INSTRUCTION MANUAL

MODEL 128

LIN-LOG/SWEEP GENERATOR

EXACT
electronics, inc.

INSTRUCTION MANUAL

MODEL 128

LIN-LOG/SWEEP GENERATOR

® Box 160 Hillsboro, Oregon
97123 Tel. (503) 648-6661
TWX 910-460-8811
EXACT electronics, inc.

IF YOUR INSTRUMENT DOES NOT OPERATE

PLEASE

1. Check operating procedure in manual for proper setup.

2. Check fuse and power supply voltages.

3. Call your Exact representative or factory. Instruments returned to the factory will be accepted only if they are sent freight prepaid, unless Exact or factory representative has authorized otherwise.

CLAIM FOR DAMAGED SHIPMENT

The instrument should be inspected as soon as received. If damage has occurred, a claim should be made with the carrier. The claim agent should receive a complete report of damage and a copy sent to Exact. After receiving this report, Exact will advise you of the dispostion of the instrument and arrange for its repair or replacement.

WARRANTY

Exact warrants its instruments to be free from defects in material and workmanship under normal use for a period of twelve months from the original date of shipment. Exact's obligation is limited to repair or replacement.

All repairs and replacements made under this warranty are f.o.b. Exact's factory or designated service depot unless otherwise authorized by Exact. This warranty is made on condition that prompt notice of defect is given to Exact, in writing, within the warranty period and that Exact shall have the sole right to determine whether in fact a defect exists.

This warranty does not apply to any instrument which has been repaired or altered by other than Exact's own service representative so as, in Exact's judgment, to adversely affect it, nor which has been subject to misuse, negligence or accident or which has been operated contrary to sound practice or operating instructions.

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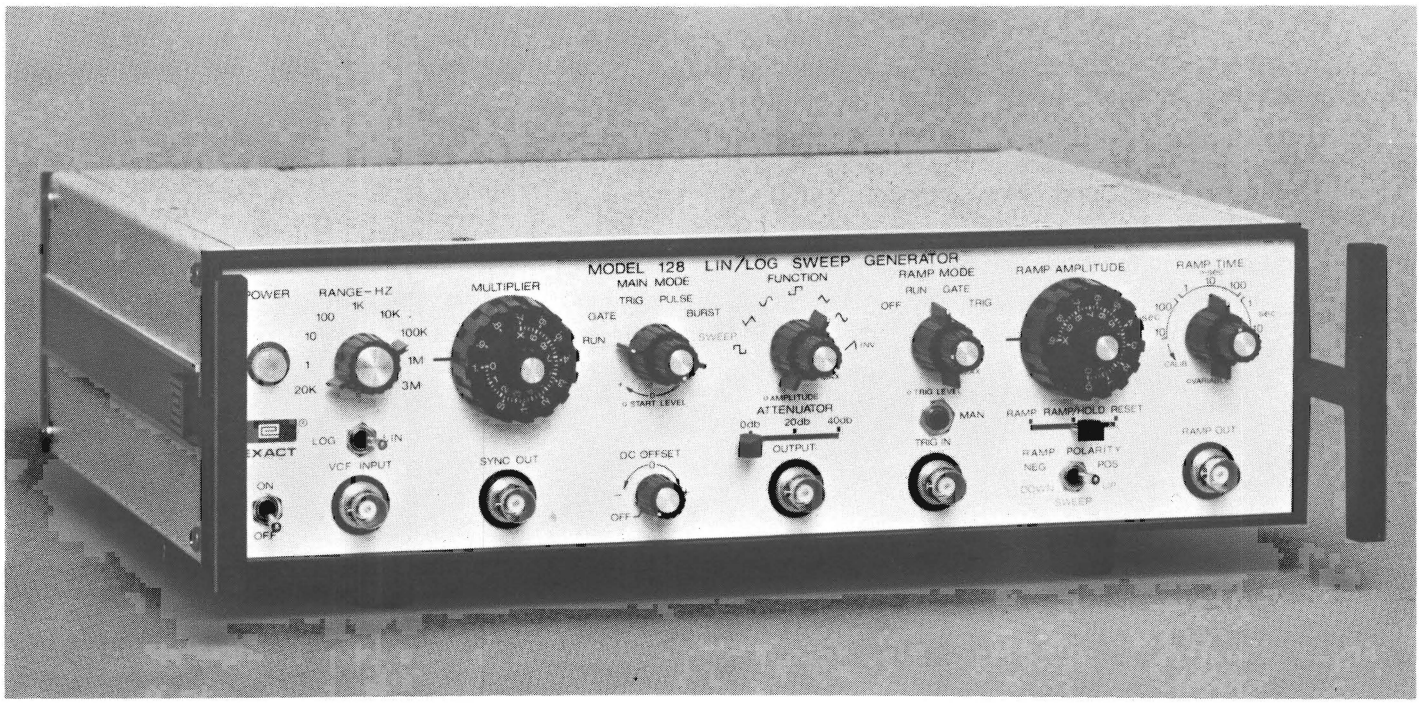
MODEL 128 LIN-LOG/SWEEP GENERATOR



FEATURES

- WAVEFORM GENERATOR — SINE, SQUARE, TRIANGLE, RAMP AND PULSE
- LINEAR OR LOG SWEEP GENERATOR (1000:1 RANGE)
- PULSE GENERATOR — VARIABLE WIDTH AND REPETITION RATE
- TONE BURST GENERATOR
- GATE/TRIGGER
- VARIABLE PHASE START/STOP
- KELVIN-VARLEY DIVIDER FREQUENCY CONTROL
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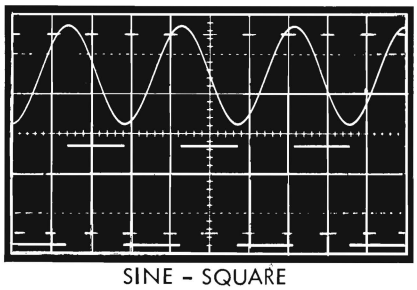
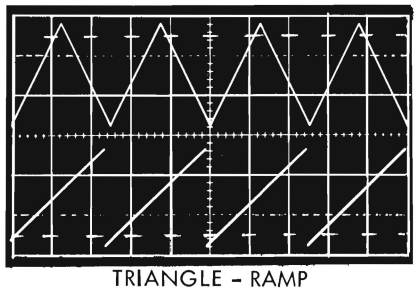
- FLOATING OUTPUT PROVISION
- DB STEP ATTENUATOR


SINE - SQUARE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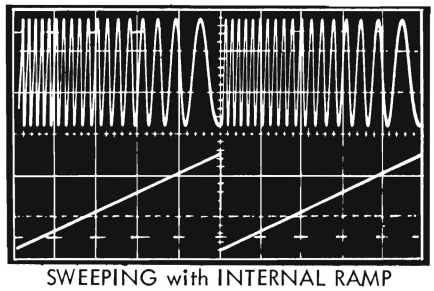
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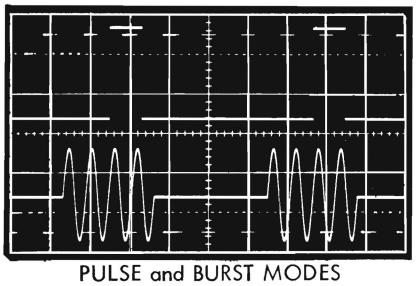
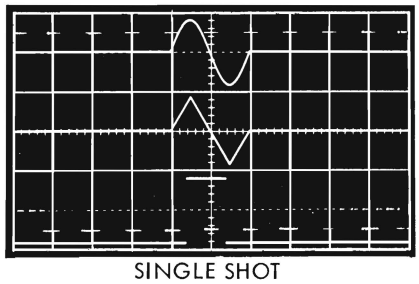
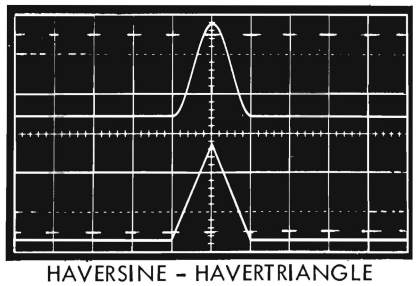

PULSE and BURST MODES


SINGLE SHOT


HAVERSINE - HAVERTRIANGLE

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GENERAL

The Model 128 is two complete generators in one small unique package. The main generator is a VCF (voltage controlled frequency) generator producing sine, square, triangle and sync waveforms over a dynamic frequency range of 0.1Hz to 3MHz. The sweep generator is a ramp generator providing a linear ramp with a duration of 100 seconds to 10μsec. It is used to internally sweep the main generator either linearly or logarithmically over a 1000:1 (three decades) range or to gate or trigger the main generator for tone-burst and pulse generator operation.

A search mode is provided using the Kelvin-Varley divider frequency multiplier vernier so the main generator can also be manually swept over three decades. In the pulse mode, pulse duration as well as repetition rate are variable. Both the main and ramp generator can be manually or externally gated or triggered.

The ramp output is available at the ramp output connector via its own attenuator and is also available inverted at the main output amplifier. The main generator can be swept up or down in frequency by the ramp generator.

The Model 128 is actually a combination SINE, SQUARE, TRIANGLE, VCF, LINEAR OR LOG SWEEP, TONE BURST, PULSE and independent RAMP GENERATOR in one versatile package.

SPECIFICATIONS

WAVEFORMS: Sine-Square-Triangle-Ramp-Pulse-Sync.

DYNAMIC FREQUENCY RANGE
Main generator, 0.1Hz to 3MHz. (20 Hz to 20KHz in 20K range)
Ramp generator, 100 sec to 10μsec.

MODES OF OPERATION
Main generator: Run-Gate-Trigger-Pulse-Burst-Linear Sweep-Log Sweep.
Ramp generator: Off-Run-Gate-Trigger.

SYNC OUTPUT
Main generator: Square wave approx 2V P-P open circuit. Approx 100Ω output impedance.
Ramp generator: Square pulse approx -1V peak open circuit. Approx. 100Ω output impedance. Coincident with start of ramp. Located on rear panel.

FREQUENCY ACCURACY
Main generator: ±2% of frequency range (typically ±2% of setting).
Ramp generator: 100 sec to 10μsec in seven calibrated steps. Accurate within ±5%. Uncalibrated, continuously variable between steps.

MAIN OUTPUT: 50Ω output impedance. All waveforms 20V P-P open circuit. 10V P-P into 50Ω with exception of ramp which is 10V peak open circuit, 5V peak into 50Ω. A full 60db of attenuation is provided in 20db steps with 20db continuously variable.

AUXILIARY RAMP OUTPUT: Typically 5V peak into 600Ω 75Ω output impedance.

V:f OUTPUT (voltage proportional to frequency) V:f output voltage directly related to frequency within selected range. Approx. 5mv to 5V for 1000:1 range.

GATE AND TRIGGER MODES
Input: D.C. coupled, input impedance approx 5K. Trigger signal requirements; manual or external voltage of approx 500mv for turn on. Trigger level adjustable.

RAMP HOLD MODE: Ramp will run to its peak and will not reset until manually reset. When ramp is placed in trig mode and ramp hold the two ends of the sweep can be measured and set.

SINE WAVE DISTORTION
<0.5% 0.1Hz to 100HKz (typically 0.2%). No harmonics <30db down 100 KHz to 3MHz (typically 38 to 42db down).

SINE FREQUENCY RESPONSE
0.1db to 100KHz, 0.5db to 3MHz.

SQUARE WAVEFORM
Rise and fall <75 nanosec. Overshoot and ringing <5%.

TRIANGLE LINEARITY: 99% to 100KHz, 95% to 3MHz.

D.C. OFFSET: Variable ±5V into 50Ω, ±10V, open circuit. Note: D.C. offset plus signal cannot exceed maximum voltage output or clipping will occur.

FREQUENCY STABILITY: 0.05% of setting for 10 min., 0.25% of setting for 24 hrs.

AMPLITUDE STABILITY: 0.05% of max. P-P amplitude for 10 min., 0.25% of max. P-P amplitude for 24 hrs.

SYMMETRY (time) ±1%

POWER REQUIREMENTS
Input Voltage — 115 VAC ±10% or 230 VAC ±10%.
Frequency — 50 to 400Hz.
Power Consumption — approx 20W.

PHYSICAL CHARACTERISTICS
12½" wide x 3½" high x 10½" deep.
Top and bottom covers are easily removable, exposing all calibration and circuit board areas.

PRICE: (f.o.b. Hillsboro, Oregon)
Option A $80 5MHz, Main Gen.
Option B $50 0.01Hz, Main Gen.
Option C $130 0.01Hz-5MHz Main Gen.

NOTE: (unless otherwise stated). Specifications apply 10% to maximum output voltage, terminated, into 50Ω and do not apply in the Search mode or 20K range. Specifications are valid at 25°C±5°C.

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CHECK-OUT PROCEDURE TO VERIFY SPECIFICATIONS

Following is a list of test equipment required to validate the specifications.

Test equipment with accuracy equal to the following list of test equipment will be acceptable for specification validation.

Oscilloscope, DC to 50MHz
Plug-in, Differential 20mv/cm sensitivity
Counter/Timer, .1μsec time base
DVM, .01% accuracy
Harmonic Distortion Analyzer, less than 0.1% residual distortion
Spectrum Analyzer, 1KHz to 100MHz

SPECIFICATIONS

FREQUENCY ACCURACY
Main generator: ±2% of frequency range (typically ±2% of setting).

Ramp generator: 100sec to 10μsec in seven calibrated steps. Accurate within ±5%. Uncalibrated, continuously variable between steps.

MAIN OUTPUT: 50Ω output impedance. All waveforms 20V P-P open circuit, 10V P-P into 50Ω with exception of ramp which is 10V peak open circuit, 5V peak into 50Ω. A full 60db of attenuation is provided in 20db steps with 20db continuously variable.

AUXILIARY RAMP OUTPUT: Typically 5V peak into 600Ω, 75Ω output impedance.

GATE AND TRIGGER MODES: Input D.C. coupled, input impedance approximately 5K. Trigger signal requirements, manual or external voltage of approximately 500mv for turn on. Trigger level adjustable.

SINE WAVE DISTORTION: Less than 0.5% 0.1Hz to 100KHz (typically 0.2%). No harmonics less than 30db down 100KHz to 3MHz (typically 38 to 42db down).

SINE FREQUENCY RESPONSE: 0.1db to 100KHz, 0.5db to 3MHz.

SQUARE WAVEFORM: Rise and fall less than 75 nanoseconds. Overshoot and ringing less than 5%.

TRIANGLE LINEARITY: 99% to 100KHz, 95% to 3MHz.

D.C. OFFSET: Variable ±5V into 50Ω, ±10V, open circuit. Note D.C. offset plus signal cannot exceed maximum voltage output or clipping will occur.

FREQUENCY STABILITY: 0.05% of setting for 10 minutes, 0.25% of setting for 24 hours.

AMPLITUDE STABILITY: 0.05% of maximum P-P amplitude for 10 minutes, 0.25% of maximum P-P amplitude for 24 hours.

SYMMETRY (time): ±1%.

If for any reason the Generator fails to meet any specifications, it is recommended that the instrument be completely calibrated using the Calibration Instructions contained within this manual.

FREQUENCY ACCURACY

Main Generator:

1. Set controls as follows:

RANGE	1K
MULTIPLIER	1.0
MAIN MODE	RUN
FUNCTION	SQUARE
ATTENUATOR	0db
AMPLITUDE	MID RANGE
D.C. OFFSET	OFF
RAMP MODE	RUN
RAMP AMPLITUDE	.9X
RAMP POLARITY	POS
RAMP TIME	1mSEC
CAL VERNIER	CAL

2. Connect the Counter/Timer to the Sync Output jack on the front panel with an appropriate coaxial cable to the A.C. input.
3. Observe time interval on counter of 1000μsec ±20μsec.
4. Set Range to 100. Observe time interval of 10msec ± .2msec.
5. Set Range to 10. Observe time interval of 100msec ±2msec.
6. Set Range to 1. Observe time interval of 1000msec ±20msec.
7. Set Multiplier to .10. Observe time interval between 8.33sec and 12.50sec.
8. Set Range to 10. Observe time interval between 833msec and 1250msec.
9. Set Range to 100. Observe time interval between 83.3msec and 125msec.
10. Set Range to 1K. Observe time interval between 8.33msec and 12.5msec.
11. Set Range to 10K. Observe frequency of 1KHz ±200Hz.
12. Set Range to 100K. Observe frequency of 10KHz ±2KHz.
13. Set Range to 1M. Observe frequency of 100KHz ±20KHz.
14. Set Range to 3M. Observe frequency of 300KHz ±60KHz.
15. Set Multiplier to 1.0. Observe frequency of 3MHz ±60KHz.

FREQUENCY ACCURACY, Main Generator (continued)

16. Set Range to 1M. Observe frequency of 1MHz ±20KHz.
17. Set Range to 100K. Observe frequency of 100KHz ±2KHz.
18. Set Range to 10K. Observe frequency of 10KHz ± .2KHz.
19. Set Range to 1K. Observe frequency of 1KHz ±20Hz.
20. Set Multiplier to .50. Observe frequency of 500Hz ±20Hz.
21. Set Multiplier to 1.0.
22. Set Range to 20K. Observe frequency of 20KHz ±400Hz.

Ramp Generator:

1. Connect the Counter/Timer to the Ramp Sync Output on rear panel with an appropriate coaxial cable.
2. Set counter to read time interval between negative slope and positive slope of pulse.
3. Set Cal vernier to Cal position.
4. Set Ramp Time to 10μsec. Observe ramp time of 10μsec ± .5μsec.
5. Set Ramp Time to 100μsec. Observe ramp time of 100μsec ±5μsec.
6. Set Ramp Time to 1msec. Observe ramp time of 1000μsec ±50 μsec.
7. Set Ramp Time to 10msec. Observe ramp time of 10msec ± .5msec.
8. Set Ramp Time to 100msec. Observe ramp time of 100msec ±5msec.
9. Set Ramp Time to 1sec. Observe ramp time of 1000msec ±50msec.
10. Set Ramp Time to 10sec. Observe ramp time of 10,000msec ±500msec.
11. Set Range to 1msec.
12. Set Cal vernier full CW. Observe ramp time greater than 10msec.
13. Set Cal vernier to Cal position.

TIME SYMMETRY

1. Connect the Counter/Timer to the Sync output jack on the front panel.
2. Set Range to 10K.

TIME SYMMETRY (continued)

3. Set Multiplier to 1.0
4. Set Counter/Timer to read time interval A to B and B to A. Observe time symmetry error <1%.
5. Set Range to 1K. Observe time symmetry error <1%.
6. Set Range to 100. Observe time symmetry error <1%.
7. Set Range to 10. Observe time symmetry error <1%.
8. Set Range to 1. Observe time symmetry error <1%.
9. Set Multiplier to .10. Observe time symmetry error <1%.
10. Set Range to 1K
11. Set Multiplier to 1.0.

FREQUENCY STABILITY

1. Observe that the frequency remains within 0.05% for 10 minutes or ± .5μsec.

SYNC OUTPUT

1. Connect oscilloscope to the Sync output on front panel with an appropriate coaxial lead.
2. Observe square wave of approximately 2V P-P open circuit.
3. Connect oscilloscope to the Ramp Sync output on rear panel.
4. Observe Sync pulse approximately -1V peak open circuit.

MAIN OUTPUT

1. Set Amplitude to Max. Connect the main output to the oscilloscope with a 50Ω coaxial cable terminated into 50Ω.
2. Observe square wave >10V P-P.
3. Switch through all square, triangle and sine waveforms, observing >10V P-P amplitude.
4. Switch to Ramp waveform. Set Ramp Amp. .9X. Observe >5V ramp on Pos or Neg Ramp as selected by Ramp Polarity switch.

MAIN OUTPUT (continued)

5. Remove 50Ω terminator and observe >20V P-P open circuit for square, triangle and sine waveforms and >10V peak for positive and negative ramp.

6. Set Attenuator at 20db and observe amplitude drops 20db or to 1/10 of amplitude at 0db.

7. Set Attenuator at 40db and observe amplitude drops another 20db, or to 1/100 of amplitude at 0db.

8. Rotate Amplitude vernier and observe another 20db of attenuation.

9. Set Amplitude to Max, Attenuator to 0db.

AUXILIARY RAMP OUTPUT

1. Connect the Ramp output jack through an appropriate coaxial cable terminated into 600Ω to the oscilloscope.

2. Observe positive ramp waveform approx. 5V peak into 600Ω.

3. Set Ramp Polarity to Neg and observe negative ramp approx. 5V peak into 600Ω.

GATE AND TRIGGER MODES

1. Set

MAIN MODE	GATE
RAMP MODE	GATE
TRIG LEVEL	MAX

2. Monitor the Main output with oscilloscope.

3. Apply signal at Trig input jack, increase signal and observe Main generator runs at approximately +500mv of signal.

4. Monitor Ramp output and observe ramp runs at approx. +500mv of signal.

SINE WAVE DISTORTION

1. Set

MAIN MODE	RUN
RANGE	10K
AMP	MID RANGE
FUNCTION	SINE

9. Calculate linearity and observe linearity is 99% or better.

SINE WAVE DISTORTION (continued)

2. Connect distortion analyzer to the Main output jack. Measure sine distortion of <.5%, typically .20%.

3. Set Range to 100K and measure sine distortion <.5%.

SINE FREQUENCY RESPONSE

1. Set Range to 10K.

2. Connect oscilloscope to Main output jack.

3. Measure sine wave P-P amplitude accurately.

4. Set Range to 100K. Observe sine amplitude drop <.1db.

5. Set Range to 3M. Observe sine amplitude drop <.5db.

SQUARE WAVEFORM

1. Set

RANGE	1M
FUNCTION	SQUARE

2. Connect the Main output through a 50Ω coaxial cable terminated into 50Ω to the oscilloscope.

3. Observe risetime and falltime of square <75ns at Main output.

4. Observe overshoot and ringing <5% of P-P amplitude.

D.C. OFFSET

1. Set Range to 1K, Amplitude vernier to Min.

2. Rotate D.C. offset switch and observe D.C. level shift ±5V into 50Ω.

3. Remove terminator and observe D.C. level shift ±10V.

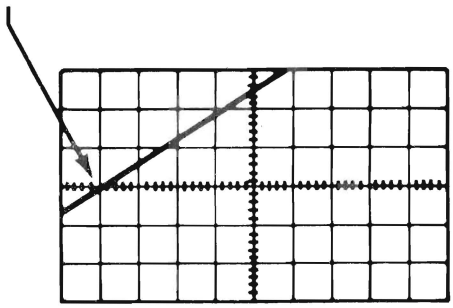
NOTE: D.C. offset plus signal cannot exceed maximum voltage output or clipping will occur.

