INSTRUCTION MANUAL

TYPE 1313-A
OSCILLATOR

Form 1313-0100-A
ID 1319
December, 1966

GENERAL RADIO COMPANY
WEST CONCORD, MASSACHUSETTS, USA

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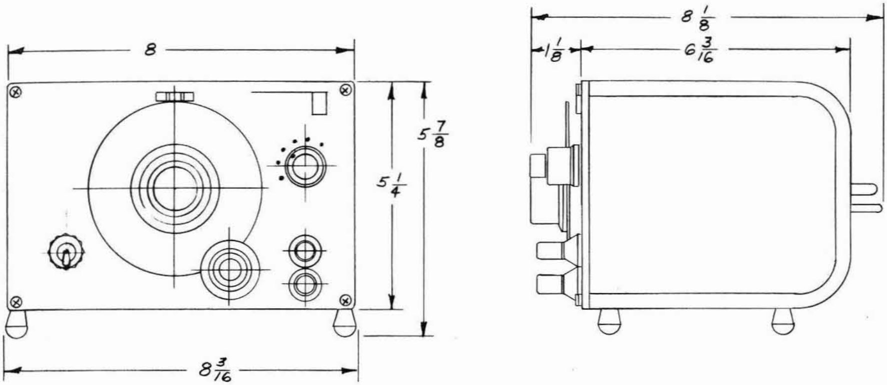


Figure 1-1. The Type 1313 Oscillator.

CONDENSED OPERATING PROCEDURE

a. Turn the **POWER** switch on.

b. Adjust the **FREQUENCY** dial to the desired frequency.

c. Set the **OUTPUT** switch to the desired output-level range. If square waves, rather than sine waves, are desired, set the **OUTPUT** switch to ⊓⊔ 5 V, p-p.

d. Adjust the **OUTPUT** control to produce the desired output level.

SECTION 1

INTRODUCTION

1.1 PURPOSE.

The Type 1313 Oscillator is a general-purpose source of sine and square waves for laboratory or production use. It features single-range coverage of the whole audio-frequency spectrum; an accurate output attenuator; low distortion, hum, and noise; rapid-transition, highly symmetric square waves; plus a synchronizing feature which allows such varied uses as filtering, leveling, frequency multiplication, jitter reduction, and slaving.

1.2 DESCRIPTION.

The all-solid state Type 1313 consists of a special wide range RC bridge oscillator, a square-wave generating circuit, a constant-impedance (600 ohms) step attenuator, and a power supply.

1.3 CONTROLS AND CONNECTORS.

The controls and connectors on the Type 1313 Oscillator are listed in Table 1-1.

TABLE 1-1
CONTROLS, CONNECTORS, AND INDICATORS

Reference (Figure 1-2)	*Name*	*Type*	*Function*
1	EXT SYNC	Input telephone jack, 2-connector.	For introducing a synchronizing or phase-locking signal from an external source.
2	POWER	Toggle switch.	Turns instrument on and off.
3	FREQUENCY	Continuously adjustable dial.	Sets output frequency.
4	FREQUENCY	Continuously adjustable vernier.	Fine frequency control (4.25:1) for FREQUENCY dial.
5	OUTPUT (larger concentric switch)	Six-position rotary switch.	A 60-dB (20 dB per step) step attenuator and output-signal selector. "0V" position removes oscillator output but maintains 600-Ω output impedance for noise measurement.
6	OUTPUT (smaller concentric control)	Continuous rotary control.	A constant-impedance bridged-T attenuator which sets output level over a 20-dB range between the steps selected by the OUTPUT switch. Full attenuation occurs in fully ccw position.
7	OUTPUT 600 Ω	3/4-inch-spaced pair.	Lower terminal grounded to chassis. (Refer to paragraph 3.3 for information on ungrounded operation.)
(Not shown)	Power input (on rear panel)	Three-terminal male connector.	For connection to power line.
(Not shown)	LINE switch (on rear panel)	Slide switch.	Selects transformer connections for input voltages as indicated by the associated legend.
8	Pilot lamp	6-V, 200-mA, size T-1 3/4.	Lights when instrument is turned on.

Figure 1-2. Controls and connectors on the Type 1313.

1.4 ACCESSORIES SUPPLIED.

The accessories supplied with the Type 1313 Oscillator are listed in Table 1-2. For a description of supplementary equipment available for use with the Type 1313, refer to the Appendix.

TABLE 1-2. ACCESSORIES

	Part Number
Instruction book	1313-0100
Power cord, 3-wire	4200-9622
Fuse, 0.125 A	5300-0450

1.5 APPLICATIONS.

1.5.1 GENERAL.

The Type 1313 is suitable for all of the general applications where audio frequency sine and square wave generators are used. Because the entire audio frequency range is covered by one dial, it is particularly useful in applications where:

1. Rapid selection of frequency is desired at widely separated frequencies in the audio spectrum.

2. Unambiguous dial setting is important. The exact output frequency of the Type 1313 is shown on the dial, complete with units and expressed the way it would normally be written, i.e., without multipliers.

3. High-speed range-changing transients must be avoided. The Type 1313 produces none of the high-amplitude pops or clicks usually associated with range changing. There are changes in amplitude as the frequency is changed quickly, but these are always slow changes of limited amplitude.

1.5.2 SWEEPING.

No provision is made for mechanical or electronic sweeping of the frequency of the Type 1313 because of the transient changes in the output amplitude as the frequency is swept. Very slow manual sweeping is possible, however, and may prove useful in some applications.

SECTION 2

INSTALLATION

2.1 ENVIRONMENT.

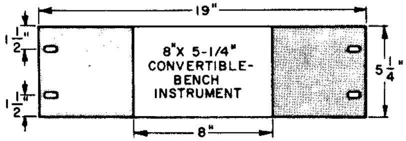
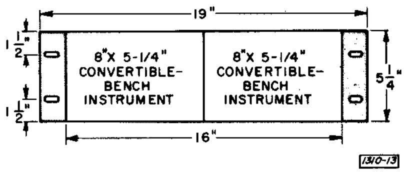
The Type 1313 is designed to operate in locations with ambient temperatures from 0° to 50°C and to be stored in locations with ambient temperatures from -40° to +70°C.

As with all low-frequency, variable-capacitance, RC oscillators, the oscillator circuit in the Type 1313 operates at impedance levels of over 1000 megohms. Consequently, circuit operation, especially frequency accuracy on the lower ranges, may be affected under conditions of very high humidity. These effects may be minimized by a warmup period long enough to permit internally generated heat to reduce the humidity within the instrument.

2.2 RACK MOUNTING.

2.2.1 RELAY-RACK ADAPTOR SETS.

The Type 1313 Oscillator can be rack-mounted, alone or with another 8- by 5 1/4-inch convertible-bench instrument, by means of the appropriate adaptor set listed below. The adaptor panels are finished in charcoal-gray crackle paint to match the front panel of the instrument and come complete with the necessary hardware to mount to the instruments and to the rack. For instructions on grounding the rack-mounted Type 1313, refer to paragraph 3.3.

Type	*Description*	*Catalog Number*
	Relay-Rack Adaptor Set used to rack-mount the Type 1313 alone.	0480-9638
	Relay-Rack Adaptor Set used to rack-mount the Type 1313 with a Type 1232, 1311, or 1396.	0480-9636

2.2.2 ATTACHMENT OF ADAPTOR SETS. (Figure 2-1).

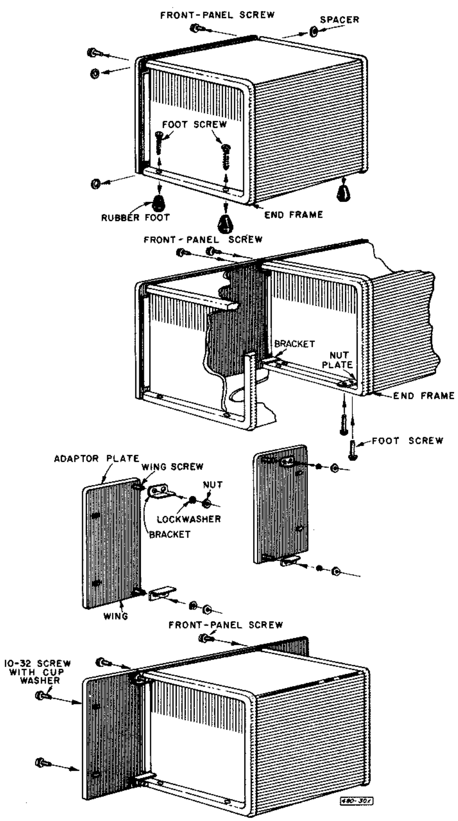


Figure 2-1. Rack mounting the Type 1313 Oscillator.

a. Remove the rubber feet, if necessary, to clear an instrument mounted below.

b. Remove the screws that secure the front panel to the aluminum end frames.

c. Remove the spacers between the front panel and the end frames.

If two instruments are to be mounted side-by-side, join them as follows:

d. On one instrument, install clips with the front-panel screws removed earlier and install the nut plates with the foot screws removed earlier.

e. Secure the two instruments together with front-panel screws through the remaining hole in each clip and with a foot screw through the remaining hole in the nut plate.

Note that the instruments can be bench-mounted side-by-side in this manner:
Simply do not remove the two feet from each outside end frame and do not install the adaptor plates.

f. Install two clips on each adaptor plate with the shorter screws, lockwashers, and nuts supplied.

g. Attach the adaptor plates to the instrument with the front-panel screws removed earlier.

h. Mount the assembly in the rack with the 10-32 screws supplied.

