CONFIDENTIAL

INSTRUCTION MATERIAL

For

CONTROL DEVICES FOR
SYNCHRONOUS CONTROL AND
CARRIER LOCKING

[redacted]

50X1

[redacted]

50X1

May 12, 1954

CONFIDENTIAL

CONTROL DEVICES FOR SYNCHRONOUS CONTROL AND CARRIER LOCKING

SPECIFICATIONS

ANTENNA UNIT: (Adapted from existing design by permission-for field testing-Model DS-2)

Rack mounting chassis:	19 in. wide by 7 in. high
Finish:	grey, wrinkle
Input Frequency Range:	4 mc to 10 mc
Input Impedance:	100 ohms (two antenna inputs)
Output Impedance:	100 ohms (to receiver antenna)
Power Requirement:	None

CONVERSION UNIT: (Designed as per contract)

Rack mounting chassis:	19 in. wide by 8-3/4 in. high
Finish:	grey, wrinkle
Input Impedance:	100 ohm cables from two receiver 455 kc outputs
Output Impedance:	two 100 ohm cables for receivers 3.5 mc conversion voltage
Audio Output Impedance:	two 600 ohms balanced lines (to land line or radio link)
Audio Output Level:	1 volt
Power Requirement:	115 volts, 60 cps, 50 watts

CONTROL UNIT: (Designed as per contract)

Rack mounting chassis:	19 in. wide by 8-3/4 in. high
Finish:	grey, wrinkle
Input Impedance:	two 600 ohm balanced lines (from land line or radio link)
Output Impedance:	100 ohms (slave oscillator r.f. output to transmitter)
Output Voltage:	3.5 volts rms

Output Frequency Range: 4 mc to 10 mc

Power Requirements: 115 volts, 60 cps, 70 watts

AUXILIARY EQUIPMENT REQUIRED:

Two Hammarlund SP600 receivers, (not furnished).

One cathode follower adaptor, furnished. (cathode follower to mount on side of crystal plug-in box of receiver with cable and adaptor to plug into 6V6 output socket for power, alligator clip to tap off oscillator switch, and output plug for HFO slave voltage).

One HFO slave voltage cable with plug-in assembly, furnished, (connects from cathode follower output to #6 crystal input of slave receiver).

Two 3.5 mc conversion voltage cable assemblies, furnished, (connect from Conversion Unit 3.5 mc output into the 6C4 conversion oscillator sockets of the two receivers).

Two cables for 455 kc i.f. outputs of receivers to the Conversion Unit, (not furnished).

One cable for connection between Antenna Unit and Master Receiver, (not furnished).

DESCRIPTION

This equipment comprises a system for synchronous frequency operation of two transmitters, whereby one is slaved to the other. Provision also is made to hold the Slave Transmitter at a fixed offset frequency from the Master Transmitter if desired. Five fixed offset audio frequencies are provided ranging from 2000 cps to 6000 cps. In operation, at a monitoring

or sensing site, the signal from the slaved transmitter will tend to predominate over the Master Transmitter signal due to its closer physical location. This signal from the slaved transmitter can be fed to one receiver without further processing. The other signal, which is comparatively low in strength, must be made to predominate over the stronger signal in the second receiver. This is accomplished by nulling out the strong signal. The Antenna Unit is used to accomplish this nulling effect. The total equipment incorporates self contained power supplies. The SP 600 receivers are used without modification except for adaptors and plugs which are connected to the receivers without soldered connections. Adaptors and plugs which are peculiar to this equipment are described and furnished.

THEORY OF OPERATION

A simpler version embodying the present type of operation is shown in Figure 1. This equipment synchronizes a local oscillator with an incoming signal. A two phase beat signal is developed which is used to drive a two phase motor. As the local oscillator is brought into synchronization, the beat frequency decreases, approaching zero in the limit. For this reason the amplifiers driving the motor are direct coupled.

For the present application a control or error voltage must be sent out over a radio link or land line circuit. This precludes sending out either the r-f oscillator signal, or the control voltage for the motor, which latter may be direct current. Also the Slave Transmitter output may be a harmonic of the r-f oscillator signal, and it may be located some miles from the receiving site. These circumstances dictate

the use of two receivers at the receiving site--one for each signal. These receivers must have common conversion oscillators to eliminate any sustained frequency difference between the incoming signals when they are finally combined in a discriminator circuit.

The final circuit, used for synchronous lock, functions the same as that shown in Figure 1 except for one intermediate step, which permits sending audio over the radio link (it is not necessary to have d-c response). This exception involves the use of one beating oscillator stage which employs separate (not common) oscillators for the two receiver channels. These oscillators are at 100 kc and 102.5 kc respectively. The receiver output from Mixer C is then 2.5 kc, a frequency adapted to sending over the land line or radio link. The outputs from the offset oscillators are applied to another mixer yeilding a 2.5 kc output, which is applied to a second land line or radio link.