AMPLITUDE STABILITY

1. Set Amplitude to Max, D.C. Offset to Off, Function to Triangle.
2. Connect the Main output through a 50Ω coaxial cable terminated into 50Ω.
3. Set plug-in sensitivity to 20mv/cm.
4. Measure accurately the positive peak of triangle and negative peak of triangle and record.
5. Wait 10 minutes and measure positive and negative peaks again. Observe amplitude change <10mv.

TRIANGLE LINEARITY

1. Connect the Main output to the differential plug-in through a 50Ω coaxial cable terminated into 50Ω.
2. Adjust oscilloscope to obtain one-half cycle of triangle across full horizontal grid on oscilloscope CRT.
3. Set differential plug-in sensitivity at 20mv/cm.
4. Adjust comparison voltage until the slope of the triangle waveform intersects the mid-scale horizontal grid line at the second major mark as shown below.

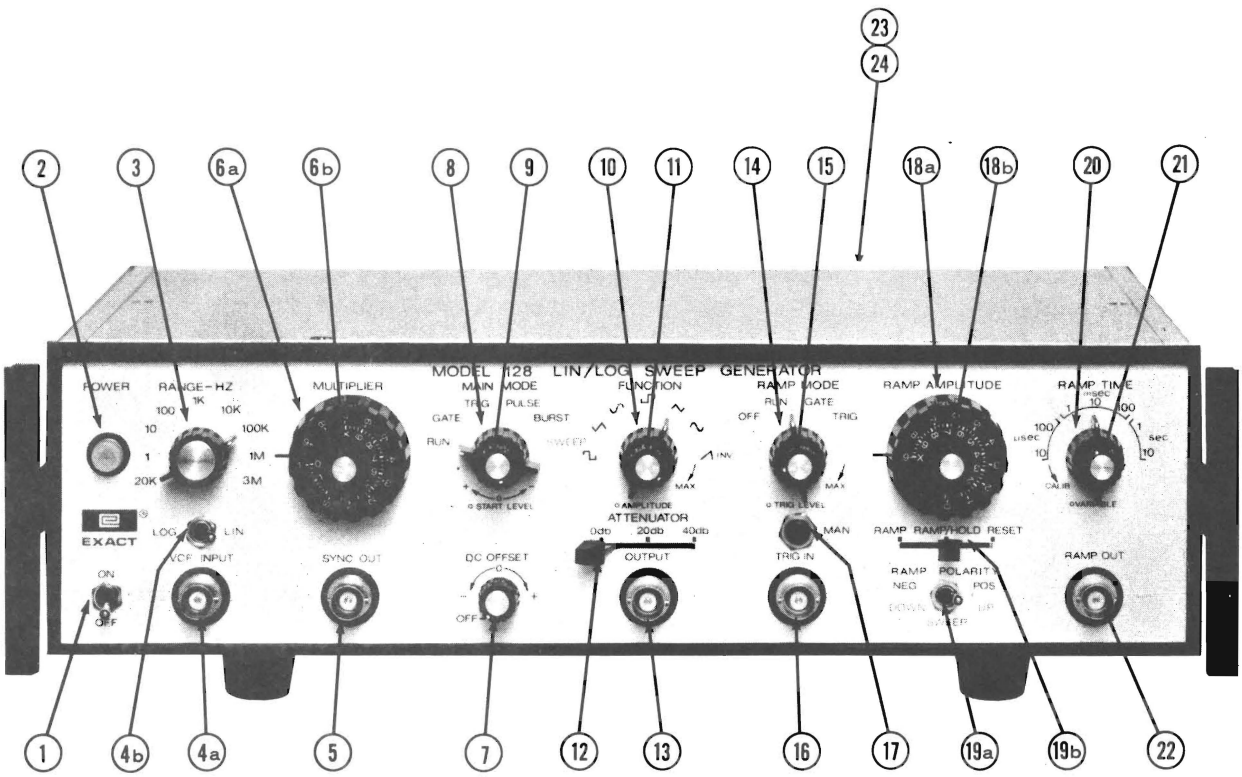


5. Record reference voltage using DVM accurate to 1mv.
6. Adjust comparison voltage until slope of triangle intersects next major horizontal grid mark.
7. Record accurately the new reference voltage.
8. Repeat to obtain as many points as desired.
9. Calculate linearity and observe linearity is 99% or better.

SECTION 3

FRONT PANEL FAMILIARITY

OPERATING INSTRUCTIONS


MODEL 128 LIN/LOG SWEEP GENERATOR
POWER
RANGE-HZ
MULTIPLIER
MAIN MODE
FUNCTION
RAMP MODE
RAMP AMPLITUDE
RAMP TIME
EXACT
ON
OFF
LOG
LIN
VCF INPUT
SYNC OUT
DC OFFSET
OUTPUT
ATTENUATOR
TRIG IN
MAN
RAMP POLARITY
RAMP OUT
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3
6a
6b
8
9
10
11
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15
18a
18b
20
21
23
24
1
4b
4a
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7
12
13
16
17
19a
19b
22

3.1.0 FRONT PANEL FAMILIARITY

1. Power Switch - Turns instrument On and Off.

2. Power Indicator Lamp - Visual indication when power is On.

3. Range Switch - Selects desired frequency range.

4a. VCF input - Provides external input for voltage control of frequency or sweeping.

4b. Lin/Log Switch - Selects linear of exponential control of freq. from VCF input or internal sweep.

5. Sync Out - Provides Sync pulse for external equipment. Sync pulse is coincident with internal square wave.

6a. Multiplier dial - Provides calibration fixed steps between range settings. Each step equals 10% of range. The "S" position places the generator in the Search mode.

6b. Multiplier Vernier - Allows variable adjustment of frequency between fixed steps of the Multiplier dial.

7. D.C. Offset switch - The Off position disables the offset potentiometer. The offset potentiometer manually adjusts the D.C. reference of the output waveform selected by the Function switch.

8. Main Mode switch - Selects Main generator modes of operation.

9. Start Level - Varies the lockout level or phase of the triangle and sine waveforms with respect to the square wave.

10. Function switch - Selects the desired function of the output.

11. Amplitude - Provides 20db variable attenuation of the output amplitude.

12. Attenuator switch - Selects desired amount of attenuation at the Main output.

13. Output jack - 50Ω output jack for all waveforms selected by the Function switch.

14. Ramp Mode - Selects Ramp generator modes of operation.

15. Trig Level - Adjusts trigger level input sensitivity.

16. Trig In - Provides input for external gating and triggering signals for the Main generator and the Ramp generator.

17. Manual pushbutton - Provides manual gating and triggering signal.

18a. Ramp Amplitude - Provides fixed positions of 10% amplitude attenuation.

18b. Ramp Amplitude Vernier - Provides variable amplitude adjustment between fixed steps of ramp attenuation.

3.1.0 FRONT PANEL FAMILIARITY (Continued)

19a. Ramp Polarity/Sweep - Selects ramp polarity at the ramp output jack and ramp polarity for sweeping the Main generator in the Sweep mode.

19b. Ramp/Ramp Hold/Reset - Ramp Hold causes the ramp to hold at peak voltage without reset. Reset provides a manual reset for the ramp.

20. Ramp Time - Selects the desired range of ramp time in seven positions from 10μ sec to 10sec.

21. Cal vernier - Provides variable ramp time between fixed ramp time ranges.

22. Ramp Out - Output jack for ramp.

23. Ramp Sync - Provides a sync pulse coincident with start of ramp.

24. V:f Output - Provides approx. 0V to +5V proportional to Main Generator frequency. For use with frequency meter, etc.

3.2.0 FIRST TIME OPERATION

NOTE: Before applying power to the instrument, the input power line switch must be in the proper position corresponding to the line voltage source which will be applied. The instrument comes supplied with the proper fuse for 117V operation. If the unit is to be operated from 230V AC line, place the line switch located on the rear panel to the 230V position and change the fuse as indicated by the fuse data silk-screened on the rear panel.

Plug the power cord into the proper source of 100V AC or 230V AC 50-400Hz and turn on the Power switch.

NOTE: This instrument is equipped with a floating circuit ground which may be tied to the chassis ground or floated to some other source by the connection of the grounding strap on the rear panel. It is recommended that the rear panel chassis ground and circuit ground be connected together with the grounding strap provided unless it is necessary to float the instrument ground.

Set controls as follows:

RANGE	1K
MULTIPLIER	1.0
MAIN MODE	RUN
FUNCTION	∿
AMPLITUDE	MAX
ATTENUATOR	0db
D.C. OFFSET	OFF
RAMP MODE	RUN
RAMP AMPLITUDE	.9X
RAMP TIME	10mSEC
CAL vernier	CAL
RAMP POLARITY	POS

3.2.0 FIRST TIME OPERATION (continued)

1. Connect the Main output through a 50Ω coaxial cable into a 50Ω terminator to a suitable oscilloscope. A 1KHz 10V P-P triangle waveform should be observed under these conditions.

2. Switch the Function switch through its various output waveforms.

3. The frequency may be selected by the Range switch and/or the Multiplier dial.

4. Switch the D.C. Offset switch On and observe the waveform D.C. level may be adjusted as desired. Set the D.C. offset switch to the Off position.

5. Observe the output amplitude can be adjusted over its 60db of dynamic range by the Amplitude Vernier and the Attenuator switch.

6. Place the Main Mode switch in the Gate position. Observe the Main generator is now locked out. Observe the output while depressing the Manual pushbutton. The generator will free run as long as the pushbutton is depressed.

7. Rotate the Start Level vernier and observe the lockout level may be adjusted to the desired level or phase.

NOTE: The generator will free run if the Start Level is rotated too far.

8. Set the Main Mode switch to the Trig position. Observe one complete cycle each time the manual pushbutton is depressed.

9. Pulse Mode

Set the Main Mode switch to Pulse. The generator is now being triggered by the ramp generator, giving a pulse output.

Set controls as follows

FUNCTION	SQUARE
RANGE	1K
MULTIPLIER	1.0
RAMP MODE	RUN
RAMP AMPLITUDE	.10
RAMP TIME	10msec
OSCILLOSCOPE	2msec/cm

Trigger scope from front panel Sync output.

Observe that the Main generator Range and Multiplier controls vary the pulse width. The repetition rate is variable by varying the ramp time and ramp amplitude.

3.2.0 FIRST TIME OPERATION (continued)

10. Burst Mode

Place the Main Mode switch to Burst. The Main generator is now being gated by the ramp generator, giving a burst output.

Set the generator controls as follows

FUNCTION	SINE
RANGE	1K
MULTIPLIER	1.0
RAMP MODE	RUN
RAMP AMPLITUDE	.10
RAMP TIME	10msec
OSCILLOSCOPE	2msec/cm

Trigger scope from front panel Sync output.

Observe by adjusting the Ramp Amplitude or Ramp Time the burst "on" and "off" time may be varied. The frequency of the Main generator determines the frequency within the burst.

Caution: If the ramp amplitude is adjusted below .06 (600mv), the Main generator will lock out. Also, if the ramp amplitude is adjusted beyond .50 the generator may appear to be free running unless properly synchronized to the scope, since the "off" time is very small in proportion to the "on" time.

If the ramp amplitude is adjusted beyond .30, it is recommended that the Ramp Sync output (located on rear panel) be used to trigger the scope while observing the burst "off" time.

11. Sweep Mode

To thoroughly understand the Sweep mode it is recommended that you read the circuit description under section 4.2.1 (Summing Amplifier).

Set Ramp Amp to .9X. Place Main Mode to Sweep, Ramp Polarity to Neg and Ramp Time to 1sec. The Main generator frequency is now being swept down over 1000:1 by the Ramp generator at the rate set by the Ramp Time switch.

Place the Main Mode switch to Run. Place the Multiplier to S. Set the Range switch to 100K. While rotating the Multiplier vernier CCW toward 0, observe the Main generator frequency will sweep down to 1/1000 of the frequency set by the Range switch.

Set Ramp Polarity to Pos, set Main Mode to Sweep. Observe the Main generator frequency is now being swept up in frequency from 1/1000 of the range setting to approximately that of the range setting.

3.2.0 FIRST TIME OPERATION (Continued)

11. Sweep Mode (Continued)

The sweep rate and width may now be adjusted as desired by the Ramp Time and Ramp Amplitude settings.

Log Mode

Repeat Step 11 for Log Mode.

12. Set

MAIN MODE	RUN
MULTIPLIER	1.0
RANGE	1K
RAMP MODE	RUN
RAMP AMPLITUDE	.9X
RAMP POLARITY	POS
RAMP TIME	1msec

13. Connect the oscilloscope to the Ramp output jack after removing the 50Ω terminator. The ramp output will not drive 50Ω at full output.

14. Observe a 1msec 5V positive ramp at the ramp output. Switch the Polarity switch to Neg and observe a 1msec 5V negative ramp at the output.

The ramp time can be set as desired by the Ramp Time switch and Cal vernier. The Ramp amplitude can be set from 5V to 0V with the Ramp Amplitude switch and vernier.

15. Set Ramp Time to 1msec, Ramp Mode to Off. Observe the ramp is locked out at 0V.

16. Set Ramp Mode to Gate. Observe the ramp is locked out and will run as long as the Manual pushbutton is depressed.

17. Set Ramp Mode to Trig. Observe the ramp is locked out and will run one complete cycle each time the Manual pushbutton is depressed.

18. Set

RAMP MODE	TRIG
RAMP/RAMP HOLD/RESET	RAMP HOLD
RAMP TIME	1sec

Depress the manual trigger pushbutton and observe the ramp rises and holds at its peak. Place Ramp/Ramp Hold/Reset switch to the reset position and observe the ramp reset to 0V. This is useful when one wishes to set upper and lower frequency in sweep mode or when it is not desirable for the ramp to reset. Place lever switch to RAMP position for normal operation.

SECTION 4

CIRCUIT DESCRIPTION

4.1.0 BLOCK DIAGRAM (figure 7.2.0)

MAIN GENERATOR

The Summing Amplifier sums the currents from the Multiplier dial, VCF input and internal sweep signal. The output of the Summing Amplifier drives the Positive and Negative Current Sources. A diode gate alternately connects the Positive and Negative Constant Current Sources to the timing capacitor selected by the Range Switch. This constant current charging and discharging the timing capacitors produces the required triangle. The Tri Buffer supplies the power to drive the associated circuitry without loading the current sources. Switching signal for the Diode Gate is supplied from the Bi-stable Switch in conjunction with the Level Detector. The Sync signal from the Level Detector and Bi-stable Switch is brought out through the Sync Output Buffer to prevent loading of the Bi-stable Switch.

The Lockout Amplifier sinks the timing current from the current source during Gate, Trigger, Pulse and Burst Modes. Logic for these modes is obtained from the Main Generator Lockout Logic. Signal from the lockout logic enables and disables the Lockout Amplifier. The Reset Buffer supplies a signal from the Level Detector-Bi-stable Switch, needed for completion of last cycle and reset for the Logic Gate.

D.C. coupled gating and triggering is accomplished by the Trig Level Comparator. Signal from the Trig Level Comparator enables the Lockout Logic Gate during lockout modes. The Manual Gate and Trig Switch serves to eliminate contact bounce of the Man Pushbutton Switch during manual triggering and gating to prevent multiple triggering of the Main and Ramp Generators. The triangle from the Tri Buffer is shaped by the Sine Converter and amplified by the Sine Amplifier to produce the Sine wave.

All output waveforms pass through the Input Buffer and are then connected to the Output Amplifier. The Output Amplifier provides the necessary power to drive the Main Output. The Output Attenuator provides two 20db pads for output attenuation.

RAMP GENERATOR

The Ramp Generator produces the required ramp waveform for internally sweeping, bursting and pulsing the Main Generator.

The Ramp Integrator uses an operational amplifier as an integrator to convert a constant input current to a linear ramp. A diode gate alternately connects the positive and negative timing resistors to produce the ramp waveform.

The Level Detector produces the signal needed for switching the Diode Gate at the proper times to produce a ramp waveform at the Integrator Output. The Ramp Sync Output Buffer prevents loading of the Level Detector from the Ramp Sync Output. The Reset Buffer prevents loading of the Level Detector while supplying a reset pulse for the Ramp Gate Trig Logic, used for reset and completion of last cycle.

The Lockout Switch disables the Integrator during the Gate and Trigger Modes of operation. The Gate-Trig Logic enables and disables the Lockout Switch at the proper time during Off-Run-Gate and Trigger Modes. The Trig Level comparator provides high speed D.C. coupling of external trigger signals to operate the Gate and Trigger Logic.

RAMP GENERATOR (continued)

The Ramp Amplitude provides attenuation of the ramp waveform. The Ramp Buffer provides the necessary power and isolation for driving the Ramp output and the Main Power Amplifier. The Ramp Inverter provides an inverted ramp for push-pull operation, positive and negative ramp and Bi-polar Sweeping of the Main Generator.

4.2.0 CIRCUIT DESCRIPTION

4.2.1 SUMMING AMPLIFIER (figure 7.2.2)

Q210 is an operational amplifier connected for a voltage gain of -1. The Main Multiplier dial (S210) forms a Kelvin-Varley Voltage Divider providing approximately +5V to +.5V to the Summing Amplifier Input (TP211). By varying the applied input voltage, the signal to the Constant Current Source Drivers can be varied, thus providing a method for changing the timing current and thus the frequency. The Summing Amplifier inverts the applied input voltage. When S210 (Mult) is in the Search Mode, the vernier (R223) is connected between +12V and ground to supply a 1000:1 voltage ratio, thus a 1000:1 frequency deviation. Main Timing Adjust (R210) establishes the correct input voltage to the Kelvin-Varley Divider to obtain the correct timing during calibration. D211 and D210 provide input protection for the μA709 operational amplifier.

The VCF Input is connected to the Summing Amplifier at TP210, providing an external source of frequency control. By applying voltage at the VCF input, the frequency may be varied as with the Multiplier Dial. The applied input voltage will add to or subtract from that established by the Multiplier Dial setting. If the Multiplier Dial is set as position 1.0, approximately +5V is applied to the input of the Summing Amplifier. If a positive voltage is now applied to the VCF Input Jack, the Summing Amplifier will saturate. If -5V is applied at the VCF Input Jack, this will add to the +5V applied by the Multiplier Dial and the resultant input voltage will approach 0V, driving the Summing Amplifier output to approximately 1/1000 of the frequency of the Range and Multiplier setting. If the Multiplier Dial were in the Search Mode of operation and set at approximately 0V input at TP211 by the Search Vernier (R223), the frequency would be approximately 1/1000 of the Range setting. By applying +5V at the VCF Input Jack, the two voltages will sum, establishing approximately +5V at the Summing Amplifier input. This will cause the frequency to sweep up to approximately the frequency of the Range setting.

TP212 is the internal sweep input, connected to the Ramp Generator when in the Sweep Mode of operation. The frequency may be swept up or down, depending upon the ramp polarity selected and the Multiplier Dial settings as previously explained. The Ramp Waveform is adjustable from +5V to 0V by the Ramp Attenuator to provide the desired amount of sweep. The VCF Balance (R222) compensates for the offset in the Summing Amplifier, establishing a 0V reference at the Summing Amplifier input. The output of the Summing Amplifier is approximately 0V to -5V and drives the Positive and Negative Current Source Drivers.

POSITIVE AND NEGATIVE CURRENT SOURCE DRIVERS

The output of the Summing Amplifier (0V to -5V) is connected to Q200, the Positive Current Source Driver, through R205. Q255 and Q200 provide a constant current source in the feedback loop of the Positive Current Source Driver. Q200 will turn on Q255 until a feedback current equal to the input current through R205 is equalized. This current causes a voltage drop across R201A which equals the voltage drop across R205.

The Search Sym Adj (R204) compensates for offset in the operational amplifier, establishing a 0V reference at Q200 input and balancing the two Current Source Drivers at 1000:1 to obtain correct symmetry at 1000:1.

Q240 in conjunction with Q250 make up the Negative Current Source Driver. The output signal from Q210 Summing Amplifier is connected to Q240 operational amplifier at the Non-inverting Input. Q240 is connected as a voltage follower. Q250 establishes a constant current equal to the input voltage ÷ R242. This constant current causes a voltage drop equal to the output voltage of the Summing Amplifier, across R201B, exactly equal to and of opposite polarity of that across R201A.