2.3 POWER CONNECTION.

Connect the Type 1313 to a source of ac power as follows:

a. Set the LINE switch (on the back panel) to the voltage of the power line (100-125 V or 200-250 V).

b. Connect the oscillator to the line via the 3-wire power cord supplied. The third wire of the power cord grounds the instrument frame.

The power requirement of the Type 1313 is 6 watts. For a discussion of the power connection of the instrument as it affects hum, refer to paragraph 3.3.

The Type 1313 can be operated from any external dc source, including batteries. The source requirements are:

Voltage: +38 to +52 V

Current: 50 to 55 mA for sine-wave output
55 to 60 mA for square-wave output

Power: approximately 2 watts minimum

These requirements do not include the pilot lamp, which needs 6 volts at 200 mA. The source, which should be externally fused with a 1/16-A fuse and equipped with an on-off switch, is connected to the two terminals of C501 as shown in Figures 5-3 and 5-5. The normal internal ac power supply may be left intact and used in place of the external source as desired.

SECTION **3**

OPERATING PROCEDURE

3.1 NORMAL OPERATION.

To use the Type 1313 Oscillator as a source of internally generated sine or square waves:

a. Set the FREQUENCY dial to the desired frequency.

b. Select the output signal:

(1) For sine-wave output, set the OUTPUT switch to one of the center four positions. The number corresponding to a position indicates the maximum voltage attainable at that position. Adjust the OUTPUT control for the exact voltage required. The voltage varies logarithmically from the OUTPUT switch selected voltage (control cw) to one tenth this value (control ccw).

(2) For square-wave output, set the OUTPUT switch in the fully clockwise position and adjust the OUTPUT control for the voltage required.

(3) For no output with 600-ohms output impedance maintained, set the OUTPUT switch in the 0V position. This position enables the operator to avoid the transients associated with turning the oscillator on and off and makes zero output possible with no disturbance of the OUTPUT control.

3.2 PRECISE ADJUSTMENTS.

3.2.1 FREQUENCY.

To set the frequency of the Type 1313 with an accuracy better than the ±4% accuracy obtainable with the FREQUENCY dial, use of a frequency counter such as the General Radio Type 1150 Digital Frequency Meter is recommended.

3.2.2 VOLTAGE.

To set accurately the output voltage between the calibrated steps of the OUTPUT attenuator, use of a voltmeter such as the General Radio Type 1806 Electronic Voltmeter or Ballantine Model 314 is recommended.

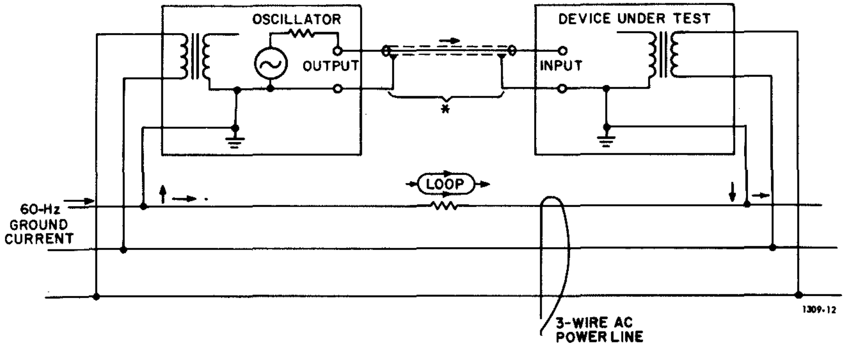


Figure 3-1. A ground loop (* 60-Hz voltage due to ground current and signal-wire shield resistance).

3.3 OUTPUT CONNECTION.

The full oscillator output is available through the front-panel OUTPUT terminals. The lower terminal, although insulated from the panel at the binding post, is internally connected to the circuit ground of the oscillator, which is in turn connected to the chassis. The chassis is normally connected to the power-line ground through the 3-wire power cord.

Hum, and extraneous signal pickup due to ground loops, may occur when the oscillator is used with other ac-line-operated equipment. These signals can be of considerable magnitude compared to the low levels available from the oscillator's attenuator.

Figure 3-1 shows a ground loop that is formed when the Type 1313 is bench mounted with another line-operated device and both use 3-wire power line connections. If there is 60-Hz ground current flowing through both sides of the loop, it can cause a voltage drop in the signal-lead ground which appears in the input of the device under test.

When the Type 1313 is used as a bench instrument, the current can usually be sufficiently reduced by operating one of the devices on a two-wire power cord (see Figure 3-2), which opens the loop.

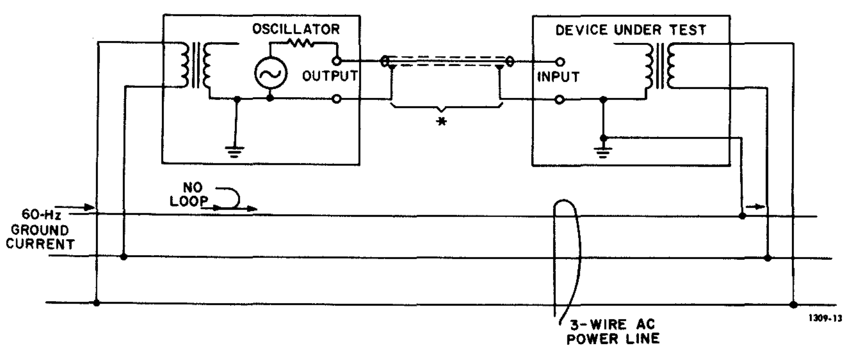


Figure 3-2. Operation of the Type 1313 with a two-wire power cord to eliminate the ground loop of Figure 3-1. (* No 60-Hz voltage, since ground current does not flow through signal-wire shield).

The "0V" position on the OUTPUT switch of the Type 1313 can be very useful in trying to reduce the effects of ground loops. Only the extraneous noise and hum appear at the device input when the oscillator is used in this position. The oscillator signal is removed, yet all of the wiring, shielding, and impedance levels connecting the two devices remain the same. The extraneous signals present are much easier to identify and measure in this case, since they are not masked by the oscillator output.

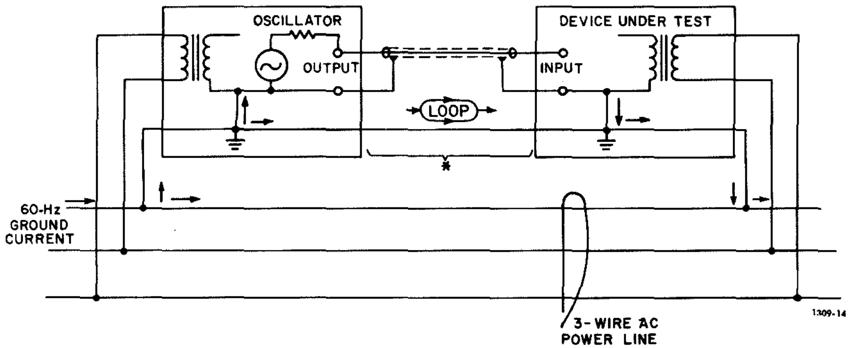


Figure 3-3. Ground loop formed when Type 1313 is rack mounted with another device, not necessarily ac-line operated (* 60-Hz voltage due to panel ground currents and resistance).

If the Type 1313 is rack mounted, the chassis will be connected to the rack frame ground and a ground loop cannot be avoided by operating the instrument with a two-wire power connection. Again, this loop may cause an appreciable amount of hum at low levels if there are 60-Hz ground currents through the rack panels (Figure 3-3).

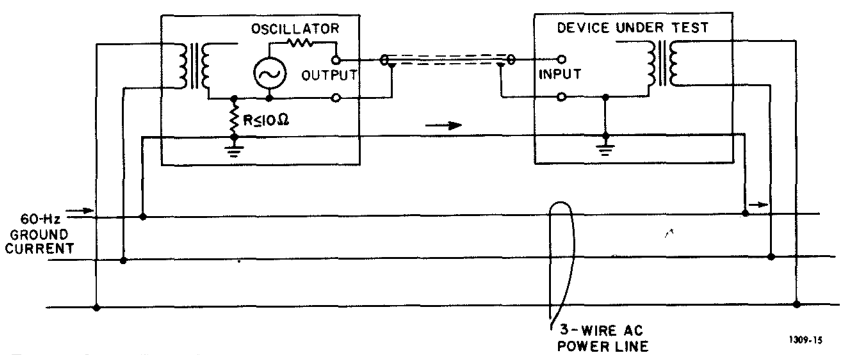


Figure 3-4. The 60-Hz voltage due to panel ground current reduced because most of voltage appears across resistance R rather than resistance of signal-wire shield.

The effect of the ground currents may be reduced by isolation of the oscillator-circuit ground from its chassis (Figure 3-4). As much as 10 ohms may be inserted to provide this isolation. A one-half watt resistor may be inserted in place of the wire lead on the etched board between AT101 and AT102 (see Figures 5-3 and 5-5). Paragraph 5.3 explains how to obtain access to the top of the board.

3.4 CHARACTERISTICS.

3.4.1 FREQUENCY RESPONSE.

The output is 5 volts, open-circuit, behind 600 ohms and is adjustable over a 60-dB range by a step attenuator (20 dB per step) and a 20-dB bridged-T constant-impedance attenuator. The output is constant within ±2% from 10 Hz to 50 kHz for loads of 600 ohms or greater. Typically, within the audio range, changes are imperceptible on the usual analog type of voltmeter.

