BROADCAST TELEVISION EQUIPMENT

RCA

Instructions

RADIO CORPORATION OF AMERICA, Industrial Electronic Products

TG-21/TG-31
Studio Sync Generator
and
Field Sync Generator

Tmk(s)®

IB-30525

INSTRUCTIONS

TG-21/TG-31 Sync Generators
ES-26986—ES-26987

RADIO CORPORATION OF AMERICA
INDUSTRIAL ELECTRONIC PRODUCTS, CAMDEN, N. J.

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TABLE OF CONTENTS

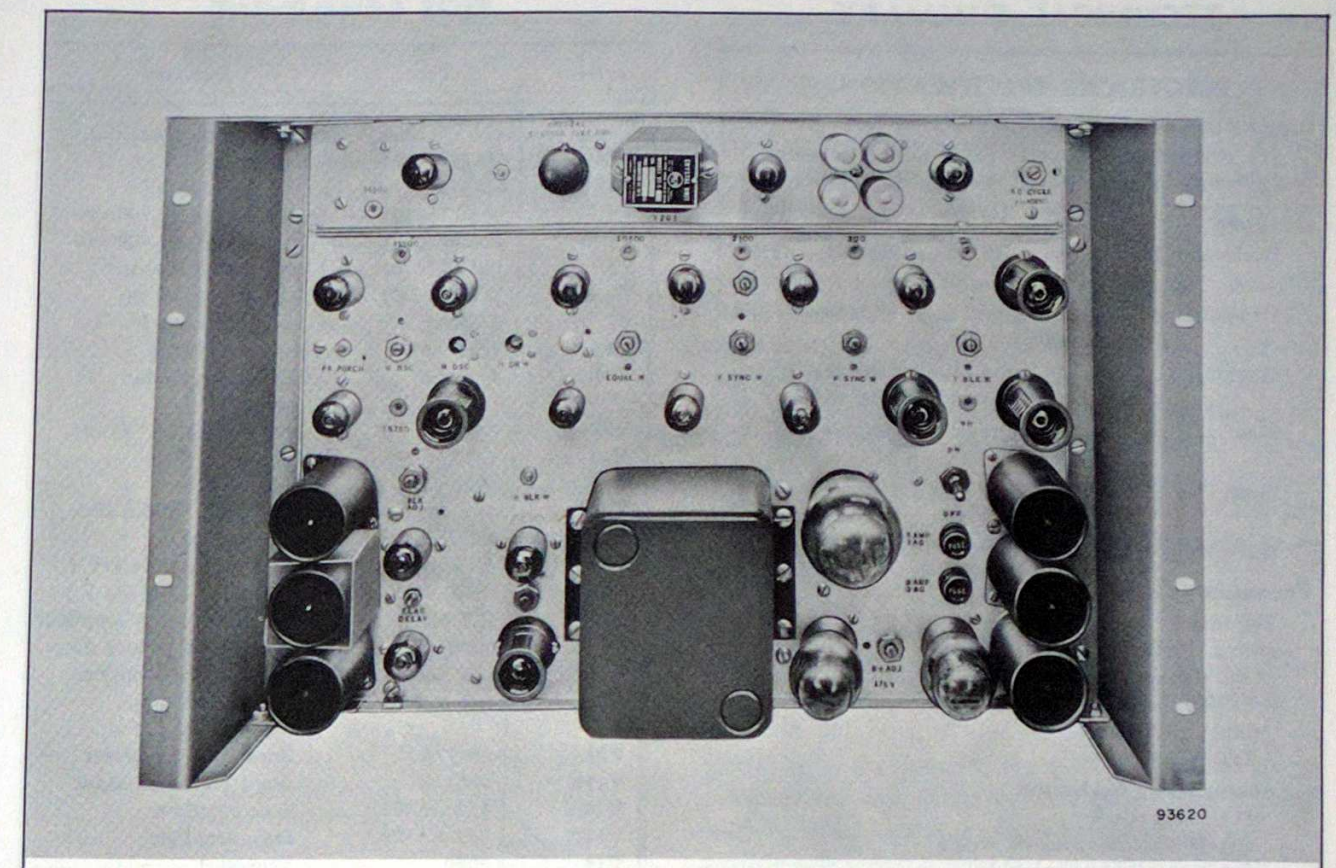
	Page
DESCRIPTION	
General	7
Field Sync Construction	7
Circuits	
Basic Multivibrator	7
Master Oscillator	8
Counter Chain	8
Frequency Control	9
60 cycle AFC	9
Crystal Control	9
Free Running Position of S201	9
Blanking Signal	11
Driving Pulse	11
EIA Sync Signal	11
Burst Flag	11
Power Supply	11
INSTALLATION	
General	11
Field Installation	12
Initial Adjustments (Studio and Field)	13
Installation of Shockmounts for Field Sync Generator	13
OPERATION	
Frequency Control	13
60-Cycle Phasing	13
MAINTENANCE	
General	13
Preventive Maintenance	14
SERVICING AND ADJUSTMENTS	
Crystal Oscillator	14
Master Oscillator	15
7:1 Counter	15
EIA Standard Pulse Widths	17
Output Levels	18
Measuring Pulse Widths	18
Horizontal Sweep with Microsecond Markers	18
Linear Sweep Method, Horizontal and Vertical Pulses	18
Trouble Shooting	19
Test Jacks	19
Basic Multivibrator Circuits	19
Trouble Shooting Procedure	20
Counter Chain	20
Equalizing and Vertical Pulse Gates	21
Overall Stability Test	21
Automatic Frequency Control Circuits	21
IDENTIFICATION OF PARTS	21
PARTS LIST	22-25
DRAWINGS	26-31
	32-36

LIST OF ILLUSTRATIONS

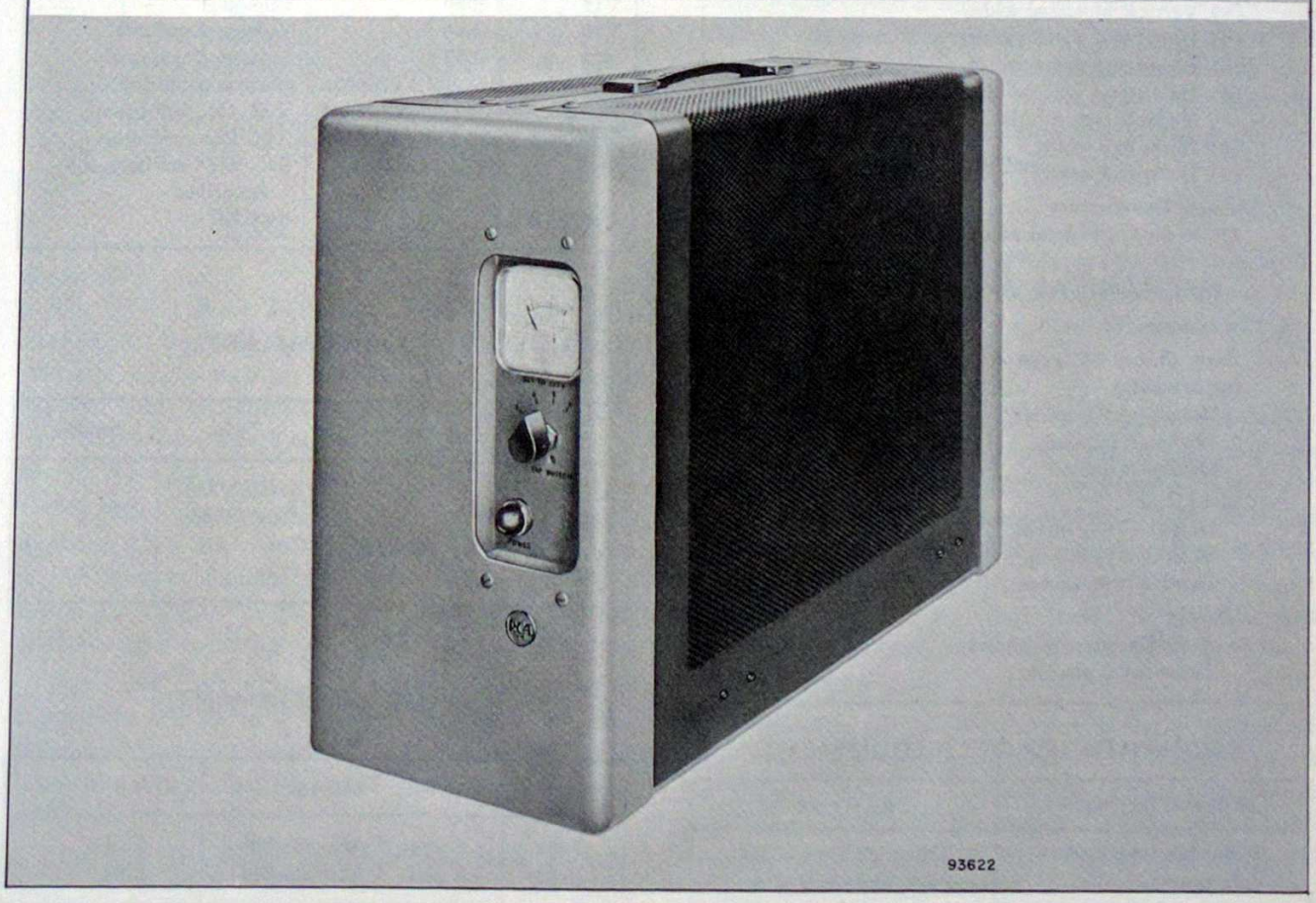
Figure		*Page*
1.	TG-21, TG-31 Sync Generators	5
2.	Schematic, Basic Multivibrator Circuit	8
3.	Horizontal Timing, Counter Chain	9
4.	Formation of EIA Sync Signal	10
5.	Master Oscillator Output at J102 (S201 in XTAL Position)	15
6.	7:1 Counter Output	15
7.	EIA Standard Signals	16
8.	EIA Blanking and Sync Signals	17
9.	Oscilloscope Markers for Pulse Width Measurement	18
10.	Linear Time-Base Method, Pulse Width Measurement	18
11.	TG-31 Field Sync Generator, Side Cover Removed showing Tube Location for TG-31 and TG-21	22
12.	TG-31 Field Sync Generator, Component Identification	23
13.	TG-21 Studio Sync Generator, Component Identification, Left Oblique view	24
14.	TG-21 Studio Sync Generator, Component Identification, Right Oblique view	25
15.	Diagram for Mounting Bracket-Adapter to Main Chassis	32
16.	Block Diagram, 60-cycle AFC Chassis	33
17.	Block Diagram, TG-21, TG-31 Sync Generator	34
18.	Schematic Diagram, TG-21, TG-31 Sync Generator	35, 36

LIST OF TABLES

Number	*Description*	*Page*
1	Voltage Connections for TG-21/TG-31	12
2	Wiring Connections for 190/240 volt AC Line (Studio Installation)	12
3	Pulse Width Adjustments and Controls	18
4	Test Jack Outputs	19
5	Basic Multivibrator Trouble Shooting Chart	19
6	Setting Counter Chain Stability, Using Oscilloscope	20
7	Counter Chain, Trouble Symptoms	21



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Figure 1—TG-21, TG-31 Sync Generators

TECHNICAL SUMMARY

ELECTRICAL SPECIFICATIONS

Input Power Requirements:

(1) 102/125 volts, 60 cycle, single phase, 250 watts.
(2) 190/240 volts, 60 cycle, single phase, 250 watts.

Outputs:

Horizontal Drive . . . 4-6 volts (not adjustable), 6.3 sec ±10%

Vertical Drive . . . . . 4-6 volts (not adjustable), 9H duration

Blanking . . . . . 4-6 volts (not adjustable), adjustable to standard EIA widths.

Sync . . . . . 4-6 volts (not adjustable), adjustable to standard EIA widths.

Burst Flag . . . . . 4-6 volts (not adjustable), adjustable in position and width.

All voltage negative and with a 75-ohm external load.

Frequency Control:

The master oscillator frequency may be controlled by setting the frequency control switch on the upper part of the chassis to one of the following positions:

(1) 60 cycle (power line)
(2) Crystal
(3) Free running

Adjustments provided for:

(1) Front porch
(2) Horizontal blanking width
(3) Vertical blanking width
(4) Horizontal drive width
(5) Equalizing pulse width
(6) Horizontal sync width
(7) Vertical sync width
(8) Burst flag width
(9) Burst flag delay

Ambient Temperature
25° to 50°C (without adjustment)

MECHANICAL SPECIFICATIONS

Dimensions

Basic chassis 60 cycles AFC (including rack mounting brackets)
Height—12¼ inches
Width—19 inches
Depth—9 inches

Field Case
Height—15½ inches
Width—8½ inches
Depth—21¾ inches

Weight
Basic Chassis—26 pounds
Case—13½ pounds

RECOMMENDED TEST EQUIPMENT

Equipment Description	*Reference*
Wideband Oscilloscope	Tektronic Type 524D
Voltohmyst	RCA, Type WV-97A

TUBE COMPLEMENT

Symbol	*Type*	*Function*
V1	12AT7/6201	Master Oscillator, 31.5 KC
V2A	6BQ7/6922	Buffer
V2B	6BQ7/6922	Hor. Dr. Amplifier
V3	12AT7/6201	3:1 Counter, 10,500 cps.
V4	12AT7/6201	5:1 Counter, 21,000 cps.
V5	12AT7/6201	7:1 Counter, 300 cps.
V6	12AT7/6201	5:1 Counter, 60 cps.
V7	6AW8A	Vert. Blanking, M.V.
V8A	1/2 5687	Blanking Mixer
V8B	1/2 5687	Hor. Drive Output Amplifier
V9	6AW8A	2:1 Counter, 15,750 cps.
V10	409A/6AS6	Sync Gate
V11	6922	Sync M.V.
V12A	1/2 6922	Vert. Sync. Width Gate
V12B	1/2 6922	7:5 H STOP
V13	6AW8A	Equal Pulse Gate (M.V.)
V14	6AW8A	Vert. Sync Gate (M.V.)
V15A	1/2 5687	Blanking Output Amplifier
V15B	6080	Vert. Drive Output Amp.
V16A	1/2 5687	Sync Output Amplifier
V16B	1/2 5687	Burst Flag Output Amplifier
V17A	6BQ7A	Burst Flag Generator
V17B	6BQ7A	Burst Flag Eliminator
V18A	1/2 6AW8A	Sync Amplifier
V18B	1/2 6AW8A	D.C. Amplifier
V19	6080	Regulator
V20	OA3	Voltage Regulator
V21	OA3	Voltage Regulator
V41A	1/2 12AT7/6201	60-cycle Amplifier
V41B	1/2 12AT7/6201	Vert. Dr. Amplifier
V42	12AX7/5751	AFC Discriminator
V43	12AT7/6201	94.5 KC Oscillator and Amplifier
CRYSTAL		94.5 KC

TUBE SUMMARY

Type	*Amount*	*Type*	*Amount*
12AT7/6201	7	12AX7/5751	1
6BQ7A/6922	4	6AS6/409A	1
6AW8A	5	6080	1
5687	3	OA3	2

FUSE COMPLEMENT

Symbol	*Type*	*Function*
F101	5 amp, 3 AG, Slo-Blo	Line
F102	5 amp, 3 AG, Slo-Blo	Line

EQUIPMENT LIST

SYNC GENERATOR TG-21 and TG-31

Quantity	*Description*	*RCA Reference*
1	Type TG-21 Monochrome Rack Mounted Sync Generator.....	ES-26986
	Including the following:	
	1, Basic Sync Generator 60 cycles AFC.....	MI-26171
	1, 12½ inch Rack Adapter	MI-26868
1	Type TG-21 Color Rack Mounted Sync Generator	ES-40986
	Including the following:	
	1, Basic Sync Generator 60 cycles AFC.....	MI-26171
*	1, 3.58 Subcarrier	MI-40431
	1, 12½ inch Rack Adapter	MI-26868
*	1, 3½ inch Rack Adapter (3.58 Subcarrier)	MI-26869
1	Type TG-31 Monochrome Field Sync Generator	ES-26987
	Including the following:	
	1, Basic Sync Generator 60 cycles AFC.....	MI-26171
	1, Field Case.....	MI-26172
1	Type TG-31 Color Field Sync Generator	ES-40987
	Including the following:	
	1, Basic Sync Generator 60 cycles AFC.....	MI-26171
*	1, 3.58 Subcarrier.....	MI-40431
	1, Field Case.....	MI-26172
*	Shock Mounting (for Field Unit)	MI-26511-A4

* These items are not supplied with the TG-21/31 Sync Generator; they are optional items which may be ordered separately.

DESCRIPTION

General

The TG-21 Rack Mounting Sync Generator and the TG-31 Portable Sync Generator have identical circuitry which includes a built-in regulated power supply. The basic chassis is the same for the Studio Sync Generator, ES-26986, and the Field Sync Generator, ES-26987.

The basic chassis MI-26171 is divided into two sections. They are the sync generator chassis which is the bottom section, and the 60-cycle automatic frequency control (AFC) chassis which is the top section. The two chassis are bolted together.

The Field Sync Generator chassis is mounted in a portable, all metal field case. See Figure 1. This same unit may be converted for studio use by using bracket adapters. See Figure 15 and top photograph of Figure 1.

