INSTRUCTION MANUAL

Type 1310-B
Oscillator

A

GENERAL RADIO

Contents

Type 1310-B Oscillator

A

GENERAL RADIO COMPANY
West Concord, Massachusetts U.S.A. 01781
Form 1310-0101 -A
July, 1969
ID 0100

SPECIFICATIONS

FREQUENCY

Range: 2 Hz to 2 MHz in 6 decade ranges. Overlap between ranges, 5%.

Accuracy: ±3% of setting.

Stability (typical at 1 kHz): Warmup drift, 0.1%. After warmup: 0.003% short term (10 min), 0.03% long term (12 h).

Controls: Continuously adjustable main dial covers decade range in 305°, vernier in 4 turns.

Synchronization: Frequency can be locked to external signal. Lock range ±3% per volt rms input up to 10 V. Frequency dial functions as phase adjustment.

OUTPUT

Voltage: > 20 V open circuit.

Power: > 160 mW into 600 Ω .

Impedance: 600 Ω. One terminal grounded.

Attenuation: Continuously adjustable attenuator with 46-dB range.

Distortion: < 0.25%, 50 Hz to 50 kHz with any linear load. Oscillator will drive a short circuit without clipping.

Hum: < 0.02%, independent of attenuator setting.

Amplitude vs Frequency: ±2%, 20 Hz to 200 kHz, into open circuit or 600-Ω load.

Synchronization: Constant-amplitude (0.8-V), high-impedance (27-kΩ) output to drive counter or oscilloscope.

GENERAL

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 400 Hz, 12 W.

Terminals: Output, GR 938 Binding Posts; sync, side-panel telephone jack.

Accessories Supplied: Power cord, spare fuses.

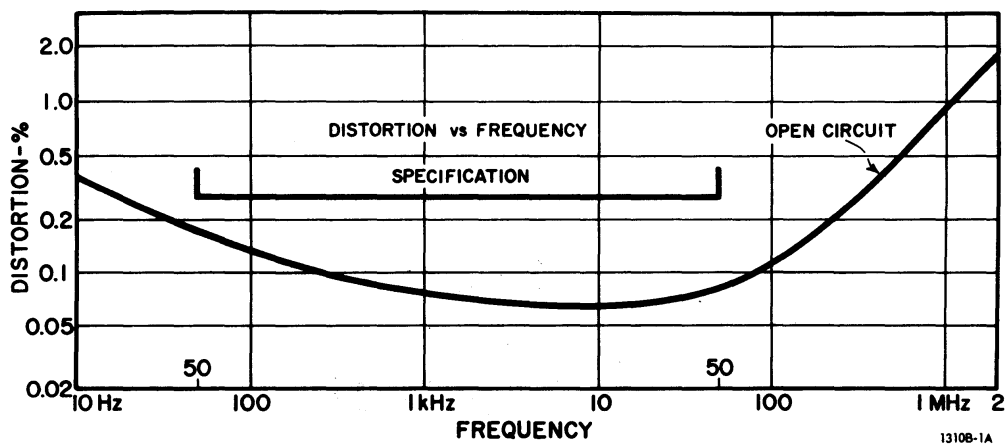
Accessories Available: Adaptor cable 1560-P95 (telephone plug to double plug); rack-adaptor set.

Mounting: Convertible-bench cabinet.

Dimensions (width x height x depth): 8 x 6 x 8 1/8 in. (205 x 155 x 210 mm).

Weight: Net, 7¾ lb (3.6 kg); shipping, 10 lb (4.6 kg).

Catalog Number	Description
1310-9701	**1310-A Oscillator**
1560-9695	**1560-P95 Adaptor Cable**
0480-9838	**480-P308 Rack-Adaptor Set**



CONDENSED OPERATING PROCEDURE

a. **Set the FREQUENCY range switch to the desired frequency range.**

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

c. **Set the LEVEL control for the desired amplitude.**

After power is applied, allow a 1-minute warmup for the thermistor to reach its normal operating temperature. For best amplitude and frequency stability, allow a 30-minute warmup.

