UNCLASSIFIED

TECHNICAL MANUAL

for

CONTROLLED MASTER OSCILLATOR

CMO-1 AND CMO-2

(0-716/URA-31)

THE TECHNICAL MATERIEL CORPORATION

MAMARONECK, N.Y. OTTAWA, ONTARIO

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IN-2005B

Issue Date: 15 August 1961

THE TECHNICAL MATERIEL CORPORATION
COMMUNICATIONS ENGINEERS
700 FENIMORE ROAD MAMARONECK, N. Y.

Warranty

The Technical Materiel Corporation, hereinafter referred to as TMC, warrants the equipment (except electron tubes,* fuses, lamps, batteries and articles made of glass or other fragile or other expendable materials) purchased hereunder to be free from defect in materials and workmanship under normal use and service, when used for the purposes for which the same is designed, for a period of one year from the date of delivery F.O.B. factory. TMC further warrants that the equipment will perform in a manner equal to or better than published technical specifications as amended by any additions or corrections thereto accompanying the formal equipment offer.

TMC will replace or repair any such defective items, F.O.B. factory, which may fail within the stated warranty period, PROVIDED:

1. That any claim of defect under this warranty is made within sixty (60) days after discovery thereof and that inspection by TMC, if required, indicates the validity of such claim to TMC's satisfaction.
2. That the defect is not the result of damage incurred in shipment from or to the factory.
3. That the equipment has not been altered in any way either as to design or use whether by replacement parts not supplied or approved by TMC, or otherwise.
4. That any equipment or accessories furnished but not manufactured by TMC, or not of TMC design shall be subject only to such adjustments as TMC may obtain from the supplier thereof.

Electron tubes*furnished by TMC, but manufactured by others, bear only the warranty given by such other manufacturers. Electron tube warranty claims should be made directly to the manufacturer of such tubes.

TMC's obligation under this warranty is limited to the repair or replacement of defective parts with the exceptions noted above.

At TMC's option any defective part or equipment which fails within the warranty period shall be returned to TMC's factory for inspection, properly packed with shipping charges prepaid. No parts or equipment shall be returned to TMC, unless a return authorization is issued by TMC.

No warranties, express or implied, other than those specifically set forth herein shall be applicable to any equipment manufactured or furnished by TMC and the foregoing warranty shall constitute the Buyers sole right and remedy. In no event does TMC assume any liability for consequential damages, or for loss, damage or expense directly or indirectly arising from the use of TMC Products, or any inability to use them either separately or in combination with other equipment or materials or from any other cause.

*Electron tubes also include semi-conductor devices.

PROCEDURE FOR RETURN OF MATERIAL OR EQUIPMENT

Should it be necessary to return equipment or material for repair or replacement, whether within warranty or otherwise, a return authorization must be obtained from TMC prior to shipment. The request for return authorization should include the following information:

1. Model Number of Equipment.
2. Serial Number of Equipment.
3. TMC Part Number.
4. Nature of defect or cause of failure.
5. The contract or purchase order under which equipment was delivered.

PROCEDURE FOR ORDERING REPLACEMENT PARTS

When ordering replacement parts, the following information must be included in the order as applicable:

1. Quantity Required.
2. TMC Part Number.
3. Equipment in which used by TMC or Military Model Number.
4. Brief Description of the Item.
5. The *Crystal Frequency* if the order includes crystals.

PROCEDURE IN THE EVENT OF DAMAGE INCURRED IN SHIPMENT

TMC's Warranty specifically excludes damage incurred in shipment to or from the factory. In the event equipment is received in damaged condition, the carrier should be notified immediately. Claims for such damage should be filed with the carrier involved and not with TMC.

All correspondence pertaining to Warranty Claims, return, repair, or replacement and all material or equipment returned for repair or replacement, within Warranty or otherwise, should be addressed as follows:

THE TECHNICAL MATERIEL CORPORATION
Engineering Services Department
700 Fenimore Road
Mamaroneck, New York

CHANGE NO. 1

INSTRUCTION BOOK CHANGE NOTICE

Date October 4, 1963

Manual affected: Controlled Master Oscillator CMO-1 and CMO-2 IN -2005B/248

page III B-4-4 Figure III B-4-1 Block Diagram

Change input from CHL to V306 from "100 KC" to "10 KC"

SHOULD ADDITIONAL COPIES OF THIS CHANGE NOTICE BE REQUIRED, PLEASE CONTACT:

THE TECHNICAL MATERIEL CORP., 700 Fenimore Road, Mamaroneck, New York

Attn.: Director of Eng. Services.

CHANGE NO. 2 CMO-1 & CMO-2

INSTRUCTION BOOK CHANGE NOTICE

Date 6/4/64

Manual affected: Controlled Master Oscillator CMO-1 & CMO-2 IN -2005/248

Page IIIB-7-3

C341. Under DESCRIPTION column "$\pm$15%" to read "$^{+30\%}_{-15\%}$".

Page IIIB-7-3

C355. Under TMC PART NO. column, change "CN106D104K" to read "CN106C104K.

Page IIIB-7-6

R321. Under TMC PART NO. column, change "RV106UF8A502A" to read "RV106UF9A502A".

Page IIIB-7-7

R348. Under DESCRIPTION column delete "Same as R303" and substitute "RESISTOR, fixed: composition; 4.7 megohms, $\pm$10% 1/2 watt".

Under FUNCTION column add part no. "RC20GF475K".

Page IIIB-8-3/8-4. Figure IIIB-8-1.

Delete 56K resistor connected across relay K301.

SHOULD ADDITIONAL COPIES OF THIS CHANGE NOTICE BE REQUIRED, PLEASE CONTACT:

THE TECHNICAL MATERIEL CORP., 700 Fenimore R ad, Mamaroneck, New York

Attn.: Direct r f Eng. Services.

RECORD OF CORRECTIONS MADE

Change No.	Date of Change	Date Entered	Entered By

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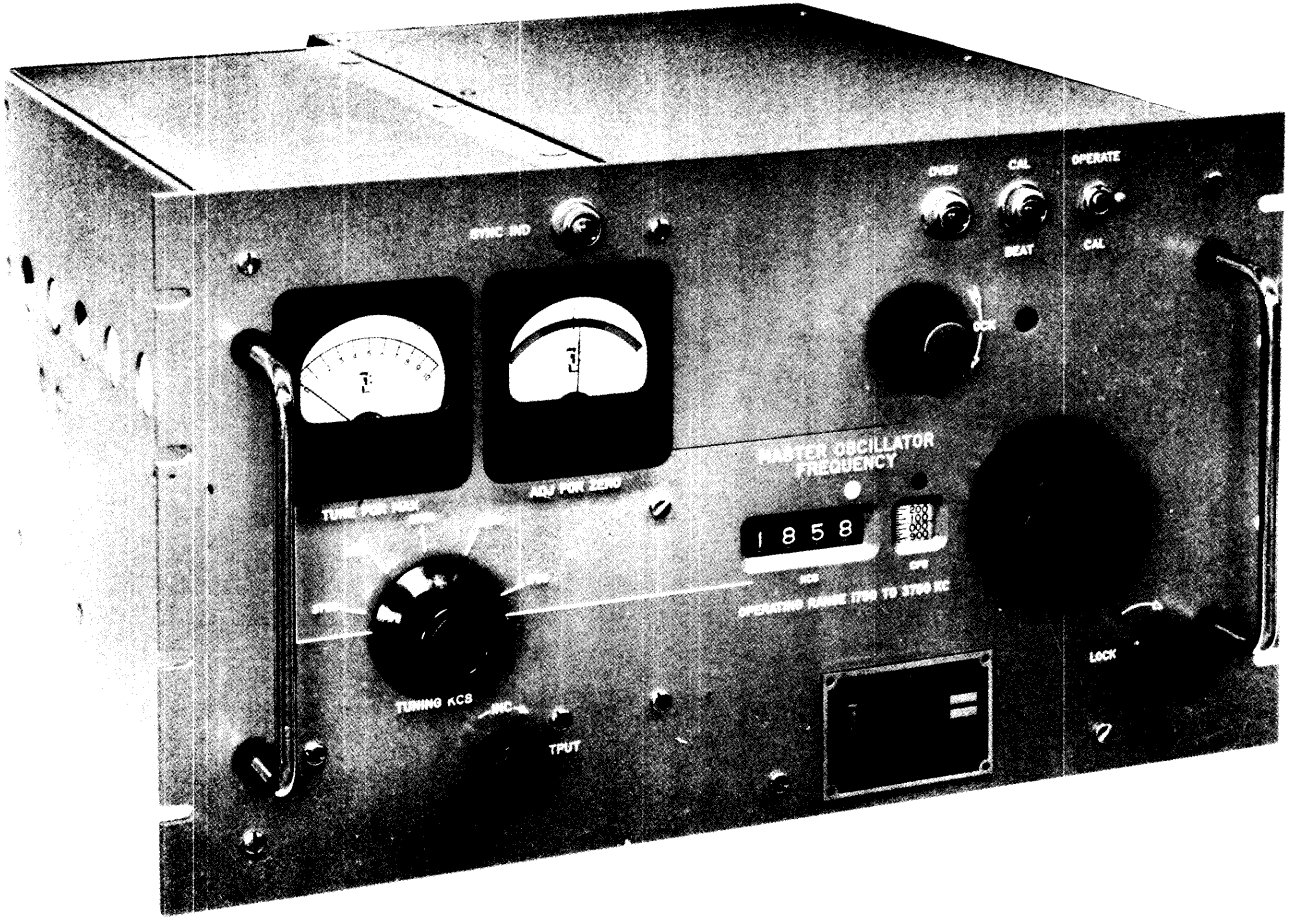
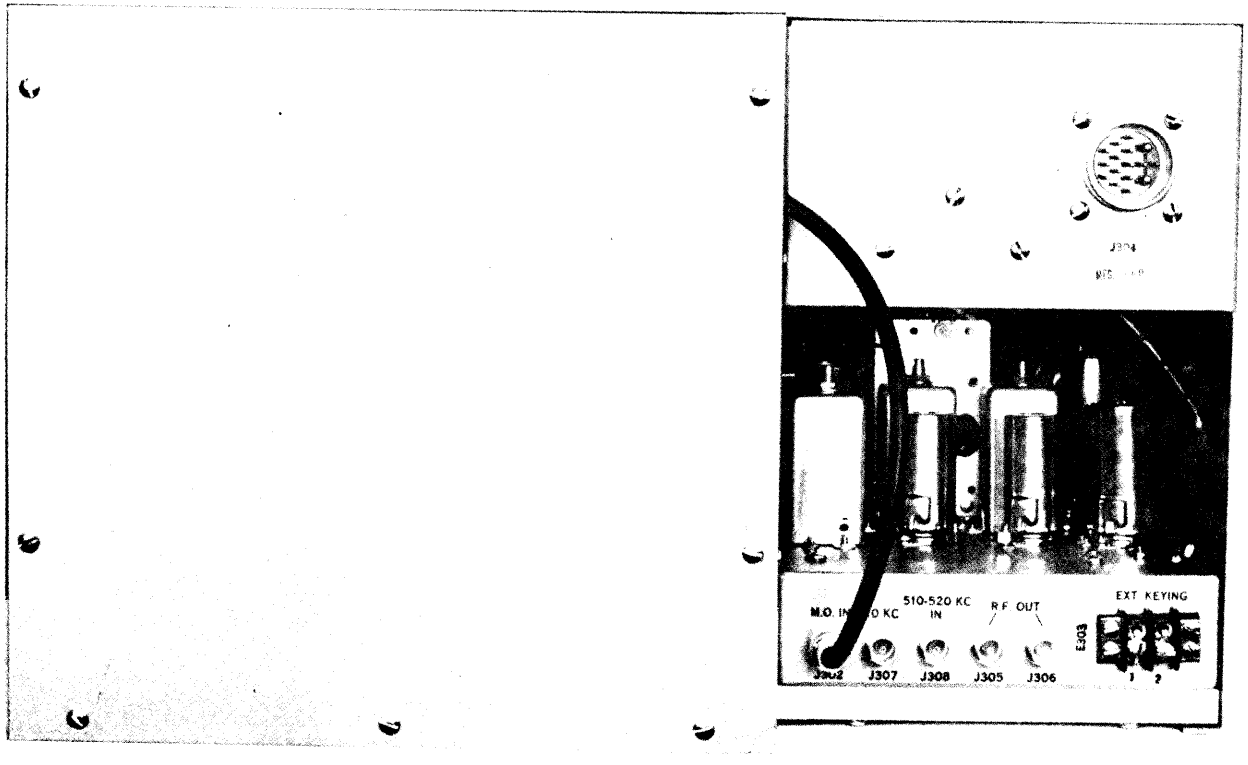


2005B-1

Figure IIIB-1-1A. Front Angl View, Controlled Master Oscillator, CMO-1



2005B-2

Figure IIIB-1-1B. Rear Angle View, Controlled Master Oscillator, CMO

SECTION 1
GENERAL DESCRIPTION

III B-1-1 INTRODUCTION

The Controlled Master Oscillator, CMO, is a precision, direct-reading variable device forming a part of a TMC controlled precision oscillator (CPO) system. In the CPO system, it performs primarily as the master oscillator with panel controls enabling adjustment and locking of its 2-4 mc frequency against a frequency standard to within one cycle.

The CMO incorporates a highly stable frequency oscillator with an extremely accurate counter type dial. Oscillator frequency determining elements are contained in a temperature stabilized oven. Adjustment and locking of the oscillator frequency to a frequency standard are accomplished by means of a phase shift detector system which operates in a manner similar to a positional servo.

Two types of the CMO are available, differing only in mechanical alignment between panel counter reading and actual output frequency (f=frequency).

Model	Counter Reading	Output Frequency
CMO-1	f	f + 250 kc
CMO-2	f	f

The CMO-1 is calibrated to produce 250 kc more than its panel counter reading in order to eliminate one calculation step in operating the CPO system for which the CMO-1 is designed. The CMO-1 range is marked 1750-3750 kc; CMO-2 range is marked 2000-4000 kc. The actual output range of both CMO-1 and CMO-2 is 2-4 mc.

Commercial and military nomenclature for the CMO is as follows:

Commercial	Military
Controlled Master Oscillator, CMO-1	Oscillator, Radio Frequency, 0-716/URA-31
Controlled Master Oscillator, CMO-2	Not assigned at date of manual issue.

Unless otherwise noted, the description of the CMO in this manual applies to the CMO-1.

The power supply for the CMO is a separate unit furnishing power to the CMO and other units in the CPO system.

The CMO requires 10-1/2 inches of height and 16 inches of depth in any standard 19-inch relay rack. It's weight is 40 lbs. and is supported by its panel and a pair of chassis slides. The unit is manufactured in accordance with JAN/MIL specifications wherever practicable. All parts and assemblies meet or exceed the highest quality standards.

A terminal block on the back of the chassis provides a connection point for a keying device when keyed control of the CMO output is desired.

III B-1-2 REFERENCE DATA

a. CMO's dimensions and weights are given in preceding paragraph IIIB-1-1. A CMO crated for shipping measures 16 in x 24-5/8 in. x 27 in and weighs 85 lbs. Electrical characteristics, front panel controls, chassis mounted adjustments and vacuum tube and diode complement are given in tables IIIB-1-1, IIIB-1-2, IIIB-1-3 and IIIB-1-4, respectively.

TABLE III B-1-1 ELECTRICAL CHARACTERISTICS

ITEM	CHARACTERISTICS
Frequency range:	2 to 4 megacycles continuous
Output impedance:	70 ohms nominal
Output level:	Continuously adjustable from 0 to a maximum of 1 watt.
Output voltage:	Sinusoidal with spurious frequencies 60 db down from max.
Stability:	When used with associated units in CPO system: 1 part in 10^8 per 24-hour period.

TABLE III B-1-1 ELECTRICAL CHARACTERISTICS (C nt.)

ITEM	CHARACTERISTICS
Connections:	Power input: TMC #JJ-183 receptacle (mates with TMC #PL-186 plug) RF output: 2 Type BNC coaxial receptacles (one for monitoring purposes) 10-kc input: 1 Type BNC coaxial receptacle 510-520 kc input: 1 Type BNC coaxial receptacle
Master oscillator calibration:	Against 100-kc crystal oscillator at 50-kc points and frequency standard of 1 part in 10^8 per 24 hour period stability.
Line voltage change effects:	When used with associated power supply unit in complete oscillator system: 0 cps for $\pm$ 10% change in line voltage

TABLE III B-1-2 FRONT PANEL CONTROLS

CONTROL	FUNCTION
TUNE FOR MAX	Meter indicates peaks for power amplifier tuning and power output level.
ADJ FOR ZERO	Meter indicates locking of oscillator frequency against frequency standard.
SYNC IND	Light indicates synchronization of oscillator frequency with frequency standard.
TUNING KCS	Knob controlled adjustable ganged tuning capacitors tune power amplifier and 10-kc harmonic selector sections.
OUTPUT	Knob controlled potentiometer adjusts power output level.
OVEN	Light indicates oven cycling.
CAL BEAT	Light indicates calibration of master oscillator to 100-kc increments.
OPERATE/CAL	Switch selects calibration action and lock-and-operate action.
Red Knob	Knob adjustable coil in master oscillator tuning circuit assists in calibrating and locking frequency.
Black outer ring knob around red knob	Locks red knob against movement.
MASTER OSCILLATOR FREQUENCY	Black knob and counter indicators in KCS and CPS adjust tuning capacitors in master oscillator circuit and indicate resulting master oscillator frequency.
LOCK	Locks MASTER OSCILLATOR FREQUENCY knob and counters against movement.

TABLE III B-1-3 CHASSIS MOUNTED ADJUSTMENTS

Reference Designation Symbol	Function
C 302	Aligns master oscillator tuning with 100-kc crystal oscillator at high end of frequency range.
C 311	Tunes 100-kc oscillator to 100-kc.
T 301, T 302	Tunes RF amplifier chain to 2-4 mc range low end.
C 329, C 311	Tunes RF amplifier chain to 2-4 mc range high end.
T 303, T 304, C 332, C 336	Aligns 10-kc harmonic selector with RF amplifier chain tuning.
T 306, T 307 T 308	Tunes IF section to 510-520-kc.
R 328	Calibrates ADJ FOR ZERO meter to zero.
R 340	Calibrates SYNC IND light to synchronized frequency indications.

TABLE III B-1-4 VACUUM TUBE AND DIODE COMPLEMENT

Reference Designation Symbol	Type	Function
V 301	6AB4	Master Oscillator
V 302	12AU7	Cathode follower
V 303	6AH6	Reactance
V 304	6AH6	1 st RF Amplifier
V 305	6CL6	Power Amplifier
V 306	6AU6	Harmonic Amplifier
V 307	6AH6	Harmonic Selector
V 308	6AH6	IF Amplifier
V 309	6BA7	Mixer
V 310	6CS6	Sync. Indicator
V 311	12AU7	Audio Amplifier
V 312	6BE6	Mixer
CR 301	1 N 100	Rectifier, J 403
CR 302	1 N 100	Rectifier, T 305
CR 303	1 N 100	Rectifier, T 305

SECTION 2
INSTALLATION

III B-2-1 INITIAL INSPECTION

The CMO has been tested and calibrated before shipment. Only minor preparations are required to put the unit into operation.

Inspect the case and its contents immediately for possible damage. Unpack the equipment carefully. Inspect all packing material for parts which may have been shipped as "loose items". Although the carrier is liable for any damage in the equipment, Technical Materiel Corporation will assist in describing and providing for repair or replacement of damaged items. The equipment is shipped with all tubes installed. Check that all such components are properly seated in their sockets.

III B-2-2 230 LINE VOLTAGE MODIFICATION

Wiring of the CMO oven temperature control circuit in the factory is arranged for 115-volt line voltage. When the CPO system, in which the CMO is used, operates from a 230-volt line, a simple modification may be performed. Refer to figure IIIB-2-2 which shows terminal block E301 located in back of the oven as shown in figure IIIB-5-4. Remove and add jumpers at E301 as shown in figure IIIB-2-2.

III B-2-3 INITIAL ADUSTMENTS The CMO unit has been factory tested and adjusted. No initial adjustments are required before installation and operation.

NOTE

Do not reset any of the chassis screwdriver adjustments listed in Table IIIB-1-3. These were correctly set and locked in position during calibration of the CMO prior to shipment.

III B-2-4 INSTALLATION PROCEDURE

a. Install the CMO in the rack specified in the technical manual describing the CPO system in which the CMO is used. The rack, including the appropriate chassis slides, will be included in the shipment of the CPO system. Figure IIIB-2-1 is an outline dimensional drawing of the CMO.

b. Connect the CMO with the associated CPP Power Supply Unit, CLL Low Frequency Loop Unit, CHL Divider Chain Unit and CHG Hight Frequency Loop Unit as outlined in the technical manual describing the CPO system in which the CMO is used.

c. If desired, a keying device can be attached to the CMO which will interrupt its output and enable the complete oscillator system to be operated to produce a keyed signal. To accomplish this, a simple connection at E303 EXT KEYING terminal block (see fig. IIIB-2-1) may be made in accordance with directions in figure IIIB-2-3 diagram.

d. The CMO, along with the CPO system, requires an initial warm-up period to bring its oven to the required temperature to produce its rated frequency stability (1 part in 10^8 per 24-hour period). This initial warm-up, a 48-hour period, must be performed before operation of the equipment. The CPO power supply has a switching provision which enables power to be supplied to the CMO oven temperature control circuit independent of power supplied to the main CMO circuitry. Once the CPO has completed its initial warm-up period, the oven temperature control is left on continuously and power to its operating circuitry may be switched on and off as desired. Refer to the CPO technical Manual for pre-operation warm-up procedure of the system.