The Sync Generator produces four basic signals. They are blanking, driving, synchronizing and burst flag signals. For monochrome television applications, the sync generator frequency is controlled by a 60-cycle power line, crystal oscillator or free-running oscillator. The monochrome sub-chassis utilizes an AFC system for comparing the frequency of the sync generator with that of the power line in order to generate the necessary correction voltage to control the master oscillator.

If color application is desired, a sub-chassis MI-40431, may be purchased on separate order. This unit is used in conjunction with the basic sync generator to supply a 3.58 megacycle output. This 3.58 megacycle output is also used to control the master oscillator frequency of the sync generator. The use of this sub-chassis with existing equipment requires no extra wiring. A twelve pin plug is disconnected from the 60-cycle AFC chassis and connected to the 3.58 sub-carrier chassis.

Field Sync Generator Construction

On the Field Sync Generator (TG-31) the output jacks and the AC inlet are located at the rear of the case (fig. 12). A line-voltage switch, meter, and pilot light are located on a recessed panel at the front of the case as shown in Figure 1. An interlock switch, which opens the line-voltage circuit when the wiring-side cover is removed, is located on the wiring side of the case. The plunger of the interlock switch is pulled up when it is desired to operate the unit with the cover removed. All operating controls are accessible when the tube-side cover is removed. The side cover is not interlocked.

Circuits

Reference to schematic diagram (fig. 18) and block diagram (fig. 17) will aid in understanding the theory of operation of the Sync Generator circuits.

Basic Multivibrator

The basic circuit (fig. 2) is a monostable multivibrator which uses a single dual triode and one germanium diode to obtain operation essentially independent of tube characteristics. This circuit is used for all counting and pulse generator applications. For some applications a pentode and triode are used in place of the dual triode tube. Operation of the multivibrator is as follows; all symbol numbers refer to Figure 2.

Without a trigger pulse present, the A section of the dual-triode is normally cut off and the B section is fully conducting. The cathode of the A section is held near ground potential by conduction in the crystal diode. These are the initial conditions in the multivibrator circuit.

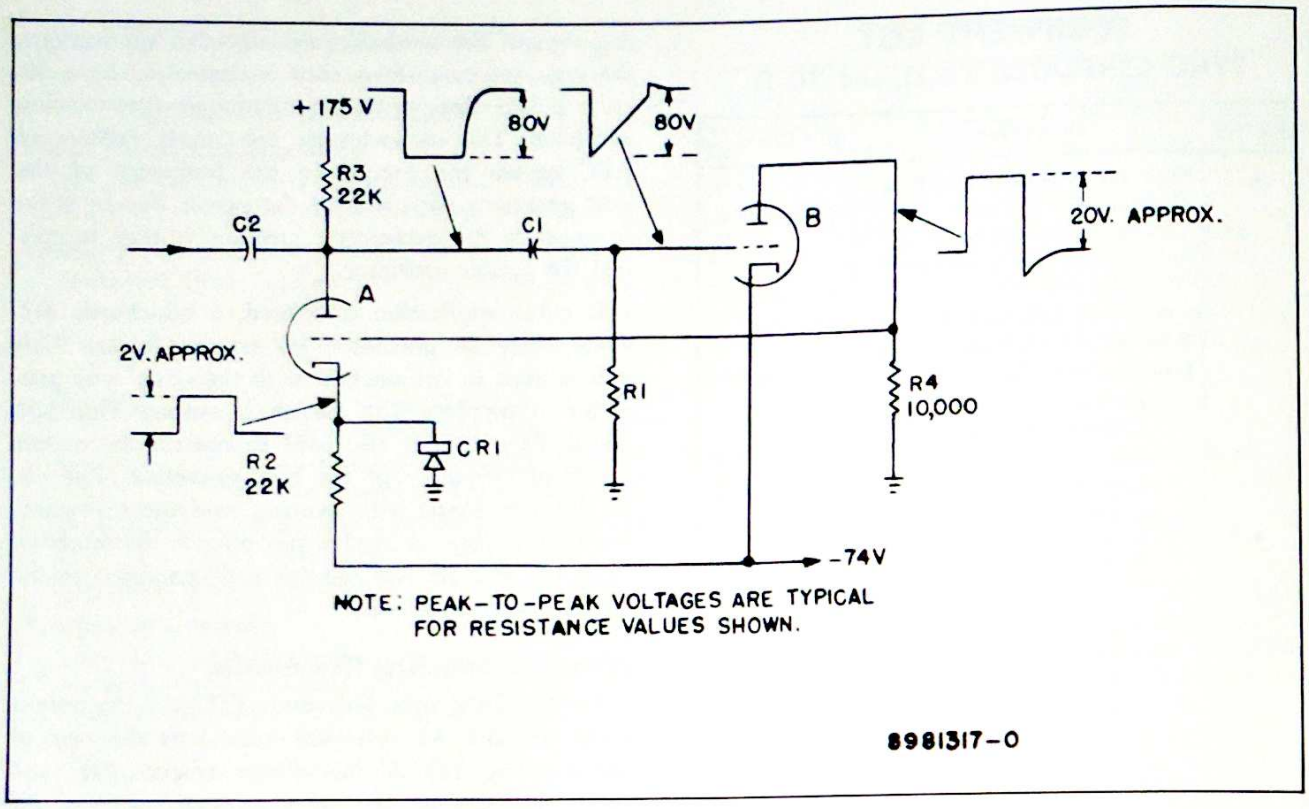


Figure 2—Schematic, Basic Multivibrator Circuit

The cycle starts as follows: a negative trigger pulse is applied through C2 to the plate of the A section, then coupled to the grid of the B section through C1. This drives section B to cutoff, and the voltage across plate resistor R4 rises from a negative value to exactly ground potential, thus setting up a predetermined level of conduction in the A section. This conduction level is determined by the cathode resistor, R2, because conduction in section A causes the cathode voltage to rise slightly, thus stopping conduction in the crystal diode.

The cathode current, whose value was established by R2, also flows through plate resistor R3 causing the voltage at the plate to drop by an accurately controlled amount. This voltage drop is transferred to the B section grid through C1, thus driving the B section well beyond cutoff. At this point C1 starts discharging through R1, heading for ground potential. This action continues until the grid voltage of the B section goes through the cutoff value. At this point, the tube starts conducting and returns the A section to its initial cutoff condition. This is the end of the timing cycle of the multivibrator. The circuit will remain in this condition until the next trigger pulse.

The duration of the timing cycle of the multivibrator depends on the time-constant R1-C1, and the initial voltage drop which was set up by the value of the cathode resistor in the A section.

This type of basic multivibrator can be used as a counter by operating it so that it runs for slightly less than the period of the number of input frequency cycles to be counted. This causes the multivibrator to stop when the proper count is reached, and the multivibrator is immediately re-triggered by the next impulse thus beginning a new timing cycle.

Master Oscillator

Basic 31,500 cycle timing pulses are generated by the master oscillator (multivibrator), V1. This circuit is a modification of the basic multivibrator circuit. The modification consists of a ringing circuit, 1C4-L101-1CR2, which allows free-running operation (no triggering pulse required). The oscillator circuit contains two frequency adjustments, C101 and R106. Capacitor C101 is used to set the frequency exactly on 31,500 cycles with R106 set to the midpoint of its range. Turning R106 from its center position to both ends of its rotation would now produce a plus and minus 5% variation in the free-running frequency of the master-oscillator. This variation in frequency is used for test purposes.

Counter Chain

The counter chain consists of a series of basic multivibrator circuits. One type of basic multivibrator

was previously described in detail. Pulses from the master oscillator V1, control the counter chain as follows:

The signal from the plate of V1, Figure 3A, which consists of positive 31,500 cycle pulses, goes to a buffer amplifier V2. The 2:1 counter V9 (15,750 cycles) and the horizontal blanking (fig. 3D) are triggered by the leading edge of the positive pulses from the cathode of V2, while the EIA synchronizing signals are triggered by the trailing edge this pulse, thus causing blanking to start ahead of sync by an interval determined by the setting of the front porch control, L101.

Negative pulses from the plate of V2 trigger the 3:1 counter V3, by using the leading edge of the master oscillator pulse. The trailing edge of the positive pulse from the plate of V3, triggers the next 5:1 counter V4. In the similar fashion, the 7:1 counter V5, and 3:1 counter V6, are triggered by pulses from the preceding counters. The output of the 60 cycle counter V6, is used simultaneously to trigger the vertical blanking multivibrator V7, and the vertical interval counters V13 and V14.

Frequency Control

The basic Sync Generator contains a 60-cycle power line AFC sub-chassis in which the master oscillator frequency may be controlled by setting the FREQ CONTROL switch to one of the following three positions:

1. 60-cycle
2. CRYSTAL
3. FREE-RUNNING

NOTE: For color applications the generator is supplied with both monochrome and color type sub-chassis, and selection of the desired mode of frequency control is accomplished by moving a plug to connect only the desired sub-chassis.

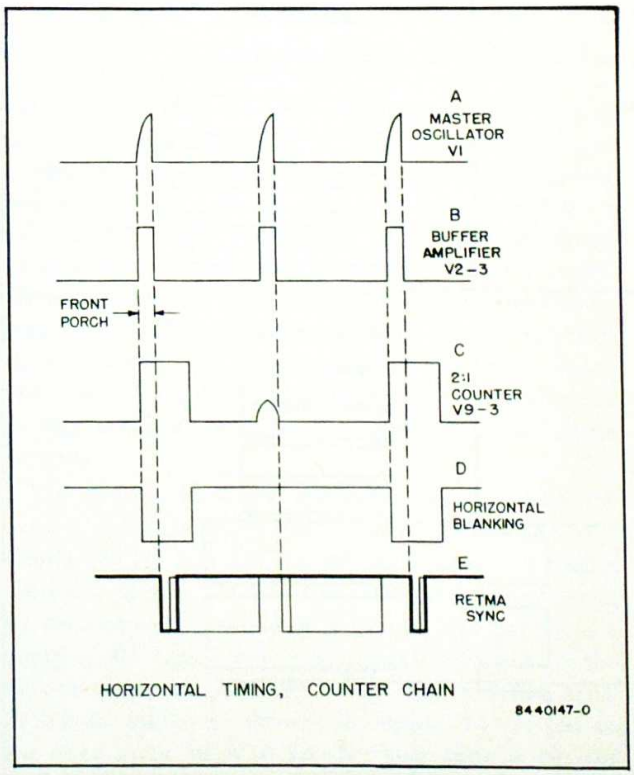


Figure 3—Horizontal Timing, Counter Chain

60-cycle (Automatic Frequency Control)

Refer to Figure 16, block diagram of 60-cycle AFC. In order to insure that the 60-cycle output from the Sync Generator is synchronous with the 60-cycle power line frequency, it is necessary to provide AFC control of the master oscillator. For this purpose the AFC discriminator V42, compares the 60-cycle vertical drive output pulse from J112 with a 60-cycle power frequency sine wave and develops a d-c control voltage which corrects the frequency of the master oscillator by means of the AFC control tube V43. The AFC discriminator tube V42, operates as an electronic switch between the 60-cycle sine-wave voltage and the output capacitor 42C3. The switch closes only during the vertical pulse, thus charging 42C3 to the voltage of the sine-wave at the instant that the vertical pulse appears. The 60-cycle vertical drive is amplified by one half of V41 and the sine-wave signal is amplified by the second half of V41. The input to the latter half of V41 is a 60-cycle sine-wave from the a-c heater voltage. The phase of this signal can be varied by adjusting R201.

Crystal Control

With S201 in XTAL position, V43 is connected as a crystal oscillator at 94.5 kc. The output from L201 couples through 43C3 and 1C1 to lock the master oscillator at 31,500 cycles. In this condition the master oscillator operates as a 3:1 counter. This type of frequency control is useful when the power line frequency is not reliable or accurate enough for operation of the television system, or as an accurate frequency standard for use in setting up the Sync Generator.

Free Running Position of S201

The position of S201 labeled FREE RUNNING allows the master oscillator to run free without any external synchronization. This position is useful primarily for testing purposes, although it may also be used for the same purposes as the CRYSTAL position.

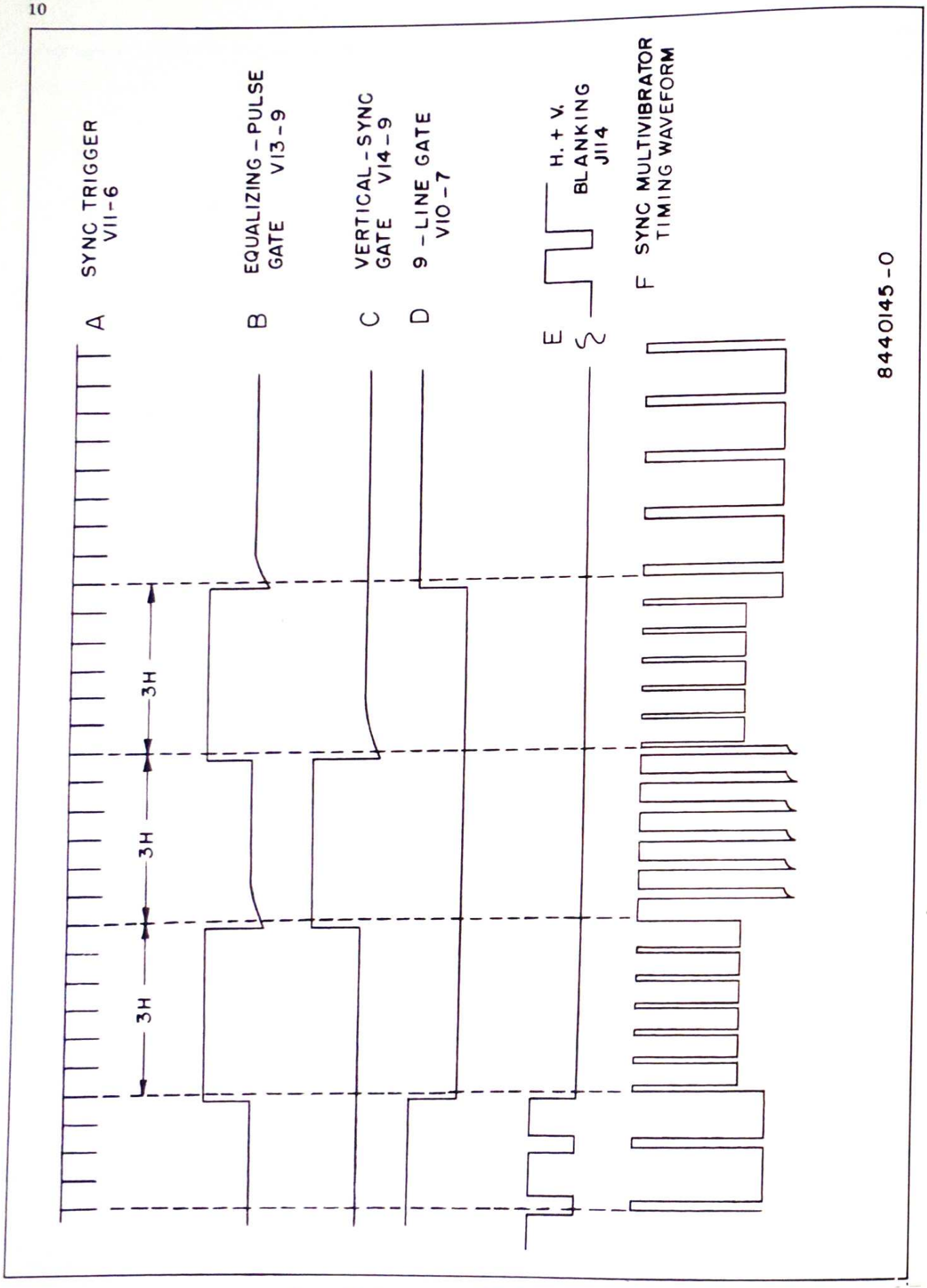


Figure 4—Formation of EIA Sync Signal

Blanking Signal

As previously mentioned, the 2:1 counter V9, is triggered from the leading edge of the master oscillator pulse applied to the cathode of V9-pin 1. The pulse form from the 2:1 counter at the plate of V9-pin 3 (see fig. 3) is controlled by the horizontal blanking width adjustment L102. The horizontal blanking from V10 pin 6, is fed to V15A where it is mixed with vertical blanking from V8 and clipped by diodes to produce composite blanking to drive the output stage. The blanking adjustment R101 should be adjusted to produce a clean composite blanking signal.

Driving Pulse

The pulse from V9 pin-9, is differentiated by C105 and 2R6, then clipped in V2 to produce horizontal driving pulses for output stage V8B. This pulse width is adjustable by the setting of the horizontal drive width control C105. The vertical driving signal is taken from the cathode of V13-pin 1 and clipped by CR108 and drives the output stage V15B. The vertical driving width is fixed at 9H duration.

EIA Sync Signal

The vertical interval counter generates two gating signals for control of pulse widths in the sync-signal multivibrator, V10-V11. These gates occur during the first nine horizontal lines following the start of the 60-cycle vertical-blanking pulse. Each gate pulse has a duration of 3H (three horizontal lines). Two stabilized multivibrators, V13 and V14, are connected so that they are triggered by the output of the 60-cycle counter V6, and then trigger one another to produce the gates for equalizing pulses and vertical sync. These gates are shown on Figure 4-B and 4-C. The "7.5 H stop" tube V12B, produces an approximate timing signal to stop the gate multivibrators after the three 3-line cycles have been completed. A 10,500-cycle signal from the 3:1-10,500-cycle counter, V3, is coupled to the two multivibrators, through 3CR2, to stop the multivibrator timing cycle at exactly the end of each 3-line interval.