SECTION 1 INTRODUCTION

1.1 PURPOSE

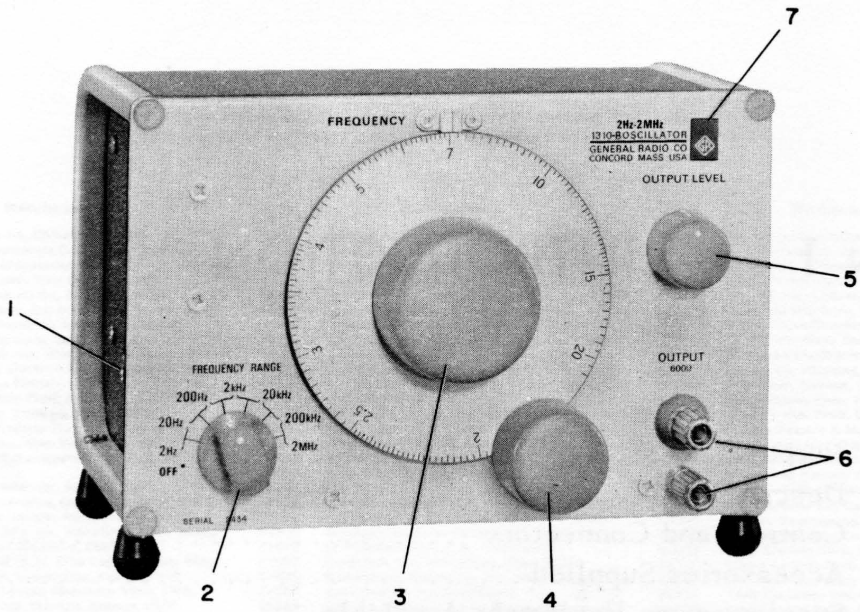
The Type 1310 Oscillator is a general-purpose signal source for laboratory or production use. It features wide frequency range; high output; low distortion, hum, and noise; high stability and accuracy; plus a synchronizing feature which allows such varied uses as filtering, leveling, frequency multiplying, jitter reducing, and slaving.

1.2 DESCRIPTION

A capacitance-tuned, RC Wien-bridge oscillator drives a low-distortion output amplifier, which isolates the oscillator from the load and delivers a constant voltage behind 600 ohms.

A jack is provided for introduction of a synchronizing signal for phase-locking or to furnish a signal, independent of the output attenuator setting, to operate a counter or to synchronize an oscilloscope or another oscillator.

1.3 CONTROLS AND CONNECTORS



The following controls and connectors are on the front panel or on the side of the oscillator:

1 EXT SYNC	Input/output telephone jack. For introducing a synchronizing or phase-locking signal from an external source or for providing a synchronizing signal, independent of the output level, to an oscilloscope, counter, or another oscillator.
2 FREQUENCY range	Seven-position rotary switch. Combination power switch and frequency range switch.
3 FREQUENCY dial	Continuously adjustable dial. Used with FREQUENCY range switch to set output frequency.
4 FREQUENCY vernier	Fine frequency control (4.25:1) for FREQUENCY dial.
5 LEVEL	A constant-impedance, bridged-T attenuator which sets output level over a 50-dB range.
6 OUTPUT	¾-inch-spaced binding post pair; lower terminal grounded to chassis. For connection to oscillator output.
7 PILOT LIGHT	Red translucent monogram. Glows when power is on.

1.3 CONTROLS AND CONNECTORS continued

The following connector is on the rear panel:

Power input Three-terminal male connector. For connection to power line.

1.4 ACCESSORIES SUPPLIED

	Part Number
Instruction book	1310-0100
Power cord, 3-wire	4200-9622
Fuses (1), 0.25 A for 115-V operation or:	5330-0700
0.125 A for 230-V operation	5330-0450