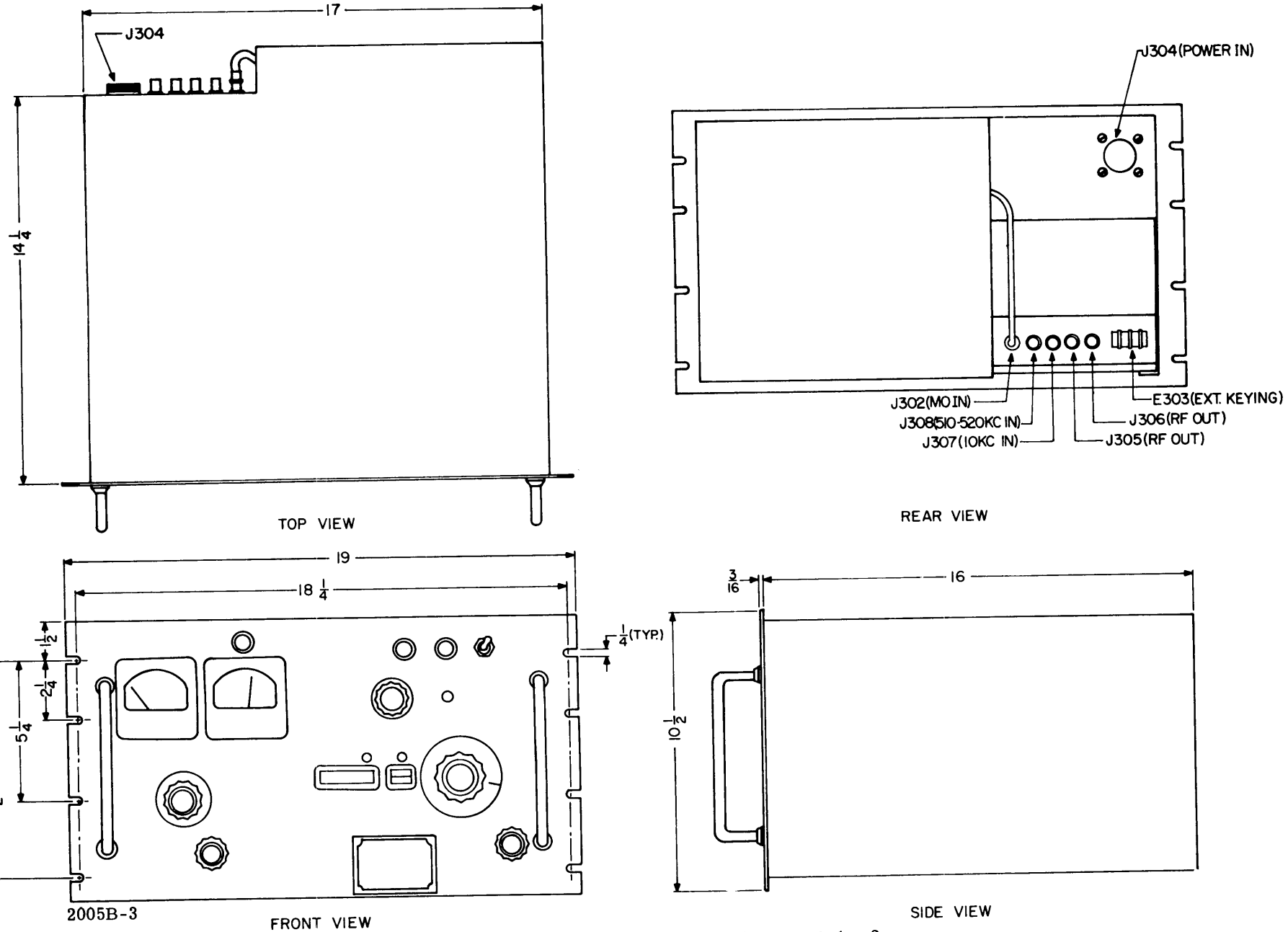


Figure IIIB-2-1. Outline Dimensional Drawing, CMO-1, -2

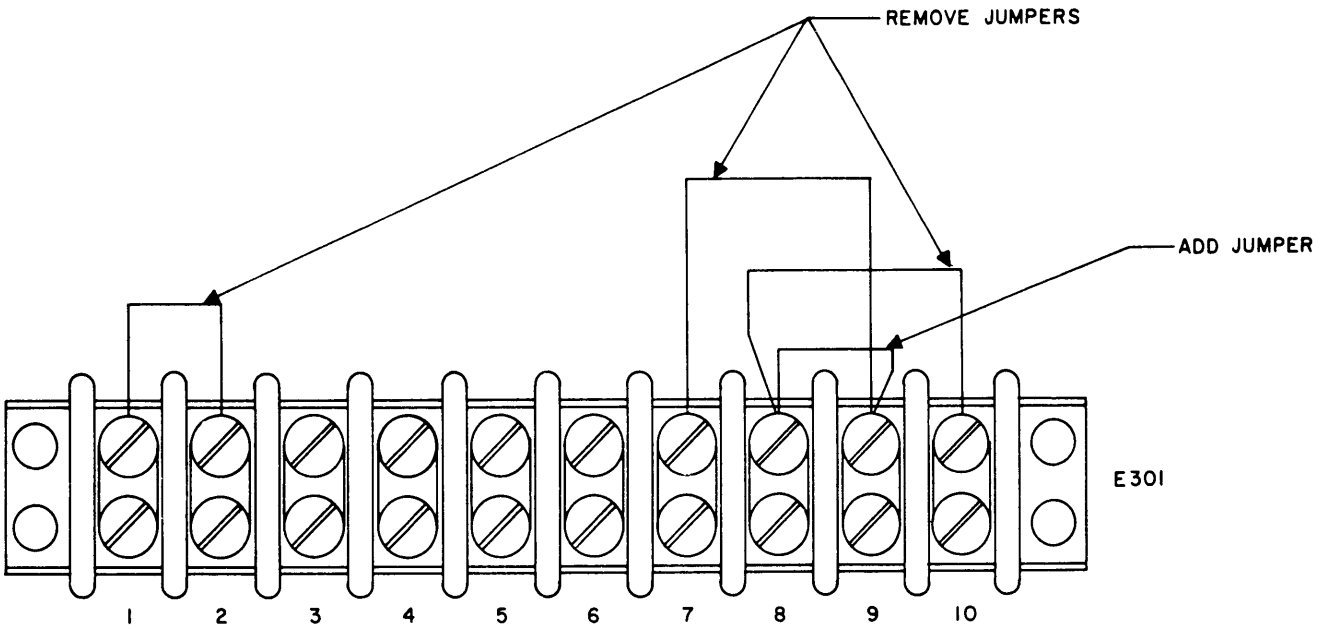


Figure IIIB-2-2. Installation Diagram Showing Modification to CMO for 230-Volt Operation

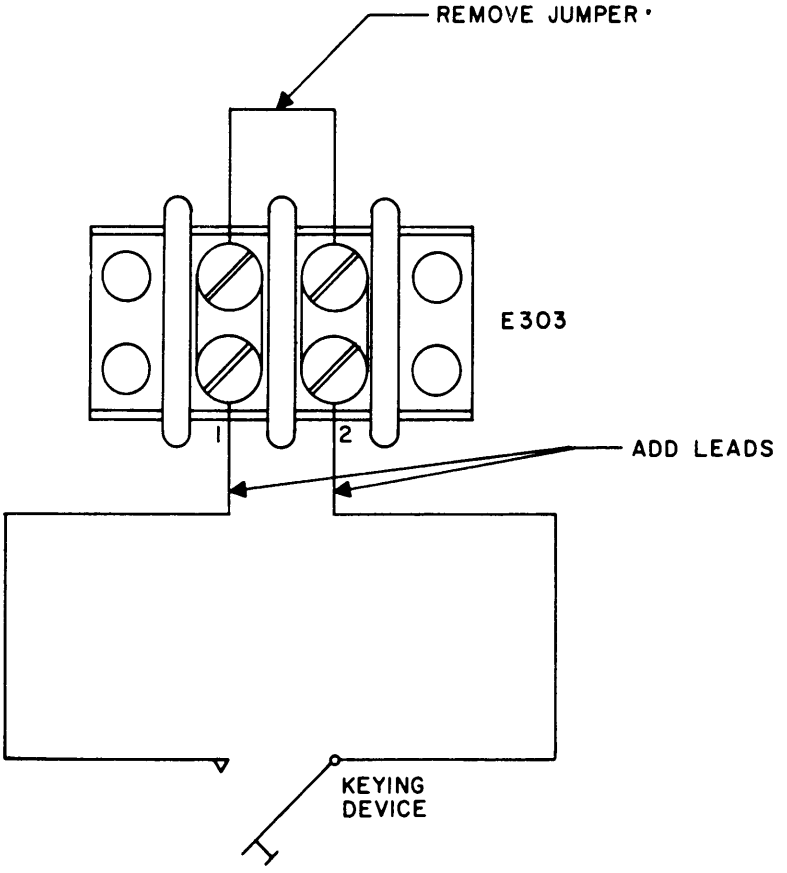


Figure IIIB-2-3. Installation Diagram Showing Modification to CMO for Addition of Keying Device

SECTION 3
OPERATOR'S SECTION

III B-3-1 OPERATOR'S MAINTENANCE The operator should note general condition of panel switches, observe whether panel indicator lamps light properly and check the condition of tubes when they appear subnormal. The locations of all tubes in the CMO are indicated in figures IIIB-5-6 and IIIB-5-7. In checking tubes, use tube substitution method.

CAUTION

When checking tubes shown in figure IIIB-5-7, do not remove oven door after warm-up period of CMO. A resulting temperature drop in the oven may cause a lengthy delay in waiting for the oven temperature to restabilize. Tube shields and tubes are removable without removing the oven door.

If all the lights fail to go on and no meter readings can be obtained, check to see if CMO is receiving power. Fuses in the CMO power circuitry are located in the CMO system power supply unit (CPP).

If, while the majority of tube filaments light, any tube filament fails to go on, remove tube and test it with a tube tester.

After initial warm-up period of the CMO (see par. IIIB-2-4d) and during its operation, the OVEN light should cycle at about 1 minute on and 5 minutes off at room temperature, indicating a stabilized oven. Ambient temperature extremes will vary this cycle accordingly (ie: it will cycle more frequently in colder surroundings and more slowly in warmer surroundings). If oven light blinks on and off erratically, while other indications on the CMO are normal, this may indicate that main oven thermostat (S301) has malfunctioned and the emergency thermostat (S302) has taken over. In this case, which will be rare, the emergency thermostat may be relied upon to keep the oven at required even temperature for the remainder of the operating period. Replacement of S301 by the operator will not be necessary.

III B-3-2 INTRODUCTION TO OPERATION PROCEDURE The CMO unit is designed to serve as a component of TMC's CPO system rather than as an end item. Therefore, the following operation instructions comprise only those steps necessary to tune the CMO during the overall operation procedure of the CPO system.

III B-3-3 PRELIMINARY CONSIDERATIONS Before attempting to operate the CMO (table IIIB-3-2 and figures IIIB-3-1 and IIIB-3-2) the following must be considered.

a. Output frequency desired for the system.

b. Output power level desired for the system.

c. Operating range marked on CMO panel beneath its counter.

The output frequency desired for the system may be chosen by referring to charts in the operation procedure described for the CPO system. When the output frequency for the system is determined, reference to these charts will indicate what the corresponding CMO output frequency should be. This CMO frequency is referred to in table IIIB-3-2 of this manual as "the desired frequency".

The ultimate output power level of the CPO system may be determined by the operator. A suggested level, however, is referred to in the operation procedure for the CPO system and gives a corresponding dial setting for the CMO to be performed after it is properly tuned.

The operating range lettered beneath the CMO MASTER OSCILLATOR FREQUENCY counter marks the limitations that the knob (control #2 on figure IIIB-3-1) should be turned in order to maintain the precision qualities of the CMO.

WARNING

Turning MASTER OSCILLATOR FREQUENCY knob to bring figures on counter beyond range printed below counter may disturb mechanical calibrations of master oscillator assembly to the extent of making it impossible to obtain and lock the desired frequency in the final stage of tuning. Once these calibrations have been disturbed, they may be readjusted only by returning the complete CMO unit to the TMC factory.

III B-3-4 OPERATING INSTRUCTIONS Table IIIB-3-2 is the operating chart for the CMO unit. Operate the unit as outlined in this table. Figures IIIB-3-1 and IIIB-3-2 provide reference designations for operating controls. Table IIIB-3-1 gives cross-reference between figures IIIB-3-1 and 2 and wiring schematic reference designation numbers. In table IIIB-3-2, examples are given in parentheses for a desired frequency of 3,001,500 CPS. Numbers in parentheses designate panel control numbers shown in figures IIIB-3-1 and IIIB-3-2.

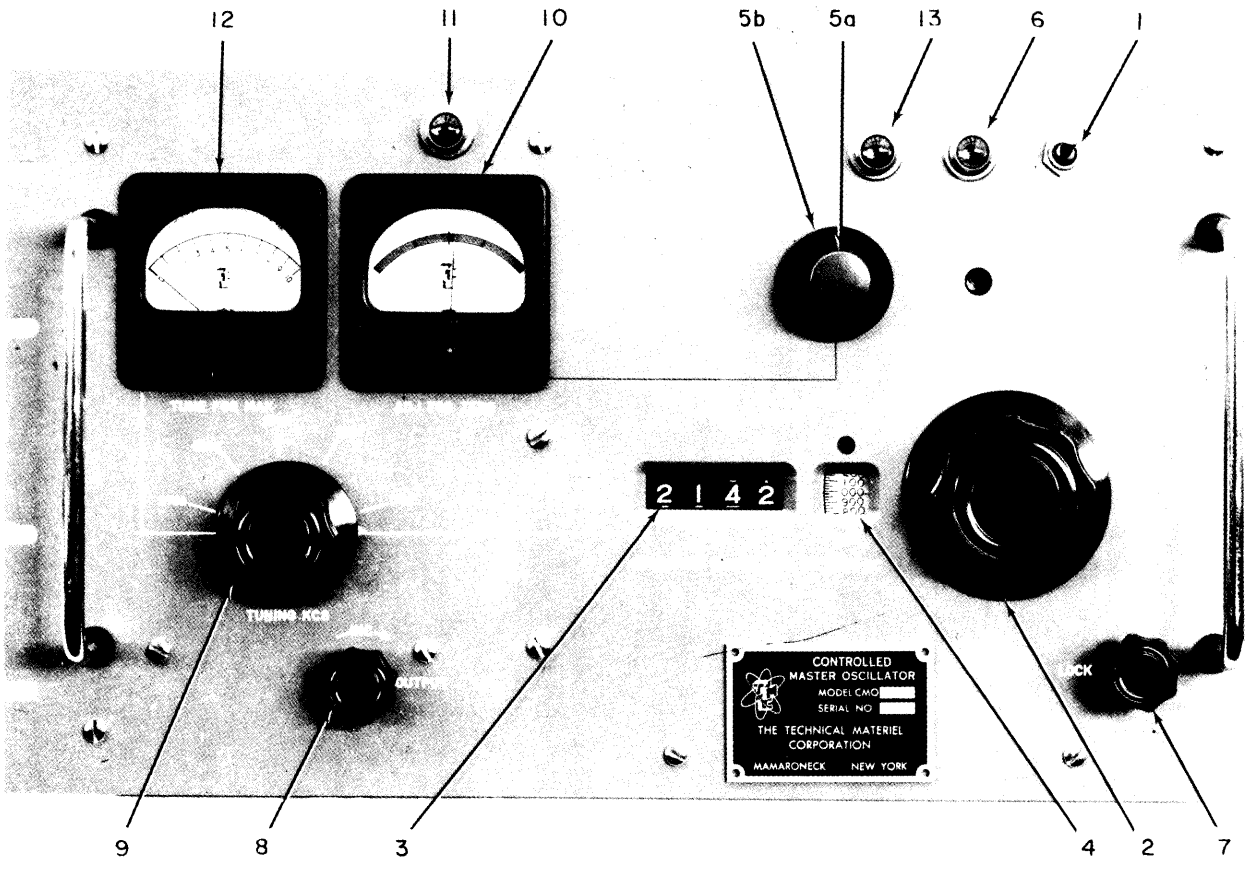


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Figure IIIB-3-1. Panel View of CMO-1 Showing Operating Controls

TABLE III B-3-1 EQUIPMENT CONTROL DESIGNATIONS

Serial Designation (Fig. IIIB-3-1)	Panel Designation (Fig. IIIB-3-1)	Component Designation on Overall Schematic (Fig. IIIB-8-1)
1	OPERATE/CAL	Toggle switch S304
2	MASTER OSCILLATOR FREQUENCY	Knob adjustable tuning capacitors C301 and C307
3	KCS	Counter geared to tuning capacitors C301 and C307
4	CPS	Counter geared to tuning capacitors C310 and C307
5a	Red Knob	Knob adjustable tuning coil L301
5b	LOCK (outer ring around red knob)	Lock for L301 knob
6	CAL BEAT	Indicator I303
7	LOCK	Lock for C301 and C307 knob
8	OUTPUT	Knob potentiometer R321
9	TUNING KCS	Knob adjustable tuning capacitors C330A, C330B, C330C and C330D
10	ADJ FOR ZERO	Meter 302
11	SYNC IND	Indicator I304
12	TUNE FOR MAX	Meter M301
13	OVEN	Indicator I301

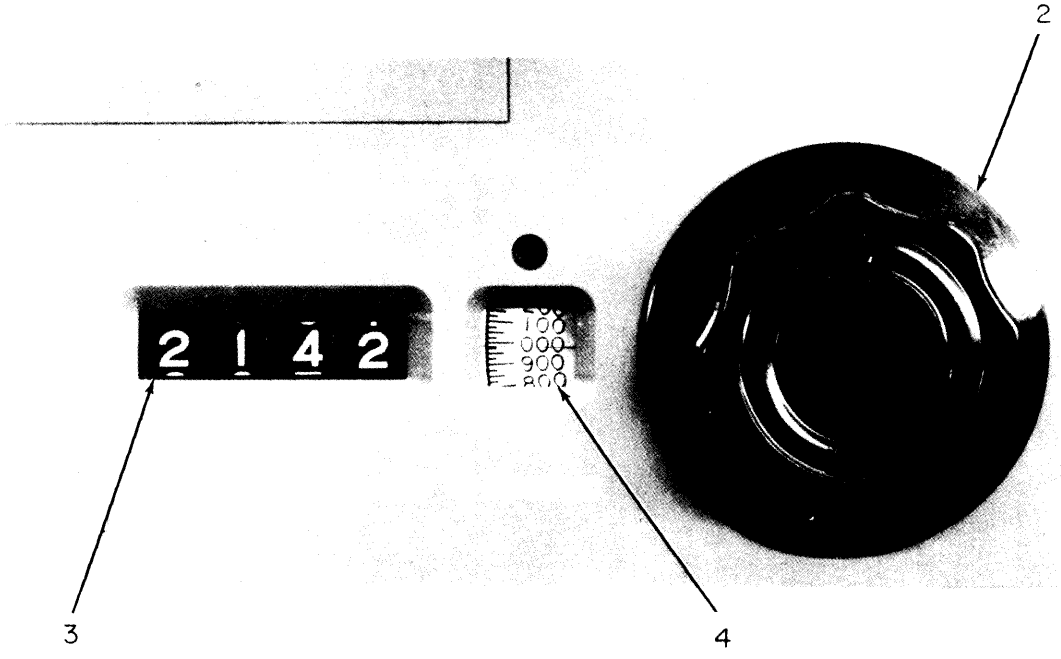

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Figure IIIB-3-2. Enlarged View of Panel Counter, CMO-1

TABLE III B-3-2 TUNE-UP OF CMO

STEP	PANEL SERIAL DESIGNATION	OPERATION	PURPOSE
1	1	Switch OPERATE/CAL switch (1) to CAL position.	Supplies calibration section with power and cuts out synthesizer loop action.
2	2, 3, 4, 5a, 6	Turn MASTER OSCILLATOR FREQ. knob (2) to bring counters (3) and (4) (see fig. IIIB-3-2) to the nearest 50 KC increment below the desired frequency (example: 3, 000, 000 CPS. Bring 3, 000-KC on KCS counter (3) and 000 cps on CPS counter (4)*. Then turn red knob (5a) to point that causes CAL BEAT light (6) to zero beat.	Sets MO frequency to exact 50-KC increment below desired frequency.
3	2, 3, 4	Turn MASTER OSCILLATOR FREQUENCY knob (2) to bring counters (3) and (4) up to the desired frequency. (Example: 3, 001, 500 CPS. Bring 3, 001-KC on KCS counter (3) and 500 cps on CPS counter (4).	Completes calibration of CMO to desired frequency.
4	7	Turn LOCK knob (7) CW until it tightens securely.	Locks MASTER OSCILLATOR FREQ. knob (2) and KCS and CPS counters, (3) and (4), against movement and locks CMO calibration to desired frequency.
5	1	Switch OPERATE/CAL switch (1) to OPERATE position.	Cuts off calibration section power and activates synthesizer loop.
6	8	Turn OUTPUT knob (8) to maximum (fully CW) position.	For good reading on TUNE FOR MAX meter (12) in order to tune power amplifiers.
7	9	Position TUNING KCS knob (9) so that while its pointer indicates the approximate desired frequency (example: 3, 001. 5-kc) a peak reading is obtained on TUNE FOR MAX meter (12).	Tunes power amplifiers.

TABLE III B-3-2 TUNE-UP OF CMO (C nt.)

STEP	PANEL SERIAL DESIGNATION	OPERATION	PURPOSE
8	5a	Adjust red knob (5a) to obtain steady green band reading on ADJ FOR ZERO meter (10) concurrently with steady light from SYNC IND light (11).	Corrects desired frequency to a frequency standard.
9	5b	Turn outer knob (5b) of red knob (5a) fully CW until securely tightened.**	Locks CMO desired frequency to a frequency standard.
10	8	Adjust OUTPUT knob (8) to obtain desired reading on TUNE FOR MAX meter (12) for mode of transmission used.	Adjusts power OUTPUT level.

*** CAUTION**

Avoid spinning MASTER OSCILLATOR FREQUENCY knob (2) at a high rate of speed from one end of the operating range to the other. A realignment of C302 trimmer capacitor inside may be necessary as a result, in order to obtain the zero beat indication as described in step 2. Realignment of C302 may be accomplished while the set is in operation as described in ***NOTE.

** Do not proceed with step 9 until indication described in step 8 is realized. If necessary, repeat procedure from steps 1 through 8.

***** NOTE**

If trouble is encountered in step 2 in obtaining a zero beat from CAL BEAT light (6), due to knob (5) being spun too fast over a long range, the operator may elect to correct this condition while the set is operating. In the front panel, to the right of the red calibration knob (5a), is an access hole for the screwdriver adjustment of C302 trimmer capacitor within the set. While the counters (3) and (4) give a reading that is the 50-KC increment below the desired frequency, set the red calibration knob (5a) approximately midway between its two extremes (about 4-1/2 revolutions from extreme CCW). Adjust C302 with screwdriver until CAL BEAT light gives a zero beat. This will complete step 2 in table IIIB-3-2 and steps 3 through 10 may then be performed. It is then advisable to have this trimmer recalibrated as described in Section 6 before using the CMO in the next transmission.