POSITIVE AND NEGATIVE CONSTANT CURRENT SOURCE

Q260, Q270, Q280 and Q290 are the Positive and Negative Constant Current Sources supplying the constant timing current to charge and discharge the timing capacitor. Q260 operational amplifier and Q270 FET are connected to form a constant current source. The signal across R201A is connected to Q260 operational amplifier at the non-inverting input. This causes a voltage of exactly the same polarity and amplitude across R262A timing resistor. This causes a constant current E(R262A) ÷ R(R262A) to charge the timing capacitor when the Diode Gate is turned on, connecting the Positive Current Source. The FET (Q270) prevents loading of the current sources at very low timing currents (1000:1).

Q290 operational amplifier and Q280 FET provide the negative constant current needed to charge the timing capacitor in exactly the same way. The 0.1Hz symmetry (R282) compensates for offset current in the operational amplifiers (Q260 and Q290) to establish the correct symmetry on slow timing ranges with large timing resistors. This adjustment is made on the 1Hz range at the .1 setting on the Multiplier Dial.

The Diode Gate is made up of D280, D282, D283 and D284. The timing capacitors are connected at TP281 through the Range Switch, which also switches the Timing resistors.

Gate switching signal is connected at D280 and D282 junction. When the Gate signal is positive, D282 is forward biased and sinks the timing current from the Negative Current Source, thus disconnecting the Negative Current Source. D280 is now reverse biased, allowing timing current to charge the timing capacitor through D284 from the Positive Current Source. When the Gate signal switches negative, D280 is forward biased, thus sinking the positive timing current through D280. D282 is now reverse biased, allowing timing current to charge the timing capacitor from the Negative Current Source through D283. D281 is connected to the Lockout Amplifier and sinks the timing current during the lockout modes.

4.2.2 TRIANGLE BUFFER (figure 7.2.3)

Q365A and B and Q370A and B serve as a unity gain, high input impedance buffer for the triangle generated at TP281. Q365A FET prevents loading of the current sources by its very high input impedance. Q365A is a source follower driving Q370A, an emitter follower. Q370B provides offset and temperature compensation for Q370A while Q365B provides offset and temperature compensation for Q365A.

Level Detector-Bistable Switch, Q385, Q390 and Q400, is a differential amplifier used as a level detector. Q390 is a constant current source for differential amplifier Q385 and Q400. The reference level at the base of Q400 is determined by one of the current sources connected by the diode gate, D395-D398. D385 and D386 limit the collector swing of the differential amplifier to improve high frequency response. The Level Detector collectors drive a non-saturating current mode switch. The Bi-stable Switch is differential input and differential output. One output, Q395, drives the reference gate for the Level Detector, the Reset Buffer, the Sync Output Buffer and the Current Source Gate. R397 and R401 adjust the positive and negative trip points of the Level Detector, establishing the positive and negative peaks of the triangle. The other output, Q415, provides the square wave signal for the Output Amplifier. D399 is a Zener diode which decreases the collector supplies from -12V to approximately -7V for Q395, Q415 and Q425 to limit power dissipation.

SQUARE BUFFER

The Square Buffer, Q420 and Q425, prevent loading of the Bi-stable Switch and drive the diode gate, D426-D429. R423 and R429 allow adjustment of the positive and negative peaks of the square wave.

SYNC OUTPUT BUFFER

Q360 is an emitter follower which prevents loading of the Bi-stable Switch while providing a sync pulse to the Sync Output Jack. The sync pulse is clipped by diodes D360 through D363.

RESET BUFFER

Q345 provides a logic pulse of proper polarity to drive the Trigger Gate Logic without loading the Bi-stable Switch.

LOCKOUT AMPLIFIER

The Lockout Amplifier is a differential amplifier which compares the triangle waveform to a fixed reference established by the Start Level Adjustment (R313). Q310 and Q305 form the input stage which drives Q315 and Q320, the output stage. D310 is a Zener diode used as a collector clamp for Q310 to keep it out of saturation. Q320 collector is connected to D281, the lockout diode connected to the Current Source Gate at TP281 (the input of the triangle buffer).

D321 enables and disables the output stage. During Run, D321 is forward biased, keeping Q320 turned off. With Q320 off, D281, the lockout diode, is reverse biased and the generator free runs. During lockout, D321 is reverse biased, enabling the Lockout Amplifier. As

LOCKOUT AMPLIFIER (continued)

the triangle charges toward its negative peak, Q310 becomes reverse biased until Q310 turns off sufficiently to cause Q320 to turn on. When Q320 turns on sufficiently, it will forward bias D281, sinking the timing current from the Negative Current Source. The level at the point of lockout is determined by the input divider to the Lockout Amplifier, R312, R313 and R314. D323 and D322 provide collector clamping for Q320 to prevent saturation.

MAIN GENERATOR LOCKOUT LOGIC GATE

Q325A is a Quadruple 2 Input Positive Nor Gate, which provides the necessary logic function to operate the Lockout Amplifier. In the Run Mode of operation, the Trigger Level Comparator supplies a logical "1" at one input of Q325A (pin 2). As long as this logical "1" is present, the output of Q325A (pin 1) will remain a "0". A "0" at pin 1 will forward bias D321, disabling the Lockout Amplifier, causing Q320 to remain "off", or in a run condition, as previously explained. In the Gate Mode of operation, the Trigger Level Comparator supplies a "0" to the logic input (Q325A pin 2). The output will remain a "0", keeping D321 forward biased in the Run Mode until a "0" is applied at the other input (pin 6).

The pulse from the Reset Buffer is coincident with the square wave from the Level Detector. When the square is in the proper phase relationship, a negative pulse or "0", from the Reset Buffer is connected to the other logic input (pin 6), which will cause the output of Q325A pin 1 to go to a logical "1", thus reverse biasing lockout diode D321. D321 will remain reverse biased in a lockout condition until one of the logic inputs goes to a logical "1" level or positive. The Reset Buffer during lockout will remain a "0" as long as the generator is locked out.

TRIG LEVEL COMPARATOR

Q350 is a high speed differential comparator providing D.C. coupled Triggering, Gating and Bursting Modes for the Main Generator Logic Gate.

Run Mode:

In the Run Mode, -12V is applied to the inverting input of Q350 through Q360A. This assures that the non-inverting input always remains more positive than the inverting input. This causes Q350 output to remain positive or in the Run Mode of operation. Both inputs of the comparator are protected by clipping diodes D350 through D353. The -12V from S360 is connected to -12V through S500A, the Main Generator Function Switch. The Main Generator Function Switch supplies -12V in all positions except Ramp. In the Ramp position the -12V is disconnected, thus removing the negative bias at Q350 pin 3, allowing it to return to a positive bias, causing the comparator output to go to its negative state (lockout condition). The Main Generator is locked out when the Function Switch is in Ramp position to prevent Main Generator noise from riding on low level ramp waveforms.

TRIG LEVEL COMPARATOR (continued)

Gate Mode:

In the Gate mode, the -12V from S360A is disconnected, causing Q350 inverting input (pin 3) to go to a more positive state than the non-inverting input. This switches the output of the comparator to its negative or "0" state. The "0" from the comparator places the Logic Gate in a lockout condition. The generator will remain in a lockout condition until signal is received at the comparator input (pin 2).

In the Gate Mode, the comparator input is connected through S360B to the Trigger Level Potentiometer connected to the External Trigger Input. At the maximum sensitivity setting of the Trigger Level Potentiometer, any signal >500mv will cause the Trigger Level Comparator to turn on, placing the Logic Gate in a "run" condition. When the input signal is removed or falls below 500mv, the comparator will allow the Logic Gate to return to its lockout condition.

Trigger Mode:

The only difference between the Gate and Trigger modes of operation is that the output of the comparator is A.C. coupled to the logic Gate instead of D.C. coupled. When the trigger signal causes the comparator to turn on, the positive output of the comparator A.C. couples a differentiated positive pulse into the Logic Gate, placing it in a run condition. The duration of this pulse is very short, allowing the Logic Gate input to return to a "0" or a lockout condition even though the comparator may still be "on" in its positive state. The Reset Buffer will couple a "0" into the Logic Gate upon completion of the first cycle and cause the generator to lock out. The external trigger signal must be removed, allowing the comparator to reset before another pulse can be coupled into the Logic Gate. One complete cycle will be generated each time a signal >500mv is applied at the Trigger Input.

Pulse Mode:

In the Pulse Mode, the Positive Ramp from the Ramp Generator is connected to the comparator input through S360B. The Pulse Mode operates exactly as in the Trigger Mode. Each time the Ramp waveform rises about 500mv, one complete cycle of the Main Generator will be completed. By adjusting the Ramp Time, the pulse repetition rate can be varied over an extremely wide range. If the Ramp Amplitude is adjusted below 500mv, the Main Generator will remain in a lockout condition.

Burst Mode:

The Burst Mode functions exactly as in the Gate Mode. The positive Ramp is connected to the comparator input in the Burst Mode. When the level of the ramp rises about 500mv, the comparator will turn on, holding the Logic Gate in a run condition as long as the ramp remains >500mv. The Ramp Amplitude controls the number of cycles in the Burst and the Ramp Time controls the Burst off time.

Note: If the Ramp Amplitude is adjusted below 500mv, the Main Generator will remain in a lockout condition.

TRIG LEVEL COMPARATOR (continued)

Sweep Mode:

In the Sweep Mode, the generator is placed in a run condition by the -12V at S360A. All trigger signal paths are disconnected. The Positive and Negative ramp is connected to the Summing Amplifier input (TP212) through S360B. This allows the Main Generator to be swept up or down in frequency depending upon the Ramp Polarity selected. By adjusting the Ramp Amplitude and Ramp Timing, the sweep width and sweep rate may be adjusted to obtain the desired result.

MANUAL GATE/TRIGGER SWITCH

The Man Pushbutton switch located on the front panel is used in conjunction with the Man Gate/Trig Switch to provide a bounce-free switch for manually gating and triggering the Main Generator and Ramp Generator. Q820A and B are one-half of a Quadruple 2 Input Positive Nand Gate. Normally, S820, the Manual Pushbutton, keeps one input of the Nand Gate, Q820 pin 1, at "0" and pins 3 and 4 at "1". Pin 5 is connected to +5V or a "1" through R826. With both inputs of Q820B Positive Nand Gate at "1", the output (pin 6) will remain at "0". The output of this Positive Nand Gate is connected through D820 to the trigger level input (TP823) which is connected to the Trigger Level Comparators of each generator through each generator's Mode Switch. When S820, the Man Pushbutton, is depressed, pin 5 of Q820B Positive Nand Gate will be set to "0". This will cause the output (pin 6) to go to a "1" or positive state. This "1" is coupled through D820 to the Trig Level Input. This "1" will remain until S820 is released, allowing the output of Q820B to return to a "0".

4.2.3 SINE CONVERTER (figure 7.2.4)

The Sine Converter converts the triangle to a sine by means of a bipolar diode shaping network. The triangle is connected at TP622. R622 and R621 form a voltage divider to correctly match the triangle amplitude to the converter network. As the triangle rises positive, each diode gate will turn on in succession, causing the output of the network to form a sine wave at the junction of the three voltage dividers. The diode gates will turn on and off in sequence following the triangle.

SINE AMPLIFIER

This sine wave is amplified by differential amplifier Q600A and B. Q605 is a constant current source for the input differential stage. Sine D.C. Adj (R589) compensates for offset in the input pair, establishing a 0V reference at the Sine Output. A second differential stage is driven By Q600A and B. The output across R575 is connected to the Output Buffer (Q560 and Q565) through an emitter follower (Q570). The output (TP560) is connected through feedback resistors R590 and Sine Amplifier adjustment R591 to the inverting input. The sine wave is connected to S500E, the Function Switch.

INPUT BUFFER

The Input Buffer, Q510 and Q500, prevents loading of the Amplitude control (R506) from the low input impedance of the Power Amplifier.

POWER AMPLIFIER

S500 B and C connect the various waveforms to either the inverting or non-inverting input selected by the Function Switch. Q515A and B are the input differential amplifier. Q530 is a constant current source for Q515A and B. The offset adjustment (R527) compensates for offset of the input pair and the Input Buffer. The D.C. Offset Switch on the front panel supplies offset current to the inverting input for adjusting the D.C. reference at the output. Q535 and Q540 are a second differential stage driven by Q515A and B. The signal at Q540 is connected to the output through the output buffer, Q545 and Q550. R552 is selected to adjust the quiescent current in the output buffer to approximately 10ma. Gain is fixed by feedback resistors R525, R523 and R514.

OUTPUT ATTENUATOR

The Output Attenuator provides three fixed levels of attenuation (0db, 20db and 40db) at 50Ω output impedance.

4.2.4 RAMP INTEGRATOR (figure 7.2.5)

The Ramp Integrator generates a linear ramp waveform over the range of 100sec to 10μsec. The Integrator is an operational amplifier used as an integrator. Q700 is a matched pair of FET's providing the very high input impedance and very low offset currents needed for very low timing currents. The input differential pair drives a second differential stage, Q720 and Q725. A high frequency feed forward FET source follower (Q735) used to improve the high frequency characteristics of the integrator. Q730 and Q740 form a differential stage used as a mixer to mix the low frequency signal and the feed forward signal. This combined signal is connected to the output through the output buffer (Q750 and Q755). Q745 is a complementary driver for the output buffer to improve slewing rate. The integrating or timing capacitors are connected across the Integrator by S700, the Ramp Time Switch. The ramp time can be changed by selecting the desired timing capacitor with the Ramp Time Switch.

The Diode Gate at the Integrator input connects either the positive or negative timing current to the summing junction of the integrator. The positive timing current supply is made up of timing resistors R705, R706 and R707 which are connected to the +12V supply through the variable potentiometer, R702. Negative timing current is supplied through R717. The ratio of fall time to ramp time is directly proportional to the timing current selected and the negative timing current supplied by R717.

LEVEL DETECTOR

The Level Detector provides the signal to switch the Diode Gate at the proper times to produce a ramp waveform. The voltage across R762 and R761 is connected to the differential comparator, Q760 and Q765, and is compared against the reference established at Q765 base. Q770 is a constant current source for the differential comparator. D765 and D766 form a diode gate which connects one of the two references to Q765 base. D760 and D761 limit the collector swing of the differential input stage, greatly increasing their slewing rate by keeping them out of saturation. Q776 and Q780 form a second differential stage used as a high-speed switch. Q780 collector signal is clamped by D781 through D785. This signal drives the Diode Gate at the Integrator input and the

LEVEL DETECTOR (continued)

Reset Buffer for the Logic Gate. As the integrator output integrates negative, the reference voltage across R762 rises negative. When the input reference reaches the reference at Q765 base, the Level Detector will switch the Diode Gate again, etc. R767, Ramp D.C., supplies offset current to the reference at Q765 base, allowing adjustment of the ramp waveform D.C. level. D775 through D778 provide collector clamping at the proper levels for switching the reference gate at Q765 base and to prevent collector saturation. Signal from Q775 collector provides a sync pulse through Q790 Ramp Sync Buffer.

RAMP LOCKOUT SWITCH

Q800 and Q810 is a differential amplifier used as a bipolar switch to connect and disconnect various diode gates to disable the integrator. In the Run Mode, Q810 base is biased more positive than Q800 by voltage divider R811 and R812 from Logic Gate Q820. Q810 collector is clamped at -1.2V by D812 and D813 when off. This signal provides forward bias for gating diodes D712 and D713. This prevents lockout current or reverse biases lockout diodes D710 and D711 which are returned to +12V through R718. Q800 collector is clamped at +1.2V through R718. Q800 collector is clamped at +1.2V by D804 and D805. This provides forward bias for D802 and D803 which keeps lockout diodes D800 and D801 forward biased. Lockout diodes D735 and D736 will remain reverse biased also as they are connected to D800 and D801. This prevents lockout current through lockout diodes D735, D736, D800 and D801. D802 and D803 will sink the current from the negative supply through R738 and R737 Lockout D.C. Adjust. Q800 collector also reverse biases gating diodes D700 and D701.

When the Logic Gate Q820 switches to a "0" or ground, Q810 will turn on, clamping Q810 collector to +1.2V by D810 and D811. D712 and D713 become reverse biased, providing lockout current through R718 and lockout diodes D710 and D711 to the Integrator summing junction (TP700).

Q800 collector will be clamped at -1.2V by D806 and D807. D803 and D802 will become reverse biased, providing lockout current through R738 and R737 and lockout diodes D735, D736, D800 and D801. The negative lockout current must supply an equal amount of current as that from the positive lockout current source (R718) plus an equal amount through D800 and D801. R737 (Lockout D.C.) compensates for integrator offset current and variation in forward voltage drops of the lockout diodes to establish 0V at the integrator output when in Lockout. Q800 collector forward biases D700 and D701 gating diodes, disabling the positive timing current source. The generator will continue integrating until the Level Detector switches and disconnects the negative current source.

RAMP TRIG/GATE LOGIC

Q820C and Q820D are one half of the Quadruple 2 Input Positive Nand Gate, providing the necessary logic to operate the Ramp Lockout Switch. In the Run Mode, Trigger Level Comparator Q830 holds one input of the Logic Gate (pin 9) at "0". As long as one input is 0, the output (pin 8) will remain "1", in a run condition. The Ramp Reset Buffer (Q840) will provide reset pulses as long as the ramp is running. These reset pulses will do nothing as long as pin 9 remains a "0". In lockout, the Trigger Level Comparator provides a "1" at pin 9 of the Logic Gate. The first reset pulse through Q840 Reset Buffer of proper

RAMP TRIG/GATE LOGIC (continued)

polarity will provide a "1" at pin 13 of Q820D logic gate. Pin 12 of Q820D is at a logic "1" from Q820C (pin 8). Q820D output will switch to a logic "1" when a "0" reset pulse is received from the Level Detector via the Reset Buffer. This "0" at Q820D (pin 13) will cause the output (pins 10 and 11) to go to a logic "1". With a logic "1" at both inputs of Q820C, Q820C output will switch to a logic "0" and remain there until the Trigger Level Comparator supplies a "0" to the Logic Gate input.

TRIGGER LEVEL COMPARATOR

Q830 is a high-speed differential comparator providing D.C. coupled triggering and gating for the Ramp Generator.

Off Mode:

In the Off Mode, Q830 reference is biased positive by R835 through S830. This positive bias is sufficient to maintain the non-inverting input at a more positive level than the inverting input. With the inverting input more negative than the positive input, the output of the comparator will remain positive. This positive output is D.C. coupled to the Logic Gate input, maintaining a logic "1". This logic "1" will keep the Ramp Generator in a lockout condition as long as the Mode Switch remains in the Off position.

Run Mode:

In the Run mode, the comparator reference is connected to -12V through R836. This maintains the input at a more positive level and causes the output to switch to ground. This maintains a "0" at the Logic Gate input (run condition).

Gate Mode:

In the Gate mode, the comparator reference is established by voltage dividerR830 and R832 at approximately +10mv. This is enough to place the comparator in a lockout condition. When an external signal > 500mv is connected to the Trigger Input, The Trigger Level Comparator will switch to a run condition and remain there until the external signal drops below 500mv. The Trigger Level Potentiometer (R825) allows adjustment of the trigger sensitivity. If the Man Pushbutton Switch is depressed, a positive signal at TP823 will cause the Trigger Level Comparator to switch to a run condition and remain there until the pushbutton is released.

Trigger Mode:

The Trigger Mode operates exactly as in the Gate Mode except that the comparator signal is A.C. coupled into the Logic Gate allowing completion of one cycle for each trigger pulse received from the external Trigger Input. The Manual Pushbutton Switch will produce the required signal each time it is depressed.

RAMP HOLD MODE

In the Ramp Hold Mode, the negative reset current to the switching bridge is shunted to ground and thus the generator is prevented from resetting until the switch is moved to either the ramp or the reset position. In the ramp position, the shunt is removed and the generator is permitted to operate in its normal manner. When the switch is moved to the reset position, a negative pulse is presented to the base of Q765, thus resetting the level detector regardless of the integrator input voltage.

RAMP AMPLITUDE

A Kelvin-Varley divider provides precise attenuation of the ramp waveform.

RAMP OUTPUT BUFFER

The Ramp Output Buffer (Q845 and Q850) provides the necessary power to drive the Ramp Output and associated circuitry.

RAMP INVERTER

Q860 is an operational amplifier used as a X1 inverter providing the positive ramp. R863 (+Ramp D.C.) is an offset adjustment to balance out the offset in the inverter.

4.2.5 POWER SUPPLY (figure 7.2.1)

Line voltage is connected to transformer T100 through S101, a line voltage switch. This switch selects either the 117V or the 230V tap on the transformer. Full wave rectification is accomplished by D100 from the center tapped secondary. C101 and C102 provide ±20V filtering.

+12V SUPPLY

Q100 is a precision voltage regulator. The output is connected to series pass driver Q110 which supplies the necessary current for the +12V supply. The reference divider, R111, R112 and R113, is connected across the +12V supply. R112 adjusts the reference to the voltage regulator, establishing +12V at the output. Q100 is short circuit protected internally. Q100, pin 10, senses the output current through R110 and will turn off the +12V supply in the event of a short circuit of >500ma.

-12V SUPPLY

Q135 is an operational amplifier. The +12V is connected through R114 and -12V adjust R115 to the inverting input (pin 2). The output of Q135 is offset by Zener diode D135 to keep the operational amplifier output level within safe limits. Q135 is an emitter follower which drives the series pass transistor (Q125). Feedback resistor R120 establishes the proper amount of negative feedback. Q120 senses the output current through R121 providing short circuit limiting at about 500ma.

+5V SUPPLY

The +5V supply is simply an emitter follower. R141 and R140 provide approximately +5V at Q150 base, establishing +5V at the emitter.