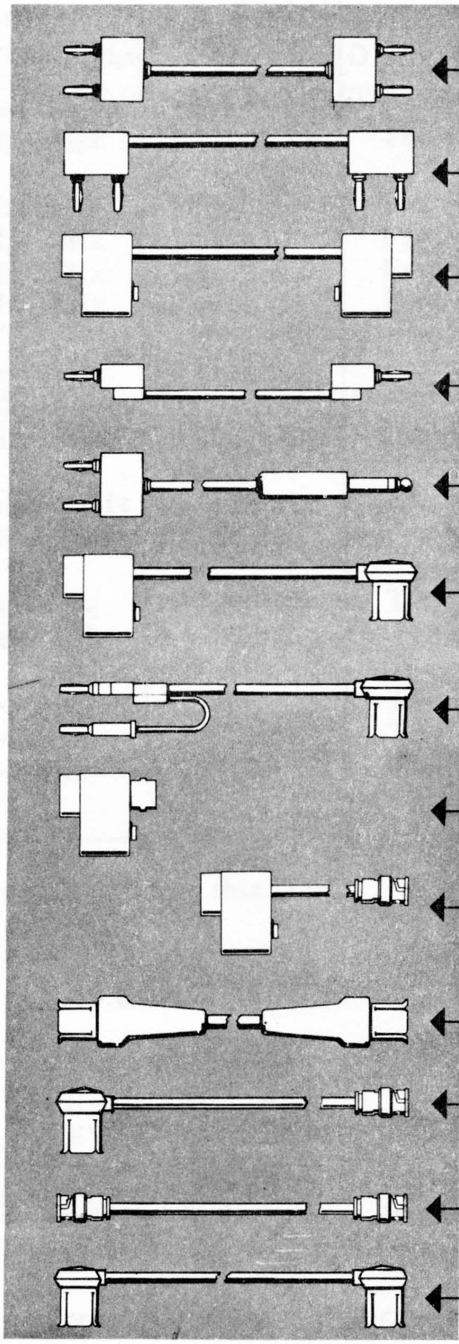
1.5 SUPPLEMENTARY EQUIPMENT AVAILABLE

Name	*GR Type or Part No.*	*Function*
Rack Adaptor Set	P/N 0480-9838	Allows the Type 1310 to be mounted in a standard 19-in. relay-rack (see paragraph 2.5).
Rack Adaptor Set	P/N 0480-9836	Allows the Type 1310 to be mounted side-by-side with another 8 x 5¼-in. convertible-bench instrument in a standard 19-in. relay rack (see paragraph 2.5).
Tone-Burst Generator	Type 1396	Allows the output of the Type 1310 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 Type 1310.
Audio-Frequency Microvolter*	Type 1346	A metered, calibrated attenuator that can be used as a self-contained, low-level dc source, supplying positive and negative voltages from 1.0 μV to 10 V and, in conjunction with an appropriate oscillator, as a source of from 0.1 μV to 10 V of any ac waveform with a spectrum up to 100 kHz. The 1346 will convert almost any sine- or square-wave, noise, tone-burst, or other generator for operation as a calibrated-output source.
Tuned Amplifier and Null Detector	Type 1232	With the Type 1310, forms a detector oscillator assembly with a sensitivity of 0.1 μV and a frequency range of 20 Hz to 20 kHz, plus two fixed frequencies of 50 and 100 kHz. With the Type 0480-9836 Relay-Rack Adaptor Set, the Type 1232 and Type 1310 can be bolted together to form a single unit for either bench or rack installation.
Patch cords and adaptors		Refer to paragraphs 1.6 and 1.7.

*Trademark registered in U.S.A.

1.6 OUTPUT SIGNAL CONNECTION

AVAILABLE INTERCONNECTION ACCESSORIES



TYPE NO.	DESCRIPTION	CATALOG NO.
274-NQ	Double-plug patch cord, in-line 36" long	0274-9860
274-NQM	Double-plug patch cord, in-line 24" long	0274-9896
274-NQS	Double-plug patch cord, in-line 12" long	0274-9861
274-NP	Double-plug patch cord, right-angle 36" long	0274-9880
274-NPM	Double-plug patch cord, right-angle 24" long	0274-9892
274-NPS	Double-plug patch cord, right-angle 12" long	0274-9852
274-NL	Shielded double-plug patch cord, 36" long	0274-9883
274-NLM	Shielded double-plug patch cord, 24" long	0274-9882
274-NLS	Shielded double-plug patch cord, 12" long	0274-9862
274-LLB	Single-plug patch cord, black, 36" long	0274-9468
274-LLR	Single-plug patch cord, red, 36" long	0274-9492
274-LMB	Single-plug patch cord, black, 24" long	0274-9847
274-LMR	Single-plug patch cord, red, 24" long	0274-9848
274-LSB	Single-plug patch cord, black, 12" long	0274-9849
274-LSR	Single-plug patch cord, red, 12" long	0274-9850
1560-P95	Adaptor cable, double-plug to telephone plug, 36"	1560-9695
874-R34	Coaxial patch cord, double plug to GR874, 36" long	0874-9692
874-R33	Coaxial patch cord, two plugs to GR874, 36" long	0874-9690
274-QBJ	Adaptor, shielded double plug to BNC jack	0274-9884
776-A	Patch cord, shielded double plug to BNC plug, 36" long	0776-9701
874-R22A	Coaxial patch cord GR874 to GR874, 36" long	0874-9682
776-B	Patch cord, GR874 (right-angle) to BNC plug, 36" long	0776-9702
776-C	Patch cord, BNC plug to BNC plug, 36" long	0776-9703
776-D	GR874 to GR874, both right-angle, 36" long	0776-9704

