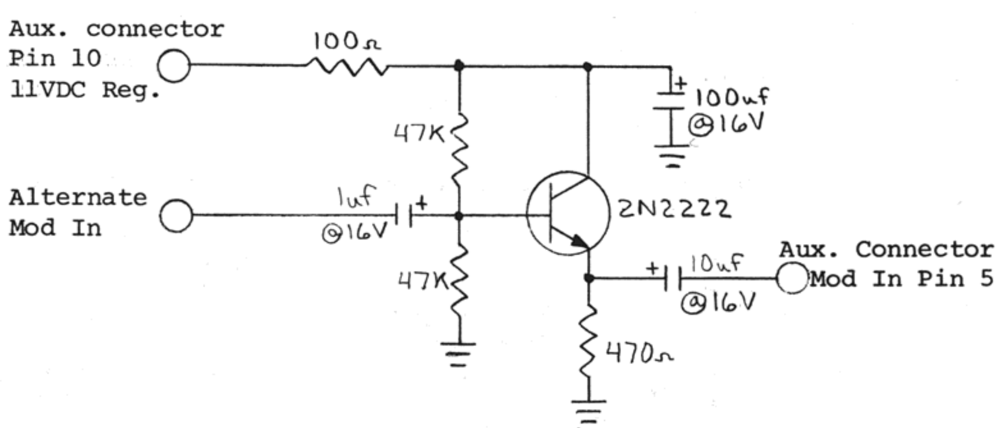
## E. OTHER FORMS OF MODULATION

For modulation formats other than Voice, for example SSTV or RTTY, a second modulation input is provided on the accessory connector, pin 5. For optimum linearity these signals should be approximately .15V peak to peak (about .05V rms) maximum. The Mic gain can be adjusted so that peak signals just start ALC to function. In an ideal system the alternate modulation level might be set with a separate control so that the MIC GAIN can be set for voice and not reset when other modulation is turned on. When the tuning microphone is in place the auxiliary modulation input impedance is about 1K ohms. It is therefore necessary that the output impedance of the alternate modulation generator be low also. If this is not the case a buffer emitter follower may be necessary; as shown below (Figure 4-4):




Emitter follower Input impedance 20K Ohm, gain times one.

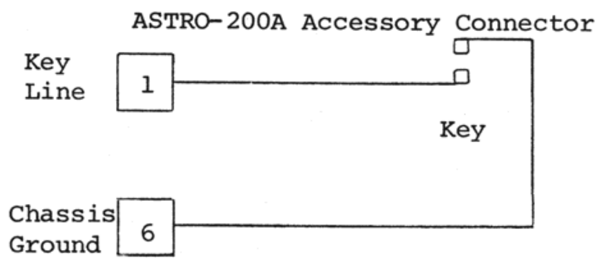
FIGURE 4-4

F. CW KEY CONNECTION

CW operation can be keyed from either of two connections:

1. Accessory connector:

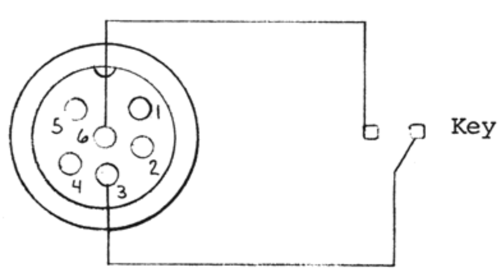
Pin 1 is the key connection and is normally about 12VDC with key open. To key the transmitter Pin 1 should be connected to chassis ground through the key contacts as shown below.




In this mode about 35 ma will be conducted through the closed key contacts.

2. Mic connector:

For CW operation from the mic connector the key contacts must connect pins 6 and 3 of the connector as shown below.



In this mode about 10 ma will be conducted through the closed key contacts.

## 5.0 OPERATING CONTROLS, AND CONNECTORS

### A. Front Panel

Each front panel control and function is described herein to assist the operator in understanding the operation of the transceiver. From left to right: See figure 5-1 for transceiver Front Panel layout.

Mic Connector: Six pin connector for connection of the supplied microphone. In addition to the standard voice and PTT function the connector provides pins for slow up and down tuning of the transceiver. See Requirements for Operation part D, Microphone, for connection diagram.

Squelch: This control is both noise blanker and squelch. The rotation of the control sets the squelch level of the receiver. When the knob is pulled out, the noise blanker circuit is activated.

Meter: Selects the information to be indicated on the meter. In normal operating mode, the switch would be in the ALC position. In this mode, while receiving, the meter will indicate signal strength to S-9, and 20, 40, and 50dB over. REF (reflected) and

FWD (forward) relative power indication positions may be used to determine VSWR and power output during transmit operation of the transceiver. The meter is factory calibrated to read 100 Watts output full scale into a 50 Ohm non-reactive load when the meter is set to the FWD position. VSWR (REF) readings on the meter are relative to a full scale power reading in the FWD position.

AF Gain: Sets the audio level to the external speaker.

MIC Gain: In SSB mode, this control sets the audio level to the transmitter. Since ALC sets the maximum power output, any increase in the MIC gain beyond a nominal mid-point reading on peak modulation (ALC meter setting) will increase the voice compression, allowing operator control of speech processing. This, in turn, will increase the average power output level. In CW mode, the MIC GAIN control is turned clockwise, RF output is decreased. With CW key down and meter in FWD position, the power output can be set to desired output with MIC GAIN control.

Function: Selects mode of operation. USB (upper sideband), LSB (lower sideband), CWW (CW sideband with 2.7KHz filter), CWN (CW narrowband with optional 400Hz filter), WWV (10MHz receive only). CWN position is inoperative when 400Hz optional filter is not installed. WWV is operative regardless of band switch position.

