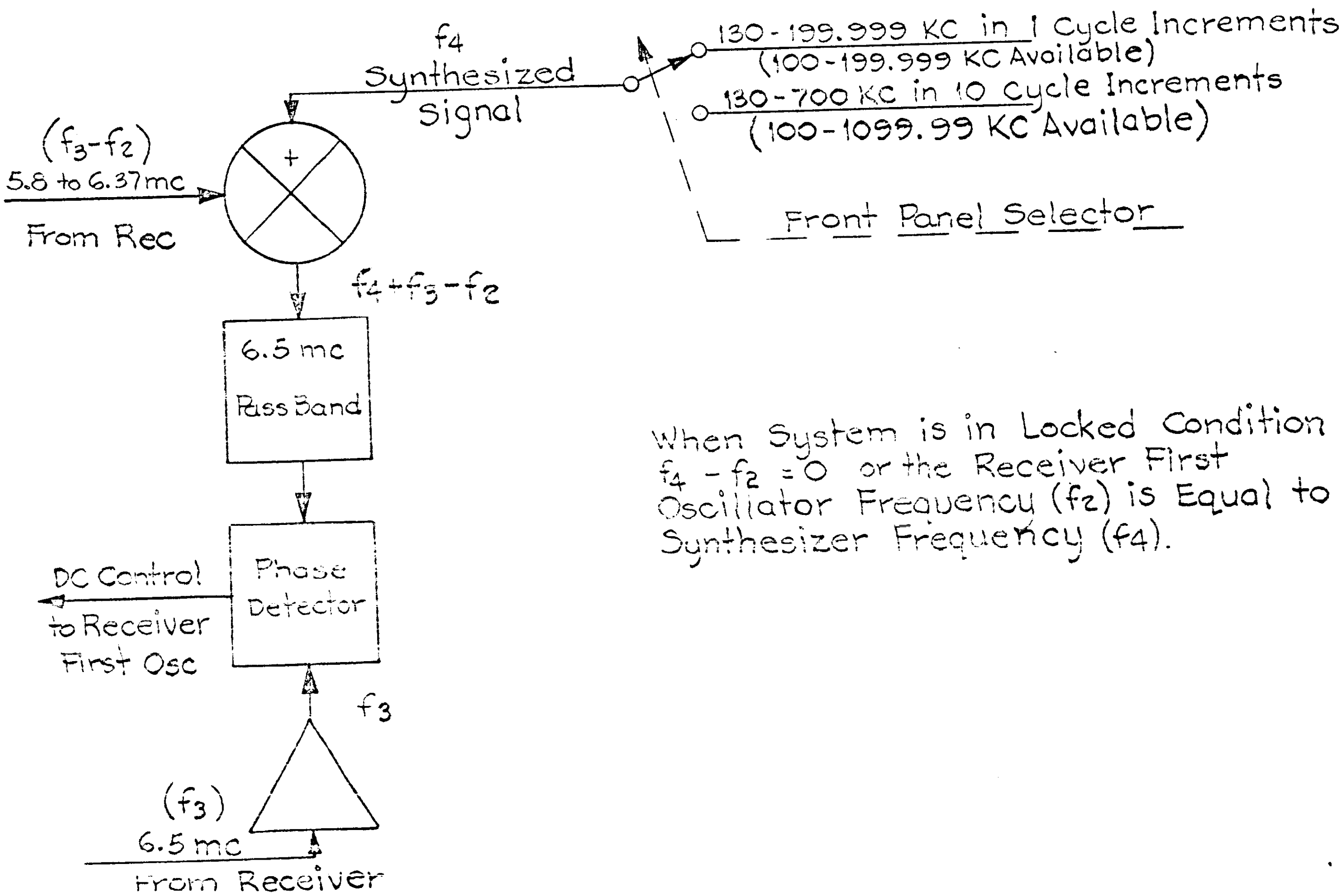
The incoming RF signal is upconverted to 6.4 mc and subsequently downconverted to the final 100 kc IF. This double conversion system is used to provide image rejection of 80 db and also to eliminate the generation of low order mixer crossings. For clarification, the following block diagram shows the number system utilized in the system.



II. THEORY OF OPERATION (Continued)

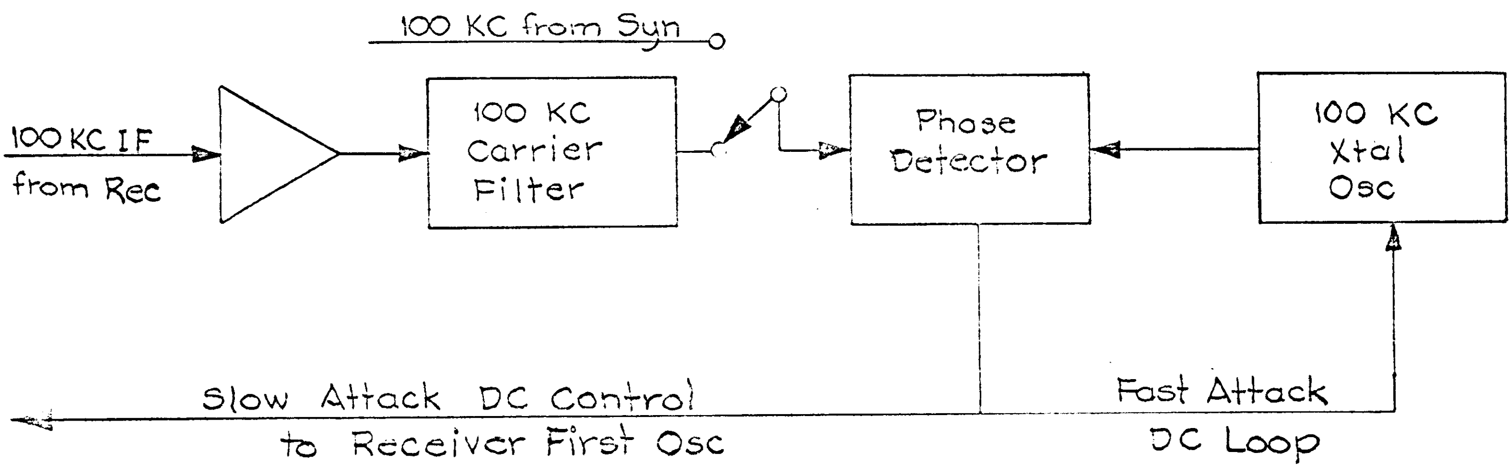
As apparent in the block diagram, the 6.5 mc oscillator frequency is effectively removed from the 100 kc output and therefore, makes the receiver stability that of the first oscillator. This system requires that the 6.5 mc switching signal must be attenuated approximately 110 db in the 5.8 to 6.37 mc passband in order to prevent a spurious signal from being generated when the RF signal is approximately 100 kc. Two crystal traps are provided to eliminate the 6.5 mc frequency from the 5.8 to 6.37 mc passband.