Attention is directed to points X and Y in Figure 1. These two audio signals obtained may be processed exactly as the two r-f signals at X and Y. The foregoing explanation applies to synchronous frequency operation.

Offset tone operation is very similar to the above. However, the offset beating oscillator is not directly used, and the oscillator difference frequency signal is no longer sent out over the land line or radio link. Instead an audio oscillator at the transmitting end is used as a reference for the beat between the master and the slave station. From this point on, operation is exactly the same as with synchronous operation. In both types of operation lowpass audio filters have been provided to keep frequencies other than the low frequency beat from reaching the amplifiers.

Detailed function of stages shown in the block diagram is as follows: The Master Receiver must receive the signal from the Master Transmitter (Reference Carrier) only. Since this signal is of the same frequency as that of the Slave Transmitter, and in practice, will be the weaker, the Antenna Unit is inserted in this line to assure acceptance of the Reference Carrier only. The greater strength of the Slave Transmitter signal, due to relative proximity, makes it unnecessary to employ a bearing discriminating (Antenna Unit) type unit.

In order to provide both receivers with the same first conversion frequency, the HFO voltage of the Master Receiver is fed to the Slave Receiver through a cathode follower and plug-in adaptor assembly. The second conversion voltage is obtained from the 3.5 mc crystal controlled oscillator in the Conversion Unit. Adaptor plugs are used to plug into both receivers 6C4 second conversion oscillator sockets. The 455 kc i-f output of the Slave Receiver is fed to Mixer A and the Master Receiver feeds into Mixer B. The above stages function identically for both Sync. Lock and Offset Tone circuits.

Figure 1A: Sync Lock Circuit

Conversion Unit:

The 100 kc oscillator voltage is combined with the i.f. from the Slave Receiver in Mixer A to give a resultant of 352.5 kc $\pm \Delta f$ (any slight difference, due to drift in the Master Transmitter, etc., which may occur between the two transmitters). This is then sent through a limiter-amplifier stage and fed to Mixer C. The 102.5 kc oscillator voltage is combined with the i.f. from the Master Receiver in Mixer B to give a

resultant of 352.5 kc. This is also fed to Mixer C through a limiter-amplifier stage. Combining the two signals in Mixer C results in a 2500 cps $\pm \Delta f$ output which is amplified and sent over a balanced line to the Control Unit. The 100 kc and 102.5 kc crystal oscillators also are fed to Mixer D to yield an output of 2500 cps which also is amplified and sent over a balanced line to the Control Unit.

Control Unit:

The output of Mixer D is split, with one part going through a 90° phase shifting network and fed to separate phase discriminators. The output of Mixer C is also split, going directly to the phase discriminators to be compared with the Mixer D signal. In comparing these two signals, if there exist any phase relationship other than 0° in the one line and 90° in the other, there will exist an audio voltage output which is proportional to the phase displacement from quadrature. This audio voltage goes through a lowpass audio filter network to remove extraneous components (i.e. 2500 cps component), and thence to an Amplifier stage. The Amplifiers drive a Two Phase Motor assembly which in turn drives a variable capacitor which controls the frequency of the Slave Transmitter to hold it in Synchronism with the frequency of the Master Transmitter.

Figure 2: Offset Tone Circuit

Differences between Offset Tone and Sync Lock operation are:

Conversion Unit:

a. 100 kc oscillator is not used, allowing Mixer D and its amplifier to be inoperative.

b. 102.5 kc oscillator feeds both Mixer A and B to create

their output difference, $\frac{1}{2}\Delta f$, which will appear at the output of Mixer C. This is then amplified and sent over the balanced line to the Control Unit.

Control Unit:

An Audio Oscillator, which has 2, 3, 4, 5 and 6 kc positions, is used as a reference voltage. This establishes the Slave Transmitter Carrier frequency exactly that far removed from the Reference Carrier frequency.

CONTROLS AND THEIR FUNCTION

Antenna Unit:

1. - PHASE - Course phase adjust (distributed constant phase changer).
2. - VERN. PH. - Vernier phase adjust (variable capacitor).
3. - AMPL. - Course amplitude adjust (250 ohm pot).
4. - VERN. AMPL. - Vernier amplitude adjust (50 ohm pot).
5. - ANT. SWITCHING - Interchanges antenna inputs.

Conversion Unit:

1. - R101 - AMPL. 2 - Vary amplitude of crystal difference output voltage.
2. - R102 - AMPL. 1 - Vary amplitude of Mixers A and B difference output voltage.
3. - S1 - Power "on-off" switch.
4. - S2 - Change from Sync Lock to Offset Tone operation.
5. - S3 - Second conversion voltage "on-off" switch.
6. - S4 - Meter selector switch for Line A and Line B.