3.4.2 FREQUENCY STABILITY.

High-stability frequency-determining components in the oscillator and low internal-power dissipation result in a stable output frequency. Drift during warm-up is typically below 0.1%.

3.4.3 NOISE.

The 60-Hz hum is less than 0.05% of full output at 1 kHz. Refer to paragraph 3.3 for a discussion of how to minimize pickup of noise from external sources.

3.4.4 DISTORTION.

Total harmonic distortion (THD) is less than 0.5% from 100 Hz to 10 kHz with a 600-Ω load or open circuited (Figure 3-5). When the attenuator is set for open-circuit voltages of 1 V or less, the load seen by the oscillator is between 600 Ω and an open circuit regardless of the size of the external load.

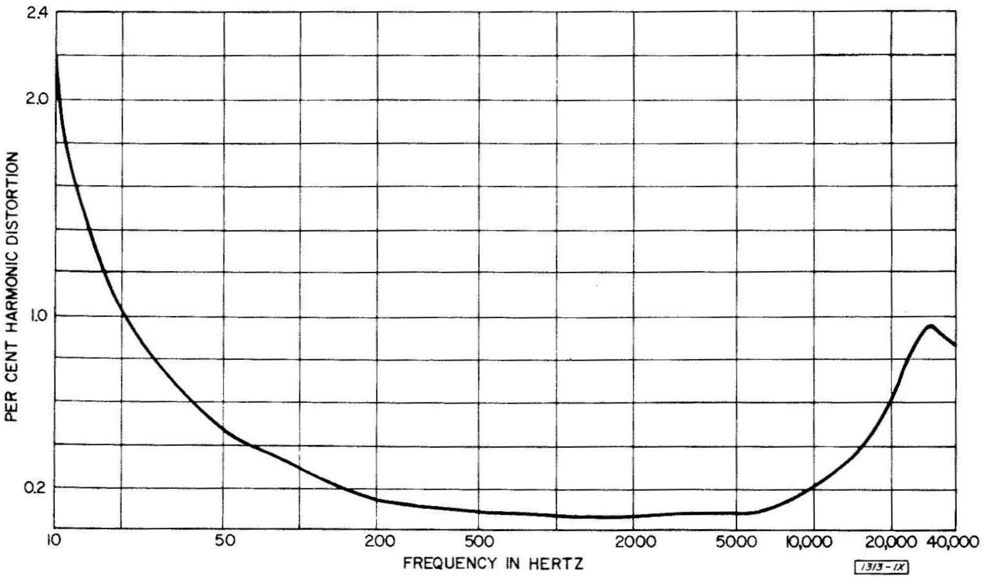


Figure 3-5. Typical harmonic distortion vs frequency of Type 1313 sine wave oscillator.

3.5 SQUARE-WAVE OUTPUT.

3.5.1 OUTPUT CHARACTERISTICS.

The square-wave output of the Type 1313 is positive-going from 0 volts to greater than +5 volts. It is dc coupled, so that there is no ramp-off. This makes the oscillator a convenient signal source for measuring the ramp-off of other circuits (see Figure 3-6). The output impedance is 600 ohms at all times during the square-wave cycle, and the voltage is variable from 0.5 to 5 volts peak-to-peak by the constant-impedance bridged-T attenuator.

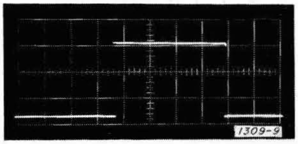


Figure 3-6. Direct-coupled 10-Hz square wave has flat top.

3.5.2 SYMMETRY.

The square-wave generator is triggered by the sine waves produced by the oscillator. It has, therefore, the same frequency accuracy and stability. The waveform is symmetrical within ±2% over the whole frequency range. The transitions take place at the zero crossing of the sine wave. If, for a particular application, nonsymmetrical pulses are required, the internal SYMMETRY control R303 (Figure 5-2) can be adjusted to trigger on a point on the sine waveform other than the zero crossing. Duty ratios of down to about 20% are possible. For a more detailed explanation of the function of this control refer to paragraph 4.4.

3.5.3 RISE TIME.

The transition times of the square waves are very fast – less than 100 ns into 50 Ω (Figure 3-7a). Still faster transitions are possible at full output and higher frequencies. The rise time is typically less than 40 ns into 50 Ω at full output and 10 kHz. The compromise between minimum rise time and acceptable overshoot may be made for a particular load by the adjustment of C302 (Figure 5-2), the internal overshoot control.

The rise time of the square wave corresponds to the response time of an amplifier with a bandwidth greater than 10 MHz. This is well beyond the bandwidth normally encountered in audio equipment, but the fast internal transition can nevertheless be used to advantage for lower frequency testing. The rise time can be externally lengthened by using the time constant (≈ 2.2 RC) of the 600-ohm output impedance and the capacitance (≈ 30 pF/foot) of

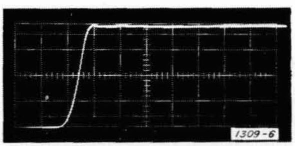


Figure 3-7a. Leading edge of 10-kHz square wave into 50-Ω load. Horizontal scale: 50 ns/div.

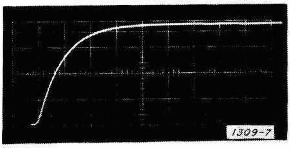


Figure 3-7b. Leading edge of 10-kHz square wave at open circuited end of cable.

the shielded cable used to connect the oscillator to the device under test. This produces a monotonically increasing leading edge with no overshoot or ripple and yet fast enough to check bandwidth up to 1 MHz. See Figure 3-7b for an example of this waveform.

A wide-bandwidth indicator system must be used to reproduce faithfully the transitions of the square waves. For a system with n individual components of specified rise time, the equation for over-all rise time is

$$T_r = \sqrt{T_1^2 + T_3^2 + \ldots . T_n^2}.$$

This means, for example, that a transition time of 50 ns would appear as a transition time of 70 ns if displayed on an oscilloscope with a 50 ns rise time.

3.6 SYNCHRONIZATION JACK.

3.6.1 GENERAL.

A telephone jack (EXT SYNC, J103) is located on the left-hand side of the oscillator. This is an input connector and is used to connect a signal to the oscillator.

3.6.2 INPUT SYNCHRONIZING CHARACTERISTIC.

The oscillator frequency may be synchronized or locked with any input signal that is applied to the EXT SYNC jack, if the oscillator is tuned to the approximate frequency of the input. The range of frequencies over which this synchronization will take place is a function of the amplitude of the frequency component to which the oscillator locks and of the oscillator frequency. It increases approximately linearly with amplitude, giving a lock range of approximately ±1% for each volt input at 10 Hz and more than ±10% for each volt input at 50 kHz.

The oscillator maintains synchronization within the lock range if either the oscillator dial frequency or the synchronizing frequency is changed. However, there is a time constant of about one second associated with the synchronization mechanism. Thus if the amplitude or frequency of the sync signal or the dial setting of the oscillator is changed, there will be transient changes in amplitude and phase for a few seconds before the oscillator returns to steady-state synchronization.

This time constant is caused by the thermistor amplitude regulator as it readjusts to the different operating conditions. The thermistor is sensitive to changes in average values of frequency or amplitude only, where the averaging time is in the order of seconds. Hence, frequency-modulated and amplitude-modulated sync signals, which have a constant average value of frequency and amplitude over a period of a second or less, are not affected by this time constant.

For slow changes in frequency or amplitude, the lock range and the capture range are the same; i.e., the frequency or amplitude at which the oscillator goes from the synchronized state to the unsynchronized state is the same as when it goes from the unsynchronized state to the synchronized state. Synchronization is truly phase locking, that is, it maintains a constant phase difference between the sync input and the oscillator output. The phase difference is 0° when the dial frequency is identical to the sync frequency and approaches ±90° as the frequency approaches the limits of the locking range. Note that the phase difference is also a function of the amplitude of the sync signal because the lock range is a function of the amplitude (see Figure 3-8).

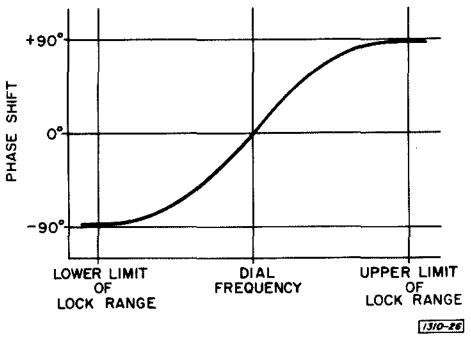


Figure 3-8. Phase shift relative to input frequency (and amplitude).

The input impedance of the EXT SYNC jack is 330 kΩ at all frequencies except the synchronizing frequency. At the synchronizing frequency the impedance, in general, is complex and can vary over a wide range including negative values because the jack is also a source at the synchronizing frequency.

3.6.3 INPUT FREQUENCY SELECTIVITY.

The RC network in the oscillator used to determine the frequency of oscillation and to reduce hum, noise, and distortion can also be used to filter signals applied externally. Signals applied to the EXT SYNC jack, which are close to the frequency of synchronization, will be amplified in the output but those frequencies distant from the frequency of synchronization will be reduced.