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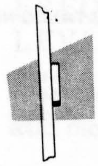
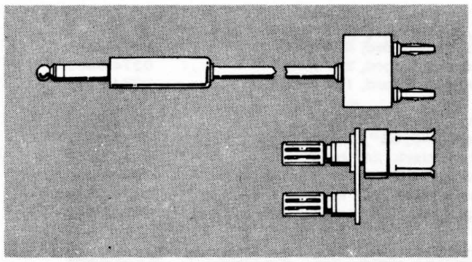
1.7 EXTERNAL SYNC CONNECTION



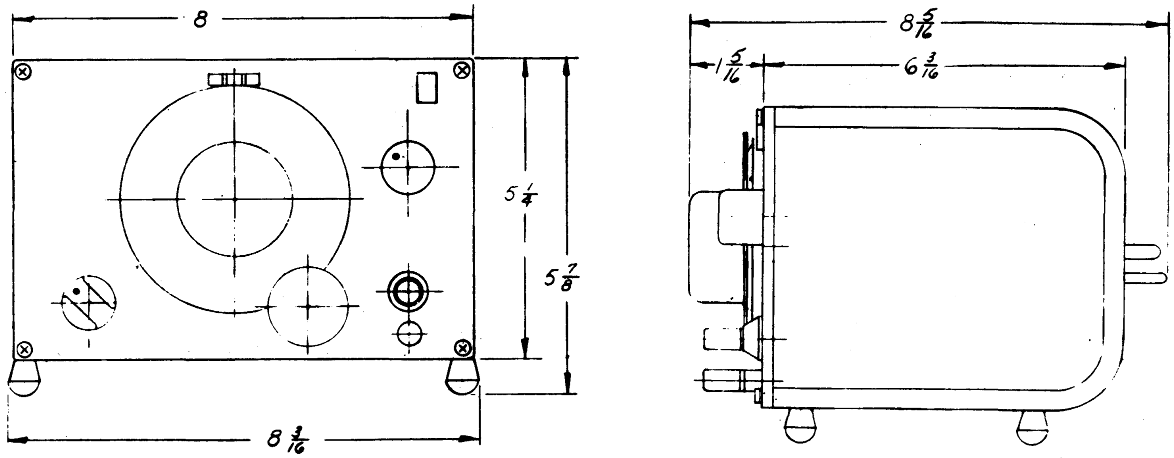
The EXT SYNC connector on the left-hand side of the Type 1310 is a telephone jack that accepts a standard telephone plug. When a Type 1560-P95 Adaptor Cable and a GR874-Q2 adaptor are used, all of the GR874 patch cords and adaptors listed for the OUTPUT connector can also be used.



1560-P95	Adaptor cable, telephone plug to double plug, 36" long	1560-9695
874-Q2	Adaptor, double-plug to GR874	0874-9870

SECTION 2 INSTALLATION

2.1 DIMENSIONS



DIMENSIONS IN INCHES

2.2 GROUNDING

A three-wire power cord is used; the third wire (ground) is connected to the instrument case.

2.3 TEMPERATURE

The Type 1310 is designed to operate with ambient temperatures of from 0 to 50 °C and is designed to be stored with ambient temperatures of -40° to +70 °C.

2.4 HUMIDITY

As with all low-frequency, variable-capacitance, RC oscillators, the oscillator circuit in the Type 1310 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 with a warmup period which allows the internally generated heat to reduce the humidity within the instrument.

2.5 RACK MOUNTING

With the Rack Adaptor Set (P/N 0480-9838), the portable bench model can be converted for use in an EIA-standard 19-in. relay rack with universal spacing.

Mount the instrument as follows:

a. Remove the rubber feet (A); retain the screws.

b. Remove and retain the screws (C) that secure the front panel to the aluminum end frames.