PTT/VOX: Push-to-talk and VOX circuitry are standard features. This toggle switch selects the mode of operation.

RF Attn: RF attenuation of a nominal 16dB may be switched in for strong signal reception.

DIM: The DIM position reduces the digital display intensity for use in low ambient light level conditions.

ON/POWER: Turns on DC power to the transceiver with the exception of the RF power output transmit circuitry. (The RF power amp DC buss is connected to the DC input connector and is not switched in the radio).

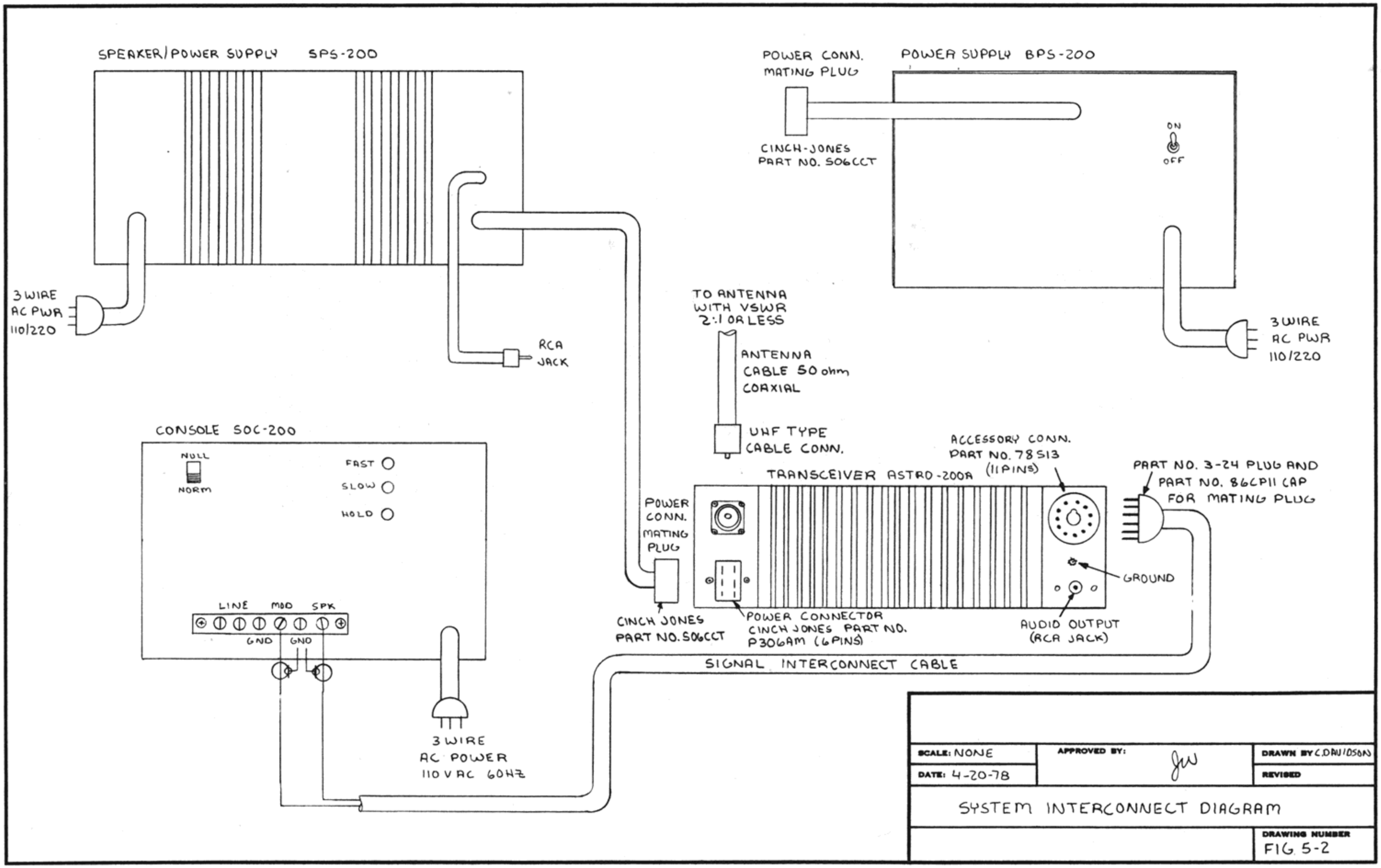
Band: Selects the desired operating band 80M through 10M.

Fast: Momentary toggle switch for frequency tuning. When the switch is pushed up, the carrier frequency is increased toward the top of the band. When the switch is pushed down, the carrier frequency is decreased toward the bottom of the band. The rate of frequency change is approximately 20kHz/sec.

Slow: Momentary toggle switch for frequency tuning. This switch operates in the same manner as the FAST


CIR
TRANSCEIVER
ASTRO 200 A
14235.6
FAST
SLOW
CARRIER
FREQUENCY
FINE
RIT
80M
40M
20M
15M
10M
BAND
NB PULL
SQUELCH
ALC
FWD
REF
METER
AF GAIN
MIC GAIN
USB
LSB
CWW
CWN
WWV
FUNCTION
PTT
VOX
IN
RF ATTN
DIM
ON
POWER
KEY/MIC
UP
DOWN

FIG. 5-1

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switch, except at a rate of about 400Hz/sec. Tuning in single 100Hz steps can be accomplished by a "push and release" momentary action of this switch.

Digital Readout: A six digit LED readout gives the carrier frequency in kHz to the nearest 100Hz. This frequency indication is the carrier frequency when the FINE and RIT controls are straight up (zero position).