SECTION 4
PRINCIPLES OF OPERATION

III B-4-1 INTRODUCTION As shown in figure IIIB-4-1, the CMO consists of the following five principal sections, which were briefly described in Section I-4-5 and are described in detail in following paragraphs IIIB-4-1, -2.

a. Master oscillator and calibration circuit.

b. RF amplifier chain

c. Synthesizer circuit

d. Oven temperature control circuit

e. Power input

a. Master oscillator and calibration circuit (figure IIIB-4-1). The master oscillator, V301, generates the 2-4 megacycle frequency to be issued by the CMO unit, and feeds it through a buffer, V302A cathode follower, to the RF amplifier chain. The master oscillator (MO) is initially tuned to the desired frequency by means of the calibrating circuit, consisting of V302B, V312, L. P. filter, V311, I303, C and L ADJ, and a counter indicator on the CMO panel. This sets the CMO output to the desired frequency within approximately 1 cycle. Then, when S304 is switched to the OPERATE position, the synthesizer circuit precisely synchronizes the MO by means of d-c from the phase detector, T305, which acts on the MO's reactance tube V303. V301, V302A and V302B are enclosed in a temperature controlled oven which keeps the variation of frequency, caused by temperature sensitive elements, within a range which can be corrected by the synthesizer loop.

The action in the calibrating circuit is in two stages. In the first C ADJ is turned to bring a frequency reading on the counter to the nearest 50 kc increment below the desired frequency. L ADJ is then turned to increase the MO frequency until I303 light beats. The 100-kc from V302B and sample of the adjusted 2-4 MC enter V312 mixer which combines an appropriate harmonic of the 100-kc with the 2-4 mc to produce difference products, all of which are 100-kc harmonics. These products are then introduced to the L. P. filter which passes only the audio frequencies. Thus it is only when the two signals are within audio frequency range of each other that voltage output (beat frequency) is obtained from the L. P. filter. This audio frequency is then amplified by V311 and causes I303 to beat. As the MO frequency is increased, by further adjustment of L ADJ, the AF decreases in cps and the light beats slower and slower until it goes out (zero beat). It is at this point that the MO output has been calibrated to a 50-kc increment. In the second stage of adjustment, C-ADJ is turned to increase the frequency reading on the counter to the desired frequency. This brings the MO output to the desired frequency.

b. RF amplifier chain (figure IIIB-4-1). The 1st RF amplifier (V304) functions to amplify the voltage output of V302A cathode follower to the point where sufficient drive is obtained for the power amplifier (V305). Tuned circuits in the output of V304, V305 and V307 are gang tuned and used to bring about the final tuning and locking of the CMO output frequency. R321 is used to control the power level in the output.

c. Synthesizer circuit (figure IIIB-4-1). The action of the synthesizer circuit makes a final adjustment on the CMO output frequency in order to bring it to the accuracy of a frequency standard and lock it against drift caused by any change in ambient temperature or other effects. This is done essentially by heterodyning a sample of MO output into the 510-520 kc range and comparing it with a stabilized frequency in this range in a phase detector. Any difference in phase is put out as a pulsating d-c voltage by the detector. The d-c voltage acts on V303 reactance tube which corrects the MO frequency. The RF amplifier chain tuning control is ganged to the harmonic selector (V307) and pre-calibrated to automatically select the correct 10-kc harmonic to bring this action about. Reference may be made to Part I, Section IV; par. 1-4-1 of this manual for more detailed theory description of the automatic phase control system used throughout TMC synthesized sideband equipment. The reactance tube (V303) is included in the temperature-controlled oven in order to keep variations of its temperature-sensitive network within a range which can be handled by the synthesizer loop section.

d. Oven temperature control. The oven is heated by heating-blankets R307A and R307B within its outer wall. A temperature-sensitive switch (S301), within the wall, cuts off the line power to the blankets when the wall temperature rises above 70° C and reconnects the power as the temperature drops below 70° C. As an added safety precaution, another temperature sensitive switch (S302) is located within the oven interior and set to trip at 80° C, performing the same function in case of S301 failure.

e. Power Input. The CMO unit requires a conventional power supply furnishing +220 unregulated and +160 regulated d-c plate voltages, 115 or 230 VAC for the oven, and 6.3 VAC and ±6 VDC regulated filament voltages. Regulated plate and filament voltages are also a contributing factor to the CMO frequency stabilization design, protecting the circuitry from extreme variations in line voltage.

III B-4-2 STAGE-BY-STAGE DESCRIPTION

a. Master oscillator and calibration section (see figure IIIB-4-2). The resonant frequency is the 2-4 mc tuning network of the MO (V301) is almost totally determined by the parallel combination of C307 and L301, both of which are precision components. By means of the slug within L301, this resonant frequency may be

slightly altered so that the oscillator is precisely set against the internal secondary standard (V302B) 100-kc oscillator. However, some device must be employed to automatically make the main tuning capacitor (C307) track the frequencies between check points. A mechanical coupling to a counter, in conjunction with the trimmer capacitor C301, serves this purpose. As the MO frequency knob is rotated on the control panel to turn the counter, a series of step-down precision gears within the oven cause C307 to rotate slowly. From here a precisely set cam and follower arm operate to rotate C301. The system is finely balanced and completely free of gear slippage. The precise follow-up of C301 movement to C307 movement is designed to repeat indefinitely, barring severe mechanical shocks, and as long as the printed range beneath the panel counter is not exceeded by the operator. C302 is used as a trimmer to adjust the oscillator at its high frequency extreme while C303 and C304 are special compensating capacitors which serve to make the unit as insensitive to temperature change as possible. C305 and C306 couple the oscillator tube into the resonant circuit and determine the degree of feedback. R301 is the grid leak resistor which established an operating bias for the stage. The load impedance is formed by L302: C309 places the plate at RF ground potential and decouples it from the power supply. In the cathode follower (V302A) circuit, C309 again serves as a plate RF grounding device for this tube, and, in conjunction with L304 effective decoupling from the power supply is obtained. R302 is the load resistor across which an output appears. The cathode follower, interposed in the MO output to the RF amplifier chain, serves to isolate the MO from any external devices used with the CMO which may possibly influence its frequency. Tapping off the cathode follower output is a line supplying the MO frequency to V312 mixer for purposes of calibration. When switch S304 is thrown into CAL position, V302B, V312 and V311 receive plate supply and the d-c issuing from the synthesizer circuit is shorted out, in order that it may not interfere with the calibration adjustment. When the calibration operation is completed, S304 is opened to place the synthesizer circuit into action and cut out the calibration action by depriving its tubes of plate supply.

The 100-kc oscillator (V302B) utilizes a highly stable crystal (Y301) in a resonant circuit in the feedback path between grid and plate. R317 is the plate load resistor. A form of cathode follower action is obtained by placing another load resistor (R303) in the cathode circuit and using voltage appearing there for output purposes. The grid leak bias is obtained from R304 and a precise adjustment of the crystal frequency against some primary standard is made by means of C311.

In the mixer (V312) circuit, the 100-kc from V302B and 2-4 mc from V302A enter to produce difference frequencies in terms of 100-kc harmonics. C347 with R350 and C362 with R354 form a coupling capacitor and grid leak combination, respectively, for each injection grid. R353 is the screen dropping resistor and C361 is the screen bypass. The plate load is R352 and the low pass filter combination in the mixer output is composed of C360, R351 and C359.

In the two-stage audio amplifier circuit V311A and V311B, C358, R349 and R346 are the coupling capacitor, grid leak, and plate load respectively for the first stage; C356, R348 and R345 perform identical functions for the second stage. These stages are designed to have excellent low frequency response. The last stage is heavily driven to light the neon lamp in I303 zero beat indicator. C355 permits passage of higher frequencies. R217 acts as a return impedance for the beat indicator. The result of this design is a device whose output becomes more pronounced as zero beat is approached.

b. RF amplifier chain (see figure IIIB-4-3) The output of the MO is coupled into the input of V304, voltage amplifier, through C367 d-c blocking capacitor and L306 voltage step-up coil. R320 and R321 form a voltage divider for the input into V305 grid. R321 is adjustable to provide a control for the CMO output level at this point. T301 is an RF tuned coil assembly tuned at 2-4 mc, and, together with C329 and C330 form a parallel resonant tank circuit for any frequency selected in this range. By offering a high impedance to the resonant frequency, V305's grid is supplied with ample drive. R309 is the plate load resistor for V305 power amplifier. C326, L309 and C328 form a low pass filter to block RF from V305's screen. T302 is another tuned coil assembly, passing a 2-4 mc frequency range. Together with C331, C330B and C318 it forms a tank circuit that resonates to the selected frequency, passing it and attenuating all others. It also provides an impedance coupling for the CMO to the next stage of equipment. C318 is the padding capacitor for C331 chassis adjustment. CR301, C363, R358 and C364 form a low-pass filter for d-c to M301, which reflects the output level of the CMO. R308 is a d-c return resistor for the meter. E303 is a terminal block for attaching an external keying device to the CMO when required. By removing the jumper between terminals 1 and 2 on E303 and connecting a manual keyer to the two terminals, V305's cathode connection to ground may be opened and closed, disabling and enabling V305 and thus the CMO output. R322 is the cathode bias resistor and C325, L307 and C324 the low pass filter for the cathode d-c.

c. Synthesizer circuit (see figure IIIB-4-4) A sample of the selected frequency in the 2-4 mc range is brought into the synthesizer circuit from the output of the voltage amplifier in the RF chain. The input is carried to one of the mixing grids (control grid) of V309 pentagrid mixer.

An external supply of 10-kc enters at J307 and is brought into the control grid of V306 harmonic amplifier, which is connected to Z301 high pass filter to pass 10-kc harmonics ranging from 1.49 mc up to 3.49 mc. C327 and 370 are d-c blocking capacitors and R324 is the grid leak resistor for V306. C330C, C332 and T303 form a tuning circuit for V307 input and T304, C330D and C336 a tuning circuit for V307 output. Both circuits are resonant at the selected frequency and, along with V307, select the proper harmonic to mix with the selected 2-4 mc frequency to produce the desired IF frequency in the 510-520 kc band out of following mixer V309. This is ac-

complished automatically by a pre-calibrated mechanical linkage with the RF amplifier 2-4 mc tuning. R326 is a dropping resistor for V307 screen grid and C335 is its RF bypass capacitor. The B2 supply is protected from RF from this group by L310, C337, L312, C333 and L311. The selected 10-kc harmonic is brought into the second mixing grid (or signal input grid 7) of V309 pentagrid through d-c blocking capacitor C343.

The output of V309 consists largely of frequency $F_s - F_h$, where F_s is the 2-4 mc selected frequency and F_h is the 10-kc harmonic (selected as described in the preceding paragraph) that is required to produce a 510 to 520 kc product out of V309. T308 and T307, series resonant circuits tuned to pass only frequencies in the 510-520 kc range, attenuate the unwanted harmonics and pass only the selected IF frequency to V308 where it becomes amplified. T306 is tuned to pass the 510-520 kc frequencies from the output of V308 to the phase detector and the input of V310.

The basic theory of the phase detector section of this circut, being typical for all TMC equipment having synthesizer loops, is described in Part I, Section IV, par. 1-4-1 of this manual. In the CMO, R328, CR302, CR303 and T305, and their associated components, comprise the phase detector. As described in par. 1-4-1, the stabilized 510-520 kc input from J308 is V1 and the 510-520 kc fed to the center-arm of R328 is V2. Any difference in phase is translated as a d-c voltage which is sent to V303 reactance tube which in turn corrects the MO tuned circuit by adding or subtracting inductive reactance to it. When L301 is further adjusted by the operator (see figure IIIB-4-2) to correct the reactance, the MO will put out the correct frequency and little or no d-c will issue from the phase detector. This is indicated to the operator by a steady green-band area reading on M302 ADJ FOR ZERO. The green band area indicates the limits of the capture range for the synthesizer loop locking action. Since the needle of M302 may also fall momentarily in the zero area when the two frequencies are out of synchronization, an additional indication of synchronization is required to insure locking procedure. I304 and V310 are inserted for this purpose so that I304 will light up only when the two frequencies are the same. The operation of this indication circuit utilizes the phase relationship between the two signals applied to the phase detector. The phase difference between the two signals will be exactly 90° when the loop is synchronized and zero d-c volts of correction are applied to the reactance tube. If the loop is not synchronized, the phase difference of the two signals applied to the phase detector will not be 90°. The sync. indicator tube (V310) samples the two inputs to the phase detector and shifts these samples each by 45° towards each other, by means of C349, R341 and C352 and C343. The two shifted signals are then added in V310, and, when the loop is synchronized, will add in phase causing the tube to draw sufficient plate current to light the neon lamp I304. When the loop is out of synchronism, the two signals to the phase detector will not have the fixed 90° phase difference and the shifted signals will no longer add in phase. The addition of these out-of-phase signals produce a value of plate current insufficient to light the neon lamp. In this manner, I304 provides an indication of synchronization of the CMO frequency with the low frequency loop standard and M302 indicates whether or not it is locked.

L313, C368, R330, C365, R331, C341, C313, and L303 make up the low pass filter for the phase detector's path to V303. V303 performs in the same manner as the conventional reactance tube modulator but is operated by d-c instead of a-f. The result is a change in the existing internal inductance between V310's plate and screen grid. This inductance, being parallel with L303, changes the total inductance in the tuned circuit. As a result, the inductive reactance is changed and thus the MO frequency.

S304 provides a cutoff of synthesizer loop action in the CAL position by shorting out the d-c, so that the calibrating operation may be performed independently.

d. Oven temperature control (see figure IIIB-4-5, 6 and 7). The CMO is wired for 115 VAC operation of its oven circuit with provisions and instructions for 230 VAC operation as may be seen in notes in figure IIIB-4-5. In order to simplify description of operation for the two alternatives, figures IIIB-4-6 and IIIB-4-7 are shown for the connection that results in either case. It will be noticed that the performance of the circuit is the same for either power supply, the difference being load distribution. C319 and R316 act as spark suppressor for K301 contacts and C369 and R310 perform the same function for S301. The heating blankets R307A and R307B within the oven's outer wall are controlled by relay K301 which is, in turn, controlled by thermostat S301 in the outer wall. The 60 cps a-c supply will not be passed by either capacitor in the circuit with sufficient current to heat the blankets or activate the relay coil and therefore may be considered as blocking capacitors. When the temperature in the outer wall rises sufficiently (to 70°C) the thermostat S301 closes. This energizes K301 which removes the line voltage from the heating blankets and permits the oven to start its downward cycle. Because of the fine construction of S301, the total excursion in temperature over 70°C is very small. As an added precaution, S302 thermostat, located in the oven interior, has been connected in such a manner that an excessive rise in temperature within the oven due to a faulty S301 thermostat will not take place. If, by such an accident, the temperature starts to rise above 80°C in the oven interior, S302 will commence to cycle before damage can be done. I301 neon lamp indicates when current is running through the heating blankets.

e. Power Input (see figure IIIB-4-8). The power supply requirements for the CMO is for a conventional electronic type supplying 6.3 volt a-c 60 cps regulated filament, + or - 6 volts d-c regulated filament, + 220 volts d-c unregulated plate voltage, + 160 volts d-c regulated plate voltage and 115/230 volts a-c 60 cps line voltage for the oven. TMC power supplies for the CMO and associated equipment supply -6 volts d-c due to polarization standardization of TMC filament rectifiers.

