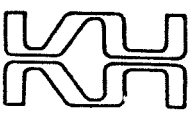
.2Hz TO 3MHz

SWEEP FUNCTION GENERATOR

MODEL 1400 SERIAL NO. _____

OPERATING AND MAINTENANCE MANUAL



KROHN-HITE CORPORATION

AVON INDUSTRIAL PARK/255 BODWELL STREET/AVON, MASS. 02322 USA

Printed in U. S. A. December, 1979

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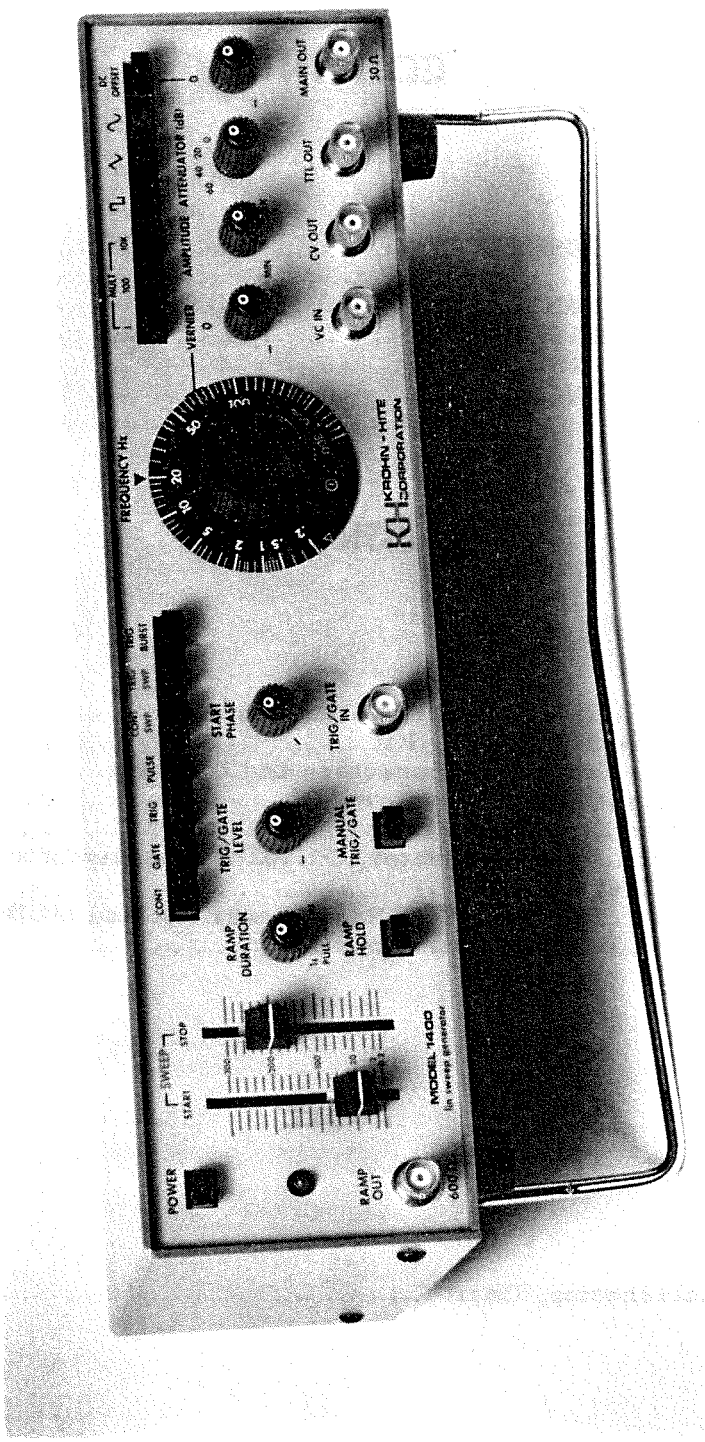


Figure 1. Model 1400 Sweep Function Generator

SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Krohn-Hite Model 1400, shown in Figure 1, is a versatile sweep generator designed for applications in the sub-audio (0.2 Hz) to high frequency (3 MHz) range. It provides 14 different modes of operation, including up or down linear sweeps, gated, burst and pulse-type signals.

The Model 1400 provides an output voltage of 20V p-p, open-circuit, controlled by a calibrated dB attenuator and vernier. The DC offset control provides variable offset capability.

In addition to the above features, several auxiliary outputs are provided. The TTL OUT, coincident with the main generator frequency, may be used for gating, blanking, etc. The RAMP OUT is a 5 volt ramp coincident with the sweep, and can be used to drive the horizontal axis of an oscilloscope or X-Y plotter. The RAMP OUT can also be used independent of the main generator in non-sweep modes. The CV output provides a DC voltage proportional to the generator frequency, accurate to within 5% to provide more precise measurement or setting of frequency.

This generator has been carefully inspected, tested and aged before shipment to insure that it is working properly. If for some reason the generator is not working properly, or appears to have been damaged in shipment, inform the freight carrier of the damage and notify KROHN-HITE or its nearest sales office immediately.

1.2 SPECIFICATIONS

MAIN OUTPUT

WAVEFORMS: Sine, square, triangle, positive and negative pulses.

FREQUENCY RANGE: 0.2 Hz to 3 MHz.

FREQUENCY CONTROL:

Dial calibrated logarithmically from 0.2 to 300, and a 3 position pushbutton multiplier switch.

Band	Multiplier	Frequency Range (Hz)
1	1	0.2-300
2	100	20-30k
3	10k	2k-3M

FREQUENCY ACCURACY: ±5% at three dial calibration settings of 10, 100 and 300; ±20% maximum at other settings.

MAXIMUM OUTPUT: 20V p-p (10V p-p into 50 ohms).

IMPEDANCE: Constant 50 ohms, ±5%.

AMPLITUDE CONTROL:

Attenuator calibrated in 20 dB steps to 60 dB and vernier. dB attenuator accuracy ±0.2 dB. Minimum output less than 5 mV.

DC COMPONENT: Nominal zero volts. Drift, less than ±5 mV/°C, reduced in proportion to dB attenuator setting.

FREQUENCY RESPONSE: Sinewave; 0.1 dB, 0.2 Hz to 300 kHz, 1.0 dB to 3 MHz.

SINEWAVE DISTORTION: Less than 0.5% 2 Hz to 300 kHz, 3% to 3 MHz.

SQUAREWAVES AND PULSES: Rise and fall time less than 40 ns, total aberrations less than 5% with 50 ohm matching load.

TRIANGLE LINEARITY: 99% 0.2 Hz to 300 kHz, 95% to 3 MHz.

TIME SYMMETRY: 99% 0.2 Hz to 300 kHz.

VC (EXTERNAL VOLTAGE CONTROL)

Frequency controlled about the dial setting with zero to ±3 volts. Range 1500:1. Impedance 10k ohms. Upper frequency limited to maximum of selected band.

VARIABLE DC OFFSET

Allows setting of waveform DC level to ±10 volts. Peak AC plus DC offset limited to ±10 volts.

OPERATIONAL MODES (MAIN OUTPUT)

CONT: Continuous output, frequency determined by dial and multiplier.

GATE: Continuous output for duration of external or manual gate.

TRIG: Single cycle output when externally or manually triggered.

PULSE: Pulse output adjustable between 160 ns and 2.5 s or single cycle of selected waveform. Rep rate from 0.001 Hz to 1 kHz.

CONT SWP: Continuous sweeping between frequencies determined by START and STOP controls. Range: 1500:1.

TRIG SWP: Holds at START frequency, single sweep when externally or manually triggered.

TRIG BURST: Single tone burst when externally or manually triggered.

The following additional modes are obtained by simultaneously depressing the mode buttons in brackets:

TONE BURST [GATE, PULSE]: Repetitive tone burst, rate variable from 0.001 Hz to 1 kHz.

GATED SWP [CONT, GATE, CONT SWP]: Holds at START frequency, continuous sweeping when externally or manually gated.

GATED SWP BURST [GATE, CONT SWP]: Continuously sweeping burst when externally or manually gated.

TRIG SWP BURST [TRIG SWP, TRIG BURST]: Single swept burst when externally or manually triggered.

HOLD SWP HOLD [GATE, TRIG SWP]: Continuous output at START frequency, swept and held at STOP frequency when externally or manually gated.

SWP-HOLD BURST [GATE, TRIG SWP, TRIG BURST]: Single swept burst and hold at STOP frequency when externally or manually gated.

TRIG/GATE CHARACTERISTICS

Manual or external. Waveform start/stop point adjustable $\pm 90^{\circ}$ to 300 kHz, $\pm 70^{\circ}$ to 3 MHz. Input level variable -10V to +10V. Triggers on positive slope. Maximum trigger frequency, 3 MHz. Impedance, 10k ohms.

SWEEP CHARACTERISTICS

Linear. Start and stop frequencies independently selected. Typical accuracy, 10% full scale. Frequencies may sweep up or down. Sweep may be stopped with RAMP HOLD control. Hold drift: (0.03 Hz/sec) X MULTiplier.

RANGE: 1500:1.

DURATION: Variable, 1 ms to 1000 s.

AUXILIARY OUTPUTS

RAMP OUT: Linear 5V. Impedance 600 ohms.

TTL OUT: Frequency same as MAIN OUT. Drives up to 10 TTL loads. Rise and fall time less than 15 ns.

CV (control voltage) OUT: 2 mV to 3 volts, proportional to generator frequency. Accuracy better than 5%. Impedance 600 ohms.

GENERAL

OPERATING TEMPERATURE RANGE: 0°C to 50°C.

POWER REQUIREMENTS: Switch selectable, 90-110, 108-132, 180-220, or 216-264 volts, single phase, 50-400 Hz, 25 watts.

DIMENSIONS AND WEIGHTS:

Cabinet Size/Weight	H	W	D	Net	Gross
U.S.	3 1/2"	14"	8 1/2"	7.5 lb.	9.5 lb.
Metric	8.9 cm	35.6 cm	21.6 cm	3.4 kg	4.3 kg

Specifications apply at 25°C, $\pm 5^{\circ}$C with maximum output voltage and dial set between 2 and 300.

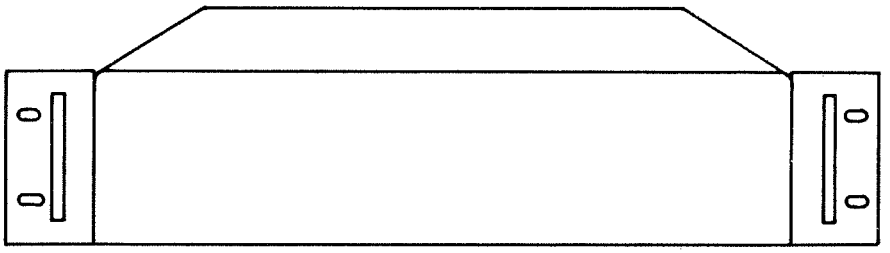


Figure 2. Optional Rack Mounting Kit

OPTIONAL RACK-MOUNTING KIT (Figure 2)

Part No. RK-314: Permits installation of the Model 1400 into a standard 19" rack spacing.

Specifications subject to change without notice.

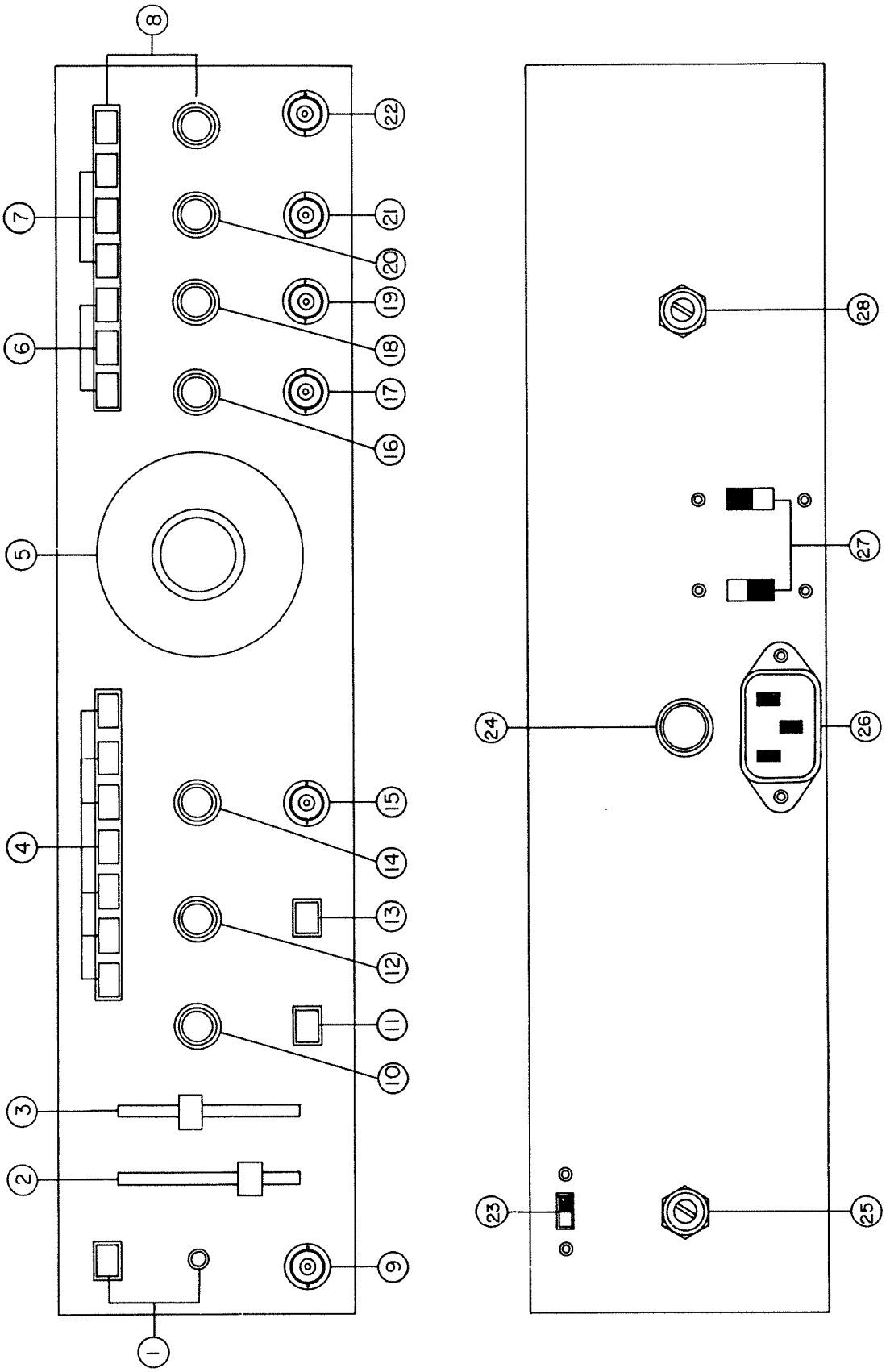


Figure 3. Operating Controls, Connectors and Displays

SECTION 2

OPERATION

2.1 POWER REQUIREMENTS

The Model 1400 Sweep Generator may be powered from a single phase, 50-400 Hz AC line voltage of either 90-110/108-132 volts, or 180-220/216-264 volts. The LINE selector switches on the rear panel select the proper mode of operation. All units are shipped with the LINE switches set to 120V and NORM, respectively, and a fuse bag attached to the line cord. The fuse bag contains a 1/8 ampere fuse. For 180V-264V operation, remove the 1/4 ampere fuse located in the fuse receptacle, replace it with the 1/8 ampere fuse from the fuse bag and switch the 120V/240V LINE switch to the 240V position. The NORM (normal)/LO (low) LINE switch is provided for operating with low AC line voltages (90-110 volts or 180-220 volts). A chart is provided in the rear panel showing the correct switch positions required for each line voltage.

CAUTION!

The cover of this instrument should not be removed when the instrument is connected to an AC power source, because of the potentially dangerous voltages that exist within the unit.

2.2 OPERATING CONTROLS, CONNECTORS AND DISPLAYS (See Figure 3)

2.2.1 Front Panel

(1) POWER: On-off pushbutton switch with power-on indicator.

(2) START: Slide control calibrated in Hertz with linear scale from 0.2 to 300, adjusts sweep start frequency in all sweep modes.