The receiver may be synthesized over the complete tuning range in 10 cycle steps. The lower frequencies (30 to 100 kc) have the additional feature of being synthesized in 1 cycle increments. Consider the following block diagram of the receiver-synthesizer inter-connecting circuitry.



This system allows the use of a phase detector that operates at a particular frequency rather than a wide band of frequencies providing a simplified electrical design. The percentage hold in range of the system is greater than 0.1% of the synthesizer frequency throughout the 130 to 700 kc range. It should be noted, this synthesizer design provides the proper frequencies to synthesize the VLRC-1 receiver without further modifications.

The receiver is capable of receiving SSB in conjunction with the SSB unit (LFCA-1). The SSB unit accepts the 100 kc IF output of the receiver and reconstructs the carrier of the single sideband signal. The following block diagram shows the method used in processing single sideband signals.



The reconstructed carrier and 100 kc crystal oscillator signal are compared in the phase detector. When the carrier is within 5 cycles of the 100 kc crystal oscillator frequency the system will become locked. This now provides a locked control to the first oscillator of receiver with a slow attack time. After the system is in lock, the incoming carrier frequency and first oscillator frequency of the receiver may separate as much as ± 0.15% of the first oscillator frequency before the system looses lock. A more complete description of the control loop is provided in the LFCA-1 tuning procedures.

When the synthesizer is used while receiving SSB, a 100 kc signal is routed from the synthesizer that controls the 100 kc crystal oscillator of the SSB unit. In this mode of operation, the first oscillator of the receiver is locked to the synthesizer rather than to the SSB unit.

This receiver provides 4 IF bandwidths, 0.5, 2, 4 and 8 kc with front panel control. The different bandwidths are generated with the use of a doubly tuned amplifier stage and a Q multiplier amplifier. The doubly tuned stage has a bandwidth of 8 kc. The output of the doubly tuned stage is routed through the Q multiplier for 0.5, 2 and 4 kc bandwidths and bypasses the Q multiplier for the 8 kc bandwidth. The Q necessary for the Q multiplier circuit is as follows:

Bandwidth (KC)	Q = 100/BW
4.0	25
2.0	50
0.5	200

The initial Q of the inductor used in the Q multiplier is nearly 200. This allows the Q multiplier design to effectively be that of degeneration rather than multiplication of the inductor Q.

The receiver information processing circuitry and audio amplifiers are of conventional design. In AM operation, the 100 kc IF signal is routed through a regular diode detector and consequently to the audio amplifiers. For CW operation, the 100 kc IF signal channels to a mixer where it mixes with a variable 100 kc signal provided by the receiver BFO. The BFO output frequency is adjustable from 97 to 103 kc. The gain of the audio and line amplifiers is set up so that one may have full power output in both channels with a 30% modulated, 0.3 microvolt RF signal.

III. MODULE DESCRIPTION

The receiver circuitry is located on 7 basic printed circuit cards. These cards are identified as the RF 100, OSC 100, IF 101, IF 102, AGC 100, BFO 100 and PS and AA 101.

A. RF 100

The RF 100 card is used for the 5 RF bands. It must be pointed out that there are only 4 RF modules since it was possible to use the same tuning coils for bands 1 and 2. This RF module is provided with additional capacitors so that the band switch adds the capacitors to the tuned tanks in the Band 1 position, effectively lowering the frequency of operation.

Each RF stage consists of a series of 3 tuned amplifiers (Q1, Q3, and Q5) terminated into an emitter follower stage (Q7). The proper gain of the RF band is 70 db to TP2. A list of the measured gains for the various bands is included below.

Band	Frequency (KC)	Gain at TP2 (db)
1	55	69
2	55	75
2	67	74
2	100	74
3	100	71
3	122	70
3	180	68
4	180	73
4	220	73
4	330	68
5	330	70
5	397	72
5	600	69

The tuned tanks of the stages consists of two coils and an adjustable capacitor. One coil is the large tuning coil (TA, TB, TC) and the other (L1, L2, L3) is used for setting of the end points of the band for a given travel. For a setting of the tuning coil (TA, TB, TC), an increase of the trimming coil (L1, L2, L3) inductance decreases the bandspread as the tuning slug is tuned from the end points of the tuning assembly.

III. MODULE DESCRIPTION (Continued)

Q2, Q4 and Q6 act as variable impedances in the emitter circuits of Q1, Q3 and Q5. The impedance is controlled with the base currents to Q2, Q4 and Q6. When no RF signal is present, the control transistors are operating in a saturated condition and the effective collector-to-emitter impedance is low. As the RF signal increases, the base current to the control transistors is decreased, allowing the effective collector-to-emitter impedance of the control transistors to increase. A rather comprehensive article describing this type of AGC control is presented by Eugene Franke in the November 8, 1962 issue of Electronics Design. This type of AGC circuitry has a high input voltage overload characteristic. Presently the AGC of the receiver controls the output within 1 db variation from 0.3 microvolt to 1.0 volt input RF signal. Some distortion is present above 0.3 volts.