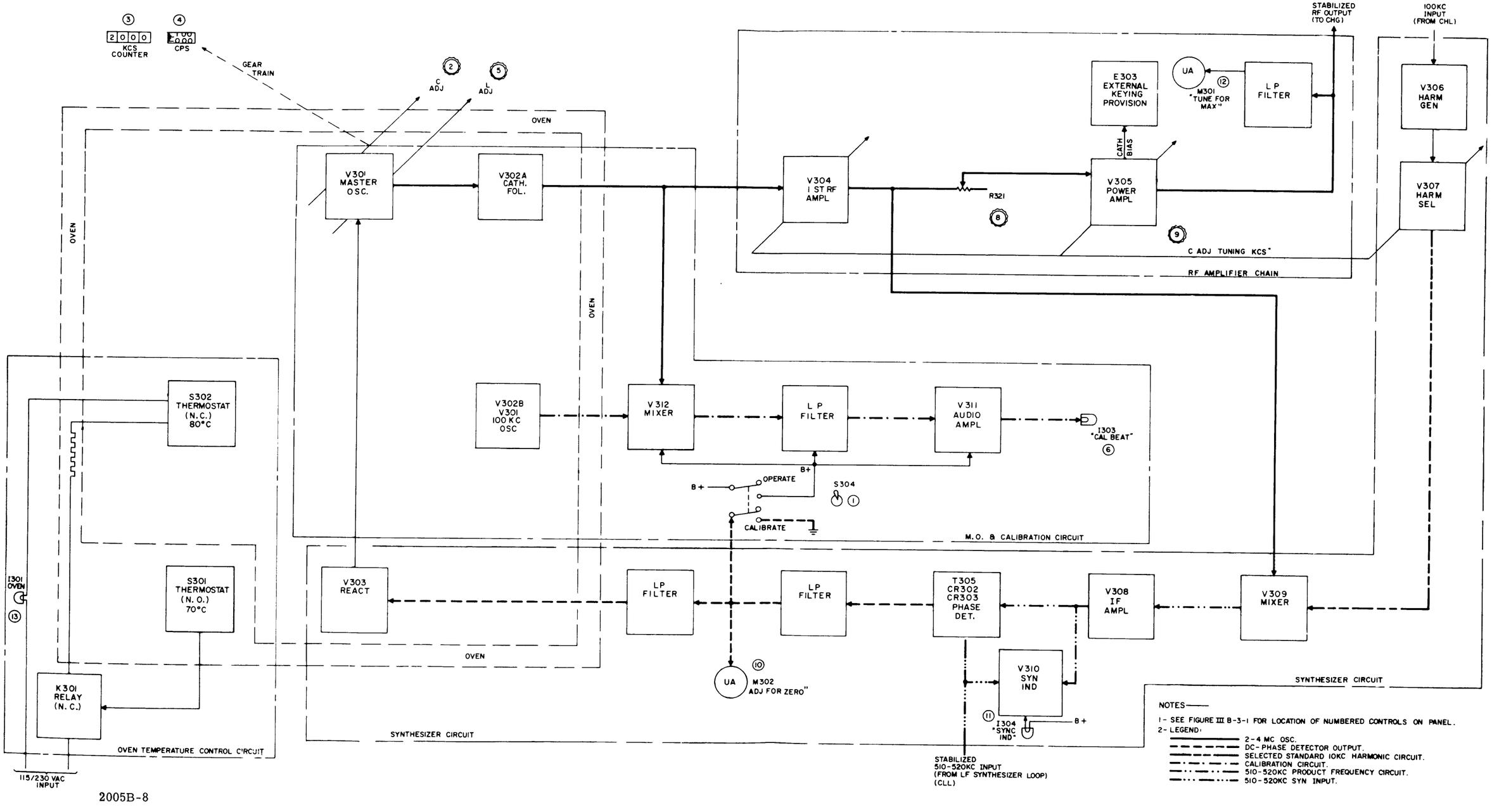


Figure IIIB-4-1. Block Diagram, Controlled Master Oscillator, CMO

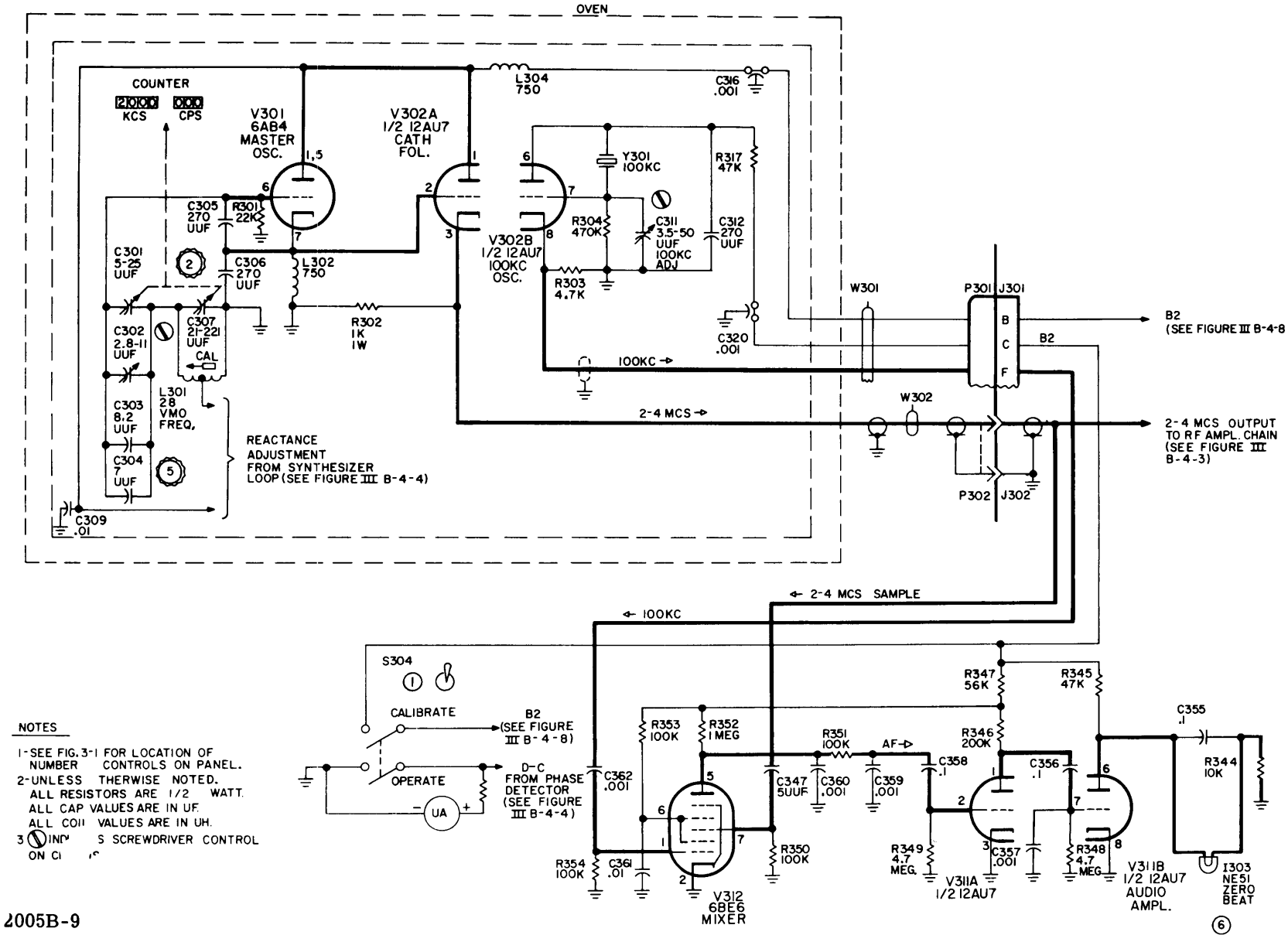
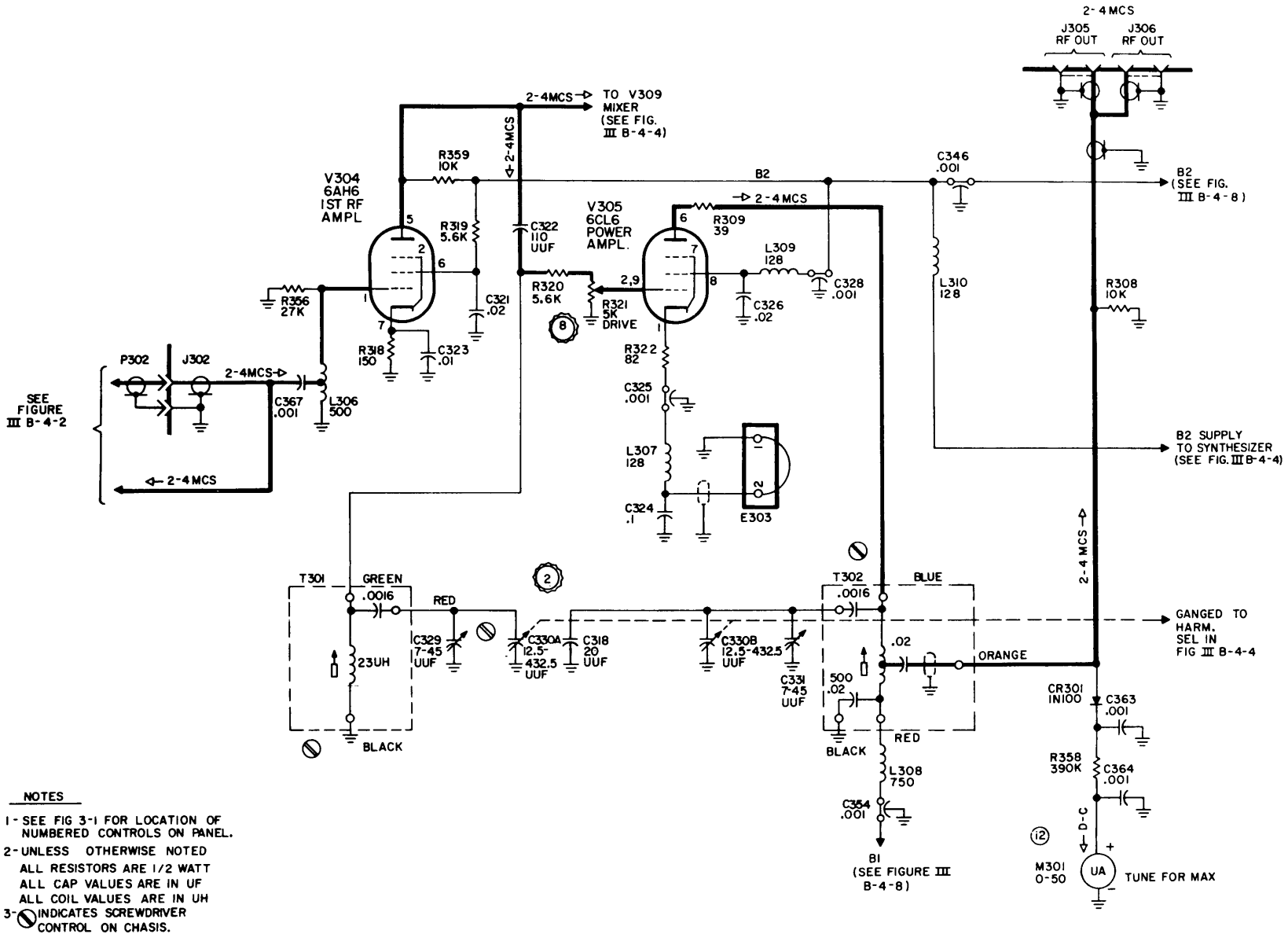


Figure IIB-4-2. Schematic Diagram, Controlled Master Oscillator CMO, MO 8 Calibration Section



NOTES

1- SEE FIG 3-1 FOR LOCATION OF NUMBERED CONTROLS ON PANEL.
2- UNLESS OTHERWISE NOTED
ALL RESISTORS ARE 1/2 WATT
ALL CAP VALUES ARE IN UF
ALL COIL VALUES ARE IN UH
3- ⊘ INDICATES SCREWDRIVER CONTROL ON CHASIS.

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Figure IIIB-4-3. Schematic Diagram, Controlled Master Oscillator CMO, RF Ampl Chain

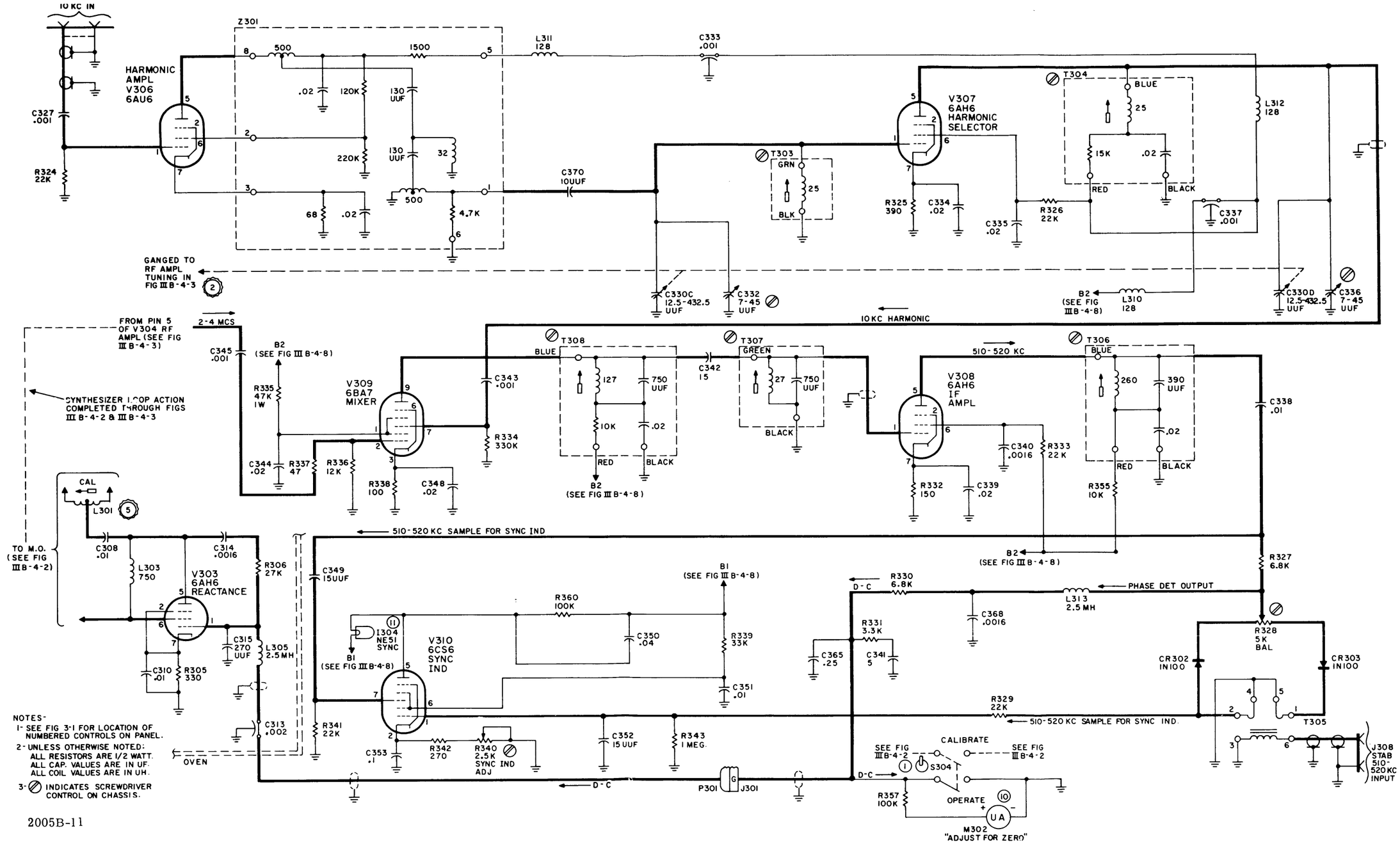

Figure IIIB-4-4. Schematic Diagram, Controlled Master Oscillator CMO, Synthesizer Circuit

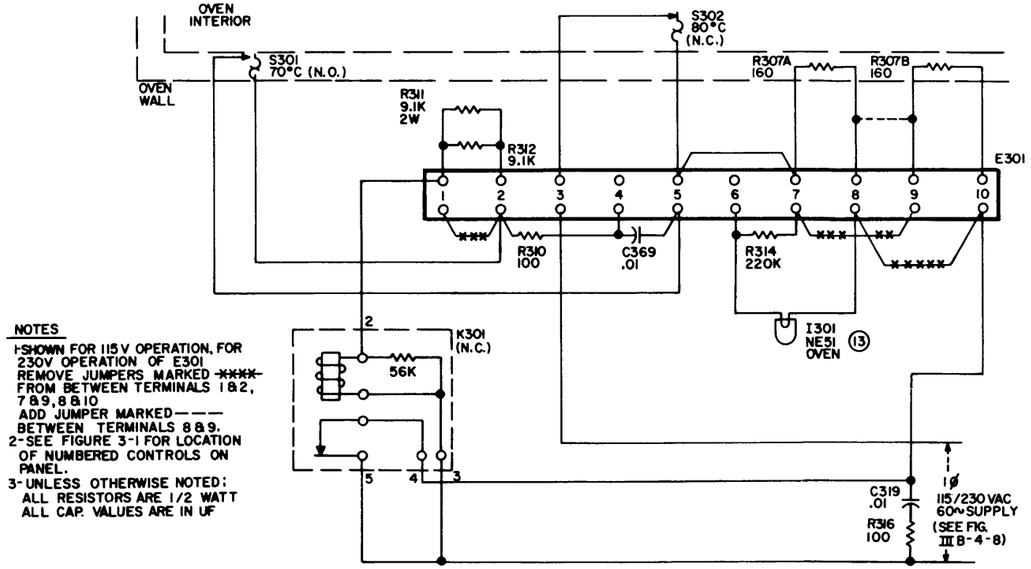

Figure IIIB-4-5. Schematic Diagram, Controlled Master Oscillator CMO, Oven Temperature Control Section

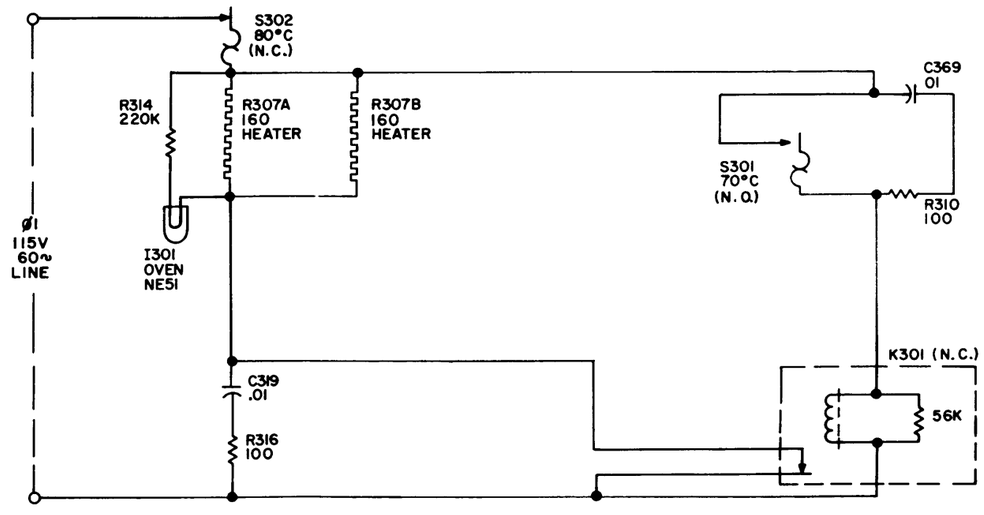

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Figure IIIB-4-6. Simplified Schematic Diagram, CMO Oven Temperature Control Section with 115V Hoop-up

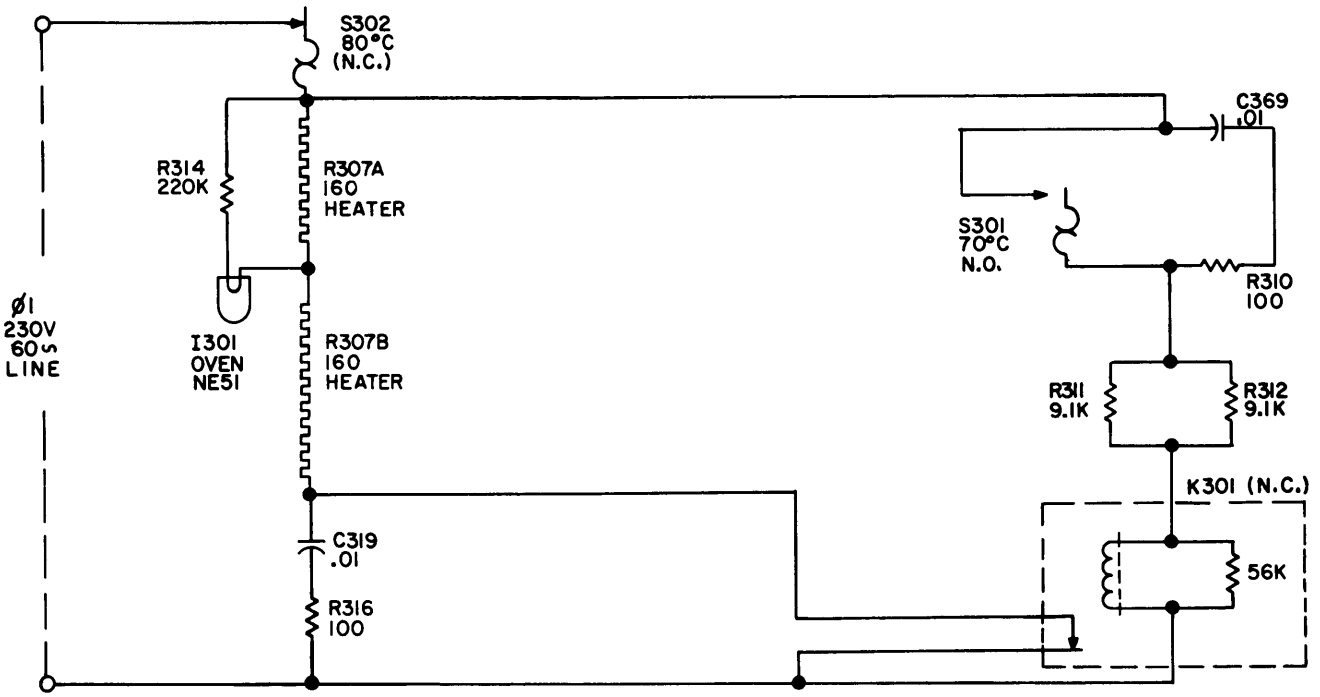


Figure IIIB-4-7. Simplified Schematic Diagram,
CMO Oven Temperature Control Section with 230V Hook-up

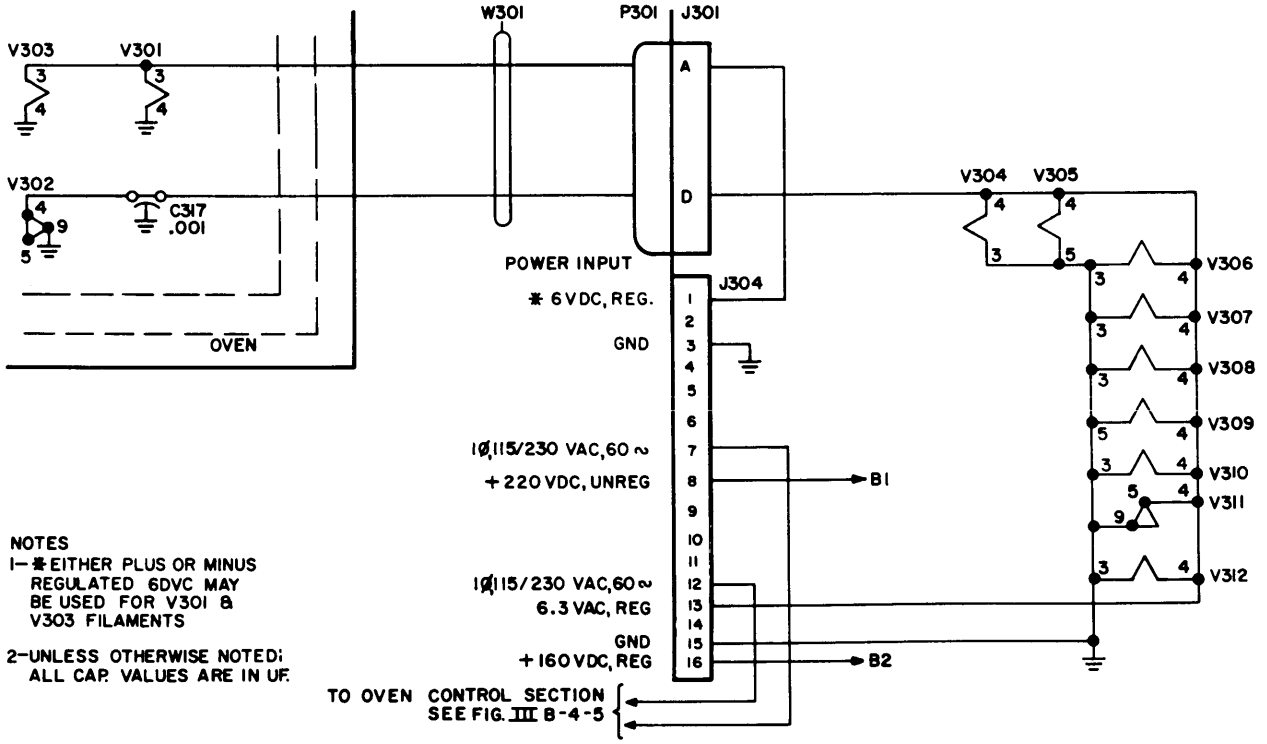


Figure IIIB-4-8. Schematic Diagram, Controlled
Master Oscillator CMO, Power Input Section

SECTION 5
TROUBLE-SHOOTING

III B-5-1 GENERAL

Trouble-shooting is the art of locating and diagnosing equipment troubles and maladjustments; the information necessary to remedy the equipment troubles and maladjustments is reserved for section 6 of the manual under the heading "Maintenance".

Trouble-shooting tools may, for convenience, be divided into the following six categories:

a. Accurate schematic diagrams.

b. Tables of voltage and resistance; waveform data.

c. Location data (photographs with callouts of the major electronic equipment elements).

d. Trouble-shooting techniques.

e. Trouble-shooting charts based on operating procedures.

f. Trouble-shooting procedures based on circuit sectionalization.

Trouble-shooting techniques are about the same for all types of electronic equipment and are covered briefly in the following paragraph.

III B-5-2 TROUBLE-SHOOTING TECHNIQUES

a. GENERAL CONSIDERATIONS. - When a piece of equipment has been working satisfactorily and suddenly fails, the cause of failure may be apparent either because of circumstances occurring at the time of failure or because of symptoms analogous to past failures. In this case, it is unnecessary to follow a lengthy and orderly course of trouble-shooting in order to localize and isolate the faulty part.

A second short cut in trouble-shooting is to ascertain that all tubes and fuses are in proper working order; also that the equipment receives proper supply voltages. Many times this eliminates further investigation.

A third short cut is to examine the equipment section by section, for burned out elements, charring, corrosion, arcing, excessive heat, dirt, dampness, etc.

It is important to recognize that defective elements may have become defective due to their own weakness or to some contributing cause beyond their control.

b. TROUBLE-SHOOTING CHARTS BASED ON OPERATING PROCEDURES. - The general purpose of these charts is to narrow the area of trouble to one or more sections of the equipment in order to minimize the labor of locating the source of trouble. These charts present a prescribed order "to turn on" the equipment, indicate what to expect as each step is taken, and give clues as to possible "troubled areas" when some expectation is not realized.

c. TABLES OF VOLTAGE AND RESISTANCE: WAVEFORM DATA. - These tables give nominal values of voltage-to-frame and resistance-to-frame, generally at tube elements and sometimes at connectors and terminal board elements. Large deviations from the nominal values should be carefully investigated. During this process accurate schematic diagrams and location data are highly essential. Schematic diagrams of equipment are found in Section 8.

A good oscilloscope is a good trouble-shooting tool. It may be connected to a number of critical points along a circuit to detect extraneous voltages, distorted waveforms, and other symptoms of trouble.

d. TROUBLE-SHOOTING PROCEDURES BASED ON CIRCUIT SECTIONALIZATION. - Equipment usually consists of a number of subassemblies or sections. It is frequently helpful to treat these subassemblies or sections as independent entities. In so doing, however, they must be properly powered. Observations may then be made with VTVM's, CRO's or their test equipment at selected points under given types and magnitudes of injection voltages. Again, the subassemblies or sections may be examined for rated performance, according to specification, for the presence of extraneous grounds, for opens, or unusual voltages.

III B-5-3 CONTROLLED MASTER OSCILLATOR, CMO

a. GENERAL - A primary consideration in trouble-shooting the CMO is that the unit is a precision instrument. As such, it has a section that requires careful handling when taking readings with test instruments. This section is clearly defined as the oven housed oscillator assembly, comprising all components as shown within the oven in figure IIIB-8-1 except oven temperature control components. The oscillator assembly reference designation in Section 7 Parts List is Z302 and includes, besides the electrical components listed therein, a precisely set cam surface which controls the follow-up adjustment of C301 with C307 adjustment.

WARNING

Do not remove oscillator assembly Z302, for trouble-shooting procedure. Cam surface misalignment will result and re-alignment can be performed only at the TMC factory, due to special tools required.

In the trouble-shooting procedure that follows, it will be noticed that readings are taken in this area only in such a way as to leave the oscillator assembly undisturbed.

Another consideration should be made for purposes of accurate analysis in trouble-shooting the CMO oven housed circuitry. If the oven door (see figure IIIB-5-7) is removed while the CMO is operating and/or the oven temperature has become stabilized, the resulting drop in oven temperature will upset the normal electrical values and frequency readings taken may be inconclusive. In addition, a long waiting period may be necessary after the oven door is replaced, in order to bring the oven back to a stable temperature.

CAUTION

Do not remove oven door (see figure IIIB-5-7) during trouble-shooting readings of CMO when oven temperature stability is required for purposes of accurate frequency readings.