3.6.4 SYNCHRONIZATION OF SQUARE-WAVE OUTPUT WITH EXTERNAL SIGNAL.

The square waves produced by the Type 1313 can be synchronized to an external signal in the same manner as can sine waves. The internal oscillator locks onto the signal at the EXT SYNC terminals in the manner described above, and the resulting sine wave triggers the square-wave generator to produce a synchronized signal. Thus a synchronous output signal whose shape and amplitude is independent of the shape of the input signal is generated. This characteristic will prove useful in, for instance, the generation of harmonics of the original signal.

SECTION **4**

PRINCIPLES OF OPERATION

4.1 GENERAL.

As shown in Figure 4-1, the Type 1313 Oscillator is a capacitively tuned RC bridge oscillator. Z_1 and Z_2 are ladder networks of parallel resistances and capacitances, whose values are selected so that the impedance of Z_1 and Z_2 decreases as a function of frequency.

The 5-V output of the oscillator is switched either to be attenuated by a 60-dB step attenuator or (in the 5 V p-p square-wave position) to drive a modified high-speed Schmitt circuit, which generates a very fast (less than 100-ns rise time) square wave. The square wave is dc coupled to the output through the 0- to 20-dB adjustable attenuator.

The EXT SYNC jack connects to the negative feedback loop of the oscillator.

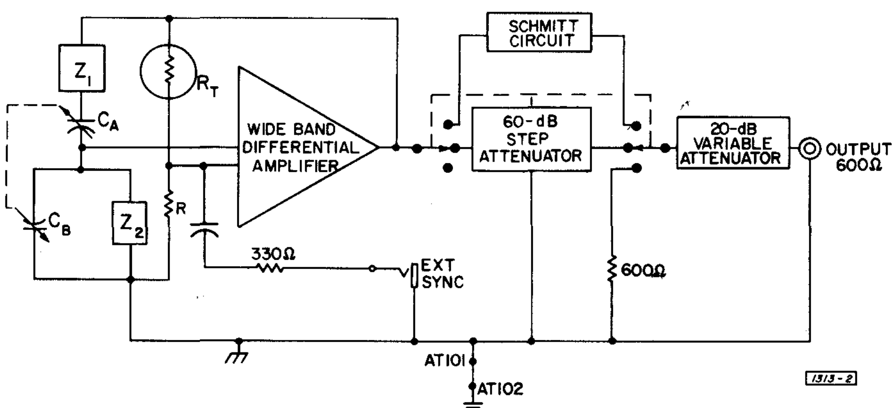


Figure 4-1. Block diagram of the Type 1313 Oscillator.

4.2 THE OSCILLATOR.

The oscillator circuit is shown in simplified form in Figure 4-2. The bridge can be thought of as consisting of two parts: a frequency-determining network (C_A, C_B, Z_1, Z_2), which supplies positive feedback to sustain oscillation; and a voltage divider (R_1 and R_2), from which is taken negative feedback to stabilize the amplitude. The resonant frequency of the oscillator is f_o, where

$$f_o = \frac{1}{2\pi |Z| C}, \quad |Z| = |Z_1| = |Z_2|, \quad C = C_A = C_B.$$

f_o, then, is determined by the ganged variable capacitors, C_A and C_B, and Z_1 and Z_2. The components r_i and c_i are chosen to make Z decrease with frequency. The rate of change of the impedance Z is adjusted so that a 10:1 change in capacitance C_A and C_B changes oscillator frequency from 10 Hz to 50 kHz.

The resistive divider, R1 and R2, is used to set the gain of the associated amplifier so that the net gain of the bridge-amplifier loop is +1 at the frequency f_o. The resistance of thermistor R1 adjusts to the value needed to maintain constant amplitude oscillation. The time constant of the thermistor is short enough to provide a rapid correction for

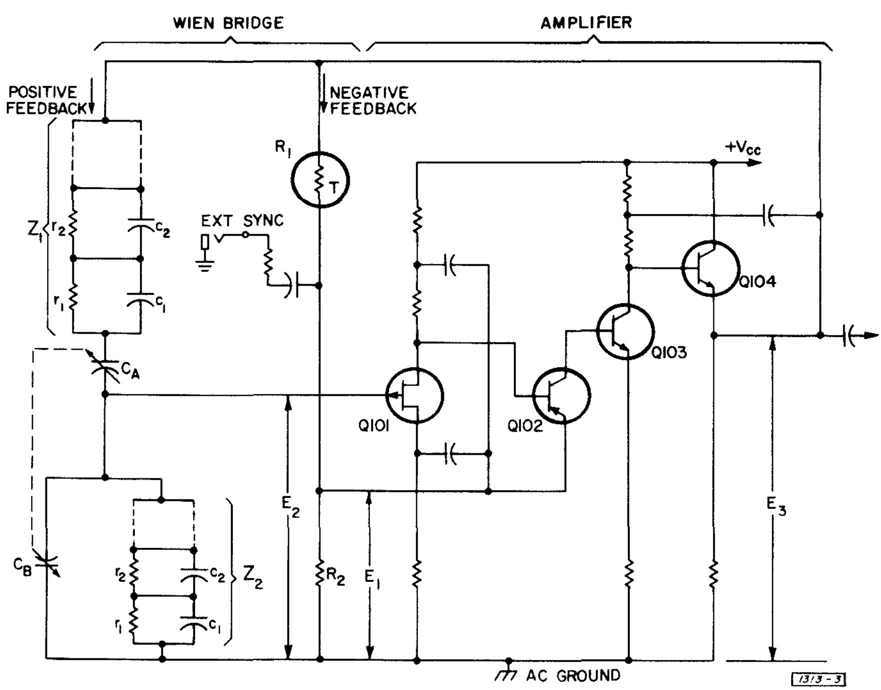


Figure 4-2. Simplified schematic diagram of the RC oscillator circuit used in the Type 1313.

amplitude variations, but long enough to cause little distortion at the lower frequencies. (The thermistor operates at a high temperature in an evacuated bulb, to minimize the effects of ambient temperature.)

4.3 THE OSCILLATOR AMPLIFIER.

The first stage of the oscillator amplifier (shown in simplified form in Figure 4-2) consists of a field-effect transistor, Q101, connected as a source-follower, the drain of which is coupled to the emitter of the following transistor Q102. This effectively degenerates any gate-to-drain impedance, thereby raising the input impedance.

Q101 is followed by PNP transistor Q102, which serves, in combination with Q101, as a differential amplifier for E_{in}, the difference between positive feedback voltage E_1 and negative feedback voltage E_2.

The next two stages are NPN transistors: Q103, in common-emitter configuration, and Q104, operating as an emitter-follower.

The oscillator has over 60 dB of negative feedback, which produces three results: low distortion, very high input impedance, and very low output impedance.

Both the signal output and the positive feedback for the Wein bridge are taken from the emitter of Q104. The sine-wave output signal is transmitted through a 600-μF coupling capacitor to switch S201, which controls a 60-dB step attenuator in the first four positions and connects, in the fully clockwise position, the square-wave generating circuit to the oscillator output. The output from the step attenuator is applied to the output jack via a 20-dB, constant-impedance bridged-T attenuator, R205 through R208.

The dc operating conditions are maintained by the negative dc feedback divider R108 and R109. The proper bias level is set with R102. The complete circuit of the oscillator appears in Figure 5-5.

4.4 THE SQUARE-WAVE GENERATING CIRCUIT.

The square-wave generator (see Figure 5-5) is a modified Schmitt circuit consisting of two emitter-coupled PNP transistors, Q301 and Q302. The circuit works in the following way: An input signal slightly more negative than the emitter voltage of Q301, applied to the base of Q301, causes it to turn on (conduct). This forms a positive-going signal at the collector of Q301 and the base of Q302. This positive signal causes Q302 to conduct less, which causes the voltage at the emitter of Q301 to rise. The rising emitter voltage causes Q301 to conduct all the harder. The result is a regenerative process which leaves Q301 conducting heavily and Q302 conducting not at all. When the input signal goes a bit more positive than the voltage on Q301's emitter, a similar regenerative process occurs which leaves Q301 off and Q302 on.

Trimmer C302 is a speed-up capacitor which determines how rapidly Q302 switches on and off, and thereby the shape of the output waveform which appears at the collector of Q302.

For maximum switching speed, Q301 is prevented from saturating by the network including CR301 and CR302. Diode CR303 prevents the base-emitter voltage of Q301 from becoming excessive during the positive swing of the input signal. The exact point on the input waveform at which the switching of Q301 takes place is set by R303, the SYMMETRY control, which adjusts the bias at the base of Q301.

4.5 THE POWER SUPPLY.

The power supply, (see Figure 5-5) consists of a full-wave rectifier (CR501 and CR502) followed by a pi-section filter (R501 and C501, A and B) and a constant-voltage regulator (Q501). The base voltage of Q501 is held fixed at +33 volts by Zener diode CR503; the emitter, therefore, is held at a fixed voltage. The power transformer T501 is wired so that either a 115-volt or a 225-volt ac power source can be used, depending on the setting of S502, the LINE switch.

SECTION 5

SERVICE AND MAINTENANCE

5.1 WARRANTY.

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards, after examination by our factory, Sales Engineering Office, or authorized repair agency personnel, will be repaired or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

5.2 SERVICE.

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest Sales Engineering Office, requesting a Returned Material Tag. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

5.3 ACCESS TO COMPONENTS.

To remove the cover of the Type 1313, turn the two knurled nuts on the rear of the cover counterclockwise and pull the cover straight back and off.

To obtain access to the components on the etched board, disconnect from the etched board the six wires that are connected to the FREQUENCY range switch, remove the two securing screws, and swing the board up. (See Figure 5-1).