Tuning Procedures:

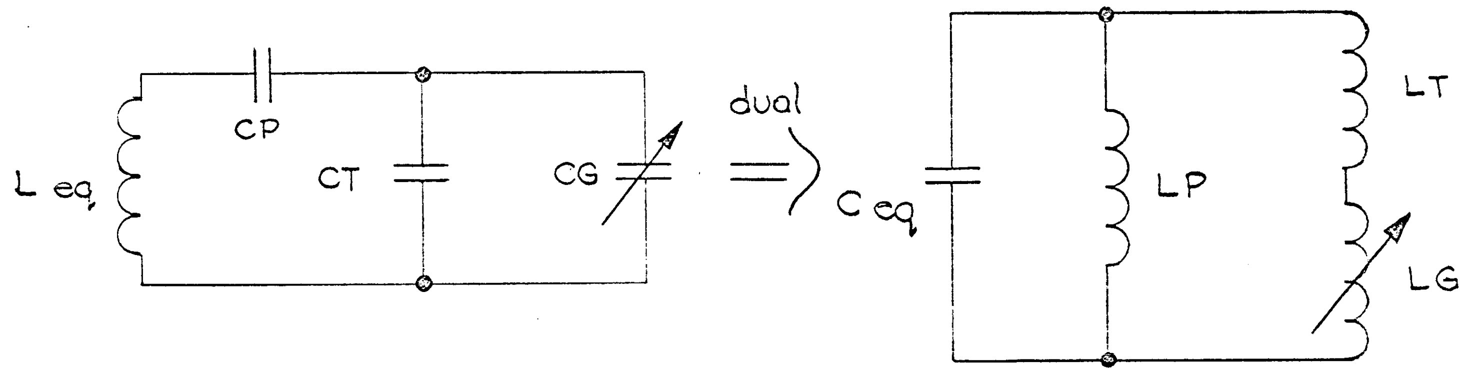
1. Adjust C11, C5 and C18 to minimum values.
2. Set tuning assembly to upper end of tuning band for bands 2, 3, 4 and 5.
3. Connect signal generator to antenna input and adjust frequency to desired frequency for the particular band being tuned. Be certain to have a counter on the signal generator output for accurate readings.
4. Connect VTVM to TP2 and adjust TA, TB and TC for maximum output.
5. Tune assembly to low end of frequency band.
6. Readjust signal generator to proper input frequency.
7. Tune C11, C5 and C18 for maximum output at TP2. If capacitance tuning does not result in maximum output, each capacitance of C11, C5 and C18 off and tune TA, TB and TC for maximum output.
8. Return tuning assembly to upper frequency position and reset input frequency to receiver.
9. Retune TA, TB and TC for maximum output.
10. Recycle receiver tuning from upper to lower ends of frequency coverage tuning the inductance at the upper frequency and capacitance at the lower frequency.
11. L1, L2 and L3 are preset before assembly, and should not have to be retuned. These coils set the band spread of the RF bands for a given travel. If the band spread is not correct, an increase or decrease of the inductance of L1, L2 and L3 will decrease or increase the band spread of the RF band.
12. After aligning band 2 one may adjust C9A, C8A and C20A for proper coverage of band 1. This band should be tuned to cover from 31 to 56 kc with the first oscillator tuned to cover from 130 to 155 kc. This tuning arrangement allows reception of the carrier or upper single sideband signals having a 2 kc bandwidth.

III. MODULE DESCRIPTION (Continued)

B. OSC 100

This module has five oscillators covering the ranges of frequencies for the various bands. The design of the oscillator is essentially a Gouriet-Clapp design, having one variable element which, in this case, is the total inductance. The inductance is made up of 3 elements tuned in the dual of the manner that 3 capacitors are tuned for geometrical mean tracking. This method of tracking is described on page 1010 of Radiotron Designers Handbook.

The following diagram, equations and charts, provide the necessary information to begin in selecting the final coil and capacitor values.



Equations:

1. Lg = Lg maximum - Lg minimum

2. Lp maximum = $\dfrac{Lg}{r - 1}$

3. LT maximum = $\dfrac{Lg}{rB^2 - 1}$

4. Lp = Lp minimum = Lp maximum - LT maximum

5. $L_O = L_T$ - Lg minimum

   α = f2 receiver/f1 receiver

   B = f2 oscillator/f1 oscillator

   $\gamma = \dfrac{\alpha^2}{B^2} \times \dfrac{2B + (1+B)\alpha^{1/2}}{2\alpha + (1+B)\alpha^{1/2}}$ for geometrical mean tracking.

Band	Receiver Coverage (KC)	Oscillator Coverage (KC)	α	$\alpha^{1/2}$	α^2	B	B^2	γ	γB^2
1	30 - 55	130 - 155	1.833	1.354	3.36	1.191	1.4185	1.91	2.71
2	55 - 100	155 - 200	1.819	1.3485	3.31	1.290	1.6641	1.71	2.845
3	100 - 180	200 - 280	1.800	1.342	3.24	1.400	1.960	1.46	2.86
4	180 - 330	280 - 430	1.833	1.354	3.36	1.535	2.355	1.31	2.08
5	330 - 600	430 - 700	1.819	1.3485	3.31	1.627	2.6451	1.18	3.14

From the above charts and knowing the maximum and minimum values of Lg as the tuner is tuned from the end points of the frequency coverage, one may calculate the Ceq, Lp and LT with a given Lg. The original values of all components were determined in this manner and final values determined from actual tracking data.

In tracking the oscillator, LT and LP of each band should be approximately adjusted correctly before assembly. Tuning the oscillator for tracking follows regular methods; however, remember that an increase of LP will increase the midband frequency for a given Lg and LT combination.

The output of the oscillator to TP1 should be about 5 millivolts. Adjustment of the series resistors from the bases of five oscillator transistors to the output emitter follower controls the output level.

III. MODULE DESCRIPTION (Continued)

Tuning Procedure - LP and LT should be preset to a particular value before assembly. LP should not have to be retuned during oscillator alignment.

1. Connect a HP 400L to TPl with its output connected to a counter. Set the mode switch to AM position.
2. Set RF tuner to 600 kc (upper frequency end point of band 5). Adjust LG for 700 kc output at TPl with trimmer capacitor in center position.
3. Set RF tuner to 330 kc (lower frequency end point of band 5). Adjust trimmer capacitor for 430 kc at TPl.
4. Set RF to 600 kc position. Tune LT for 700 kc output.
5. Recycle between steps 3 and 4 until end point tracking is achieved.
6. Check frequency tracking through mid-band positions. If oscillator frequency is below desired frequency through midrange, decrease LG slightly and repeat steps 3, 4 5 and 6. If oscillator frequency is above desired frequency through midrange increase LG slightly and repeat steps 3, 4, 5 and 6.
7. Repeat steps 2 through 6 to tune bands 1, 2, 3 and 4, using appropriate bands and frequency settings.
8. Check output level throughout band at TPl with HP400L. Desired level is nominally 5 mv. See prototype output levels as follows:

Band	Tuner Position	Output Level From 5 Millivolts in db
1	low	2.5
1	mid	1.5
1	high	0.5
2	low	1.1
2	mid	0.5
2	high	0.0
3	low	1.5
3	mid	0.8
3	high	0.2
4	low	3.5
4	mid	1.8
4	high	0.0
5	low	0.4
5	mid	- 1.2
5	high	1.0

9. The capacitors of the oscillator are specified as 1% values; however, 1 % values are not close enough in some cases, and the artwork provides a position for trimming capacitors to be added. For

instance, band 1 of the prototype required 1500 + 250 pf for tracking rather than the 1800 pf calculated. Trimming capacitor holes are provided by C6, C13, C20, C27 and C34 capacitors.