The outputs from the vertical interval counter are used to drive the pulse width control tube V12A and diodes 11CR3 and 13CR2, of the sync signal multivibrator. Mixing of the two vertical interval gates by the common cathode of V13 and V14 produces a positive 9H signal which is clipped and fed to the vertical drive output tube V15B. The vertical drive of 9-line widths as shown on Figure 4-D is fed to the suppressor of V10 so that this tube is cut off during the vertical interval. At other times the grid of V10 receives a negative horizontal blanking signal, and between blanking pulses its plate shunts the sync multivibrator such that it is only possible to trigger the sync-signal multivibrator during horizontal blanking. Therefore, the 31,500-cycle trigger pulses which are fed to the sync multivibrator are effectively "notched," that is, only the trigger occurring during the horizontal blanking signal produces a sync pulse. However, the notching action is not required during the 9-line vertical interval when all sync pulses must recur at 31,500 cycles. Thus the action of the 9-line gate to cut off V10 during this time serves to switch the pulse rate to 31,500 cycles.

The sync signal multivibrator itself comprises V10 and V11. The plate of V11 is triggered by 31,500-cycle pulses from the cathode of V2. The stabilization circuit in the cathode of V11 is arranged so that conduction in 13CR2 reduces the amplitude of the multivibrator timing waveform to produce the equalizing pulses, and conduction in V12A greatly increases the amplitude of the timing waveform to produce the relatively wide vertical sync serrated pulses. The timing waveform of the sync multivibrator is shown in Figure 4-F.

The sync multivibrator timing waveform is clipped and amplified by the sync output stage V16A.

Burst Flag

The sync signal from the sync output tube V16A is fed to and amplified by V18A. After differentiation, the signal from V18A drives V17A to generate the burst flag time pulses which are eliminated during the vertical drive by applying positive 9H pulses from V13-1 to the grid of V17 (pin-7). The delay and width of the burst flag are controlled by C109 and R116 respectively. These pulses are only used in color applications.

Power Supply

The power supply for the Sync Generator includes six diodes (CR101 to CR106) a series regulator (V19) and a d-c amplifier (V188) and two shunt regulators, V20 and V21. The circuit regulates both positive and negative voltages against line-voltage variations. Normal operating voltages are minus (—) 74 and plus (+) 175.

INSTALLATION

General

Upon receipt of the equipment, the unit should be unpacked and inspected for any damage that may have occurred during shipment. Shipping lists should be checked to insure that all quantities are correct.

Before attempting to put the equipment into operation in the system, it is necessary to make preliminary adjustments and to determine the operating

status of the unit in order to locate any de-rangements caused by shipping.

Terminations and Output Levels

Sync, horizontal drive, vertical drive, burst flag, and blanking outputs are not internally terminated with 75 ohms. If an external 75-ohm termination is used, 4 to 6 volts output is available.

Studio Installation

The chassis must first be mounted to the 12½ inch rack Adapter, see Figure 15. Then proceed to install the Studio Sync Generator ES-26986, as follows:

1. Mount the chassis in a standard 19-inch rack.

2. Plug in the crystal.

3. (A) For 102/125 volt-60 cycle line, connect the a-c line to terminals 8 and 7 on the eight conductor plug. Also connect a jumper between terminal 6, and depending on the full-load line voltage, to either one of the terminals shown in the tabulation of Table 1A.

TABLE 1—CONNECTIONS FOR TG-21/31

(A) 102/125 V-60 cycle Pwr. Line	
Line Voltage	*Jumper Required*
102	6 - 2
109	6 - 3
117	6 - 4
125	6 - 5
(B) 190/240 V-60 cycle Pwr. Line	
Line Voltage Tap	*Jumper Required*
190	6 - 2
205	6 - 3
220	6 - 4
240	6 - 5

3 (B). For use on 190/240 volts 60-cycle AC line, connection from T101 to J115 should be rewired as shown in Table 2. The sync generator is normally wired for operation on 102/125 volts, 60-cycle lines.

Connect the AC line wires to terminals 8 and 7 on the 8-conductor plug. Also connect a jumper between terminal 6 and depending on the full load-line voltage to either one of the terminals shown in Table 1B.

4. Set the ON-OFF switch (S101) to the OFF position. Then insert the plug into J115 on the Sync Generator. The 8-conductor plug is now wired for local operation.

5. Using the four coaxial connectors and adaptors, connect the SYNC, HOR DR, VERT DR, and BLANKING cables in accordance with the station plan. The coaxial cable is not supplied with the Sync Generator but may be purchased in bulk from RCA. Note, Burst Flag is needed only for color application.

6. Turn on the switch which supplies a-c power to the sync generator, then place the ON-OFF switch of the generator in the ON position. The studio Sync Generator is now ready for INITIAL ADJUSTMENTS which are described later in this section.

TABLE 2—WIRING CONNECTIONS, STUDIO INSTALLATION FOR 190/240 AC LINE

Wire	*Remove From*	*Connect To*
J115-5 to T101-5	T101-5	T101-9
J115-4 to T101-4	T101-4	T101-8
J115-3 to T101-3	T101-3	T101-7
J115-2 to T101-2	T101-2	T101-6

Field Installation

Prior to initial installation of the Field Sync Generator, it is usually more convenient to prepare and perform initial adjustments in the studio. To prepare the generator in the studio proceed as follows:

1. Remove the side covers by rotating the fasteners (located at the top edge of the covers) a quarter turn. Then lift the cover from the bottom of the case.

> NOTE: It is important that the cover be lifted straight upward so that it clears the bottom of the case. This avoids damaging the spring-clips which are mounted on the reverse side of cover.

2. Plug the crystal into the socket located on the tube side of the chassis. Make certain that all the tubes are tight in their sockets.

3. Place the LINE VOLTAGE switch, located at the front end, in the OFF position. The POWER switch located on the tube side of the chassis is inoperative on this unit.

4. Connect the power cord to the power input receptacle with a 115-volt power line.

5. Terminate the outputs with 75-ohm terminations. Under these conditions, the unit is capable of delivering 4-6 volts peak-to-peak output.

6. Center and pull up the plunger of the interlock switch at the top of the case on the wiring-side of the chassis.

7. Turn the LINE VOLTAGE switch clockwise until the pointer on the meter indicates at the middle heavy-line on the meter scale. Allow the unit to warm up for a few minutes, perform the INITIAL ADJUSTMENTS described under the heading which follows, then replace the two side-covers.

Initial Adjustments (Studio and Field)

1. Check +B voltage and adjust to +175 volts if necessary.

2. Check the frequency of the master oscillator as described in the MAINTENANCE section.

3. Check counter-circuit operation as described in the TROUBLE SHOOTING portion of the MAINTENANCE section.

4. Check adjustment of the pulse widths and readjust if necessary as described in the MAINTENANCE section.

5. Check output levels.

Installation of Shockmounts for TG-31, Field Sync Generator

Shockmount assemblies, 26511-A4, are for use when the Field Sync Generator is installed in mobile units or when located where shock or vibration may affect the life or operation of the units. To attach the shockmount to the case, engage the holes in the lower back edge of the case with the spring-actuated pins on one end of the shockmount. Then engage the slotted plates on the thumbscrews, on the other end of the shockmount, with the extended lugs on the lower front edge of the case.

OPERATION

Unless otherwise indicated, operation of the TG-21 Studio Sync Generator is the same as the TG-31 Field Sync Generator. To place the Studio Sync Generator in operation, place the POWER switch to the ON position.

To place the Field Sync Generator in operation, turn the LINE VOLTAGE RAISE switch to the position that will cause the meter indicator to read on the middle heavy-line on the meter scale. The power switch located on the tube side of the chassis is inoperative on this unit.

It is advisable to apply power to the Sync Generator at least 30-minutes prior to the start of the program. This allows the equipment to warm up. The equipment should not be shut off unnecessarily once it has been turned on.

Frequency Control

Position of the FREQ CONTROL switch, S201, determines the method of frequency control for the master oscillator.

1. 60-cycle oscillator controlled by power line.
2. XTAL—Crystal controlled.
3. Free Running (no control).

60-Cycle Phasing

The 60-cycle phasing control is used only for film programs. For that application, this is used to adjust the vertical driving signal for the camera so that it is in phase with the projector. Otherwise the phasing control should be set at its mid-range.

MAINTENANCE

WARNING

THE VOLTAGES EMPLOYED IN THIS EQUIPMENT ARE SUFFICIENTLY HIGH TO ENDANGER LIFE. EVERY REASONABLE PRECAUTION HAS BEEN OBSERVED TO SAFEGUARD MAINTENANCE PERSONNEL. POWER SHOULD BE REMOVED COMPLETELY BEFORE MAKING INTERNAL REPAIRS. MAKE CERTAIN POWER IS OFF AND CAPACITORS ARE DISCHARGED BEFORE TOUCHING ANY COMPONENT. BE VERY CAREFUL WHEN TOUCHING TUBES. A SERIOUS BURN CAN RESULT FROM CARELESSLY TOUCHING TUBES THAT HAVE BEEN IN OPERATION FOR A CONSIDERABLE LENGTH OF TIME.
WHEN MAKING RESISTANCE MEASUREMENTS, TURN POWER OFF.
WHEN TESTING VOLTAGES WITH THE INTERLOCK SWITCH BYPASSED, USE WELL-INSULATED TEST PROBES.

General

The sync generator has been conservatively designed for continuous operation. With ordinary care a minimum of service will be required to keep the equipment in satisfactory operation. To avoid interruptions due to equipment failure during operation, a regular schedule of inspection should be established.

Since the field equipment will probably be subjected to conditions of excessive dust and moisture by reason of its use in the field, a periodic inspection routine should be established to assure the removal of dust and other extraneous substances that may cause leakage or arc-over between high-potential points. The unit should be cleaned and dusted thoroughly during inspection periods. All terminal boards, should be kept free of dust. The studio sync generator requires less frequent cleaning.

All cable connections should be checked periodically and tightened when necessary. Make certain all ground connections are tight. A spare set of

cables will facilitate cable maintenance. When fuses are renewed, the fuse cartridge caps should be clean to insure good contact and to prevent fuse heating due to contact resistance.

When improper operation is experienced, make certain all controls are properly adjusted. This is the most frequent cause of improper operation. The use of elaborate test equipment is not always a necessity if correct trouble-shooting procedure is followed. The cause of faulty operation may often be detected by visual inspection of wiring and components. The amplitude and pulse widths of the output signals should be checked periodically, as aging of tubes may cause small variations.

The most effective way of assuring continuous satisfactory operation of the equipment is to initiate a regular schedule of maintenance. All performance data should be recorded on previously-prepared forms so that a continuous record of all parts of the equipment will be available. A suggested schedule follows:

Daily

Note any abnormal conditions such as position of knobs. A general inspection should be made immediately after shut-down. Check for signs of overheating in all parts of the equipment.

Weekly

Clean internal and external parts of the equipment. Inspect and tighten all cable connections. Check adjustment of the equipment controls and readjust if necessary.

Monthly

Check all tubes in the equipment noting the tube tester readings on previously-prepared forms. Record and compare all cable socket voltages. As far as possible, tube failure should be anticipated by keeping a log of tube life. Spare tubes should be available for immediate use in the event of an obvious failure.

Preventive Maintenance

To determine how far the sync generator has degraded from its nominal operating condition, perform the following tests:

1. Apply power to the sync generator; place the FREQ CONTROL switch, S201, in the FREE Running position and allow the unit to warm up for approximately 15 minutes.

2. Connect the S (sync) output of J113 to the vertical input of an oscilloscope, then add BL (blanking) by connecting a jumper from J113 and J114.

3. Use external synchronization for the oscilloscope by connecting a lead from the vertical drive jack, J112, on the sync generator to the external-synchronization input of the oscilloscope. Adjust the oscilloscope synchronizing control to obtain a stable pattern showing two cycles of the 60-cycle sync generator output.

4. Observe the oscilloscope waveform while turning R106, Figure 11, throughout its range. Watch for erratic behavior or jumping of pulses in the vertical interval. Note the position of the potentiometer slot (with reference to midrange) at which the waveform shows any instability, then return the slot to midrange. The results of this test are interpreted as follows:

a. If the waveform is stable throughout the rotation of R106, the sync generator is adjusted for nominal operation and there has been no appreciable degradation of components.

b. The degree of stability is indicated by how close the potentiometer can be moved to either extreme end of its rotation without causing erratic behavior or jump in the waveform. That is, the closer the potentiometer is moved towards the end of its rotation before instability occurs, the longer the period of time that the sync generator can be expected to operate without a failure caused by deterioration of components (sudden failure of components excepted).

If desired, the sync generator can be placed in nominal operating condition as explained under the heading "TROUBLE SHOOTING PROCEDURE."

SERVICING AND ADJUSTMENTS

This group of service adjustments must be done in the following order:

1. Crystal Oscillator
2. Master Oscillator
3. 7:1 Counter

Crystal Oscillator

Adjust the crystal oscillator as follows:

1. Apply power to the sync generator, then place the FREQ CONTROL switch in the XTAL position.

2. Connect a low capacity probe of an oscilloscope across the crystal terminals of the crystal, Y201.

3. Adjust the core of the crystal-oscillator coil, L201, for maximum signal indication on the oscilloscope, then turn the core of the coil in the counterclockwise direction until the voltage drops to one-third of its maximum value.

Master Oscillator

In order to properly check counter chain operation, the master oscillator frequency must be within ±1% of its nominal value of 31.5 kc. However, the sync generator will usually operate properly if the oscillator is within ±3%.

To adjust the master oscillator, use one of the following procedures:

Using an oscilloscope with a triggered sweep, such as RCA Type TO-524-D:

1. Apply power to the sync generator, place the FREQ CONTROL switch, S201, in the XTAL position, then allow the unit to warm up for approximately 15 minutes.

2. Place R106, Figure 11, in the center of its range. This is accomplished by turning the screwdriver slot of the potentiometer so that it is parallel to the direction of the terminal boards on the chassis.

3. Connect the vertical input of the oscilloscope to the 31.5 kc test jack, J102. See Figure 11. Using internal oscilloscope synchronization with a triggered sweep, synchronize the pattern so that at least two square waves appear on the screen.

Count the number of sine-wave cycles that are present between the two square waves. The number should be three, as shown in Figure 5. If a different number of cycles appear, adjust C101, Figure 14, until the oscilloscope display is similar to that of Figure 5.

4. Turn the FREQ CONTROL switch to the OFF position, then carefully synchronize the pattern so that 1½ cycles of the waveform occur over the entire sweep trace. To insure that the waveform will remain stationary when the master oscillator frequency is changed by turning R106, set the synchronizing controls on the oscilloscope at the center of their range.

Horizontally expand the negative pulse which appears just to the right of the center of the sweep trace. Then line-up an edge of the expanded pulse with one of the calibrations on the oscilloscope scale.

5. Turn the FREQ CONTROL switch, on the sync generator, back and forth from the XTAL to the OFF position, and observe the horizontal position of the pulse edge.

If the horizontal position of the pulse edge does not change, the master oscillator frequency is correct. If the pulse does move, adjust C101 and recheck until it is stationary when the FREQ CONTROL switch is moved from the XTAL to the FREE RUN position.

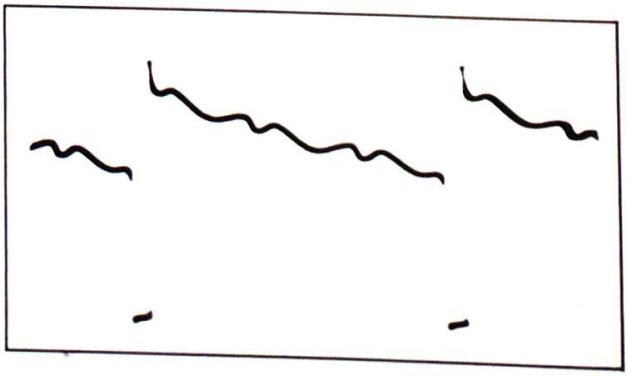


Figure 5—Master Oscillator Output at J102 (S201 in XTAL Position)

7:1 Counter Test and Adjustment

NOTE: Make certain that the master oscillator has been properly adjusted as described under the preceding heading before proceeding with this test or adjustment.

1. Check operation of the 7:1 counter as follows:

a. With the sync generator in operation, set the FREQ CONTROL switch to the OFF position, then connect the vertical-input cable of an oscilloscope across the 300-cycle test jack, J105.

b. Using the internal sweep of the oscilloscope, synchronize the sweep to obtain two complete square waves as shown on Figure 6.