(3) STOP: Slide control calibrated with same scales as START control, adjusts sweep stop frequency.

(4) MODE: 7-station pushbutton control for selecting the generator mode of operation. See Section 2.3.2.

(5) FREQUENCY Hz dial: See Section 2.3.1.

(6) MULTiplier: 3 station control, multiplies FREQUENCY Hz dial setting and START and STOP scales by x1, x100 or x10K.

(7) WAVEFORM: 3 station pushbutton control selects sine, triangle, or square waveforms. The selected waveform appears at the MAIN OUT.

(8) DC OFFSET: Pushbutton on-off switch plus single turn control provides variable adjustment of MAIN OUT DC offset, ±10V.

(9) RAMP OUT: Linear zero to 5 volt ramp, duration adjusted with RAMP DURATION control. Provides auxiliary output independent of main generator frequency in CONT, GATE or TRIG modes. See Section 2. 3. 3.

(10) RAMP DURATION: Single turn control with push-pull switch adjusts ramp duration between 1s-1ms (push) and 1000s-1s (pull); adjusts burst and pulse rate in TONE BURST and PULSE modes; adjusts sweep duration in all sweep modes.

(11) RAMP HOLD: Pushbutton switch to manually stop the RAMP (sweep). RAMP (sweep) resumes when RAMP HOLD switch is returned to extended position.

(12) TRIG/GATE LEVEL: Single turn control, varies the threshold level of the TRIG/GATE input between -10V and +10V, (on the positive slope). In TONE BURST mode adjusts burst duration between 10% and 90% of burst period.

(13) MANUAL TRIG/GATE: Manually triggers or gates the generator frequency on in TRIG, GATE, TRIG SWP, TRIG SWP BURST, HOLD SWP HOLD, SWP HOLD BURST, TRIG BURST, GATED SWP and GATED SWP BURST modes.

(14) START PHASE: Single turn control adjusts the phase angle at which the sine or triangle waveform starts in any of the following modes: TRIG, PULSE, GATE, TRIG BURST, TONE BURST, GATED SWP BURST, TRIG SWP BURST and SWP-HOLD BURST. Start-stop points adjustable ±90° to 300 kHz, ±70° to 3 MHz. Produces haversine or havertriangle waveforms in TRIG and PULSE modes.

(15) TRIG/GATE IN: Input for external trigger or gate signal. Input impedance, 10k ohms. Maximum trigger frequency, 3 MHz. Will withstand ±50 volts peak without damage.

(16) VERNIER: Single-turn control provides 5% fine adjustment of FREQUENCY Hz dial.

(17) VC IN: Input for external voltage control of frequency. Zero to ±3 volts gives 1500:1 frequency control, within FREQUENCY Hz dial range. Input impedance, 10k ohms.

(18) AMPLITUDE: Single turn potentiometer for controlling the MAIN OUT voltage in each position of the dB ATTENUATOR.

(19) CV OUT: DC voltage proportional to main generator frequency, 2 mV to 3 volts, 5% accuracy over calibrated portion of FREQUENCY Hz dial. Output impedance, 600 ohms.

(20) ATTENUATOR (dB): 4 position attenuator, calibrated in dB steps from 0 dB to 60 dB. Attenuator accuracy, ±0. 2 dB.

(21) TTL OUT: TTL compatible pulse coincident with main generator frequency, in phase with respect to MAIN OUT squarewave. Rise and fall less than 15 ns.

(22) MAIN OUT: The selected waveforms appear at this output. Maximum output, 20V p-p, open-circuit. Impedance 50 ohms, ±5%.

2.2.2 Rear Panel

(23) CHASSIS/FLOATING: 2 position slide switch that disconnects signal ground (⏚) from chassis ground (⏚) when in the FLOATING position.

(24) FUSE RECEPTACLE: 1/4A slow blow fuse for 120V operation, 1/8A slow blow fuse for 240V operation.

(25) DC LEVEL ADJ: Single turn screwdriver adjustment for MAIN OUT DC level.

(26) AC POWER RECEPTACLE: Standard 3-prong connector. A detachable 3-wire line cord is included.

(27) LINE: Complimentary slide switches for selecting 120 or 240 volt operation, and NORMal or LOW line conditions. The 120/240V LINE switch determines the proper voltage range (90-132V or 180-264V), while the NORM/LO LINE switch selects normal (108-132V, 216-264V) or low (90-110V, 180-220V) line voltage.

(28) SYM ADJ: Single-turn screwdriver adjustment for waveform symmetry.

2.3 OPERATION

2.3.1 FREQUENCY Hz dial and MULTiplier

The FREQUENCY Hz dial is a single turn dial, calibrated in Hertz with a logarithmic scale from 0.2 to 300. The effective dial range is 1500:1. The MULTiplier is a 3-position pushbutton control calibrated in x1, x100 and x10K steps.

The dial determines the frequency or period of the MAIN OUT in the CONT, GATE, TRIG, PULSE, TRIG BURST and TONE BURST modes.

If an external voltage is applied to the VC IN connector it will vary the frequency of the generator about the MARKER/FREQ Hz dial setting and within the dial range.

2.3.2 Modes of Operation

The Model 1400 provides a selection of 14 different modes of operation. Seven of these modes are selected by the pushbutton MODE switch; six additional modes are obtained by simultaneously depressing 2 or 3 specific MODE buttons. The fourteenth mode of operation is the External Frequency control (VC IN) which is functional in all positions of the MODE switch.

Each MODE corresponds to a specific interconnection between the 1400's main generator circuit and its internal ramp generator and/or gate-trigger circuit to produce the desired function.

The frequency or period of the output waveform is controlled by the FREQUENCY Hz dial and MULTiplier in the CONT, GATE, TRIG, PULSE, TRIG BURST and TONE BURST modes. In all sweep modes, the frequency sweep range is controlled by the sweep START and STOP controls and the MULTiplier.

The waveform rep-rate or frequency duration will depend on the MODE selected. In the TRIG and GATE modes, the waveform rep-rate and frequency duration respectively, are determined by the external signal at the TRIG/GATE IN connector. In the PULSE and TONE BURST modes, rep-rate is determined by the RAMP DURATION control. In the TRIG BURST mode an external TRIG/GATE IN signal controls the burst rep-rate; the RAMP DURATION controls the burst duration. In

the CONT SWP, TRIG SWP and TRIG SWP BURST modes, the sweep duration is controlled by the RAMP DURATION. In the GATED SWP, and GATED SWP BURST modes, the sweep duration is controlled by the RAMP DURATION, while the number of integral sweep cycles is determined by the gate signal at the TRIG/GATE IN connector. In the HOLD SWP HOLD and SWP-HOLD BURST modes, the single sweep duration is controlled by the RAMP DURATION: the gate signal at the external TRIG/GATE IN connector determines the duration of the STOP frequency hold.

All parameters of the main generator (AMPLITUDE, WAVEFORM and DC OFFSET) are adjustable in all modes of operation. Figure 4 shows the MAIN OUT waveform for each mode of operation.

2.3.2.1 Continuous and/or External VC Mode

Operates as conventional generator. Ramp generator is entirely independent and may be used simultaneously.

a) Depress CONT.
b) Select frequency with FREQUENCY Hz dial and MULTiplier.
c) Frequency may also be controlled within the dial range by an external voltage of zero to ±3 volts.

2.3.2.2 Gate Mode

Continuous output for duration of external or manual gate.

a) Depress GATE.
b) Select frequency with dial and MULTiplier.
c) Adjust TRIG/GATE LEVEL control if required.
d) Adjust START PHASE for desired position.
e) Apply external gate or depress manual TRIG/GATE.

NOTE: If the TRIG/GATE LEVEL is rotated clockwise, the generator may be gated on with no signal at the TRIG/GATE in. This is normal and can be corrected by momentarily depressing the MANUAL TRIG/GATE button before applying the external gate signal.

2.3.2.3 Triggered Mode

Single cycle output when externally or manually triggered.

a) Depress TRIG.
b) Select single cycle period with dial and MULTiplier.
c) Adjust TRIG/GATE LEVEL control.
d) Adjust START PHASE for desired position.
e) Initiate with external or manual trigger.

2.3.2.4 Pulse Mode

Repetitive pulse or single cycle output, with adjustable rep-rate and width.

a) Depress PULSE.
b) Adjust rep-rate with RAMP DURATION control (0.001 Hz-1 kHz).
c) Adjust pulse width with dial and MULTiplier (160 ns-2.5 s).
d) Set baseline with START PHASE control.

2.3.2.5 Continuous Sweep Mode

Continuous frequency sweep, up or down.

a) Depress CONT SWP.
b) Set sweep frequency limits with sweep START and STOP controls and frequency MULTiplier.
c) Set sweep duration with RAMP DURATION control.

2.3.2.6 Triggered Sweep Mode

Output holds at start frequency, then single sweeps when externally or manually triggered, then returns to start frequency.

a) Depress TRIG SWP.
b) Set sweep frequency limits with sweep START and STOP controls and frequency MULTiplier.
c) Set sweep duration with RAMP DURATION control.
d) Adjust TRIG/GATE LEVEL control.
e) Initiate with external or manual trigger.

2.3.2.7 Triggered Burst Mode

Provides single tone burst when externally or manually triggered.

a) Depress TRIG BURST.
b) Select burst frequency with dial and MULTiplier.
c) Select burst duration with RAMP DURATION control.
d) Adjust TRIG/GATE LEVEL control.
e) Initiate with external or manual trigger.

2.3.2.8 Tone Burst Mode

Repetitive tone burst with variable rep-rate.

a) Depress GATE and PULSE.
b) Set burst frequency with dial and MULTiplier.
c) Select burst rep-rate with RAMP DURATION control.
d) Set on/off ratio of burst with TRIG/GATE LEVEL control.
e) Set base line with START PHASE control.

2.3.2.9 Gated Sweep Mode

Output holds at start frequency, continuously sweeps when gated, finishes last sweep duration after gate removed, and then returns to start frequency.

a) Depress CONT, GATE and CONT SWP.
b) Set sweep frequency limits with sweep START and STOP controls and frequency MULTiplier.
c) Set sweep duration with RAMP DURATION control.
d) Initiate with external or manual gate.

2.3.2.10 Gated Sweep Burst Mode

No output until gate signal is applied. Then output continously sweeps for period of gate signal and completes last sweep duration.

a) Depress GATE and CONT SWP.
b) Set sweep frequency limits with sweep START and STOP controls.
c) Set sweep duration with RAMP DURATION control.
d) Adjust TRIG/GATE LEVEL for desired control.
e) Set baseline with START PHASE control.
f) Initiate with external or manual gate.

2.3.2.11 Triggered Sweep Burst Mode

Single swept burst when triggered.

a) Depress TRIG SWP and TRIG BURST.
b) Set sweep frequency limits with sweep START and STOP controls and frequency MULTiplier.
c) Set sweep duration with RAMP DURATION control.
d) Adjust TRIG/GATE LEVEL control.
e) Set baseline with START PHASE control.
f) Initiate with external or manual trigger.

2.3.2.12 Hold Sweep Hold Mode

Generator free runs at START frequency until gated, then sweeps to STOP frequency and holds until gate signal ends.

a) Depress GATE and TRIG SWP.
b) Set sweep frequency limits with sweep START and STOP controls and frequency MULTiplier.
c) Set sweep duration with RAMP DURATION control.
d) Adjust TRIG/GATE LEVEL control.
e) Initiate with external or manual gate.

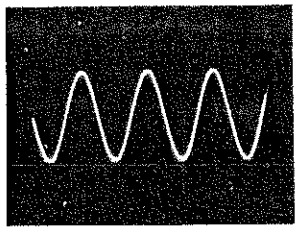
2.3.2.13 Sweep Hold Burst Mode

Single sweep and hold at upper frequency for duration of gate signal.

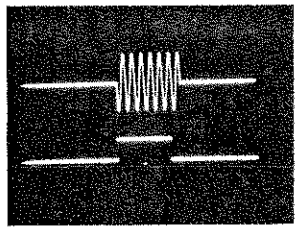
a) Depress GATE, TRIG SWP and TRIG BURST.
b) Set upper and lower limits with sweep START and STOP controls and frequency MULTiplier.
c) Set sweep duration with RAMP DURATION control.
d) Adjust TRIG/GATE LEVEL control.
e) Initiate with external or manual gate.

2.3.3 Ramp Generator Output

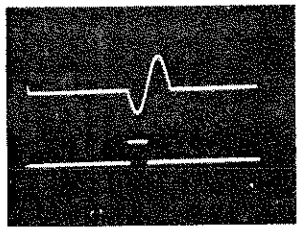
The internal Ramp Generator may be used independent of the Main Generator in the CONT, TRIG or GATE modes of operation. A fixed, zero to five volt linear ramp is present at the front panel RAMP OUT connector in the CONT, GATE, TRIG, PULSE, CONT SWP and TONE BURST modes. The linear ramp duration is controlled by the RAMP DURATION control.



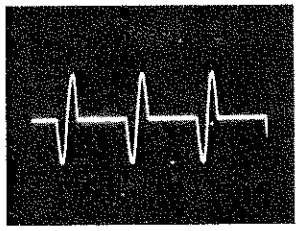
a. Continuous, External VC



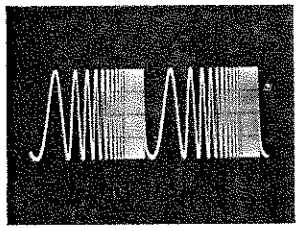
b. Gate



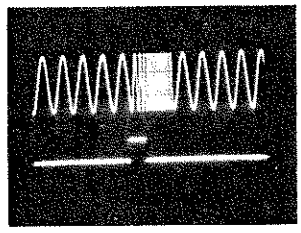
c. Triggered



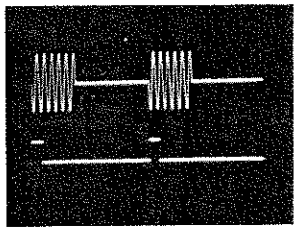
d. Pulse



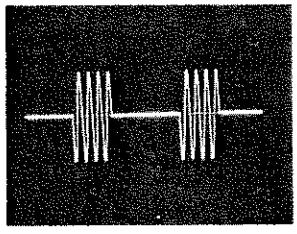
e. Continuous Sweep



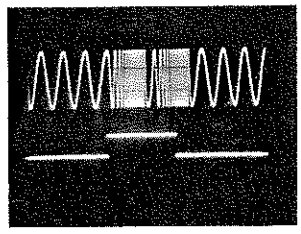
f. Triggered Sweep



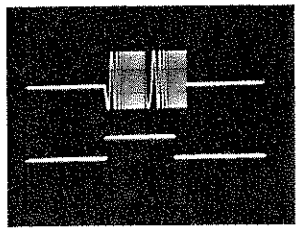
g. Triggered Burst



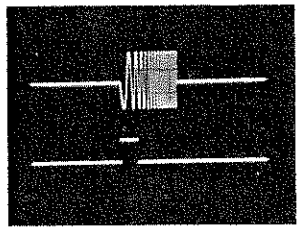
h. Tone burst



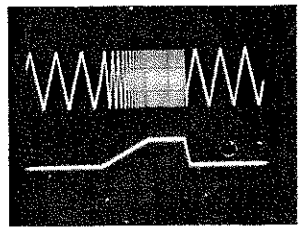
i. Gated Burst



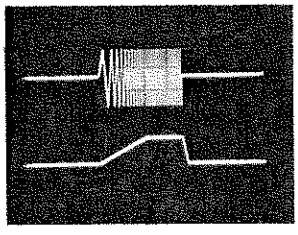
j. Gated Sweep Burst



k. Triggered Sweep Burst



l. Hold Sweep Hold



m. Sweep Hold Burst

Figure 4. Main Output MODE Waveforms

SECTION 3

INCOMING INSPECTION AND CHECKOUT

3.1 INTRODUCTION

The following procedure should be used to verify that the generator is operating within specifications, both for incoming inspection and for routine servicing. Tests should be made with all covers in place, and the procedure given below should be followed in sequence. Familiarize yourself with the initial set-up and operating procedures outlined in Section 2, Operation.

3.2 EQUIPMENT REQUIRED

Refer to the Appendix on page 38.