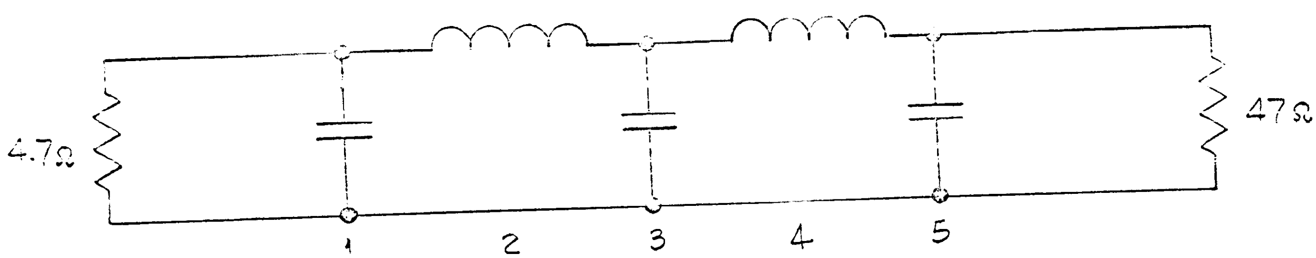
C. IF 102

This module contains circuitry of the 6.5 crystal oscillator and the 5.8 to 6.37 mc passband amplifiers. The 6.5 crystal oscillator consists of Q1 and Q2. The output of Q2 feeds Q3 which serves as a current source in the emitter circuitry of the balanced mixer of Q4 and Q5. The mixer "subtracts" the input of the first oscillator (130 to 700 kc) from 6.5 mc, resulting in 6.37 to 5.8 mc. In order to eliminate harmonics of the first oscillator from being present in the 5.8 - 6.37 mc passband, the first oscillator signal is routed through a low pass filter before being introduced into the mixer. The 5.8 to 6.37 mc amplifiers consist of Q6 and Q7. Q8 serves as an emitter follower to provide the 6.8 to 6.37 mc signal to the synthesizer unit. The 5.8 to 6.37 amplifier circuitry consist of T1, T2, L6, T3 and T4, which act as the 5 poles of a maximally flat 5 pole bandpass design. The calculated characteristics of the inductances are as follows:

Coil	Inductance (uh)	Loaded Q
T1	7.96	12.5
T2	7.96	12.5
L6	6.24	32.8
T4	10.10	10.1

It should be noted that pole represented by T4 in the regular output is not present in the output to the synthesizer and is located in the input circuitry of the synthesizer unit.

The low pass filter is a n=5 maximally flat design and consists essentially of 2 coils and 3 capacitors plus the source and load resistances. The coils, L7 and L8, are preset before assembly and should not be retuned. The 33 pf capacitors, C17 and C20 were added to the filter to resonate the coils at about 6.5 mc. Calculated values of the low pass filter are as follows:



III. MODULE DESCRIPTION (Continued)

Component	Calculated Value	Use	Circuit Designation
C1	2735 pf	2700	C16
L2	17.85 uh	17.85	L6
C3	8840 pf	8200 + 620	C18 + C19
L2	17.85 uh	17.85	L8
C5	2735 pf	2700	C21

Also present in the 5.8 to 6.37 passband circuitry are crystal traps to the 6.5 mc signal. Close balance of the balanced mixer and the crystal traps are necessary to eliminate the 6.5 mc signal from the 5.8 to 6.37 mc signal. This is necessary for two reasons. The first is when the receiver is tuned to about 100 kc, the output of the 5.8 to 6.37 passband is approximately 6.3 mc. This mixes with the RF signal of 100 kc to create 6.4 mc. But a 6.5 mc signal minus 100 kc also creates a 6.4 mc signal and consequently a spurious signal results. The second reason is that the synthesizer circuitry required to phase lock the first oscillator of the receiver for synthesized operation compares the signals at 6.5 mc and cannot operate properly if 6.5 mc is present in the 5.8 to 6.37 mc signal.

Tuning Procedures:

1. With a high frequency oscilloscope connected to TP1 tune L1 for maximum signal (6.5 mc). Peak to peak signal level should be approximately 100 mv. Output at pin 22 is nominally 5 mv rms. Capacitor C2 may be adjusted to tune the crystal oscillator to exactly 6.5 mc but after original setting of C2 do not retune. Retuning C2 would change oscillator frequency and make retuning of the crystal traps necessary.

2. Short TP1 of OSC 100 module to ground. Attach a sensitive high frequency scope to the collector of Q7 and balance R13 for minimum 6.5 mc response. Align C29 and C39 for no response of 6.5 mc signal. Connect 5.8 to 6.37 IF output of receiver to synthesizer unit. Connect scope to TP1 of Phase Detector card of Synthesizer unit. Retune capacitors C29 and C39 for minimum 6.5 mc response at TP1 of Phase Detector card. Up until this point the IF 102 module will have been mounted on a riser card for tuning. Insert IF 102 module into chassis and tune R13 for minimum response of 6.5 mc at TP1 of the Phase Detector module of Synthesizer unit. This completes tuning for rejection of 6.5 mc in the 5.8 to 6.37 mc passband. Do not retune C2, C29, C39 or R13 after this alignment.

III. MODULE DESCRIPTION (Continued)

3. Disconnect short from TP1 on OSC 100 module. Attach probe of high frequency scope across R27 of IF 102 card. Switch band switch to band 5 and tune to highest frequency (600 kc). Tune T1 and L6 for maximum response on scope. Switch band switch to band 1 and do not adjust tuning knob. Tune T2 and T3 for maximum response on scope. Return band switch to band 5 and retune T1 and L6 for maximum response. Return bandswitch to band 1 and retune T2 and T3 for maximum response. Continue this process until no tuning is required.