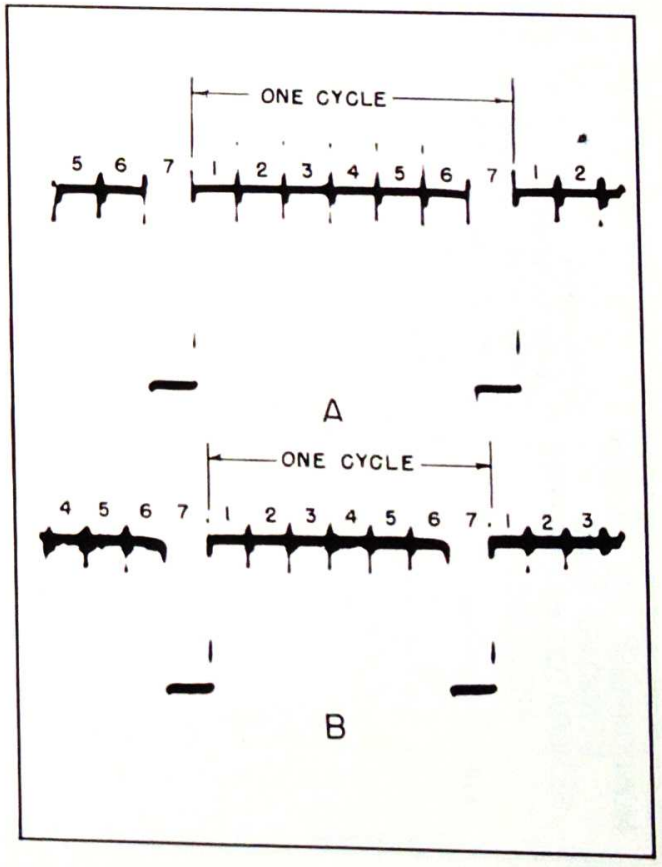
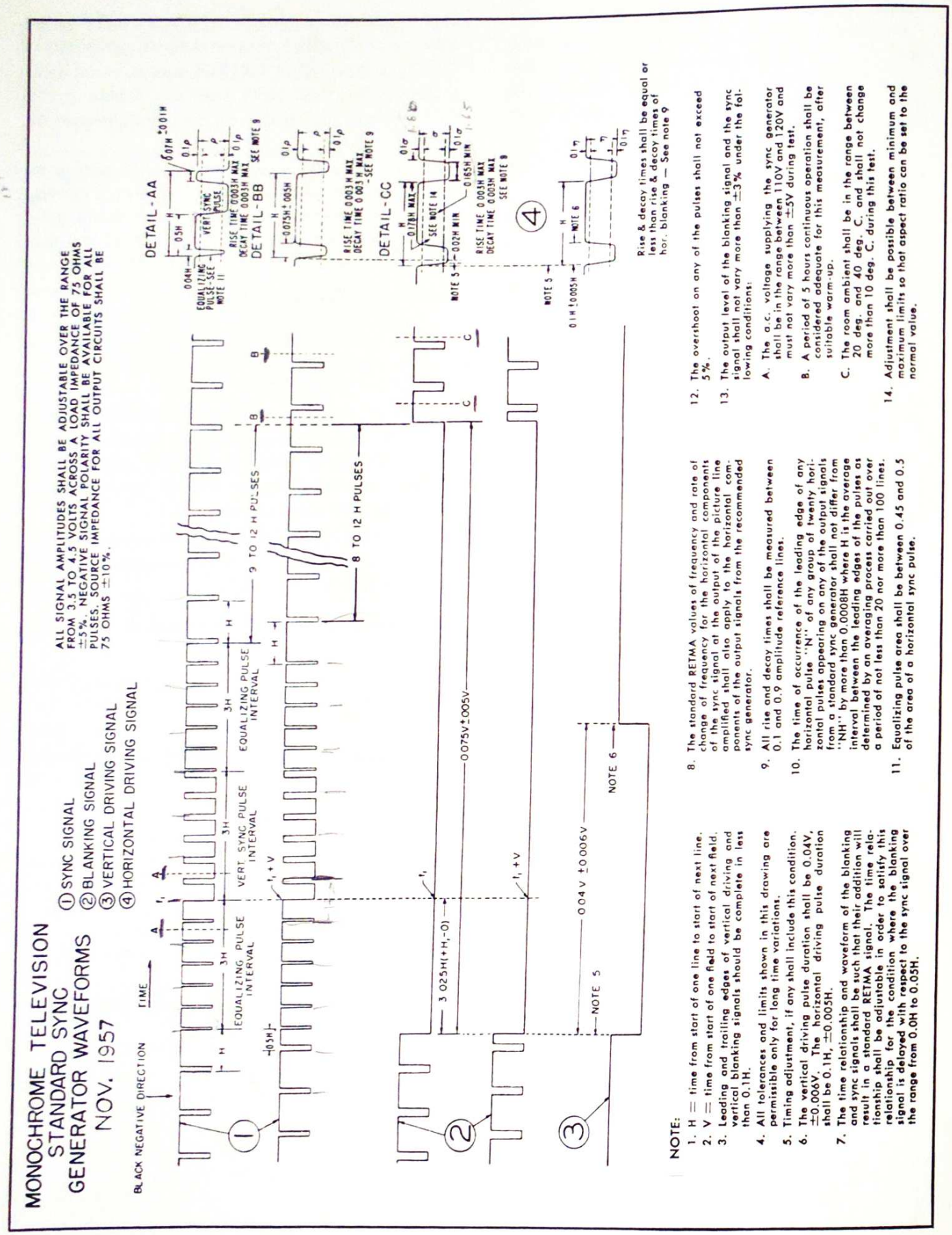


Figure 6—7:1 Counter Output



NOTE:

1. H = time from start of one line to start of next line.
2. V = time from start of one field to start of next field.
3. Leading and trailing edges of vertical driving and vertical blanking signals should be complete in less than 0.1H.
4. All tolerances and limits shown in this drawing are permissible only for long time variations.
5. Timing adjustment, if any shall include this condition.
6. The vertical driving pulse duration shall be 0.04V, ±0.006V. The horizontal driving pulse duration shall be 0.1H, ±0.005H.
7. The time relationship and waveform of the blanking and sync signals shall be such that their addition will result in a standard RETMA signal. The time relationship shall be adjustable in order to satisfy this relationship for the condition where the blanking signal is delayed with respect to the sync signal over the range from 0.0H to 0.05H.
8. The standard RETMA values of frequency and rate of change of frequency for the horizontal components of the sync signal at the output of the picture line amplifier shall also apply to the horizontal components of the output signals from the recommended sync generator.
9. All rise and decay times shall be measured between 0.1 and 0.9 amplitude reference lines.
10. The time of occurrence of the leading edge of any horizontal pulse "N" of any group of twenty horizontal pulses appearing on any of the output signals from a standard sync generator shall not differ from "NH" by more than 0.0008H where H is the average interval between the leading edges of the pulses as determined by an averaging process carried out over a period of not less than 20 nor more than 100 lines.
11. Equalizing pulse area shall be between 0.45 and 0.5 of the area of a horizontal sync pulse.
12. The overshoot on any of the pulses shall not exceed 5%.
13. The output level of the blanking signal and the sync signal shall not vary more than ±3% under the following conditions:
    A. The a.c. voltage supplying the sync generator shall be in the range between 110V and 120V and must not vary more than ±5V during test.
    B. A period of 5 hours continuous operation shall be considered adequate for this measurement, after suitable warm-up.
    C. The room ambient shall be in the range between 20 deg. and 40 deg. C. and shall not change more than 10 deg. C. during this test.
14. Adjustment shall be possible between minimum and maximum limits so that aspect ratio can be set to the normal value.

Figure 7—EIA Standard Signals

c. Turn R106 throughout its range while observing the count as indicated by the number of spaces between pips for one cycle as shown on Figure 6. RESET THE SCREWDRIVER SLOT OF R106 SO THAT IT IS PARALLEL TO THE TERMINAL BOARDS (MIDRANGE). If the count remains at seven throughout the range of R106, the 7:1 counter is properly adjusted. When necessary, readjust the counter as described in step 2.

The oscilloscope pattern may change when the shaft of R106 is turned so that the pips are positioned as shown on Figure 6B. It is also possible that the pattern may become unstable because the oscilloscope drops out of synchronization. If this occurs, readjust the oscilloscope synchronization. Should this fail to produce a stable pattern, the 7:1 counter requires readjustment as explained in step 2.

2. If the preceding test indicates that the 7:1 counter requires adjustment, proceed as follows:

a. Set the slot of R106 so that it is parallel to the terminal boards (midrange) then adjust R149 until the count reaches seven as shown on Figure 6A or 6B.

b. Repeat the "R106 test" described in step 1c. Readjust R149 if necessary, until the requirements of step 1c are met.

EIA Standard Pulse Widths

Pulse width adjustments should be periodically checked and corrected if necessary. The standard EIA sync generator waveforms are shown on Figure 7. Several suggested methods for pulse width are described under the heading "MEASURING PULSE WIDTH" in this section.

Adjust the pulse widths as follows:

1. Insert 75-ohm termination plugs into all output jacks.

2. Apply power to the sync generator and allow at least 15 minutes for the equipment to warm up.

3. Connect the vertical input terminals of an oscilloscope to the sync output jack, J115.

4. Connect a clip lead or jumper between the blanking output jack, J114, and the sync jack, J115, then adjust the oscilloscope to obtain the waveform shown on Figure 8.

5. With the same setting of the oscilloscope triggering and Sweep-time, remove the input probe from Sync and Blanking to Burst Flag output. The latter will be displayed as shown in the dotted line in Figure 8.

6. Using any desired method for measuring pulse width (see MEASURING PULSE WIDTH) adjust the applicable controls for the EIA standard pulse widths. (See Table 3.)

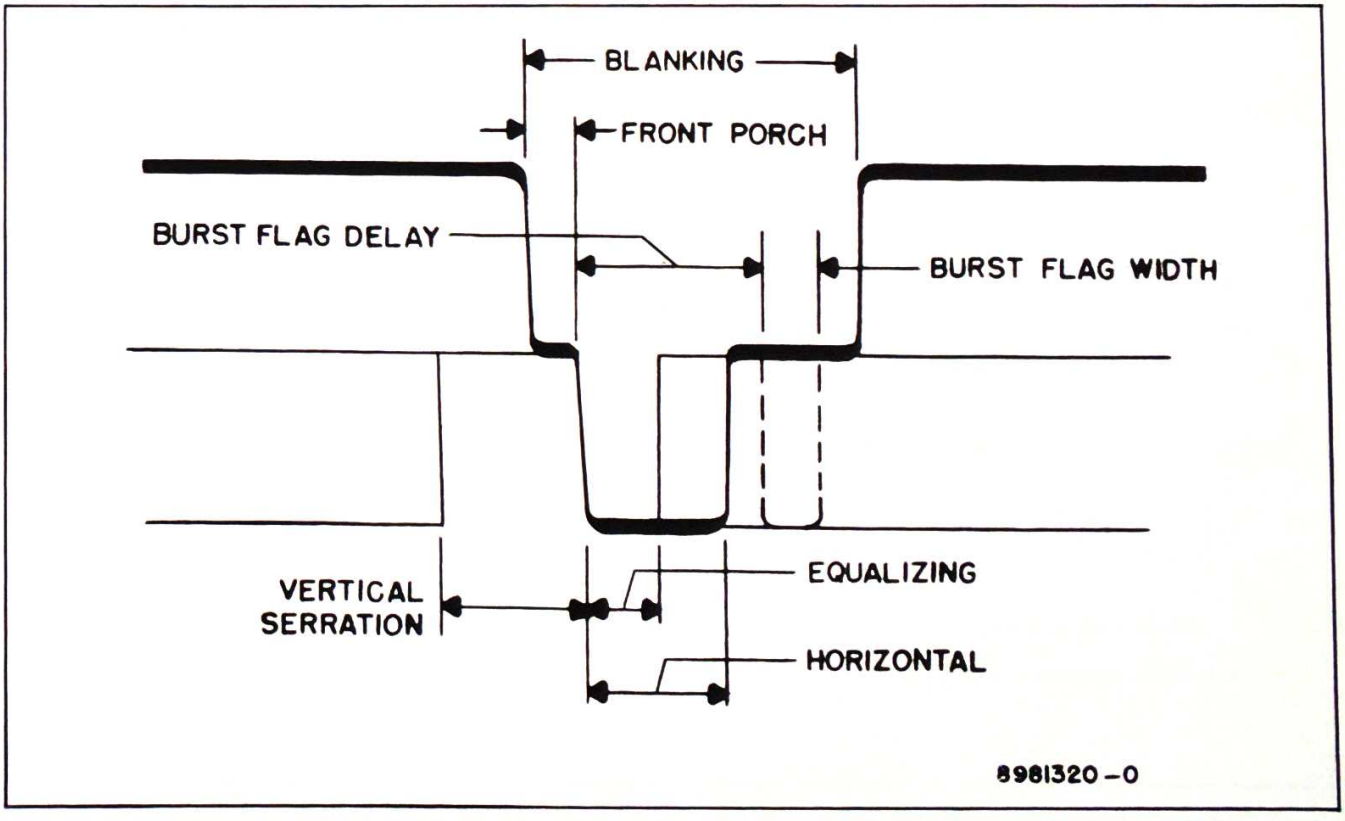


Figure 8—EIA Blanking and Sync Signals

NOTE: H = Time from start of one line to the start of the next line or 63.5 microseconds. V = 1/60 second. Pulse widths are measured at points shown on Figure 7 (10% below maximum amplitude).

7. After adjustments, lock all controls which are equipped with lock nuts.

TABLE 3—PULSE WIDTH ADJUSTMENTS AND CONTROLS

Pulse (See Notes)	*Width*	*Micro-seconds*	*Applicable Control*
Equalizing	4.0%H	2.54	R109
Horizontal Sync	7.5%H	4.76	R111
Horizontal Blanking	17.5%H	11.0	L102
Vertical Sync Serrations	7.0%H	4.45	R108
Vertical Blanking	19.7%H	1250	R107
Front Porch	2.5%H	1.6	L101
Horizontal Drive	10%H	6.4	C105
Vertical Drive	9%H	572	Fixed
Burst Flag Width	3.75%	2.38	R116
Burst Flag Delay (From Front Porch)	8.25%	5.25	C109

NOTE: 1. Adjust pulses in the order given above.
2. Prior to adjusting sync pulses, check the blanking output to see that the horizontal and vertical blanking pulses have the same height, and that no other pulse occurs during vertical blanking. If not, adjust Blanking Adjustment R101.

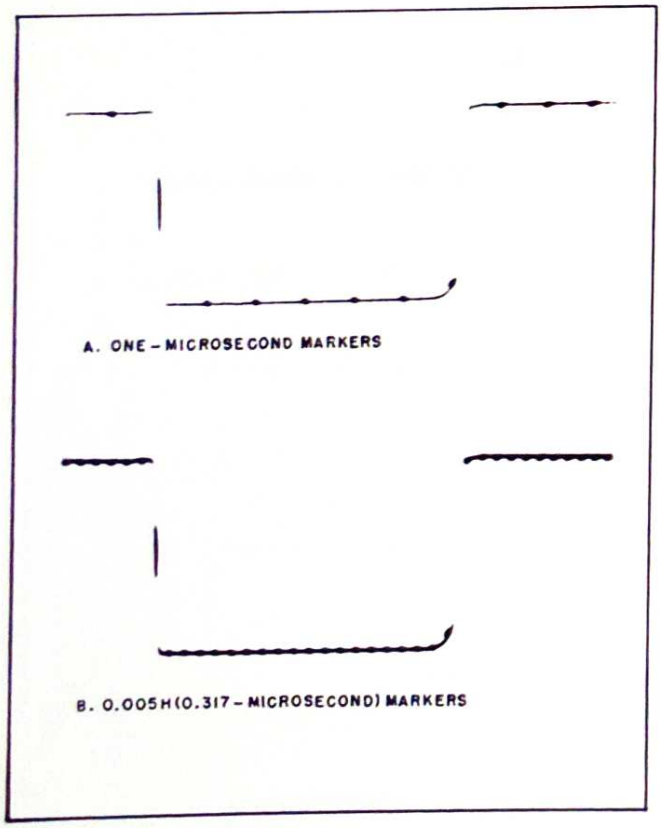


Figure 9—Oscilloscope Markers for Pulse Width Measurement

Output Levels

The signal output levels are not adjustable. With 75-ohm external terminations, 4 to 6 volts is available from each output.

Measuring Pulse Width

An accurate and convenient method of measuring 31,500 and 15,750-cycle pulse widths involves the use of the RCA Type TO-524-D Oscilloscope, or equivalent, which has a horizontal sweep on which it is possible to place markers.

Horizontal Sweep With Microsecond Markers

Using either internal or external oscilloscope syncronization, adjust the synchronizing control until a one-microsecond marker lines up with the leading edge of the pulse which is being measured. The width of the pulse is determined by counting the number of microsecond markers that appear on the pulse. See Figure 9A.

In order to reduce the interpolation errors when the trailing edge of the pulse occurs between markers, use the 0.1-microsecond markers that are available on the RCA Type TO-524-D Oscilloscope. First count the one-microsecond markers up to and including the last marker within the pulse, mark the position of the last marker, switch to the 0.1-microsecond markers, then count the number of markers from the mark on the screen to the end of the pulse. The pulse width is the sum of the two measurements.

Figure 9B shows 0.005 H (0.317 microseconds) markers, which are available on the TO-524-D Oscilloscope, superimposed on the same pulse as Figure 9A.

Linear Sweep Method — Horizontal and Vertical Pulses

This method is usually less accurate than the method previously described, but can be used to measure both horizontal and vertical sync pulses. The oscilloscope MUST HAVE A LINEAR time base. Accuracy depends on the linearity of the time base.