CAUTION

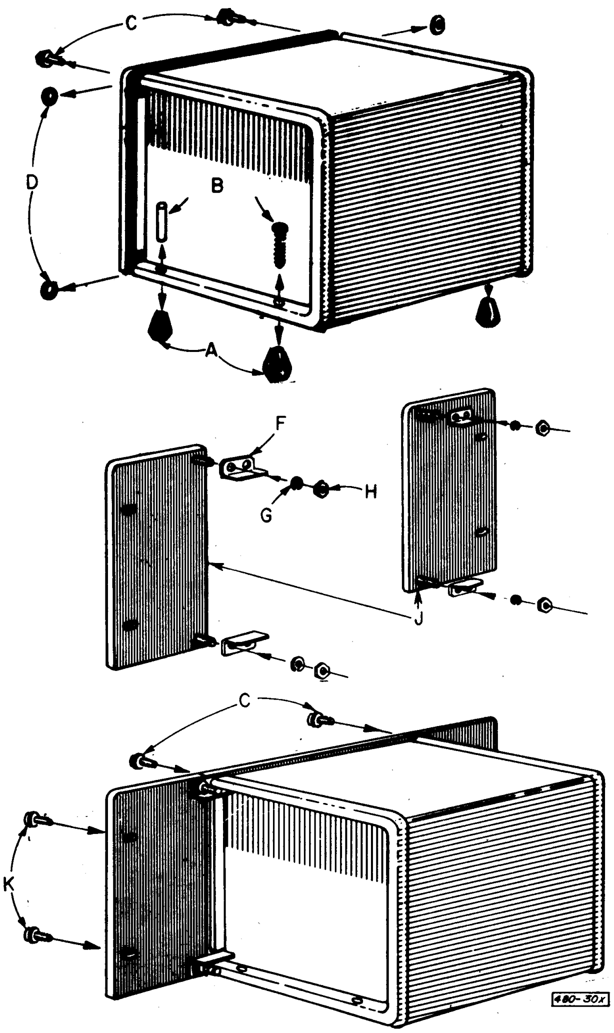
Do not lose the spring and pin held in the threaded-bottom-end of each frame. The pins may pop out when the screws are removed.

c. Remove the spacers (D) between the front panel and end frames.

d. Install two brackets (F) on each adaptor panel (J) using screws (C), lockwashers (G) and nuts (H) provided. The springs and pins should be retained in the threaded ends of the frames, to prevent their loss.

e. Attach the panels to the instrument with the front-panel screws (C) removed in step b. The protruding brackets on the adaptor panel slide into the space left by removal of the spacers (D).

f. To reconvert the instrument to a bench-mount unit, reverse the rack mounting procedure. It may be necessary, however, to remove the end frames when reinstalling the rigid (metal shafts) front feet. The end frames slide off the side panels. Make sure the spring and pin are inserted in the bottom threaded hole on the frame, with the spring inserted first. Push the pin back with a pointed object and insert the rigid foot through the frame, threaded end first; screw the feet on to the shafts.



2.5 RACK-MOUNTING continued

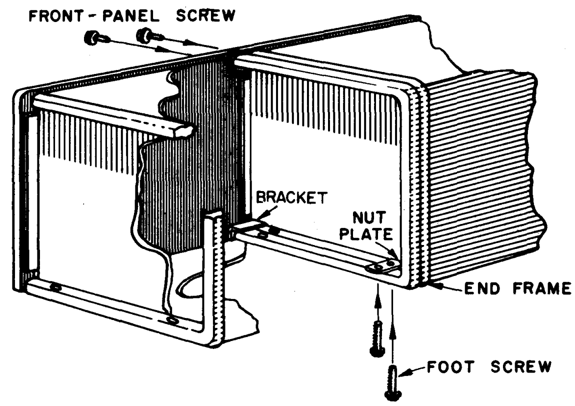
With Rack Adaptor Set P/N 0480-9836 two instruments can be mounted side-by-side; join them together as follows:

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

b. 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.



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

d. Install the adaptor plates to the instrument with the front-panel screws removed earlier.

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

PARTS INCLUDED IN THE RACK ADAPTOR SET, P/N 0480-9838

Fig. Ref.	*No. Used*	*Item*	*GR Part No.*
J	2	Adaptor Plate	0480-8720
—	1	Hardware Set includes:	0480-3230
F	4	Bracket	-
C	8	Screw, No. 10-32 1/2-in., with fiber washer.	-
H	8	Nut, hex, No. 10-32	-
G	8	Lockwasher, No. 10	-
K	4	Screw, No. 10-32 1/2-in., with nylon cupwasher	-

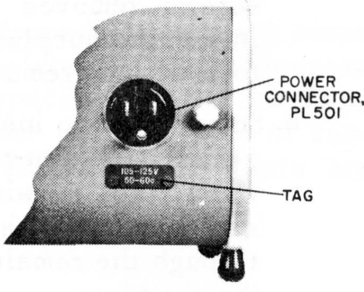
PARTS INDLUDED IN THE RACK ADAPTOR SET, P/N 0480-9836

Fig. Ref.	*No. Used*	*Item*	*GR Part No.*
J	2	Adaptor Plate	0480-8724
—	1	Hardware Set includes:	0480-3240
F	6	Bracket	-
C	8	Screw, No. 10-32 1/2-in., with fiber washer	-
—	1	Nut Plate	-
H	8	Nut, hex, No. 10-32	-
G	8	Lockwasher, No. 10	-
K	4	Screw, No. 10-32 1/2-in., with nylon cupwasher	-

2.6 POWER CONNECTION

The power transformer can be wired to accept 50- to 400-Hz line voltages of 105 to 125, 195 to 230, or 210 to 250 volts.