5.4 MINIMUM PERFORMANCE SPECIFICATIONS.

The check of specifications outlined in Table 5-1 is recommended for incoming inspection or periodic operational testing. Detailed procedures are given in the Calibration Procedure, paragraph 5.7.

Conditions: 115-V line, 30-minute warmup.

5.5 TROUBLE-SHOOTING NOTES.

Tables 5-2 and 5-3 offer means of isolating the more straight-forward difficulties that might occur in the Type 1313-A. Additional trouble-shooting information is contained in the Calibration Procedure, paragraph 5.7, and on the schematic diagram, Figure 5-5.

In all cases, except total failures such as a blown fuse, first check the power supply voltages and dc operating level. These must be correct for proper operation.

NOTE: Always allow a 30-minute warmup before making any final adjustments.

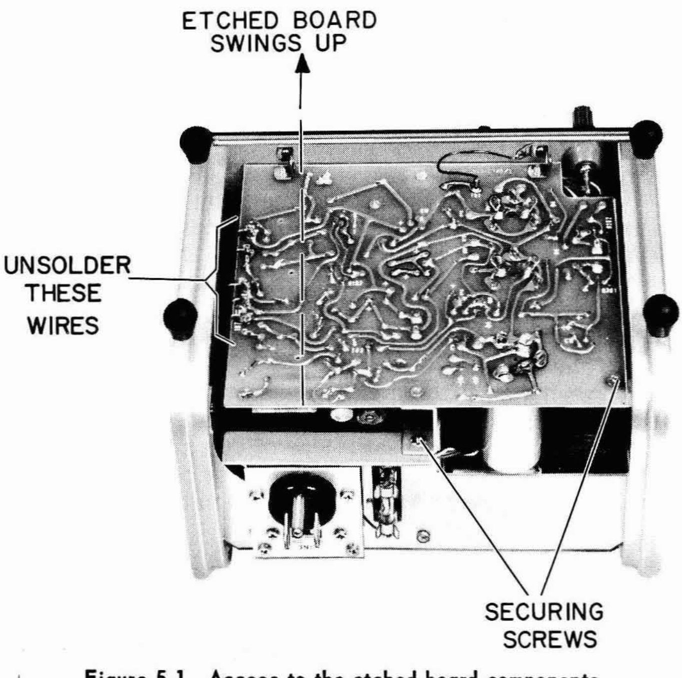


Figure 5-1. Access to the etched-board components.

TABLE 5-1
MINIMUM PERFORMANCE SPECIFICATIONS

OUTPUT LEVEL			*FREQUENCY*	
Check	*Switch*	*Control*	*Dial Setting*	*Specifications*
Sine wave Output level	5 V	fully cw	1 kHz	5 ±0.25 V rms (open circuit)
Frequency	5 V	fully cw	each major division at multiples of 1, 2, 5 from 10 Hz to 50 kHz	±4% of indicated value
Distortion	5 V	fully cw	100 Hz 10 kHz	< 0.5% < 0.5%
Hum	5 V	fully cw	1 kHz	< 0.05%
Output power	5 V	fully cw	1 kHz	≥ 2.45 V into 600 Ω (10 mW)
Output response	5 V		1 kHz	Use voltmeter to set initial level. *
Square wave	⊓⊔ 5 V p-p			
Rise time		fully cw	10 kHz	< 100 ns into 50 Ω
Symmetry		fully cw	1 kHz	±2% (48 - 52% duty ratio) on scope trace, or less than 6% 2nd harmonic component to fundamental.
Output		fully cw	1 kHz	≥ 5 V p-p

* Refer to Table 5-6.

TABLE 5-2 SPOT CHECK OF IMPORTANT VOLTAGE LEVELS

Supply	*Voltage*		*Test Point*
Power	+32	V DC	Emitter Q501
DC bias	+18.0	V DC	TP A

TABLE 5-3
TROUBLE SYMPTOMS AND THEIR CAUSES
(See Figures 5-2 through 5-5 for component locations.)

Inaccurate frequency	Extreme high end of range: misadjustment of C105. Extreme low end of range: misadjustment of C415. Error in same direction throughout range: FREQUENCY dial misalignment. Varies through range: C_A and/or C_B misadjusted. Refer to paragraph 5.7.5 for adjustment procedure
Excessive distortion	DC bias improper, adjust R102 for +18 V at TP A.
Excessive hum	Power supply not regulating properly.
Poor response	(Output varies with frequency) R111 (thermistor) or grossly improper frequency adjustments, refer to paragraph 5.7.5 for adjustment procedure.
Instability or excessive noise	Dust between plates of C401 or wiper dirty or otherwise making poor contact.

TABLE 5-4
OPEN-LOOP VOLTAGES AND WAVEFORMS IN THE OSCILLATOR AMPLIFIER

Test Point	*Voltage (peak-to-peak)*
AT109	60 mV
AT110	30 mV
Q101, drain and source	30 mV
Junction of R105, C103	30 mV
AT108	30 mV
Q102, collector	40 mV
Q103, emitter	30 mV
Q103, collector	14 V
Q104, emitter	14 V
Junction of R115, C110	14 V
AT111	14 V

Voltages are approximate. Actual voltages may vary 2 to 1 in individual instruments.

5.6 AMPLIFIER OPEN-LOOP TESTING.

The amplifier uses a large amount of ac feedback, so that trouble at any one point in the circuit will manifest itself at most other points. For this reason it may be difficult to isolate a failure under closed-loop conditions; therefore, the following open-loop test is recommended:

a. Unsolder the lead to AT111 on the etched board and unsolder one end of the thermistor, R111, to open the ac feedback path (see Figure 5-4).

b. Set the controls of the Type 1313 as follows:
FREQUENCY . . . 10 kHz
OUTPUT switch . . . 5 V
OUTPUT control . . . fully cw

c. Apply a 60-mV, p-to-p, 1-kHz signal to the EXT SYNC jack, J401.

d. Trace the signal through the amplifier with an oscilloscope, using a short, low-capacitance, high-impedance probe to prevent spurious oscillation.

The voltages observed should agree with those of Table 5-4, and the waveforms should all be sine waves.

5.7 CALIBRATION PROCEDURE.

5.7.1 INTRODUCTION.

This procedure can be used for trouble shooting or calibration.

If used for trouble shooting, the steps can be performed in any order. The usual practice would be to perform only the step that pertains to the suspected circuit.

If used for calibration, the steps should be performed in sequence since one step serves as a foundation for the next. A complete calibration insures that all circuits are operating properly and within specifications. The Type 1313 Oscillator incorporates the high reliability one would expect of conservatively designed, semiconductor circuits and routine calibrations are unnecessary.

5.7.2 EQUIPMENT.

The following equipment is required for a complete calibration of the Type 1313 Oscillator. The specifications given for the equipment are those necessary for the calibration of the Type 1313 and are not necessarily those of the recommended equipment.

Metered, adjustable autotransformer

Output: 105 to 125 V (or 195 to 235 or 210 to 250 V), 12 W.
Meter: Ac, ±3% accuracy.
The Type W5MT3W Metered Variac® Autotransformer is recommended.

Electronic voltmeter

Voltage: 0 - 50 V, dc; 5 mV - 5 V ac, rms, 10 Hz - 100 kHz, ±2% accuracy,
Impedance: 100 kΩ or greater.

Digital frequency meter (counter)

Frequency: 10 Hz to 100 kHz, ±0.1% accuracy.
Sensitivity: 1 V, rms.
Impedance: 100 kΩ or greater.
The Type 1151 Digital Time and Frequency Meter or the Type 1142 Frequency Meter and Discriminator is recommended.

The frequency accuracy of the Type 1313 is ±4%. The counter accuracy should be at least 20 times this, or 0.2%, to prevent counter errors from entering into the measurements. The ±one-count uncertainty in a counter with a 100-kHz time base represents an error of greater than 0.1% unless the measurement conditions are as follows:
above 1000 Hz; direct frequency measurement, 1-second counting interval;
below 1000 Hz; period measurement, 10-period count.

Oscilloscope

Bandwidth: dc to 30 MHz (-3-dB points)
Sensitivity: 50 mV.
Impedance: 100 kΩ or greater.
The Tektronix Type 543/543A Oscilloscope with a Type CA Plug-in and Type P6000 Probe is recommended.

Wave Analyzer and/or Distortion Meter

Frequency: 100 Hz to 50 kHz.
Sensitivity: 50 μV to 5 V.
Impedance: 100 kΩ or greater.
The Type 1900 or Type 1568 Wave Analyzer and/or the Hewlett Packard Type 334-A Distortion Meter are recommended.

Test Oscillator

Frequency: 1 kHz.
Amplitude: 1 V into 25 kΩ.
The Types 1309, 1310, 1311, and 1313 Oscillators are recommended.

Load resistors

50 Ω ±1%, 1 W. The Type 500-C Resistor is recommended.
600 Ω ±1%, 1 W. The Type 500-G Resistor is recommended.

Cables

Telephone-plug to double plug. The Type 1560-P95 Cable is recommended.

5.7.3 POWER SUPPLY AND BIAS VOLTAGES.

Connect the Type 1313 to an ac line via a metered adjustable auto-transformer and set the transformer for 115-V output. Set the Type 1313 controls as follows:

FREQUENCY . . . 1 kHz
OUTPUT switch . . . 5 V
OUTPUT control . . . fully cw

Power Supply. Connect a voltmeter to the emitter of Q501. Voltage should be 32 ±2 volts dc. If not, check CR503 and replace if necessary.