Control Unit:

1. - C101 - Main tuning condenser.
2. - C102 - Vernier capacitor to control oscillator.
3. - E101 - Control to position C102.

CONFIDENTIAL

4. - R101 - Vary amplitude of Line A input.

5. - R102 - Vary amplitude of Line B and Offset Tone Oscillator input.

6. - S1 - Power "on-off" switch.

7. - S2 - Sync Lock - Offset Tone selector. This has 6 positions and selects the proper phasing network for the specific frequency used.

SETUP PROCEDURE

1. Connect line between Conversion Unit and Control Unit.

2. Connect the two antennas to the input of the Antenna Unit.

3. Connect output of Antenna Unit to the input of the Master Receiver.

4. Attach to the Master Receiver, the Cathode Follower Assembly on the side of crystal box, aligator clip to oscillator switch, and adaptor plug in the 6V6 output socket replacing the 6V6 in the adaptor.

5. Connect HFO Voltage Cable from the output of the Cathode Follower Assembly to the #6 crystal position of the Slave Receiver (turn crystal selector switch to position 6).

6. Remove the 6C4 second conversion oscillator tube of both receivers and plug in the Second Conversion Voltage Cable from the 3.5 mc output of the Conversion Unit to the 6C4 socket of both receivers.

7. Connect cable from IF Output from Master Receiver to J1 and Slave Receiver to J2 of Conversion Unit.

8. Connect Control Unit output (J1) to Slave Transmitter External HFO input.

9. Connect scope to J2 of Control Unit.

10. Set pointer of E101 on Control Unit at 12:00 (this will be set at 6:00 if the unit does not lock in).

11. Determine position of S2 on the Control and Conversion Units.

CONFIDENTIAL

12. Determine coil to be used for HFO oscillator of Control Unit (turn on 3.5 mc oscillator switch of the Conversion Unit if the frequency is above 7.4 mc).

13. Turn all pots to minimum (CCW), and the Meter Selector Switch (S4) off.

14. Turn on equipment.

15. Tune C101 of the Control Unit to the same frequency as the Reference Carrier.

16. Adjust the Antenna Unit for deepest null of the Slaved Transmitter signal. Interchanging the antenna inputs may be necessary (ANT. SWITCHING).

17. Adjust Outputs 1 and 2 on the meter in the Conversion Unit to 100 microamps with R102 and R101 respectively.

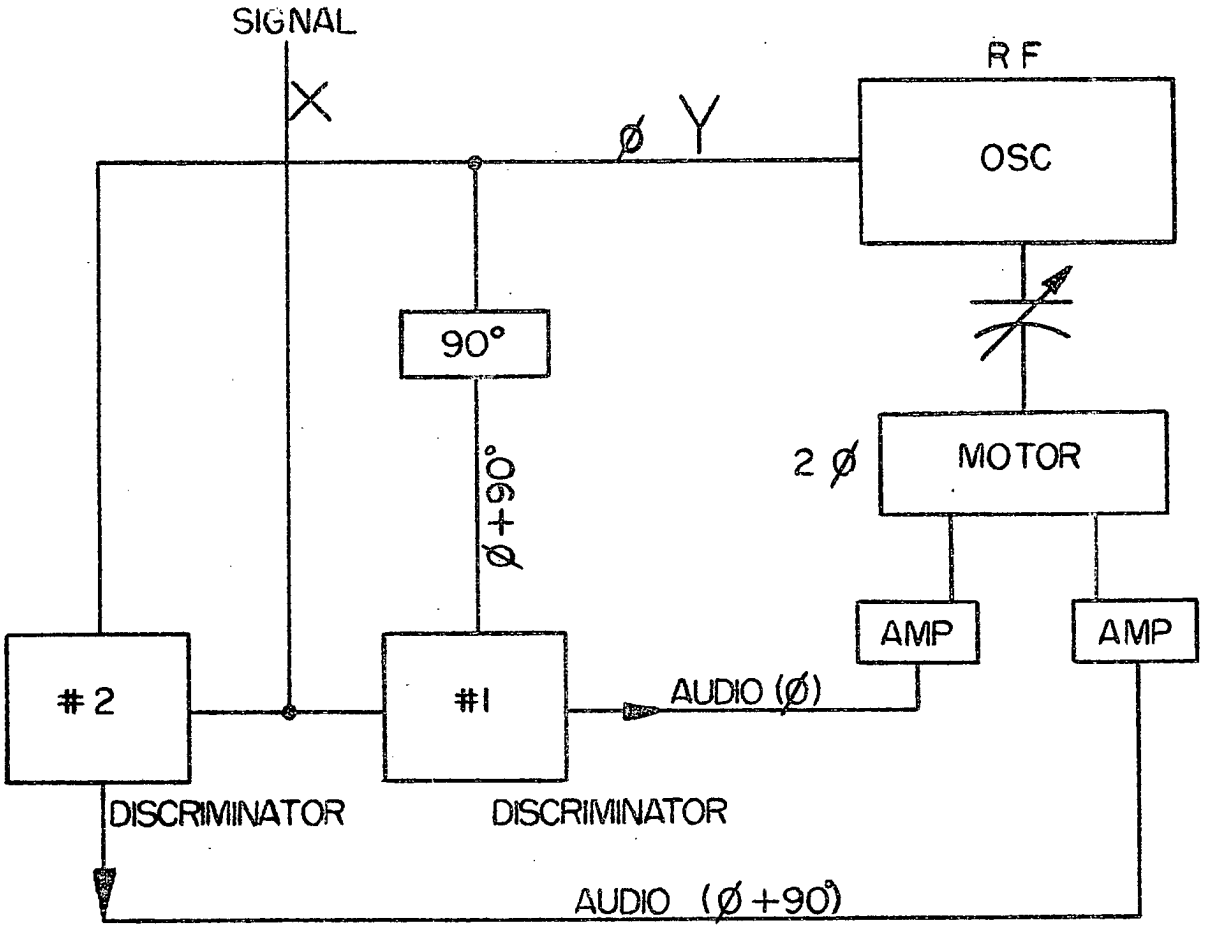
CAUTION: Output 1 varies with final tuning.