3.3 PROCEDURE

After allowing the instrument to warm up for at least 30 minutes, set the controls initially to the following positions:

FREQUENCY Hz	100
MULTIPLIER	x100
WAVEFORM	∿
AMPLITUDE	Maximum CW
ATTENUATOR	0 dB
MODE	CONT
DC OFFSET	Off
CHASSIS/FLOATING	Chassis

CAUTION!

The cover of this instrument should not be removed when the instrument is connected to an AC power source, because of the potentially dangerous voltages that exist within the unit.

3.3.1 Waveforms

Connect the oscilloscope to the generator's MAIN OUT and check for a 20V p-p, undistorted sine, triangle or square waveform.

3.3.2 Amplitude Controls

Vary the AMPLITUDE control from maximum to minimum; the waveform amplitude should diminish by more than 60 dB. Return the AMPLITUDE control to its

Maximum CW position. Check the operation of the ATTENUATOR in each of its positions; the waveform amplitude should diminish in 20 dB steps. The ACVM may be used to further verify the accuracy of the ATTENUATOR (±0.2 dB). Return the ATTENUATOR to the 0 dB position.

3.3.3 DC Offset

Turn the AMPLITUDE control to its maximum CCW position. Push the VARIABLE OFFSET control to "ON"; you should be able to vary the main output DC level by ±10 volts. Return the OFFSET control to "OFF".

3.3.4 Frequency Controls and Accuracy

Connect the frequency counter to the MAIN OUT (WAVEFORM switch on ⊓⊔) and check the accuracy of the frequency dial in each position of the MULTiplier. Frequency accuracy is specified as within ±5% at dial settings of 10, 100 and 300, and ±20% maximum at all other settings (vernier in calibrated (0) position).

3.3.5 External Voltage Control (VC)

Set FREQUENCY Hz dial to maximum CW (0.2) end. Connect a zero to +3 volt DC source to the VC input. Vary the DC source and observe the change in the generator's frequency.

3.3.6 CV (Control Voltage) Output

The CV output is a DC voltage proportional to the generator frequency. Connect the DCVM to the CV output and check to see that its value is within 5% of the frequency reading observed on the frequency counter. Disconnect the frequency counter and DCVM.

3.3.7 Frequency Response

The frequency response specifications apply to sinewave, only.

Connect the ACVM to the generator's MAIN OUT, WAVEFORM switch on ∿, and measure the variations in output amplitude, as the generator frequency is tuned from 0.2 Hz to 3 MHz.

The alternative and perhaps more convenient method is to sweep the generator frequency using the CONT SWP mode, and observe the sweep response on the scope. To use this method, set the MODE switch to CONT SWP, and the START and STOP frequency sweep limits to 0.2 and 300, respectively. Adjust the RAMP DURATION to obtain a static display on the scope. The vertical resolution will be determined by the vertical sensitivity of the scope.

For either method, the variations in output amplitude are specified as less than 0.1 dB (approx 1%) up to 300 kHz, and less than 1.0 dB to 3 MHz.

Return the MODE switch to the CONT position.

3.3.8 Sinewave Distortion

Connect the distortion analyzer to the generator's MAIN OUT. Set the Waveform switch to ∿. Check the distortion of the output sinewave at the various frequencies. Distortion should be less than 0.5% from 2 Hz to 300 kHz.

For distortion measurements between 300 kHz-3 MHz, KROHN-HITE uses a specially-designed, "twin-tee" rejection filter. Because of the difficulty in obtaining a sharp null at high frequencies the filter is fixed at discrete frequencies rather than tunable. Distortion is specified as less than 3% to 3 MHz.

3.3.9 TTL Output

Connect the oscilloscope to the TTL output, and set the generator frequency to between 1-10 kHz. Check to see that the peak to peak excursions are between approximately +0.3V and +3.0V.

3.3.10 Ramp Duration and Manual Hold

Connect the oscilloscope to the RAMP OUT connector and check for a zero to five volt linear ramp.

The Ramp duration may be measured by using either the oscilloscope, or a frequency counter set for period operation. Vary the RAMP DURATION control from Max CCW to Max CW; the RAMP DURATION should cover the ranges indicated.

Set the RAMP DURATION to a slow period (approximately 10 s) and observe the RAMP OUT on the oscilloscope. Depress the manual HOLD button; the ramp voltage should hold at a DC level. Release the HOLD button; the ramp will resume its positive excursion.

3.3.11 GATE mode

Set the MODE switch to GATE; the generator should produce a continuous output as long as the MANUAL TRIG/GATE button is depressed.

3.3.12 TRIG mode

Set the MODE switch to TRIG. The generator should produce one cycle of dial frequency or one pulse of one-half the dial period each time the MANUAL TRIG/GATE button is depressed.

3.3.13 PULSE mode

Set the MODE switch to PULSE. You should be able to vary the pulse width and rep-rate with the FREQUENCY Hz dial and RAMP DURATION control.

3.3.14 CONT SWP mode

Set the MODE switch to CONT SWP. The output frequency should sweep between the limits set by the sweep START and STOP controls, at a rate set by RAMP DURATION controls.

3.3.15 TRIG SWP mode

Set the MODE switch to TRIG SWP. The generator should be holding at the START frequency setting. Depress the MANUAL TRIG/GATE button; the generator should produce a single sweep to the STOP frequency setting, at a rate controlled by the RAMP DURATION control, then should reset to the START frequency setting.

3.3.16 TRIG BURST mode

Set the MODE switch to TRIG BURST and depress the MANUAL TRIG/GATE button; the generator should produce a single tone burst of dial frequency, for a period determined by the RAMP DURATION controls.

3.3.17 TONE BURST mode

Simultaneously depress the GATE and PULSE mode buttons. You should be able to vary the burst duration and rep-rate with the TRIG/GATE LEVEL and RAMP DURATION controls, respectively.

3.3.18 GATED SWP mode

Simultaneously depress the CONT, GATE and CONT SWP mode buttons; the frequency of the generator should be holding at the START frequency setting. Depress the MANUAL TRIG/GATE button; the generator should continuously sweep between the START and STOP frequency settings, at a rate determined by the RAMP DURATION control, for as long as the MANUAL TRIG/GATE button is depressed. The generator should complete the last sweep cycle and reset to the START frequency after the MANUAL TRIG/GATE button is released.

3.3.19 GATED SWP BURST mode

Simultaneously depress the GATE and CONT SWP mode buttons. Depress the MANUAL TRIG/GATE button; the generator should produce a burst of continuous sweeps between the START and STOP frequencies, for as long as the MANUAL TRIG/GATE button is depressed. Sweep duration is controlled by the RAMP DURATION. The generator will complete the last sweep cycle after the MANUAL TRIG/GATE button is released.

3.3.20 TRIG SWP BURST mode

Simultaneously depress the TRIG SWP and TRIG BURST mode buttons. Depress the MANUAL TRIG/GATE button; the generator should produce a single swept burst between the START and STOP frequencies. The burst period is determined by the RAMP DURATION control.

3.3.21 HOLD SWP HOLD mode

Simultaneously depress the GATE and TRIG SWP mode buttons. The generator frequency should be holding at the START frequency setting. Depress and hold the MANUAL TRIG/GATE button; the generator will produce a single sweep and hold at the STOP frequency until the MANUAL TRIG/GATE button is released.

3.3.22 SWP-HOLD BURST mode

Simultaneously depress the GATE, TRIG SWP and TRIG BURST mode buttons. Depress the MANUAL TRIG/GATE button; the generator should produce a single sweep between the START and STOP frequencies, then hold at the STOP frequency until the MANUAL TRIG/GATE button is released.

3.3.23 START PHASE control

Set the MODE switch to PULSE and the WAVEFORM switch to ∿ . Adjust the RAMP DURATION control to obtain one or two single cycles on the oscilloscope. Vary the START PHASE control from max CCW to max CW; the start of the sine-wave should vary from approximately -90° to approximately $+90^{\circ}$.

SECTION 4

CIRCUIT DESCRIPTION

4.1 SYSTEM OPERATION

A simplified block diagram of the Model 1400 is shown in Figure 5.

The basic oscillating loop consists of the Integrator and Square Wave Generator. The frequency of oscillation is determined by the output of the + VC and - VC Amplifiers, and the time-constant of the Integrator R and C elements. The frequency is controlled by (1) varying the + VC and - VC voltage levels by means of the FREQUENCY Hz dial, the internal sweep, or the external VC input, or (2) by changing the value of the integrating capacitor, C via the MULTiplier switch.

The FREQUENCY Hz dial potentiometer is tied to the + 13. 5V supply. In the non-sweep modes, the frequency control voltage for the VC Amplifiers is from the center arm of this potentiometer. The external VC input sums its fixed or time-varying voltage with the center arm voltage, at the input to the - VC Amplifier.

The + VC and - VC voltages are alternately connected to the input of the Integrator by the VC switching circuit. To describe one cycle of operation, assume the + VC voltage is connected to the Integrator input through R. A negative-going ramp is produced on the Integrator output, and is fed to the Square Wave Generator. The Square Wave Generator triggers during the negative excursion of the Integrator output and changes state, driving the VC switches, which in turn, connect the - VC voltage to the Integrator input. The negative input to the Integrator forces its output to reverse its direction, and a positive-going ramp is produced. The Square Wave Generator again triggers during the Integrator output' s positive excursion, and returns to its initial state, driving the VC switches, connecting the + VC voltage to the Integrator input and starting a new cycle.

The output of the Integrator is a triangle waveform, and is fed to the input of the Square Wave Generator, the input of the Sine Shaper and to the Output Amplifier. The output from the Square Wave Generator is used to drive the VC switching circuit and also provides the square wave to the Output Amplifier and TTL output. The Sine Shaper converts its triangle input to a sine wave with minimum distortion (typically 0. 25%) and is fed to the Output Amplifier. The three functions are selected by the WAVEFORM switch, which in turn feeds the Output Amplifier through AMPLITUDE potentiometer R604. The Output Amplifier provides a 20 volt p-p output and low impedance drive for the generator's 50 ohm output.

4.2 VC AMPLIFIERS AND VC SWITCHING

The + VC and - VC Amplifiers produce equal, positive and negative DC voltages, respectively. The VC voltage and the integration time-constant of the R-C elements determine the system's frequency of oscillation. The + VC and - VC Amplifiers are operational amplifiers consisting of U200, U201 respectively and emitter followers, Q200, Q201 respectively. The input voltage is from the MARKER/FREQ Hz dial potentiometer center arm and/or the external VC input, and is applied to the

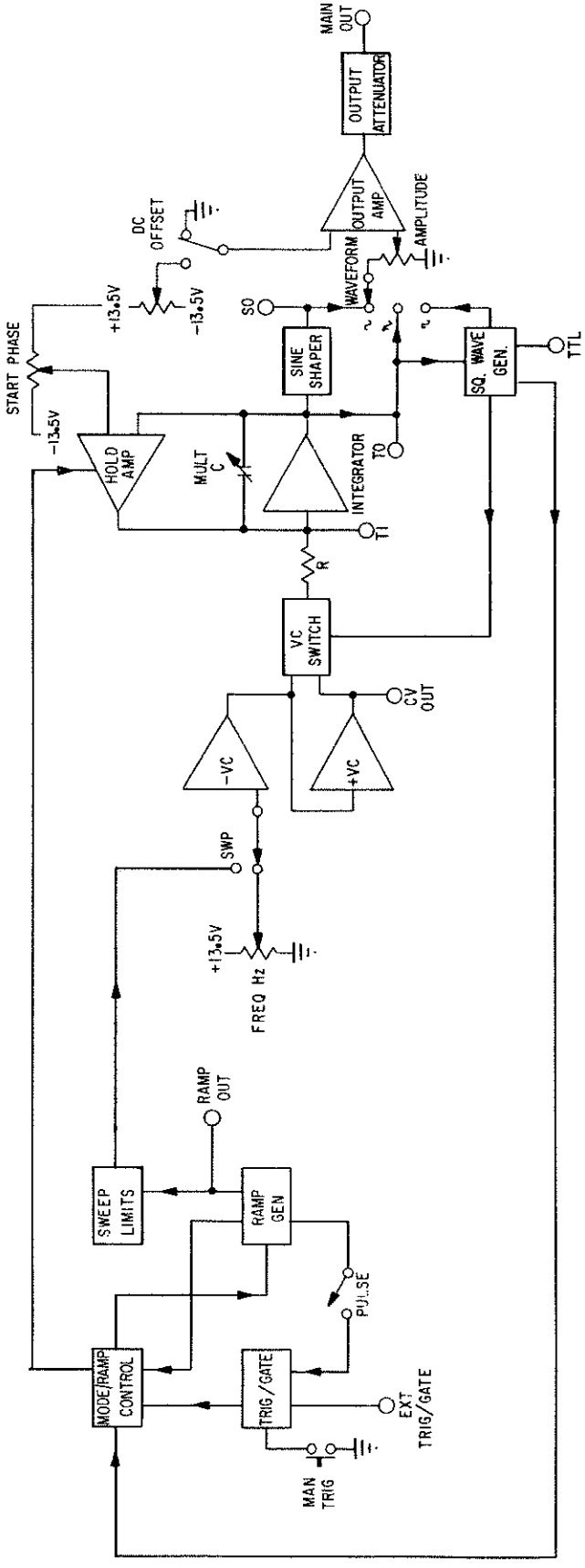


Figure 5. Simplified Block Diagram

inverting input of U200, the -VC Amplifier. The -VC Amplifier exhibits a gain of less than -1. The VERNier control R219 varies the gain of the -VC Amplifier ±2.5%. The -VC voltage at the output of U200 is coupled through an emitter follower stage Q200, to provide the negative current to the Integrator. The -VC voltage is also fed to the input of U201, which functions as a unity gain inverter. The +VC voltage on the output of U201 is fed through emitter follower Q201 and provides the positive current to the Integrator.

The +VC and -VC voltages are alternately switched in every half-cycle by the VC switching circuit and applied to the Integrator input. The switching circuit consists of two pairs of FETS Q202-Q203 and Q204-Q205 driven by a differential signal developed by the Square Wave Generator (Section 4.4). Potentiometer R234 compensates for impedance differences of the FET switches Q203 and Q205.

4.3 INTEGRATOR

The Integrator consists of an inverting amplifier with very high gain, plus a capacitor C in feedback to provide the integrating function. The Integrator is driven from the output of the VC Switch.

The amplifier consists of a differential input stage Q300, a differential second stage Q301-Q302, a driver stage Q303, an output amplification stage Q304-Q306 and an emitter follower stage, Q305-Q307.

The output of the Integrator is a triangle waveform that is fed to the Output Amplifier, to the input to the Sine Shaper and to the input of the Square Wave Generator. Capacitor C is selected by the MULTiplier. Potentiometer R300 provides symmetry adjustment at the low end of the dial, by cancelling offset voltages and bias currents.

4.4 SQUAREWAVE GENERATOR

The Square Wave Generator consists of an IC sense amplifier, U500, a hysteresis switch Q500, a differential buffer stage Q501-Q502, and a TTL output stage Q503-Q504.

The output of the Integrator is fed to the input of the Square Wave Generator. The hysteresis is determined by the current in CR501 and R506 in the positive direction of the Integrator output, and by the current in R508, CR500, CR501, and R506 in the negative direction. The differential output of U500 drives Q206 and Q207 which in turn controls the VC switches and differential switch Q501. The output from Q501 drives the follower-clamp transistors Q503-Q504 providing the TTL output. The output from Q502 is fed to the Output Amplifier through the WAVEFORM switch.

4.5 SINE WAVE SHAPER

The Sine Wave Shaper processes the triangle waveform from the Integrator output and generates a sinewave that exhibits typically 0.25% distortion. The shaping network consists of five pairs of diodes, each pair associated with a voltage divider. Transistors Q400-Q401 set the levels at which the diodes clamp, which in turn vary the slope of the triangle waveform at five (5) discrete points within each 90° or quarter-cycle. A two-stage amplifier further processes the sine wave function for use as the MAIN OUTPUT waveform, and consists of a differential input stage Q402-Q403 and a driver stage Q404-Q407. An emitter follower output stage Q405-Q406 provides a low impedance drive to the output amplifier. Potentiometers R411 and R416 minimize the distortion level by optimizing the clamping level.