The various trouble-shooting procedures described in this section mention the oven condition under which normal readings may be obtained (i. e.: oven temperature stabilized or "cold" oven with power disconnected).

b. VOLTAGE AND RESISTANCE DIAGRAMS. Figure IIIB-5-1 shows normal voltage- and resistance-to-chassis measurements at vacuum tube pins and pertinent transformer and filter pins on the main chassis. Figures IIIB-5-6 and IIIB-5-8 are photographs showing top view and bottom view locations of main components in this area.

Figures IIIB-5-2 shows normal resistance-to-chassis measurements at vacuum tube pin and P302 and P301 plug pins for the oven housed oscillator assembly described in paragraph IIIB-5-3a. It will be noticed in the conditions listed on figure IIIB-5-2 that these measurements are to be taken with the tubes removed but with the oscillator assembly unremoved. With the oscillator assembly remaining in place, the only check points available will be through the tops of the tube sockets with the tubes removed and at plug pins with the plugs disconnected. Oven door may or may not be removed since these readings are not intended to simulate operating conditions. Figure IIIB-5-7 is a photograph of this area, showing oven door in place.

Figure IIIB-5-4 shows normal resistance measurements for oven temperature control circuitry with power disconnected and oven off. As shown in this diagram, all measurements can be taken at E301, the oven temperature control terminal block. Before taking measurements, it should be observed, by referring to notes 3 and 4 of figure IIIB-5-4, whether E301 is wired for 115 V or 230 V operation. Readings for both conditions are given in the diagram. Figure IIIB-5-7, photograph, shows location of E301.

c. TROUBLE-SHOOTING CHART BASED ON OPERATING PROCEDURES. Table IIIB-5-1 estimates faulty section of the CMO upon encountering any malfunction during operation of unit. See figure IIIB-3-1 for interpretation of control designations in parentheses. Analysis of trouble listed in this table is made under the assumption that associated equipment is functioning correctly.

d. TROUBLE-SHOOTING PROCEDURES BASED ON CIRCUIT SECTIONALIZATION. The following paragraphs present selected factory checkout performance data of the CMO unit. Refer to figure IIIB-5-4 for test setup.

The Low Frequency Loop, Divider Chain and Power Supply should be of the type associated with the CMO in the complete precision oscillator system and should all function correctly. Other test equipments required are listed as follows:

70-ohm load (non-inductive), 5 watt

20 decibel pad

Hewlett-Packard Model 524C Frequency Counter or equiv.

RF VTVM, Hewlett-Packard Model 410B or equiv.

Connect remainder of Divider Chain outputs to appropriate equipment in the CPO system in order to preserve normal Divider Chain loads.

Although it is preferable to allow the CMO to warm up sufficiently to obtain the required stable oven temperature for accurate operation, it is not entirely necessary since the readings given here are nominal figures. Warm-up time may be about 20 minutes. Indication that required stable oven temperature has been reached is normal cycling of OVEN light: 1 minute on and 5 minutes off at normal room temperature.

If the entire CMO is being checked, rather than one particular section, it is advisable to perform the checks in the sequence outlined in the following paragraphs, for best results in detecting the faulty section.

(1) OVEN TEMPERATURE CONTROL. If CMO has had the required warm-up period, record cycling of OVEN light for several cycles. Time on should be about 1 minute and time off should be about 5 minutes, for normal room temperature. Rhythm should be steady. If CMO oven is "cold" at the beginning of the check, observe behavior of OVEN light when power is connected to CMO. Light should come on immediately and remain on for some while.

(2) POWER INPUT. With VTVM grounded to chassis place probe at red dot terminal of T308 transformer. Reading should be approximately +160 volts d-c. Place probe at pin 4 of V312. Reading should be approximately 6.3 VAC. Probe

at pin 3 of V312 should give zero volts. Place VTVM across pin 5 of K301 relay and terminal #3 of E301 terminal block. Voltage should read 115 VAC or 230 VAC depending on line voltage. Ground VTVM to chassis and place probe at red dot terminal of T302 transformer. Voltage should be approximately 220 volts d-c. Observe, without removing oven door, if V301, V302 and V303 tube filaments are lit.

(3) 100 KC OSCILLATOR. With equipment connected as shown in figure IIIB-5-4, solid lines, leave P301 connected to J301 and disconnect P302 from J302. Switch S304 to CAL position. Place frequency counter at pin 1 of V312 mixer tube. Frequency should read 100-kc. Place VTVM across pin 1 of VTVM and ground. Voltage should read about 8.8 VRMS.

(4) MASTER OSCILLATOR. With equipment connected as shown in figure IIIB-5-4, solid lines, leave P301 connected to J301 and disconnect P302 from J302. Switch S304 to CAL position. Turn MASTER OSCILLATOR FREQUENCY knob (C307) to bring 3,000,000 CPS reading on CMO panel counter, approaching from lower frequency side. Turn red knob (L301) fully CCW and then fully CW. Take readings with frequency counter at pin of disconnected plug P302 at CCW and CW positions. CCW frequency should be around 3,244,600 CPS; CW frequency should be around 3,263,900 CPS. Take voltage-to-ground readings with VTVM at same point for CCW and CW positions. Voltage should be approximately the same at both positions: about 1.0 VRMS.

(5) CALIBRATION. With equipment connected as shown in figure IIIB-5-4, solid lines, leave P301 connected to J301 and P302 connected to J302. Switch S304 to CAL position. Turn MASTER OSCILLATOR FREQUENCY knob (C307) to bring 3,000,000 CPS reading on CMO panel counters, approaching from lower frequency side. Turn red knob (L301) to cause CAL BEAT light (I303) to come to zero beat. Disconnect P302 from J302 and take a frequency reading with counter attached to pin of P302. Frequency should be 3,250,000 CPS. Reconnect P302 to J302. TURN MASTER OSCILLATOR FREQUENCY knob (C307) to increase CMO panel counter reading to 3,020,000 CPS. Disconnect P302 from J302 and take a frequency reading with counter attached to pin of P302. Frequency should be 3,270,000 CPS.

(6) RF AMPLIFIER CHAIN. With controls set as in paragraph IIIB-5-3 (5) and having obtained normal readings, reconnect P302 to J302. Turn TUNING KCS knob to 3,020.000 kc area where peak reading is obtained on TUNE FOR MAX meter (M301). Leave 70-ohm load across J305 and attach 20 Decibel Pad and frequency counter as shown in broken lines in figure IIIB-5-4. Frequency reading should be 3,270,000 CPS. Remove pad and counter and attach VTVM across J305 and ground. Voltage should be around 12 VRMS.

(7) IF SECTION. With controls set as in paragraph IIIB-5-3d (6) and having obtained normal readings, attach frequency counter to pin 5 of V308 IF amplifier. Frequency should be 510,000 CPS.

(8) SYNCHRONIZATION. With controls set as in paragraph IIIB-5-3d (7) and having obtained normal readings, tune low Frequency Loop unit to zero CPS. Switch S304 to OPERATE position. Adjust red knob (L301) until SYNC IND light (I304) remains on concurrently with a steady green band reading on M302, ADJ FOR ZERO meter. It should be possible to obtain these two indications with adjustment of L301 only. Then turn MASTER OSCILLATOR FREQUENCY knob (C307) to bring first 3,019,600 CPS and then 3,020,400 CPS on CMO panel counters. Observe behavior of ADJ FOR ZERO needle and SYNC IND light (I304). Needle should stay mainly within the green band area and should follow variation of C307 knob. Light should remain lit throughout green band area reading. Light may remain lit beyond green band area, varying with frequency setting.

TABLE III B-5-1 TROUBLE-SHOOTING CHART BASED ON OPERATING PROCEDURES

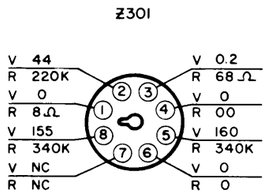
Step	Control Operated	Normal Indication	Analysis
1	After 48-hour warm-up period and before or during operation of CMO Observe OVEN light (13) behavior for several cycles	OVEN light should cycle normally (1 minute on, 5 minutes off) at normal room temperature (75°F)	Any extreme deviations from the norm may be caused by the oven temp. control sect. which in turn, can cause malfunctions in steps 2, 3, and 4 (see par. IIIB-3-1).
2	Switch OPERATE/CAL switch (1) to CAL position. Adjust MASTER OSCILLATOR FREQUENCY knob (2) to bring nearest 50-kc increment below desired freq. on counters (3) and (4). Adjust red knob (5a) to make CAL BEAT light (6) come to zero beat.	Light should beat from adjustment of red knob (5a) only.	If light cannot be made to zero beat from adjustment of red knob alone, check MO and calibration sect. If MO and cal. section check out cam surface in MO oscillator assembly may have become misaligned. If light fails to light at all, check bulb and power input section.

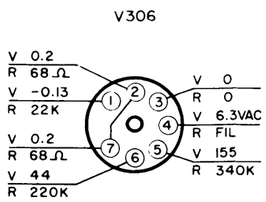
TABLE III B-5-1 TROUBLE-SHOOTING CHART BASED ON OPERATING PROCEDURES (Cont.)

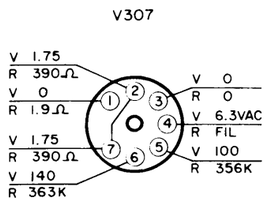
Step	Control Operated	Normal Indication	Analysis
3	Adjust MASTER OSCILLATOR FREQUENCY knob (2) to bring desired frequency up on counters (3) and (4). Lock knob (2) with knob (7). Switch OPERATE/CAL switch (1) to OPERATE position. Turn OUTPUT knob (8) to max. (fully CW) and tune TUNING KCS knob for max reading on TUNE FOR MAX meter (12).	TUNE FOR MAX meter (12) should read at least 7.5.	If meter reading falls too far short of 7.5., check RF ampl. chain.
4	Adjust red knob (5a) to place needle of ADJ FOR ZERO meter (10) in green band area of dial concurrently while SYNC IND light (11) is lit.	It should be possible to obtain this simultaneous indication from adjustment of knob (5a) only.	If simultaneous indication cannot be obtained from adjustment of knob (5a) alone, check HF synth. loop 510-520 kc sect alignment and tuning circuits in RF ampl. chain. If these check out, cam surface in MO oscillator assembly may have become misaligned. If SYNC IND light will not light at all, check bulb and input power section.
5	Lock red knob (5a) by turning ring (5b) CW. Adjust OUTPUT knob (8) to bring desired reading on TUNE FOR MAX meter (12).	It should be possible to obtain desired reading from adjustment of knob (8).	If meter cannot be brought to desired reading, check R321 potentiometer in RF amplifier chain.

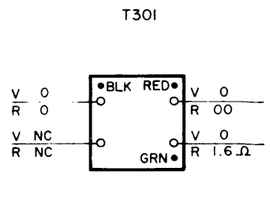
NOTE

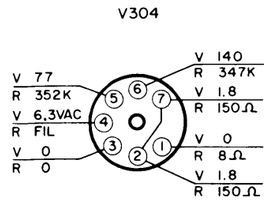
If difficulty is experienced at any time in turning panel control knobs, the cause may be the deterioration of the oven support shock absorbers on some of the earlier models of the CMO. TMC part numbers for replacement shock absorbers are listed in Section 7. For replacement directions, see paragraph IIIB-6-2f.

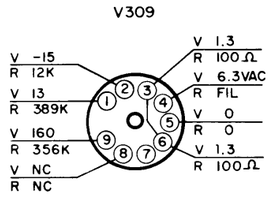


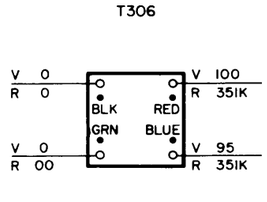


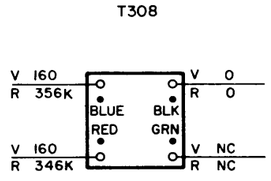


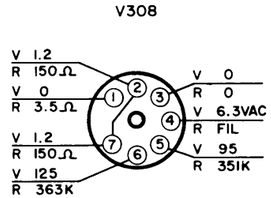


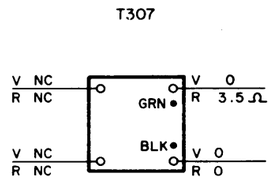


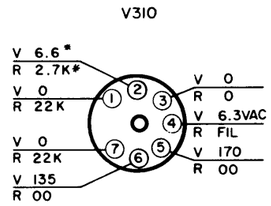


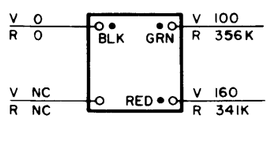


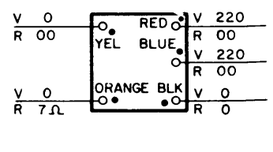


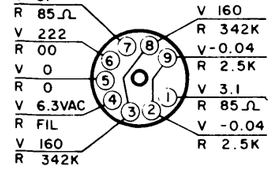


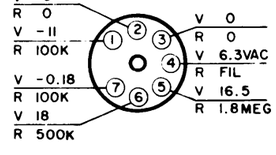


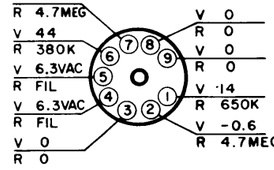












CONDITIONS

1 - TUBES INSTALLED.

2 - POWER ON FOR VOLTAGE READINGS.

3 - POWER OFF FOR RESISTANCE READINGS.

4 - 70 OHM LOAD ACROSS J305.

5 - NO CONNECTIONS TO J306, J307 AND J308.

6 - S304 IN CAL POSITION.

7 - "TUNING KCS" KNOB TURNED TO 3000KC.

8 - "M.O. FREQUENCY" KNOB TURNED TO BRING 3000KC ON PANEL COUNTER. CAL KNOB TURNED TO MIDWAY POSITION.

9 - "OUTPUT" KNOB TURNED FULLY CW. (MAX.)

10 - ALL MEASUREMENTS WITH RESPECT TO GROUND, USING VTVM. ALL VOLTAGE DC.

11 - P301 CONNECTED TO J301.

12 - P302 DISCONNECTED FROM J302.

13 - NORMAL VOLTAGES GIVEN FOR +225 VDC INPUT AT PIN 8 OF J304 (INPUT MAY VARY FROM 200 TO 250 VDC).

14 - * READING WILL VARY GREATLY WITH SETTING OF R340 POTENTIOMETER IN ALIGNMENT PROCEDURE.

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Figure IIIB-5-1. Voltage and Resistance Diagram HF Loop Chassis

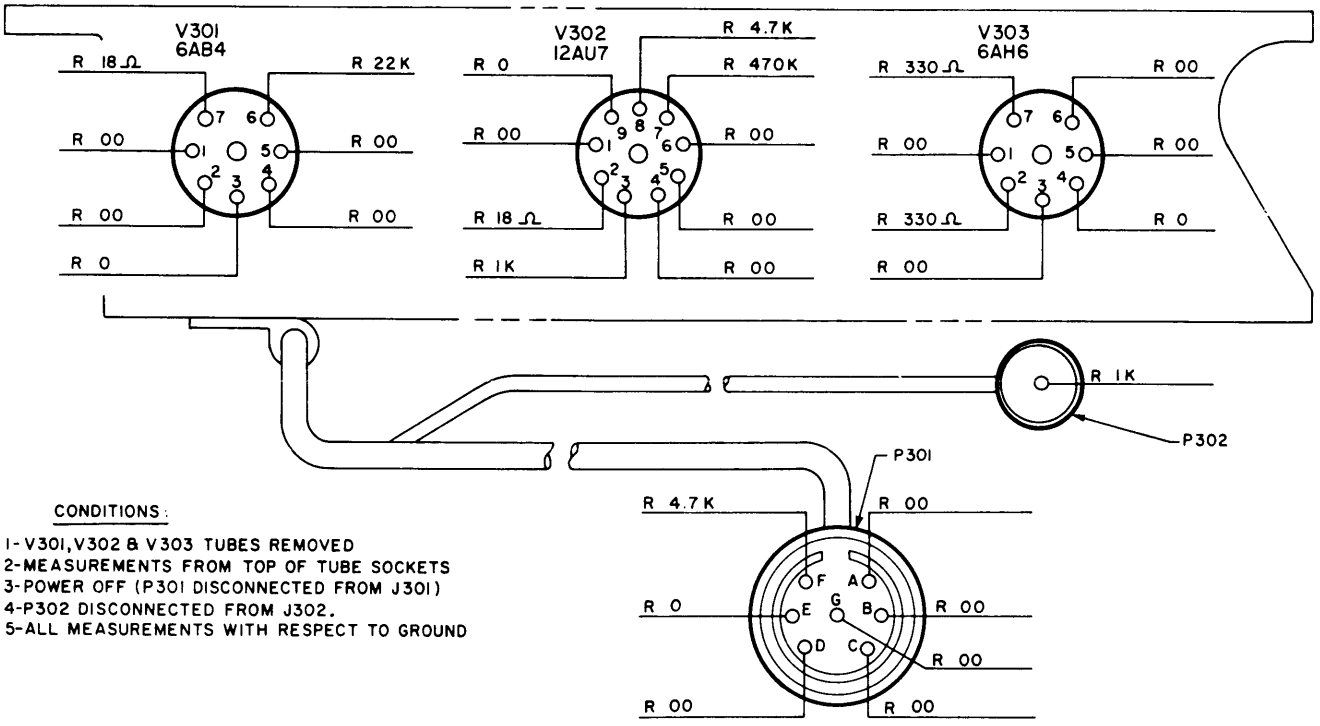
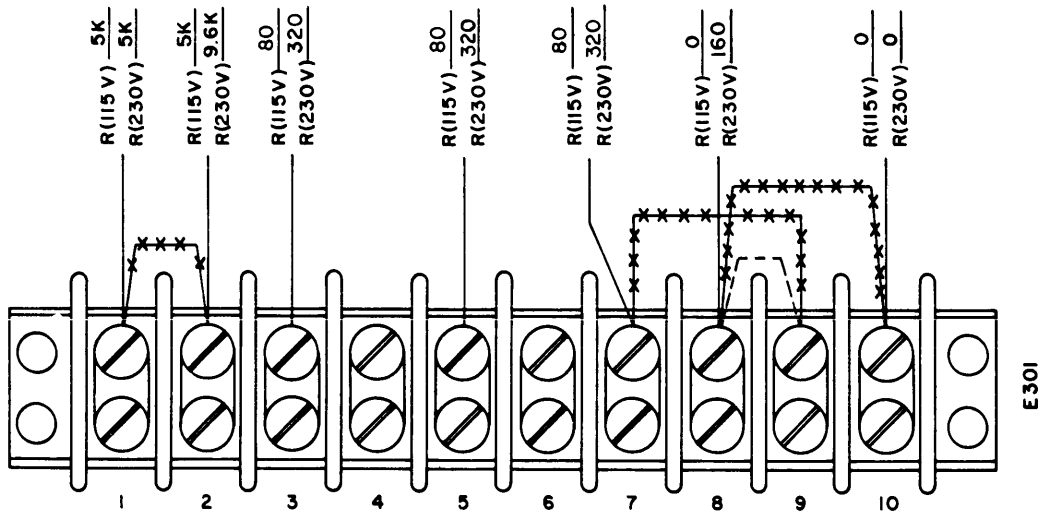


Figure IIIB-5-2. Resistance Diagram, Oven Circuitry



CONDITIONS:
1- PLUG DISCONNECTED FROM J304 RECEPTACLE (NO POWER).
2-K301 PIN 3 OR 5 GROUNDED.
3-115V HOOK-UP, ✕✕✕ JUMPERS LEFT IN, - - - JUMPER OMITTED.
4-230V HOOK-UP, ✕✕✕ JUMPERS REMOVED, - - - JUMPER ADDED.