-6V SUPPLY

The -6V supply is also an emitter follower. R161 and R160 provide approximately -6V at Q170 base, establishing -6V at Q170 emitter.

4.2.6 LOG AMPLIFIER

The Log Amplifier is used to obtain an exponential signal proportional to the VCF input voltage for use when sweeping over a 60db range (1000:1).

The output of the summing amplifier normally drives the positive and negative current source drivers to obtain frequency control of the generator.

In the linear mode of operation (normal), the frequency of the generator changes linearly with a linear change in input voltage at the VCF input. The Log Amplifier converts this linear drive signal to an exponential signal. The principal of operation of the Log Amplifier is that the collector current of a transistor is logarithmetically related to the base emitter voltage by $I_c = A_{exp}(mV_b)$. The output of the summing amplifier is connected to the Log Amp input in the log mode. Q975 (Log Amp) has four separate 30db inputs for use over 120db range. Each stage is capable of approximately 30db. To obtain linearity over a 60db range, three of the four inputs are utilized and the fourth is grounded.

A_1 input will provide approximately 30db of useful range. To obtain an exponential curve over a 60db range, B_1 input is increased 30db by Amp_1. Q970 and A_2 input is attenuated 30db by the 15K resistor R975 and the 500Ω input. A_1 A_2 B_1 B_2 inputs will saturate at approximately 3V. Amp_1 and differential amp Q960 must be supply limited to keep the Log Amp input from saturating and becoming reverse biased internally. The three input stages will add, providing an exponential curve from approximately 2mv to > 2.5V. Q960 is a differential amplifier in the feedback loop of the Log Amp. This produces an inverted log function or an exponential curve.

R962 establishes the ORIGIN or zero input output voltage. R960, 965, 964 and 977 set the closed loop gain at approximately 1/10.

Q980 is an operational amp used to invert the signal and provide the necessary current for the current source drivers. The log timing pot R967 adjusts the gain of the inverter, thus the frequency.

V:f output Q985 is also an operational amplifier used to invert the negative signal to provide a low impedance voltage which is proportional to output frequency. This output can be used to drive an XY recorder or frequency meter.

The ±6V supply is provided by two zener diodes and the ±4V supplies are provided by two emitter followers Q950 and Q955.

SECTION 5

CALIBRATION

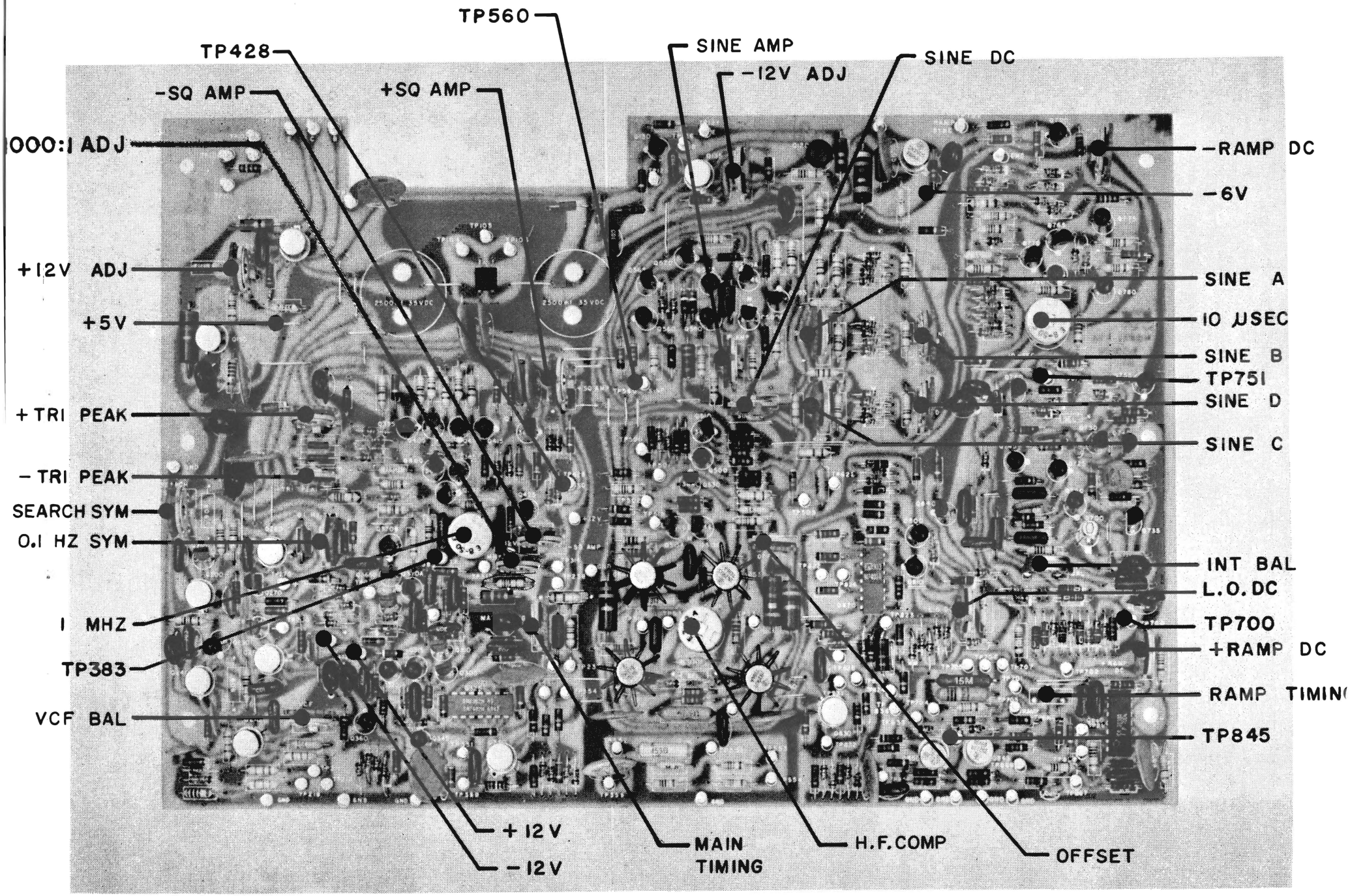


FIG. 5.3.1 MODEL 126 ADJUSTMENTS & TEST POINTS

SECTION 5 CALIBRATION

5 1.0 EQUIPMENT REQUIRED

The following test equipment or suitable equivalents of known accuracy are required for complete calibration.

Oscilloscope - D.C. to 50MHz. Differential plug-in with 10mv resolution.
Distortion Analyzer
Variable Transformer
Variable Regulated Power Supply - 1mv resolution
Frequency Counter/Time Interval Counter
Differential Voltmeter - 0.01% accuracy

5.2.0 INITIAL CONTROL SETTINGS

POWER SWITCH	ON
RANGE	1K
MULTIPLIER	1.0
MAIN MODE	RUN
FUNCTION	∿
AMPLITUDE	MAX
ATTENUATOR	0db
D.C. OFFSET	OFF
RAMP MODE	RUN
RAMP AMPLITUDE	.9X
RAMP POLARITY	NEG
RAMP TIME	1mSEC

5.3.0 CALIBRATION PROCEDURE

5.3.1 Main Generator

+12V Adjust - Connect voltmeter from +12V to ground. Adjust +12V Adj for +12V ±5mv.

-12V Adjust - Connect voltmeter from -12V to ground. Adjust -12V for -12V ±5mv.

VCF Balance Adjust - Connect frequency counter to sync out jack. Adjust VCF balance until there is no frequency shift on frequency counter when VCF input is grounded.

±Triangle Peak Adjust - Using differential plug-in, adjust +Tri Peak and -Tri Peak to obtain ±1.25V peak ±10mv at TP383.

Main Timing Adjust - Adjust Main Timing to obtain 1KHz ± .5% at Sync output jack as observed on frequency counter.

1000:1 Adjust - Set Range to 100K, Multiplier to S0. Monitor main output with oscilloscope and adjust 1000:1 adjust to obtain 100Hz triangle as indicated on frequency counter.

Search Symmetry Adjust - Set Range to 100K, Multiplier to S 0. Monitor Main output with oscilloscope and adjust Search Symmetry to obtain symmetrical waveform. Check for proper adjustment using time interval counter connected at the Sync Output jack.

0.1Hz Symmetry Adjust - Set Range to 1, Multiplier to .10. Connect time interval counter to the Sync Output jack and adjust 0.1Hz Sym for correct symmetry ±.5%.

Repeat 1000:1 Adjust, Search Symmetry and 0.1Hz Symmetry adjustments.

1MHz Timing Adjust - Set Range to 1M, Multiplier to 1.0. Connect frequency counter to Sync Output jack. Adjust 1MHz trimmer to obtain 1MHz ±1% as indicated on frequency counter.

3MHz Timing Adjust - Set Range to 3M, Multiplier to 1.0. Connect frequency counter to the Sync Output jack. Adjust 3MHz trimmer mounted on Range switch to obtain 3MHz ±1% on frequency counter.

±Square Amplitude Adjust - Set Range to 1K, Function to Square. Using differential plug-in adjust +Square Amp and -Square Amp to obtain ±1.25V peak ±10mv square wave at TP428.

Offset Adjust - Set Range to 1K, Multiplier to 1.0 and Amplitude to minimum (full CCW). Monitor Main output with oscilloscope and adjust offset to obtain minimum offset while switching between the Normal triangle and Inverted triangle with Function switch.

H.F. Comp Adjust - Set Range to 1M, Multiplier to 1.0, Function to Square, Amplitude to Max. Terminate the Main output into 50Ω and monitor with oscilloscope. Adjust H.F. Comp to obtain optimum square wave with minimum overshoot.

Sine A, B, C, D Adjust - Set Range to 10K, Multiplier to 1.0 and Function to Sine. Connect distortion analyzer to Main Output jack. Adjust Sine A, B, C and D to obtain minimum sine distortion, typically less than 0.25%.

Sine Amplitude - Sine D.C. Adjust - Connect differential plug-in to TP560. Adjust Sine Amp and Sine D.C. to obtain ±1.25V peak ±10mv.

Repeat previous two steps due to interaction.

5.3.2 Ramp Generator

Internal Balance Adjust - Set Ramp Mode to Gate. Connect differential voltmeter to TP700 and adjust Int Bal to obtain 0V ±2mv at TP700.

Lockout D C. Adjust - Set Ramp Mode to Gate, Ramp Polarity to Negative. Connect differential voltmeter to TP845 and adjust L.O D.C. to obtain 0V ±2mv.

+Ramp D.C. Adjust - Set Ramp Polarity to Positive. Adjust +Ramp D.C. to obtain 0V ±10mv at TP845.

-Ramp D.C. Adjust - Set Ramp Mode to Run, Ramp Time to 1msec. Adjust -Ramp D.C. until positive peak of ramp is 0V ±10mv at TP751.

Ramp Timing Adjust - Set Ramp Mode to Run, Ramp Time to 1msec, variable to Cal. Connect time interval counter to ramp sync jack on rear panel. Measure time interval - to +. Adjust Ramp timing to obtain 1msec ±1%.

10µsec Adjust - Set Ramp time to 10µsec. Adjust 10µsec trimmer to obtain 10µsec ±2% as indicated on time interval counter.

5.3.3 LOG AMPLIFIER

Set:		
	RANGE	IK
	MULT	1.0
	MAIN MODE	Run
	LIN/LOG SW	LIN

AMP 1 BAL

Ground TP960 at Ground turret on log PC board using short lead, and adjust Amp 1 BAL to obtain 0V at TP970. Remove jumper.

ORIGIN

Set Mult to S.X. Switch to log mode and adjust ORIGIN to obtain 2.90V at TP960.

AMP 2 BAL

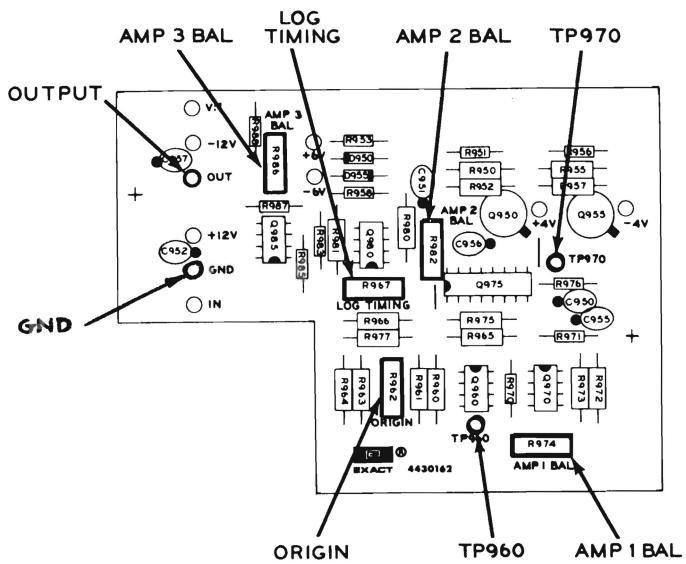
Ground TP960 and adjust Amp 2 BAL for 0V at output terminal. Remove jumper.

LOG MODE TIMING

Adjust log mode timing to obtain same frequency as in linear mode.

AMP 3 BAL

Set Mult to S.0 (100Hz), Lin/Log Sw to LOG. Adjust Amp 3 BAL to obtain 5mv at V:f output terminal.



CHECK LOG LINEARITY

1. Range 20K
   Mult 1.0
   Main Mode Run
   Lin/Log SW Log
   Search Vernier Max CCW

   Monitor frequency on counter with 0V ± 1mv connected to VCF Input and adjust search vernier to obtain 20Hz ± .5Hz on counter.

2. Apply pos. voltage at VCF Input until frequency increases to 20KHz ± 500Hz, and record input voltage.

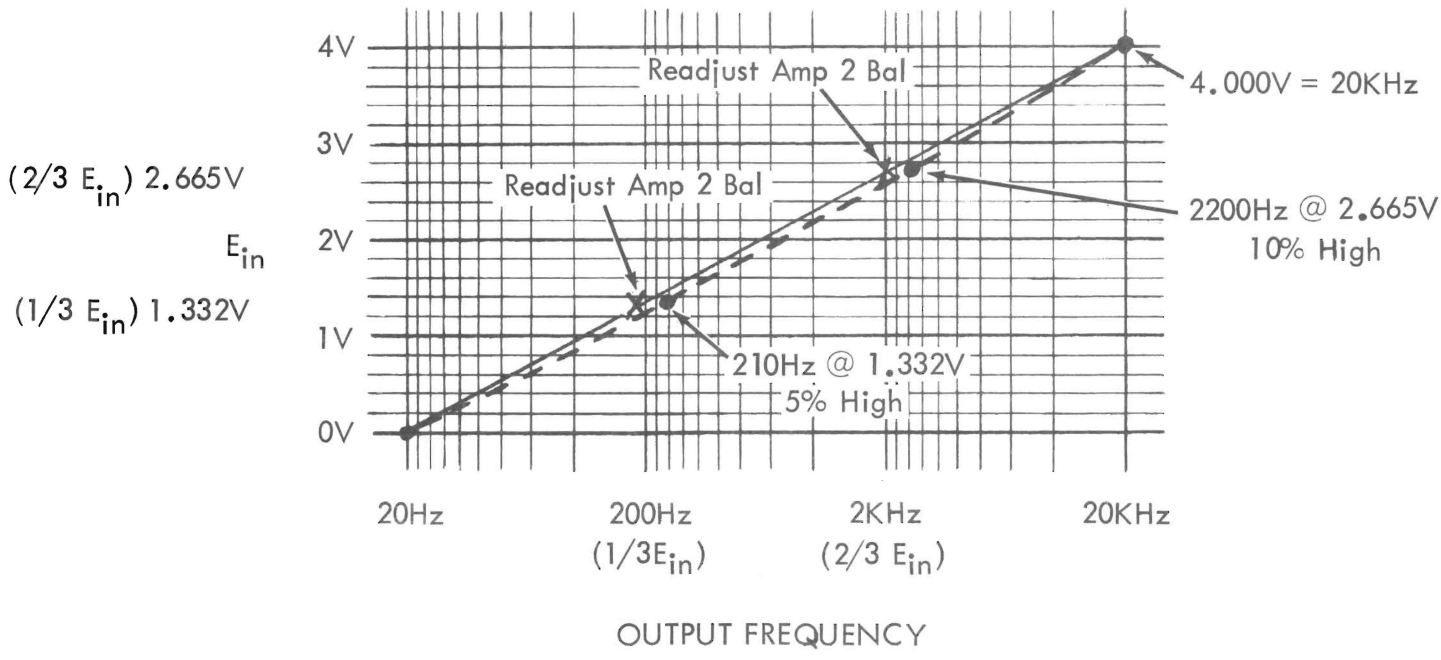
3. Multiply input voltage by 1/3 and 2/3.

4. Apply 2/3 $E_{in\ max}$ at VCF Input and observe 2KHz ± 200Hz.

5. Apply 1/3 $E_{in\ max}$ at VCF Input and observe 200Hz ± 20Hz.

6. Adjust Amp 2 Bal to correct linearity if required at approximately 10%/mv. (Pos. increases frequency, Neg. decreases frequency)

EXAMPLE:



Step 1:

Range	20K
Mult	1.0
Main Mode	Run
Lin/Log SW	Log
Search Vernier	Max CCW

Monitor frequency on counter with 0V ± 1Mv connected to VCF Input and adjust search vernier to obtain 20Hz ± .5Hz on counter

Step 2:

VCF Input Voltage	Output Frequency
Let Ein = + 4.000V	20KHz

Step 3: 4.000V X 2/3 = 2.665 Volts
4.000V X 1/3 = 1.332 Volts

Step 4: E in = 2.665 Volts = 2200Hz (should be 2KHz)

Step 5: E in = 1.332 Volts = 210Hz (should be 200Hz)

Step 6: In the above example, both frequency readings are high indicating a slight bow in the curve. When both readings are high, as in the above example or both low; the "bow" may be decreased by adjusting Amp 2 BAL as indicated in #6 of the Log Linearity check.

In this case, the frequency was 10% high at 2KHz and 5% high at 200Hz. By readjusting Amp 2 BAL 1mv more negative than its original setting, it will decrease the frequency from 2200Hz (10% high) to approximately 2000Hz, and from 210Hz (5% high) to approximately 190Hz (-5%) as indicated on the graph.

By carefully adjusting Amp 2 BAL, the curve may be adjusted to its optimum linearity (when the error at 2KHz is equal and opposite to the error at 200Hz).