4.6 OUTPUT AMPLIFIER

The Output Amplifier amplifies the incoming signal selected by the WAVEFORM switch, and provides a low impedance, 20 volt peak to peak source for the generator's 50 ohm output. The Amplifier consists of a balanced input stage Q600-Q601, a driver and output amplification stage Q604, constant current source Q606, and a push-pull emitter follower output stage Q605-Q607. At higher frequencies, transistors Q602-Q603 provide an additional balanced drive for Q604-Q606 via capacitors C612 and C615. The Amplifier has an overall gain of approximately 5, set by resistors R606, R607. AMPLITUDE potentiometer R604 varies the input to the Amplifier resulting in a control of the output voltage swing. DC level potentiometer R600 is provided to zero any output offset voltage. Potentiometer R602 provides a DC offset adjustment on the amplifier's output via R603; its operation is not affected by the position of the AMPLITUDE potentiometer, R604.

4.7 RAMP GENERATOR

The ramp generator consists of a current source, U1717, Q1712, Q1715 and RAMP DURATION control R1718; an integrator capacitor C1711; a buffer amplifier Q1719 and Q1720; a limit detector U1703 and control circuitry.

During a ramp cycle the retrace transistor Q1708 is held off by the limit detector U1703. This allows the current source to charge C1711 at a rate set by R1718. When the output of the buffer amplifier reaches +5V, U1703's output goes negative, thereby turning on Q1708. This causes C1711 to discharge, the rate of discharge controlled by C1702, R1702 and Q1702. When the buffer's output reaches zero volts, the limit detector's output goes high, turning off Q1708 and starting a new cycle.

It is possible to use a single detector by setting its threshold to two different levels, one for ramping and one for retracing. The retrace level is automatically set to zero volts by the circuit configuration; the second level is set by adding current to the level detector's summing node, Pin #2. This current is set by R1700 and R1701 and is controlled by Q1733.

The normal source of control for Q1733 is from the level detector itself, through Q1721, Q1722, Q1727 and Q1728. However, whenever a sweeping mode is selected this path is blocked by CR1930 which is pulled to +5V. This path is replaced by U1929-A which is a D Type flip-flop that is clocked by the main generator. This arrangement causes the ramp generator to be synchronized to the main generator.

4.8 SWEEP LIMIT CIRCUIT

The sweep limit circuit consists of a shift and invert amplifier, U1210 and start and stop limit potentiometers.

The 0V to +5V ramp output is fed directly to STOP FREQUENCY potentiometer, R1802, through an attenuator R1230, R1222 which reduces the ramp peak voltage to +4V. The 0V to +5V ramp is simultaneously fed to amplifier, which shifts and inverts the ramp output from 0V to +5V, to +4V to 0V. The output of U1210 is fed to the START FREQUENCY potentiometer, R1801.

The center arm ramp voltages of R1801 and R1802 are summed through R1244, R1245, respectively, and fed to the -VC Amplifier.

4.9 HOLD AMPLIFIER

The hold amplifier is used to stop and hold the Main Generator's integrator output (TO) at a DC level determined by the setting of the START LEVEL control. The circuit accomplishes this by nulling the current at the integrator's input (TI).

The hold amplifier is deactivated by pulling the anode of CR1931 high. This forward biases CR1934 clamping the amplifier's positive input, Q1934's base, at 0.6V. Q1934 will turn off which turns off Q1940, causing its collector voltage to increase. CR1938 will forward bias and pull the negative input, Q1935's base up. When the two bases are equal the currents in Q1934 and Q1935 will be balanced and the circuit will be stable.

When the hold amplifier is activated, Q1940 turns on, forward biasing the base-collector junction of Q1941. This action cancels the integrator input current at TI. The system will become stable when the current through R1939 exactly cancels the current through R1934 thereby setting the "start" level of TO.

The hold amplifier is normally controlled by the hold flip-flop U1929-B. However, whenever the TRIG BURST mode button is depressed, control is transferred to the ramp flip-flop U1929-A.

4.10 TRIG/GATE CIRCUIT

There are two possible sources for trigger and gate signals, manual (S1801A) and external signals applied to J1802.

Manual signals are generated by Q1911 and Q1913. Q1913 is forced off by S1801A which causes the collector of Q1913 to be at +4.7V. When S1801A is depressed the base of Q1911 is grounded, which turns Q1911 off and Q1913 on causing Q1913's collector voltage to fall to +0.2V. The regeneration supplied by R1912 prevents any contact bounce by S1801A from appearing at the collector of Q1913. The voltage transition on the collector of Q1913 produces a current pulse in C1913.

External signals are compared to the TRIG/GATE LEVEL setting by U1908. When the external level exceeds the setting of the TRIG/GATE LEVEL control, U1908's output will a -0.6V, otherwise it will be +3.5V. The transition between these levels produces a current pulse in C1916.

The current pulse in C1913 and C1916 are used by the MODE circuits to perform the various trigger and gate functions.

4.11 MODE SELECTION

A desired mode of operation is determined by the specific interconnection between the 1400's Main Generator circuit, and one or more of the functional circuits, such as the TRIG/GATE circuit or Ramp Generator. A 7 station, pushbutton control (S1000B-S1000H) performs the necessary interconnections.

The following is a brief description of how each circuit or circuits are interconnected in each mode of operation.

Note: In all SWEEP modes, the FREQUENCY Hz dial is disconnected from the Main Generator VC circuits, and is replaced by the SWEEP START and STOP limit controls.

1) Continuous Mode

   In the CONT mode, pin 10 of U1929 is held low, forcing pin 9 high which turns off the Hold Amplifier, allowing the Main Generator to free run.

2) Gate Mode

   When an external or manual gate signal is applied, a current pulse through C1913 or C1916 turns off Q1916, which turns on Q1918. Q1918 pulls the

junction of R1914 and R1915 to ground via S1000C2 which holds Q1916 off. Q1930 will be turned on pulling pin 10 of U1929 low, forcing pin 9 of U1929 high, which turns off the Hold Amplifier.

When the gate signal is removed, a reverse current pulse through C1913 or C1916 turns Q1916 on, turning off Q1918 and Q1930. This pulls pin 10 of U1969 high forcing pin 9 of U1929 to go low after being clocked by the Main Generator at pin 11. This turns on the Hold Amplifier, which inhibits the Main Generator.

3) Triggered Mode

The TRIG mode is basically the same as the GATE mode, except that the collector of Q1918 is disconnected from the junction of R1914 and R1915. Because of this, when a current pulse flows through C1913 or C1916, Q1916 will be turned off only for the duration of the pulse (approximately 100 ns), which will always be less than the Main Generator period. With Q1916 off, Q1930 will be pulsed in pulling pin 10 of U1929 low, forcing pin 9 of U1929 high, turning off the Hold Amplifier.

When the Main Generator completes the first half of its cycle, pin 11 of U1929 is pulled high which clocks pin 9 of U1929 low, turning on the Hold Amplifier.

4) Pulse Mode

The PULSE mode is the same as the TRIG mode except that the output of the Ramp Generator (emitter of Q1720) provides a repetitive trigger to the TRIG/GATE circuit via S1000E2.

5) Continuous Sweep Mode

In the CONT SWP mode, Q1923 is held on by S1000F4 and S1000G4, S1000H1. This, via S1000C2, turns Q1916 off and Q1918 on. Q1922 is turned on, which turns on Q1927, pulling pin 4 of U1929 low. This forces pin 5 high, turning off Q1733, which allows the Ramp Generator to begin a cycle. When the Ramp voltage reaches +5V, Q1728 turns on, forward biasing CR1929, which pulls pin 2 of U1929 low, turning off Q1922. This will turn off Q1927, forcing pin 4 of U1929 high; at the next clock pulse at pin 3 of U1929, pin 5 will go low, turning on Q1733, thereby initiating a ramp retrace. When the output of the Ramp Generator reaches zero volts, Q1733 will turn off, and the sweep cycle will repeat.

6) Triggered Sweep Mode

In the TRIG SWP mode, pin 2 of U1929 is held low by Q1921; the Main Generator free runs, but the Ramp Generator is inhibited. When a trigger occurs, Q1918 turns on, which turns Q1921 off and Q1927 on, pulling pin 4 of U1929 low, thereby forcing pin 5 to go high, shutting off Q1733, and allowing the ramp to cycle. When +5V is reached Q1728 turns on, pulling pin 2 of U1929 low. At the next clock pulse on pin 3 of U1929, pin 5 of U1929 will go low, which turns on Q1733, holding the ramp in a retrace (0V) state, until the next input trigger.

7) Triggered Burst Mode

The TRIG BURST mode is similar to the GATE mode with two exceptions: (1) both the Main and Ramp Generator are inhibited, and (2) the duration of the ramp, when triggered, determines the on-time of the BURST. Before an external or manual trigger is applied, pin 5 of U1929 is low; following the trigger, pin 5 of U1929 goes high turning off the Hold Amplifier and at the same time turning on the Ramp. When the ramp reaches +5V, Q1728 will be turned on, which pulls pin 2 of U1929 low; at the next clock pulse at pin 3 of U1929 pin 5 will go low, which simultaneously turns on the Hold Amplifier and turns on Q1733 which inhibits the Ramp.

8) Tone Burst Mode

The TONE BURST mode is the same as the GATE mode, except that a repetitive gate signal is provided by the Ramp Generator via S1000E2.

9) Gated Sweep Mode

In the GATED SWP mode, the Main Generator free runs at the START frequency setting. When an external or manual gate is applied, Q1918 will be turned on, which turns on Q1927, pulling pin 4 of U1929 low, forcing pin 5 of Q1929 high, which turns off Q1733 and allows the Ramp to free run. When the gate signal is removed, Q1733 will be turned off, inhibiting the Ramp.

10) Gated Sweep Burst Mode

The GATED SWP BURST mode is the same as the GATED SWP mode, except that the Hold Amplifier is turned on, inhibiting the Main Generator until a gate signal is applied.

11) Triggered Sweep Burst Mode

The TRIG SWP BURST mode is the same as the TRIG SWP mode, except that the Hold Amplifier is turned on, inhibiting the Main Generator until a trigger signal is applied.

12) Hold, Sweep and Hold Mode

The HOLD SWP HOLD mode is the same as the TRIG SWP mode, except that the collector of Q1916 is connected to the junction of R1914 and R1915. This holds Q1916 off when a gate signal is applied, which in turn pulls pin 4 of U1929 low and forces pin 5 of U1929 high.

When the gate signal is removed a current pulse through C1913 or C1916 turns Q1916 on which turns Q1918 and Q1927 off, allowing pin 4 of U1929 to go high. If and when the ramp cycle is completed, Q1728 will be turned on, pulling pin 2 of U1929 low. On the next cycle of the Main Generator, pin 5 of U1929 will go low and the ramp generator will retrace.

13) Sweep Hold Burst Mode

The SWP HOLD BURST mode is the same as the HOLD SWP HOLD mode except that when the gate signal is removed, the Hold Amplifier is turned on, which inhibits the Main Generator.

4.12 POWER SUPPLIES

The Main power supply provides ±13.5 volts regulated power to all circuits. The supply consists of two (2) series pass regulator circuits, with the +13.5 volt as the slave to the -13.5 volt supply. Zener reference VR100 sets a reference voltage on the input of sense amplifier U110, which detects any variations in the -13.5 volt supply. The output of U110 drives the base of transistor Q111. The collector of Q111 in turn drives the base of series pass regulator Q110, to compensate for the supply variation.

The +13.5 volt supply is the slave to the -13.5 volt supply. Variations in the +13.5 supply will be sensed by amplifier U100 through resistor divider R106-R108. The output of U100 drives the base of Q101 which in turn controls regulator Q100.

The +5V supply is developed from the +13.5 volt supply, and is produced by zener diode VR1943 and transistor Q1943.

SECTION 5

MAINTENANCE

5.1 INTRODUCTION

If the generator is not functioning properly and requires service, the following procedure may facilitate locating the source of trouble. Access to the interior of the generator is accomplished by removing the two screws on both sides of the cover.

> **WARNING!**
>
> This maintenance procedure should be performed by qualified personnel, only. If the covers must be removed during the troubleshooting procedure, it is strongly recommended that extra precautions be taken in working with exposed circuitry, and that insulated probes and/or tools be used.
>
> SHUT THE POWER SWITCH OFF AND DISCONNECT THE LINE CORD FROM THE POWER SOURCE BEFORE REPAIRING OR REPLACING COMPONENTS.

When a malfunction is detected, first check the line voltage and fuses, and then make an inspection for broken wires, burnt or loose components, poor solder joints, or similar conditions which could cause trouble. Before troubleshooting, it should be determined if the normal adjustments mentioned in Section 6, Calibration, will correct the trouble. The troubleshooting of the generator will be greatly simplified if there is an understanding of the operation of the circuit. Reference should be made to Section 4, Circuit Description.

5.2 EQUIPMENT REQUIRED

Refer to the Appendix on page 38.

5.3 PRELIMINARY SET-UP

Before troubleshooting, set the controls to the following initial positions:

SWEEP START	20
SWEEP STOP	300
RAMP DURATION	Centered
RAMP HOLD	Off
MODE	CONT
TRIG/GATE LEVEL	Centered

START PHASE	Centered
FREQUENCY Hz	100
MULT	100
WAVEFORM	∿
DC OFFSET	Off
ATTENUATOR	0 dB
AMPLITUDE	Max CW

The simplest way to locate a fault in the system is to first localize the fault to one of the generator's major sections, and then to trace the signal through the particular section until the defective component or components are found. Table 5. 1 lists several symptoms that may occur due to a fault; reference is then made to a specific paragraph. Once the fault is isolated the signal may be traced through the section, using the AC and DC reference voltages provided on the circuit schematics at the rear of this manual. Any great deviation from the normal voltages listed will help locate the fault.

A review of Section 4, Circuit Description will help simplify the understanding of the generator's major circuit sections, and the interfacing between sections, in each mode of operation.

Table 5. 1. Troubleshooting Chart

SYMPTOM	PROCEDURE	REFER TO SECTION #
1. No signal at MAIN OUT, in any MODE	1a. Is POWER switch on?	-
	YES ↓ NO →	
	1b. Check for zero to ~ 3. 5V signal at TTL OUT	
	NO ↓ YES →	go to step 1p
	1c. Check for ~ 5V signal at RAMP OUT	
	NO ↓ YES →	go to step 1h
	1d. Check for proper AC line voltage and correct setting of 120V/240V LINE switches	
	YES ↓ NO →	2. 1

Table 5. 1. Troubleshooting Chart (Cont.)

SYMPTOM	PROCEDURE	REFER TO SECTION #
	1e. With POWER switch off and line cord removed from AC source, check fuse receptacle. If fuse OK, go to step 1f. If blown or missing, replace with properly rated fuse. If fuse blows again, go directly to paragraph 5. 4	
	Replacing fuse corrects fault	
	NO ↓ YES →	-
	1f. Check for correct regulated supply voltages of + 13. 5V and - 13. 5V	
	YES ↓ NO →	5. 4
	1g. Check for + 5V on emitter of Q1943	
	YES ↓ NO →	5. 4
	1h. Check for ~ + 1. 2V on base of Q1941	
	NO ↓ YES →	Check Q1941; if OK, go to step 1k
	1i. Check for ~ 4V on pin 9 of U1929.	
	NO ↓ YES →	go to step 1k
	1j. Pin 10 of U1929 should be tied to ground via S1000B1, S1000B2. If it is, U1929 is probably defective.	
	1k. Center arm of FREQUENCY Hz dial (pin CA) should be ~ + 3. 8V.	
	YES ↓ NO →	Check tuning pot R1800

Table 5. 1. Troubleshooting Chart (Cont.)

SYMPTOM	PROCEDURE	REFER TO SECTION #
	1l. Output of -VC Amplifier (emitter of Q200) should be ~-1V.	
	YES ↓ NO →	5. 5. 1
	1m. Output of +VC Amplifier (emitter of Q201) should be ~+1V.	
	YES ↓ NO →	5. 5. 1
	1n. Check for 15. 5V p-p ⋀⋁ signal on Integrator output (TP TO).	
	NO ↓ YES →	go to step 1p
	1o. Polarity of Integrator output (TP TO) should be of opposite polarity as Integrator input (TP TI).	
	YES ↓ NO →	5. 5. 2
	Go to Section 5. 5. 3	
	1p. Center arm of AMPLITUDE pot R604 should have a 4. 5V p-p ⋀⋁ signal.	
	YES ↓ NO →	Check WAVEFORM switch and R604.
	1q. Check for 20V p-p signal at Output of Output Amplifier (junction of R623, R624).	
	YES ↓ NO →	5. 5. 5
	1r. Check for defective ATTENUATOR switch, or open or shorted cable to MAIN OUT BNC connector.	
2. No sinewave at MAIN OUT.	2a. Check for 6V p-p ∿ signal at TP SO.	
	YES ↓ NO →	5. 5. 4
	2b. Check WAVEFORM switch.	