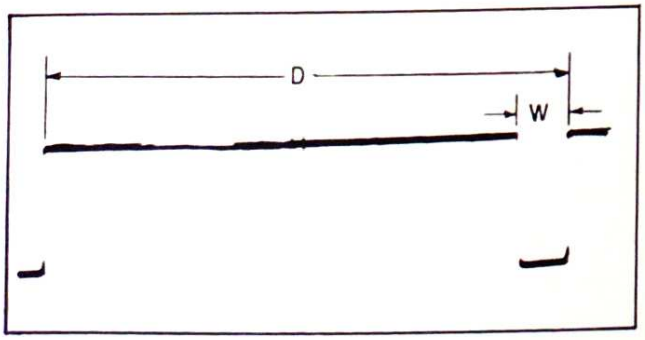


Figure 10—Linear Time-Base Method, Pulse Width Measurement

Adjust the oscilloscope to show several cycles of the pulse to be measured. Measure the distance between corresponding points on two adjacent pulses, then measure the width of the pulse. See Figure 10. Calculate the percent width by the following formula:

$$\text{Percent Width} = \frac{W}{D} \times 100$$

W = Pulse Width
D = Distance between corresponding points on two adjacent pulses.
Percent Width = Percent of H or V
H = 63.5 microseconds
V = 1/60 second

It is usually more accurate to use the first cycle for these measurements. A millimeter scale is convenient to use in order to avoid large fractions.

Trouble Shooting

Although the sync generator contains 24 tubes, there are no difficult trouble shooting problems involved. Maintenance personnel will find that the illustrations in this instruction book generally pertain to trouble shooting.

The block diagram, Figure 17, schematic diagram, Figure 18, and the photographs showing component parts, will aid in trouble shooting and identifying components in the sync generator. THE SCHEMATIC DIAGRAM INCLUDES D-C VOLTAGES, WAVEFORMS, AND PEAK-TO-PEAK A-C VOLTAGES.

With the exception of POWER switch S3, all the controls and test jacks are accessible from the tube side of the chassis.

Test Jacks

The Test Jacks which are available are listed in Table 4.

TABLE 4—TEST JACK OUTPUTS

Tube-Side Designation	*Wiring-Side Designation*	*Output From*
94.5	J202	Crystal controlled oscillator, 94.5KC, J43 across L201
31.5	J102	Master Osc. (31.5KC), V1-3 across 10,000 ohms
15.75	J107	2:1 Counter (15,750), V9-1 across 100 mmf.
10.5	J103	3:1 Counter (10,500), V3-3 across 22,100 ohms
2100	J104	5:1 Counter, V4-3 across 22,100 ohms
300	J105	7:1 Counter, V5-3 across 22,100 ohms
60	J106	3:1 Counter, V6-3 across 22,100 ohms
9H*	J108	Equalizing-pulse gate V13-1 and Vertical Sync gate V14-1.

* 9H = 571.5 microseconds.

Basic Multivibrator Circuits

The following tubes use the basic multivibrator circuit (fig. 2) V3, V4, V5, V6, V7, V13, and V14. Tubes V13 and V14 are triode-pentode type 6AW8A. The others are dual triode type 12AT7. In addition to these multivibrators, the master oscillator (V1) and the 2:1-15,750 counter (V9) are all similar to the basic multivibrator circuit.

TABLE 5—BASIC MULTIVIBRATOR TROUBLE SHOOTING CHART

Symptom	*Primary Cause (most likely)*	*Secondary Cause (less likely)*
1. Pulse too wide or count too high, or frequency too low by LARGE AMOUNT.	Crystal shorted	Precision components C1, R1, R2, R3. Also check tube.
2. Pulse too wide or count too high, or frequency too low ONLY SLIGHTLY.	Tube	Precision components C1, R1, R2, R3, and R4.
3. Frequency too high by great amount (V1 only).	ICR2	
4. Free-running or count too low by great amount.	Crystal open	Tube, low value R4.
5. Erratic operation of counters.	If operation is close to normal range, refer to step 1 or 2 depending on direction of miscount.	Trigger capacitor C2.
6. Multivibrator completely in-operative.	Check for presence of trigger pulse. Tube or components. Check d-c voltages.	Triggering circuit.

The BASIC MULTIVIBRATOR TROUBLE SHOOTING CHART will aid in trouble shooting that particular circuit. The component symbol numbers refer to Figure 2.

Trouble Shooting Procedure

When the sync generator becomes unstable or inoperative, it is best to perform tests and adjustments in the following order:

1. Counter Chain Stability Test
2. Equalizing and Vertical Pulse Gates Test
3. Overall Stability Test
4. Automatic Frequency Control Circuits

Counter Chain Stability Test

1. Place the sync generator in normal operation with the FREQ CONTROL switch in FREE RUNNING position. Connect the vertical input of an oscilloscope to the "60" test jack, J106. Use the oscilloscope 60-cycle power-line sweep.

2. Observe the oscilloscope waveform and turn the shaft of R106 throughout its range. The results of this test are interpreted as follows:

a. If the waveform is stable (one cycle moving around slowly) throughout the rotation of R106, the master oscillator and 7:1 counter are adjusted for nominal operation and the rest of the counter chain is stable.

b. If the waveform is continuously erratic, or no output exists, the master oscillator and/or 7:1 counter is misadjusted or a circuit component is defective. Another possibility is that there is a defective component in the balance of the counter chain.

The erratic condition of the oscilloscope pattern mentioned in the previous paragraph is evident as follows: As R106 is turned from its normal position (midrange) the speed of rotation of the pattern should increase smoothly. Erratic operation will be visible as an abrupt change in the speed of rotation.

c. If any of the conditions in step b are encountered, adjust the master oscillator and 7:1 counter for nominal operation as described under SERVICE ADJUSTMENTS in this section, then recheck the counter chain by rotating R106 throughout its range. If the counter chain is still unstable over a large portion of the range of R106, isolate and repair the defective counter as explained in the steps which follow.

3. Make certain that R106 is set at midrange. This is true when the slot on the shaft is parallel to the terminal boards. Check the 3:1-10,500, 5:1-2100, and 5:1-60 counters. A method for checking these counters is described in step 4.

4. The three steps which follow give detailed instructions for testing any counter in the chain. The tabulation in step "c" shows the proper sequence and connections. Step 5 suggests a procedure for locating a defective component after the tests show which counter is at fault.

a. Connect the oscilloscope vertical input cable and the oscilloscope external-synchronizing-input lead to the test jack of the preceding counter.

b. Synchronize the oscilloscope so that exactly the same number of cycles as the count to be determined is visible on the oscilloscope screen.

c. Without disturbing the oscilloscope external synchronizing lead or the synchronizing control, move the vertical-input cable to the test jack of the next counter (counter to be tested). If the count is correct, EXACTLY ONE cycle should be visible on the oscilloscope sweep.

5. If a counter is inoperative, or the count is wrong, erratic, or unstable, check all the circuit components for that counter; replace defective components, then retest. Reference to the DESCRIPTION section and to the BASIC MULTIVIBRATOR TROUBLE SHOOTING CHART in this section should aid in locating individual counter troubles.

When the entire counter chain is in nominal operating condition repeat the R106 test; if counter chain is operating properly, SET R106 AT MIDRANGE.

TABLE 6—SETTING COUNTER-CHAIN STABILITY, USING OSCILLOSCOPE

Step No.	*Counter To Be Tested*	*Connect Scope to Vert. Input and Ext. Sync To:*	*Adjust Scope for No. of Cycles*	*Move Vertical Input Cable To:*
1	3:1, 10,500 cycle	31,500 (J102)	3	10,500 (J103)
2	5:1, 2100 cycle	10,500 (J103)	5	2100 (J104)
3	7:1, 300 cycle	2100 (J104)	7	300 (J105)
4	5:1, 60 cycle	300 (J105)	5	60 (J106)
*5	2:1, 15,750 cycle	31,500 (J102)	2	15,750 (J107)

* May be checked any time after MASTER OSCILLATOR adjustment.

Equalizing and Vertical Pulse Gate Test

After completing the counter chain test, a failure in the basic sync generator circuits can be localized as follows:

1. Apply power to the sync generator and place the frequency control switch to Free Running position and wait for 15 minutes.

2. Check the vertical drive output with an oscilloscope. The waveform should be stable and have a pulse width of exactly 9H (nine complete cycles of horizontal drive). If the waveform is not correct, check 9H (V13 pin 1) test jack with a low-capacity oscilloscope probe. The correct waveform is shown in the schematic. This indicates whether the equalizing pulse gate, V13, the vertical sync gate, V14, the 7.5H stop gate, V12B, and Sync multivibrator V11 are working correctly and jointly to produce sync and vertical pulses. The 9H waveform has three portions, each of 3H width. The first and the third portion is mainly determined by the time constant of 13C1, 13C2 and 13RB, while the middle portion by the time constant of 14C2 and 14R3. The time constant of V12B (12R3 and 6C1) permits the multivibrators, V13 and V14 to operate once at every 1/60 second. These time constants normally need not be modified unless an unfavorable combination of component tolerances exists. Check tubes, V12, V13, V14, V15 and V17. Check for and repair the defective parts associated with all tubes in order to produce the correct waveforms of 9H and vertical drive, both of which control the sync gates, V10, V11 and V12A. Then proceed with the test of the sync signal.

3. If the 9H and the vertical drive waveforms are correct and stable, check the waveform of sync output.

a. If there are 6 equalizing pulses, before and after the 6 vertical sync pulses in both fields, the pulse widths can be adjusted in sequence as outlined under adjustment. (Important: 1st-equalizing pulse, 2nd-horizontal sync, and 3rd-vertical sync. For this adjustment, all tubes in the main chassis should be in place.)

b. If the number of the equalizing pulses or the vertical pulses in group is different from 6 in either one of the two fields, and if the master oscillator and the counter chain all work properly, try with new tubes V12, V13 and V14. If faulty operation still exists, chances are that the time constants of V13 and V14 are a little off under the existing condition. It can be corrected by changing the values of 13C2 and 14C2 slightly.

Overall Stability Test

Having completed the Counter Chain Stability Test, a failure in the basic sync generator circuits can be localized as follows:

1. Apply power to the sync generator, place the FREQ CONTROL switch, S201, in the FREE RUNNING position and allow the unit to warm up for approximately 15 minutes.

2. Connect the sync output of J113 to the vertical input of an oscilloscope, then add BL (blanking) by connecting a jumper from J114 to J113.

3. Use external synchronization for the oscilloscope by connecting a lead from the vertical drive jack, J112, on the sync generator, to the external-synchronization input of the oscilloscope. Adjust the oscilloscope synchronizing control to obtain a stable pattern showing two cycles of the 60-cycle sync generator output.

4. Observe the oscilloscope waveform while turning R106 throughout its range. RETURN R106 TO MIDRANGE. Erratic behavior of an individual signal is usually caused by a fault in the related circuit as tabulated in Table 7.

TABLE 7—COUNTER CHAIN TROUBLE SYMPTOMS

Symptom	*Probable Circuit At Fault*
Erratice horizontal pulses, horizontal frequency drastically changed.	2:1-15, 750 counter, V9. This is the basic circuit for all horizontal pulses. Check individual horizontal circuits as per schematic diagram, Figure 18.
Erratic vertical interval: a. Erratic equalizing pulses b. Erratic vertical sync c. Erratic equalizing and sync pulses	V10, V11, V12, V13, V14, V15 & V17.

Automatic Frequency Control (60-cycle)

When a fault in the AFC circuit is suspected, perform the following tests and adjustments before attempting to trouble-shoot the AFC circuit:

1. Test and adjust if necessary the master oscillator.

2. Test and adjust if necessary the 7:1 counter.

3. Perform the overall stability test. If the sync generator output is stable throughout the rotation of R106, turn the FREQ CONTROL switch to the 60-cycle position and repeat the R106 test just mentioned. The waveform should be stable throughout the test. If not, check the AFC circuits V41, V42 and V43. The circuit is shown schematically on Figure 18. The signal flow is indicated more clearly on the block diagram, Figure 16.

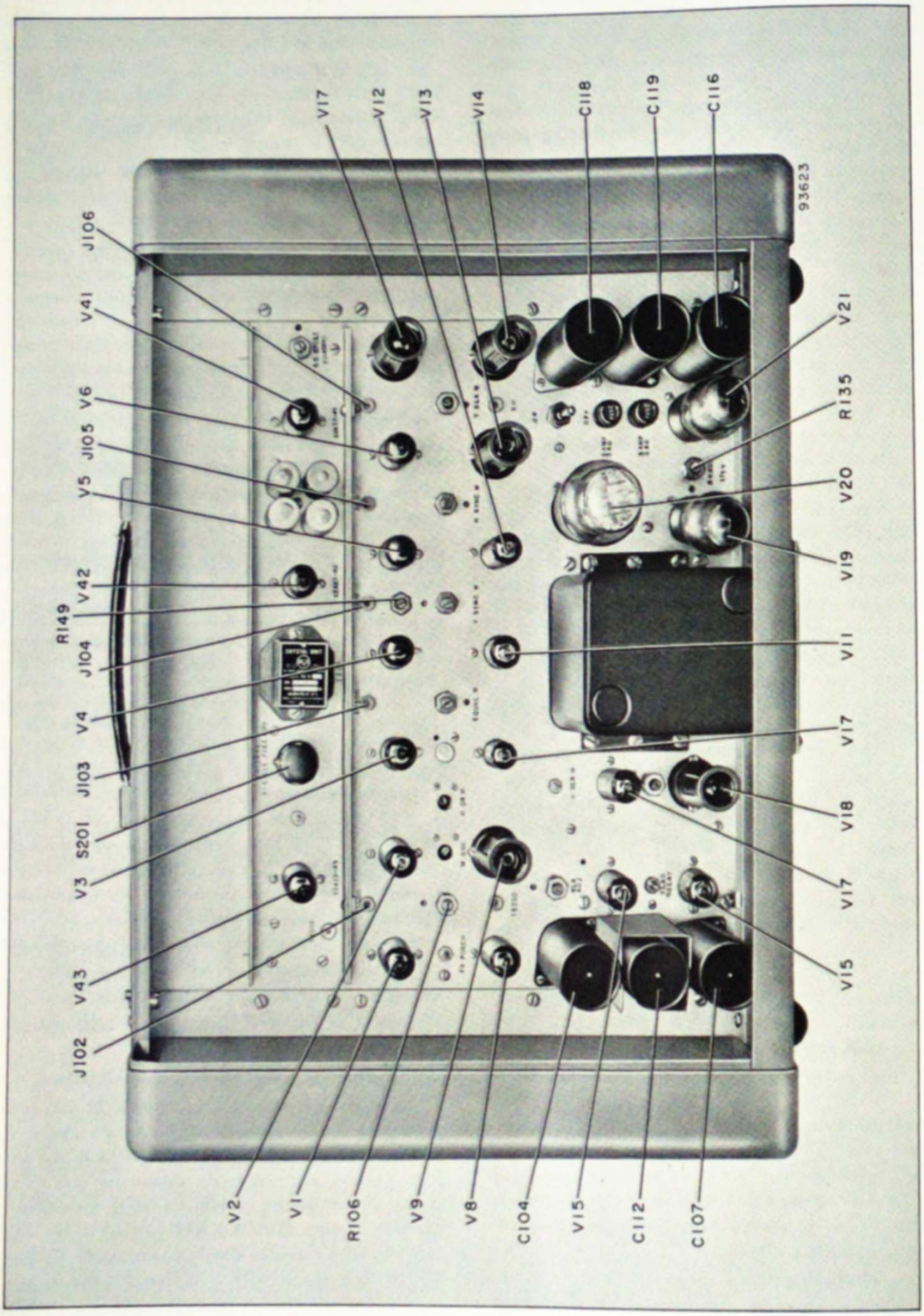


Figure 11—TG-31 Field Sync Generator, Side Cover Removed Showing Tube Location for TG-31 and TG-21.