NOTE: There will be no Output 2 with Offset Tone operation.

18. Adjust Ampl. 1 and 2 of Control Unit for approximately equal maximum amplitudes on the scope.

19. Tune C101 of Control Unit for "lock-in" condition by observing scope and listening for zero beat in the receiver.

Figure 1



BASIC SYNCHRONIZING CIRCUIT

FIGURE 1A
BLOCK DIAGRAM
SYNC LOCK CIRCUIT

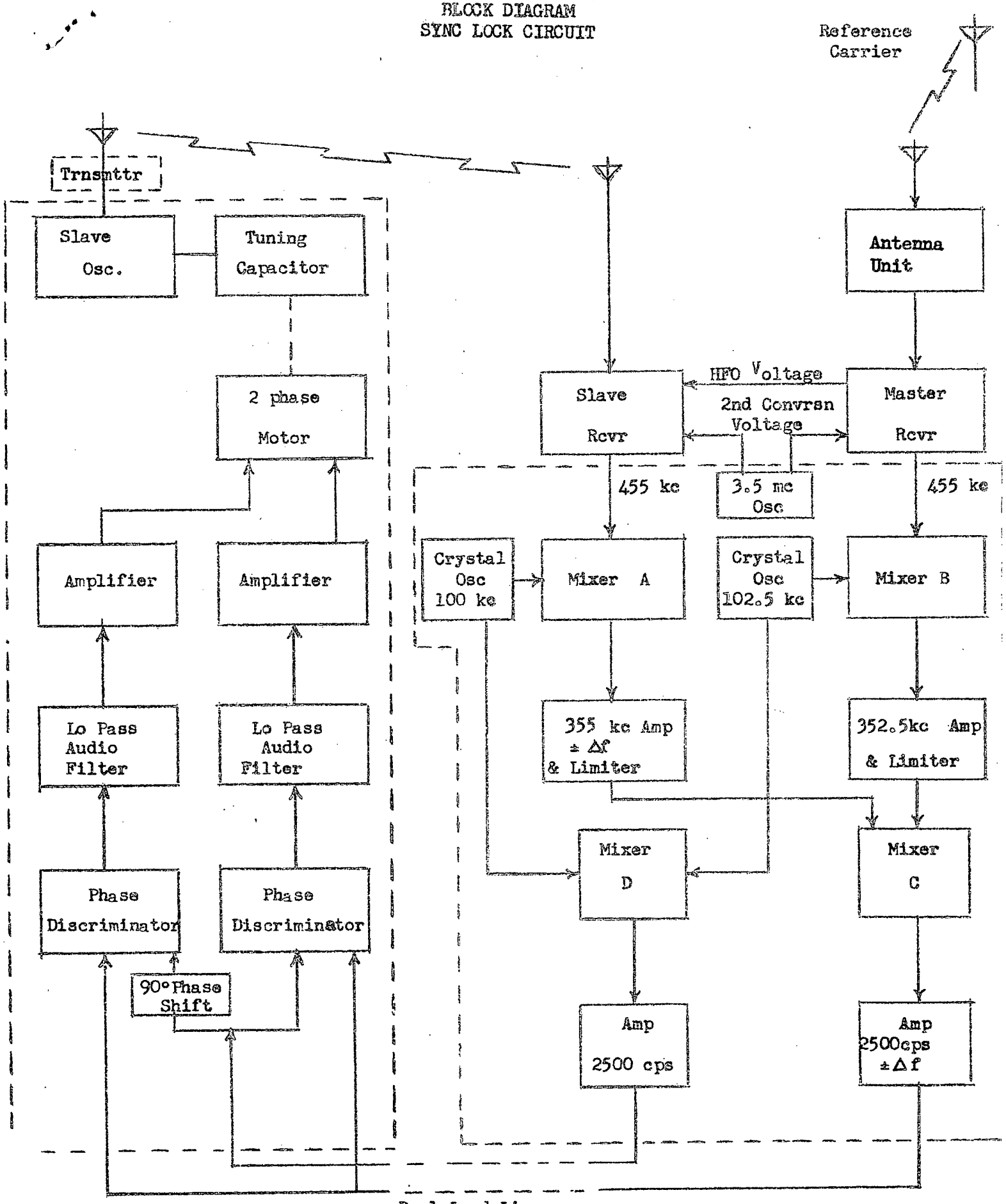
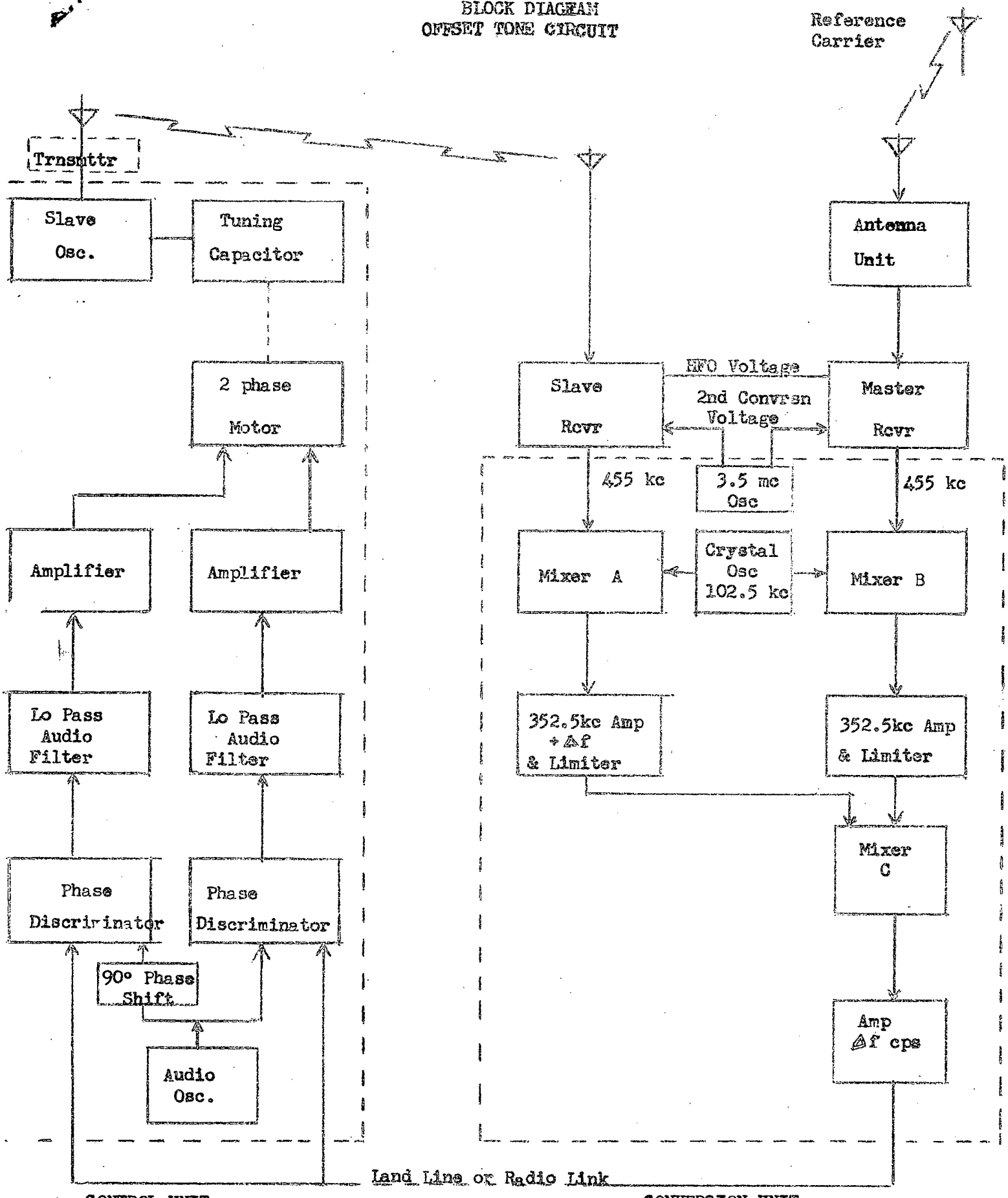