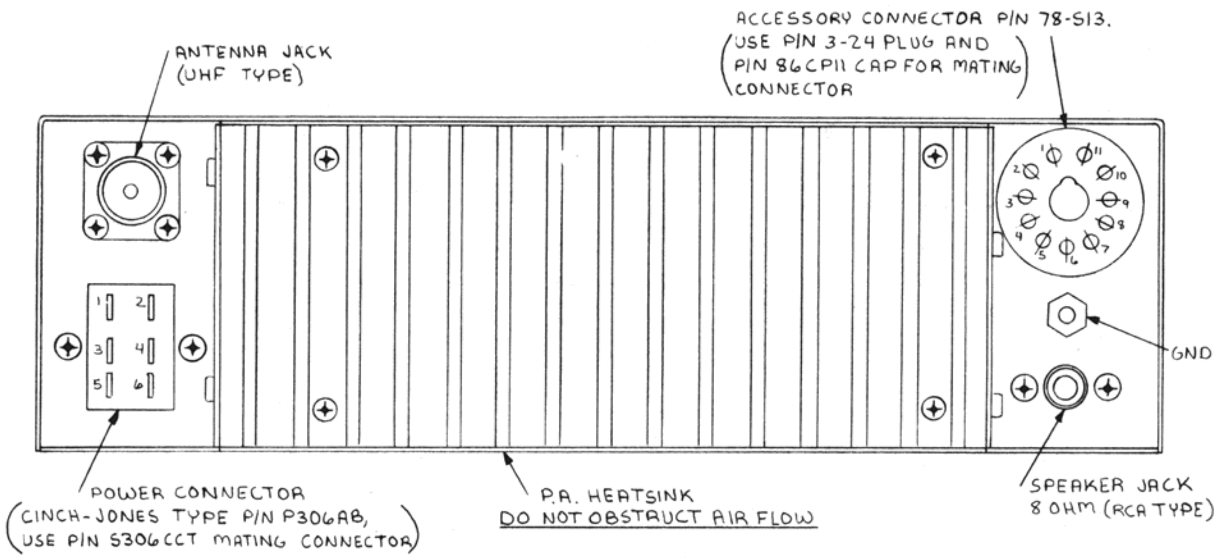
Fine: This control moves the operating carrier frequency to greater than ±50Hz from the digitally indicated LED frequency. This allows operation in between the 100Hz steps of the digital synthesizer.

Rit: This control moves the receiver carrier frequency from the transmitting carrier frequency by greater than ±50Hz.

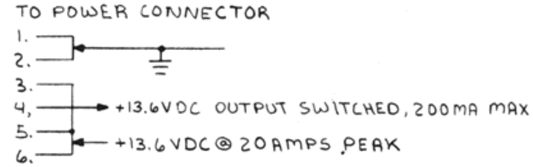
B. Rear Panel

Each rear panel connector, as well as a total system hook up is shown by System Interconnect Diagram (Figure 5-2). In addition more detailed transceiver connections are shown by the Back Plate Outline drawing (Figure 5-3). Referring to the back plate outline drawing it should be noted that pins 3,5, and 6 should be connected in parallel on the power connector. This will provide power to the transmitter through pins 5 and 6, and power to the remainder of the

| ACCESSORY CONNECTOR | |
|---|---|
| PIN | FUNCTION |
| 1 | LINE - DIRECT CONNECTION TO INTERNAL PTT BUS. |
| 2 | 13.6 VDC OUTPUT @ 200 ma MAX SWITCHED BY TRANSCEIVER POWER SWITCH. |
| 3 | TRANSISTOR SWITCH, OPEN COLLECTOR. "ON" IN TRANSMIT. CURRENT LIMIT 200 ma "ON". VOLTAGE LIMIT 35 VDC "OFF". |
| 4 | "RECEIVER ON" SIGNAL, 8 VDC AT 2 ma MAX WHEN RECEIVER ON. 0 VDC FOR RECEIVER OFF. |
| 5 | MOD IN - PARALLEL WITH FRONT PANEL MIC. INPUT IMPEDANCE ABOUT 1K |
| 6 | GROUND |
| 7 | EXT. L.O. INPUT (1V P-P). |
| 8 | EXTERNAL ALC CONTROL INPUT POSITIVE GOING 0 TO 8 VDC RANGE. |
| 9 | EXT. L.O. GATE, 12 VDC = EXT. L.O. ON. |
| 10 | 11 VDC REGULATED OUTPUT 50 ma MAX. |
| 11 | AUDIO OUTPUT 1 WATT, 8 OHM IMPEDANCE |




RECOMMENDED CONNECTIONS
TO POWER CONNECTOR




| POWER CONNECTOR | |
|---|---|
| PIN | FUNCTION |
| 1 | GROUND |
| 2 | GROUND |
| 3 | $V_{cc}$ INPUT |
| 4 | $V_{cc}$ OUT/SWITCHED |
| 5 | P.A. $V_{cc}$ |
| 6 | P.A. $V_{cc}$ |

| | | |
|---|---|---|
| SCALE: NONE | APPROVED BY: JW | DRAWN BY C. DAVIDSON |
| DATE: 4-20-78 | | REVISED |

BACK PLATE OUTLINE

DRAWING NUMBER FIG. 5-3

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transceiver through pin 3. NOTE: NO reverse polarity protection is provided. See Requirements for Operation part 2, DC Operation.

## 6.0 OPERATING INSTRUCTIONS

### A. Frequency Tuning

All-electronic tuning of digitally synthesized HF transceivers is a new state-of-the-art technology which offers many advantages over the older, more conventional knob-VFO configuration. These advantages include precise frequency setting, no backlash, no mechanical interconnections, and, of course, a more precise tuning method of finding signals down in the noise.