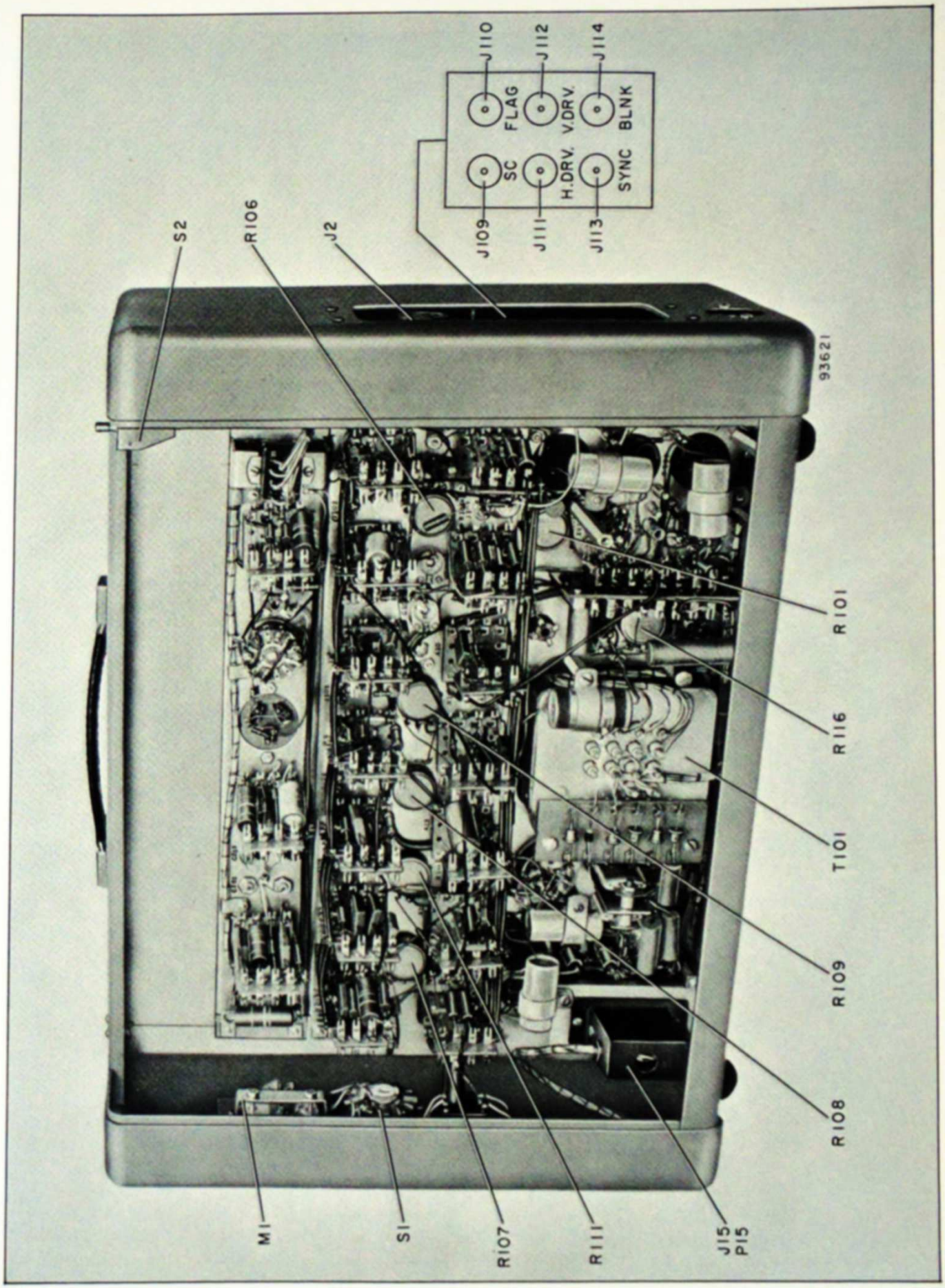


Figure 12—TG-31 Field Sync Generator, Component Identification

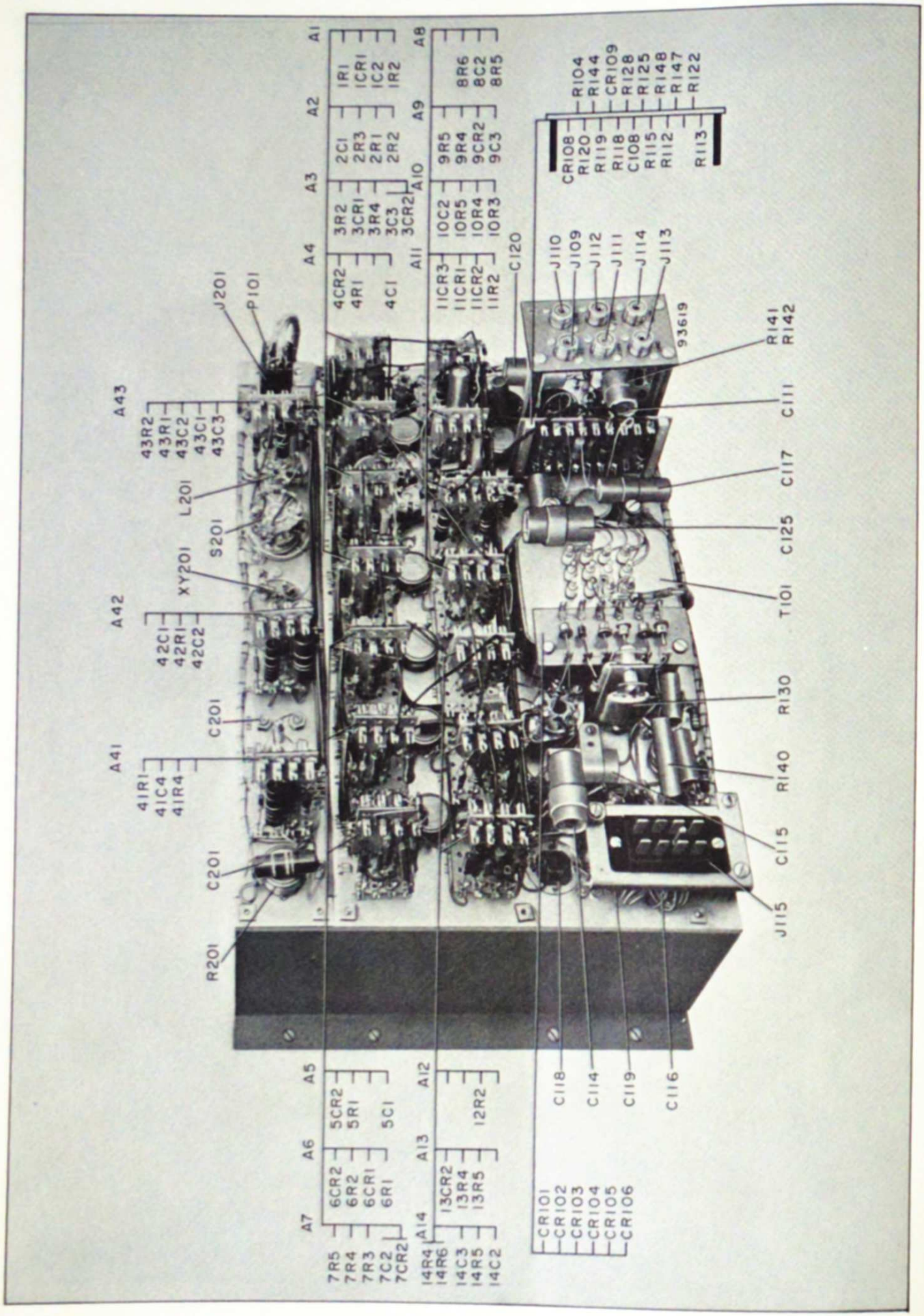


Figure 13—TG-21 Studio Sync Generator, Component Identification, Left Oblique View

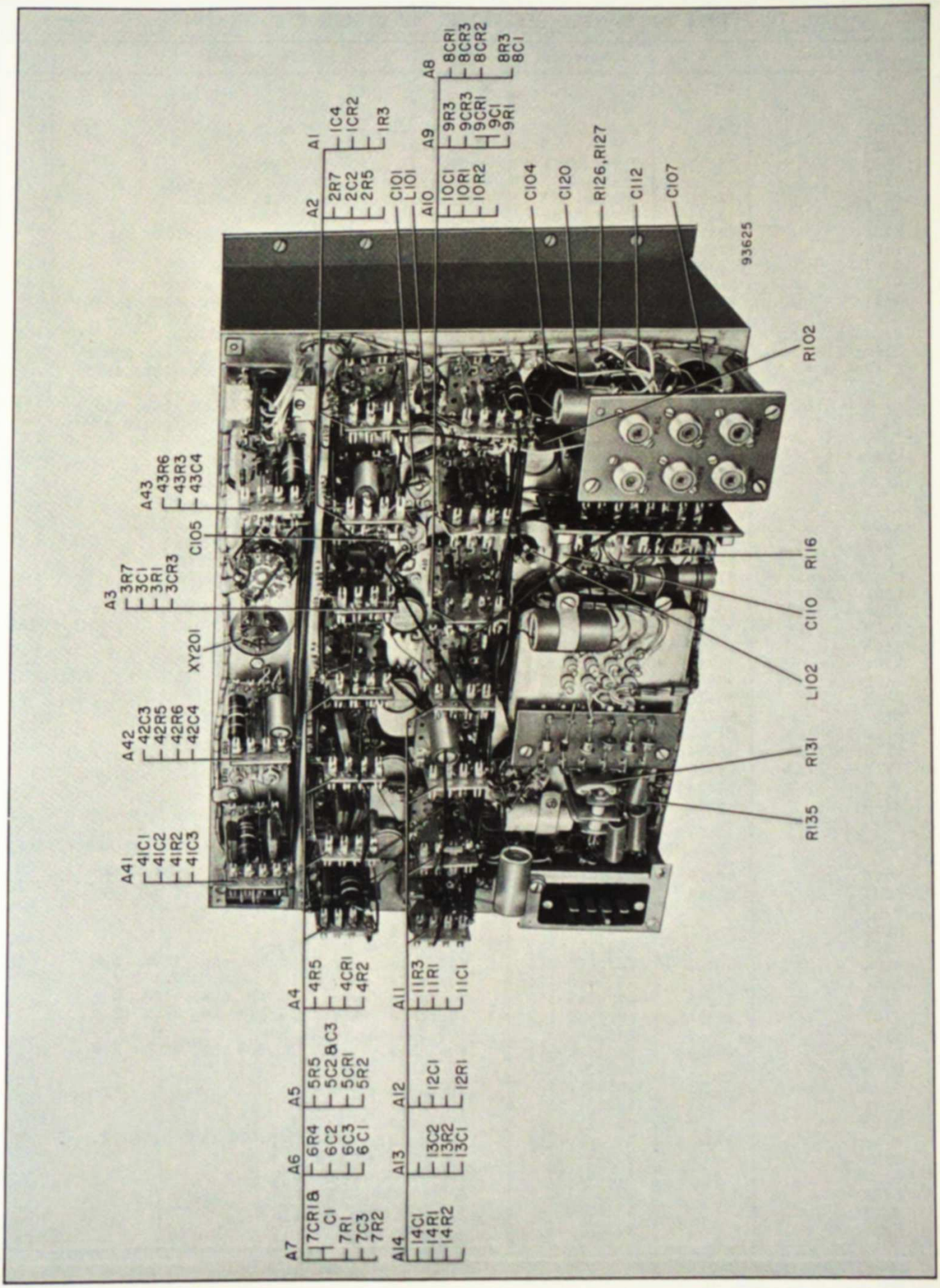


Figure 14—TG-21 Studio Sync Generator, Component Identification, Right Oblique View

PARTS LIST
TG-21/31, BASIC SYNC GENERATOR, 60 CYCLES AFC, MI-26171

Symbol No.	Stock No.	Drawing No.	Description
			CAPACITORS:
C101	54221	984003-5	variable, ceramic, 7-45 μμf
C102			not used
C103	93943	727851-104	mica, 15 μμf, ±10%, 500 v
C104	95914	458558-1	electrolytic, 125 μf, +100% -10%, 350 v
C105	54221	984003-5	variable, ceramic, 7-45 μμf
C106	93943	727851-104	mica, 15 μμf, ±10%, 500 v
C107	95914	458558-1	electrolytic, 125 μμf, +100% -10%, 350 v
C108	96998	727851-107	mica, 22 μμf, ±10%, 500 v
C109	214730	8941279-1	variable, ceramic, 5-50 μμf
C110	212473	737818-55	paper, 0.22 μμf, ±10%, 200 v
C111	212980	471574-27	electrolytic, 10.0 μf, +100% -10%, 350 v
C112	212978	458557-19	electrolytic, 100 μf, +50% -10%, 300 v
C113	98954	727851-105	mica, 18 μμf, ±10%, 500 v
C114,C115	212980	471574-27	electrolytic, 10.0 μf, +100% -10%, 350 v
C116/A/B	217383	458558-46	electrolytic, 80-20 μf, +100% -10%, 450 v
C117		735715-179	paper, 0.22 μf, ±10%, 400 v
C118/A/B,C119/A/B	217383	458558-46	electrolytic, 80-20 μf, +100% -10%, 450 v
C120	212980	471574-27	electrolytic, 10 μf, +100% -10%, 350 v
C121	96998	727851-107	mica, 22.0 μμf, ±10%, 500 v
C122			not used
C123	73960	990167-19	ceramic, 10,000 μμf, 500 v
C124	59905	727851-102	mica, 10 μμf, ±10%, 500 v
C125	216717	471574-18	electrolytic, 20 μf, 350 v
C126	59905	727851-102	mica 10 μμf, ±10%, 500 v
CR101,CR106	218392		Rectifier: crystal diode, 1N540
CR107	59395		Rectifier: crystal diode, 1N34A
CR108,CR109	217391		Rectifier: crystal diode, 1N67A
F101,F102	94802	990157-113	Fuse: 5 amp
J102 to J108	205675	8825493-3	Connector: pin jack, black
J109 to J114	51800	255223-2	Connector: female, coax
J115	55806	727969-7	Connector: male, 8 cont.
L101	218237	476900-502	Coil: peaking
L102	218238	476900-503	Coil: peaking
P101	43116	459695-2	Connector: female, 12 cont.
P15	56751	174697-5	Connector: female, 8 cont.
P109 to P114	215661	252868-1	Connector: male, coax
XF101,XF102	48894	99088-2	Holder: fuse
XV15 to XV17	94880	737870-18	Socket: tube, 9 cont.
XV18	94926	737870-14	Socket: tube, 7 cont.
XV19	68590	99100-4	Socket: tube, octal
			RESISTORS *Fixed, composition unless otherwise specified:*
R101	98077	8971860-113	variable, comp. 50,000 ohm, ±10%, 2 w
R102	98394	458572-69	variable, ww. 6000 ohm, ±5%, 5 w
R103		82283-135	100 ohm, ±5%, ½ w
R104		99126-170	3000 ohm, ±5%, 2 w
R105		82283-183	10,000 ohm, ±5%, ½ w
R106	57402	8971860-116	variable, comp. 250,000 ohm, ±10%, 2 w
R107	92231	8971860-118	variable, comp., 1.0 meg., ±20%, 2 w
R108	93175	8971860-110	variable, comp., 10,000 ohm, ±10%, 2 w
R109	205045	8971860-112	variable, comp., 25,000 ohm, ±10%, 2 w
R110		82283-209	120,000 ohm, ±5%, ½ w
R111	205044	8971860-114	variable, comp., 100,000 ohm, ±10%, 2 w
R112		82283-135	100 ohm, ±5%, ½ w
R113		99126-170	3000 ohm, ±5%, 2 w
R114		82283-135	100 ohm, ±5%, ½ w
R115		99126-177	5600 ohm, ±5%, 2 w
R116	97961	8971860-117	variable, comp., 500,000 ohm, ±10%, 2 w
R117		82283-187	15,000 ohm, ±5%, ½ w
R118		82283-197	39,000 ohm, ±5%, 2 w
R119		82283-193	27,000 ohm, ±5%, ½ w
R120		82283-223	470,000 ohm, ±5%, ½ w
R121		82283-135	100 ohm, ±5%, ½ w

Symbol No.	*Stock No.*	*Drawing No.*	*Description*
R122		99126-170	3000 ohm, ±5%, 2 w
R123		82283-135	100 ohm, ±5%, ½ w
R124		82283-183	10,000 ohm, ±5%, ½ w
R125		99126-170	3000 ohm, ±5%, 2 w
R126		82283-139	75 ohm, ±5%, ½ w
R127		82283-159	1000 ohm, ±5%, ½ w
R128		82283-190	20,000 ohm, ±5%, ½ w
R129		82283-187	15,000 ohm, ±5%, ½ w
R130,R131	218395	8869485-5	3300 ohm, ±5%, 30 w
R132		90496-192	24,000 ohm, ±5%, 1 w
R133		90496-187	15,000 ohm, ±5%, 1 w
R134		90496-200	51,000 ohm, ±5%, 1 w
R135	93175	8971860-110	variable, comp., 10,000 ohm, ±5%, 2 w
R136		82283-214	200,000 ohm, ±5%, ½ w
R137,R138		82283-135	100 ohm, ±5%, ½ w
R139		82283-218	300,000 ohm, ±5%, ½ w
R140	102241	458574-70	ww., 10,000 ohm, ±5%, 10 w
R141		82283-141	180 ohm, ±5%, ½ w
R142		82283-143	220 ohm, ±5%, ½ w
R143		90496-50	100 ohm, ±10%, 1 w
R144		82283-70	4700 ohm, ±10%, ½ w
R145,R146		90496-139	150 ohm, ±5%, 1 w
R147		82283-151	470 ohm, ±5%, ½ w
R148		82283-199	47,000 ohm, ±5%, ½ w
R149	219096	474878-12	variable, comp; 500,000 ohms ±10%, 1/3 w
R150	218253	990730-434	fixed, composition, 22,000 ohms ±1%, ½ w
S101	93263	95559-5	Switch: toggle
T101	218397	8435806-1	Transformer: power
XV20,XV21	68590	99100-4	Socket: tube
			MODULE A-1
1C1	79191	727851-135	Capacitor: mica, 330 μμf, ±10%, 500 v
1C2	98422	727851-123	Capacitor: mica, 100 μμf, ±10%, 500 v
1C3	216971	8914319-308	Capacitor: mica, 22 μμf, ±5%, 500 v
1C4	204346	727853-232	Capacitor: 240 μμf, ±5%, 300 v
1CR1,1CR2	59395		Diode: crystal, 1N34A
1R1	207243A	990733-401	Resistor: 10,000 ohm, ±1%, 1 w
1R2	207844A	990733-373	Resistor: 5620 ohm, ±1%, 1 w
1R3	59540	990730-630	Resistor: 2 megohm, ±1%, ½ w
XV1	218240	8434273-1	Socket: tube
			MODULE A-2
2C1	96998	727851-107	Capacitor: 22 μμf, ±10%, 500 v
2C2	218393	8941243-38	Capacitor: electrolytic, 15 μf, 150 v
2R1		82283-100	Resistor: 1.5 megohm, ±10%, ½ w
2R2		90496-183	Resistor: 10,000 ohm, ±5%, 1 w
2R3	207846A	990733-418	Resistor: 15,000 ohm, ±1%, 1 w
2R4		82283-191	Resistor: 22,000 ohm, ±5%, ½ w
2R5		82283-50	Resistor: 100 ohm, ±10%, ½ w
2R6		82283-218	Resistor: 300,000 ohm, ±5%, ½ w
2R7		90496-207	Resistor: 100,000 ohm, ±5%, 1 w
XV2	218240	8434273-1	Socket: tube, 9 cont.
			MODULE A-3
3C1	59905	727851-102	Capacitor: mica, 10 μμf, ±10%, 500 v
3C2	218241	8914319-218	Capacitor: mica, 56 μμf, ±2%, 500 v
3C3	53119	727856-145	Capacitor: mica, 820 μμf, ±10%, 500 v
3CR1,3CR2	59395		Rectifier: crystal diode, 1N34A
3CR3	209425		Rectifier: crystal diode, 620
3R1,3R2	218253	990733-434	Resistor: 22,100 ohm, ±1%, 1 w
3R3		82283-142	Resistor: 470,000 ohm, ±5%, ½ w
3R4		90496-168	Resistor: 2400 ohm, ±5%, 1 w
3R5		82283-112	Resistor: 15,000 ohm, ±5%, ½ w
3R6	59540	990730-630	Resistor: 2 megohm, ±1%, ½ w
3R7		90496-180	Resistor: 7500 ohm, ±5%, 1 w
XV3	218240	8434273-1	Socket: tube, 9 cont.