FIGURE 2
BLOCK DIAGRAM
OFFSET TONE CIRCUIT



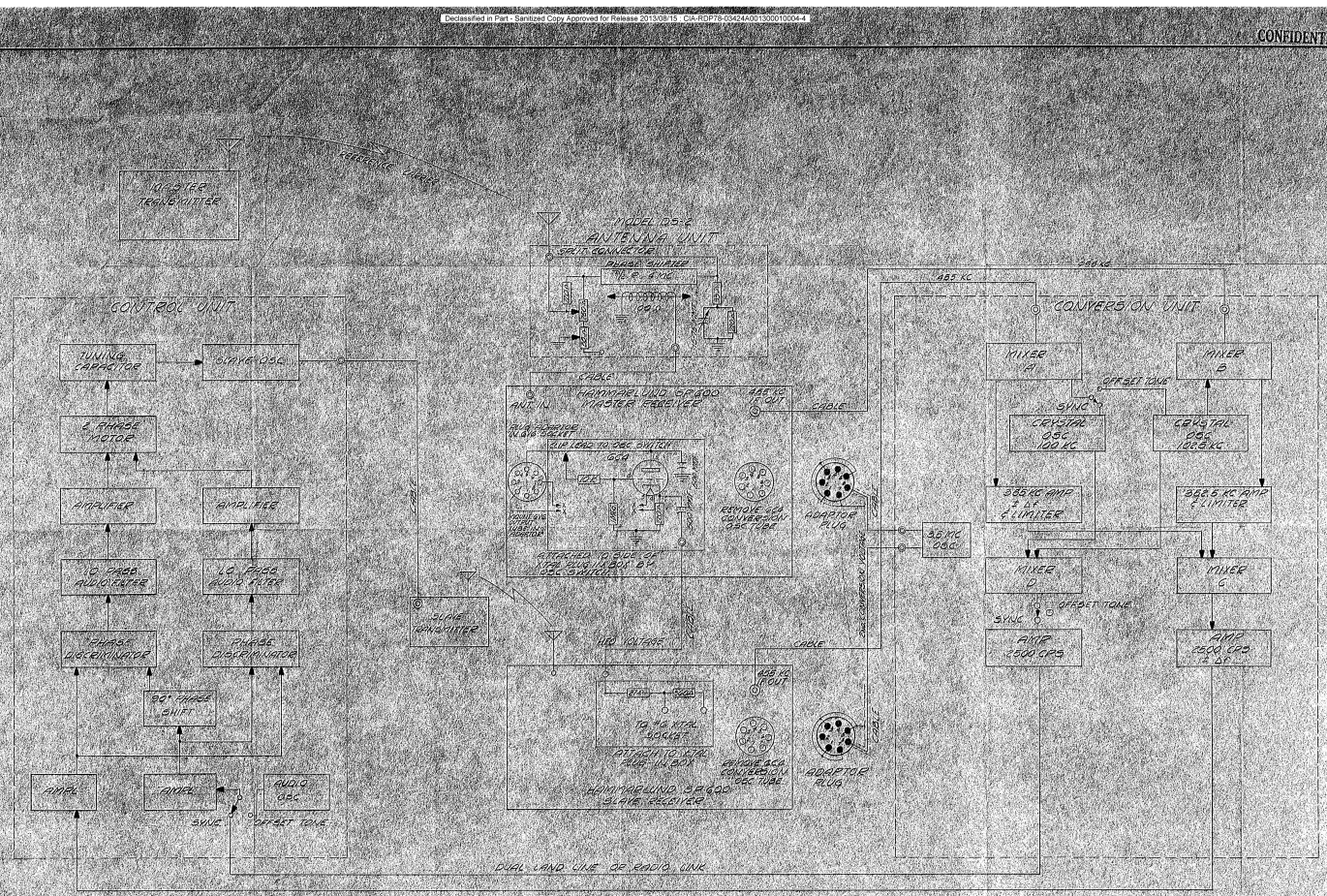


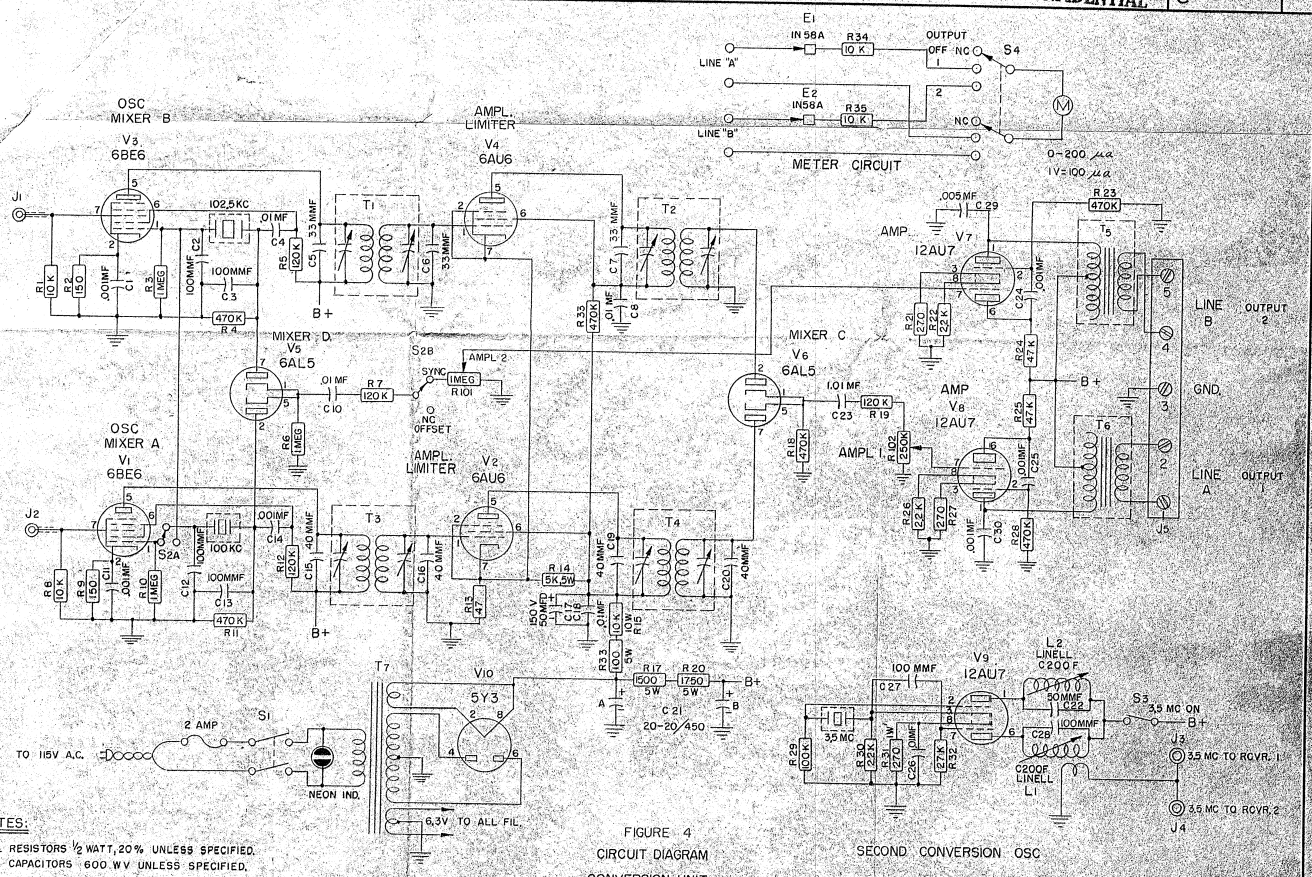
FIGURE 3
SYSTEM BLOCK DIAGRAM
WITH ADAPTOR CIRCUITS

NOTE: MAKE CERTAIN THIS IS THE LATEST ISSUE BEFORE PROCEEDING WITH WORK

CONFIDENTIAL
SECURITY INFORMATION

CONFIDENTIAL

DRAWING NUMBER C REV.



NOTES:

1. ALL RESISTORS 1/2 WATT, 20% UNLESS SPECIFIED.
2. ALL CAPACITORS 600 WV UNLESS SPECIFIED.

FIGURE 4

CIRCUIT DIAGRAM

CONVERSION UNIT

NOTE: MAKE CERTAIN THIS IS THE LATEST ISSUE BEFORE PROCEEDING WITH WORK

CONFIDENTIAL

SECURITY INFORMATION

REVISIONS

USED ON

RELEASED FOR MFG. E.A. NO.

SCALE:

DRAWN WAG DATE 4-30-54

CHECKED DATE

DIM. TOLERANCES FRACT. ± DECIMAL ± UNLESS OTHERWISE SPECIFIED

MATERIAL

FINISH

DRAWING NUMBER C REV.