115-volt line. Power required is 105 to 125V, 50 to 400 Hz, 12W. Input plate for 115-V operation is part number 5590-0500 and attaches to the rear of the cover, under the hole for the power connector, by means of two 4-40 x 3/16-inch screws with attached lockwashers, part number 7090-4030 each. For transformer wiring, connect 1 to 3 and 2 to 4. Fuse for F502 is 0.25A, 3AG Slo-Blo, part number 5330-0700. F501 is a spare fuse. Domestic instruments are shipped with this connection unless ordered otherwise.



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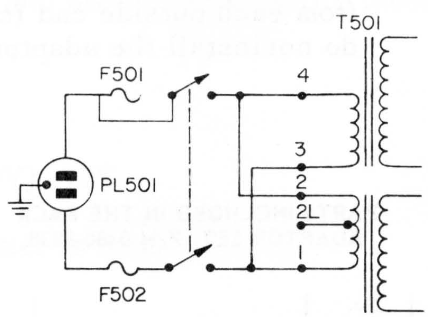
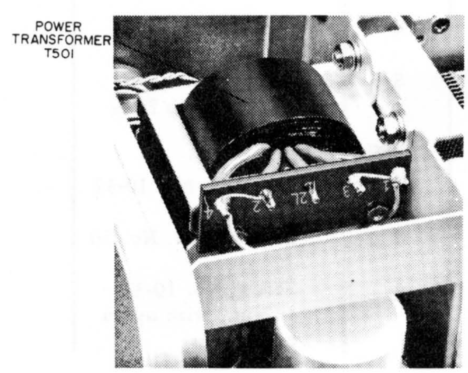
215-volt line. Power required is 195 to 235V, 50 to 400 Hz, 12W. Input plate for 215-V operation is part number 5590-1668 and attaches to the rear of the cover, under the hole for the power connector, by means of two 4-40 x 3/16-inch screws with attached lockwashers, part number 7090-4030 each. For transformer wiring, connect 3 to 2L only. Fuse for F502 is 0.125A, 3AG Slo-Blo, partnumber 5330-0450. F501 is a spare fuse. Export instruments are shipped with this connection unless ordered otherwise.



1310-29

230-volt line. Power required is 210 to 250V, 50 to 400 Hz, 12W. Input plate for 230-volt operation is part number 5590-1664 and attaches to the rear of the cover, under the hole for the power connector, by means of two 4-40 x 3/16-inch screws with attached lockwashers, part number 7090-4030 each. For transformer wiring, connect 2 to 3 only. Fuse for F502 is 0.125 A, 3AG Slo-Blo, part number 5330-0450. F501 is a spare fuse.



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SECTION 3 OPERATING PROCEDURE

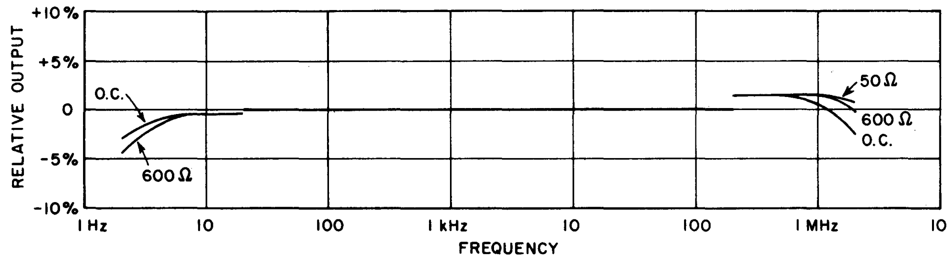
3.1 NORMAL OPERATION

a. Set the FREQUENCY range switch to the desired frequency range.
b. Set the FREQUENCY dial to the desired frequency
c. Set the LEVEL control for the desired amplitude.

After power is applied, allow a one-minute warmup for the thermistor to reach its normal operating temperature. For best amplitude and frequency stability, allow a 30-minute warmup.