Symbol No.	Stock No.	Drawing No.	Description
			MODULE A-4
4C1	59905	727851-102	Capacitor: 10 μμf, ±10%, 500 v
4C2	218245	8914319-36	Capacitor: 330 μμf, ±1%, 500 v
4CR1	209425		Rectifier: crystal diode, 620
4CR2	59395		Rectifier: crystal diode, 1N34A
4R1, 4R2	218253	990733-434	Resistor: 22,100 ohm, ±1%, 1 w
4R3		82283-94	Resistor: 470,000 ohm, ±10%, ½ w
4R4	218251	990730-630	Resistor: 1.82 megohm, ±1%, ½ w
4R5		90496-190	Resistor: 7500 ohm, ±5%, 1 w
4R6		82283-94	Resistor: 470,000 ohm, ±10%, ½ w
XV4	218240	8434273-1	Socket: tube, 9 cont.
			MODULE A-5
5C1	59905	727851-102	Capacitor: mica, 10 μμf, ±10%, 500 v
5C2	218248	8924416-127	Capacitor: mica, 2200 μμf, ±1%, 500 v
5C3	211497	727853-333	Capacitor: mica, 270 μμf, ±2%, 500 v
5CR1	209425		Rectifier: crystal diode, 620
5CR2	59395		Rectifier: crystal diode, 1N34A
5R1, 5R2	218253	990733-434	Resistor: comp. film, 22,100 ohm, ±1%, 1 w
5R3		82283-94	Resistor: 470,000 ohm, ±10%, ½ w
5R4	59540	990730-630	Resistor: comp. film, 2 meg., ±1%, ½ w
5R5		90496-180	Resistor: 7500 ohm, ±5%, 1 w
XV5	218240	8434273-1	Socket: tube, 9 cont.
			MODULE A-6
6C1	219095	8914319-246	Capacitor: mica, 820 μμf, ±2%, 500 v
6C2	215229	8929295-111	Capacitor: mica, 10,000 μμf, ±1%, 500 v
6C3	218249	8924416-312	Capacitor: mica, 12,000 μμf, ±5%, 500 v
6CR1	209425		Rectifier: crystal diode, 620
6CR2	59395		Rectifier: crystal diode, 1N34A
6R1, 6R2	218253	990733-434	Resistor: comp. film, 22,100 ohm, ±1%, 1 w
6R3	59540	990730-630	Resistor: comp. film, 2.0 meg., ±1%, ½ w
6R4		90496-180	Resistor: 7500 ohm, ±5%, 1 w
XV6	218240	8434273-1	Socket: tube, 9 cont.
			MODULE A-7
7C1	218193	727856-147	Capacitor: mica, 1000 μμf, ±10%, 300 v
7C2	39650	727866-245	Capacitor: mica, 820 μμf, ±5%, 500 v
7C3	208787	737818-93	Capacitor: paper, 0.1 μμf, ±10%, 400 v
7CR1	59395		Rectifier: crystal diode, 1N34A
7R1 to 7R3	218253	990733-434	Resistor: comp. film, 22,100 ohm, ±1%, 1 w
7R4		90496-237	Resistor: 1.8 meg., ±5%, 1 w
7R5		90496-180	Resistor: 7500 ohm, ±5%, 1 w
7R6		82283-223	Resistor: 470,000 ohm, ±5%, ½ w
XV7	218240	8434273-1	Socket: tube, 9 cont.
			MODULE A-8
8C1		735715-163	Capacitor: paper, 0.01 μf, ±10%, 400 v
8C2	217061	737818-56	Capacitor: paper, 0.47 μf, ±10%, 200 v
8CR1	59395		Rectifier: crystal diode, 1N34A
8CR2	209425		Rectifier: crystal diode, 620
8CR3	59395		Rectifier: crystal diode, 1N34A
8R1		82283-223	Resistor: 470,000 ohm, ±5%, ½ w
8R2		90496-195	Resistor: 33,000 ohm, ±5%, 1 w
8R3		90496-159	Resistor: 1000 ohm, ±5%, 1 w
8R4		82283-215	Resistor: 220,000 ohm, ±5%, ½ w
8R5		82283-207	Resistor: 100,000 ohm, ±5%, ½ w
8R6		90496-170	Resistor: 3000 ohm, ±5%, 2 w
8R7		82283-142	Resistor: 200 ohm, ±5%, ½ w
XV8	218240	8434273-1	Socket: tube, 9 cont.

Symbol No.	Stock No.	Drawing No.	Description
			MODULE A-9
9C1	98422	727851-123	Capacitor: mica, 100 μμf, ±10%, 500 v
9C2	218242	8914319-22	Capacitor: mica, 82μμf, ±1%, 500 v
9C3	39666	727868-161	Capacitor: mica, 3900 μμf, ±10%, 500 v
9CR1, 9CR2	59395		Rectifier: crystal diode, 1N34A
9CR3	209425		Rectifier: crystal diode, 620
9R1	207846A	990733-418	Resistor: comp. film, 15,000 ohm, ±1%, 1 w
9R3	207845A	990733-385	Resistor: comp. film, 7500 ohm, ±1%, 1 w
9R4	59540	990730-630	Resistor: comp. film, 2 meg. ±1%, ½ w
9R5		82283-191	Resistor: 22,000 ohm, ±5%, ½ w
XV9	218240	8434273-1	Socket: tube, 9 cont.
			MODULE A-10
10C1	218193	727856-147	Capacitor: mica, 1000 μf, ±10%, 500 v
10C2		735715-163	Capacitor: paper, 0.01 μf, ±10%, 500 v
10C3	97946	727851-113	Capacitor: 39 μμf, ±10%, 500 v
10R1		82283-70	Resistor: 4700 ohm, ±10%, ½ w
10R2		82283-94	Resistor: 470,000 ohm, ±10%, ½ w
10R3		99126-196	Resistor: 27,000 ohm, ±5%, 2 w
10R4		82283-198	Resistor: 43,000 ohm, ±5%, ½ w
10R5		82283-94	Resistor: 470,000 ohm, ±10%, ½ w
XV10	218240	8434273-1	Socket: tube, 9 cont.
			MODULE A-11
11C1	218241	8914319-18	Capacitor: mica, 56 μμf, ±1%, 500 v
11CR1 to 11CR3	59395		Rectifier: crystal diode, 1N34A
11R1	209781	990730-581	Resistor: comp. film, 681,000 ohm, ±1%, ½ w
11R2	207845A	990733-385	Resistor: comp. film, 7500 ohm, ±1%, 1 w
11R3		82283-199	Resistor: 47,000 ohm, ±5%, ½ w
XV11	218240	8434273-1	Socket: tube, 9 cont.
			MODULE A-12
12C1	218398	455528-11	Capacitor: ceramic, 1.0 μf, ±10%, 200 v
12R1		82283-231	Resistor: 1.0 meg ±5%, ½ w
12R2		82283-94	Resistor: 470,000 ohm, ±10%, ½ w
12R3	215793	990730-609	Resistor: comp. film, 1.2. meg, ±1%, ½ w
XV12	218240	8434273-1	Socket: tube, 9 cont.
			MODULE A-13
13C1	218239	741632-135	Capacitor: mica, 150 μμf, ±1%, 500 v
13C2	59905	8914319-303	Capacitor: mica, 10 μμf, ±5%, 500 v
13CR1			Not used
13CR2	59395		Rectifier: crystal, diode, 1N34A
13R1			Not used
13R2	207846A	990733-418	Resistor: comp. film, 15,000 ohm, ±1%, 1 w
13R3	218251	990730-626	Resistor: comp. film, 1.82 meg, ±1%, ½ w
13R4	218250	990730-458	Resistor: comp. film, 39,200 ohm, ±1%, 1 w
13R5		82283-215	Resistor: 220,000 ohm, ±5%, ½ w
13R6		82283-187	Resistor: 15,000 ohm, ±5%, ½ w
13R7	209648	990730-401	Resistor: comp. film, 10,000 ohm, ±1%, ½ w
XV13	218240	8434273-1	Socket: tube, 9 cont.
			MODULE A-14
14C1	95254	727851-117	Capacitor: mica, 270 μμf, ±10%, 500 v
14C2	218239	741632-135	Capacitor: mica, 150 μμf, ±10%, 500 v
14C3	93943	727851-104	Capacitor: mica, 15 μμf, ±10%, 500 v
14C3	218587	8914319-303	Capacitor: mica 10 μμf, ±5%, 500 v
14R1	218253	990733-434	Resistor: comp. film, 22,100 ohm, ±1%, 1 w
14R2	207846A	990733-418	Resistor: comp. film, 15,000 ohm, ±1%, 1 w
14R3	218251	990730-626	Resistor: comp. film, 1.82 meg., ±1%, ½ w
14R4		90496-179	Resistor: 6800 ohm, ±5%, 1 w

Symbol No.	Stock No.	Drawing No.	Description
14R5	58735	990730-505	Resistor: comp. film, 110,000 ohm, ±1%, ½ w
14R6	207846A	990730-418	Resistor: comp. film, 15,000 ohm, ±1%, ½ w
XV14	218240	8434273-1	Socket: tube, 9 cont.
			MISCELLANEOUS
	211765	8914731-4	Base: tube shield (for 9 pin min.)
	213965	8914731-3	Shield: tube (2 11/32" ht.)
60 CYCLE AUTOMATIC FREQUENCY CONTROL, MI-26171			
C201		735715-175	Capacitor: paper, 0.1 μf, ±10%, 400 v
C202 to C205	94868	737863-237	Capacitor: mica, 1.0 μf, ±5%, 300 v
J201	54196	181508-1	Connector: male, 12 contacts
J202	205675	8825493-3	Connector: pin jack, black
L201	218396	476900-504	Coil: peaking
R201	57221	433196-19	Resistor: variable comp., 100,000 ohms, ±10%, 2 w
R202		82283-102	Resistor: 2.2 meg, ±5%, ½ w
S201	218394	472891-1	Switch: rotary
XY201	17340	834496-1	Socket: crystal
Y201	MI-26545	895300-501	Crystal: 94.5 KC
			MODULE A-41
41C1	39664	727871-159	Capacitor: mica, 3300 μμf, ±10%, 500 v
41C2		735715-171	Capacitor: paper, 0.047 μf, ±10%, 400 v
41C3	39660	727871-155	Capacitor: mica, 2200 μμf, ±10%, 500 v
41C4		735715-171	Capacitor: paper, 0.047 μf, ±10%, 400 v
41R1		82283-93	Resistor: 390,000 ohms, ±10%, ½ w
41R2		82283-98	Resistor: 1.0 meg, ±10%, ½ w
41R3		90496-199	Resistor: 47,000 ohms, ±5%, 1 w
41R4		82283-98	Resistor: 1.0 meg, ±10%, ½ w
41R5		90496-199	Resistor: 47,000 ohms, ±5%, 1 w
XV41	218240	8434273-1	Socket: tube, 9 contacts
			MODULE A-42
42C1		735715-167	Capacitor: paper, 0.022 μf, ±10%, 400 v
42C2		735715-175	Capacitor: paper, 0.1 μf, ±10%, 400 v
42C3		735715-171	Capacitor: paper, 0.047 μf, ±10%, 400 v
42C4		735715-83	Capacitor: paper, 0.47 μf, ±10%, 200 v
42R1		82283-110	Resistor: 10 meg, ±10%, ½ w
42R2		82283-86	Resistor: 100,000 ohms, ±10%, ½ w
42R3		82283-176	Resistor: 5100 ohms, ±5%, ½ w
42R4		82283-98	Resistor: 1.0 meg, ±10%, ½ w
42R5		82283-84	Resistor: 68,000 ohms, ±10%, ½ w
42R6		82283-224	Resistor: 510,000 ohm ±5%, ½ w
XV42	218240	8434273-1	Socket: tube, 9 contacts
			MODULE A-43
43C1	79191	727856-235	Capacitor: mica, 330 μμf, ±5%, 500 v
43C2		735715-163	Capacitor: paper, 0.01 μf, ±10%, 400 v
43C3	59905	727851-102	Capacitor: mica, 10 μμf, ±10%, 500 v
43C4		735715-175	Capacitor: paper, 0.1 μf, ±10%, 400 v
43R1		82283-62	Resistor: 1000 ohms, ±10%, ½ w
43R2		90496-78	Resistor: 22,000 ohms, ±10%, 1 w
43R3		90496-78	Resistor: 22,000 ohms, ±10%, 1 w
43R4		90496-74	Resistor: 10,000 ohms, ±10%, 1 w
43R5		82283-62	Resistor: 1000 ohms, ±10%, ½ w
43R6		90496-74	Resistor: 10,000 ohms, ±10%, 1 w
XV43	218240	8434273-1	Socket: tube, 9 contacts
			MISCELLANEOUS
	30075	737820-507	Knob: for S201

Symbol No.	*Stock No.*	*Drawing No.*	*Description*
		FIELD SYNC GENERATOR, MI-26172	
DS1	101857	872291-9	Lamp: pilot NE51
J2	52002	722805-14	Connector: female, 7 contacts
J3	210267	8887007-1	Connector: power
M1	218400	8971847-1	Meter: A.C.
P2	54248	722805-15	Connector: male, 7 contacts
P3	32661	184181-4	Connector: female
P4 to P14			Not used
P15	56751	174697-5	Connector: female, 8 contacts
S1	57289	433779-3	Switch: rotary
S2	218399	8434293-1	Switch: interlock
XADS1	56612	990788-501	Jewel: red
XDS1	218025	990789-205	Socket: pilot light
11	MI-26171	8971377-501	Sync. Generator