In order to utilize the full potential of all-electronic tuning and realize the many advantages over the conventional methods, the operator must understand not only what is taking place in the tuning operation, but he must learn the easy operating techniques of such a revolutionary development in order to make use of these inherent advantages.

The ASTRO-200A has two toggle tuning switches for frequency selection. Functionally, they operate in the following manner:

The 'FAST' toggle switch is for rapid frequency tuning. When this switch is pushed up, the carrier frequency is increased toward the top of the band. If the switch is held up through the maximum frequency, the synthesizer loops back to a frequency below the top band edge and again continues to increase. When the switch is pushed down, the carrier frequency is decreased toward the bottom of the band. When the switch is held down through the low end of the band, the synthesizer locks the carrier frequency to the lowest frequency in the band.

The 'SLOW' momentary switch operates in the same manner as the 'FAST' switch except at a much slower tuning rate. The 'SLOW' tune rate is set so that the operator will not miss hearing a threshold level signal as he tunes through the signal.

There is a built-in delay when the operator first activates these switches before the up/down circuits are enabled. This delay enables the operator to have positive control over tuning to an anticipated particular spot in the band.

After acquiring minimal operator experience, one learns when to release the pressure as a signal is approached, Then if desired, a single push up or down allows the synthesizer to move the carrier frequency up or down in 100Hz steps.

B. Transmitter Tuning

The transmitter is designed to operate into a 50 Ohm load impedance with a VSWR of 2:1 or less. No transmitter tuning is required if a matched antenna is used in the usual operating bands. If the antenna has an unknown VSWR the proper tune-up procedure is as follows:

With an antenna of unknown characteristics it will be necessary to install an antenna tuner between the ASTRO-200A and the antenna. To properly adjust the antenna tuner set the function switch to CWW mode and the mic gain to full clockwise rotation. Activate the transmitter by CW key or microphone switch and set forward power with the mic gain control to about mid scale with the meter switch in the FWD position. This gives about 25 Watt output to the antenna. Put the meter switch in the REF position and adjust the antenna tuner per the tuner instructions to achieve minimum needle deflection in the REF reading.

NOTES:

1. It is not always possible to achieve fullscale deflection in FWD mode because the VSWR shutdown will limit output when operating into a mismatch.

2. Never exceed fullscale in FWD during CW operation or tuning operation. This will generate excessive power output and may cause amplifier damage.

## C. Transmitter ALC Operation

The ALC (automatic level control) is designed to maintain an average power (as opposed to the more usual peak power control). The ALC is set at the factory to hold an average power of 40 watts. This results in speech peak powers considerably in excess of 100 watts, and 40 watts on a single tone. This form of ALC allows the variable speech compression to function. Normal Mic Gain setting is between 9:00 and 12:00 position for linear operation. If greater "punch" is required the Mic Gain control can be turned up to provide greater compression and average power. Since ALC holds 40 watts average power, and total transmitter gain reduces on 10M band, it is normal to get very little ALC action on 10M, except for high compression Mic Gain settings.

The average ALC circuits are not operative in CW modes and power is set by the mic gain control.

In addition to the average ALC control a VSWR sensitive ALC is provided to limit RF output to about 75 - 90 watts, into a VSWR of 2:1. The power output is progressively reduced as VSWR increases. For a VSWR of about 1.7 or less this shutdown mode is not in operation. The VSWR shutdown operates in any transmitter mode.

## 7.0 THEORY OF OPERATION

### A. General Description

The ASTRO-200A transceiver is constructed of essentially plug-in circuit boards providing easy access to all key signal and test points.

Figure 7-1 shows the functional block diagram of the ASTRO-200A illustrating signal path flow. The transceiver utilizes generally separate receiver and transmitter circuitry for optimum performance. The receiver is single conversion with PIN diode AGC to achieve greater than 100dB dynamic range. The transmitter utilizes broadband circuits through-out to eliminate alignment problems. Bandpass filters for each band and a double balanced transmitter mixer assure freedom from TVI and band splatter. The balanced modulator gives greater than 50dB carrier suppression.

Figure 7-2 is a top inside view of the ASTRO-200A, illustrating the location of functional circuits and controls on the top side of the transceiver.

### B. Digital Synthesizer

The digital synthesizer is the heart of the versatility of the ASTRO-200A transceiver. Before describing the operation of this particular synthesizer, it is informative to review the fundamental operation of a basic phase locked loop. Figure 7-3 illustrates a simple form of a phase locked loop in a block diagram form.

The desired output frequency is phase locked, i.e. frequency stable, to a crystal reference oscillator. In this example loop, the desired output frequency has the long term stability characteristics of the stable reference oscillator -- hence, crystal stability for all frequencies over the entire VCO band of operation. The $x_o$ is selected to operate at a frequency that is applicable to the particular frequency scheme of the radio, and optimum as far as a stable operating crystal frequency is concerned.