SECTION 6

PARTS LIST

CODE LIST OF MANUFACTURERS

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Sprgs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00334	Humidall Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Prod. Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Eng. Labs, Inc.	Burlington, Wis.
00853	Sangamo Electric Co. Ordill Div. (Caps)	Marion, Illinois
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Transistor Prod. Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chase-Trak Corp.	Indianapolis, Inc.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Illinois
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp/Amer.	Saugertias, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg El. Corp.	Chicago, Illinois
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Company of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine and Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q, Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co. Electronics Div.	Burbank, Calif.
04354	Precision Paper Tube Co.	Chicago, Illinois
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prod., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola/Semicon. Prod.	Phoenix, Arizona
04732	Filtron Co/Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Illinois
04777	Automatic Elect. Sales Corp.	Northlake, Illinois
04796	Sequoia Wire/Cable Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P.M. Motor Co.	Chicago, Illinois
05006	20th Century Plastics	Los Angeles, Calif.
05277	Westinghouse/Semicon. Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Eng. Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Illinois
05728	Tiffen Optical Co.	Roslyn Heights, L.I., N.Y.
05729	Metropolitan Telecomm. Corp Metro Cap Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06175	Bausch and Lomb Optical	Rochester, N.Y.
06402	E.T.A. Products/Amer.	Chicago, Illinois
06425	Western Devices, Inc.	Inglewood, Calif.
06540	Anchor Electric Hardware Co.	New Rochelle, N.Y.
06555	Beede Electrical Inst.Co.	Penacook, N.H.
06731	U.S. Semcor Div. of Nuclear Corp/Amer.	Phoenix, Ariz.
06812	Torrington Mfg Co. West Div.	Van Nuys, Calif.
07088	Kaiser Electro Co.	Van Nuys, Calif.
07115	Corning Glass Works Electronics Comp. Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Translator Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	The Bircher Corp.	Los Angeles, Calif.
07700	Technical Wire Products	Springfield, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Labs	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert, Co.	Pasona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario
08717	Sloan Company	Burbank, Calif.
08718	Canvas Elect Co., Phoenix Div.	Phoenix, Ariz.
08792	CBS Elect., Semiconductor Oper., Div. C.B.S., Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Akston Electronics	Sun Valley, Calif.
09280	Electro Assemblies, Inc.	Chicago, Illinois
09859	Mallory Battery Co/Canada Ltd.	Toronto, Ontario, Canada
09864	The Bristol Company	Waterbury, Conn.
10214	Gen. Trans. Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10997	Exact Electronics, Inc.	Hillsboro, Oreg.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Tel. of Calif., Inc.	S. Pasadena, Calif.
11312	Microwave Elect. Corp.	Palo Alto, Calif.
11534	Dutnall Electronics, Inc.	Santa Ana, Calif.
11711	Gen'l Inst/Semiconductor Div.	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N.J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Elect. Co., Ltd.	Tokyo, Japan
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13103	Thermalloy	Dalbs, Texas
13396	Telefunken (G.M.B.H.)	Hannover, Germany
13835	Midland Mfg. Co.	Kansas City, Kansas
14099	Sem-Tech, Inc.	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components Inc.	Conshohocken, Pa.
14655	Cornell Dubilier El. Corp.	So. Plainfield, N.J.
14960	Williams Mfg. Co.	San Jose, Calif.
15103	Webster Elect., Co., Inc.	Brooklyn, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15909	The Daven Co.	Livingston, N.J.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16352	Computer Diode Corp.	Lodi, N.J.
16688	De Jur-Amsco Corp.	Long Island City, N.Y.
16759	Delco Radio, Division of G.M. Corp.	Kokomo, Ind.
17109	Thermonetics, Inc.	Canoga Park, Calif.
17474	Transe Company	Mountain View, Calif.
18486	Radio Industries	Des Plaines, Illinois
18583	Curtis Instrument, Inc.	Mt. Kisco, N.Y.
18873	E.I. Dupont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries Div. McGraw-Edison Co.	West Orange, N.J.
19701	Electro Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21226	Executive, Inc.	New York, N.Y.
21520	Fansteel Metallurgical Corp.	No. Chicago, Illinois
21335	The Fafnir Bearing Co.	New Britain, Conn.
21984	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E. Lamp Div.	Nela Park, Cleveland, Ohio
24655	General Radio Co.	W. Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co/America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	GE Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm, Inc.	Chicago, Ill.
36196	Stanwyck Corp.	Hawkesburn, Ontario, Cd.
37942	P.R. Mallory and Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod.	Akron, Ohio
40920	Miniature Precision Bearings	Keene, N.H.
42190	Muter Co.	Chicago, Illinois
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Illinois
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer/Inst.	Philadelphia, Pa.
49936	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Baltimore, Md.
53743	Ward Leonard Electric	Mt. Vernon, N.Y.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Illinois
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson and Co., Inc.	S. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	N. Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
59730	Thomas and Betts Co.	Elizabeth, N.J.
60741	Tripplett Electrical Inc.	Bluffton, Ohio
61775	Union Switch and Signal, Div. Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	West Inst./Div. Daystrom	Newark, N.J.
66295	Witnik Manufacturing Co.	Chicago, Illinois
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Manufacturing Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70319	Allmetal Screw Prod. Co, Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works	Chicago, Illinois
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Manufacturing Co.	Chicago, Illinois
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Elect. Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Illinois
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C.P. Clare and Co.	Chicago, Illinois
71590	Controltab, Div. Globe Union, Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Illinois
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Wks	Chicago, Illinois
71753	A. O. Smith Corp. Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Illinois
71984	Dow Corning Corp.	Midland, Mich.
72092	Ethel-McCullough, Inc.	San Bruno, Calif.
72136	Electro Motive Mfg. Co, Inc.	Willimantic, Conn.
71707	Cote Coil, Co., Inc.	Providence, R.I.
72354	John E Fast and Company	Chicago, Illinois
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72699	General Instrument Corp. Semiconductor Div.	Newark, N.J.
72738	Girard-Wagkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Illinois
72825	Hugh H. Eby, Inc.	Philadelphia, Pa.
72925	Gudeman Co.	Chicago, Illinois
72955	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Harison Mfg. Co., Inc.	Princeton, Ind.
73076	H. M. Harper Co.	Chicago, Illinois
73138	Helipot, Div. Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Div. of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. No. American Phillips Co., Inc.	Hicksville, N.Y.
73490	Beckman Helipot Corp.	S. Pasadena, Calif.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Prod. Co.	Chicago, Illinois
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73846	Goshen Stamping and Tool	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74276	Signalite, Inc.	Neptune, N.J.
74455	J. H. Winns and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Illinois
74868	R.F. Prod. Div. of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Div. of Cinch Mfg. Corp.	Chicago, Illinois
75378	James Knights Co.	Sandwich, Illinois
75382	Kulka Electric Corp.	Mt. Vernon, N.Y.
75818	Lena Electric Mfg. Co.	Chicago, Illinois
75915	Littlefuse, Inc.	Des Plaines, Illinois
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Crystal Lake, Illinois
77068	Bendix Pacific Div. of Bendix Corp.	N. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phaostron Instrument and Electronic Co.	S. Pasadena, Calif.
77250	Phoell Manufacturing Co.	Chicago, Illinois
77252	Philadelphia Steel and Wire Corporation	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine/Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof, Div. of Illinois Tool Works	Elgin, Illinois
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn, Inc.	Pitman, N.J.
78452	Thompson-Bremer and Co.	Chicago, Illinois
78471	Tilley Manufacturing Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78498	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ueinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Illinois
79727	Continental-Wirt Elect. Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco, Div. of Sessions Clock Company	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Assoc. Any brand tube meeting EIA standards.	Washington D.C.
80207	Unimax Switch, Div. of W L Maxson Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Illinois
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Aero, Div. Robertshaw Fulton Controls Co.	Columbus, Ohio
80486	All Star Products, Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80883	Hammarlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Graychill Co.	LaGrange, Illinois
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Electronics Co, Inc.	Norwalk, Conn.
81349	Military Specifications	.....
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div, Industrial Tube Oper.	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81541	The Alpan Products Co.	Cambridge, Mass.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Illinois
82142	Jeffers Electronics, Div. of Speer Carbon Co.	DuBois, Pa.
82170	Allen B. DuMont Labs, Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod., Electronic Tube Div.	Emporium, Pa.
82376	Astron Company	E. Newark, N.J.
82389	Switchcraft, Inc.	Orange, Illinois
82647	Metals and Controls, Inc., Div. Texas Instruments, Spencer Products	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wisc.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83058	Western Washer Mfr. Co.	Los Angeles, California
83098	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electra Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp/Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Illinois
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Illinois
83501	Gavitt Wire and Cable Co., Div. Ameraco Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Battery	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Nebr.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Co.	Boonton, N.J.
85474	R.M. Bracamontes and Co.	San Francisco, Calif.
85660	Kolled Kards, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Illinois
86197	Clifton Precision Products	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansing Div.)	Lansing, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco
87664	Van Waters and Rogers, Inc.	Seattle, Wash.
87930	Tower Mfg. Co.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Illinois
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89462	Waldes Kohinoor, Inc.	Cambridge, Mass.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baker Co.	Chicago, Illinois
89665	United Transformer Co.	Chicago, Illinois
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial and Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Illinois
91506	Augat Brothers', Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia
91737	Gremar Mfg Co., Inc.	Wakefield, Mass.
91929	Minneapolis-Honeywell Regulator Co., Microswitch Div.	Freeport, Illinois
91961	Nahm-Bras. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92196	Universal Metal Prod., Inc.	Bassett Puente, Calif.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tinsulits Insulated Wire Co.	Tarrytown, N.Y.
93332	Sylvania Electric Prod, Inc. Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93768	Howard J. Smith, Inc.	Port Monmouth, N.J.
93929	G.V. Controls	Livingston, N.J.
93983	Insulina-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Mfg. Co., Industrial Comp., Div, Rec. Tube Div.	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div, Calif. St. Plt	Newton, Mass.
94148	Scientific Radio Products	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtis-Wright Corp. Electronics Div.	E. Paterson, N.J.
94222	Southco, Div. S. Chester Corp.	Lester, Pa.
94310	Tru Ohm Prod., Div. Model Engineering and Mfg. Co.	Chicago, Illinois
94330	Wire Cloth Products, Inc.	Chicago, Illinois
94662	Worcester Pressed Alum. Corp.	Worcester, Mass.
95083	Philtrols Researchers, Inc.	Boston, Mass.
95236	Alltec Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lorco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Illinois
95712	Dage Electric Co., Inc.	Franklin, Ind.
95987	Weckesser Co.	Chicago, Illinois
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Div. of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner, Div. Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Illinois
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg.	Yonkers, N.Y.
97966	CBS Electronics Div. C.B.S., Inc.	Danvers, Mass.
97979	Ikon Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers, Inc.	Jamaica, N.Y.
98159	Rubber Teak, Inc.	Gardena, Calif.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	S. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Cibrad Corp.	Redwood City, Calif.
98731	General Mills	Minneapolis, Minn.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technicol Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Div, Controls Co. of America	El Segundo, Calif
99800	Delevan Electronics Corp.	E. Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Illinois
99957	Technology Instrument Corp. of California	Newbury Park, Calif.

PART	DESCRIPTION	EXACT NO	MFG
P102	PILOT LIGHT	1360045	100005
C107	CAPACITOR, 470PF MICA	2810539	853
C101	CAPACITOR, 2500MFD 35V	2900034	853
C102	CAPACITOR, 2500MFD 35V	2900034	853
C103	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C117	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C111	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C122	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C121	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C135	CAPACITOR, 5002 PF DISCAP	2830011	91418
C136	CAPACITOR, 220PF MICA	2810555	853
C140	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C150	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C151	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C162	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C172	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C202	CAPACITOR, 220PF MICA	2810555	853
C201	CAPACITOR, 5002 PF DISCAP	2830011	91418
C212	CAPACITOR, 220PF MICA	2810555	853
C211	CAPACITOR, 5002 PF DISCAP	2830011	91418
C212	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C213	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C214	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C242	CAPACITOR, 5002 PF DISCAP	2830011	91418
C250	CAPACITOR, 220PF MICA	2810555	853
C251	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C262	CAPACITOR, 5002 PF DISCAP	2830011	91418
C261	CAPACITOR, 220PF MICA	2810555	853
C280	CAPACITOR, 220PF MICA	2810555	853
C281	CAPACITOR, TIMING SET	2950004	10597
C282	CAPACITOR, 8-52PF TRIM	2810022	72982
C290	CAPACITOR, 5002 PF DISCAP	2830011	91418
C291	CAPACITOR, 220PF MICA	2810555	853
C305	CAPACITOR, 10PF MICA	2810529	853
C310	CAPACITOR, 47PF MICA	2810532	853
C316	CAPACITOR, 47PF MICA	2810532	853
C320	CAPACITOR, 100PF MICA	2810537	853
C321	CAPACITOR, 68PF MICA	2810523	853
C326	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C345	CAPACITOR, 82PF MICA	2810533	853
C346	CAPACITOR, 47PF MICA	2810532	853
C347	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C350	CAPACITOR, 470PF MICA	2810539	853
C360	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C365	CAPACITOR, 68PF MICA	2810523	853
C370	CAPACITOR, 8-52PF TRIM	2810022	72982
C371	CAPACITOR, 47PF MICA	2810532	853
C400	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C421	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C420	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C425	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C515	CAPACITOR, 470PF MICA	2810539	853
C520	CAPACITOR, 3-12PF TRIM	2810036	72982
C545	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C546	CAPACITOR, 220PF MICA	2810555	853
C550	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C551	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C600	CAPACITOR, 100PF MICA	2810537	853
C720	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C721	CAPACITOR, 0.01 UF DISCAP	2830005	91418
C702	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C719	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C737	CAPACITOR, 1000 PF DISCAP	2830000	91418
C735	CAPACITOR, 5002 PF DISCAP	2830011	91418
C736	CAPACITOR, TIMING SET	2950002	10597
C745	CAPACITOR, 0.01 UF DISCAP	2830005	91418
C750	CAPACITOR, 470PF MICA	2810539	853
C760	CAPACITOR, 8-52PF TRIM	2810022	72982
C795	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C822	CAPACITOR, 470PF MICA	2810539	853
C840	CAPACITOR, 82PF MICA	2810533	853
C841	CAPACITOR, 47PF MICA	2810532	853
C845	CAPACITOR, 470PF MICA	2810539	853
C850	CAPACITOR, 1000 PF DISCAP	2830000	91418
C852	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C862	CAPACITOR, 47PF MICA	2810532	853
C861	CAPACITOR, 22PF MICA	2810530	853
C862	CAPACITOR, 39PF MICA	2810531	853
C863	CAPACITOR, 0.05 UF DISCAP	2830010	91418
D120	RECTIFIER BRIDGE, MDA920A	1520920	4713
D101	DIODE, 1N4001	1524001	1295
D102	DIODE, 1N4001	1524001	1295
D112	DIODE, 1N4001	1524001	1295
D122	DIODE, 1N4001	1524001	1295
D135	DIODE, 1N756	1527756	1295
D210	DIODE, 1N914	1520914	7910
D211	DIODE, 1N914	1520914	7910
D282	DIODE, FD777	1520777	1295
D281	DIODE, 1N914	1520914	7910
D282	DIODE, FD777	1520777	1295
D283	DIODE, FD777	1520777	1295
D284	DIODE, FD777	1520777	1295
D312	DIODE, 1N748	1520748	1295
D311	DIODE, 1N914	1520914	7910
D321	DIODE, 1N914	1520914	7910
D322	DIODE, 1N914	1520914	7910
D323	DIODE, 1N914	1520914	7910
D324	DIODE, 1N914	1520914	7910
D350	DIODE, 1N914	1520914	7910
D351	DIODE, 1N914	1520914	7910
D352	DIODE, 1N914	1520914	7910
D353	DIODE, 1N914	1520914	7910
D360	DIODE, 1N914	1520914	7910
D361	DIODE, 1N914	1520914	7910
D362	DIODE, 1N914	1520914	7910
D363	DIODE, 1N914	1520914	7910
D385	DIODE, 1N914	1520914	7910
D386	DIODE, 1N914	1520914	7910

PART	DESCRIPTION	EXACT NO	MFG
D390	DIODE, 1N914	1520914	7910
D395	DIODE, 1N914	1520914	7910
D396	DIODE, 1N914	1520914	7910
D397	DIODE, 1N914	1520914	7910
D398	DIODE, 1N914	1520914	7910
D399	DIODE, 1N753A	1520753	1295
D420	DIODE, 1N914	1520914	7910
D425	DIODE, 1N914	1520914	7910
D426	DIODE, 1N914	1520914	7910
D427	DIODE, 1N914	1520914	7910
D428	DIODE, 1N914	1520914	7910
D429	DIODE, 1N914	1520914	7910
D500	DIODE, 1N914	1520914	7910
D510	DIODE, 1N914	1520914	7910
D550	DIODE, 1N914	1520914	7910
D551	DIODE, 1N914	1520914	7910
D560	DIODE, 1N914	1520914	7910
D561	DIODE, 1N914	1520914	7910
D605	DIODES, MATCHED SET FD777	1530777	10597
D612	DIODES, MATCHED SET FD777	1530777	10597
D613	DIODES, MATCHED SET FD777	1530777	10597
D700	DIODE, 1N914	1520914	7910
D700	DIODE, CD1541	1521541	14655
D702	DIODE, 1N914	1520914	7910
D703	DIODE, CD1541	1521541	14655
D704	DIODE, CD1541	1521541	14655
D705	DIODE, 1N914	1520914	7910
D706	DIODE, CD1541	1521541	14655
D707	DIODE, 1N914	1520914	7910
D708	DIODE, CD1541	1521541	14655
D709	DIODE, 1N914	1520914	7910
D710	DIODE, CD1541	1521541	14655
D711	DIODE, 1N914	1520914	7910
D712	DIODE, 1N914	1520914	7910
D713	DIODE, 1N914	1520914	7910
D735	DIODE, CD1541	1521541	14655
D736	DIODE, 1N914	1520914	7910
D742	DIODE, 1N914	1520914	7910
D741	DIODE, 1N914	1520914	7910
D745	DIODE, 1N914	1520914	7910
D746	DIODE, 1N914	1520914	7910
D760	DIODE, 1N914	1520914	7910
D761	DIODE, 1N914	1520914	7910
D765	DIODE, 1N914	1520914	7910
D766	DIODE, 1N914	1520914	7910
D770	DIODE, 1N914	1520914	7910
D775	DIODE, 1N914	1520914	7910
D776	DIODE, 1N914	1520914	7910
D777	DIODE, 1N914	1520914	7910
D778	DIODE, 1N914	1520914	7910
D780	DIODE, 1N914	1520914	7910
D781	DIODE, 1N914	1520914	7910
D782	DIODE, 1N914	1520914	7910
D783	DIODE, 1N914	1520914	7910
D784	DIODE, 1N914	1520914	7910
D785	DIODE, 1N914	1520914	7910
D800	DIODE, CD1541	1521541	14655
D801	DIODE, 1N914	1520914	7910
D802	DIODE, CD1541	1521541	14655
D803	DIODE, 1N914	1520914	7910
D804	DIODE, CD1541	1521541	14655
D805	DIODE, 1N914	1520914	7910
D806	DIODE, CD1541	1521541	14655
D807	DIODE, 1N914	1520914	7910
D810	DIODE, 1N914	1520914	7910
D811	DIODE, 1N914	1520914	7910
D812	DIODE, 1N914	1520914	7910
D813	DIODE, 1N914	1520914	7910
D822	DIODE, 1N914	1520914	7910
D821	DIODE, 1N914	1520914	7910
D830	DIODE, 1N914	1520914	7910
D831	DIODE, 1N914	1520914	7910
D832	DIODE, 1N914	1520914	7910
D833	DIODE, 1N914	1520914	7910
D845	DIODE, 1N914	1520914	7910
D846	DIODE, 1N914	1520914	7910
F100	FUSE, 3AG 1/2 AMP	1592015	71400
J102	BINDING POST, BLACK	3550536	10597
J101	BINDING POST, WHITE	3550535	10597
P100	POWER CORD, 3 WIRE	1750203	10597
Q100	INTEGRATED CIRCUIT, UA723	1582012	7263
Q110	TRANSISTOR, 2N4910	1564910	4713
Q120	TRANSISTOR, 2N3643	1563643	4713
Q125	TRANSISTOR, 2N4898	1564898	4713
Q132	TRANSISTOR, 2N4121	1564121	7263
Q135	OPERATIONAL AMPLIFIER, UA709	1580016	7263
Q150	TRANSISTOR, 2N2219	1562219	1295
Q170	TRANSISTOR, 2N2905	1562905	1295
Q202	OPERATIONAL AMPLIFIER, UA709	1580016	7263
Q210	OPERATIONAL AMPLIFIER, UA709	1580016	7263
Q240	OPERATIONAL AMPLIFIER, UA709	1580016	7263
Q250	TRANSISTOR, 2N4250	1564250	7263
Q255	TRANSISTOR, 2N5485	1565485	4713
Q260	OPERATIONAL AMPLIFIER, UA709	1580016	7263
Q270	TRANSISTOR, 2N5462	1565462	4713
Q280	TRANSISTOR, 2N5485	1565485	4713
Q290	OPERATIONAL AMPLIFIER, UA709	1580016	7263
Q305	TRANSISTOR, MPS6543	1566543	4713
Q310	TRANSISTOR, MPS6543	1566543	4713
Q315	TRANSISTOR, 2N4258	1564258	7263
Q320	TRANSISTOR, 2N4258	1564258	7263
Q325	INTEGRATED CIRCUIT, SN7422N	1580021	1295
Q345	TRANSISTOR, 2N4121	1564121	7263
Q350	INTEGRATED CIRCUIT, UA710C	1582220	7263
Q360	TRANSISTOR, 2N4121	1564121	7263
Q365	TRANSISTORS, MATCHED 2N5485	1575485	10597
Q370	TRANSISTORS, MATCHED PAIR MPS3646	1572208	10597
Q392	TRANSISTOR, MPS3646	1563646	4713