PE & R FORM G114

50X1

CONFIDENTIAL

DRAWING NUMBER C REV.

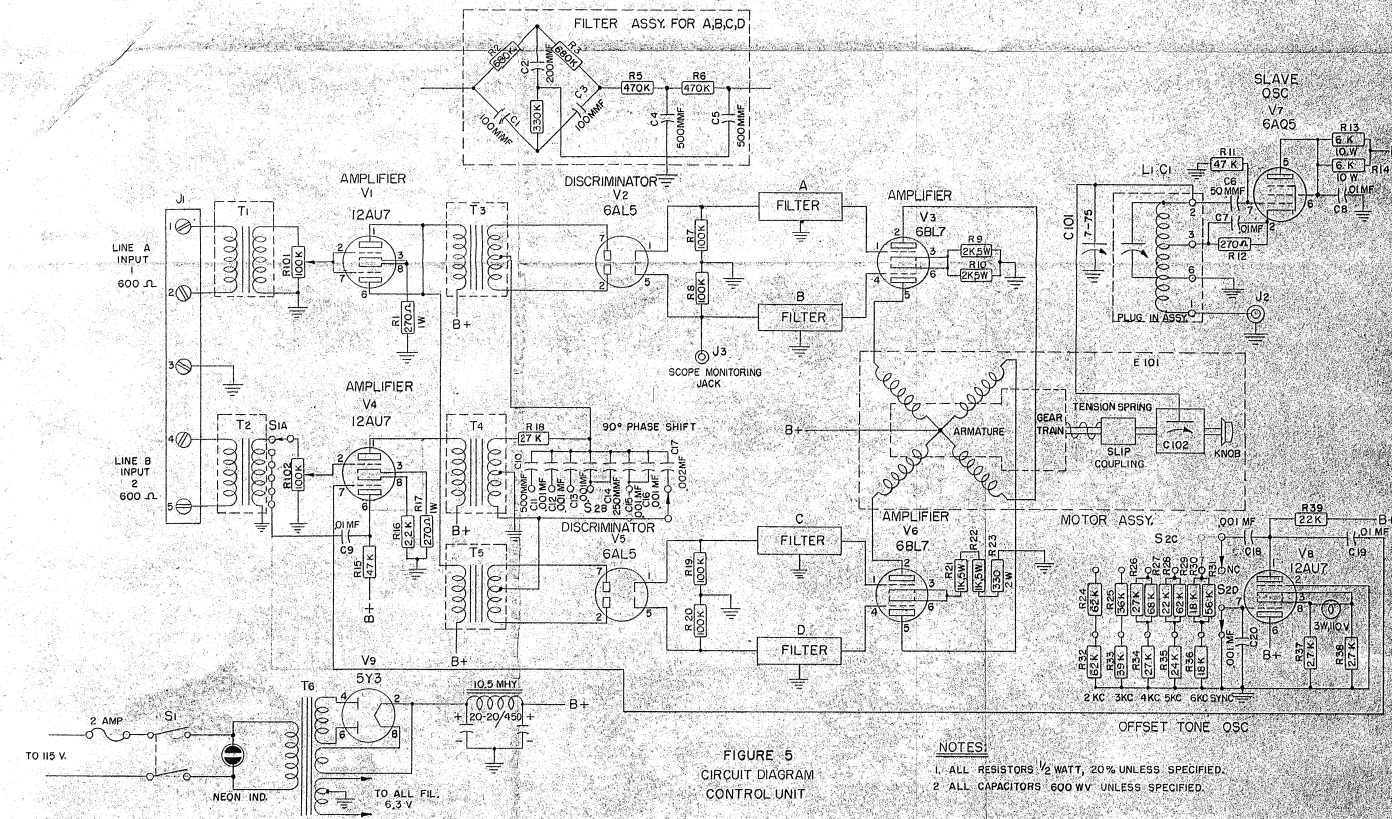


FIGURE 5
CIRCUIT DIAGRAM
CONTROL UNIT

NOTES:
1. ALL RESISTORS 1/2 WATT, 20% UNLESS SPECIFIED.
2 ALL CAPACITORS 600 WV UNLESS SPECIFIED.

NOTE: MAKE CERTAIN THIS IS THE LATEST ISSUE BEFORE PROCEEDING WITH WORK

CONFIDENTIAL
SECURITY INFORMATION

REVISIONS	RELEASED FOR MFG.	USED ON	SCALE:	MATERIAL:
			DRAWN WAG DATE 5-10-54	FINISH:
			CHECKED DATE	
			DIM. TOLERANCES FRACT. ± DECIMAL ± UNLESS OTHERWISE SPECIFIED	

DRAWING NUMBER C REV.

PE & R FORM 0114

50X1