3.2 CHARACTERISTICS

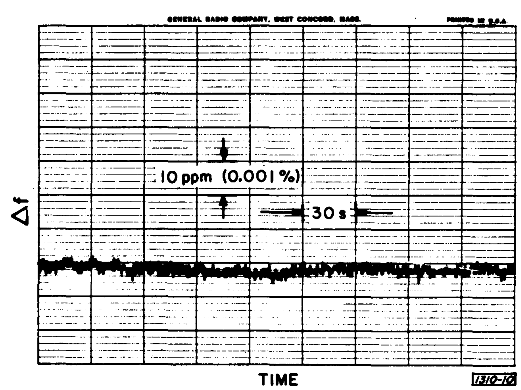
3.2.1 FREQUENCY RESPONSE



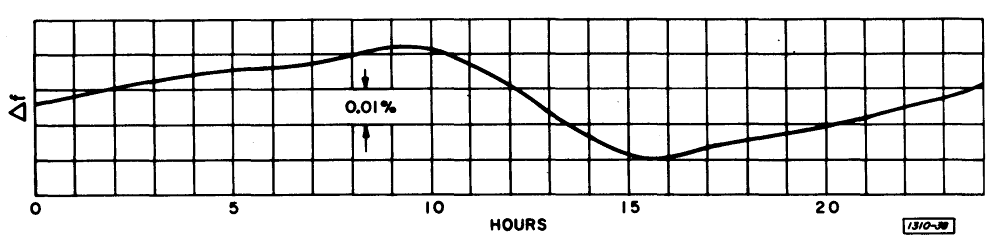
The output is 20 volts, open-circuit, behind 600 ohms and is adjustable over a 50-dB range by a constant-percentage-resolution attenuator. The output is constant within ±2% from 20 Hz to 200 kHz for loads of 600 ohms or higher. Within the audio range, changes are imperceptible on the usual analog type of voltmeter.

3.2.2 FREQUENCY STABILITY

Typical short-term drift



Typical long-term drift

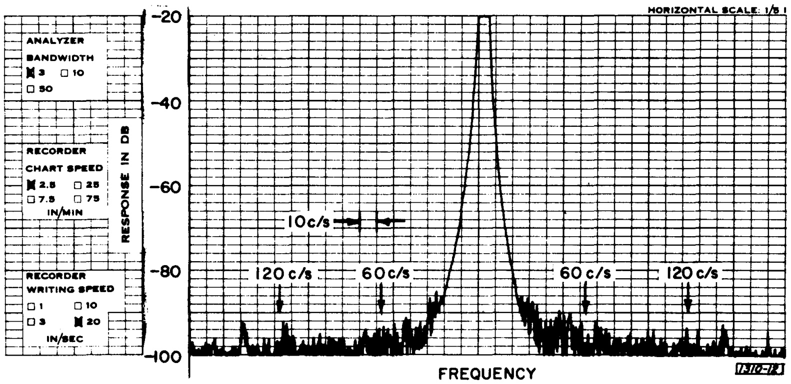


High-stability, frequency-determining components in the oscillator and low, internal power dissipation result in a stable output frequency. Drift during warm-up is typically below 0.1% at frequencies above 20 Hz.

Typically short- and long-term stabilities after warmup are shown at 1 kHz. Both are with a sampling time of 0.1 s (100 periods) and under normal laboratory conditions during the winter months (heat on during the day and off at night).

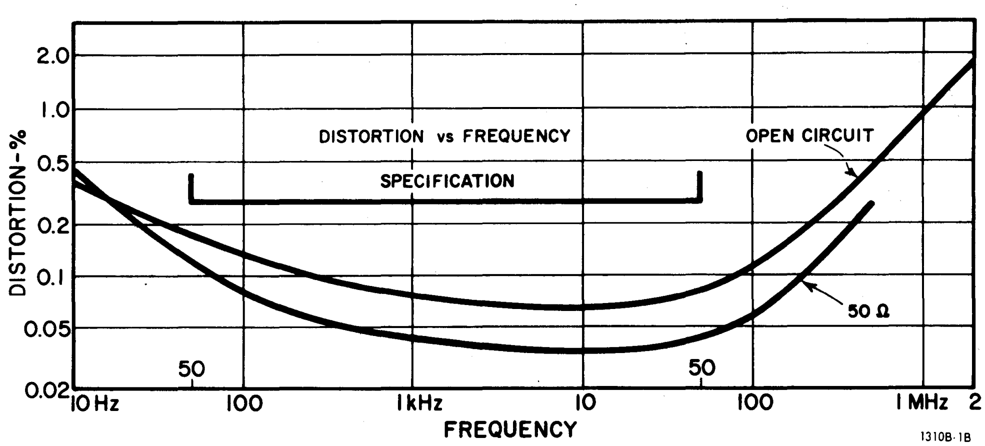
3.2 CHARACTERISTICS continued

3.2.3 NOISE



Hum is below 0.02% of the output (typically 0.005%), regardless of the attenuator setting. Noise at frequencies distant from a 1-kc fundamental, measured in a bandwidth of 5 Hz to 500 kHz, is typically less than 0.02%. Noise close to the fundamental is also low as the spectrum analysis of a 1-Hz output shows. Note the absence of components at the line frequency or its multiples.