4. Set band switch to band 4 with tuner at 300 kc position. Place scope across R27 and tune T4 for maximum response.

5. Check response of 5.8 to 6.37 mc passband by monitoring BNC output on back of receiver unit. The proper response will vary from 12 to 18.5 mv if 5.8 to 6.37 mc is properly aligned and output of first oscillator is fairly constant. Prototype results are as follows after tuning receiver as described above.

Band Position	Tuner Position	TP1 of OSC 100 Reading in db from 5 mv	BNC Output of 5.8 to 6.37 mc in Millivolts
1	low	+ 2.5	16.0
1	mid	+ 1.5	15.0
1	high	+ 0.5	13.6
2	low	+ 1.1	14.4
2	mid	+ 0.5	14.3
2	high	0.0	13.9
3	low	+ 1.5	16.0
3	mid	+ 0.8	14.8
3	high	+ 0.2	12.9
4	low	+ 3.5	18.6
4	mid	+ 1.8	14.8
4	high	+ 0.0	12.0
5	low	+ 0.4	12.6
5	mid	- 1.2	14.0
5	high	+ 1.0	13.8

If output of 5.8 to 6.37 mc is not within these limits, retune bandpass inductors. It will be noticed that transformers T1 and T2, L6 and T3 are actually double tuned circuits with coupling coefficients of .726 and 3.08 respectively. Conventional double tuning techniques do not appear to properly tune the 5.8 to 6.37 mc passband; however, test points are provided if it is necessary to use this technique in production tuning.

D. AGC 100

The AGC module contains the noise silencer circuitry, 6.4 mc mixer and passband and the dc circuitry of the AGC system.

The RF signal with noise pulses is amplified by Q8 and Q9. The signal is then routed to Q10 which serves as an active transformer. The transformer load is a noise detector that converts all noise pulses to positive pulses. The pulses feed an emitter follower (Q11) and are used to trigger a Schmitt circuit (Q12, Q13 and Q17). The output of the Schmitt turns on transistor (Q6) which effectively turns Q3 and Q4 off. Q3 and Q4 are used in the 6.4 mc passband in a balanced amplifier that cancels the noise blanking pulse from the output 6.4 mc signal. The complete noise silencer circuitry (Q8, Q9, Q10, Q11, Q12 and Q17) is turned on and off with the front panel noise silencer on-off switch.

The 6.4 mc mixer (Q1, Q2 and Q5) is a balanced mixer that converts the RF signals (30 to 600 kc) to 6.4 mc by switching the mixer with 6.37 to 5.8 mc. A crystal bandpass filter (8 kc bandwidth) serves as the mixer load and routes the signal to the balanced amplifier (Q3 and Q4) which the noise silencer turns off during noise pulse transmissions. This stage has AGC and the Q7 transistor serves as the varying emitter impedance of the amplifier. This method of AGC is described under the RF 100 module description.

The AGC control dc voltage is obtained by rectifying the 100 kc IF signal in the Q14 circuitry. The rectified dc voltage is referenced to 10 volts obtained with the 10 volt zener CR17. After rectification, the control dc voltage is amplified and routed to the automatic gain controlled stages with Q15 and Q16.

The collector circuit of Q15 contains the switched capacitors used in the slow, medium and fast AGC decay positions. Slow decay corresponds to a time constant of 16.5 seconds, medium decay to a time constant of 9.9 seconds and fast decay to a time constant of 3.3 seconds. The slow and medium decay time capacitors are located on the IF 102 module.

III. MODULE DESCRIPTION (Continued)

Metering of the AGC control voltage is provided to monitor the relative RF signal level. A chart of the 50 microampere meter position versus RF input signal with proper adjustments of R52 is provided as follows:

RF Signal (Millivolts)	AGC Control Voltage (Volts)	Meter Current Microamperes
.001	6.6	1.0
.003	7.8	13.0
.010	8.2	23.0
.030	8.4	28.0
.10	8.45	31.0
.30	8.55	34.0
1.0	8.6	36.0
3.0	8.65	37.0
10.0	8.70	39.5
30.0	8.75	43.2
100.0	8.90	47.0
300.0	9.00	49.0
1000.0	9.1	50.0

The above data was taken with the AGC set to hold TP5 of IF 101 constant at 56 millivolts.

Tuning Procedures:

1. Adjust R37 for 1.2 volts at TP5 with the noise silencer switch (front panel) on. This sets the noise silencer threshold and is the only adjustment necessary.

2. Connect an accurate 6.4 mc signal across R47 of about 100 mv level. Adjust T1 for a maximum response at TP4.

3. To adjust the AGC threshold level, the receiver should be completely aligned. For a 0.3 microvolt RF signal one should have approximately 50 millivolts at TP5 of the IF 101 module. With this condition, switch the AGC Decay switch to the Fast position and adjust R46 on the AGC module until the signal at TP5 located on the IF 101 module just begins to drop from the full RF gain position. For a quick comparison, switch the AGC Decay control back and forth from Manual to Fast position. After setting the threshold level, check the output variation at TP5 on the IF 101 module as the RF input is varied from 0.3 microvolts to 1.0 volt. Maximu[illegible]ation of the testpoint voltage should be about 0.5 db.

III. MODULE DESCRIPTION (Continued)

E. IF 101

This module provides a mixer, Q1, that converts the 6.4 mc signal containing the RF signal to 100 kc. The switching signal of the mixer, 6.5 mc, is routed to the mixer through an amplifier, Q10. The collector of the mixer consists of a critically coupled, double-tuned stage having an 8 kc bandwidth.

From the double-tuned stage, the signal is routed either to the output amplifiers, Q8 and Q9, or through a Q multiplying circuit, Q6 and Q7, that provides bandwidths of 0.5, 2 and 4 kc. Q2, Q3, Q4 and Q5 serve as buffer amplifiers for the various bandwidth positions and provide the proper gain for the different bandwidths. The proper buffer transistor - Q2, Q3, Q4 or Q5 - is turned on with the IF bandwidth selectivity switch. The switch also shunts L4 with a particular resistance load in the 2 and 4 kc positions in order to maintain a constant feedback (R20 and R21) in the Q multiplier circuit.

Tuning Procedures:

1. Connect a high frequency scope probe across C41. Adjust L7 for maximum 6.5 mc signal. Be certain that IF 102 module is in the chassis to insure a 6.5 mc signal input at TP6.