PART	DESCRIPTION	EXACT NO	MFG
Q395	TRANSISTOR, 2N4121	1564121	7263
Q400	TRANSISTORS, MATCHED PAIR MPS3646	1570008	10597
Q405	TRANSISTOR, MPS3640	1563640	4713
Q410	TRANSISTOR, MPS3640	1563640	4713
Q415	TRANSISTOR, 2N4121	1564121	7263
Q420	TRANSISTOR, MPS3646	1563646	4713
Q425	TRANSISTOR, MPS3640	1563640	4713
Q500	TRANSISTOR, 2N4121	1564121	7263
Q510	TRANSISTOR, MPS3646	1563646	4713
Q515	TRANSISTORS, MATCHED PAIR MPS3646	1570008	10597
R312	RESISTOR, 432 OHM 1/4W 1% METAL FILM	3134320	7115
Q530	TRANSISTOR, MPS3646	1563646	4713
Q535	TRANSISTOR, 2N2905	1562905	1295
Q540	TRANSISTOR, 2N2905	1562905	1295
Q545	TRANSISTOR, 2N2219	1562219	1295
Q550	TRANSISTOR, 2N2905	1562905	1295
Q560	TRANSISTOR, 2N4121	1564121	7263
Q565	TRANSISTOR, MPS3646	1563646	4713
Q570	TRANSISTOR, MPS3646	1563646	4713
Q575	TRANSISTOR, 2N4121	1564121	7263
Q580	TRANSISTOR, 2N4121	1564121	7263
Q600	TRANSISTORS, MATCHED PAIR MPS3646	1570008	10597
Q605	TRANSISTOR, MPS3646	1563646	4713
Q700	TRANSISTOR, UC2138	1562138	61637
Q720	TRANSISTOR, 2N4121	1564121	7263
Q725	TRANSISTOR, 2N4121	1564121	7263
Q730	TRANSISTOR, TIS87	1560087	1295
Q735	TRANSISTOR, 2N5485	1565485	4713
Q740	TRANSISTOR, TIS87	1560087	1295
Q745	TRANSISTOR, 2N4121	1564121	7263
Q750	TRANSISTOR, TIS87	1560087	1295
Q755	TRANSISTOR, 2N4121	1564121	7263
Q760	TRANSISTOR, MPS3646	1563646	4713
Q765	TRANSISTOR, MPS3646	1563646	4713
Q770	TRANSISTOR, MPS3646	1563646	4713
Q775	TRANSISTOR, 2N4121	1564121	7263
Q780	TRANSISTOR, 2N4121	1564121	7263
Q790	TRANSISTOR, 2N4121	1564121	7263
Q800	TRANSISTOR, 2N4121	1564121	7263
Q810	TRANSISTOR, 2N4121	1564121	7263
Q820	INTEGRATED CIRCUIT, SN7402N	1580011	1295
Q830	INTEGRATED CIRCUIT, UA710C	1580022	7263
Q840	TRANSISTOR, MPS3646	1563646	4713
Q845	TRANSISTOR, 2N2219	1562219	1295
Q850	TRANSISTOR, 2N2905	1562905	1295
Q860	OPERATIONAL AMPLIFIER, CA3030A	1580008	2735
R100	RESISTOR, 1200 OHM 1/4W 5% CARBON	3272122	1121
R101	RESISTOR, 68K OHM 1/4W 5% CARBON	3270683	1121
R110	RESISTOR, 1.0 OHM 1/2W 5% CARBON	3210010	1121
R111	RESISTOR, 2210 OHM 1/4W 1% METAL FILM	3132211	7115
R112	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R113	RESISTOR, 3240 OHM 1/4W 1% METAL FILM	3133241	7115
R114	RESISTOR, 9760 OHM 1/4W 1% METAL FILM	3139761	7115
R115	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R120	RESISTOR, 10002 OHM 1/4W 1% METAL FILM	3131002	7115
R121	RESISTOR, 1.0 OHM 1/2W 5% CARBON	3210010	1121
R125	RESISTOR, 68 OHM 1/4W 5% CARBON	3270680	1121
R132	RESISTOR, 1002 OHM 1/4W 5% CARBON	3272102	1121
R131	RESISTOR, 3320 OHM 1/4W 5% CARBON	3270332	1121
R135	RESISTOR, 5112 OHM 1/4W 5% CARBON	3272512	1121
R136	RESISTOR, 1502 OHM 1/4W 5% CARBON	3272152	1121
R137	RESISTOR, 51 OHM 1/4W 5% CARBON	3270510	1121
R142	RESISTOR, 1002 OHM 1/4W 1% METAL FILM	3131001	7115
R141	RESISTOR, 1102 OHM 1/4W 1% METAL FILM	3131101	7115
R150	RESISTOR, 150 OHM 1W 5% CARBON	3032151	1121
R151	RESISTOR, 10K OHM 1/4W 5% CARBON	3272103	1121
R160	RESISTOR, 1002 OHM 1/4W 1% METAL FILM	3131001	7115
R161	RESISTOR, 1472 OHM 1/4W 1% METAL FILM	3131471	7115
R170	RESISTOR, 10K OHM 1/4W 5% CARBON	3270103	1121
R171	RESISTOR, 470 OHM 1W 5% CARBON	3032471	1121
R200	RESISTOR, 1520 OHM 1/4W 5% CARBON	3272152	1121
R201	RESISTOR, 826 OHM MATCHED PAIR	3128062	10597
R202	RESISTOR, 100 OHM 1/4W 1% METAL FILM	3131000	7115
R203	RESISTOR, 100K OHM 1/4W 1% METAL FILM	3131003	7115
R204	POTENTIOMETER, 100K OHM TRIM	3110143	71450
R205	RESISTOR, 826 OHM MATCHED PAIR	3128062	10597
R210	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R211	RESISTOR, 1500 OHM 1/4W 1% METAL FILM	3131521	7115
R212	RESISTOR, 24970 OHM 1/4W 1% METAL FILM	3132492	7115
R213	RESISTOR, 24900 OHM 1/4W 1% METAL FILM	3132492	7115
R214	RESISTOR, 31602 OHM 1/4W 1% METAL FILM	3133162	7115
R215	RESISTOR, 24920 OHM 1/4W 1% METAL FILM	3132492	7115
R216	RESISTOR, 1520 OHM 1/4W 5% CARBON	3272152	1121
R217	RESISTOR, 1000 OHM 1/4W 1% METAL FILM	3131001	7115
R221	RESISTOR, 562K OHM 1/4W 1% METAL FILM	3135623	7115
R222	POTENTIOMETER, 100K OHM TRIM	3110143	71450
R223	CONCENTRIC SWITCH & POTENTIOMETER	2600313	71450
R224	RESISTOR, SELECTED VALUE		
R225	TO		
R234	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3101002	7115
R235	RESISTOR, 332 OHM 1/4W 1% METAL FILM	3133322	7115
R236	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3101002	7115
R237	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3101002	7115
R238	RESISTOR, 100 OHM 1/4W 1% METAL FILM	3131000	7115
R239	RESISTOR, 475 OHM 1/4W 1% METAL FILM	3134753	7115
R240	RESISTOR, 1502 OHM 1/4W 5% CARBON	3272152	1121
R241	POTENTIOMETER, 100 OHM TRIM	3110141	71450
R260	RESISTOR, 1502 OHM 1/4W 5% CARBON	3272152	1121
R261	RESISTOR, 102 OHM 1/4W 5% CARBON	3272101	1121
R262	RESISTOR, 826 OHM MATCHED PAIR	3128062	10597
R263	RESISTOR, 8062 OHM MATCHED PAIR	3128061	10597
R264	RESISTOR, 82602 OHM MATCHED PAIR	3128062	10597
R280	RESISTOR, 100 OHM 1/4W 5% CARBON	3272101	1121
R281	RESISTOR, 10000K OHM 1/4W 5% CARBON	3272106	1121
R282	POTENTIOMETER, 100K OHM TRIM	3110143	71450
R283	RESISTOR, 10K OHM 1/4W 5% CARBON	3272103	1121
R290	RESISTOR, 1500 OHM 1/4W 5% CARBON	3272152	1121
R305	RESISTOR, 1102 OHM 1/4W 1% METAL FILM	3131101	7115

PART	DESCRIPTION	EXACT NO	MFG
R306	RESISTOR, 3012 OHM 1/4W 1% METAL FILM	3133011	7115
R312	RESISTOR, 3320 OHM 1/4W 5% CARBON	3270332	1121
R311	RESISTOR, 1502 OHM 1/4W 5% CARBON	3272152	1121
R313	CONCENTRIC SWITCH & POTENTIOMETER	2600315	71450
R314	RESISTOR, 1652 OHM 1/4W 1% METAL FILM	3131651	7115
R315	RESISTOR, 912 OHM 1/4W 5% CARBON	3270911	1121
R316	RESISTOR, 243 OHM 1/4W 5% CARBON	3270241	1121
R320	RESISTOR, 6802 OHM 1/4W 5% CARBON	3270682	1121
321	RESISTOR, 6200 OHM 1/4W 5% CARBON	3270622	1121
R322	RESISTOR, 1202 OHM 1/4W 5% CARBON	3270122	1121
R325	RESISTOR, 470 OHM 1/4W 5% CARBON	3270471	1121
R326	RESISTOR, 1002 OHM 1/4W 5% CARBON	3270102	1121
R345	RESISTOR, 1002 OHM 1/4W 5% CARBON	3270102	1121
R346	RESISTOR, 1002 OHM 1/4W 5% CARBON	3270102	1121
R347	RESISTOR, 470 OHM 1/4W 5% CARBON	3270471	1121
R348	RESISTOR, 470 OHM 1/4W 5% CARBON	3270471	1121
R350	RESISTOR, 330K OHM 1/4W 5% CARBON	3270334	1121
R351	RESISTOR, 100 OHM 1/4W 5% CARBON	3270101	1121
R352	RESISTOR, 120K OHM 1/4W 5% CARBON	3270124	1121
R353	RESISTOR, 470 OHM 1/4W 5% CARBON	3270471	1121
R354	RESISTOR, 10K OHM 1/4W 5% CARBON	3270103	1121
R355	RESISTOR, 10K OHM 1/4W 5% CARBON	3270103	1121
R360	RESISTOR, 4702 OHM 1/4W 5% CARBON	3270472	1121
R361	RESISTOR, 100 OHM 1/4W 5% CARBON	3270101	1121
R362	RESISTOR, 4702 OHM 1/4W 5% CARBON	3270472	1121
R363	RESISTOR, 1002 OHM 1/4W 5% CARBON	3270102	1121
R365	RESISTOR, 100 OHM 1/4W 5% CARBON	3270101	1121
R370	RESISTOR, 220 OHM 1/2W 5% CARBON	3210221	1121
R371	RESISTOR, 402 OHM 1/4W 1% METAL FILM	3134020	7115
R372	RESISTOR, 392 OHM 1/4W 1% METAL FILM	3133920	7115
R382	RESISTOR, 383 OHM 1/4W 1% METAL FILM	3133830	7115
R385	RESISTOR, 4220 OHM 1/4W 1% METAL FILM	3134221	7115
R386	RESISTOR, 4220 OHM 1/4W 1% METAL FILM	3134221	7115
R387	RESISTOR, 274 OHM 1/4W 1% METAL FILM	3132742	7115
R390	RESISTOR, 3012 OHM 1/4W 1% METAL FILM	3133011	7115
R391	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002	7115
R392	RESISTOR, 2212 OHM 1/4W 1% METAL FILM	3132211	7115
R395	RESISTOR, 475 OHM 1/4W 1% METAL FILM	3134750	7115
R396	RESISTOR, 4532 OHM 1/4W 1% METAL FILM	3134531	7115
R397	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R398	RESISTOR, 1002 OHM 1/4W 5% CARBON	3270102	1121
R402	RESISTOR, 4532 OHM 1/4W 1% METAL FILM	3134531	7115
R401	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R405	RESISTOR, 624 OHM 1/4W 1% METAL FILM	3136240	7115
R415	RESISTOR, 2402 OHM 1/4W 5% CARBON	3270242	1121
R416	RESISTOR, 100 OHM 1/4W 5% CARBON	3270101	1121
R417	RESISTOR, 475 OHM 1/4W 1% METAL FILM	3134750	7115
R418	RESISTOR, 715 OHM 1/4W 1% METAL FILM	3137150	7115
R422	RESISTOR, 167 OHM 1/4W 5% CARBON	3270161	1121
R585	RESISTOR, 1212 OHM 1/4W 1% METAL FILM	3131211	7115
R421	RESISTOR, 5102 OHM 1/4W 5% CARBON	3270512	1121
R422	RESISTOR, 15 OHM 1/4W 5% CARBON	3270150	1121
R423	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R424	RESISTOR, 750 OHM 1/4W 5% CARBON	3270751	1121
R425	RESISTOR, 15 OHM 1/4W 5% CARBON	3270150	1121
R426	RESISTOR, 5102 OHM 1/4W 5% CARBON	3270512	1121
R427	RESISTOR, 750 OHM 1/4W 5% CARBON	3270751	1121
R428	RESISTOR, 180 OHM 1/4W 5% CARBON	3270181	1121
R429	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R500	RESISTOR, 4.7 OHM 1/4W 5% CARBON	3270047	1121
R501	RESISTOR, 4.7 OHM 1/4W 5% CARBON	3270047	1121
R502	RESISTOR, 150 OHM 1/4W 5% CARBON	3270151	1121
R503	RESISTOR, 5602 OHM 1/4W 5% CARBON	3270562	1121
R504	RESISTOR, 51 OHM 1/4W 5% CARBON	3270510	1121
R505	RESISTOR, 180 OHM 1/4W 5% CARBON	3270181	1121
R506	CONCENTRIC SWITCH & POTENTIOMETER	2600316	71450
R507	RESISTOR, 4.7 OHM 1/4W 5% CARBON	3270047	1121
R508	RESISTOR, 240 OHM 1/4W 5% CARBON	3270241	1121
R509	RESISTOR, 22 OHM 1/4W 5% CARBON	3270220	1121
R510	RESISTOR, 4.7 OHM 1/4W 5% CARBON	3270047	1121
R511	RESISTOR, 51 OHM 1/4W 5% CARBON	3270510	1121
R512	RESISTOR, 5600 OHM 1/4W 5% CARBON	3270562	1121
R513	RESISTOR, 152 OHM 1/4W 5% CARBON	3272151	1121
R514	RESISTOR, 10.2 OHM 1/8W 1% METAL FILM	3100102	7115
R515	RESISTOR, 2002 OHM 1/4W 1% METAL FILM	3132001	7115
R516	RESISTOR, 75 OHM 1/4W 5% CARBON	3270750	1121
R517	RESISTOR, 102 OHM 1/4W 5% CARBON	3272101	1121
R518	RESISTOR, 2002 OHM 1/4W 1% METAL FILM	3132001	7115
R521	RESISTOR, 150 OHM 1/4W 5% CARBON	3272151	1121
R522	RESISTOR, 102 OHM 1/4W 5% CARBON	3272101	1121
R523	RESISTOR, 88.7 OHM 1/4W 1% METAL FILM	3130887	7115
R524	RESISTOR, 1002 OHM 1/4W 1% METAL FILM	3131001	7115
R525	RESISTOR, 976 OHM 1/4W 1% METAL FILM	3139760	7115
R526	RESISTOR, 33207 OHM 1/4W 1% METAL FILM	3133322	7115
R527	POTENTIOMETER, 100K OHM TRIM	3110143	71450
R528	POTENTIOMETER, 10K OHM WITH SWITCH	3112332	71450
R530	RESISTOR, 3012 OHM 1/4W 1% METAL FILM	3133011	7115
R531	RESISTOR, 4992 OHM 1/4W 1% METAL FILM	3134991	7115
R532	RESISTOR, 1002 OHM 1/4W 1% METAL FILM	3131001	7115
R535	RESISTOR, 143 OHM 1/2W 1% METAL FILM	3101432	7115
R545	RESISTOR, 68 OHM 1W 5% CARBON	3230680	1121
R546	RESISTOR, 10 OHM 1/4W 5% CARBON	3270100	1121
R547	RESISTOR, 47.5 OHM 1/2W 1% METAL FILM	3122475	7115
R551	RESISTOR, 12 OHM 1/4W 5% CARBON	3270120	1121
R552	RESISTOR, SELECTED VALUE		
R553	RESISTOR, 1502 OHM 1W 5% CARBON	3232152	1121
R554	RESISTOR, 68 OHM 1W 5% CARBON	3230680	1121
R555	RESISTOR, 56.2 OHM 1/4W 1% METAL FILM	3135620	7115
R556	RESISTOR, 453 OHM 1/2W 1% METAL FILM	3124530	7115
R557	RESISTOR, 41.2 OHM 1/8W 1% METAL FILM	3104120	7115
R558	RESISTOR, 41.2 OHM 1/8W 1% METAL FILM	3104120	7115
R559	RESISTOR, 10.2 OHM 1/8W 1% METAL FILM	3100102	7115
R560	RESISTOR, 4.7 OHM 1/4W 5% CARBON	3270047	1121
R561	RESISTOR, 3202 OHM 1/4W 5% CARBON	3270302	1121
R565	RESISTOR, 4.7 OHM 1/4W 5% CARBON	3270047	1121
R575	RESISTOR, 2402 OHM 1/4W 5% CARBON	3272242	1121
R576	RESISTOR, 39 OHM 1/4W 5% CARBON	3270390	1121
R577	RESISTOR, 332 OHM 1/2W 5% CARBON	3210331	1121

SECTION 6

PARTS LIST

PART	DESCRIPTION	EXACT NO	MFG
R580	RESISTOR, 39 OHM 1/4W 5% CARBON	3070390	1121
R586	RESISTOR, 22 OHM 1/4W 5% CARBON	3070220	1121
R587	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101	1121
R588	RESISTOR, 33200 OHM 1/4W 1% METAL FILM	3133322	7115
R589	POTENTIOMETER, 100K OHM TRIM	3110143	71450
R590	RESISTOR, 442 OHM 1/4W 1% METAL FILM	3134420	7115
R591	POTENTIOMETER, 100 OHM TRIM	3110141	71450
R592	RESISTOR, 63.4 OHM 1/4W 1% METAL FILM	3130634	7115
R600	RESISTOR, 1210 OHM 1/4W 1% METAL FILM	3131211	7115
R601	RESISTOR, 49.9 OHM 1/4W 1% METAL FILM	3130499	7115
R602	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101	1121
R605	RESISTOR, 681 OHM 1/4W 1% METAL FILM	3136810	7115
R606	RESISTOR, 4990 OHM 1/4W 1% METAL FILM	3134991	7115
R607	RESISTOR, 4990 OHM 1/4W 1% METAL FILM	3134991	7115
R608	RESISTOR, 19100 OHM 1/4W 1% METAL FILM	3131912	7115
R609	RESISTOR, 127 OHM 1/4W 1% METAL FILM	3131270	7115
R610	RESISTOR, 19100 OHM 1/4W 1% METAL FILM	3131912	7115
R611	RESISTOR, 200 OHM 1/4W 1% METAL FILM	3132000	7115
R612	RESISTOR, 309 OHM 1/4W 1% METAL FILM	3133090	7115
R613	POTENTIOMETER, 2K OHM PC TRIM	3110130	78488
R614	RESISTOR, 9530 OHM 1/4W 1% METAL FILM	3139531	7115
R615	RESISTOR, 9530 OHM 1/4W 1% METAL FILM	3139531	7115
R616	POTENTIOMETER, 2K OHM PC TRIM	3110130	78488
R617	POTENTIOMETER, 2K OHM PC TRIM	3110130	78488
R618	RESISTOR, 7500 OHM 1/4W 1% METAL FILM	3137501	7115
R619	RESISTOR, 7500 OHM 1/4W 1% METAL FILM	3137501	7115
R620	POTENTIOMETER, 2K OHM PC TRIM	3110130	78488
R621	RESISTOR, 499 OHM 1/4W 1% METAL FILM	3134990	7115
R622	RESISTOR, 82.5 OHM 1/4W 1% METAL FILM	3130825	7115
R700	RESISTOR, 47 OHM 1/4W 5% CARBON	3070470	1121
R701	POTENTIOMETER, 250 OHM	3110145	71450
R702	CONCENTRIC SWITCH & POTENTIOMETER	2600317	71450
R703	RESISTOR, 160 OHM 1/4W 5% CARBON	3070161	1121
R704	RESISTOR, 27 OHM 1/4W 5% CARBON	3070270	1121
R705	RESISTOR, 13700 OHM 1/4W 1% METAL FILM	3131372	7115
R706	RESISTOR, 1500K OHM 1/2W 1% METAL FILM	3101504	7115
R707	RESISTOR, 15000K OHM 1/2W 1% DEP, CARBON	3091505	75042
R708	RESISTOR, 274K OHM 1/4W 1% METAL FILM	3132743	7115
R709	RESISTOR, 274K OHM 1/4W 1% METAL FILM	3132743	7115
R710	RESISTOR, 470 OHM 1/4W 5% CARBON	3070471	1121
R711	RESISTOR, 324K OHM 1/4W 1% METAL FILM	3133243	7115
R712	RESISTOR, 16500 OHM 1/4W 1% METAL FILM	3131652	7115
R713	POTENTIOMETER, 5K OHM PC TRIM	3110052	37942
R714	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002	7115
R715	RESISTOR, 1000 OHM 1/4W 1% METAL FILM	3131001	7115
R716	RESISTOR, 16500 OHM 1/4W 1% METAL FILM	3131652	7115
R717	RESISTOR, 2700 OHM 1/4W 5% CARBON	3070272	1121
R718	RESISTOR, 210K OHM 1/4W 1% METAL FILM	3132103	7115
R719	RESISTOR, 27 OHM 1/4W 5% CARBON	3070270	1121
R720	RESISTOR, 15K OHM 1/4W 5% CARBON	3070153	1121
R730	RESISTOR, 11K OHM 1/4W 5% CARBON	3070113	1121
R731	RESISTOR, 160 OHM 1/4W 5% CARBON	3070161	1121
R735	RESISTOR, 10K OHM 1/4W 5% CARBON	3070103	1121
R736	RESISTOR, 10K OHM 1/4W 5% CARBON	3070103	1121
R737	POTENTIOMETER, 50K OHM PC TRIM	3110133	78488
R738	RESISTOR, 75000 OHM 1/4W 1% METAL FILM	3137502	7115
R740	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101	1121
R741	RESISTOR, 68K OHM 1/4W 5% CARBON	3070683	1121
R742	RESISTOR, 5600 OHM 1/4W 5% CARBON	3070562	1121
R745	RESISTOR, 51 OHM 1/4W 5% CARBON	3070510	1121
R746	RESISTOR, 360 OHM 1/4W 5% CARBON	3070361	1121
R747	RESISTOR, 4300 OHM 1/4W 5% CARBON	3070432	1121
R750	RESISTOR, 22 OHM 1/4W 5% CARBON	3070220	1121
R751	RESISTOR, 47 OHM 1/4W 5% CARBON	3070470	1121
R752	RESISTOR, 68 OHM 1/4W 5% CARBON	3070680	1121
R755	RESISTOR, 22 OHM 1/4W 5% CARBON	3070220	1121
R760	RESISTOR, 3010 OHM 1/4W 1% METAL FILM	3133011	7115
R761	RESISTOR, 2000 OHM 1/4W 1% METAL FILM	3132001	7115
R762	RESISTOR, 221 OHM 1/4W 1% METAL FILM	3132210	7115
R765	RESISTOR, 3010 OHM 1/4W 1% METAL FILM	3133011	7115
R766	RESISTOR, 68K OHM 1/4W 5% CARBON	3070683	1121
R767	POTENTIOMETER, 100K OHM TRIM	3110143	71450
R768	RESISTOR, 332 OHM 1/4W 1% METAL FILM	3133320	7115
R769	RESISTOR, 5490 OHM 1/4W 1% METAL FILM	3135491	7115
R770	RESISTOR, 3010 OHM 1/4W 1% METAL FILM	3133011	7115
R771	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002	7115
R772	RESISTOR, 1650 OHM 1/4W 1% METAL FILM	3131651	7115
R775	RESISTOR, 2700 OHM 1/4W 5% CARBON	3070272	1121
R780	RESISTOR, 510 OHM 1/4W 5% CARBON	3070511	1121
R781	RESISTOR, 2700 OHM 1/4W 5% CARBON	3070272	1121
R790	RESISTOR, 4700 OHM 1/4W 5% CARBON	3070472	1121
R791	RESISTOR, 470 OHM 1/4W 5% CARBON	3070471	1121
R792	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101	1121
R793	RESISTOR, 470 OHM 1/4W 5% CARBON	3070471	1121
R800	RESISTOR, 2200 OHM 1/4W 5% CARBON	3070222	1121
R801	RESISTOR, 2200 OHM 1/4W 5% CARBON	3070222	1121
R802	RESISTOR, 2200 OHM 1/4W 5% CARBON	3070222	1121
R810	RESISTOR, 240 OHM 1/4W 5% CARBON	3070241	1121
R811	RESISTOR, 3300 OHM 1/4W 5% CARBON	3070332	1121
R812	RESISTOR, 1600 OHM 1/4W 5% CARBON	3070162	1121
R813	RESISTOR, 2200 OHM 1/4W 5% CARBON	3070222	1121
R822	RESISTOR, 4700 OHM 1/4W 5% CARBON	3070472	1121
R823	RESISTOR, 100K OHM 1/4W 5% CARBON	3070104	1121
R824	RESISTOR, 1000 OHM 1/2W 5% CARBON	3010102	1121
R825	CONCENTRIC SWITCH & POTENTIOMETER	2600314	71450
R826	RESISTOR, 4700 OHM 1/4W 5% CARBON	3070472	1121
R827	RESISTOR, 4700 OHM 1/4W 5% CARBON	3070472	1121
R828	RESISTOR, 3000 OHM 1/4W 5% CARBON	3070302	1121
R829	RESISTOR, 4700 OHM 1/4W 5% CARBON	3070472	1121
R830	RESISTOR, 100K OHM 1/4W 5% CARBON	3070104	1121
R831	RESISTOR, 33K OHM 1/4W 5% CARBON	3070333	1121
R832	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101	1121
R833	RESISTOR, 10K OHM 1/4W 5% CARBON	3070103	1121
R834	RESISTOR, 820 OHM 1/4W 5% CARBON	3070821	1121
R835	RESISTOR, 10K OHM 1/4W 5% CARBON	3070103	1121
R836	RESISTOR, 10K OHM 1/4W 5% CARBON	3070103	1121
R840	RESISTOR, 1000 OHM 1/4W 5% CARBON	3070102	1121
R841	RESISTOR, 1000 OHM 1/4W 5% CARBON	3070102	1121
R845	RESISTOR, 4700 OHM 1/4W 5% CARBON	3070472	1121
R846	RESISTOR, 180 OHM 1/4W 5% CARBON	3070181	1121
R847	RESISTOR, 22 OHM 1/4W 5% CARBON	3070220	1121
R848	RESISTOR, 910 OHM 1/4W 5% CARBON	3070911	1121
R849	RESISTOR, 22 OHM 1/4W 5% CARBON	3070220	1121
R850	RESISTOR, 47 OHM 1/4W 5% CARBON	3070470	1121
R851	RESISTOR, 22 OHM 1/4W 5% CARBON	3070220	1121
R852	RESISTOR, 22 OHM 1/4W 5% CARBON	3070220	1121
R853	RESISTOR, 4700 OHM 1/4W 5% CARBON	3070472	1121
R854	RESISTOR, 180 OHM 1/4W 5% CARBON	3070181	1121
R860	RESISTOR, 680 OHM 1/4W 5% CARBON	3070681	1121
R861	RESISTOR, 332 OHM 1/4W 1% METAL FILM	3133320	7115
R862	RESISTOR, 33200 OHM 1/4W 1% METAL FILM	3133322	7115
R863	POTENTIOMETER, 100K OHM TRIM	3110143	71450
R864	RESISTOR, 150 OHM 1/4W 5% CARBON	3070151	1121
R865	RESISTOR, 1000 OHM 1/4W 5% CARBON	3070102	1121
R866	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002	7115
R867	RESISTOR, 2000 OHM 1/4W 5% CARBON	3070202	1121
R868	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002	7115
R500	CONCENTRIC SWITCH & POTENTIOMETER	2600316	71450
R869	CONCENTRIC SWITCH & POTENTIOMETER	2600313	71450
R871	TO		
R881	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3181000	7115
R900	POTENTIOMETER, 200 OHM 15T TRIM	3110125	19701
R901	TO		
R911	RESISTOR, 20.0 OHM 1/8W 1% METAL FILM	3182000	7115
R912	RESISTOR, 270 OHM 1/4W 5% CARBON	3070271	1121
R913	TO		
R923	RESISTOR, 4.7 OHM 1/4W 5% CARBON	3070047	1121
R924	RESISTOR, 10 OHM 1/4W 5% CARBON	3070100	1121
S100	SWITCH, TOGGLE SPDT	2600103	100005
S101	SWITCH, SLIDE	2600323	10597
S210	CONCENTRIC SWITCH & POTENTIOMETER	2600313	71450
S260	SWITCH, ROTARY 5P8T	2600312	71450
S360	CONCENTRIC SWITCH & POTENTIOMETER	2600315	71450
S550	SWITCH, LEVER 5P3T	2600251	10597
T100	TRANSFORMER, POWER	1200039	10597
S700	CONCENTRIC SWITCH & POTENTIOMETER	2600317	71450
S820	SWITCH, PUSH BUTTON	2600318	10597
S830	CONCENTRIC SWITCH & POTENTIOMETER	2600314	71450
S845	SWITCH, TOGGLE DPDT	2600109	100005
S900	SWITCH, 3 POLE THUMBWHEEL	2600343	10597
S860	CONCENTRIC SWITCH & POTENTIOMETER	2600313	71450