Bias. Connect a voltmeter to TP A and adjust R102 for +18 V dc.

Ripple. Connect the oscilloscope to the emitter of Q501 and check ripple at 100, 115, and 125-V line; must be less than 100 mV, p-to-p.

Allow a 30-minute warmup then recheck the adjustment of R102

5.7.4 OUTPUT LEVEL.

FREQUENCY . . . 1 kHz
OUTPUT . . . 5 V
OUTPUT control . . . fully cw

Maximum output. Connect a voltmeter to the OUTPUT terminals and adjust R112 for 5 V, rms. The instrument should be on for at least 30 minutes before this adjustment is made.

OUTPUT control operation. Vary the OUTPUT control over its full range; the output level must change smoothly. If it does not, the OUTPUT potentiometer, R205, is noisy and should be replaced.

5.7.5 FREQUENCY.

OUTPUT switch . . . 5 V
OUTPUT control . . . fully cw

Flatness adjustment. Connect the oscilloscope to the OUTPUT terminals of the Type 1313. Vary the FREQUENCY control of the Type 1313 back and forth between 10 kHz and 20 kHz while watching the oscilloscope. The amplitude of the sine wave may vary as the frequency is varied. If necessary, adjust C402 and C403 (through the end of the left-hand panel) with a non-metallic screwdriver for minimum variation in amplitude vs frequency.

Sweep the FREQUENCY control rapidly from greater than 20 kHz to less than 50 Hz while watching the oscilloscope. The sine wave must recover its amplitude immediately after the dial has stopped turning. Repeat this test, going from less than 50 Hz to greater than 20 kHz. If necessary, readjust C402 and C403.

1-kHz mechanical adjustment. Connect the counter to the OUTPUT jack and set the FREQUENCY dial for a frequency count of exactly 1.000 kHz. Loosen the set screws on the FREQUENCY dial and position the dial on the shaft to read exactly 1 with a reading of 1.000 kHz on the counter. Snug-up the set screws but do not tighten.

10-kHz capacitor adjustments. Set the FREQUENCY dial to exactly 10 kHz. Adjust C402 and C403 equally for counter-frequency reading of exactly 10 kHz. (For example, if the frequency at 10 kHz is found to be 11 kHz, adjust C402 until the counter indicates 10.5 kHz, then adjust C403 for 10.0 kHz. This preserves the flatness adjustment.) The previous mechanical adjustment and this capacitor adjustment interact: repeat until both the frequencies are correct.

100-Hz mechanical adjustment. Turn the frequency control to 100 Hz and, if necessary, slip the dial for an indication of the frequency meter of 100 ±4%. Repeat the adjustments at 1 kHz, 10 kHz, and 100 Hz until the frequency at each setting is within 4% of the dial indication.

50-kHz adjustment. Set the FREQUENCY control to 50 kHz and, if necessary, adjust C105 for a counter frequency reading of from 50 kHz to 51.5 kHz. If this cannot be accomplished by adjustment of C105 only, adjust C402 and C403 equally for a counter indication of 50 to 51.1 kHz, then repeat the 1-kHz, 10-kHz, and 100-Hz adjustments.

10-Hz adjustment. Turn the FREQUENCY control fully clockwise. The period of the sine wave as indicated by the counter should be greater than 100 ms. Adjust C415, if necessary, to obtain the correct period, then recheck the 100-Hz and 1-kHz frequency settings.

TABLE 5-5
FREQUENCY CHECK

FREQUENCY	*Counter Reading*		*Remarks*
1 kHz	Frequency:	960 to 1040 Hz	Mechanically position
500 Hz	Frequency:	480 to 520 Hz	FREQUENCY dial
2 kHz	Frequency:	1920 to 2080 Hz	
200 Hz	Frequency:	192 to 208 Hz	
10 kHz	Frequency:	9600 to 10,400 Hz	Adjust C402 and C403
100 Hz	Ten period:	10.4 to 9.6 ms	Reposition FREQUENCY
20 kHz	Frequency:	19,2000 to 20,800 Mz	dial, if necessary
50 kHz	Frequency:	50 kHz to 52 kHz	Adjust C105
50 Hz	Ten period:	21 to 19 ms	
10 Hz	One period:	108 to 92 ms	Adjust C415

5.7.6 DISTORTION.

FREQUENCY . . . 100 Hz and 10 kHz
OUTPUT switch . . . 5 V
OUTPUT control . . . fully cw

100 Hz. Disconnect the counter from the OUTPUT terminals and connect the wave analyzer and the 600-Ω load resistor in its place. Measure the second- and third-harmonic components (200 and 300 Hz) or the fundamental frequency. Total harmonic distortion (THD) should be less than 0.5%.

$$\text{THD} = \sqrt{(\text{second-harmonic distortion})^2 + (\text{third-harmonic distortion})^2}$$

1 kHz. Set the FREQUENCY control of the Type 1313 to 1 kHz and measure the second- and third-harmonic components (2 kHz and 3 kHz). THD should be less than 0.5%.

10 kHz. Set the FREQUENCY control to 10 kHz and measure the second- and third-harmonic components (20 kHz and 30 kHz). THD should be less than 0.5%.

These measurements can also be made with a distortion meter.

5.7.9 OUTPUT RESPONSE.

Connect the 600-ohm load resistor and the voltmeter to the OUTPUT terminals and check as follows:

TABLE 5-6
OUTPUT RESPONSE

FREQUENCY	*Output Voltage, rms*
1 kHz	Set OUTPUT controls for exactly 2.5 V
500 Hz	2.55 to 2.4 V
100 Hz	2.55 to 2.4 V
10 Hz	2.55 to 2.4 V
10 kHz	2.55 to 2.4 V
50 kHz	2.55 to 2.4 V

5.7.10 CALIBRATION PROCEDURE FOR SQUARE-WAVE OUTPUT.

5.7.10.1 Symmetry.

FREQUENCY range . . . 100 Hz - 1 kHz
FREQUENCY dial . . . 10
OUTPUT switch . . . 5 V p-p
OUTPUT control . . . cw

Adjustment of R503. Connect the 50-Ω load resistor and the wave analyzer to the output of the Type 1313. Measure the second-harmonic component (2 kHz) of the square wave. Adjust R303 (Figure 5-3) to minimize this component.

5.7.10.2 Square-wave Checks.

Rise-time adjustment.

FREQUENCY . . . 50 kHz
OUTPUT switch . . . 5 V p-p
OUTPUT control . . . cw

With the oscilloscope observe the output of the Type 1313 into the 50-Ω load resistor. Set the scope controls as follows:
Dual trace operation (MODE) . . . one channel only
Volts/div . . . 0.1 V
Time/div . . . 10 μs

Adjust C302 (Figure 5-3) for minimum overshoot and fastest rise time on the leading edge. There should be no noticeable ringing.

Measure the rise time of the square wave. It should be less than 100 μs.

Output Amplitude. Remove the 50-Ω load resistor and measure the unloaded square-wave output. It should be at least 5 volts peak-to-peak.

Droop.

FREQUENCY . . . 10 Hz

Observe the square wave on the oscilloscope. There should be no measurable droop or ramp-off.

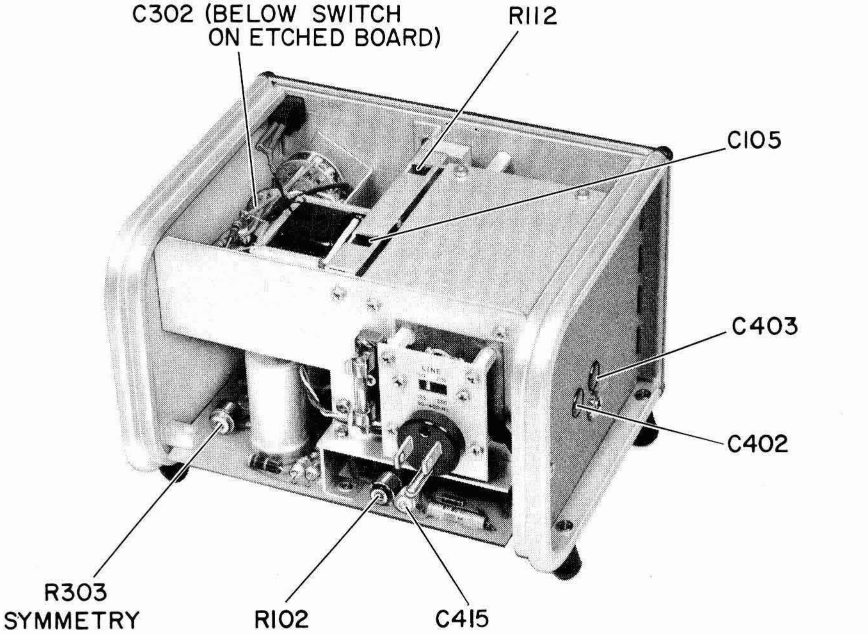


Figure 5-2. Top interior view of the Type 1313-A Oscillator.