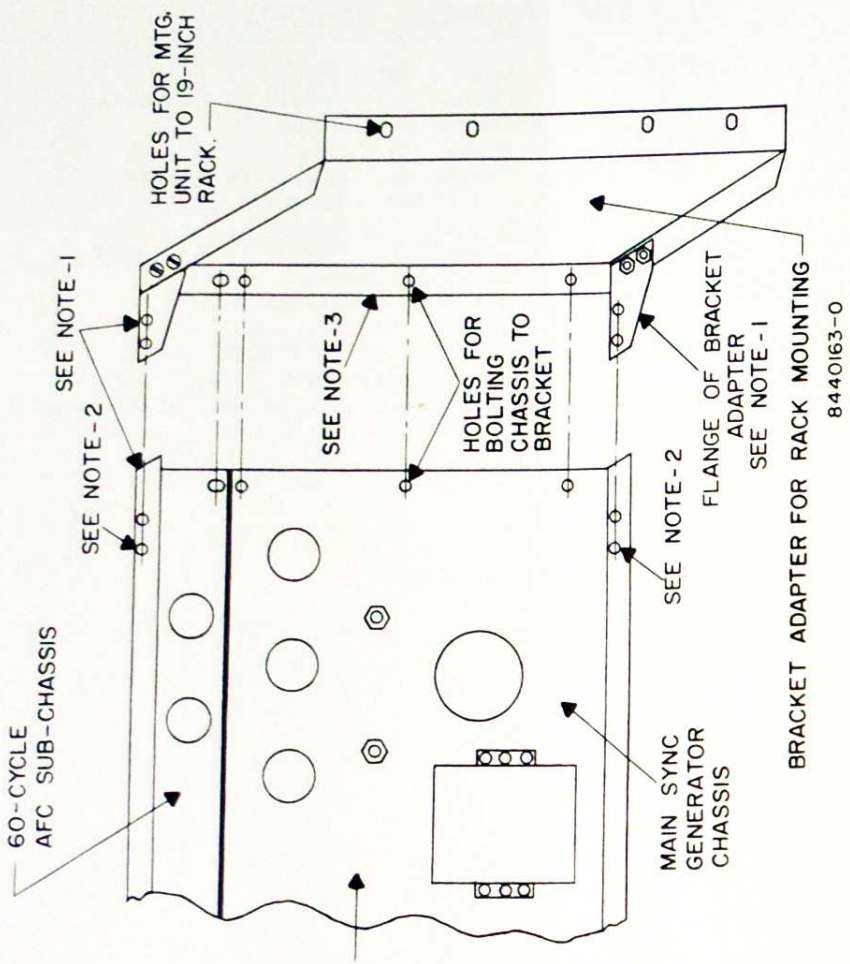


Figure 15—Diagram for Mounting Rack Adapters to Main Chassis

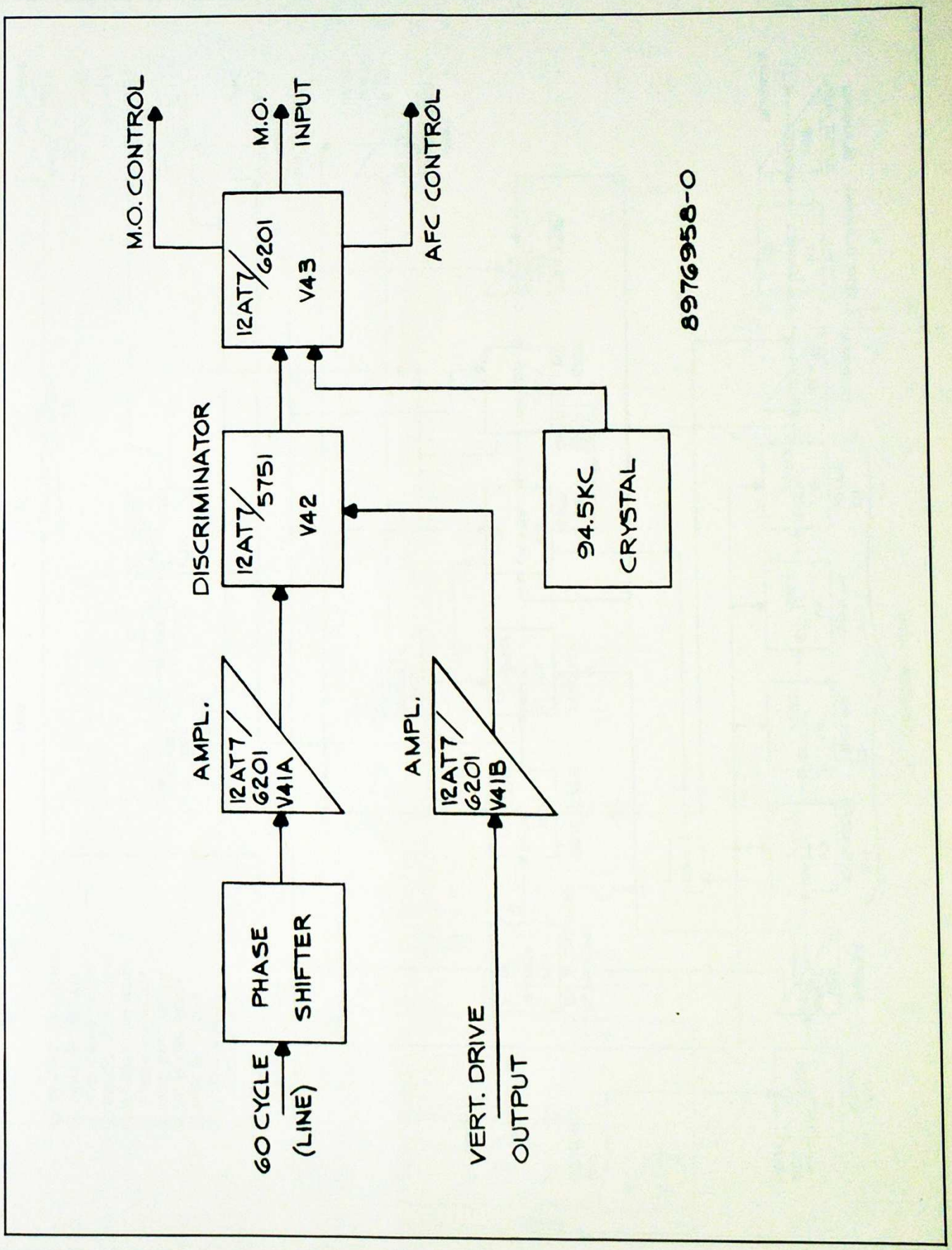


Figure 16—Block Diagram, 60-cycle AFC Chassis

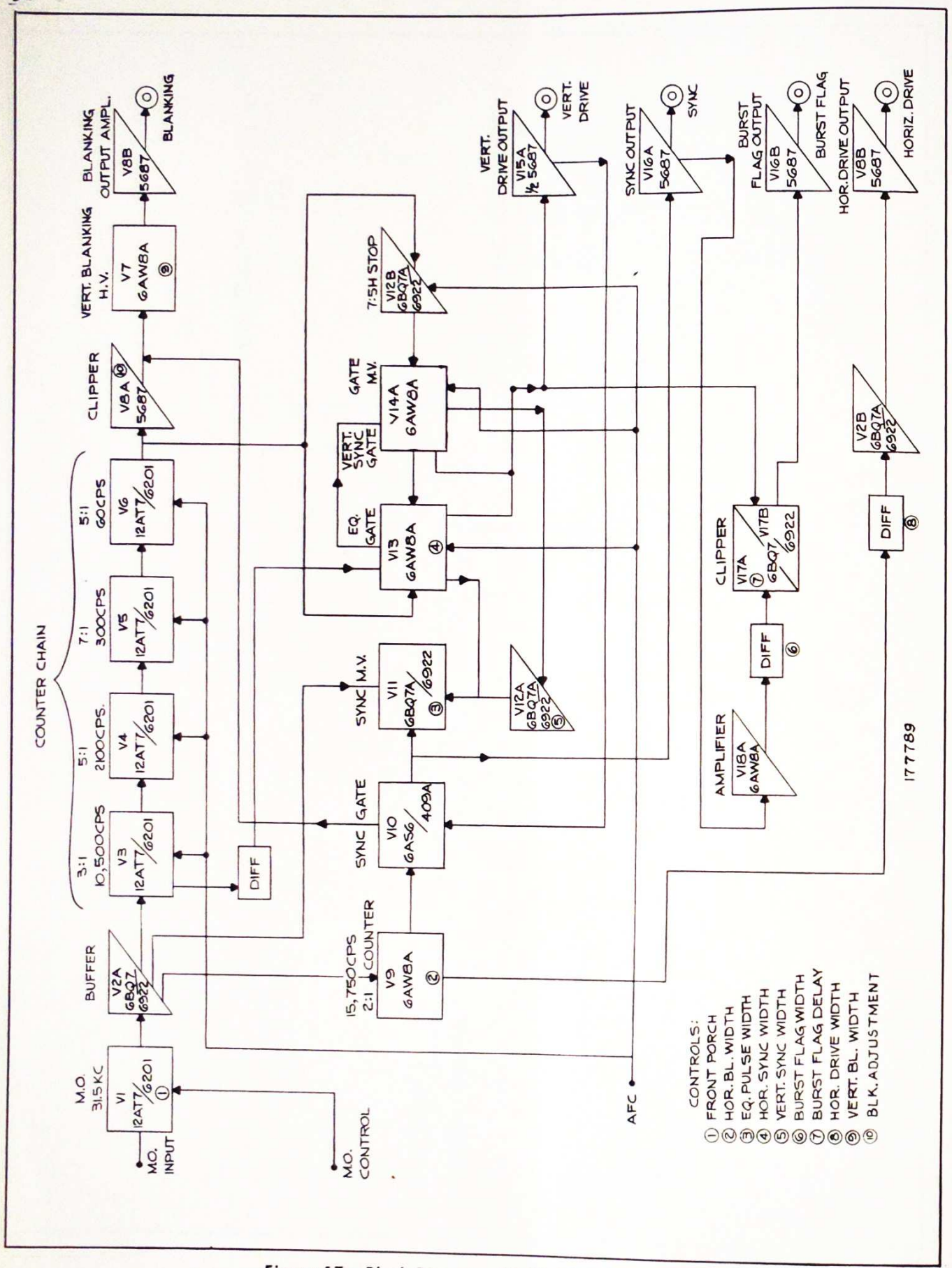
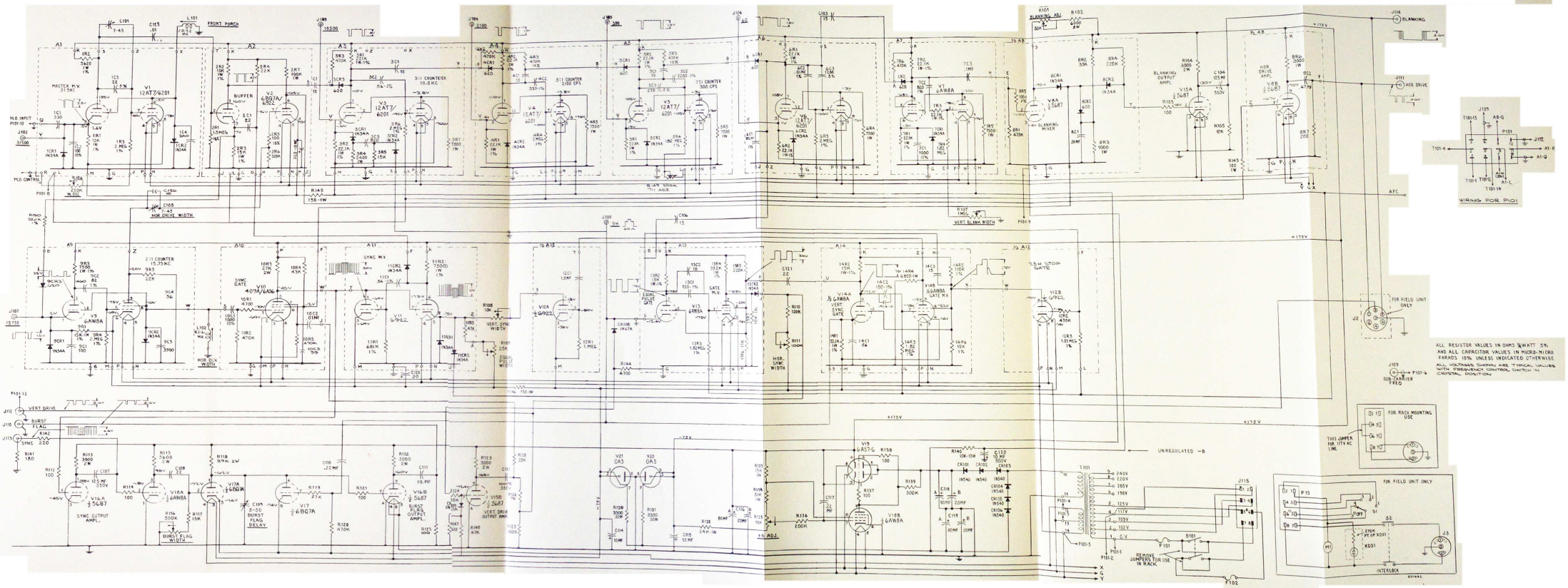
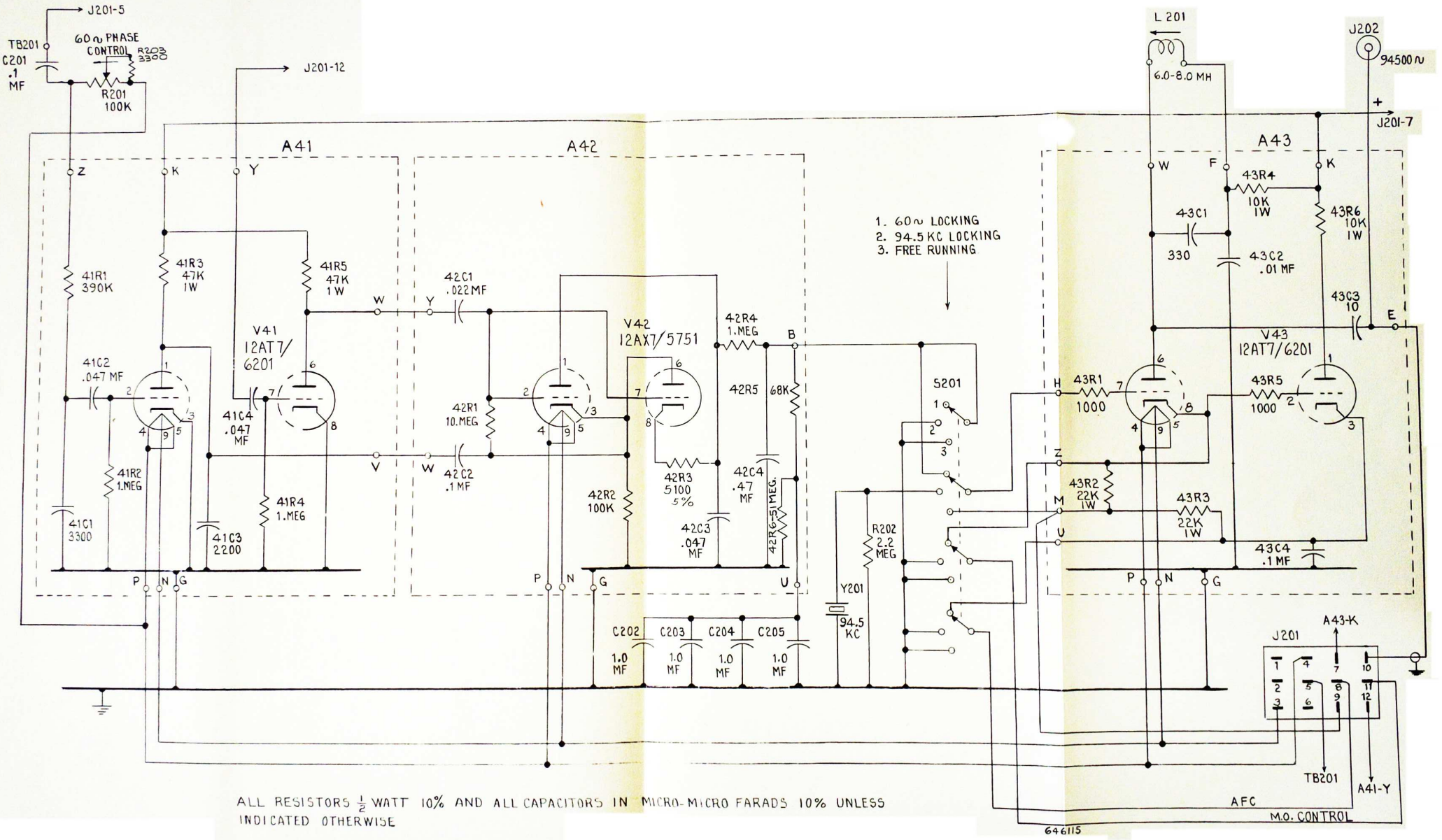


Figure 17—Block Diagram, TG-21, TG-31 Sync Generator


ALL RESISTOR VALUES IN OHMS ½WATT 5%
AND ALL CAPACITOR VALUES IN MICRO-MICRO
FARADS 10% UNLESS INDICATED OTHERWISE.
ALL VOLTAGES SHOWN ARE TYPICAL VALUES
WITH FREQUENCY CONTROL SWITCH IN
CENTRAL POSITION
WIRING FOR P101
FOR FIELD UNIT ONLY
FOR RACK MOUNTING USE
REMOVE JUMPERS FOR USE IN RACK
INTERLOCK
UNREGULATED −B
+175V
−72V
−12V
FRONT PORCH
BURST FLAG
VERT DRIVE
SYNC
AFC
BLANKING
HOR DRIVE
SUB-CARRIER FREQ
MASTER M.V.
SYNC GATE
SYNC OUTPUT AMPL.
BURST FLAG DELAY
BURST FLAG WIDTH
VERT DRIVE OUTPUT AMPL.
BLANKING OUTPUT AMPL.
BLANKING WIDTH ADJ
VERT BLANK WIDTH
HOR DRIVE WIDTH
VERT SYNC WIDTH
SYNC MIX
GATE MIX
SYNC GATE
VERT SYNC GATE
GATE PULSE
HOR SYNC WIDTH
SYNC STOP GATE
HOR DRIVE AMPL.
BLANKING MIXER
GATE MIX
BUFFER
MULTIVIBRATOR
GATE PULSE
HOR DRIVE OUTPUT AMPL.
MULTIVIBRATOR
MULTIVIBRATOR
MULTIVIBRATOR



ALL RESISTORS ½ WATT 10% AND ALL CAPACITORS IN MICRO-MICRO FARADS 10% UNLESS INDICATED OTHERWISE

Figure 19 - Schematic Diagram, 60-Cycle Automatic Frequency Control



RADIO CORPORATION OF AMERICA

INDUSTRIAL ELECTRONIC PRODUCTS, CAMDEN, N. J.