Table 5. 1. Troubleshooting Chart (Cont.)

SYMPTOM	PROCEDURE	REFER TO SECTION #
3. No TTL out.	3a. Check collector of Q501 for 6V p-p ⊓⊔ signal. If correct, Q503 or Q504 may be bad. If incorrect, Q501 or Q502 may be bad.	
4. Generator only works in CONT and CONT SWP modes	4a. Go to Section 5. 9.	
5. No PULSE or CONT SWP and TRIG SWP output.	5a. Set MODE switch to CONT and check for zero to +5V Ramp signal at RAMP OUT connector.	
	NO ↓ YES →	go to Section 5. 7
	5b. In CONT mode, pin 4 of U1929 should be +0. 6V and pin 5 of U1929 should be ~+4. 5V.	
	YES ↓ NO →	U1929 defective
	Go to Section 5. 6	
6. Generator does not sweep in CONT SWP or TRIG SWP mode; RAMP OUTPUT OK.	6a. Go to Section 5. 8.	

5.4 POWER SUPPLIES

The Main power supply for the generator provides a plus and minus 13. 5 volts. If either supply voltage is low it may be due to excessive load current. The supplies are designed to shut down if shorted, with current being supplied only through series shunt resistors R101 and R110.

If the -13. 5 volt supply is operating normally, but the +13. 5 volt supply is not, the variation of the plus supply voltage will produce a minus supply voltage of about double the magnitude of the voltage across zener reference VR100.

The following procedure will localize the trouble to the area where the expected measurement does not occur.

If the -13.5 volt supply is incorrect, check the zener reference voltage across VR100. If the zener voltage is correct but the -13.5 volts is more negative than normal, pin 2 of U110 should read negative, making its output pin 6, more positive than normal. Q111 should be driven off, turning off series pass transistor Q110 which will force the -13.5 volts to be more positive.

If the -13.5 volts is less negative than normal, check the minus unregulated voltage and ripple frequency to determine if the rectifiers, CR101 and CR103, and the filter capacitor, C110, are defective. If these measurements are correct, trace the error correcting voltage as above using opposite polarities.

If the +13.5 volt supply is in error, first check the -13.5 volts, used for its reference. A normally operating plus supply should develop a voltage equal in magnitude to the minus supply. If not operating properly, trace the error correcting voltage as in the minus supply to localize the trouble area.

If the +5V supply is not working, check Q1943 and zener VR1943.

5.5 MAIN GENERATOR

5.5.1 VC Amplifiers

If the voltage at the center arm of the FREQUENCY Hz dial R1800, is correct, (dial set to 100) pin 3 of U1953 should be approximately +1.3V.

In the following procedure, the measurement that deviates from the expected result will localize the trouble. For opposite polarity errors, the same error correcting voltage may be traced with opposite polarities expected.

In the -VC Amplifier, if the emitter of Q200 is more negative than normal, pin 2 of U200 should be negative making pin 6 of U200 more positive, correcting the voltage at the emitter of Q201.

FET switches Q202, Q203, Q204 and Q205 are driven from the Square Wave Generator through Q206 and Q207. If the generator is not oscillating, either Q202 and Q203 or Q204 and Q205 will be switched on connecting the corresponding VC voltage to the Integrator input, TI. When Q206 is not conducting and Q207 is, Q204 and Q205 will be switched on and Q202 and Q203 will be switched off.

5.5.2 Integrator

If the generator is not oscillating, the trouble is in either the Integrator, the Square Wave Generator, or the VC circuit.

If the Output of the Integrator, TO has a DC offset greater than ±8 volts and is of opposite polarity as its input, TI, the Integrator is probably functioning properly, and the trouble is probably in the square wave generator (Section 5.5.3) or VC switching circuits, Q202-Q205.

If the Polarity of TP TO is the same polarity as TP TI the following signal tracing procedure should aide in localizing the trouble.

If TI is positive, the collectors of Q300 should be unbalanced with the input collector R302 being less positive than R303 collector. This should turn on Q302 making its collector more positive than normal, making the emitter of Q303 more positive, turning on Q306 and Q307, making the output, TO, more negative. In the same manner, if the input and output are negative, the error correcting voltage levels may be traced from input to output.

5.5.3 Square Wave Generator

If the triangle output, TO, has a DC level greater than ±8 volts and it has been determined that the Integrator is functioning properly, the most likely source of trouble is either the Square Wave Generator or the VC switching circuit.

With the triangle output greater than +8 volts, pin 2 of U500 should be more positive than pin 3. This should make pin 6 more positive than pin 7. If pin 6 is more positive than pin 7, the base of VC switch driver Q206 should be more positive than the base of Q207, turning on Q206 and turning off Q207. This will turn off VC FET switches Q204 and Q205 and turn on switches Q202 and Q203, connecting a positive voltage source to the input of the Integrator, TI, through R236 and R239.

The trouble will be localized to the area at which these correct measurements do not occur. In like manner if the output of the Integrator is negative, the same procedure may be used with opposite polarity readings.

As pin 6 of U500 alternately switches from a high state to a low state it drives Q500 off and on, which alternately changes the current to the input of U500, in turn reversing the polarity required from the output of the Integrator to flip U500. When pin 6 of U500 is high (~4 volts), Q500 is off. The current supplied to the input of U500 through R508 and CR500 requires the output of the Integrator to reach approximately -8 volts to flip U500.

A summary of the logic sequence is as follows:

TP TO	pin 6 U500	pin 7 U500	collector Q206	collector Q207	Q202, Q203	Q204, Q205
≥+8V	+4.5V	+0.2V	-10V	-1V	ON	OFF
≤-8V	+0.2V	+4.5V	-1V	-10V	OFF	ON

The output of U500 is also used to drive Q501 and Q502 and provide the square drive signal to the Output Amplifier and the TTL transistors Q503 and Q504.

5.5.4 Sine Shaper

If the triangle is present at the Integrator output, TO, with minimum DC offset, and a distorted output or no output appears at the Sine Wave Shaper output, TP SO the trouble may be localized as follows:

A defective diode, CR400 thru CR409 or resistance divider, R400 thru R409, will usually produce a distorted signal at TP SO.

A faulty amplifier component will generally result in a DC offset at TP SO. If SO has a DC offset greater than plus 1 volt, the error correcting voltage may be traced by measuring the collector of Q402. Q402 collector should be more positive than normal. This should turn off Q404 making the base of emitter follower Q405 more negative, restoring the output to zero. The error correcting measurement that does not occur will localize the problem.

5.5.5 Output Amplifier

A defective Output Amplifier will usually result in a DC level at the output when the AMPLITUDE control is max CCW (assuming the DC OFFSET control is turned off).

The error correcting levels may be traced through the Output Amplifier in the following manner. If the DC level at the output is positive, feedback through R607 should turn on Q600 and turn off Q601. The collector of Q601 will be more positive than normal making the base of Q604 more positive than normal, turning off Q604. Q604 collector will be more negative, in turn making the output more negative through emitter followers Q605 and Q606.

A defect in Q602 and Q603 may only show up at high frequencies.

5.6 RAMP GENERATOR

If a zero to +5V Ramp signal is not present at the RAMP OUT in any mode, then a defect within the Ramp Generator circuit is the most probable cause.

If a +5V Ramp signal is present at the RAMP OUT only in a non-sweep mode (i. e., CONT, GATE, TRIG or PULSE) then the most likely cause of trouble is the Mode Logic circuits consisting of Q1921-Q1923, Q1927 or Flip-Flop U1929. (See Section 5. 7.)

If the +5V Ramp is present at the RAMP OUT in all non-sweep and CONT SWP modes, but the generator frequency does not sweep, or sweeps incorrectly, check the Sweep Limit circuit (Section 5. 8).

If it has been determined the Ramp Generator is at fault set the MODE switch to CONT and proceed as follows:

1) If the RAMP OUT is $\geq$+5V Q1722 should be turned off; its collector should be more negative, shutting off Q1727 allowing the base of Q1728 to go more positive. Q1728 will turn on and pull the base of Q1733 more negative which should turn on Q1733. The positive current through Q1733 should pull pin 2 of U1703 positive, forcing the output, pin 6 negative, turning on Q1708 to discharge C1711, and reduce the Ramp voltage to zero.

2) If the RAMP OUT is between zero and +5V, check the current source Q1711, Q1712 and Q1715, U1717.

3) If the RAMP OUT is zero or negative, Q1722 will be turned on, pulling the base of Q1727 more positive which should turn on Q1727. Q1727 collector will pull the base of Q1728 more negative, shutting off Q1728 allowing the base of Q1733 to be pulled positive by pin 5 of U1929. Q1733 should turn off, allowing pin 2 of U1703 to be pulled negative, which will force its output, pin 6 positive, shutting off Q1708 and allowing C1711 to charge up.

5.7 MODE CONTROL LOGIC

If the Ramp voltage is present at the RAMP OUT only in a non-sweep mode, the Mode Control Logic consisting of Q1921-Q1923, Q1927 or U1929A may be at fault. To localize the problem, set the MODE switch to CONT SWP and proceed as follows:

1) If the RAMP OUT is +5V, Q1728 should be on. This should forward bias CR1929 which then pulls pin 2 of U1929 low, and at the same time shuts off Q1922 and Q1927. Pin 4 of U1929 should be high, which should force pin 5 low. When pin 5 is low, Q1733 should be turned on which allows the Ramp to retrace.

2) If the RAMP OUT is zero volts, the same approach may be taken in localizing the defective part. For this case, Q1728 should be off and Q1922 and Q1927 should be on. Pin 4 of U1929 should be low and pin 5 should be high, which would shut off Q1733, allowing the Ramp voltage to cycle.

5.8 SWEEP LIMIT CIRCUIT

If the Ramp Generator appears to be working normally, but the Main Generator frequency does not sweep, or sweeps incorrectly, the problem may be in the Sweep Limit circuit.

With a +5V Ramp at the RAMP OUT connector, measure the AC and DC voltages as shown on the schematic, PC-102 until the defective circuit is localized.

5.9 TRIG/GATE CIRCUIT

If the Trig/Gate Circuit is inoperative, the Main Generator will not function in any of the trigger or gate modes (including PULSE and BURST). To localize the problem, proceed as follows (set MODE switch to GATE):

1) If the Main Generator gates on when the MAN TRIG button is depressed, but does not gate on for an external gate signal (including PULSE mode) U1908 may be defective. To check U1908, set the MODE switch to CONT and feed the MAIN OUT squarewave into the TRIG/GATE IN. Connect the oscilloscope to pin 9 of U1908; it should switch between ~+3.5V and ~-0.6V.

2) If the Main Generator does not manually gate or trigger, only, check Q1911 and Q1913. With the MAN TRIG button depressed, the collector of Q1913 should be ~+0.2V; when the MAN TRIG button is released, the collector of Q1913 should be ~+4.7V.

3) If neither the external or manual trigger and gate is working, check Q1916, Q1918 and Q1930. With the MAN TRIG button depressed, and the MODE switch set for GATE, the collector of Q1916 should be ~+3.5V and the collector of Q1918 ~+0.2V which should turn on Q1930, pulling pin 10 of U1929 low, forcing pin 9 high.

When the MAN TRIG button is released, collector of Q1916 should be ~+0.2V and the collector of Q1918 +5V, which should turn off Q1930, forcing pin 10 of U1929 high, forcing pin 9 low.

SECTION 6

CALIBRATION

6.1 INTRODUCTION

The following procedure is provided for the calibration and adjustment of the generator in the field, and adherence to this procedure should restore the generator to its original performance specifications. If the generator cannot be calibrated by the procedure given, refer to Maintenance, Section 5, or consult our Factory Service Department. The location of all test points and adjustable components may be found in the circuit layout drawing at the rear of this manual.

6.2 EQUIPMENT REQUIRED

Refer to the Appendix on page 38.

6.3 TEST PROCEDURE

After turning the generator on, allow it to warm up for at least 30 minutes, then set the controls to the following positions:

FREQUENCY Hz	300
VERNier	(0)
MULTiplier	x1
MODE	CONT
ATTENUATOR (dB)	0
AMPLITUDE	Maximum CCW
WAVEFORM	∿
DC OFFSET	Off
SWEEP START	20 (Lin)
SWEEP STOP	300 (Log)
RAMP DURATION	Centered
TRIG/GATE LEVEL	Centered
START PHASE	Centered

Initially set all screwdriver-adjustable trims to the center of their range (including rear panel SYM ADJ and DC LEVEL potentiometers).

WARNING!

This calibration procedure should be performed by qualified personnel only. Remove the cover before connecting the instrument to the AC source and use only insulated probes and/or tools.

6.3.1 Power Supply Check

Connect the DMM to the -13.5V test point, and check for a reading of -13.5V, ±0.5V. Adjust R119, if necessary. Connect the DMM to the +13.5V test point and check for a reading of +13.5V, ±0.5V.

6.3.2 Main Output DC Level Adjust

Connect the DMM (DC Mode) to the MAIN OUT; adjust the DC LEVEL ADJ potentiometer on the rear panel for zero ±0.001V on the MAIN OUT.

6.3.3 Triangle Amplitude and DC Level Adjust

With the DMM still connected to the MAIN OUT, turn the AMPLITUDE pot Max CW; adjust R505 for zero, ±0.001V reading on the MAIN OUT. Switch the DMM to AC Mode and adjust R503 for a triangle amplitude of 5.6V, ±0.02V.

6.3.4 VC Amplifiers DC Level Adjust

Connect the DMM (DC Mode) to the VC IN connector (J802); adjust R215 for a reading of zero volts, ±0.2 mV.

Set the FREQUENCY Hz dial to 1. Note the DC voltage on emitter of Q200 (should be ~-10 mV). Connect the DMM to emitter of Q201 and adjust R224 for same reading, but opposite polarity, as emitter of Q200 (±0.2 mV).

6.3.5 Symmetry and Distortion Adjustment

Set the FREQUENCY Hz dial to 50, MULTiplier to x100. Set the WAVEFORM switch to ∿. Connect the generator MAIN OUT to the distortion analyzer input.

Tune the distortion analyzer to 5 kHz. Adjust R234, then R411 and R416 for a minimum distortion reading. Tolerance: less than 0.4%.

Set the FREQUENCY Hz dial to 300; readjust the distortion analyzer for 30 kHz. Adjust R228 for a distortion reading of less than 0.4%.

Set the FREQUENCY Hz dial to 0.2; readjust the distortion analyzer for 20 Hz. Adjust the rear panel SYM ADJ potentiometer, R300, for minimum distortion. Disconnect the distortion analyzer.

6.3.6 Sine Shaper DC Level

Connect DMM (DC Mode) to test point SO; adjust R438 for a reading of zero, ±0.001V.

6.3.7 Frequency Calibration

Set the FREQUENCY Hz dial to its maximum CW (0.2) end; check the alignment of the "▲" symbol with the dial index. If necessary loosen dial set screws, readjust dial and retighten set screws.

NOTE

To eliminate backlash, always approach the desired setting from the CCW (300 end) direction.

Connect the frequency counter to the TTL output. Set the generator VERNier to the middle of its range (0). Set the FREQUENCY Hz dial to the following settings and adjust each potentiometer for the counter reading indicated.

Dial Setting	Adjustment	Counter Reading
300	R1205	30.0 kHz, ±0.6 kHz
(Set counter to PERIOD operation)		
0.2	R1207	50 ms, ±2.0 ms
If out of range, redo step 6.3.4		
(Reset counter for FREQUENCY operation)		
10	R1201	1.00 kHz, ±0.02 kHz
100	R1203	10.0 kHz, ±0.2 kHz

Repeat above adjustment, if necessary, until all are correct. Reset FREQUENCY Hz dial to 10, MULTiplier to x10K. Adjust C330 for a frequency reading of 100 kHz, ±2 kHz.