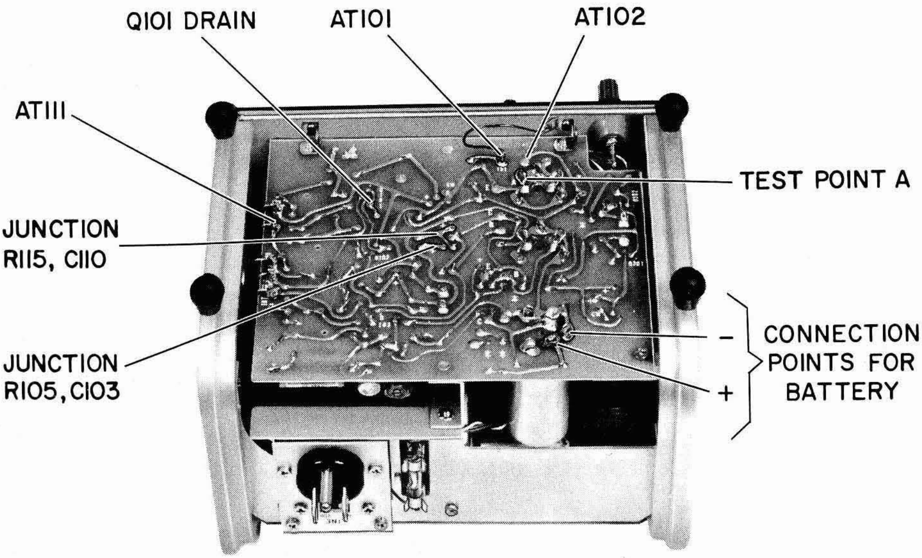


Figure 5-3. Bottom interior view.

PARTS LIST

CAPACITORS

Ref No.	Description	Part No.
C101	Electrolytic, 15 μF +100-10% 15 V	4450-3700
C102	Electrolytic, 15 μF +100-10% 15 V	4450-3700
C103	Electrolytic, 15 μF +100-10% 15 V	4450-3700
C104	Electrolytic, 10 μF +100-10% 25 V	4450-3800
C105	Trimmer, 5-25 pF	4910-1150
C106	Mica, 68 pF ±5%	4700-0371
C107	Ceramic, 0.1 μF ±20% 50 V	4403-4100
C108	Electrolytic, 200 μF ±100% 6 V	4450-2610
C109A,B	Electrolytic, 300-300 μF 35 V	4450-2400
C110	Electrolytic, 15 μF +100-10% 25 V	4450-3800
C111	Ceramic, 470 pF ±10%	4404-1478
C301	Electrolytic, 10 μF +100-10% 25 V	4450-3800
C302	Trimmer, 8-50 pF	4910-1170
C401	Variable, Air FREQUENCY	1210-4000
C402	Trimmer, 5.5-18 pF	4910-2041
C403	Trimmer, 5.5-18 pF	4910-2041
C404	Mica, 39 pF ±5%	4640-0200
C405	Mica, 137 pF ±1%	4710-0137
C406	Mica, 137 pF ±1%	4710-0137
C407	Mica, 267 pF ±1%	4710-0447
C408	Mica, 267 pF ±1%	4710-0447
C409	Mica, 453 pF ±1%	4710-0524
C410	Mica, 453 pF ±1%	4710-0524
C411	Mica, 787 pF ±1%	4710-0787
C412	Mica, 787 pF ±1%	4710-0787
C413	Mica, 634 pF ±1%	4710-0631
C414	Mica, 649 pF ±1%	4710-0630
C415	Trimmer, 7-25 pF	4910-2032
C501A,B	Electrolytic, 200-200 μF 50 V	4450-5591
C502A,B	Electrolytic, 300-300 μF 35 V	4450-2400

RESISTORS

Ref No.	Description	Part No.
R101	Composition, 22 kΩ ±5% 1/2 W	6100-3225
R102	Potentiometer, composition 25 kΩ ±20% BIAS	6040-0800
R103	Composition, 22 kΩ ±5% 1/2 W	6100-3225
R104	Composition, 12 kΩ ±5% 1/4 W	6100-3125
R105	Composition, 47 kΩ ±5% 1/2 W	6100-3475
R106	Composition, 51 kΩ ±5% 1/2 W	6100-3515
R107	Composition, 27 kΩ ±5% 1/2 W	6100-3275
R108	Composition, 3.3 kΩ ±5% 1/2 W	6100-2335
R109	Composition, 15 kΩ ±5% 1/2 W	6100-3155
R110	Composition, 620 Ω ±5% 1/2 W	6100-1625
R111	Thermistor, 35 kΩ ±20%	6741-2023
R112	Potentiometer, composition, 500 Ω ±20%	6040-0300
R113	Composition, 10 kΩ ±5% 1/2 W	6100-3105
R114	Composition, 620 Ω ±5% 1/2 W	6100-1625
R115	Composition, 5.6 kΩ ±5% 1/2 W	6100-2565
R116	Composition, 1 kΩ ±5% 1/2 W	6100-2105
R117	Composition, 100 Ω ±5% 1/2 W	6100-1105
R118	Composition, 2.4 kΩ ±5% 1/2 W	6100-2245
R119	Composition, 510 Ω ±5% 1 W	6110-1515
R201	Film, 665 Ω ±1% 1/2 W	6450-0665
R202	Film, 6.65 kΩ ±1% 1/2 W	6450-1665
R203	Film, 66.5 kΩ ±1% 1/2 W	6450-2665
R204	Film, 604 kΩ ±1% 1/2 W	6450-3604
R205A,B	Potentiometer, form, with R206-R208, a constant-impedance attenuator OUTPUT	6045-1100
R206	Composition, 620 Ω ±5% 1/2 W	6100-1625

PARTS LIST (cont)

Ref No.	Description	Part No.
R207	Composition, 620 Ω ±5% 1/2 W	6100-1625
R208	Composition, 36 Ω ±5% 1/2 W	6100-0365
R301	Composition, 1.2 kΩ ±5% 1/2 W	6100-2125
R302	Composition, 15 kΩ ±5% 1/2 W	6100-3155
R303	Potentiometer, composition, 2.5 kΩ ±20% SYMMETRY	6040-0500
R304	Composition, 10 kΩ ±5% 1/2 W	6100-3105
R305	Composition, 22 kΩ ±5% 1/2 W	6100-3225
R306	Composition, 620 Ω ±5% 1/2 W	6100-1625
R307	Composition, 2 kΩ ±5% 1/2 W	6100-2205
R308	Composition, 100 Ω ±5% 1/2 W	6100-1105
R309	Composition, 11 kΩ ±5% 1/2 W	6100-3115
R310	Composition, 4.7 kΩ ±5% 1/2 W	6100-2475
R401	Film, 18.2 kΩ ±1% 1/2 W	6450-2182
R402	Film, 18.2 kΩ ±1% 1/2 W	6450-2182
R403	Film, 66.5 kΩ ±1% 1/2 W	6450-2665
R404	Film, 66.5 kΩ ±1% 1/2 W	6450-2665
R405	Film, 226 kΩ ±1% 1/2 W	6450-3226
R406	Film, 226 kΩ ±1% 1/2 W	6450-3226
R407	Film, 887 kΩ ±1% 1/2 W	6450-3887
R408	Film, 887 kΩ ±1% 1/2 W	6450-3887
R409	Film, 3.65 MΩ ±1% 1/2 W	6450-4365
R410	Film, 3.65 MΩ ±1% 1/2 W	6450-4365
R411	Film, 1.33 MΩ ±1% 1/2 W	6450-4133
R412	Film, 1.33 MΩ ±1% 1/2 W	6450-4133
R413	Film, 71.5 mΩ ±1% 1 W	6189-5715
R414	Film, 71.5 MΩ ±1% 1 W	6189-5715
R501	Composition, 47 Ω ±5% 1 W	6110-0475
R502	Composition, 2.7 kΩ ±5% 1/2 W	6100-2275
R503	Composition, 10 Ω ±5% 1/2 W	6100-0105

DIODES

Ref No.	Description	Part No.
CR301	Rectifier, high-speed, Type 1N4009	6082-1012
CR302	Zener, 27-V, Type 1N971B	6083-1049
CR303	Rectifier, high-speed, Type 1N4009	6082-1012
CR501	Rectifier, Type 1N4003	6081-1001
CR502	Rectifier, Type 1N4003	6081-1001
CR503	Zener, 33-V, Type 1N973B	6083-1036

MISCELLANEOUS

Ref No.	Description	Part No.
F501	FUSE, Slo-Blo, 0.125 A	5330-0450
J201	Type 938 Jack-top binding post Ground	0938-3000
J202	Type 938 Jack-top binding post OUTPUT	0938-3000
J401	JACK, Telephone, 2-connector EXT SYNC	4260-1260
P501	LAMP, Pilot, 6V, 200 mA, size T-1 3/4	5600-1001
PL501	PLUG, Power	4240-0700
Q101	TRANSISTOR, Type U-147, field effect	8210-1090
Q102	TRANSISTOR, Type 2N2188	8210-1045
Q103	TRANSISTOR, Type 2N3416	8210-1047
Q104	TRANSISTOR, Type 2N697	8210-1040
Q301	TRANSISTOR, Type 2N2188	8210-1045
Q302	TRANSISTOR, Type 2N2188	8210-1045
Q501	TRANSISTOR, Type 2N697	8210-1040
S201	SWITCH, Rotary, 6-position OUTPUT	7890-4210
S501	SWITCH, Toggle, POWER OFF	7910-1300
S502	SWITCH, Slide, LINE	7910-0831
T501	TRANSFORMER, Power	0745-4380