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Figure IIIB-5-3. Resistance Diagram, Oven Temp. Control

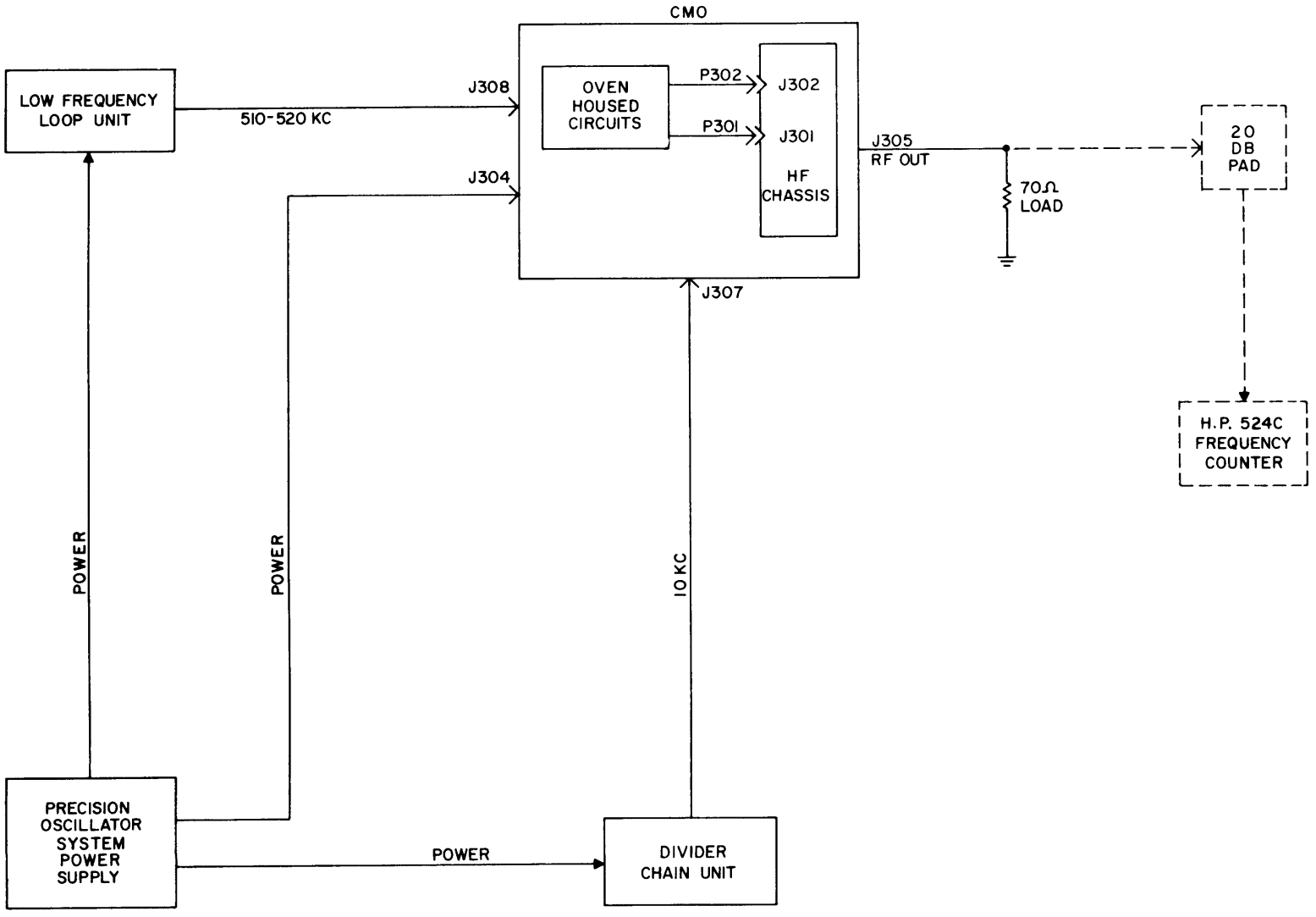

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Figure IIIB-5-4. Test Set-Up, Circuit Section Check

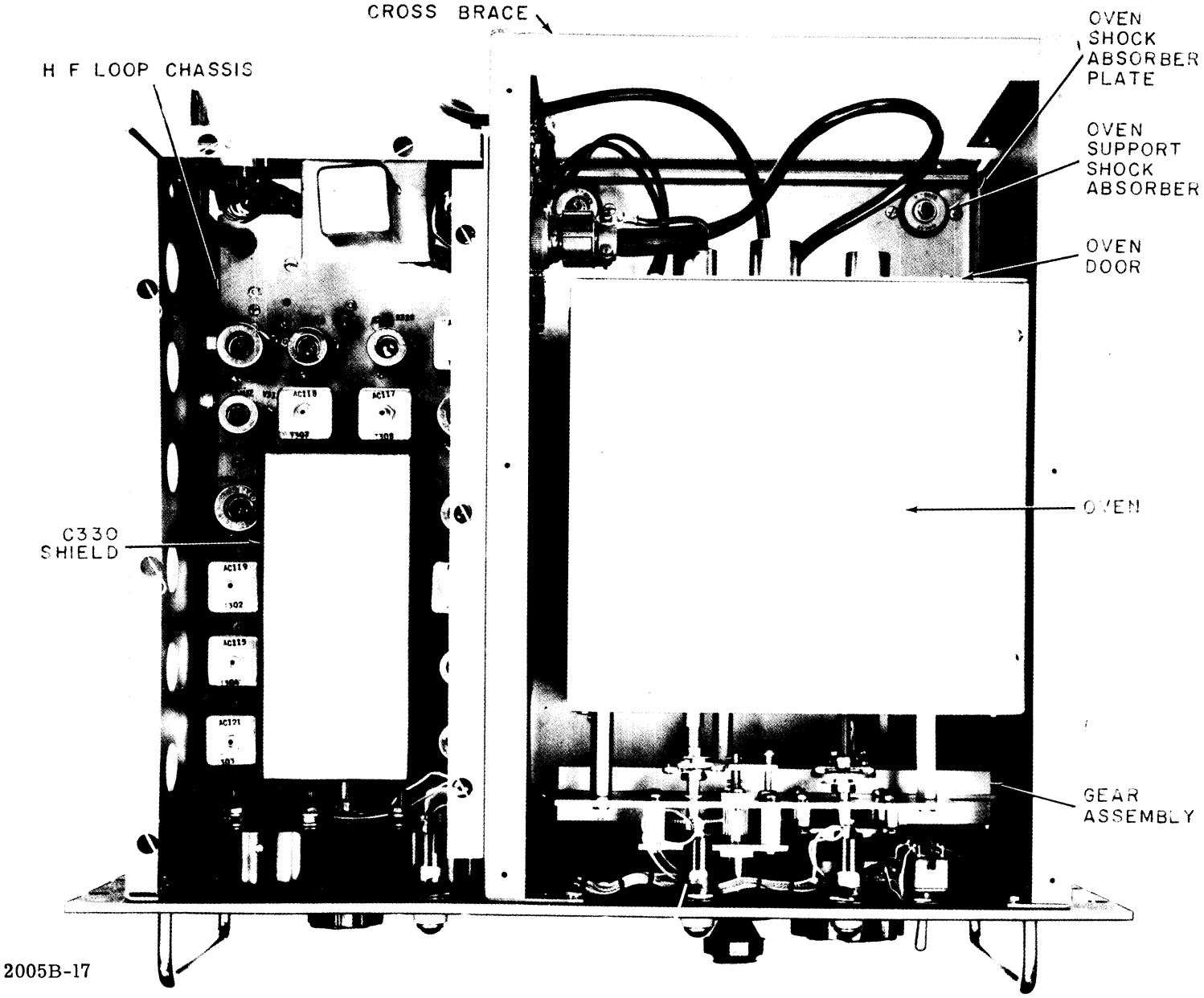

Figure IIIB-5-5. Top View, Controlled Master Oscillator, CMO, with Covers Removed

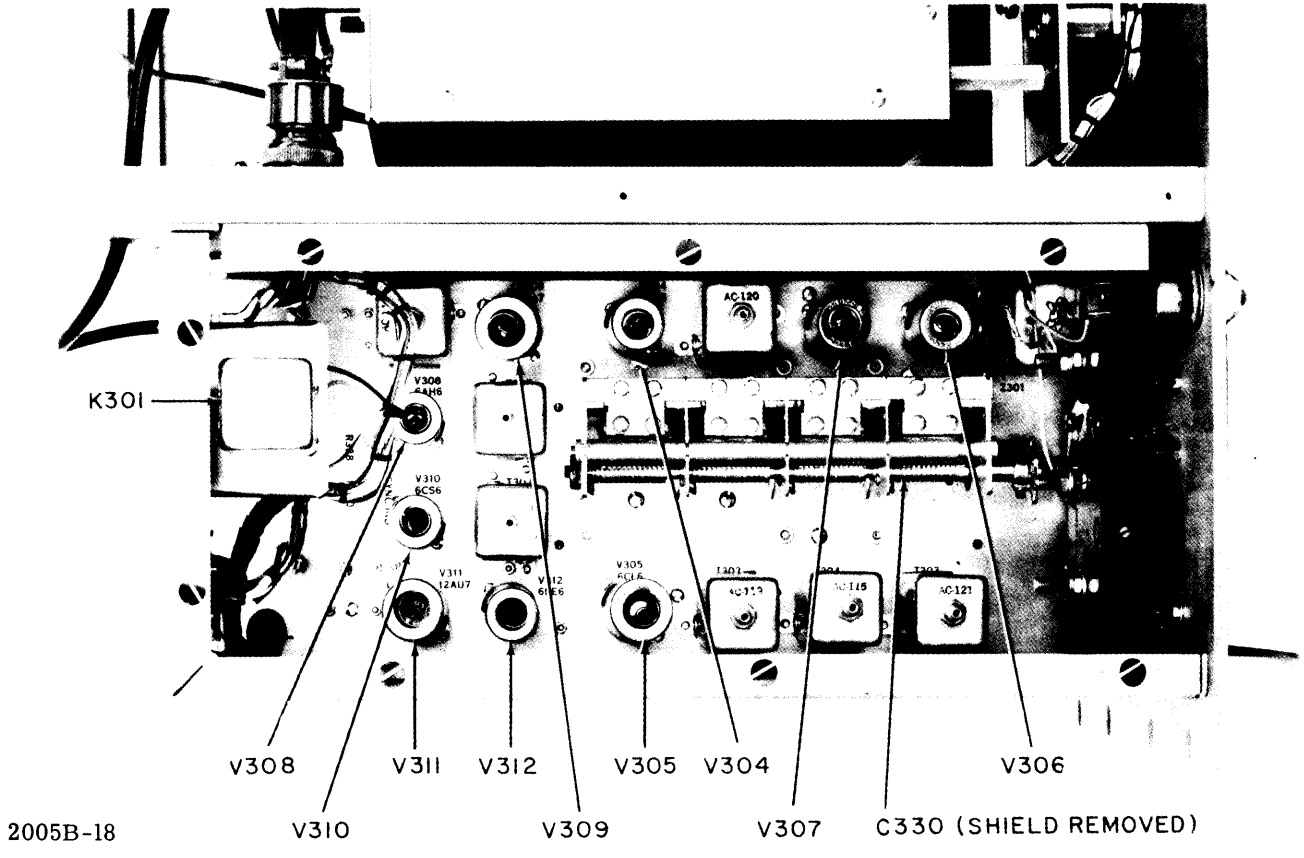

Figure IIIB-5-6. Location Diagram of Major Electronic Components, HF Loop Chassis, Top View

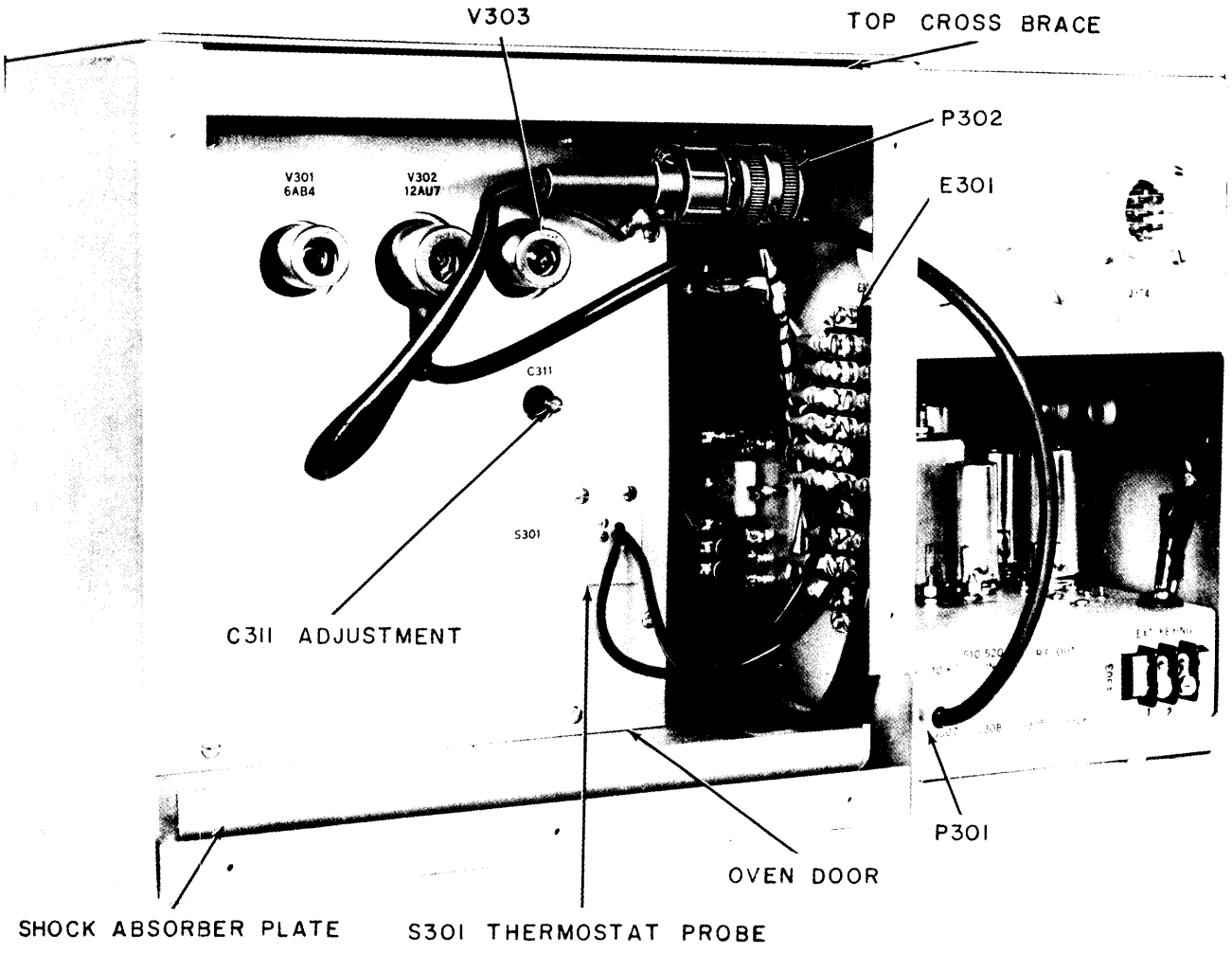

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Figure IIIB-5-7. Location Diagram of Major Electronic Equipment Components, Oven Section, Rear View

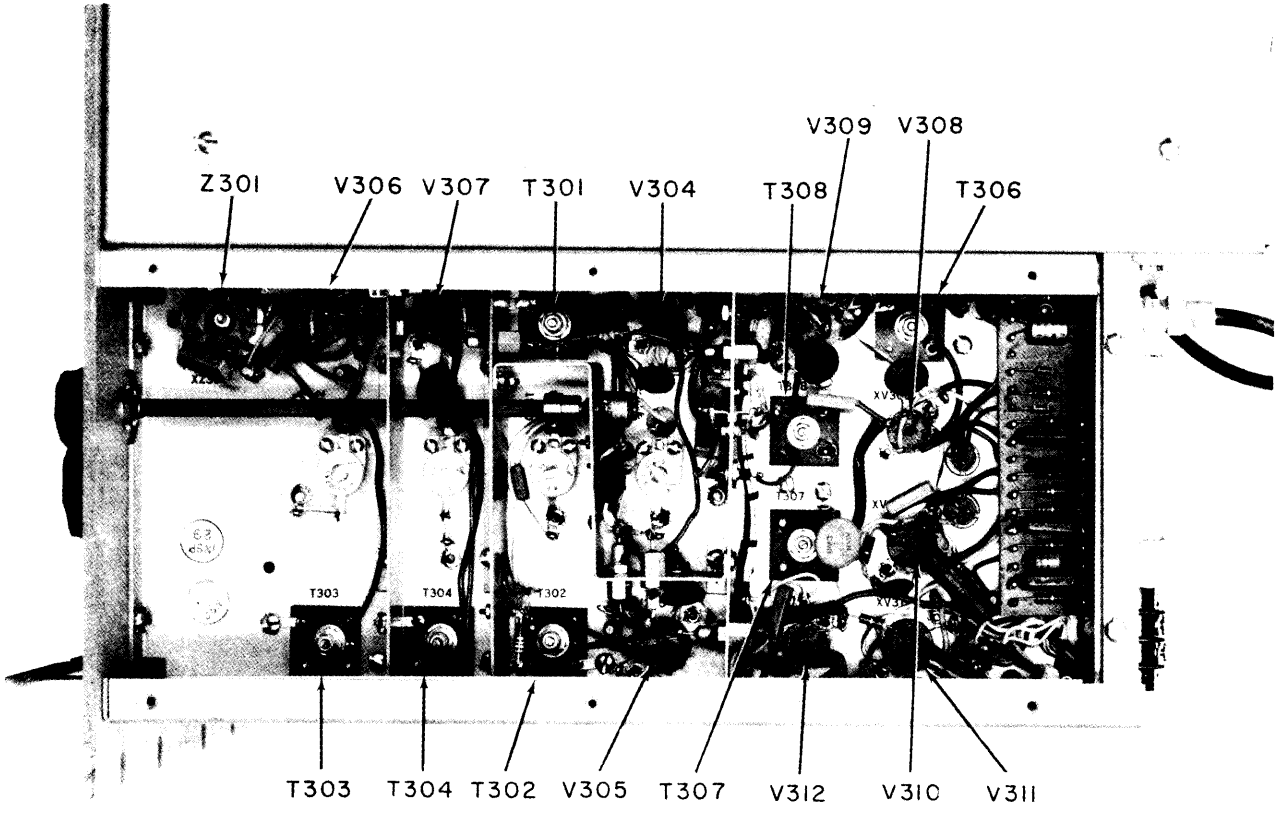

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Figure III. B-5-8 Location Diagram of Major Electronic Equipment Components, HF Loop Chassis, Bottom View

SECTION 6
MAINTENANCE

III B-6-1 GENERAL

Maintenance may be divided into three categories: operator's maintenance, preventive maintenance, and corrective maintenance. Operator's maintenance for this unit is described in Section 3 of this manual. Preventive maintenance is included in Section 6. Corrective maintenance is sometimes considered as consisting of information useful in locating and diagnosing equipment troubles and maladjustments, existing and/or pending, and information necessary to remedy the equipment troubles and maladjustments. For reasons stated in Section 5, the remedial type of information is presented under corrective maintenance (Section 6) while the diagnosis of information is presented under trouble-shooting (Section 5).

The CMO has been designed to provide long-term, trouble-free operation under continuous duty conditions. It is recommended that any necessary maintenance be done by a competent maintenance technician familiar with sideband techniques. Otherwise, advantage may be taken of the required specialized test equipment and personnel trained in its use in the Test Department of Technical Material Corporation. If trouble develops which cannot be corrected by following the procedures outlined in the following paragraphs, it is recommended that the instrument be returned to Technical Material Corp. for servicing. To expedite the return of the serviced equipment to you, it is recommended that the equipment be shipped to us by Air Freight and that we be authorized to return it the same way.

WARNING

The CMO is a precision instrument and, as such, requires special handling during maintenance. Under no circumstances should the master oscillator assembly Z302 (see part list, Section 7) be removed from the oven. Misalignment of the precisely set cam surface in this assembly may result and re-adjustment of the surface can only be performed by trained TMC personnel with the special tools that are required. Turning the MASTER OSCILLATOR FREQUENCY knob (control #2 in figure IIIB-3-1) past the OPERATING RANGE limitations printed below the panel counters may bring the same result. Spinning the knob at a high rate of speed from one end of the range to the other should also be avoided.

By removing the oven door, tubes V301, V302 and V303, and crystal Y301 may be removed from Z302 oscillator assembly and replaced without disturbing its installation (see figure IIIB-6-1). Also the tubes may be replaced, if necessary, with the oven door on, while the set is operating, in order to prevent a temperature drop in the oven. S301 and S302, which are not included in Z302 oscillator assembly, may also be removed and replaced without disturbing Z302.

As stated in Section 1 of this manual, the actual output of CMO-1 will be found to be 250-kc higher than the panel counter and TUNING KCS knob settings.

III B-6-2 PREVENTIVE MAINTENANCE

a. In order to prevent failure of the equipment due to corrosion, tube failure, dust, or other destructive elements, it is suggested that a schedule of preventive maintenance be set up and adhered to.

b. At periodic intervals (at least every six months) the equipment should be removed from the rack for cleaning and inspection. All accessible covers should be removed and the wiring and all components inspected for dirt, corrosion, charring, discoloring, or grease; in particular, the tube sockets should be carefully inspected for deterioration. Dust may be removed with a soft brush or a vacuum cleaner if one is available. Remove dirt or grease from electrical parts with trichlorethylene or ethylene-dichloride. Remove dirt or grease from other parts with any good dry cleaning fluid.

WARNING

When using trichloroethylene or carbon tetrachloride, make certain that adequate ventilation exists. These are toxic substances. Avoid prolonged contact with skin.

c. While unit is out of the rack and covers are removed, it is advisable to check the tubes, all of which are accessible from the top of the chassis and the back of the oven.

CAUTION

Tubes should be removed and checked one at a time to eliminate the danger of replacing a tube in the wrong socket. Do not fail to replace tube shields.

d. Carefully inspect for loose solder connections or screws, especially those on solder lugs. Recommended time interval is every 6 to 12 months, depending on the amount of vibration encountered in service.

e. Study all the gears which are contained in the region between the front panel and oven (see figure IIIB-5-5). These are the two gears associated with the calibrate control and the two right angle gears connecting the counter with the master oscillator tuning control. If any of these units show signs of becoming dry, coat them heavily with molybdenum disulphide compound such as that made by the Alpha

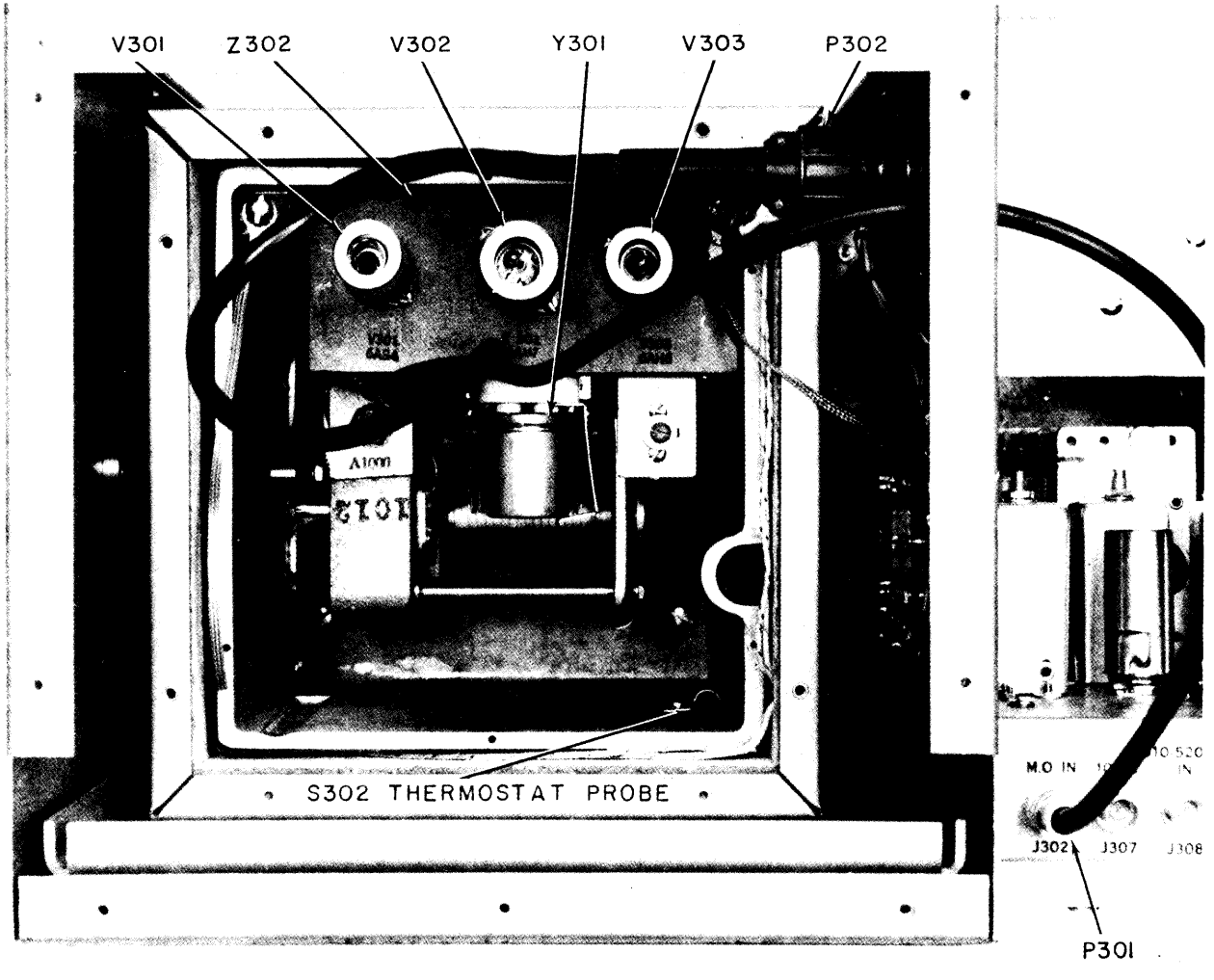

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Figure IIIB-6-1. Location Diagram of Major Electronic Components, Oven Section, Rear View, Oven Opened

Corporation of Greenwich, Conn. and referred to by the trade name of Molykote - Type G. Recommended time interval: every two years.

f. Some of the early CMO models have oven support shock absorbers which may eventually deteriorate due to the type of rubber employed. Should this occur, it will be noticed by a general sinking of the entire oven installation to the extent that the knob shafts may rest on the knob shaft holes in the control panel, making it difficult to turn the knobs. The new type of shock absorbers presently being installed on the CMO have a longer life and are listed in Section 7 Parts List. They are interchangeable, with the old type in every respect.