Set FREQUENCY Hz dial to 100; adjust C500 for a reading of 1.000 MHz, ±0.02 MHz.

Set FREQUENCY Hz dial for 300; adjust R500 for a counter reading of 3.00 MHz, ±0.06 MHz. Remove frequency counter.

6.3.8 Squarewave Amplitude and DC Level

Set the FREQUENCY Hz dial to 300, MULTiplier to x1. Set the WAVEFORM switch to ⌐⌙, AMPLITUDE control to Max. CW. Connect the DMM (DC Mode) to the MAIN OUT and adjust R530 for a squarewave DC level of zero, ±0.001V. Set the DMM to AC and adjust R528 for a reading of 11.2V, ±0.02V.

6.3.9 Squarewave Response

Set the FREQUENCY Hz dial to 100, MULTiplier to x10K. Connect the oscilloscope to the MAIN OUT, using a 50 ohm terminator at the scope vertical input. Adjust the scope horizontal and vertical controls for two cycles approximately 5 cm in height. Adjust C607 for a flat square wave. Remove 50 ohm terminator.

6.3.10 Sine Wave Response

Leave the oscilloscope connected to the MAIN OUT. Set the FREQUENCY Hz dial to 1, waveform switch to ∿. Adjust the scope vertical sensitivity for a 6 cm display. Tune the dial to 300 and adjust C419 for minimum change when tuning the dial from 1 to 300.

Disconnect the scope from the MAIN OUT.

6.3.11 Ramp Output Amplitude and DC Level Adjust

Depress GATE and TRIG SWP. Connect the DMM (DC Mode) to the RAMP OUT. Adjust R1706 for zero, ±0.01V. Depress and hold MAN TRIG button and adjust R1701 for 5.0V, ±0.01V.

6.3.12 Sweep Limit Adjust

Depress GATE and TRIG-SWP. Set SWEEP START and STOP controls to their minimum (0.2) end. Connect frequency counter set for PERIOD to TTL OUT. Set MULTiplier to 100. Adjust R1216 for 65 ms, ±10 ms. Depress the MANUAL TRIG/GATE button and adjust R1222 for the same reading.

Set SWEEP START to 300. Depress MANUAL TRIG/GATE and adjust R1209 for 65 ms, ±10 ms.

6.3.13 Ramp Duration Adjust

Depress CONT. Set the RAMP DURATION to 1 s. Set frequency counter to PERIOD operation, adjust R1717 for reading of 1.05 to 1.20 s.

APPENDIX

A.1 Test Equipment Required

The following is a list of recommended test equipment for Incoming Inspection, Maintenance and Calibration of the 1400.

Description	Applicable to Section No. 3	5	6
a) Oscilloscope, bandwidth from DC to 30 MHz, vertical sensitivity 5 mV/cm, AC/DC coupled (Tektronix type 544 Mainframe with type 1A1 Vertical Amplifier plug-in).	X	X	X
b) Frequency Counter, capable of frequency measurements between 0.2 Hz and 3 MHz, 0.1% accuracy (General Radio 1192-B or equivalent).	X		X
c) AC Differential Voltmeter (ACVM), 3 MHz bandwidth or greater, for voltage measurements up to 20 volts, and voltage variations less than 0.1 dB (1%). (Fluke Model 931A or equivalent).	X		X
d) Digital Multimeter (DMM) for AC and DC voltage measurements between zero and ±50 volts and resistance measurements. (Fluke Model 8000A or equivalent.)	X	X	X
e) Distortion Analyzer, bandwidth at least 300 kHz, to measure distortion down to 0.1% (Hewlett Packard Model 333A or equivalent).	X		X
f) (1) 50 ohm terminator	X		X

POWER SUPPLY

VC

INTEGRATOR

SINE SHAPER

OUTPUT AMPLIFIER

SQ. WAVE GEN.

NOTES:

ALL RESISTORS IN OHMS, 1/4 WATT, 10%, UNLESS SPECIFIED OTHERWISE

- PC BOARD CONTROL
- REAR PANEL CONTROL
- FRONT PANEL CONTROL
- TEST POINT
- CIRCUIT GROUND
- CHASSIS GROUND

ALL VOLTAGES MEASURED WITH RESPECT TO CIRCUIT GROUND WITH THE GENERATOR SET AS FOLLOWS:
- FREQUENCY DIAL SET AT 100
- MULTIPLIER SET TO +100
- MODE SWITCH SET TO CONT
- DC OFFSET OFF
- AMPLITUDE AT MAX CW
- ATTENUATOR AT 0 dB
- WAVEFORM SWITCH TO ∿
- LINE VOLTAGE AT 120 VOLT, 60Hz

ALL VOLTAGES ±10% UNLESS SPECIFIED OTHERWISE

TITLE: SWEEP GENERATOR PC-102

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KH KROHN-HITE CORPORATION, AVON, MASS. U.S.A.

TOLERANCES	FRACTIONS	DECIMALS	ANGLES
	±	±	±

MODEL	DRN. BY	DATE
400,1600	RCrossman	4/4/79
SCALE	CKD. BY	DWG. NO.
R 28	SLG	S-3860
APP. BY	DATE	APP. BY

DATE: 3-24-80

REV. E

SHEET 1 OF 2

TRIG / GATE

MODE

HOLD AMP

SWEEP LIMIT

RAMP

S1801A MANUAL TRIG/GATE

J1802 TRIG/GATE IN

J1803 600Ω RAMP OUTPUT

FREQ Hz

CV CAL

100 CAL

START ZERO

START NULL

STOP NULL

GATE S1000C2

TRIG/GATE LEVEL

PULSE

CONT S1000B1

CONT S1000B2

TRIG BURST S1000H2

START PHASE

GATE S1000C1

TRIG S1000D1

PULSE S1000E1

CONT SWP S1000F4

TRIG SWP S100064

TRIG BURST S1000H1

SWP S1000F3

TRIG SWP S100063

S1000E2

S1000F1

S1000G1

S1000F2

S1000H1

S1000G2

RAMP HOLD S1801B

S1002 X1K

HAX DURATION

RAMP DURATION

U1929 7474

U1908 LM710CN

U1210 LF356N

U1705 LF356N

U1717 LF356N

Q1911 MPS3646

Q1913 MPS3646

Q1916 MPS3646

Q1918 MPS3646

Q1921 MPS3646

Q1922 MPS3640

Q1923 MPS3646

Q1927 MPS3646

Q1930 MPS3646

Q1934 MPS6518

Q1935 MPS6518

Q1940 MPS6515

Q1941 MPS3640

Q1702 MPS6518

Q1711 TIS 97

Q1712 2N5087

Q1719 2N4340

Q1720 MPS6515

Q1721 MPS6518

Q1722 MPS6518

Q1727 MPS6515

Q1728 MPS3646

Q1733 MPS3640

Q1943 2N2219A

VR1908 IN9596 8.2V

VR1943 IN752 5.6V

CR1928 IN4149

CR1929 IN4149

CR1930 IN4149

CR1931 IN4149

CR1934 IN4149

CR1938 IN4149

CR1700 IN4149

CR1703 IN4149

CR1704 IN4149

CR1705 IN4149

CR1706 IN4149

CR1707 IN4149

CR1708 IN4149

CR1719 MZ2361

R323 (S3860)

S200E (S3860)

Q 300 (S3860)

PIN #6 U500 (S3910)

PIN #2, U200 (S3860)

PIN #3, U200 (S3860)

0V 7V

+3.5 -.6V

+4V 0V

+100NS +4.2V

+1.8V -.6V

+5V -.6V

NOTES:

1. ALL RESISTORS IN OHMS, 1/4 WATT, 10%, UNLESS SPECIFIED OTHERWISE
2. ALL WAVEFORMS AND VOLTAGE LEVELS MEASURED WITH RESPECT TO CIRCUIT GROUND, UNDER THE FOLLOWING CONDITIONS:
   AC LINE 120V 60Hz
   S800, S801: 120V AND NORM, RESPECTIVELY
   FREQ Hz DIAL: 100
   MULT: 100
   MODE: CONT
   ATTENUATOR (dB): 0
   AMPLITUDE: MAX
   WAVEFORM: ∿
   DC OFFSET: OFF
   SWEEP START: 20
   SWEEP STOP: 300
   RAMP DURATION: CENTERED
   TRIG/GATE LEVEL: CENTERED
   START PHASE: CENTERED

3. ⌀ PC BOARD CONTROL
4. ⌀ FRONT PANEL CONTROL
5. ⌀ REAR PANEL CONTROL
6. ○ TEST POINT
7. □ WIRING TIE-POINT
8. ⏚ CIRCUIT GROUND
9. ⏚ CHASSIS GROUND

TOP VIEW

S1000F, G

S1000B-E, H

TITLE	PC 102 SCHEMATIC
MODEL	1400
DRN. BY	P. Crossman 5/9/79
SCALE	R 28
DES. BY	S.L.G. 3-24-80
DWG. NO.	S-3911
REV.	E
SHEET	2 OF 2

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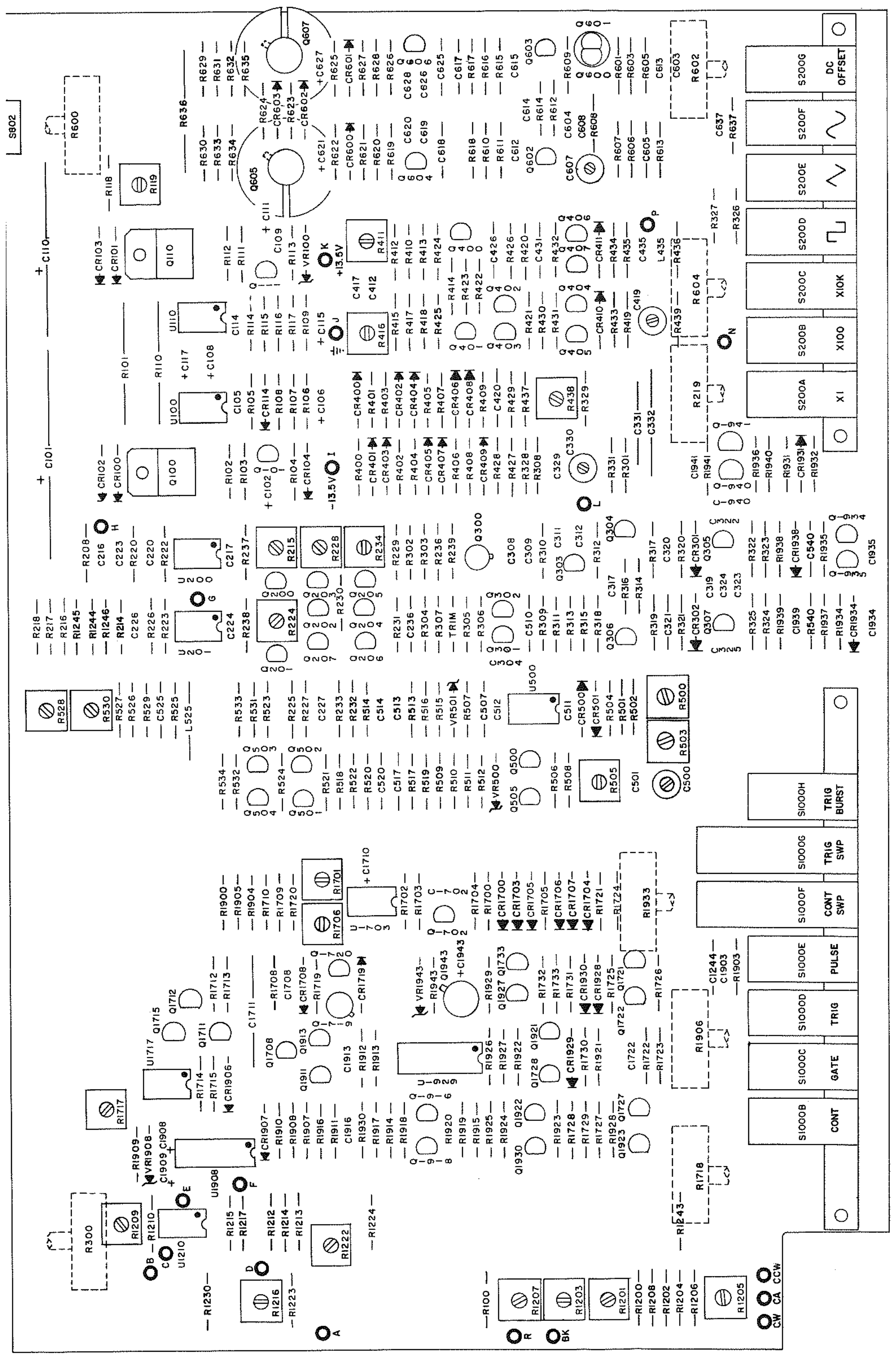

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PC—102

PARTS LIST

When ordering parts, please specify Instrument Model No. and serial No., circuit symbol, description and manufacturers' part No.

Engineering modifications incurred since the printing of this document may be found (when applicable), at the rear of this manual.

The Manufacturer's part numbers listed below are either those used in the Instrument, or a directly interchangeable part.

CAPACITORS

Symbol	Description			Mfr.	Mfr. Part No.
C1244	.001uf	20%	500V	SP	C023B501E102M
C1702	.0047uf	20%	500V	SP	C023B501F472M
C1708	.02uf	20%	500V	SP	C023A501J203M
C1710	1uf	20%	35V	MAL	TDC105M035AL
C1711	.1uf	+1%-3%	200V	KH	KHC-11-104
C1722	.02uf	20%	500V	SP	C023A501J203M
C1903	22pf	10%	500V	KGN	DM15C220K
C1908	1uf	20%	35V	MAL	TDC105M035AL
C1909	1uf	20%	35V	MAL	TDC105M035AL
C1913	15pf	10%	500V	KGN	DM15C150K
C1916	15pf	10%	500V	KGN	DM15C150K
C1934	3.3pf	10%	500V	ASP	9209-33910
C1935	15pf	10%	500V	KGN	DM15C150K
C1939	8.2pf	10%	500V	ASP	9212-82910
C1940	15pf	10%	500V	KGN	DM15C150K
C1941	4.7pf	10%	500V	ASP	9210-47910
C1943	1uf	20%	35V	MAL	TDC105M035AL