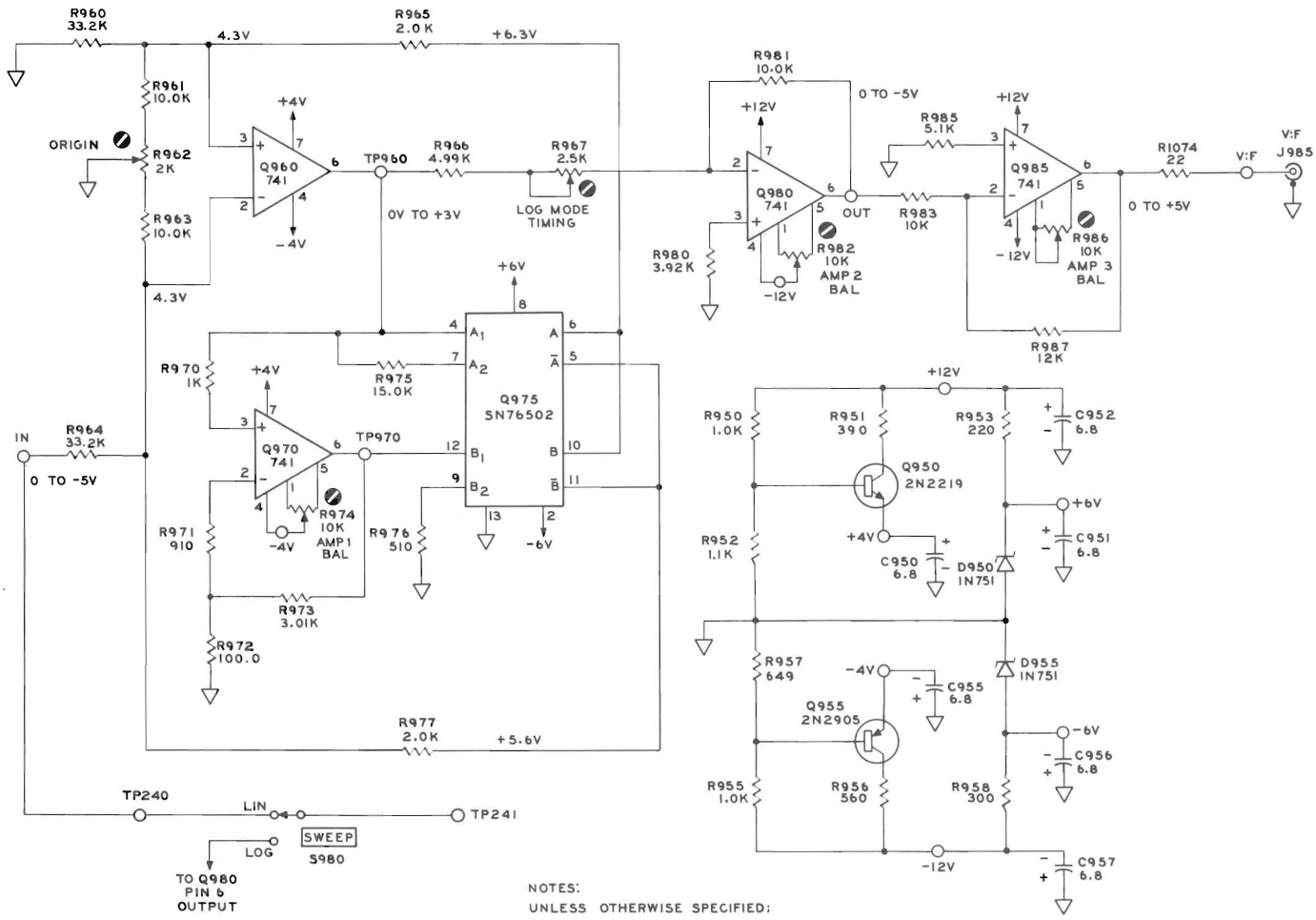
LOG AMPLIFIER

PART	DESCRIPTION	EXACT NO	MFG
C283	CAPACITOR, 0.05 MFD 50 VOLT	2900052	10597
C950	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C951	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C952	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C955	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C956	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C957	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
D950	DIODE, 1N751A	1520751	75042
D955	DIODE, 1N751A	1520751	75042
J985	CONNECTOR, BNC	1310047	91836
Q950	TRANSISTOR, 2N2219	1562219	1295
Q955	TRANSISTOR, 2N2905	1562905	1295
Q960	OPERATIONAL AMPLIFIER, UA741	1580010	7263
Q970	OPERATIONAL AMPLIFIER, UA741	1580010	7263
Q975	INTEGRATED CIRCUIT, SN76502N	1580030	1295
Q980	OPERATIONAL AMPLIFIER, UA741	1580010	7263
Q985	OPERATIONAL AMPLIFIER, UA741	1580010	7263
R265	RESISTOR, 806 OHM MATCHED PAIR	3128060	10597
R950	RESISTOR, 1000 OHM 1/4W 1% METAL FILM	3131001	7115
R951	RESISTOR, 390 OHM 1/4W 5% CARBON	3070391	1121
R952	RESISTOR, 649 OHM 1/4W 1% METAL FILM	3136490	7115
R953	RESISTOR, 220 OHM 1/4W 5% CARBON	3070221	1121
R955	RESISTOR, 1000 OHM 1/4W 1% METAL FILM	3131001	7115
R956	RESISTOR, 560 OHM 1/4W 5% CARBON	3070561	1121
R957	RESISTOR, 649 OHM 1/4W 1% METAL FILM	3136490	7115
R958	RESISTOR, 300 OHM 1/4W 5% CARBON	3070301	1121
R960	RESISTOR, 36500 OHM 1/4W 1% METAL FILM	3133652	7115
R961	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002	7115
R962	POTENTIOMETER, 1K OHM TRIM	3110147	71450
R963	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002	7115
R964	RESISTOR, 36500 OHM 1/4W 1% METAL FILM	3133652	7115
R965	RESISTOR, 2000 OHM 1/4W 1% METAL FILM	3132001	7115
R966	RESISTOR, 4990 OHM 1/4W 1% METAL FILM	3134991	7115
R967	POTENTIOMETER, 2.5K OHM TRIM	3110148	71450
R970	RESISTOR, 1000 OHM 1/4W 5% CARBON	3070102	1121
R971	RESISTOR, 910 OHM 1/4W 5% CARBON	3070911	1121
R972	RESISTOR, 100 OHM 1/4W 1% METAL FILM	3131000	7115
R973	RESISTOR, 3010 OHM 1/4W 1% METAL FILM	3133011	7115
R974	POTENTIOMETER, 10K OHM TRIM	3110150	71450
R975	RESISTOR, 15000 OHM 1/4W 1% METAL FILM	3131502	7115
R976	RESISTOR, 510 OHM 1/4W 5% CARBON	3070511	1121
R977	RESISTOR, 2000 OHM 1/4W 1% METAL FILM	3132001	7115
R980	RESISTOR, 3920 OHM 1/4W 1% METAL FILM	3133921	7115
R981	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002	7115
R982	POTENTIOMETER, 10K OHM TRIM	3110150	71450
R983	RESISTOR, 10K OHM 1/4W 5% CARBON	3070103	1121
R985	RESISTOR, 5100 OHM 1/4W 5% CARBON	3070512	1121
R986	POTENTIOMETER, 10K OHM TRIM	3110150	71450
R987	RESISTOR, 12K OHM 1/4W 5% CARBON	3070123	1121
R988	RESISTOR, 22 OHM 1/4W 5% CARBON	3070220	1121
S710	SWITCH, LEVER 2P3T	2600308	10597
S710	SWITCH, LEVER 2P3T	2600308	10597

SECTION 7

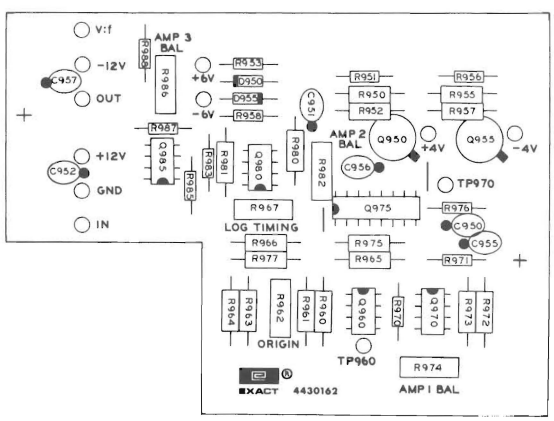
SCHEMATICS

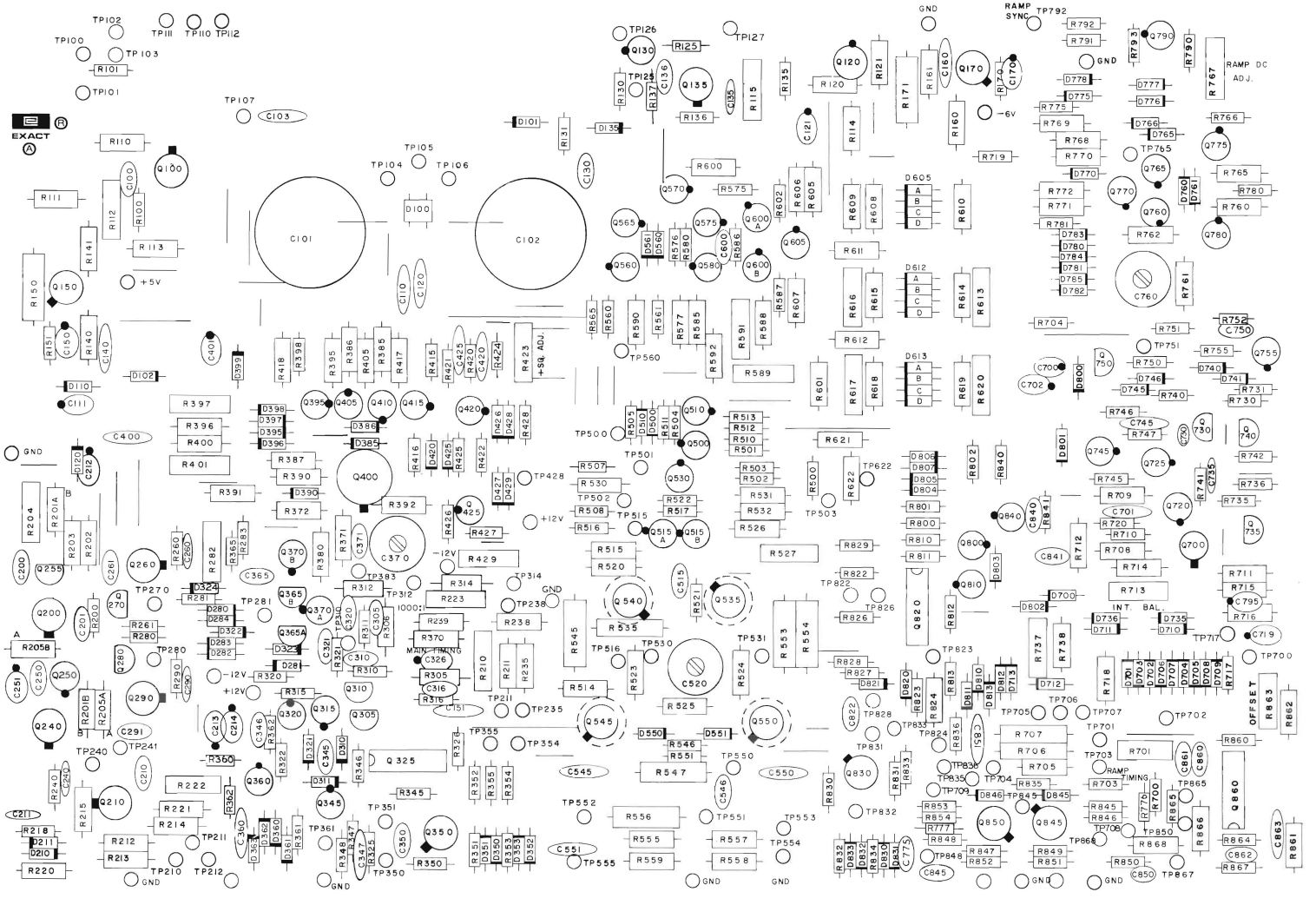
	Log Amplifier
	Component Assembly Layout
7.2.0	Block Diagram
7.2.1	Power Supply Circuit Diagram
7.2.2	Current Sources, Main Generator
7.2.3	Main Generator
7.2.4	Signal Shaping and Amplifying Circuits
7.2.5	Ramp Generator

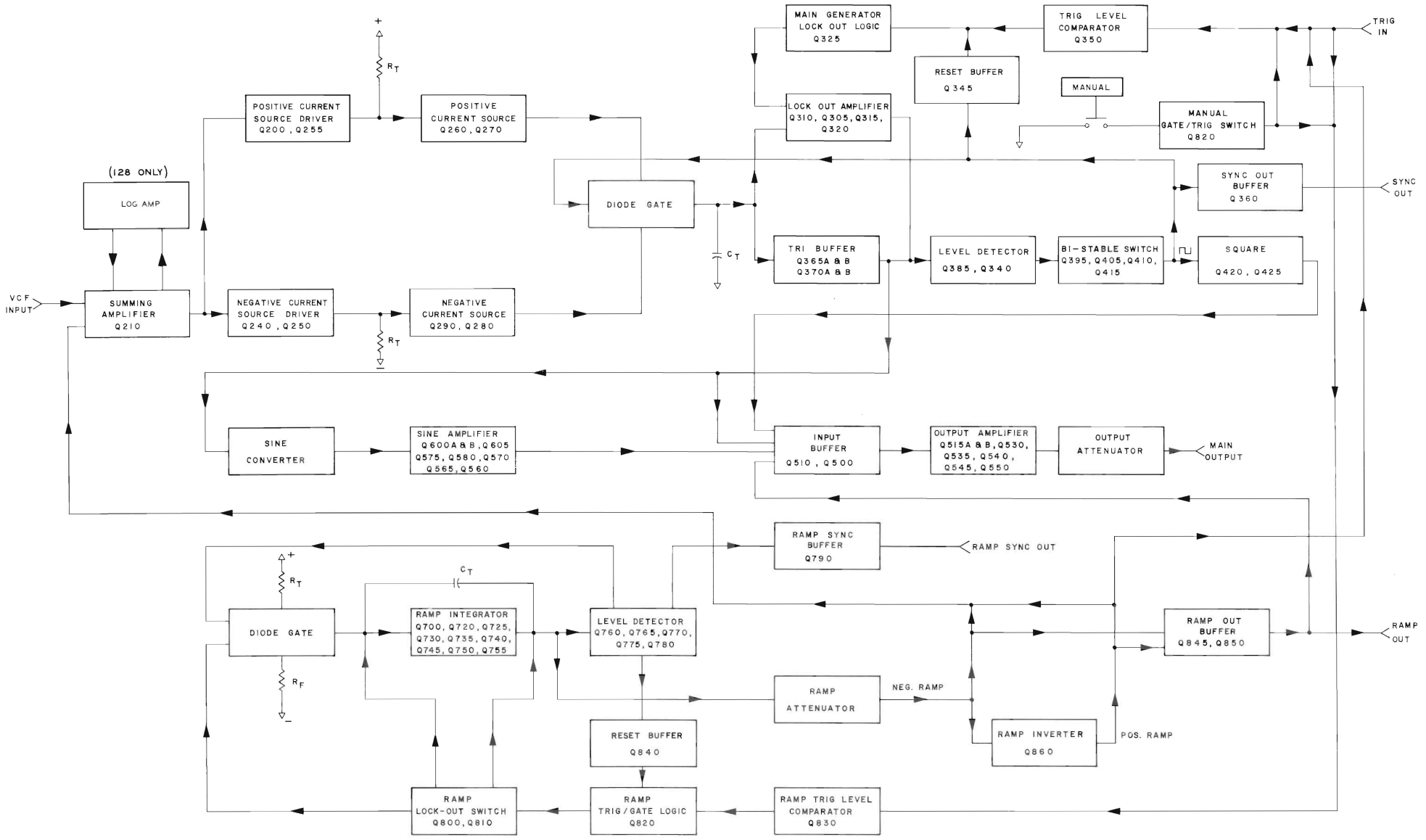


NOTES:
UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTORS ARE IN OHMS
2. ALL CAPACITORS ARE IN MICROFARADS
3. ▽ CIRCUIT GND