In order to replace shock absorbers in the CMO, it is first necessary to remove the bolted-on cross brace (see figs. IIIB5-5 and -7). By removing the panel knobs, disconnecting P301 and P302 plugs and S301 thermostat probe and removing the 4 shock absorber retaining bolts from the bottom of the CMO chassis floor it will be possible to pull out the entire oven, gear assembly and shock absorber plate intact. This will afford access to the shock absorbers in the shock absorber plate. The 11-lb absorbers, identified by a red or yellow dot on the rubber portion, go toward the front of the CMO; the 4-lb absorbers, identified by a blue or white dot, go toward the back. When the new shock absorbers have been replaced in the plate, reinstall the oven and plate assembly on the CMO chassis floor, and replace the shock absorber retaining bolts from the bottom. Removing and replacing the bolts requires access only from the bottom of the unit.

III B-6-3 CORRECTIVE MAINTENANCE

The corrective maintenance procedure presented below is essentially Technical Material Corporation's factory alignment procedure. To obtain precise alignment of the CMO unit, a correctly aligned and properly functioning Low Frequency Loop Unit of the type used in the complete CPO system must be available, as well as the Power Supply Unit associated with this system. When correctly aligned, the CMO unit is then interchangeable in any CPO system of the same type.

In addition, the following test equipment is required:

70-ohm load (noninductive), 5 watt

20 decibel pad

RF Generator

RF VTVM (Hewlett-Packard 410B or equiv.)

Frequency Counter (Hewlett-Packard 524 C or equiv.)

Connect the Power Supply unit, the low Frequency Loop unit, the Divider Chain unit and the 70-ohm load as shown in solid lines of figure IIIB-5-4.

It is not necessary to perform the 48-hour warm-up of the oven in order to align the CMO. Sufficient frequency stability will be available for the relatively short period required for this operation.

Alignment for the CMO unit resolves itself into the following eight general adjustments and should be performed in this sequence, as outlined in table IIIB-6-1.

1. 100-kc oscillator calibration
2. IF strip
3. RF amplifier chain
4. Master oscillator
5. Cam surface alignment
6. Harmonic selector
7. Phase detector
8. Sync. indicator

In table IIIB-6-1 numbered panel controls in parenthese refer to figure IIIB-3-1.

TABLE III B-6-1

ALIGNMENT PROCEDURE

Adjustment	Step	OPERATION
1	1	Set OPERATE/CAL switch (1) to CAL position. Connector frequency counter to pin 1 of V312 tube socket. Adjust C311 at back of oven (see figure IIIB-5-7) for a 100, 000 CPS reading on the counter. Do not remove oven door.
2	2	Disconnect P302 plug from J302 receptacle. Disconnect CHL Divider Chain unit and CLL Low Frequency Loop unit from receptacles J307 and J308, respectively. Connect the RF generator to pin 2 of V309 tube socket. Set the generator to 510-kc at 1.0 volt. Connect the VTVM to pin 7 of V310 tube socket. Adjust T308, T307 and T306 for about 9.5 V reading on VTVM. Then set generator for 519.9 kc at 1.0 volt. Adjust T308, T307 and T306 for about 10.5 V reading on VTVM. Repeat adjustments of T308, T307 and T306, if necessary, until VTVM reads approximately 9.5 volts at 510 kc and 10.5 volts at 519.9-kc. Reconnect P302 and CLL.

TABLE III B-6-1

ALIGNMENT PROCEDURE (Cont.)

Adjustment	Step	OPERATION
3	3	Set OUTPUT control (8) to max. (fully CW). Disconnect P302 from J302. Attach RF generator to J302 and set it for 1750 KC at 1.0 volt. Set TUNING KCS control (9) to the 1750-kc position. Adjust T301 and T302 for maximum reading on TUNE FOR MAX meter (12).
	4	Set RF generator for 3750 kc at 1.0 volt. Set TUNING KCS control to the 3750-kc position. Adjust C329 and C331 for maximum reading on TUNE FOR MAX meter.
	5	Repeat steps 3 and 4 until selected signal is at maximum in both positions without further adjustment. Meter reading should be approx. 8.
	6	Connect VTVM across 70-ohm load at J305. Voltage should read 8.5 volts or better. Reconnect P302 and J302.
4	7	Switch OPERATE/CAL switch (1) to CAL position. Turn MASTER OSCILLATOR FREQUENCY knob (2) to bring 1,800,000 CPS on counters (3) and (4). Approach this figure from the lower side in order to prevent error due to backlash. Adjust red knob (5a) until zero beat is observed on CAL BEAT light (6). As an additional check the output of the CMO can be read on a frequency counter through a 20 dp pad, attached at J305 per broken lines in figure IIIB-5-4. Frequency should read 2,050,000 CPS.
	8	Turn MASTER OSCILLATOR FREQUENCY knob (2) to bring 3,750,000 CPS on counters (3) and (4). As in step 7, approach this figure from the lower side. Adjust C302 trimmer capacitor (through hole in panel adjacent to red knob) until zero beat is observed on CAL BEAT light (6). A frequency meter, attached to J305 as described in step 7, should read 4,000,000 CPS.
	9	Repeat steps 7 and 8 until zero beat from CAL BEAT light is observed when CMO panel counters read 1,800,000 CPS without further adjustment of red knob (2) or C302 trimmer.
5	10	Without touching either red knob (5a) or C302 trimmer from settings in step 9, rotate MASTER OSCILLATOR FREQUENCY knob (2) to bring 1,900,000 CPS on counters (3) and (4), approaching from the lower side. CAL BEAT light should give zero beat. If it does not, vary knob (2) until it does. Then record amount of error from comparing 1,900,000 CPS with figure appearing on counters (3) and (4). Repeat this process for 2,000,000 CPS, 2,100,000 CPS and all 100,000 CPS check points up through 3,700,000 CPS recording all errors. No error should be over 200 CPS*.
6	11	Connect RF generator to 10 KC INPUT receptacle J307 and set for 1,485-kc at approximately 2 volts. Connect frequency counter and VTVM to pin 9 of V309 tube socket. Set trimmers C332 and C336 to mid range. Set MASTER OSCILLATOR FREQUENCY knob (2) to bring 1,750,000 CPS on counters (3) and (4). Tune TUNING KCS knob (9) to 1750-kc. Vary the RF generator around the 1,485-kc setting until a reading of 515-kc is obtained on frequency counter. Adjust T303 and T304 for max. reading on VTVM.
		*** WARNING** Do not remove oscillator assembly from oven in an attempt to realign cam surface. This can be done only at the TMC factory due to special alignment tools required.

TABLE III B-6-1

ALIGNMENT PROCEDURE (Cont.)

Adjustment	Step	OPERATION
6	12	Set RF generator for 3,485-kc at approximately 2 volts. Set MASTER OSCILLATOR FREQUENCY knob (2) to bring 3,750,000 CPS on counters (3) and (4). Tune TUNING KCS knob (9) to 3,750-kc. Vary the RF generator around the 3,485-kc setting until a reading of 515-kc is obtained on frequency counter. Adjust C332 and C336 for max. reading on VTVM.
	13	Repeat steps 11 and 12 until selected signal is at maximum in both positions without further adjustment.
7	14	Tune Low Frequency Loop unit to zero CPS. Switch OPERATE/CAL switch (1) to OPERATE position. Turn MASTER OSCILLATOR FREQUENCY knob (2) to bring 3,000,000 CPS on counters (3) and (4). Set TUNING KCS knob (9) pointer at 3250-kc. This will insure that HF loop is not synchronized. Then remove P302 from J302. Adjust R328 potentiometer for center of scale reading on ADJ FOR ZERO meter (10)**. Reconnect P302 to J302.
8	15	Connect Divider Chain 10-kc to CMO J307 input. Leave Low Frequency Loop unit (CLL) connected and set as in step 14. Leave 3,000,000 CPS setting on counters. Set TUNING KCS knob (9) pointer in 3000-kc area for max. reading on TUNE FOR MAX meter (12). Vary MASTER OSCILLATOR FREQUENCY knob (2) to bring first 3,000,500 CPS and then 2,999,500 CPS on counters (3) and (4). The needle on the ADJ FOR ZERO meter (10) will follow in the same direction as this control is varied. This indicates that the HF loop is synchronized. With the loop in sync. and the needle on ADJ FOR ZERO meter in center position, vary R340 potentiometer to the point where SYNC IND light (11) ignites.
	16	Vary the MASTER OSCILLATOR FREQUENCY knob (2) to bring first 3,001,000 CPS and then 2,999,000 CPS on counters (3) and (4). The SYNC IND light (11) should remain on through the green sector and the ADJ FOR ZERO meter needle should follow the variation of knob (2).
	17	If results in step 16 are not realized, repeat step 15.
		**CAUTION Do not attempt to bring ADJ FOR ZERO needle to center of dial by adjusting meter calibration screw on panel side. This should only be done when the CMO unit is completely disconnected from power and all other inputs.

SECTION 7
PARTS LIST

INTRODUCTION Reference designations have been assigned to identify all maintenance parts of the equipment. They are used for marking the equipment (adjacent to the part they identify) and are included on drawings, diagrams and the parts list. The letters of a reference designation indicate the kind of part (generic group), such as resistor, amplifier, electron tubes, etc. The number differentiates between parts of the same generic group. Parts of the CMO unit are numbered in the 300 series. Sockets associated with a particular plug-in device, such as electron tube or fuse, are identified by reference designations which include the reference designations of the plug-in device. For example, the socket for tube V301 is designated XV301. Column 1 lists the reference series of each major unit, followed by the reference designations of the various parts in alphabetical and numerical order. Column 2 gives the name and describes the various parts. Major part assemblies are listed in their entirety; subparts of a major assembly are listed in alphabetical and numerical order with reference to its major assembly. Column 3 indicates how the part is used within a major component. Column 4 lists each Technical Material Corporation part number.

PARTS LIST—CMO-1 and CMO-2

SYM	DESCRIPTION	FUNCTION	TMC PART NO.
C301	CAPACITOR, variable: air dielectric; one section, 7 plates: 5 to 25 uuf, ±5 uuf. Not a replaceable item, part of Z302.	VMO Connection	CB-105
C302	CAPACITOR, variable; air dielectric; one section, 3 plates: 2.8 to 11 uuf. Not a replaceable item, part of Z302.	Trimmer, V301	CB-121
C303	CAPACITOR, fixed: ceramic; 8.2 uuf, ±5%, 500 wvdc. Not a replaceable item, part of Z302.	Trimmer V301	CC-102-5
C304	CAPACITOR, fixed: ceramic; temperature compensating; temp. coeff. ±60%, 7 uuf, ±2%. Not a replaceable item, part of Z302.	Trimmer, V301	CC107RH070C
C305	CAPACITOR, fixed: ceramic; 270 uuf ±5% wvdc. Not a replaceable item, part of Z302.	Coupling, V301	CC45LG271J
C306	Same as C305. Not a replaceable item, part of Z302.	Coupling, V301	
C307	CAPACITOR, assembly: variable; air dielectric; 21.0 to 220 uuf. Not a replaceable item, part of Z302.	VMO tuning, V301	A-1000
C308	CAPACITOR, fixed: mica; .01 uf, ±5%, char. C, 300 wvdc. Not a replaceable item, part of Z302.	Coupling, L303	CM35C103J
C309	Same as C308. Not a replaceable item, part of Z302.	Decoupling, V303	
C310	Same as C308. Not a replaceable item, part of Z302.	Cath. Bypass V303	
C311	CAPACITOR, variable: air dielectric; 1 section 19 plates, 3.5-50 uuf. Not a replaceable item part of Z302.	100 Kc Adjust	CT-103-1
C312	Same as C305. Not a replaceable item, part of Z302.	Feedback, V302	
C313	CAPACITOR, fixed: ceramic; feed thru type; 2000 uuf, ±20%, char. A, 500 wvdc. Not a replaceable item, part of Z302.	RF Bypass, L305	CK70A202M
C314	CAPACITOR, fixed: mica; 1600 uuf ±2%, 500 wvdc, char. D. Not a replaceable item, part of Z302.	Coupling, V303	CM20D162G
C315	CAPACITOR, fixed: mica; dielectric, 270 uuf, ±2%, 300 wvdc. Not a replaceable item, part of Z302.	Suppressor, V303	CM15D271G
C316	CAPACITOR, fixed: ceramic; feed thru type; 1000 uuf, ±20%, 500 wvdc, Char. A Not a replaceable item, part of Z302.	RF Bypass, L304	CK70A102M

PARTS LIST—CMO-1 and CMO-2 (C nt.)

SYM	DESCRIPTION	FUNCTION	TMC PART NO.
C317	Same as C316. Not a replaceable item, part of Z302.	RF Bypass, V302	
C318	CAPACITOR, fixed: mica; 20 uuf, ±5%, 300 wvdc.	Padder, C330B	CM15C200J
C319	CAPACITOR, fixed: mica-dielectric; .01 uf ±10%,char. B, 300 wvdc.	Relay Arc Supp. K301	CM35B103K
C320	Same as C316. Not a replaceable item, part of Z302.	RF Bypass, P301	
C321	CAPACITOR, fixed: ceramic-dielectric: .02 uf +80 -20%, 500 wvdc, disc type.	Decoupling, V304	CC-100-24
C322	CAPACITOR, fixed: mica-dielectric; 110 uuf, ±10%,char. B, 500 wvdc.	Coupling, V304	CM20B111K
C323	CAPACITOR, fixed: ceramic-dielectric; .01 uf, GMV, 500 wvdc.	Filter, V304	CC-100-16
C324	CAPACITOR, fixed: ceramic-dielectric; .1 uf, +80 -20%, 500 wvdc.	Filter, V304	CC-100-28
C325	CAPACITOR, fixed: Feed thru type; 1000 uuf, ±20%, 500 wvdc, char. A.	Cath. Bypass V305	CK70A102M
C326	Same as C321	Decoupling, V305	
C327	CAPACITOR, fixed: mica-dielectric; 1000 uuf, ±10%, char. B, 500 wvdc.	Coupling, V306	CM20B102K
C328	CAPACITOR, fixed: ceramic-dielectric; 1000 uuf, ±20%, 500 wvdc, char. P.	RF Bypass, V305	CK70A102M
C329	CAPACITOR, variable: ceramic; 7-45 uuf, char. C, 500 wvdc.	Trimmer	CV11C450
C330 A, B, C, D	CAPACITOR, variable: air dielectric; four sections, 25 plates per section, 12.5 to 432.5 uuf per section.	Main tuning	CB-151
C331	Same as C329	Trimmer	
C332	Same as C329	p/o Main tuning	
C333	Same as C328	RF Bypass, V307	
C334	Same as C321	Cath. Bypass, V307	
C335	Same as C321	Decoupling, V307	
C336	Same as C329	Trimmer	
C337	Same as C328	RF Bypass, L312	
C338	Same as C323	Coupling, T306	
C339	Same as C321	Cath. Bypass, V308	

PARTS LIST—CMO-1 and CMO-2 (C nt.)

SYM	DESCRIPTION	FUNCTION	TMC PART NO.
C340	CAPACITOR, fixed: mica; 1600 uuf, ±10%, char. C, 500 wvdc.	Decoupling, V308	CM20C162K
C341	CAPACITOR, tantalum: 5 uf, ±15%, 25 wvdc.	Coupling, R331	CX-105
C342	CAPACITOR, fixed: mica; 15 uuf, ±10%, 500 wvdc char. B.	Coupling, T308	CM20B150K
C343	Same as C327	Coupling, V309	
C344	Same as C321	Decoupling, V309	
C345	Same as C327	Coupling, V304	
C346	Same as C328	RF Bypass, L310	
C347	CAPACITOR, fixed: mica; 5 uuf, ±20%, char. B. 500 wvdc.	Coupling, V309	CM20B050M
C348	Same as C321	Cathode Bypass V309	
C349	Same as C342	Coupling, V310	
C350	CAPACITOR, fixed: metalized paper, high temperature .04 uf, ±10%, 400 wvdc.	Fast time constant comp. V310	CP106C403-4
C351	Same as C323	Decoupling, V310	
C352	Same as C342	Phase Shift, V310	
C353	Same as C324	Cath. Bypass, V310	
C354	Same as C328	RF Bypass, T302	
C355	CAPACITOR, fixed: metal case, mylar, dielectric; 1. uf ±10%, 300 wvdc.	Coupling, V311	CN106D104K
C356	Same as C355	Coupling, V311	
C357	CAPACITOR, fixed: ceramic; 1000 uuf, ±10%, 500 wvdc, disc type.	RF Bypass, V311	CC-100-9
C358	Same as C355	Coupling, V311	
C359	Same as C327	RF Bypass, V311	
C360	Same as C327	RF Bypass, V312	
C361	Same as C323	Decoupling, V312	
C362	Same as C327	Coupling, V312	
C363	Same as C357	RF Bypass, I304	
C364	Same as C357	RF Bypass, I304	
C365	CAPACITOR, fixed: metallized mylar; .25 uf, ±20%; 100 wvdc.	Coupling, J301	CN112A254M1

PARTS LIST—CMO-1 and CMO-2 (C nt.)

SYM	DESCRIPTION	FUNCTION	TMC PART NO.
C366	NOT USED		
C367	Same as C327	Coupling, V304	
C368	Same as C340	Filter, L313	
C369	Same as C319	Thermostat arc Supp E301	
C370	CAPACITOR, fixed: mica; 10 uuf, ±20%, char. B, 300 wvdc.**	Coupling, Z301	CM15B050M
CR301	DIODE, Germanium	Rectifier, J304	1N100
CR302	Same as CR301	Rectifier, T305	
CR303	Same as CR301	Rectifier, T305	
E301	BOARD, terminal: barrier type; ten 6-32 x 1/4 in. binding head machine screws.	Oven Connections	TM-102-10
E302	NOT USED		
E303	BOARD, terminal: general purpose barrier type, two 6-32 binding head machine screws; moulded phenolic.	Ground Contact, V304	TM-100-2
I301	LAMP, neon: miniature; 110 volts, 1/25 watt; T-3-1/4 clear bulb; bayonet base.	Oven Indicator	BI-100-51
I302	NOT USED		
I303	Same as I301	Zero Beat Ind.	
I304	Same as I301	SYNC IND.	
J301	CONNECTOR, receptacle: AN socket type; 7 contacts rated at 20 amps, 200 vdc, 150 VAC (rms), mtg. dim. 1-1/32" mtg. centers.	VMO Power	MS3102A-16-1S
J302	CONNECTOR, receptacle: electrical; 1 female contact; 52 ohms, BNC type.	VMO IN	UG-625/U
J303	NOT USED		
J304	CONNECTOR, receptacle: male, 16 contacts, aluminum alloy cad. plated; mates with PL-186.	Input Power	JJ-183
J305	Same as J302	RF Out	
J306	Same as J302	RF Out	
J307	Same as J302	10 Kc in	
J308	Same as J302	510-520 Kc Input	
K301	RELAY, assembly: 4500 ohms DC; hermetically sealed.	Thermostat Control	A-123

**C370 is a 5 uuf capacitor in earlier CMO models. In replacing C370, a capacitor of the same rating should be used to eliminate the necessity of realigning the harmonic selector tuning circuits.

PARTS LIST—CMO-1 and CMO-2 (Cont.)

SYM	DESCRIPTION	FUNCTION	TMC PART NO.
L301	COIL, oscillator tank: inductance-38.5 - 29.0 uh, min. Q = 200. Not a replaceable item, part of Z302.	VMO Freq.	CL-236
L302	COIL, R.F.: 750 microhenries, ±20%; 100 ma max. current, DC resistance approx. 17 ohms; bakelite body. Not a replaceable item, part of Z302.	RF Choke, V301	CL-100-5
L303	Same as L302. Not a replaceable item, part of Z302.	RF Choke, V303	
L304	Same as L302. Not a replaceable item, part of Z302.	RF Choke, V302	
L305	COIL, R.F.: 2.5 mh, 100 ma; molded. Not a replaceable item, part of Z302.	RF Choke, V303	CL-140-1
L306	COIL, R.F. fixed: 500 uh, ±10 uh, Q = 90 or greater at frequency 790 kc.	Step-up, V304	CL-227
L307	COIL, R.F. fixed: 128 uh.	RF Choke, V304	CL-177
L308	Same as L302	RF Choke, T302	
L309	Same as L307	RF Choke, V305	
L310	Same as L307	RF Choke, V304	
L311	Same as L307	Low Pass Filter V306	
L312	Same as L302	Low Pass Filter V307	
L313	Same as L305	RF Choke, R328	
M301	METER, DC microamps: movement 0-50 microamps, approximate resistance 2000 ohms.	Output Level Indicator	MR-141
M302	METER, DC microamps: movement-25-0-25 microamps, approximate resistance 2000 ohms.	Synthesizer Indicator	MR-140
P301	CONNECTOR, plug: AN pin type; 7 contacts rated at 20 amps, 200 vdc, 150 vac (RMS). Part of W301.	VMO Power Input	MS3106B-16S-1P
P302	CONNECTOR, coaxial: male contact; BNC type. Part of W302.	VMO Signal Output	UG-260/U
R301	RESISTOR, fixed: composition; 22,000 ohms, ±10%; 1/2 watt. Not a replaceable item. Part of Z302.	Grid Detector V301	RF20GF223K
R302	RESISTOR, fixed: composition; 1,000 ohms, ±10%, 1 watt. Not a replaceable item, part of Z302.	Cath. Bias, V302	RC32GF102K
R303	RESISTOR, fixed: composition; 4700 ohms, ±10%, 1/2 watt. Not a replaceable item, part of Z302.	Cath. Bias V302	RC20GF472K

PARTS LIST—CMO-1 and CMO-2 (C nt.)