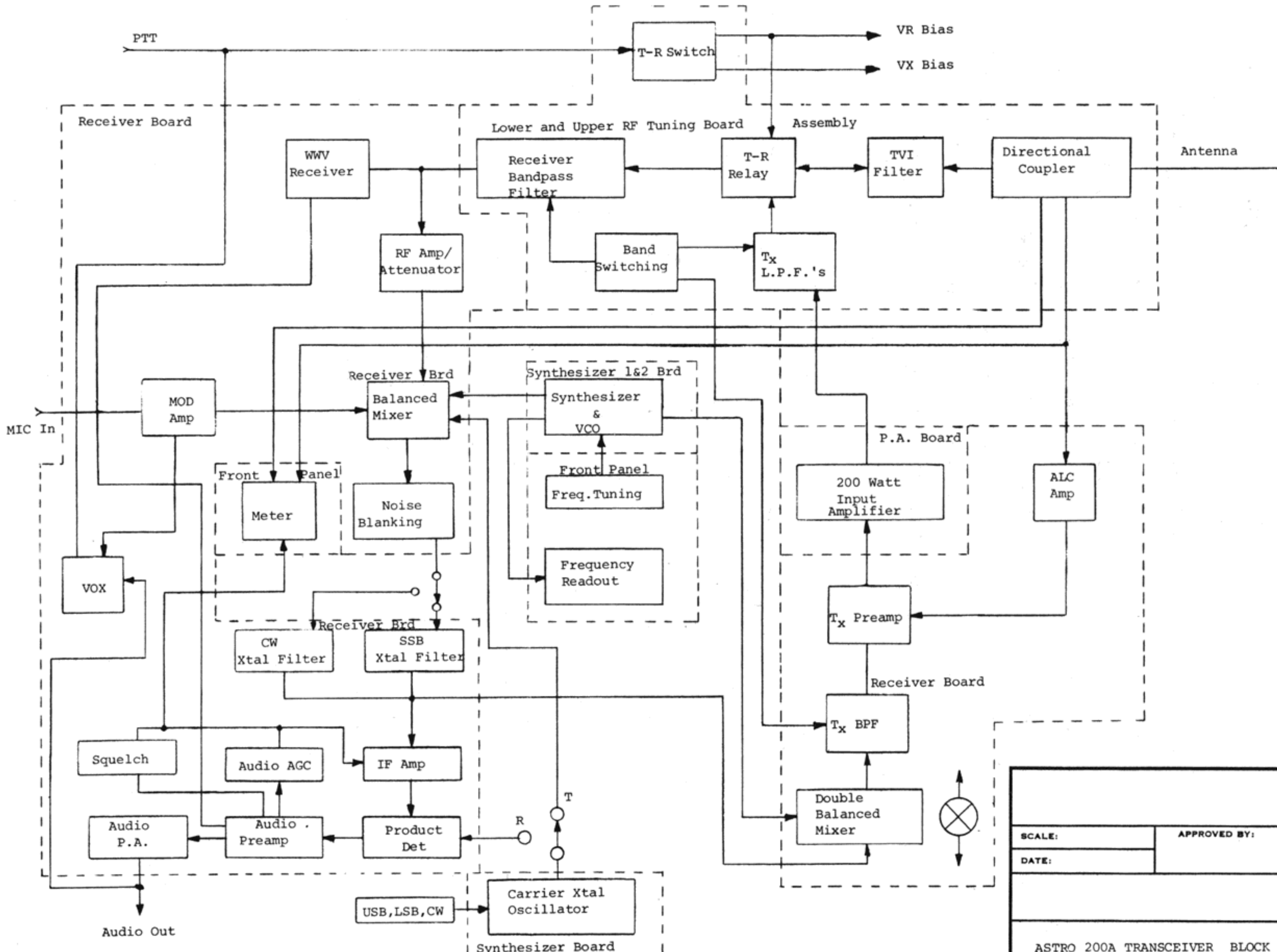
The output of the reference oscillator is divided by some number N such that the reference frequency $F_r$ is compatible with the phase detector and the divided frequency from the voltage controlled oscillator (VCO). This reference frequency $F_r$ also determines the digital frequency step resolution of the synthesizer, i.e. for a 100Hz $F_r$, the synthesizer can produce phase locked output frequencies in 100Hz steps.

The VCO operates over a band of desired output frequencies. The frequency of the VCO is determined by a DC control voltage. One of the outputs of the VCO is the desired output frequency. A second output is divided by some number M, and $F_s$ is fed to the phase detector.

If $F_s = F_r$, the output of the phase detector will be some DC voltage, and for discussion purposes, let's say zero volts. If the VCO output frequency increases, the loop frequency, $F_s$, will increase, and the phase detector sees an increasing phase with respect to its stable reference $F_r$. The output of the phase detector will be a DC voltage that is filtered through a low pass filter which drives the VCO to the exact frequency such that $F_r = F_s$ and thus "locks" the loop. If the VCO output frequency decreases, the phase detector DC output is of the opposite polarity and the DC control voltage drives the VCO in the opposite direction to regain $F_s = F_r$.

Again, for discussion purposes, let's assume a 10MHz reference oscillator frequency and N is 100,000. This establishes $F_r$ = 100Hz. Now, let's assume that we desire a stable 5MHz output frequency. If M is 50,000, then $F_s$ = 100Hz and the phase detector and filter will keep zero voltage applied to the VCO, or will correct the frequency to zero error with the proper DC error voltage. This action phase locks the 5MHz output to the 10MHz reference oscillator.

Now, let's say we want to change our desired output frequency to 5.5MHz. We need only to change the programmable divider M to 55,000, then the $F_s$ = 100Hz for a 5.5MHz desired output frequency and the loop will acquire phase lock.




| | | |
|---|---|---|
| SCALE: | APPROVED BY: | DRAWN BY |
| DATE: | | REVISED |
| ASTRO 200A TRANSCEIVER BLOCK DIAGRAM | | DRAWING NUMBER FIG. 7.1 |