2. Short TP6 to ground and connect a signal generator to TP1 that will provide a variable 100 kc signal. Set input signal to 100 kc, using counter. Short TP3 to ground. Adjust L1 for a maximum signal at TP2. Disconnect short from TP3 and tune L2 for a minimum signal at TP2. The double-tuned stage should be properly tuned.

3. Set selectivity switch to 8 kc position. Connect signal generator to TP1 and set frequency to 100 kc using a counter adjust input signal level such that there is a 50 millivolt signal at TP5. Turn selectivity switch to 0.5 kc position. Adjust R21 for an 0.5 kc bandwidth at TP5.

   Turn selectivity switch to 2.0 kc position. Adjust R41 for a 2.0 kc bandwidth at TP5.

   Turn selectivity switch to 4.0 kc position. Adjust R43 for a 4.0 kc bandwidth at TP5.

   Check output level in 4 positions. If there is more than one db variation, the gain of the offending channel may be adjusted by changing the series emitter resistor of Q2, Q3, Q4 or Q5.

4. With 50 mv of 100 kc signal at TP5 there should be approximately 1.5 mv of 100 kc at pin 17 or at 100 kc BNC on rear of chassis.

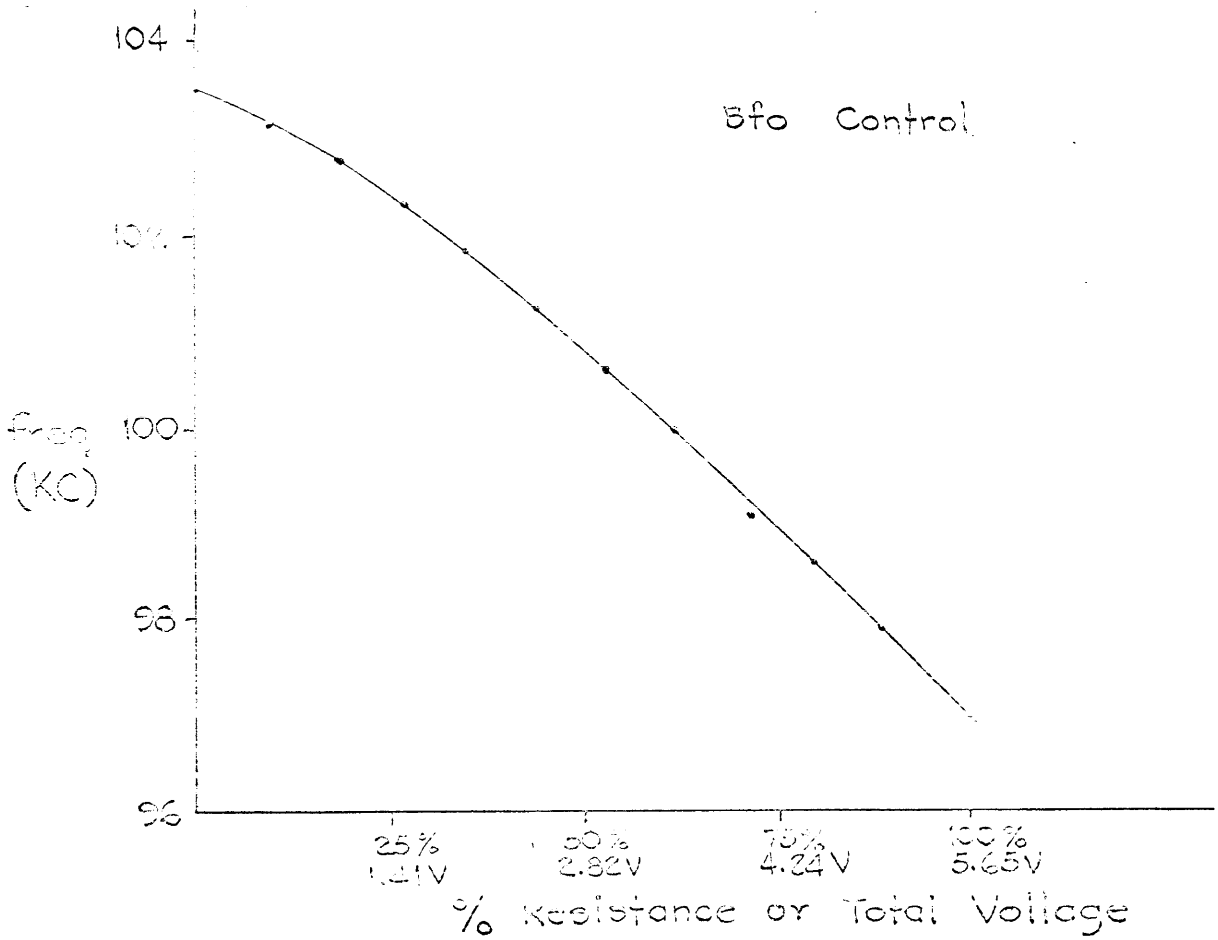
III. <u>MODULE DESCRIPTION</u> (Continued)

5. After system is completely aligned, there should be approximately 50 to 60 millivolts at TP5 for an 0.3 microvolt RF signal at the antenna. Adjustment of this level may be necessary by the adjustment of R62 located on AGC 100 module. Nominal value of R62 is 270 ohms.

F. <u>BFO 100</u>

Circuitry of this module provides the beat frequency oscillator, AM detector, product detector, and line amplifier circuitry. In the AM mode of operation, the 100 kc IF signal is introduced to this module through the Q1 amplifier. The signal is routed to Q2 transistor which has the AM diode detector circuitry in its collector circuit. From the AM detector, the detected signal is routed to the mode switch.

In the CW mode of operation, Q3, Q4, Q5 and Q6 transistors are turned on. The 100 kc IF signal is routed to the product detector (Q3 mixer) from the emitter of Q2. The beat frequency oscillator (Q6) is an LC oscillator with a voltage controlled capacitor (CR3) for tuning the oscillator from 97 to 103 kc. Following is a graph of the output frequency of the BFO versus the front panel BFO frequency control potentiometer which varies the dc voltage to CR3.



The oscillator frequency is amplified (Q5 and Q4) and provides the switching signal for the product detector. From the detector the detected signal is routed to the mode switch.

From the mode switch, the AM and CW dtected signals are routed to an isolation amplifier (Q1) located on PS and AA 101 module. This amplifier's output load is the input gain potentiometers of the output line and audio amplifiers.