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

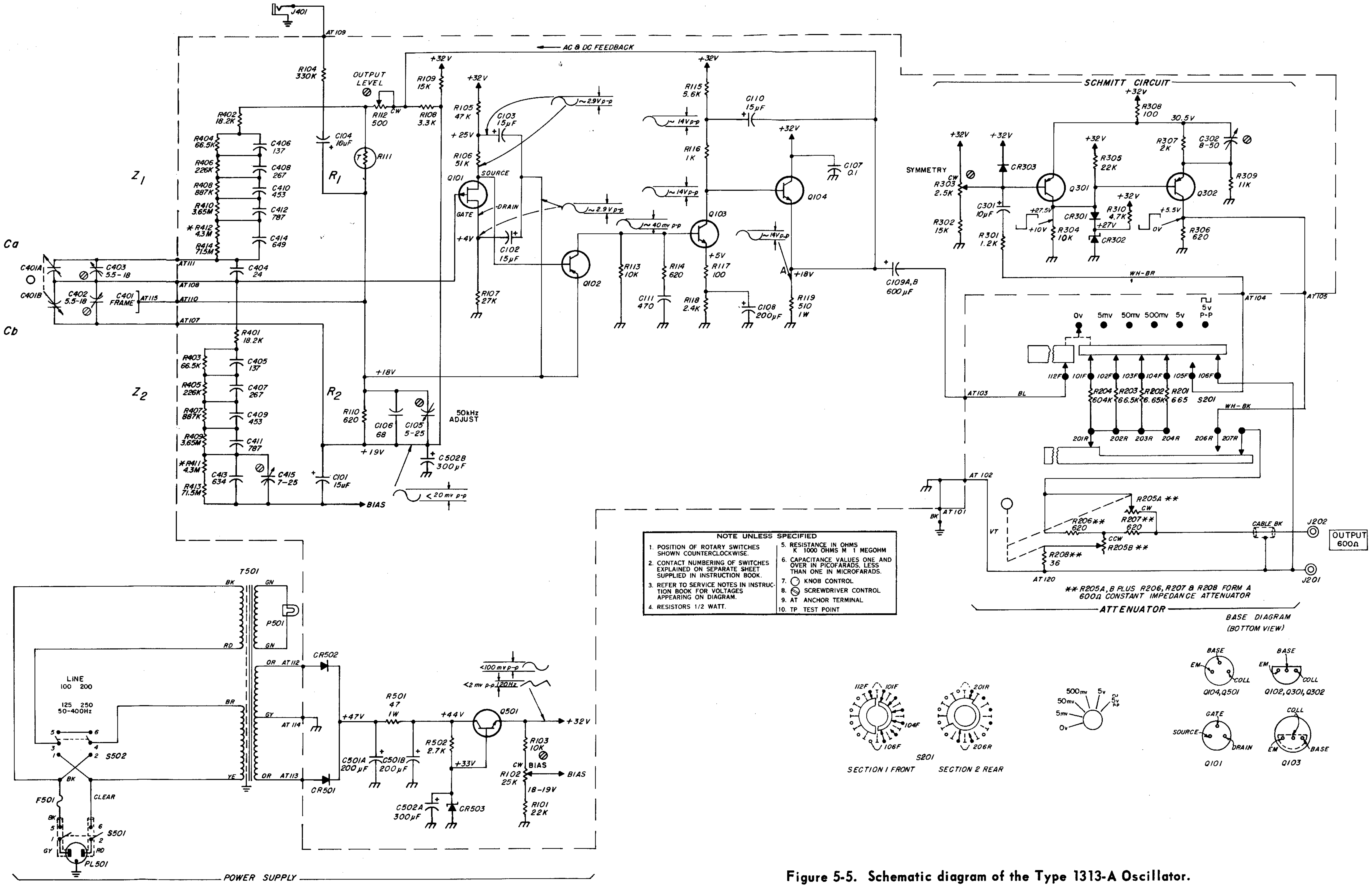


Figure 5-5. Schematic diagram of the Type 1313-A Oscillator.

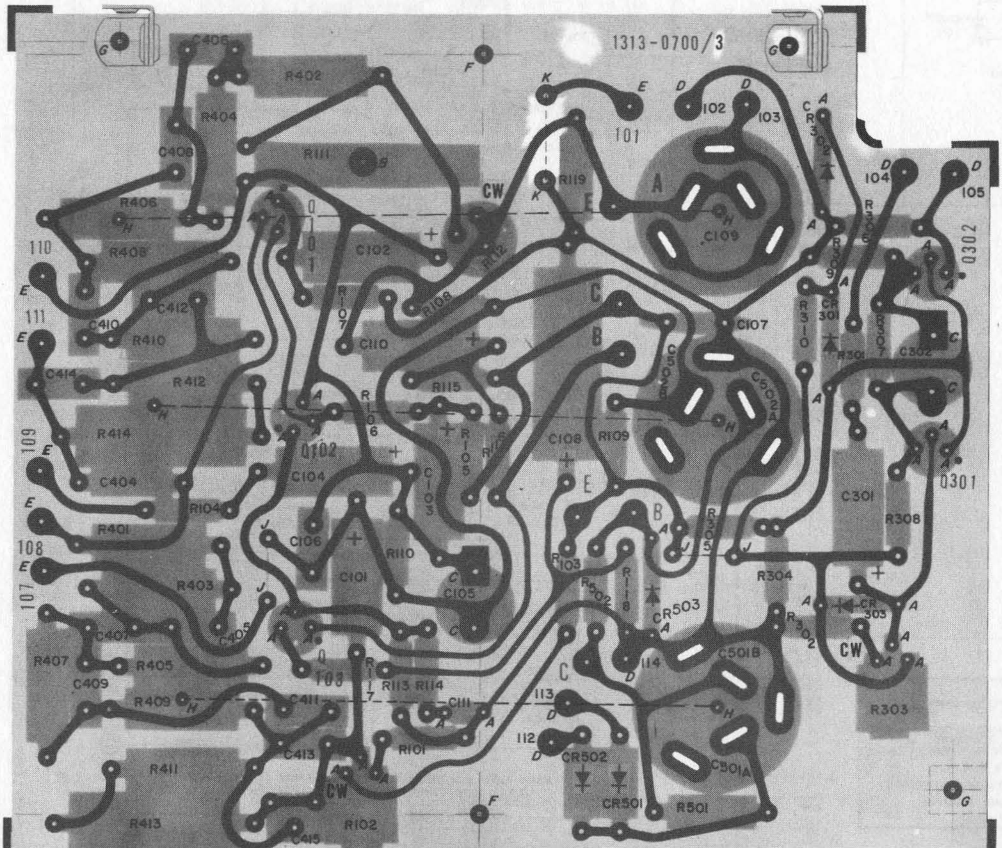


Figure 5-4. Etched-board assembly of the Type 1313-A Oscillator.

Note: The number appearing on the etched board is the number of the board only, without circuit components. When ordering a new etched board assembly use the following part number: 1313-2700.

A dot on the etched board indicates a transistor collector.

APPENDIX

SUPPLEMENTARY EQUIPMENT AVAILABLE

Type 0480-4638 Relay-Rack Adaptor Set

This adaptor set allows the oscillator to be mounted in a standard 19-inch relay-rack.

Type 0480-9636 Relay-Rack Adaptor Set

This adaptor set allows the oscillator to be mounted side-by-side with another 8 x 5¼-inch, convertible-bench instrument in a standard 19-inch relay rack.

Type 1396 Tone Burst Generator.

This instrument allows the output of the oscillator to be gated on and off coherently. The gate-on and gate-off times are independently adjustable from 2 to 128 cycles of any output frequency of the oscillator up to 500 kc/s.

With the Type 0480-9636 Relay-Rack Adaptor Set, listed above, the Type 1396 and the oscillator can be bolted together to form a single unit for either bench or rack installation.

Type 1232 Tuned Amplifier and Null Detector.

This instrument, with the oscillator, forms a detector-oscillator assembly with a sensitivity of 0.1 μV and a frequency range of 20 c/s to 20 kc/s, plus two fixed frequencies of 50 and 100 kc/s.

With the Type 0480-9636 Relay-Rack Adaptor Set, listed above, the Type 1232 and oscillator can be bolted together to form a single unit for either bench or rack installation.

GENERAL RADIO COMPANY

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SYRACUSE

Pickard Building
East Molloy Road
Syracuse, New York 13211
Telephone 315 454-9323

PHILADELPHIA

Fort Washington Industrial Park
Fort Washington, Pennsylvania 19034
Telephone 215 646-8030

WASHINGTON* AND BALTIMORE

11420 Rockville Pike
Rockville, Maryland 20852
Telephone 301 946-1600

ORLANDO

113 East Colonial Drive
Orlando, Florida 32801
Telephone 305 425-4671

* Repair services are available at these district offices.

CHICAGO*

6605 West North Avenue
Oak Park, Illinois 60302
Telephone 312 848-9400

CLEVELAND

5579 Pearl Road
Cleveland, Ohio 44129
Telephone 216 886-0150

LOS ANGELES*

1000 North Seward Street
Los Angeles, California 90038
Telephone 213 469-6201

SAN FRANCISCO

626 San Antonio Road
Mountain View, California 94040
Telephone 415 948-8233

DALLAS*

2600 Stemmons Freeway, Suite 210
Dallas, Texas 75207
Telephone 214 637-2240

TORONTO*

99 Floral Parkway
Toronto 15, Ontario, Canada
Telephone 416 247-2171

MONTREAL

1255 Laird Boulevard
Town of Mount Royal, Quebec, Canada
Telephone 514 737-3673