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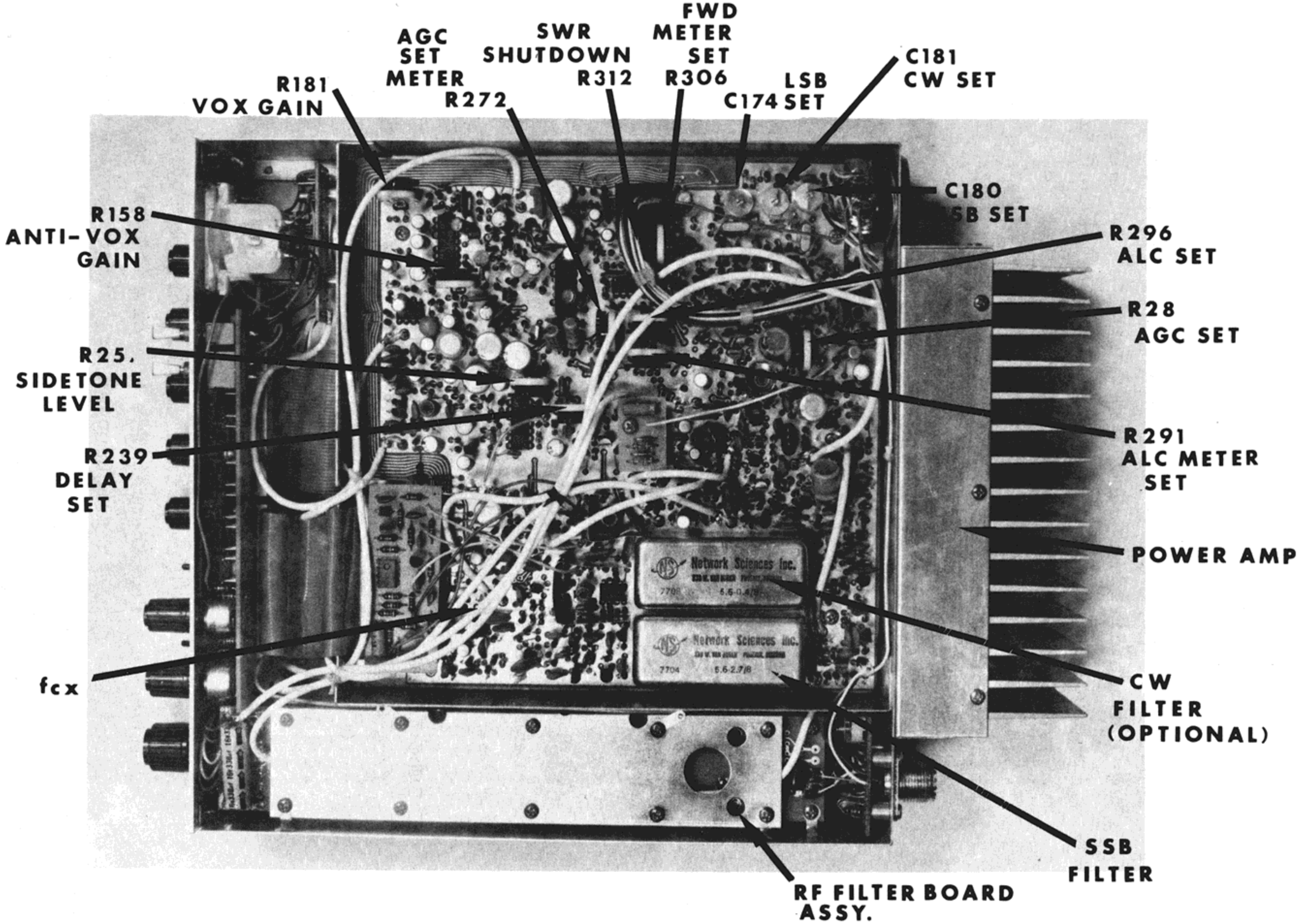

R181
VOX GAIN
AGC
SET
METER
R272
SWR
SHUTDOWN
R312
FWD
METER
SET
R306
C174
LSB
SET
C181
CW SET
C180
SB SET
R158
ANTI-VOX
GAIN
R296
ALC SET
R28
AGC SET
R25.
SIDETONE
LEVEL
R239
DELAY
SET
R291
ALC METER
SET
POWER AMP
fcx
CW
FILTER
(OPTIONAL)
SSB
FILTER
RF FILTER BOARD
ASSY.

FIG 7.2

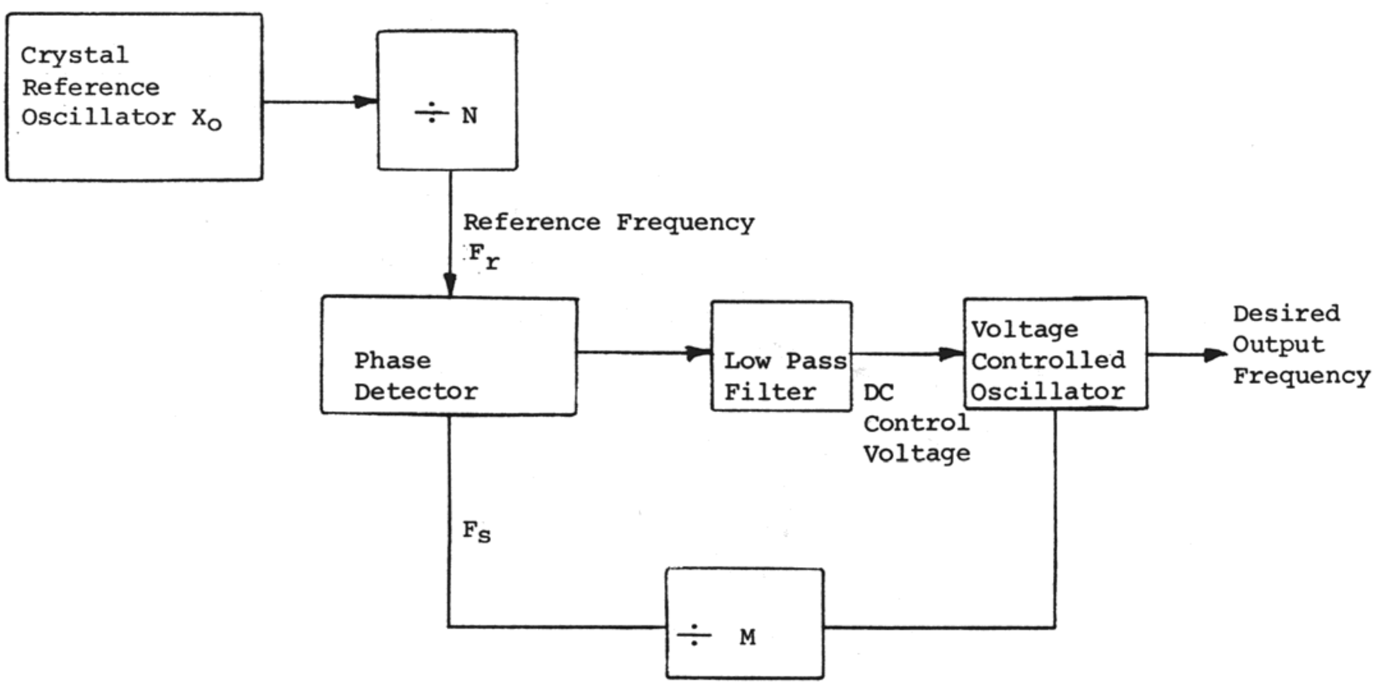
It is now clear that by merely changing M, the programmable divider, a complete spectrum of output frequencies may be derived, each phase locked to the crystal stable reference oscillator. One further note, the output of the phase detector could be any reasonable DC voltage range compatible to the VCO design (not necessarily centered around zero volts) and an increase in the zero "error" or control voltage from its zero error reference will drive the VCO in the opposite direction. In each case, the error voltage drives the VCO output frequency such that $F_s$ will equal $F_r$.