The signal from the line potentiometer is routed to the Q7 amplifier of the BFO 100 module. From the Q7 amplifier, the signal goes to the output balanced amplifier (Q8 and Q9). Attached to the output is a metering circuit for setting the line output level. The output level versus meter current is provided for meter calibration in the following chart.

Output Signal in dbm	Meter Current in Microamperes
- 10	6.6
- 9	8.0
- 8	9.5
- 7	11.2
- 6	13.0
- 5	15.0
- 4	18.0
- 3	21.0
- 2	24.2
- 1	28.0
0	32.5
1	37.5
2	43.5
3	50.0

The line output was checked for harmonic distortion. The second harmonic was 44 db below the fundamental.

Tuning Procedures:

1. Turn the front panel BFO control completely counterclockwise. Switch Mode switch to the CW position. Short TP 1 to ground

III. MODULE DESCRIPTION (Continued)

and tune L4 for a 97 kc signal at TP 3. Turn front panel BFO control completely clockwise. The frequency at TP3 should read 103 kc if control potentiometer is wired correctly.

2. Turn Mode switch to CW position. Insert 100 kc signal at TP 1. Adjust BFO for 1 kc signal at line output terminals. Connect 600 ohm load to line output. Adjust 100 kc input signal for 3 dbm output into 600 ohm load. Adjust R49 for 50 microamperes or 3 dbm on front panel meter. Meter switch must be in 0 dbm position.

G. PS and AA 101

This module consists of the power supply circuits and audio amplifier circuits. The design of this circuitry is the same as that used in the VLFRC system. No tuning is necessary on this card.

A two tone test was conducted using two RF inputs separated in frequency by 1 kc. The receiver was under automatic gain control and the input RF signals were one millivolt in level. The line output was monitored with a HP 310 wave analyzor with the converted two tones at 1.5 and 2.5 kc. The results are tabulated below.

Frequency (KC)	Relative Level in db
1.5	0
2.5	0
1.0	<- 40
2.0	<- 40
3.0 (2 X 1.5)	<- 40
3.5	- 44
4.0	- 44
4.5 (3 X 1.5)	- 46
5.0 (2 X 2.5)	- 52
5.5	- 41

The analyzor would not discriminate properly at the 1.0, 2.0 and 3.0 kc signals but the response at these frequencies was greater than 40 db below the tone levels. As may be noted, the harmonic distortion is greater than 40 db. The signals were also compared

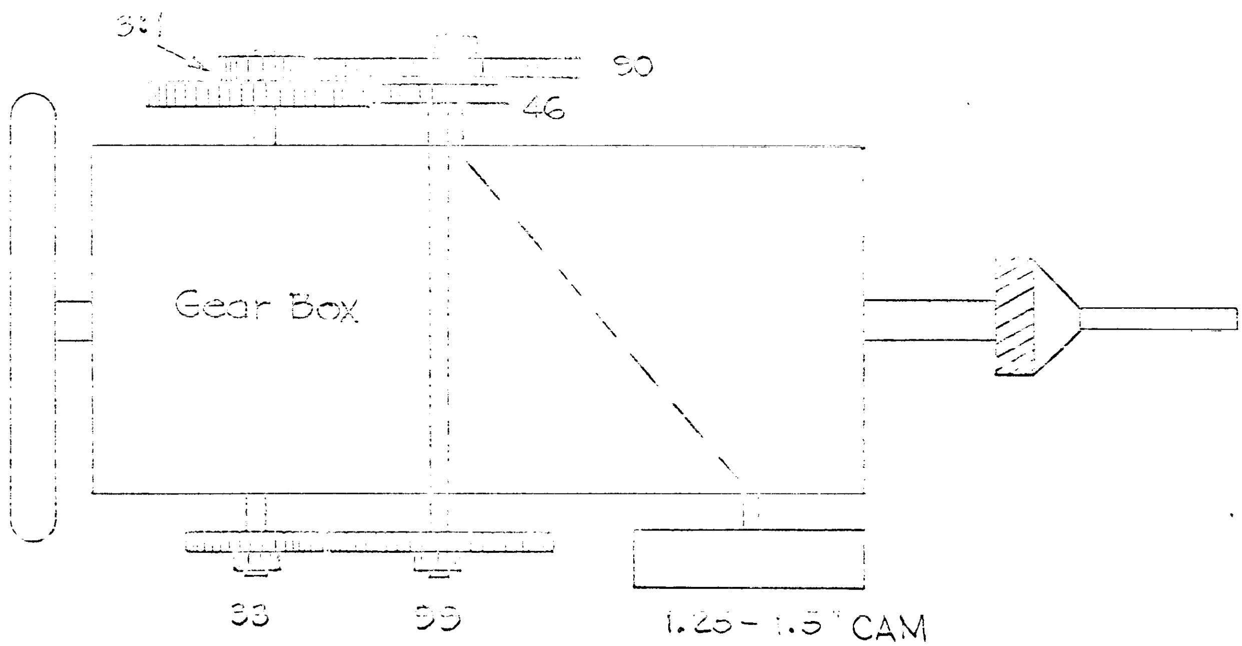
III. <u>MODULE DESCRIPTION</u> (Continued)

in the 100 kc IF where all products were greater than 45 db below the two tone signal levels.

H. Coil winding data for RF and oscillator slug tuned coils.

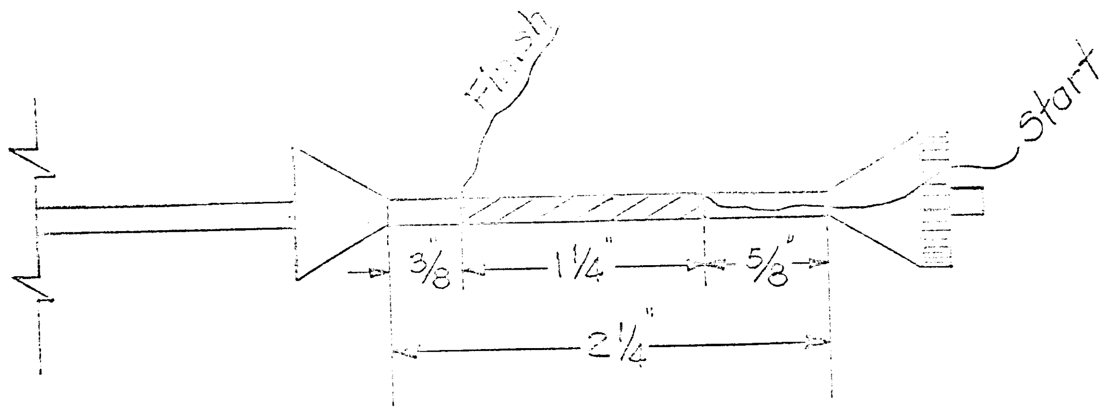
1. Coil winder used was a Coil Winding Equipment Co. Type WX. All coils were wound with a universal wind and a 1.25 inch throw. The machine setting is as follows:

   a. Set variable gain to zero.
   b. Gear ratio on front of gear box is 33-99 step down (driver over driven).
   c. Gear ratio on back of gear box is 46-90 step down (driver over driven). Actually using a 45-90 step down will give an exact 18 to total ratio. After experimentation, it was determined that for the smoothest universal wind a ratio of 17.6 to 1 was needed.
   d. A step down idler gear, Coweco type WA-309, was used with gears in back.
   e. Use standard, 1.25 to 1.500 inch adjustable cam set at 1.25 inch.
   f. Total turns ratio = 17.6 to 1.
      Total turns per crossing = 8.8 to 1.
   g. Diagram of gear box (top view) with proper gears is shown.



III. MODULE DESCRIPTION (Continued)

2. Coil forms used was XXX Natural Paper Base Bakelite with an O.D. of 1/4 inches and an I.D. of 3/16 inches. Coil forms were cut to 2 1/4 inches long. Coils were wound on form between two imaginary lines, one 3/8 inch from top of form with the other 5/8 inch from bottom of form. A sketch of form mounted in winder is shown below.



Forms should be waxed to prevent wire slippage and a slow winding speed should be used.

3. Wire used for coils was 7/41 Litz wire. The number of turns measured data for the coils are as follows:

III. MODULE DESCRIPTION (Continued)

Coil	Turns	Test Frequency (KC)	Circuit Bandwidth	Antenna Input Impedance
LA 2	860:196:56	55	15.8	50
		100	20.3	50
LA 3	473:100:35	100	16.1	74
		180	16.1	56
LA 4	260:57:18	180	16.3	58
		330	16.1	35
LA 5	136:20:10	330	15.8	60
		600	29.0	62
LB2=LC2	860:210	55	15.8	
		100	20.0	
LB3=LC3	743:100	100	16.0	
		180	16.5	
LB4=LC4	260:50	180	16.0	
		330	19.7	
LB5=LC5	136:18	330	15.7	
		600	25.0	
LG1=LG2 =LG3	682			
LG4=LG5	375			

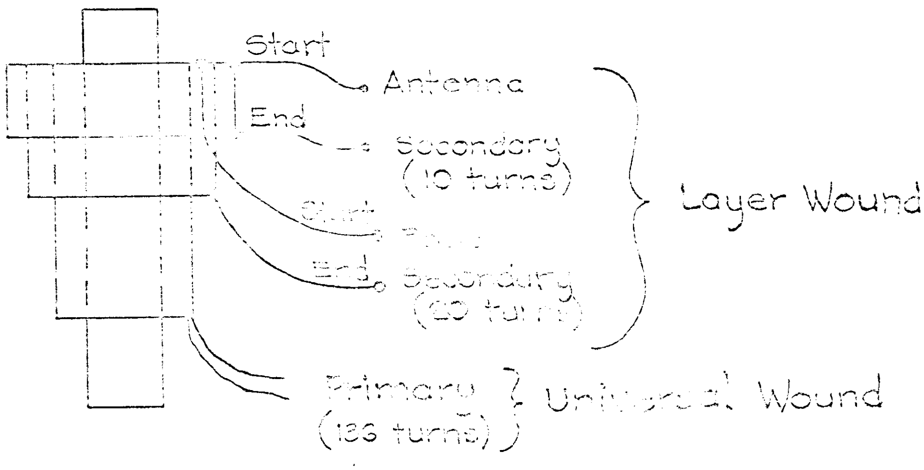
The antenna input impedance and bandwidths of the RF coils were measured in the actual RF circuit. With the exception of LA5, LB5 and LC5 secondaries, all secondary windings were wound using the coil winder machine. The following procedure was used in winding the coils.

a. Wind primary winding.
b. When primary winding is completed, pull out a loop of wire (end of primary and start of secondary) for leads of primary and secondary, and begin secondary winding where primary ends.
c. Wind secondary winding.
d. If antenna secondary is needed, repeat steps b and c for antenna secondary.

The LA5, LB5 and LC5 secondaries were wound by hand on the top end of primary coil. The longest secondary is layer wound

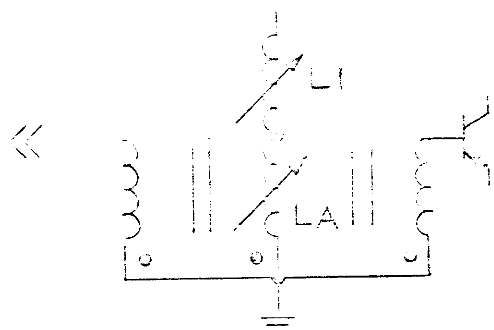
III. MODULE DESCRIPTION (Continued)

from top of primary coil until completed. LA5 has an antenna winding which is layer wound on top of first secondary. For clarification, a sketch is shown of the finished LA5 coil.

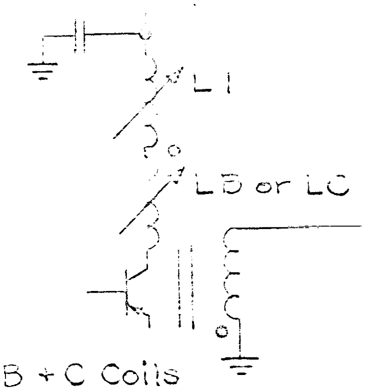


LB5 and LC5 coils are wound like LA5 with the exception that no antenna winding is needed.

It is important to note that the RF coils showed slightly different inductance values in the circuits, depending on the manner that the coils were connected into the circuits. For consistant results, the beginning of all coil windings (primary and secondaries) should be tied to the lowest impedance point in the circuit. A sketch of proper RF coil connections is shown as follows:



A Coils



B + C Coils

The sketch uses the dot convention where the dot is shown on the coil at the beginning of coil winding.