RESISTORS

Symbol	Description			Mfr.	Mfr. Part No.
R1200	1K	10%	1/4W	AB	CB1021
R1201	100K	POT		BKM	72PM
R1202	470	10%	1/4W	AB	CB4711
R1203	25K	POT		BKM	72PM
R1204	825	1%	1/4W	AB	CC8250F
R1205	500	POT		BKM	72PM
R1206	374	1%	1/4W	AB	CC3740F
R1207	100K	POT		BKM	72PM
R1208	2M	5%	1/4W	AB	CB2055
R1209	100K	POT		BKM	72PM
R1210	1.5M	10%	1/4W	AB	CB1551
R1212	3.3K	10%	1/4W	AB	CC1622F
R1213	4.3M	5%	1/4W	AB	CC2672F
R1214	26.7K	1%	1/4W	AB	Type CC
R1215	8.25K	1%	1/4W	AB	CC8251F
R1216	100K	POT		BKM	72PM
R1217	10K	1%	1/4W	AB	CC1002F
R1222	100K	POT		BKM	72PM
R1223	1M	10%	1/4W	AB	CB1051
R1224	1M	10%	1/4W	AB	CB1051
R1230	200	5%	1/4W	AB	CB2015
R1243	2.7	10%	1/4W	AB	CB27G1
R1244	13.3K	1%	1/4W	AB	CC1332F
R1245	13.3K	1%	1/4W	AB	CC1332F
R1246	2.7	10%	1/4W	AB	CB27G1
R1700	11K	5%	1/4W	AB	CB1135
R1701	5K	POT		BKM	72PM
R1702	3.3K	10%	1/4W	AB	CB3321
R1703	5.1K	5%	1/4W	AB	CB5125
R1704	1M	10%	1/4W	AB	CB1051
R1705	15K	10%	1/4W	AB	CB1531
R1706	10K	POT		BKM	72PM
R1708	100	10%	1/4W	AB	CB1011
R1709	1.5K	10%	1/4W	AB	CB1521
R1710	100	10%	1/4W	AB	CB1011
R1712	7.5K	5%	1/4W	AB	CB7525
R1713	6.2K	5%	1/4W	AB	CB6225
R1714	10M	10%	1/4W	AB	CB1061
R1715	7.5K	5%	1/4W	AB	CB7525
R1716	100K	10%	1/4W	AB	CB1041
R1717	10K	POT		BKM	72PM
R1718	5K POT (RAMP DURATION)				PART OF S1002
R1719	2.7K	10%	1/4W	AB	CB2721
R1720	2.7K	10%	1/4W	AB	CB2721
R1721	6.2K	5%	1/4W	AB	CB6225
R1722	5.6K	10%	1/4W	AB	CB5621
R1723	620	5%	1/4W	AB	CB6215
R1724	3.9K	10%	1/4W	AB	CB3921
R1725	1.5K	10%	1/4W	AB	CB1521
R1726	56K	10%	1/4W	AB	CB5631
R1727	10K	10%	1/4W	AB	CB1031
R1728	4.7K	10%	1/4W	AB	CB4721
R1729	2.2K	10%	1/4W	AB	CB2221
R1730	2.2K	10%	1/4W	AB	CB2221
R1731	2.2K	10%	1/4W	AB	CB2221
R1732	4.7K	10%	1/4W	AB	CB4721
R1733	1.2K	10%	1/4W	AB	CB1221
R1800	2K	(FREQUENCY Hz)		KH	A-3098
R1801	1K	(START FREQ)			Series 470
R1802	1K	(STOP FREQ)			Series 470
R1900	620	5%	1/4W	AB	CB6215
R1903	11K	5%	1/4W	AB	CB1135
R1904	13K	5%	1/4W	AB	CB1335
R1905	2.4K	5%	1/4W	AB	CB2425
R1906	25K POT (TRIG/GATE LEVEL)			KH	B3765-2
R1907	13K	5%	1/4W	AB	CB1335
R1908	5.6K	10%	1/4W	AB	CB5621
R1909	220	10%	1/4W	AB	CB2211
R1910	180K	10%	1/4W	AB	CB1831
R1911	10K	10%	1/4W	AB	CB1031
R1912	10K	10%	1/4W	AB	CB1031
R1913	1.8K	10%	1/4W	AB	CB1821
R1914	12K	10%	1/4W	AB	CB1231
R1915	1K	10%	1/4W	AB	CB1021
R1916	1.8K	10%	1/4W	AB	CB1821
R1917	1K	10%	1/4W	AB	CB1021
R1918	3.3K	10%	1/4W	AB	CB3321
R1919	2.2K	10%	1/4W	AB	CB2221
R1920	3.3K	10%	1/4W	AB	CB3321
R1921	4.7K	10%	1/4W	AB	CB4721
R1922	1K	10%	1/4W	AB	CB1021

RESISTORS (CONT.)

Symbol	Description			Mfr.	Mfr. Part No.
R1923	10K	10%	1/4W	AB	CB1031
R1924	4.7K	10%	1/4W	AB	CB4721
R1925	10K	10%	1/4W	AB	CB1031
R1926	4.7K	10%	1/4W	AB	CB4721
R1927	4.7K	10%	1/4W	AB	CB4721
R1928	10K	10%	1/4W	AB	CB1031
R1929	2.2K	10%	1/4W	AB	CB2221
R1930	2.2K	10%	1/4W	AB	CB2221
R1931	3.3K	10%	1/4W	AB	CB3321
R1932	1.2K	10%	1/4W	AB	CB1221
R1933	25K POT (START PHASE)			KH	B3765-5
R1934	12K	10%	1/4W	AB	CB1231
R1935	1.5K	10%	1/4W	AB	CB1521
R1936	150	10%	1/4W	AB	CB1511
R1937	150	10%	1/4W	AB	CB1511
R1938	4.7K	10%	1/4W	AB	CB4721
R1939	7.5K	5%	1/4W	AB	CB7525
R1940	2.7K	10%	1/4W	AB	CB2721
R1941	820	10%	1/4W	AB	CB8211
R1943	390	10%	1/4W	AB	CB3911

SEMICONDUCTORS & MISC.

Symbol	Description	Mfr.	Mfr. Part No.
CR1700	DIODE, SWITCHING	APD	IN4149
CR1703	DIODE, SWITCHING	APD	IN4149
CR1704	DIODE, SWITCHING	APD	IN4149
CR1705	DIODE, SWITCHING	APD	IN4149
CR1706	DIODE, SWITCHING	APD	IN4149
CR1707	DIODE, SWITCHING	APD	IN4149
CR1708	DIODE, SWITCHING	APD	IN4149
CR1719	DIODE, DUAL	MOT	MZ2361
CR1906	DIODE, SWITCHING	APD	IN4149
CR1907	DIODE, SWITCHING	APD	IN4149
CR1928	DIODE, SWITCHING	APD	IN4149
CR1929	DIODE, SWITCHING	APD	IN4149
CR1930	DIODE, SWITCHING	APD	IN4149
CR1931	DIODE, SWITCHING	APD	IN4149
CR1934	DIODE, SWITCHING	APD	IN4149
CR1938	DIODE. SWITCHING	APD	IN4149
Q1702	TRANSISTOR, PNP	MOT	MPS6518
Q1708	TRANSISTOR, NPN	TI	TIS97
Q1711	TRANSISTOR, NPN	TI	TIS97
Q1712	TRANSISTOR, PNP	MOT	2N5087
Q1715	N-CHANNEL J-FET	MOT	MPF4392
Q1719	N-CHANNEL J-FET	MOT	2N4340
Q1720	TRANSISTOR, NPN	MOT	MPS6515
Q1721	TRANSISTOR, PNP	MOT	MPS6518
Q1722	TRANSISTOR, PNP	MOT	MPS6518
Q1727	TRANSISTOR, NPN	MOT	MPS6515
Q1728	TRANSISTOR, NPN	MOT	MPS3646
Q1733	TRANSISTOR, PNP	MOT	MPS3640
Q1911	TRANSISTOR, NPN	MOT	MPS3646
Q1913	TRANSISTOR, NPN	MOT	MPS3646
Q1916	TRANSISTOR, NPN	MOT	MPS3646
Q1918	TRANSISTOR, NPN	MOT	MPS3646
Q1921	TRANSISTOR, NPN	MOT	MPS3646
Q1922	TRANSISTOR, PNP	MOT	MPS3640
Q1923	TRANSISTOR, NPN	MOT	MPS3646
Q1927	TRANSISTOR, NPN	MOT	MPS3646
Q1930	TRANSISTOR, NPN	MOT	MPS3646
Q1934	TRANSISTOR, PNP	MOT	MPS6518
Q1935	TRANSISTOR, PNP	MOT	MPS6518
Q1940	TRANSISTOR, NPN	MOT	MPS6515
Q1941	TRANSISTOR, PNP	MOT	MPS3640
Q1943	TRANSISTOR, NPN	MOT	2N2219A
U1210	FET INPUT OP AMP	NS	LF356N
U1703	FET INPUT OP AMP	NS	LF356N
U1717	FET INPUT OP AMP	NS	LF356N
U1908	COMPARATOR OP AMP	NS	LM710CN
U1929	DUAL D FLIP-FLOP	FR	9N74PC/7474
VR1908	DIODE, ZENER, 8.2V	APD	IN959B
VR1943	DIODE, ZENER, 5.6V	APD	IN752
S1000	SWITCH, PUSHBUTTON, 7 STATION	KH	B3770
S1002	SWITCH, PUSH-PULL W/ GANGED POTENTIOMETER	KH	B3805A
S1801	SWITCH, PUSHBUTTON, 2 STATION	KH	B3745
J1802	CONNECTOR, FEMALE, BNC	AMP	31-010
J1803	CONNECTOR, FEMALE, BNC	AMP	31-010

MANUFACTURERS' CODE

Code		Name	Location
AB	(01121)	Allen Bradley Co.	Milwaukee, Wisc.
AMP	(02660)	Amphenol-Borg Elec. Corp.	Broadview, IL.
APD	(50273)	American Power Devices	Andover, MA.
ASP	(82142)	Airco Speer	Dubois, PA.
BKM	(30646)	Beckman Instr. Co.	Cedar Grove, N.J.
BUS	( )	Bussman Manufacturing Co.	St. Louis, MO.
CD	(88419)	Cornell-Dubilier	Newark, N.J.
DLV	(99800)	Delevan Electronics	East Aurora, N.Y.
ERT	(72982)	Erie Technological	Erie, PA.
FR	(07263)	Fairchild Semiconductor	San Rafael, CA.
ITT	( )	ITT Semiconductor	Woburn, MA.
KGN	( )	Kahgan Electronics	Hempstead, N.Y.
KH	(88865)	Krohn-Hite Corp.	Avon, MA.
MAL	(37942)	P.R. Mallory & Co.	Indianapolis, Ind.
MOT	(04713)	Motorola Semiconductor	Phoenix, Ariz.
NS	(36462)	National Semiconductor, Ltd.	Plattsburgh, N.Y.
PI	( )	Phillips Industries	Chicago, Ill.
SP	(562-9)	Sprague Electric Co.	North Adams, MA.
STT	( )	Stettner-Trush	Cazanovia, N.Y.
SWC	(82389)	Switchcraft Inc.	Chicago, Ill.
TI	(01295)	Texas Instruments, Inc.	Dallas, Texas

PARTS LIST

When ordering parts, please specify Instrument Model No. and serial No., circuit symbol, description and manufacturers' part No.

Engineering modifications incurred since the printing of this document may be found (when applicable), at the rear of this manual.

The Manufacturer's part numbers listed below are either those used in the Instrument, or a directly interchangeable part.

CAPACITORS

Symbol	Description	Mfr.	Mfr. Part No.
C100	.01uf 20% 500V	SP	C023B501G103M
C101	800uf 20% 25V	MAL	TVA-1209
C102	6.8uf 20% 35V	SP	150D685X0035B2
C105	.0033uf 20% 500V	SP	C023B501F332M
C106	1uf 20% 35V	MAL	TDC105M035AL
C108	6.8uf 20% 35V	SP	150D685X0035B2
C109	.01uf 20% 500V	SP	C023B501G103M
C110	500uf 20% 25V	MAL	TT50IN025GP
C111	6.8uf 20% 35V	SP	150D685X0035B2
C114	.0033uf 20% 500V	SP	C023B501F332M
C115	1uf 20% 35V	MAL	TDC105M035AL
C117	6.8uf 20% 35V	SP	150D685X0035B2
C216	220pf 10% 500V	KGN	DM15C221K
C217	100pf 10% 500V	KGN	DM15C101K
C220	.02uf 20% 500V	SP	C023A501J203M
C223	220pf 10% 500V	KGN	DM15C221K
C224	100pf 10% 500V	KGN	DM15C101K
C226	.02uf 20% 500V	SP	C023A501J203M
C227	.002uf 20% 500V	SP	C023B501F202M
C236	5.6pf 10% 500V	ASP	9210-56910
C304	.01uf 20% 500V	SP	C023B501G103M
C308	200pf 10% 500V	KGN	DM15C201K
C309	100pf 10% 500V	KGN	DM15C101K
C311	100pf 10% 500V	ELM	DM15C101K
C312	.01uf 20% 500V	SP	C023B501G103M
C317	.01uf 20% 500V	SP	C023B501G103M
C319	.01uf 20% 500V	SP	C023B501G103M
C320	7.5pf 10% 500V	ASP	9212-75910
C321	7.5pf 10% 500V	ASP	9212-75910
C322	.01uf 20% 500V	SP	C023B501G103M
C323	.01uf 20% 500V	SP	C023B501G103M
C324	.01uf 20% 500V	SP	C023B501G103M
C325	.01uf 20% 500V	SP	C023B501G103M
C329	75pf 10% 500V	KGN	DM15C750K
C330	4.5-20pf TRIMMER	STT	75-TR1K0-02-4.5/20pf
C331	9900pf 1% 100V	ELM	CD20FD992F03
C332	1uf +.5%,-3.5% 200V	KH	KHC-11-105
C412	.01uf 20% 500V	SP	C023B501G103M
C417	.01uf 20% 500V	SP	C023B501G103M
C419	4.5-20pf TRIMMER	STT	75-TR1K0-02-4.5/20pf
C420	10pf 10% 500V	ASP	9213-10110
C426	12pf 10% 500V	ASP	9213-12110
C431	3.9pf 10% 500V	ASP	9202-39910
C435	100pf 10% 500V	KGN	DM15C101K
C500	7-35pf TRIMMER	STT	75-TR1K0-02-7/35pf
C501	10pf 10% 500V	ASP	9213-10110
C507	5.1pf 10% 500V	ASP	9210-51910
C510	6.2pf 10% 500V	ASP	9212-62910
C511	.1uf 20% 100V	ERT	8131-100-651-104M
C512	.1uf 20% 100V	ERT	8131-100-651-104M
C513	18pf 10% 500V	KGN	DM15C180K
C514	10pf 10% 500V	KGN	DM15C100K
C517	5.1pf 10% 500V	ASP	9210-51910
C520	5.1pf 10% 500V	ASP	9210-51910
C525	6.8pf 10% 500V	ASP	9212-68910
C540	6.8pf 10% 500V	ASP	9212-68910
C603	.01uf 20% 500V	SP	C023B501G103M
C604	.01uf 20% 500V	SP	C023B501G103M
C605	2pf 10% 500V	ASP	9209-33910
C607	2.5-6pf TRIMMER	STT	75-TR1K0-02-2.5/6pf
C608	8.2pf 10% 500V	ASP	9212-82910
C612	.01uf 20% 500V	SP	C023B501G103M
C613	3.3pf 10% 500V	ASP	9209-33910
C614	.01uf 20% 500V	SP	C023B501G103M
C615	.01uf 20% 500V	SP	C023B501G103M
C617	2pf 10% 500V	SP	9208-20910
C618	3.9pf 10% 500V	SP	9209-39910
C619	.1uf 20% 100V	ERT	8131-100-651-104M
C620	.1uf 20% 100V	ERT	8131-100-651-104M
C621	6.8uf 20% 35V	SP	150D685X0035B2
C625	3.9pf 10% 500V	ASP	9209-39910
C626	.1uf 20% 100V	ERT	8131-100-651-104M
C627	6.8uf 20% 35V	SP	150D685X0035B2
C628	.1uf 20% 100V	ERT	8131-100-651-104M
C632	.01uf 20% 500V	SP	C023B501G103M

RESISTORS

Symbol	Description	Mfr.	Mfr. Part No.
R100	680 10% 1/4W	AB	CB6811
R101	51 5% 2W	AB	HB5105
R102	100 10% 1/4W	AB	CB1011
R103	470 10% 1/4W	AB	CB4711
R104	100 10% 1/4W	AB	CB1011
R105	8.2K 10% 1/4W	AB	CB8221
R106	9.31K 1% 1/4W	AB	CC9311F
R107	2.7K 10% 1/4W	AB	CB2721
R108	9.31K 1% 1/4W	AB	CC9311F
R109	2K 5% 1/4W	AB	CB2025
R110	51 5% 2W	AB	HB5105
R111	100 10% 1/4W	AB	CB1011
R112	470 10% 1/4W	AB	CB4711
R113	100 10% 1/4W	AB	CB1011
R114	8.2K 10% 1/4W	AB	CB8221
R115	9.31K 1% 1/4W	AB	CC9311F
R116	2.7K 10% 1/4W	AB	CB2721
R117	4.42K 1% 1/4W	AB	CC4421F
R208	10K 1% 1/4W	AB	CC1002F
R214	3.3K 5% 1/4W	AB	CB3325
R215	100K POT	BKM	72PM
R216	8.66K 1% 1/4W	AB	CC8661F
R217	909 1% 1/4W	AB	CC9090F
R218	12K 10% 1/4W	AB	CB1231
R219	100K POT (VERN)	KH	B3765-3-A
R220	10 10% 1/4W	AB	CB1001
R222	10K 1% 1/4W	AB	CC1002F
R223	10K 1% 1/4W	AB	CC1002F
R224	100K POT	BKM	72PM
R225	2.2K 10% 1/4W	AB	CB2221
R226	10 10% 1/4W	AB	CB1001
R227	620 5% 1/4W	AB	CB6215
R228	25K POT	BKM	72PM
R229	2.7K 10% 1/4W	AB	CB2721
R230	360 5% 1/4W	AB	CB3615
R231	360 5% 1/4W	AB	CB3615
R232	100 10% 1/4W	AB	CB1011
R233	150 10% 1/4W	AB	CB1511
R234	100 POT	BKM	72PM
R236	274 1% 1/4W	AB	CC2740F
R237	22M 10% 1/4W	AB	CB2261
R238	39M 10% 1/4W	AB	CB3961
R239	2.7K 10% 1/4W	AB	CB2721
R300	25K POT (SYM ADJ)	KH	B3765-2-A
R301	3.3M 10% 1/4W	AB	CB3351
R302	51.1K 1% 1/4W	AB	CC5112F
R303	51.1K 1% 1/4W	AB	CC5112F

RESISTORS (CONT.)