The frequency synthesizer in the ASTRO-200A utilizes these fundamental principles in a two phase locked loop design.

Figure 7-4 is a picture of the inside bottom of the transceiver illustrating the location of the synthesizer circuit boards of the ASTRO-200A.

The frequency synthesizer generates crystal controlled frequencies in 100Hz steps for all amateur bands 80 - 10 meters. Figure 7-5 is a block diagram of the complete synthesizer.

Two phase locked loops (PLL) are used to generate the crystal controlled frequencies. (It is again noted that frequency generation of this nature obviously removes any requirement for the crystal calibrator since the derived frequencies are phase locked to the crystal controlled reference oscillator).




BASIC PHASE LOCKED LOOP

Figure 7-3

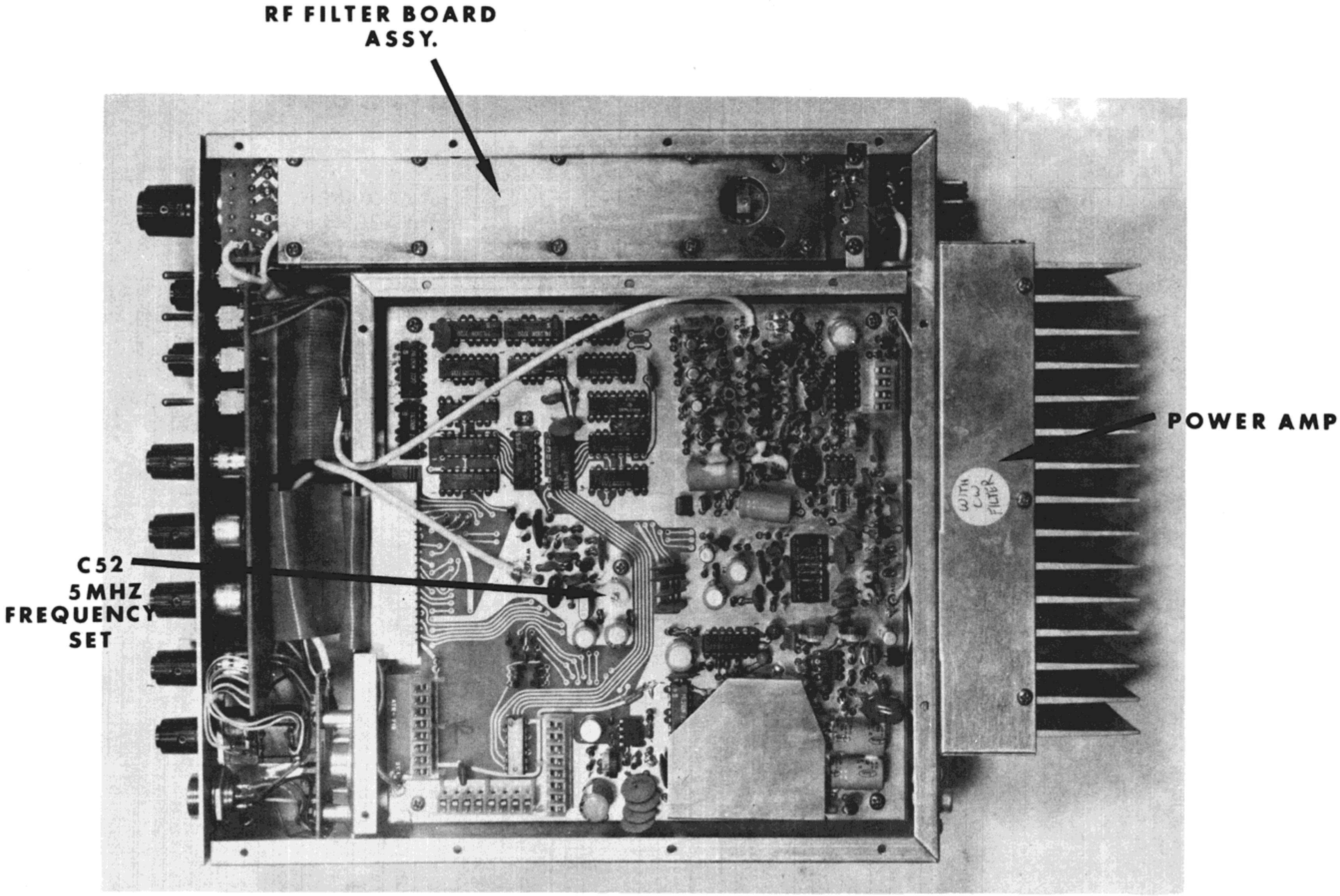
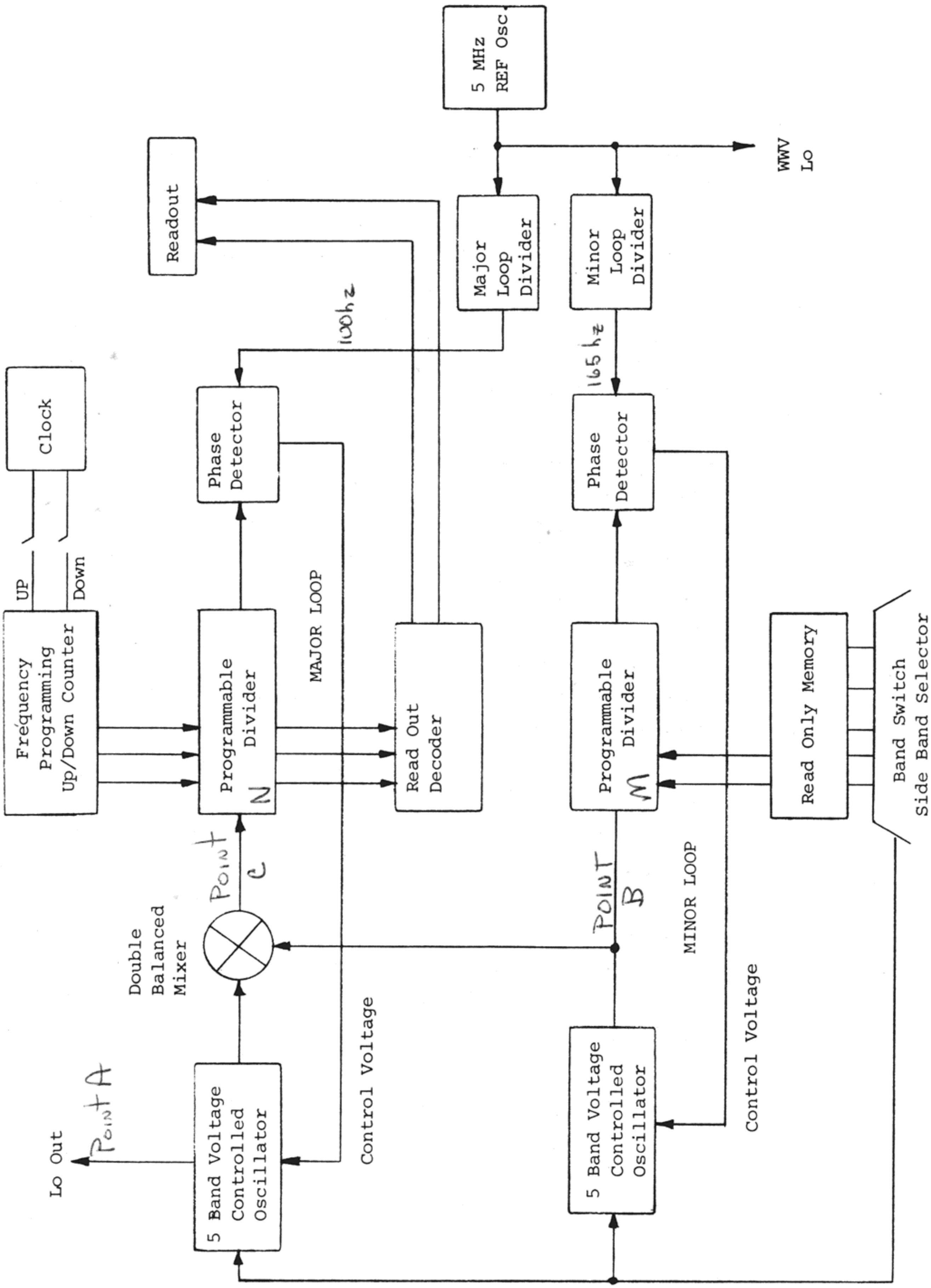

RF FILTER BOARD
ASSY.
POWER AMP
C52
5MHZ
FREQUENCY
SET
WITH
CW
FILTER

FIG 7.4




DIGITAL SYNTHESIZER

Figure 7-5

The major phase locked loop generates the local oscillator frequencies for both the transmitter and reciever. The 100Hz steps are derived from a programming code generated by the up/down counter. The code is selected by front panel frequency selecting switches. These switches gate a clock signal to the up or down counter input to raise or lower the local oscillator frequency.

The minor loop is used to off-set the local oscillator frequency to a value compatible with the programming divider clock rate. The minor loop frequency is also programmed to account for the sideband selected, and selected band.

Both phase locked loops are referenced to a stable 5MHz crystal oscillator -- hence, the very stable frequency characteristic of the ASTRO-200A.

With WWV receiver, this reference oscillator can be set to WWV accuracy for exact frequency operation.

The status of the major loop is monitored by the readout decoder and the selected loop frequency is translated to the carrier frequency readout. The readout is a six digit LED display. The display resolution is to the nearest 100Hz.

The following schematics provide the complete circuit