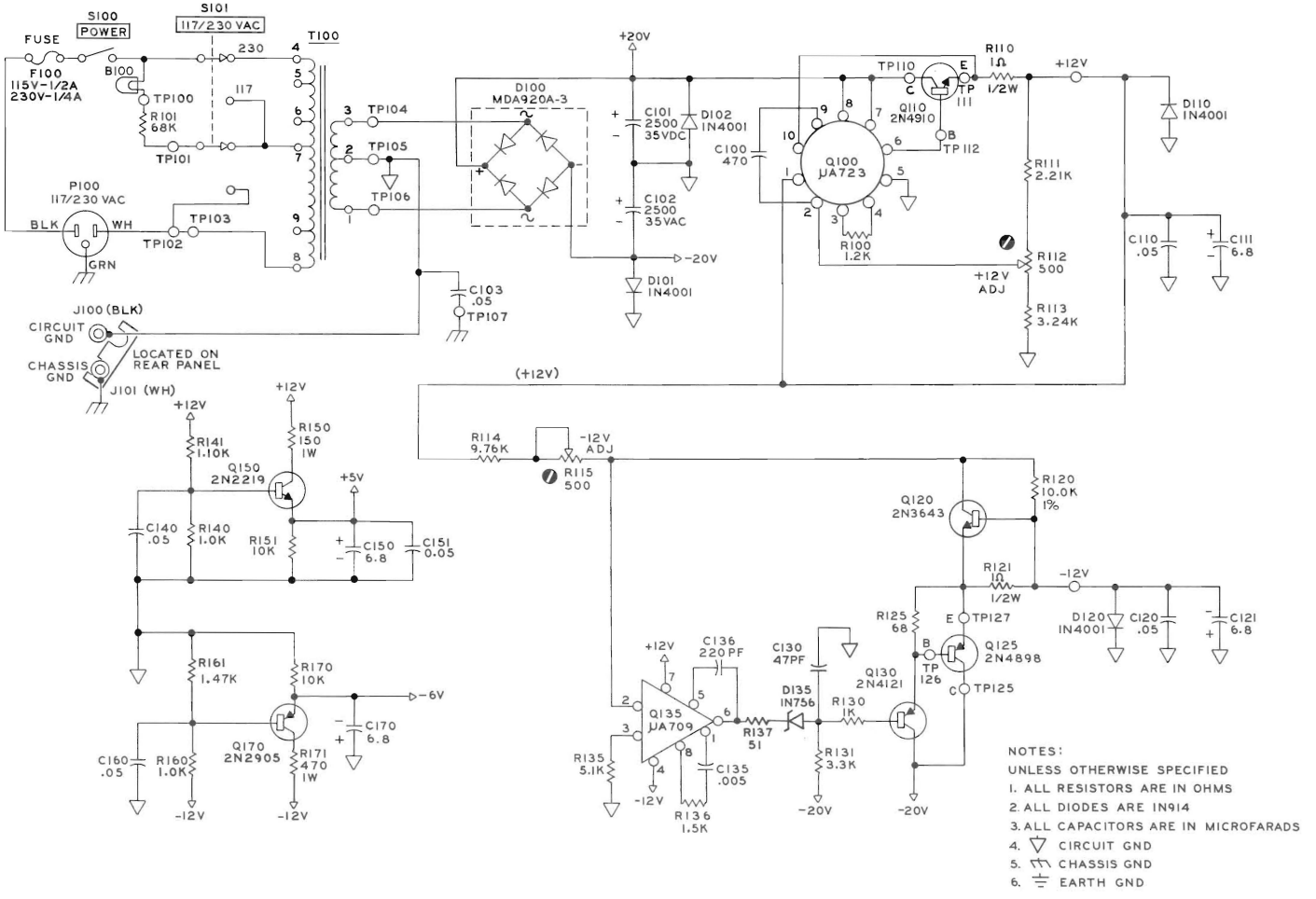
SCHEMATIC DIAGRAM - LOG AMP




EXACT
RAMP SYNC
RAMP DC ADJ.
+89 ADJ.
MAIN TIMING
INT BAL
OFFSET
RAMP TIMING
GND
+5V
+12V
-12V
-6V

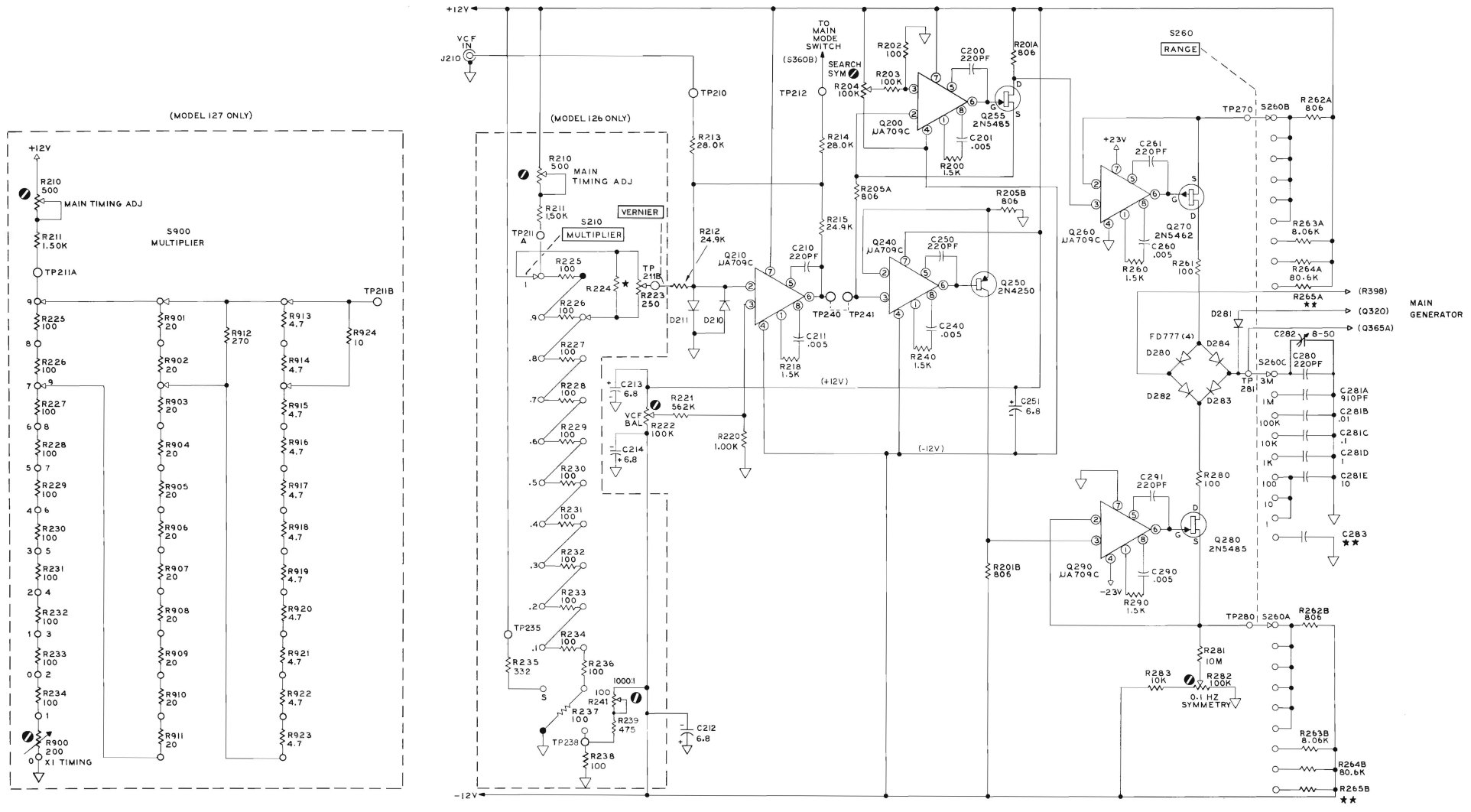


BLOCK DIAGRAM -126-127-128 FIGURE 7.2.0



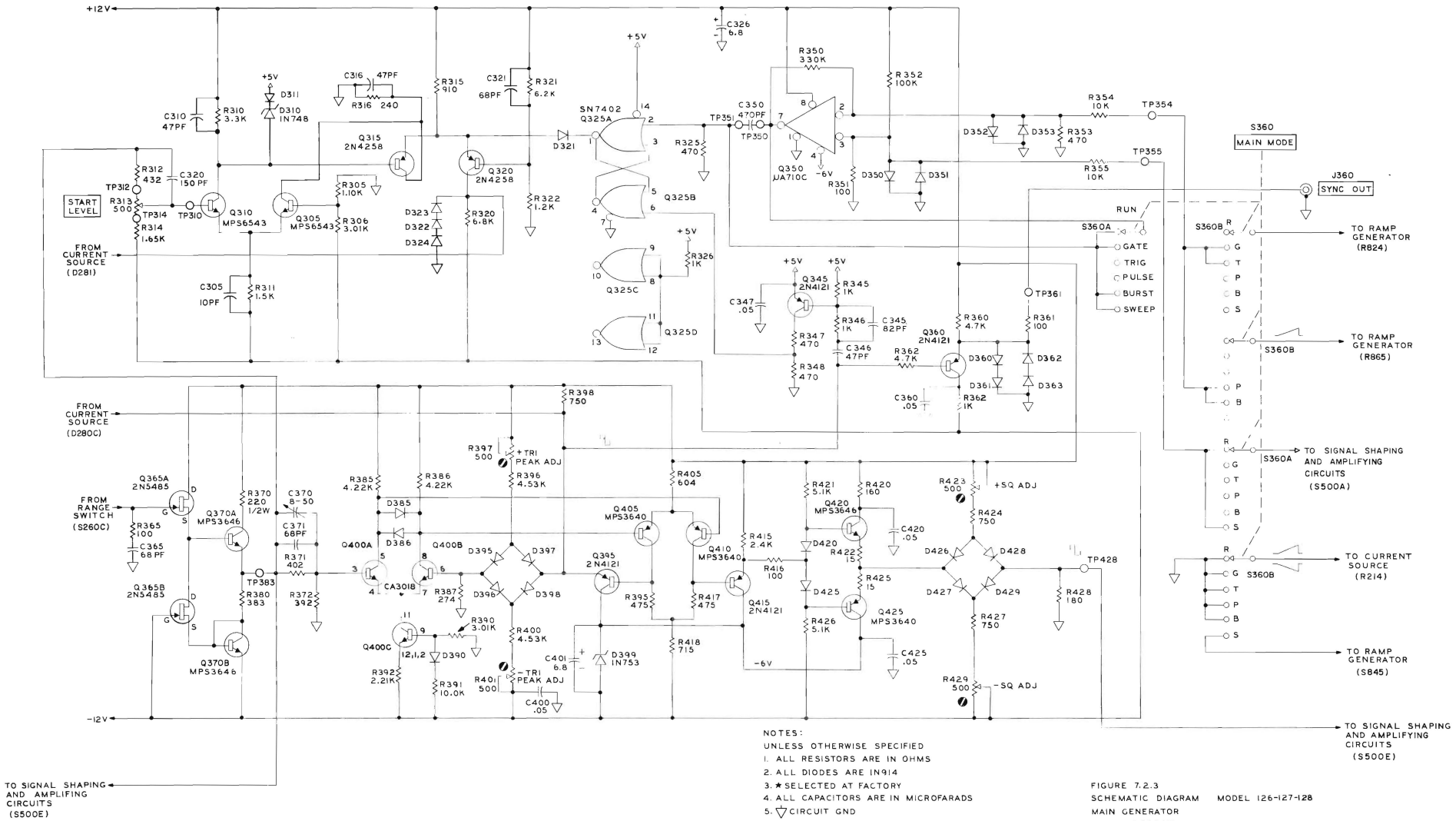
NOTES:
UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE IN OHMS
2. ALL DIODES ARE IN914
3. ALL CAPACITORS ARE IN MICROFARADS
4. ▽ CIRCUIT GND
5. ⏚ CHASSIS GND
6. ⏚ EARTH GND

FIGURE 7.2.1
SCHEMATIC DIAGRAM MODEL 126-127-128
POWER SUPPLY CIRCUIT
1171 SN 3155 & UP
REV Ⓐ



NOTES:
UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE IN OHMS
2. ALL DIODES ARE IN914
3. ★ SELECTED AT FACTORY
4. ALL CAPACITORS ARE IN MICROFARADS
5. ▽ CIRCUIT GND
6. ★★ OPTIONAL OR SELECTED

FIGURE 7.2.2
SCHEMATIC DIAGRAM MODEL 126-127-128
CURRENT SOURCES – MAIN GENERATOR
1171 SN 3155 & UP
REV (A)



NOTES:
UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE IN OHMS
2. ALL DIODES ARE IN914
3. ★ SELECTED AT FACTORY
4. ALL CAPACITORS ARE IN MICROFARADS
5. ▽ CIRCUIT GND

FIGURE 7.2.3
SCHEMATIC DIAGRAM MODEL 126-127-128
MAIN GENERATOR
1171 SN3155 & UP
REV (A)

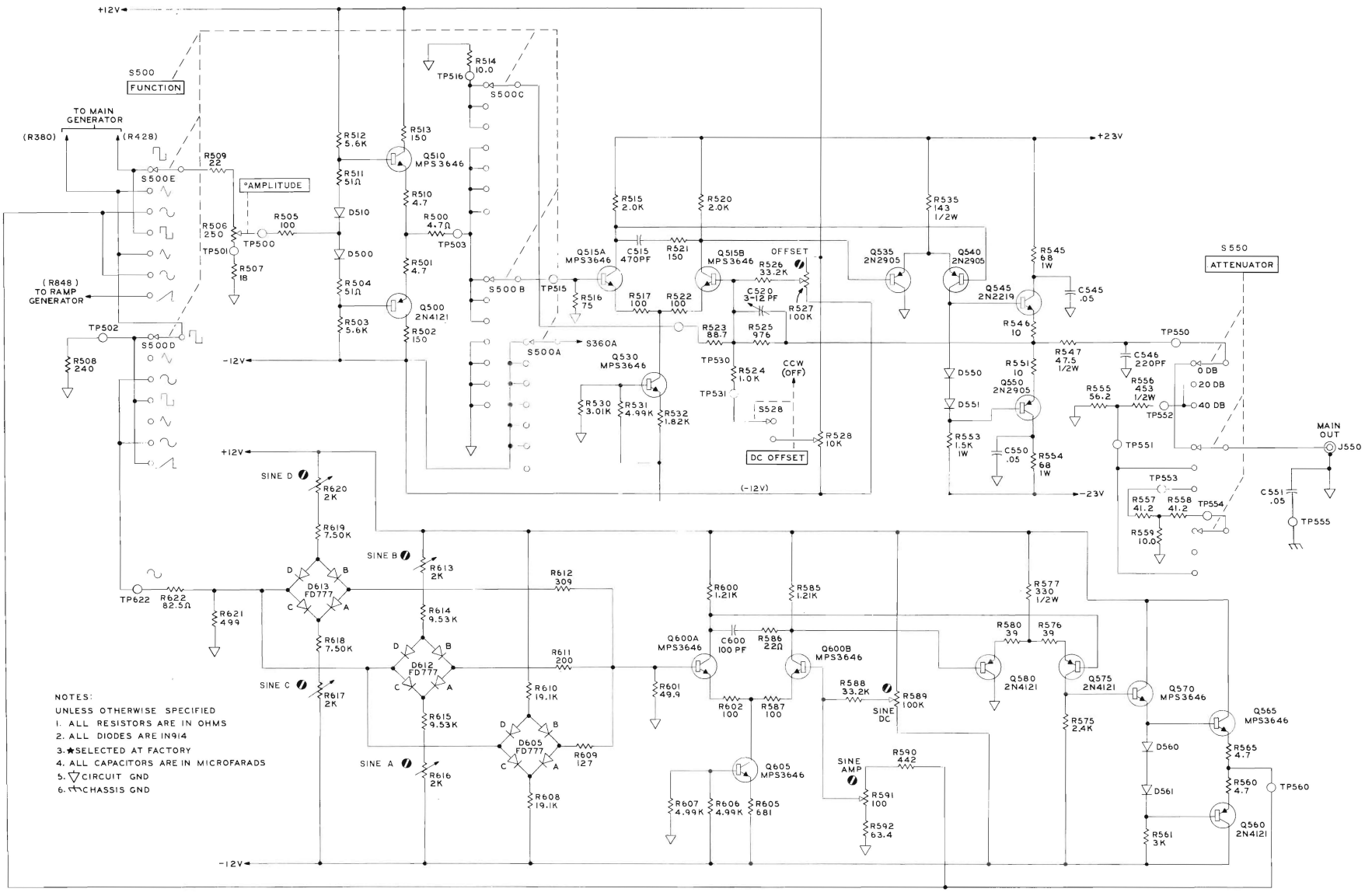


FIGURE 7.2.4
SCHEMATIC DIAGRAM MODEL 126-127-128
SIGNAL SHAPING & AMPLIFING CIRCUITS
1171 SN3155 & UP

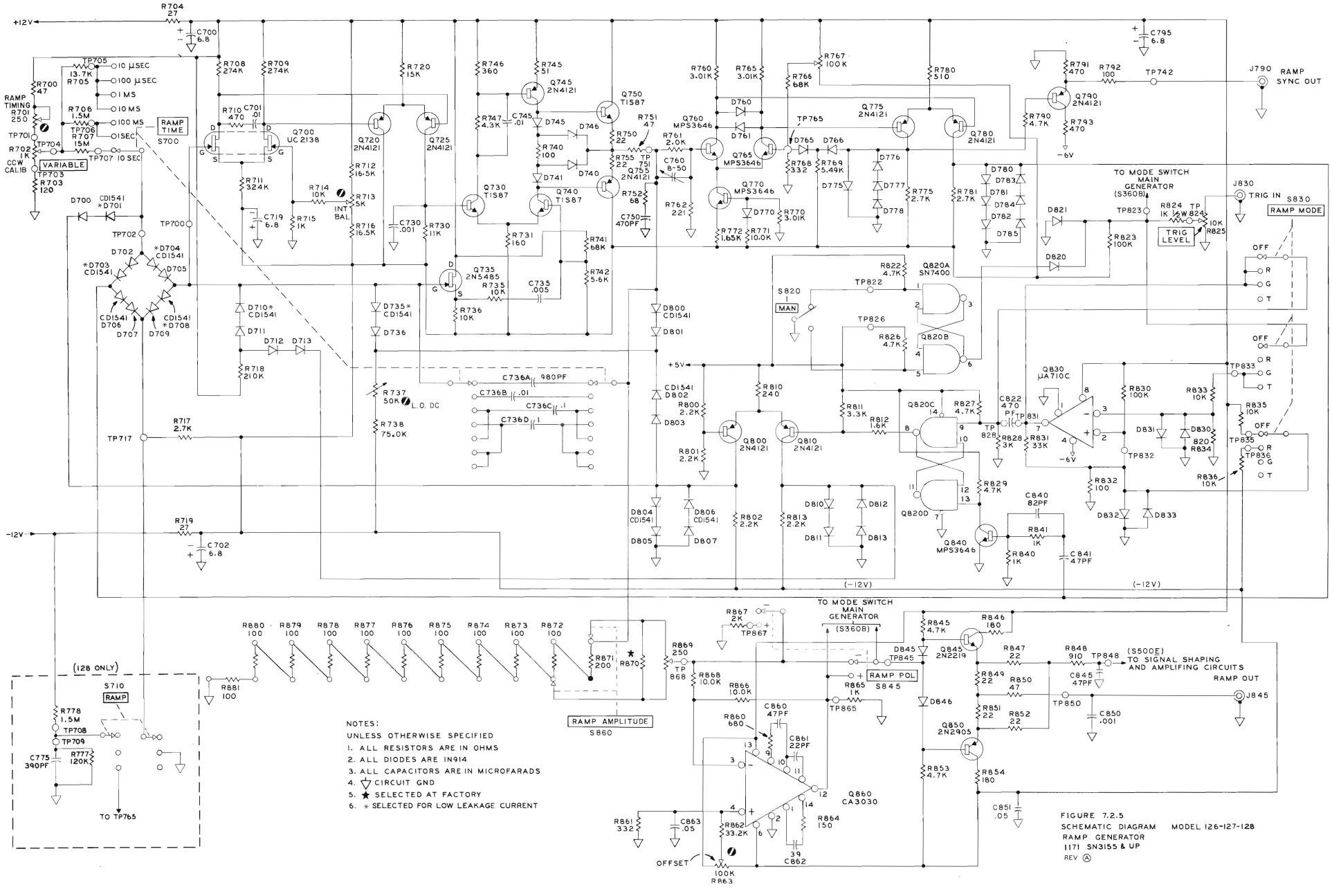


FIGURE 7.2.5
SCHEMATIC DIAGRAM MODEL 126-127-128
RAMP GENERATOR
1171 SN3155 & UP
REV (A)

SECTION 8

ADDENDA

ADDENDUM

R 752 was 68Ω 5% is now 22Ω 5% (307-0220)

Models 126, 127, 128

Rev. B

4-11-73