Symbol	Description	Mfr.	Mfr. Part No.
R304	220 10% 1/4W	AB	CB2211
R305	47K 10% 1/4W	AB	CB4731
R306	330 10% 1/4W	AB	CB3311
R307	12K 10% 1/4W	AB	CB1231
R308	150 10% 1/4W	AB	CB1511
R309	9.1K 5% 1/4W	AB	CB9125
R310	47 10% 1/4W	AB	CB4701
R311	39 10% 1/4W	AB	CB3901
R312	1.5K 10% 1/4W	AB	CB1521
R313	680 10% 1/4W	AB	CB6811
R314	1.5K 10% 1/4W	AB	CB1521
R315	10K 10% 1/4W	AB	CB1031
R316	100 10% 1/4W	AB	CB1011
R317	220 10% 1/4W	AB	CB2211
R318	100 10% 1/4W	AB	CB1011
R319	220 10% 1/4W	AB	CB2211
R320	2.2K 10% 1/4W	AB	CB2221
R321	2.2K 10% 1/4W	AB	CB2221
R322	100 10% 1/4W	AB	CB1011
R323	10 10% 1/4W	AB	CB1001
R324	10 10% 1/4W	AB	CB1001
R325	100 10% 1/4W	AB	CB1011
R326	681 1% 1/4W	AB	CC6810F
R327	365 1% 1/4W	AB	CC3650F
R328	100 10% 1/4W	AB	CB1011
R329	2.7 10% 1/4W	AB	CB27G1
R330	TRIM	AB	Type CB
R331	100K 10% 1/4W	AB	CB1041
R400	6.04K 1% 1/4W	AB	CC6041F
R401	1.07K 1% 1/4W	AB	CC1071F
R402	6.34K 1% 1/4W	AB	CC6341F
R403	1.33K 1% 1/4W	AB	CC1331F
R404	3.92K 1% 1/4W	AB	CC3921F
R405	1.1K 1% 1/4W	AB	CC1101F
R406	4.12K 1% 1/4W	AB	CC4121F
R407	2.05K 1% 1/4W	AB	CC2051F
R408	4.87K 1% 1/4W	AB	CC4871F
R409	6.65K 1% 1/4W	AB	CC6651F
R410	10K 10% 1/4W	AB	CB1031
R411	500 POT	BKM	72PM
R412	1K 10% 1/4W	AB	CB1021
R413	1.33K 1% 1/4W	AB	CC1331F
R414	330 10% 1/4W	AB	CB3311
R415	1K 10% 1/4W	AB	CB1021
R416	500 POT	BKM	72PM
R417	10K 10% 1/4W	AB	CB1031
R418	1.33K 1% 1/4W	AB	CC1331F
R419	825 1% 1/4W	AB	CC8250F
R420	8.2K 10% 1/4W	AB	CB8221
R421	2.7K 10% 1/4W	AB	CB2721
R422	10K 1% 1/4W	AB	CC1002F
R423	10K 1% 1/4W	AB	CC1002F
R424	TRIM	AB	Type CB
R425	TRIM	AB	Type CB
R426	510 5% 1/4W	AB	CB5115
R427	100K 10% 1/4W	AB	CB1041
R428	18K 10% 1/4W	AB	CB1831
R429	100 10% 1/4W	AB	CB1011
R430	100 10% 1/4W	AB	CB1011
R431	470 10% 1/4W	AB	CB4711
R432	470 10% 1/4W	AB	CB4711
R433	47 10% 1/4W	AB	CB4701
R434	47 10% 1/4W	AB	CB4701
R435	150 10% 1/4W	AB	CB1511
R436	330 10% 1/4W	AB	CB3311
R437	270K 10% 1/4W	AB	CB2741
R438	100K POT	BKM	72PM
R439	100K 10% 1/4W	AB	CB1041
R500	5K POT	BKM	72PM
R501	100 10% 1/4W	AB	CB1011
R502	2.21K 1% 1/4W	AB	CC2211F
R503	500 POT	BKM	72PM
R504	180K 10% 1/4W	AB	CB1841
R505	100K POT	BKM	72PM
R506	4.02K 1% 1/4W	AB	CC4021F
R507	1.2K 10% 1/4W	AB	CB1221
R508	4.02K 1% 1/4W	AB	CC4021F
R509	27K 10% 1/4W	AB	CB2731
R510	4.7K 10% 1/4W	AB	CB4721
R511	3.9K 10% 1/4W	AB	CB3921
R512	4.7K 10% 1/4W	AB	CB4721
R513	6.2K 5% 1/4W	AB	CB6225
R514	6.2K 5% 1/4W	AB	CB6225
R515	2.2K 10% 1/4W	AB	CB2221
R516	2.2K 10% 1/4W	AB	CB2221
R517	3.9K 10% 1/4W	AB	CB3921
R518	2K 1% 1/4W	AB	CC2001F
R519	2K 1% 1/4W	AB	CC2001F
R520	3.9K 10% 1/4W	AB	CB3921
R521	2K 1% 1/4W	AB	CC2001F
R522	2K 1% 1/4W	AB	CC2001F
R523	6.8K 10% 1/4W	AB	CB6821
R524	499 1% 1/4W	AB	CC4990F
R525	220 10% 1/4W	AB	CB2211
R526	2K 1% 1/4W	AB	CC2001F
R527	510 5% 1/4W	AB	CB5115
R528	200 POT	BKM	72PM
R529	22K 10% 1/4W	AB	CB2231
R530	100K POT	BKM	72PM
R531	390 10% 1/4W	AB	CB3911
R532	3.3K 10% 1/4W	AB	CB3321
R533	27 10% 1/4W	AB	CB2701
R534	560 10% 1/4W	AB	CB5611
R540	2.7K 10% 1/4W	AB	CB2721
R600	100K POT (DC LEVEL ADJ)	KH	A3100
R601	1.2M 10% 1/4W	AB	CB1251
R603	18K 10% 1/4W	AB	CB1831
R604	2K POT (AMPLITUDE)	KH	B3765-1-A
R605	10K 10% 1/4W	AB	CB1031
R606	3.32K 1% 1/4W	AB	CC3321F
R607	14.7K 1% 1/4W	AB	CC1472F
R608	1K 10% 1/4W	AB	CB1021
R609	2.7K 10% 1/4W	AB	CB2721
R610	360 5% 1/4W	AB	CB3615
R611	1.5K 10% 1/4W	AB	CB1521
R612	1.5K 10% 1/4W	AB	CB1521
R613	2.2K 10% 1/4W	AB	CB2221
R614	330 10% 1/4W	AB	CB3311
R615	5.1K 5% 1/4W	AB	CB5125
R616	360 5% 1/4W	AB	CB3615
R617	470 10% 1/4W	AB	CB4711
R618	470 10% 1/4W	AB	CB4711
R619	47 10% 1/4W	AB	CB4701
R620	10 10% 1/4W	AB	CB1001
R621	2.7 10% 1/4W	AB	CB27G1
R622	100 10% 1/4W	AB	CB1011
R623	10 10% 1/4W	AB	CB1001
R624	10 10% 1/4W	AB	CB1001
R625	100 10% 1/4W	AB	CB1011
R626	47 10% 1/4W	AB	CB4701
R627	2.7 10% 1/4W	AB	CB27G1
R628	10 10% 1/4W	AB	CB1001
R629	499 1% 1/4W	AB	CC4990F
R630	499 1% 1/4W	AB	CC4990F
R631	61.9 1% 1/4W	AB	CC619RF
R632	10 1% 1/4W	AB	CC10R0F
R633	49.9 1% 1/4W	AB	CC49R9F
R634	44.2 1% 1/4W	AB	CC44R2F
R635	12.7 1% 1/4W	AB	CC12R7F
R636	51 5% 2W	AB	HB5105
R637	10 10% 1/4W	AB	CB1001

SEMICONDUCTORS & MISC.

Symbol	Description	Mfr.	Mfr. Part No.
CR100	DIODE, RECTIFIER, 100 PIV	ITT	IN4002
CR101	DIODE, RECTIFIER, 100 PIV	ITT	IN4002
CR102	DIODE, RECTIFIER, 100 PIV	ITT	IN4002
CR103	DIODE, RECTIFIER, 100 PIV	ITT	IN4002
CR104	DIODE, RECTIFIER, 100 PIV	ITT	IN4002
CR114	DIODE, RECTIFIER, 100 PIV	ITT	IN4002
CR301	DIODE, SWITCHING	APD	IN4149
CR302	DIODE, SWITCHING	APD	IN4149
CR400	DIODE, SWITCHING	APD	IN4149
CR401	DIODE, SWITCHING	APD	IN4149
CR402	DIODE, SWITCHING	APD	IN4149
CR403	DIODE, SWITCHING	APD	IN4149
CR404	DIODE, SWITCHING	APD	IN4149
CR405	DIODE, SWITCHING	APD	IN4149
CR406	DIODE, SWITCHING	APD	IN4149
CR407	DIODE, SWITCHING	APD	IN4149
CR408	DIODE, SWITCHING	APD	IN4149
CR409	DIODE, SWITCHING	APD	IN4149
CR410	DIODE, SWITCHING	APD	IN4149
CR411	DIODE, SWITCHING	APD	IN4149
CR500	DIODE, SWITCHING	APD	IN4149
CR501	DIODE, SWITCHING	APD	IN4149
CR600	DIODE, SWITCHING	APD	IN4149
CR601	DIODE, SWITCHING	APD	IN4149
CR602	DIODE, SWITCHING	APD	IN4149
CR603	DIODE, SWITCHING	APD	IN4149

SEMICONDUCTORS & MISC. (CONT.)

Symbol	Description	Mfr.	Mfr. Part No.
Q100	TRANSISTOR, PNP	TI	TIP32A
Q101	TRANSISTOR, NPN	MOT	MPS6515
Q110	TRANSISTOR, NPN	TI	TIP31A
Q111	TRANSISTOR, PNP	MOT	MPS6518
Q200	TRANSISTOR, NPN	MOT	MPS6515
Q201	TRANSISTOR, NPN	MOT	MPS6515
Q202	N-CHANNEL J-FET	MOT	MPF4392
Q203	N-CHANNEL J-FET	MOT	MPF4392
Q204	N-CHANNEL J-FET	MOT	MPF4392
Q205	N-CHANNEL J-FET	MOT	MPF4392
Q206	TRANSISTOR, NPN	MOT	MPS3646
Q207	TRANSISTOR, NPN	MOT	MPS3646
Q300	TRANSISTOR DUAL, NPN	MOT	2N2917
Q301	TRANSISTOR, PNP	MOT	MPS6518
Q302	TRANSISTOR, PNP	MOT	MPS6518
Q303	TRANSISTOR, NPN	MOT	MPS6515
Q304	TRANSISTOR, PNP	MOT	MPS6518
Q305	TRANSISTOR, NPN	MOT	MPS6515
Q306	TRANSISTOR, NPN	MOT	MPS6515
Q307	TRANSISTOR, PNP	MOT	MPS6518
Q400	TRANSISTOR, NPN	MOT	MPS6515
Q401	TRANSISTOR, PNP	MOT	MPS6518
Q402	TRANSISTOR, NPN	TI	TIS97
Q403	TRANSISTOR, NPN	TI	TIS97
Q404	TRANSISTOR, PNP	MOT	MPS6518
Q405	TRANSISTOR, NPN	MOT	MPS6515
Q406	TRANSISTOR, PNP	MOT	MPS6518
Q407	TRANSISTOR, NPN	MOT	MPS6515
Q500	TRANSISTOR, PNP	MOT	MPS6518
Q501	TRANSISTOR, PNP	MOT	MPS3640
Q502	TRANSISTOR, PNP	MOT	MPS3640
Q503	TRANSISTOR, NPN	MOT	MPS3646
Q504	TRANSISTOR, PNP	MOT	MPS3640
Q505	TRANSISTOR, NPN	MOT	MPS6515
Q600	TRANSISTOR, NPN	TI	TIS97
Q601	TRANSISTOR, NPN	TI	TIS97
Q602	TRANSISTOR, NPN	MOT	MPS6515
Q603	TRANSISTOR, PNP	MOT	MPS6518
Q604	TRANSISTOR, PNP	MOT	MPS6518
Q605	TRANSISTOR, NPN	MOT	2N2219A
Q606	TRANSISTOR, NPN	MOT	MPS6515
Q607	TRANSISTOR, PNP	MOT	2N2905A
U100	OP AMP	MOT	MC1741CP1
U110	OP AMP	MOT	MC1741CP1
U200	OP AMP	NS	LM308AN
U201	OP AMP	NS	LM308AN
U500	OP AMP	NS	LM360N-8
VR100	DIODE, ZENER, 6.4V	NS	IN4577A
VR500	DIODE, ZENER, 8.2V	APD	IN959
VR501	DIODE, ZENER, 8.2V	APD	IN959
DS800	LED, INDICATOR, POWER ON	DIA	559-0101-003
F800	FUSE, SLOW-BLOW, 115V	BUS	MDL1/4A
	FUSE, SLOW-BLOW, 230V	BUS	MDL1/8A
J800	RECEPTACLE, AC POWER	SWC	EAC-301
J801	CONNECTOR, FEMALE, BNC	AMP	31-010
J802	CONNECTOR, FEMALE, BNC	AMP	31-010
J803	CONNECTOR, FEMALE, BNC	AMP	31-010
J804	CONNECTOR, FEMALE, BNC	AMP	31-010
J805	CONNECTOR, FEMALE, BNC	AMP	31-010
J806	CONNECTOR, FEMALE, BNC	AMP	31-010
L435	15uHy	DLV	1537-40
L525	1uHy	DLV	1537-12
S100	SWITCH, PUSHBUTTON, POWER	KH	B3386
S200, A-G	SWITCH, PUSHBUTTON, 7 STATION	KH	B3769
S201	SWITCH, ROTARY, ATTENUATOR	KH	B3800
S800	SWITCH, SLIDE, NORM/LO	SWC	46256LFR
S801	SWITCH, SLIDE, 120V/240V	SWC	46256LFR
S802	SWITCH, SLIDE, GROUND	CK	GF123
T800	TRANSFORMER, POWER	KH	B3761A
	LINECORD	BEL	17250B

MANUFACTURERS' CODE

AB	(01121)	Allen Bradley Co.	Milwaukee, Wisc.
AMP	(02660)	Amphenol-Borg Elec. Corp.	Broadview, IL.
APD	(50273)	American Power Devices	Andover, MA.
ASP	(82142)	Airco Speer	Dubois, PA.
BKM	(30646)	Beckman Instr. Co.	Cedar Grove, N.J.
BUS	( )	Bussman Manufacturing Co.	St. Louis, MO.
DLV	(99800)	Delevan Electronics	East Aurora, N.Y.
ERT	(72982)	Erie Technological	Erie, PA.
ITT	( )	ITT Semiconductor	Woburn, MA.
KGN	( )	Kahgan Electronics	Hempstead, N.Y.
KH	(88865)	Krohn-Hite Corp.	Avon, MA.
MAL	(37942)	P.R. Mallory & Co.	Indianapolis, Ind.
MOT	(04713)	Motorola Semiconductor	Phoenix, Ariz.
NS	(36462)	National Semiconductor, Ltd.	Plattsburgh, N.Y.
PI	( )	Phillips Industries	Chicago, Ill.
SP	(562-9)	Sprague Electric Co.	North Adams, MA.
STT	( )	Stettner-Trush	Cazanovia, N.Y.
SWC	(82389)	Switchcraft Inc.	Chicago, Ill.
TI	(01295)	Texas Instruments, Inc.	Dallas, Texas