SYM	DESCRIPTION	FUNCTION	TMC PART NO.
R304	RESISTOR; fixed: composition; 470,000 ohms, ohms, ±10%, 1/2 watt. Not a replaceable item, part of Z302.	Grid Detector V302	RC20GF474K
R305	RESISTOR, fixed: composition; 330 ohms, ±10%, 1/2 watt. Not a replaceable item, part of Z302.	Cath. Bias, V302	RC20GF331K
R306	RESISTOR, fixed: composition; 27,000 ohms, ±10%, 1/2 watt. Not a replaceable item, part of Z302.	Plate Load, V303	RC20GF273K
R307 A, B	RESISTOR, fixed: wirewound; heater element, two sections, 160 ohms each section, insulated.	Heater Element	RR-130-1
R308	RESISTOR, fixed: composition; 10,000 ohms, ±10%, 1/2 watt.	Meter Grd. Return	RC20GF103K
R309	RESISTOR, fixed: composition; 39 ohms, ±10%, 1/2 watt.	Plate Load V305	RC20GF390K
R310	RESISTOR, fixed: composition; 100 ohms, ±10%, 1/2 watt.	Inner Thermostat Arc. Supp.	RC20GF101K
R311	RESISTOR, fixed: composition; 9100 ohms, ±5%, 2 watts.	Volt. Dropping	RC42GF912J
R312	Same as R311	Volt. Dropping	
R313	NOT USED		
R314	RESISTOR, fixed: composition; 220,000 ohms, ±10%, 1/2 watt.	Inner Oven Ind. Protector	RC20GF224K
R315	NOT USED		
R316	Same as R310	Relay Arc Supp.	
R317	RESISTOR, fixed: composition; 47,000 ohms, ±10%, 1/2 watt. Not a replaceable item, part of Z302.	Plate Load, V302	RC20GF473K
R318	RESISTOR, fixed: composition; 150 ohms, ±10%, 1/2 watt.	Cath. Bias V304	RC20GF151K
R319	RESISTOR, fixed: composition; 5600 ohms, ±10%, 1/2 watt.	Volt. Dropping V304	RC20GF562K
R320	Same as R319	Grid Detector	
R321	RESISTOR, variable: composition; 5000 ohms, ±10%, 1/2 watt.	Drive Adjust.	RV106UF8A502A
R322	RESISTOR, fixed: composition; 82 ohms, ±10%, 1/2 watt.	Cath. Bias V305	RC20GF820K
R323	NOT USED		
R324	Same as R301	Grid Detector V306	

PARTS LIST—CMO-1 and CMO-2 (C nt.)

SYM	DESCRIPTION	FUNCTION	TMC PART NO.
R325	RESISTOR, fixed: composition; 390 ohms, ±10%, 1/2 watt.	Cath. Bias V307	RC20GF391K
R326	Same as R301	Screen Load V307	
R327	RESISTOR, fixed: composition; 6800 ohms, ±10%, 1/2 watt.	Volt. Dropping, T306	RC20GF682K
R328	RESISTOR, variable: composition; 5000 ohms, ±10%, 1/2 watt.	5K Bal. T305	RV106UX10C502A
R329	Same as R301	Volt. Dropping, T305	
R330	Same as R327	Volt. Dropping	
R331	RESISTOR, fixed: composition; 3300 ohms, ±10%, 1/2 watt.	Volt. Dropping	RC20GF332K
R332	Same as R318	Cath. Bias V308	
R333	Same as R301	Screen Load V308	
R334	RESISTOR, fixed: composition; 330,000 ohms, ±10%, 1/2 watt.	Grid Detector, V309	RC20GF334K
R335	RESISTOR, fixed: composition; 47,000 ohms, ±10%, 1 watt.	Screen Load, V309	RC32GF473K
R336	RESISTOR, fixed: composition; 12,000 ohms, ±10%, 1/2 watt.	Grid Detector, V309	RC20GF123K
R337	RESISTOR, fixed: composition; 47 ohms, ±10%, 1/2 watt.	Grid Limiter, V309	RC20GF470K
R338	Same as R310	Cath. Bypass V309	
R339	RESISTOR, fixed: composition; 33,000 ohms, ±10%, 1/2 watt.	Volt. Dropping, V312	RC20GF333K
R340	RESISTOR, variable: composition; 2.5K ohms, ±10%, 1/2 watt.	SYNC Ind. Adj.	RV106UX10C252A
R341	Same as R301	Grid Detector, V310	
R342	RESISTOR, fixed: composition; 270 ohms, ±10%, 1/2 watt.	Cath. Bias V310	RC20GF271K
R343	RESISTOR, fixed: composition; 1 megohm, ±10%, 1/2 watt.	Grid Detector, V310	RC20GF105K
R344	Same as R308	Volt. Dropping, V311	
R345	Same as R335	Plate Load V311	
R346	Same as R314	Plate Load V311	
R347	RESISTOR, fixed: composition; 56,000 ohms, ±10%, 1/2 watt.	Volt. Dropping, V311	RC20GF563K
R348	Same as R303	Grid Detector, V311	

PARTS LIST—CMO-1 and CMO-2 (C nt.)

SYM	DESCRIPTION	FUNCTION	TMC PART NO.
R349	RESISTOR, fixed: composition; 4.7 megohms, ±10%, 1/2 watt.	Grid Detector, V311	RC20GF475K
R350	RESISTOR, fixed: composition: 100,000 ohms, ±10%, 1/2 watt.	Grid Detector, V312	RC20GF104K
R351	Same as R350	Volt. Dropping V312	
R352	Same as R343	Plate Load, V312	
R353	Same as R350	Screen Load, V312	
R354	Same as R350	Grid Detector, V312	
R355	Same as R308	Volt. Dropping T306	
R356	Same as R306	Grid Detector, V304	
R357	Same as R350	Meter Shunt M302	
R358	RESISTOR, fixed: composition; 390,000 ohms, ±10%, 1/2 watt.	Volt. Dropping, T304	RC20GF394K
R359	Same as R308	Plate Load, V304	
R360	Same as R350	Plate Load	
S301	SWITCH ASSEMBLY, thermostatic: bi-metallic; operate at 70°C, ±5°C.	Thermostat 70°C	A-1236
S302	SWITCH, thermostatic: bi-metallic; operate at 80°C, ±2°C.	Thermostat 80°C	SS-100-3
S303	NOT USED		
S304	SWITCH, toggle	CAL-operate	ST-22K
T301	COIL, R.F.: tuned; L = 19 (±1) uh, Q = 25 or greater, frequency = 2.5 mc.	RF Tuned Imped. Coupling	AC-120
T302	COIL, R.F.: tuned; L = 19 (±1) uh, Q = 75 or greater, frequency = 2.5 mc.	Tuned Impedance Coupling	AC-119
T303	COIL, R.F.: tuned; L = 23 (±1) uh, Q = 40 or greater, frequency = 2.5 mc.	Peaking V307	AC-121
T304	COIL, R.F.: tuned; L = 23 (±1) uh, Q = 20 or greater, frequency - 2.5 mc.	Filter	AC-115
T305	TRANSFORMER, pulse: three windings; primary inductance, 4.7 millihenries, pulse width 0.05 to 5 microseconds, 500 volts RMS.	510-520 KC Input	TF-228K15
T306	COIL, R.F.: tuned; L = 230 uh, ±5 uh, Q = 85 or greater, frequency = 790 Kc.	IF Transformer	AC-116
T307	COIL, R.F.: tuned; L = 96 uh, ±3 uh, Q = 75 or greater, frequency 790 Kc.	Tuned Impedance Coupling	AC-118

PARTS LIST—CMO-1 and CMO-2 (Cont.)

SYM	DESCRIPTION	FUNCTION	TMC PART NO.
T308	COIL, R. F.: tuned; L = 96 uh, ± 3 uh, Q = 75 or greater, frequency = 790 kc.	Tuned impedance Coupling	AC-117
V301	TUBE, vacuum; high mu triode, 7 pin miniature, part of Z302.	Master Osc.	6AB4
V302	TUBE, electron: medium-mu duo-triode, 9 pin miniature, part of Z302.	Cath. Follower	12AU7
V303	TUBE, electron: sharp cutoff RF pentode; 7 pin, miniature, part of Z302.	Reactance	6AH6
V304	Same as V303	1st RF ampl.	
V305	TUBE, electron: power pentode; wide band amplifier, 9 pin miniature.	Power Ampl.	6CL6
V306	TUBE, electron: sharp cutoff RF pentode; 7 pin miniature.	Harmonic Ampl.	6AU6
V307	Same as V303	Harmonic Selector	
V308	Same as V303	IF Ampl.	
V309	TUBE, electron: remote cutoff RF pentode; 7 pin miniature.	Mixer	6BA7
V310	TUBE, vacuum: pentagrid amplifier	SYNC Ind.	6CS6
V311	Same as V302.	Audio Ampl.	
V312	TUBE, electron: pentagrid converter; 7 pin miniature.	Mixer	6BE6
W301	CABLE, controlled: M.O.; consists of insulation sleeving, cable clamp, insulated cable; one MS3106B-16S-1P (P301) and a ground lug. Total length 20". Not a replaceable item, part of Z302.	Oscillator Power Cable Assy.	CA-568
W302	CABLE R. F.: master oscillator; consists of 21-1/4 in. RG-54/U cable; 3 in flexible shield; P302 connector UG-260/U; one ferrule inner (CU-101-3) and one ferrule outer (CU-101-4). Not a replaceable item, part of Z302.	Oscillator Signal Cable Assy.	CA-535
XI301	LIGHT, indicator: with clear white lens: for miniature bayonet base, T-3-1/4 bulb.	I301 Socket	TS-106-2
XI302	NOT USED		
XI303	Same as XI301	I303 Socket	
XI304	Same as XI301	I304 Socket	
XK301	SOCKET, electron tube: octal	K301 Socket	TS101P01
XV301	SOCKET, electron tube: 7 pin miniature. Not a replaceable item, part of Z302.	V301 Socket	TS102P01

PARTS LIST—CMO-1 and CMO-2 (C nt.)

SYM	DESCRIPTION	FUNCTION	TMC PART NO.
XV302	SOCKET, electron tube: 9 pin miniature. Not a replaceable item, part of Z302.	V302 Socket	TS103P01
XV303	Same as XV301. Not a replaceable item part of Z302.	V303 Socket	
XV304	Same as XV301	V304 Socket	
XV305	Same as XV302	V305 Socket	
XV306	Same as XV301	V306 Socket	
XV307	Same as XV301	V307 Socket	
XV308	Same as XV301	V308 Socket	
XV309	Same as XV302	V309 Socket	
XV310	Same as XV301	V310 Socket	
XV311	Same as XV302	V311 Socket	
SV312	Same as XV301	V312 Socket	
XY301	SOCKET, cyrstal: .487" spacing for .095' pins. Not a replaceable item, part of Z302.	Y301 Socket	TS-105-1
XZ301	Same as XK301	Z301 Socket	
Y301	CRYSTAL UNIT, quartz: 100 kcs, part of Z302.	Ytal 100 kc	CR-100
Z301	FILTER, high pass: metal case, plug-in type; octal socket, frequency 1.3 mc.	Filter network	FX-161
Z302	OSCILLATOR ASSEMBLY, variable: *consists of C301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 320; L301, 302, 303, 304, 305, P301, 302; R301, 302, 304, 305, 306, 317, V301, 302, 303, W301, 302, XV301, 302, 303; XY301, Y301.	Master Oscillator	AO-103
MP301	SHOCK ABSORBER, 11-1b., neoprene	Vibration Insul. for Oven front end.	SH-106-3
MP302	Same as MP301	Vibration Insul. for Oven front end.	
MP303	SHOCK ABSORBER, 4-1b., neoprene	Vibration Insul. for Oven back end.	SH-106-5
MP304	Same as MP303	Vibration Insul. for Oven back end.	

*See Par. III B-6-1 (Warning Note)

SECTION 8
SCHEMATIC DIAGRAMS

NOTES:

1- SEE FIGURE III B-3-1 FOR LOCATION OF NUMBERED CONTROLS ON PANEL.
2- UNLESS OTHERWISE NOTED:
ALL RESISTORS ARE 1/2 WATT.
ALL CAPACITOR VALUES ARE IN UF.
ALL COIL VALUES ARE IN UH.
3- ⊘ INDICATES SCREWDRIVER CONTROL ON CHASSIS.

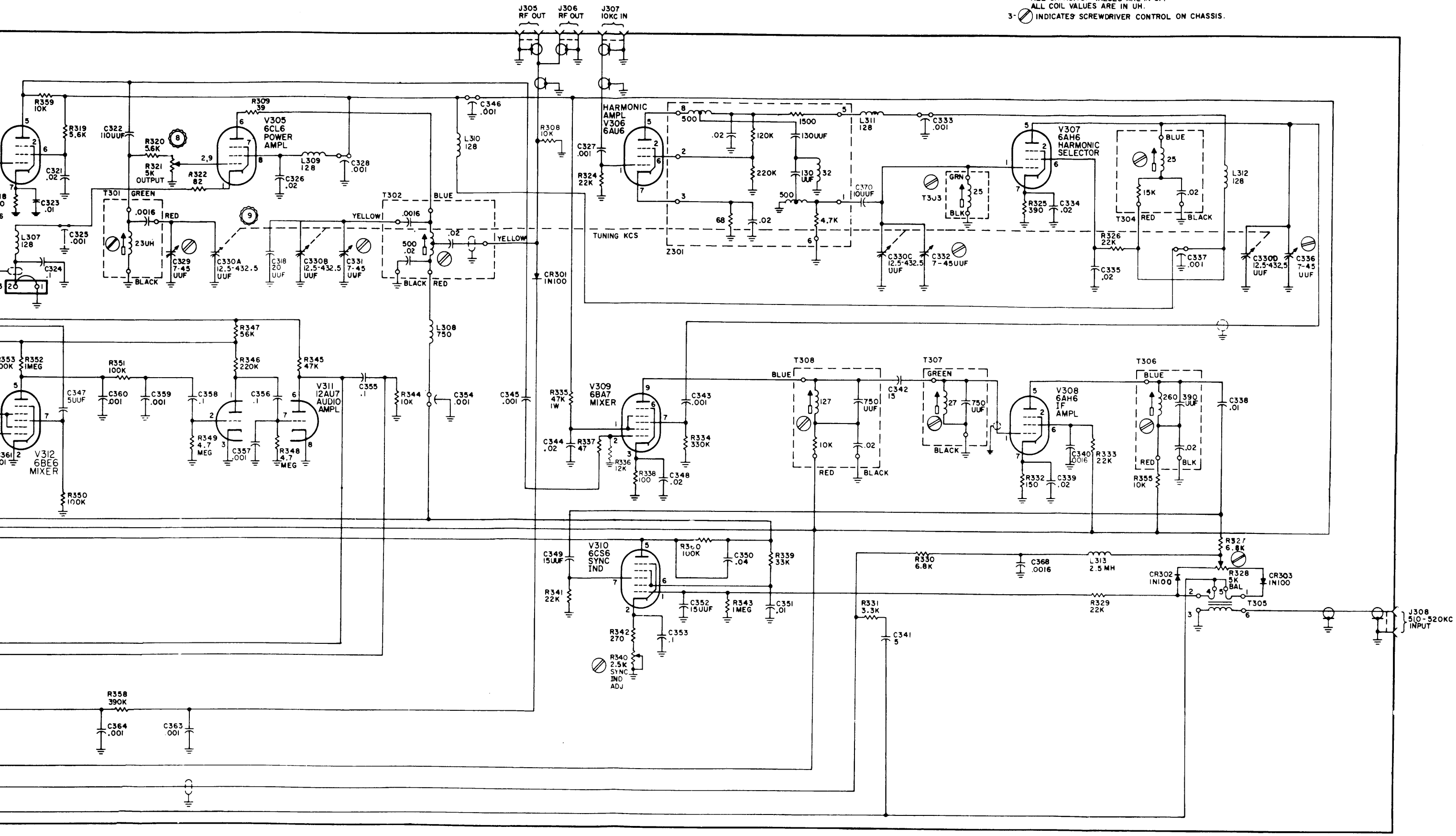
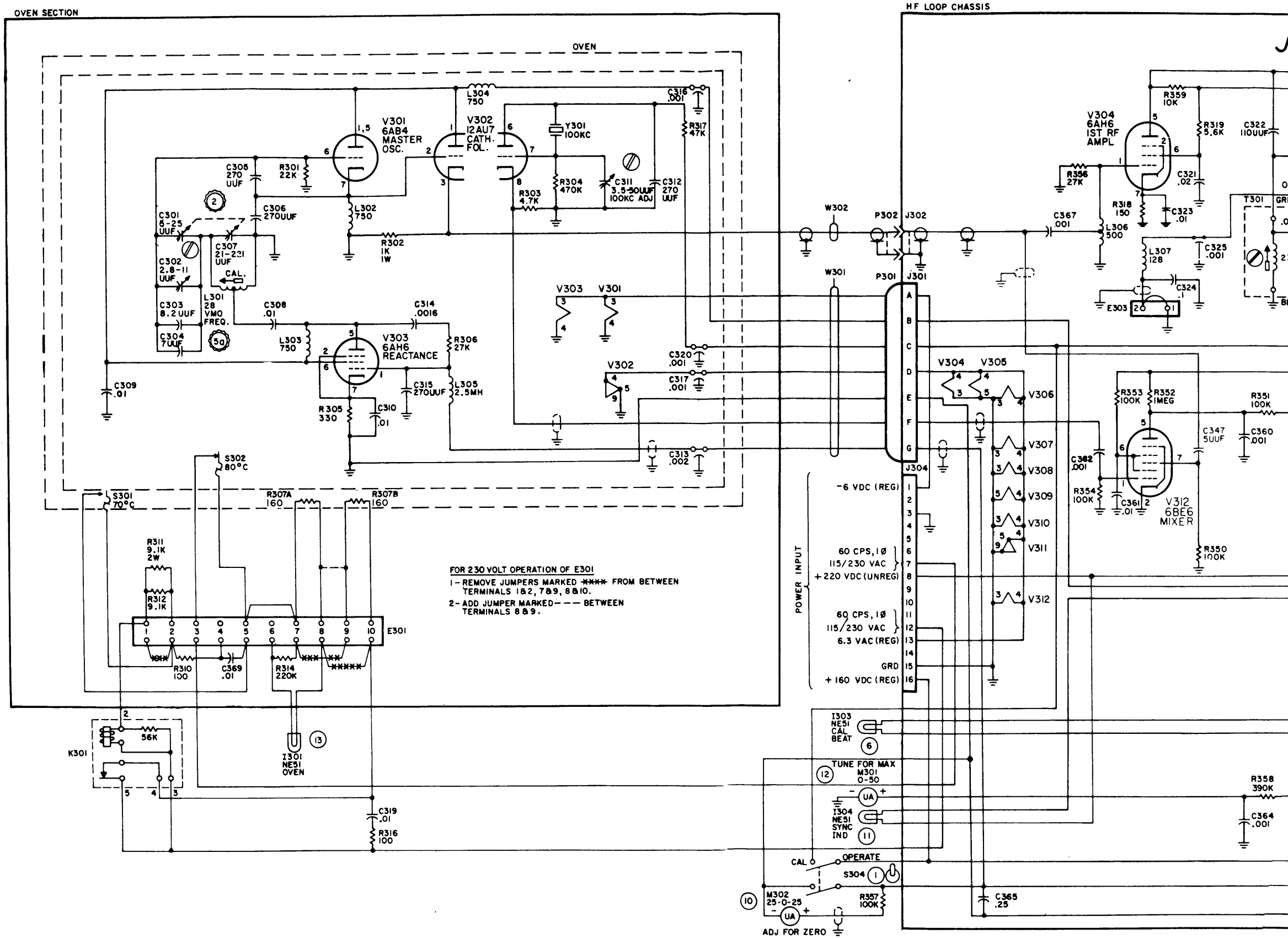


Figure IIIB-8-1. Schematic Diagram, Controlled Master Oscillator. CMO


OVEN SECTION
OVEN
HF LOOP CHASSIS
V301 6AB4 MASTER OSC.
V302 12AU7 CATH. FOL.
V303 6AH6 REACTANCE
V304 6AH6 IST RF AMPL
V305
V306
V307
V308
V309
V310
V311
V312 6BE6 MIXER
L304 750
C316 .001
Y301 100KC
R317 47K
C305 270 UUF
R301 22K
C306 270UUF
L302 750
R303 4.7K
R304 470K
C311 3.5-30UUF 100KC ADJ
C312 270 UUF
R302 1K 1W
C301 6-25 UUF
C307 21-221 UUF
CAL.
C302 2.8-11 UUF
C303 8.2 UUF
C304 7 UUF
L301 28 VMC FREQ.
C308 .01
C314 .0016
L303 750
R306 27K
C309 .01
C315 270UUF
L305 2.5MH
R305 330
C310 .01
C320 .001
C317 .001
C313 .002
S302 80°C
S301 70°C
R307A 160
R307B 160
R311 9.1K 2W
R312 9.1K
E301
R310 100
C369 .01
R314 220K
FOR 230 VOLT OPERATION OF E301
1- REMOVE JUMPERS MARKED ~~XXXX~~ FROM BETWEEN TERMINALS 1&2, 7&9, 8&10.
2- ADD JUMPER MARKED - - - BETWEEN TERMINALS 8&9.
K301
56K
I301 NE51 OVEN
C319 .01
R316 100
W302
P302
J302
W301
P301
J301
J304
POWER INPUT
-6 VDC (REG)
60 CPS, 1Ø 115/230 VAC
+220 VDC (UNREG)
60 CPS, 1Ø 115/230 VAC
6.3 VAC (REG)
GRD
+160 VDC (REG)
I303 NE51 CAL BEAT
TUNE FOR MAX
M301 0-50
I304 NE51 SYNC IND
CAL
OPERATE
S304
M302 25-0-25
ADJ FOR ZERO
R357 100K
C365 .25
R359 10K
R319 5.6K
C322 110UUF
R356 27K
C321 .02
R318 150
C323 .01
C367 .001
L306 500
L307 128
C325 .001
C324
E303
T301
R353 100K
R352 1MEG
C347 5UUF
C362 .001
R354 100K
C361 .01
R351 100K
C360 .001
R350 100K
R358 390K
C364 .001