3.2.4 OUTPUT DISTORTION



Harmonic distortion is less than 0.25% over most of the audio range (50 Hz to 50 Hz). This low distortion is always available, even at full output, because it remains essentially constant regardless of the size of the linear load applied, including a short circuit.

When the attenuator is set for open-circuit output voltages of five volts or less, the load seen by the oscillator is 600 ohms, regardless of the size of the external load.

3.3 SYNCHRONIZATION JACK

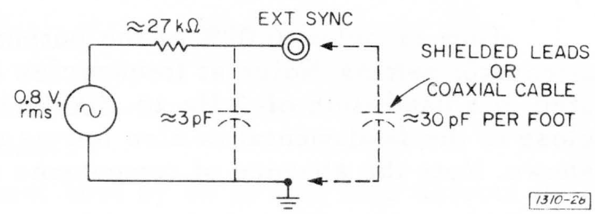
3.3.1 GENERAL

A telephone jack (EXT SYNC, J103) is located on the left-hand side of the oscillator. This is an input/output connector and is used to connect a signal *to* the oscillator or to take one *from* it.

There are three important characteristics associated with the use of the EXT SYNC feature:

1. Output characteristic.
2. Input synchronizing or phase-locking characteristic.
3. Input frequency-selectivity or filtering characteristic.

3.3.2 OUTPUT CHARACTERISTIC



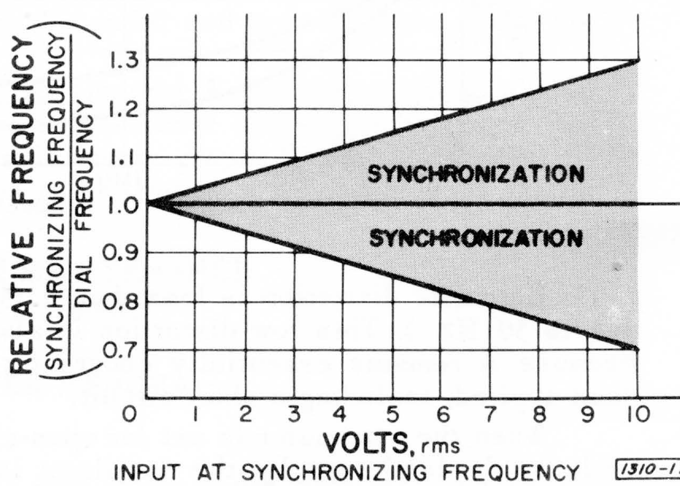
A nominal 0.8-volt, rms, output signal, behind 27 kΩ, is available from the EXT SYNC jack. The level of this sync output signal is independent of the LEVEL control or the front-panel OUTPUT load. One side of the sync output is grounded and the signal is 180° out-of-phase with the front-panel OUTPUT.

The sync output will drive any size load without increasing oscillator distortion. However, only high-impedance loads are recommended where full frequency accuracy is required. The worst-case load, a short circuit, will decrease the frequency 1 or 2%.

Stray capacitance of most shielded leads or coaxial cables is about 30 pF per foot which, at 100 kHz, amounts to shunt impedance of about 55 kΩ. Therefore, cable length should be kept to a minimum when a high-impedance load is to be driven at high frequencies.

3.3.3 INPUT SYNCHRONIZING CHARACTERISTIC

The oscillator frequency may be synchronized or locked with any input signal which 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. It increases approximately linearly, and produces a lock range of about ±3% for each volt input.



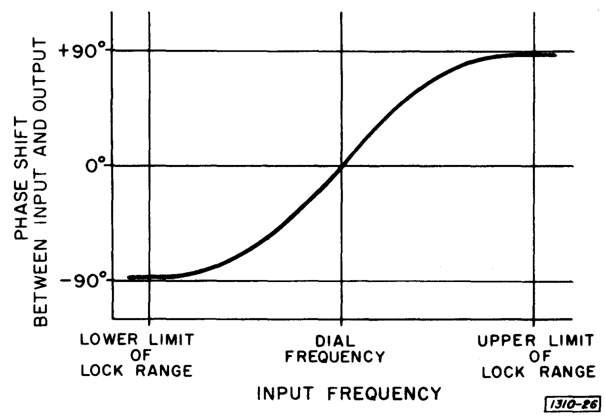
3.3 SYNCHRONIZATION JACK continued

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 syncronization 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 only to changes in average values of frequency or amplitude 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. They *are* affected by the equivalent time constant of the filter characteristic discussed in paragraph 3.3.4.

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 a true phase-lock because 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 lock 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.



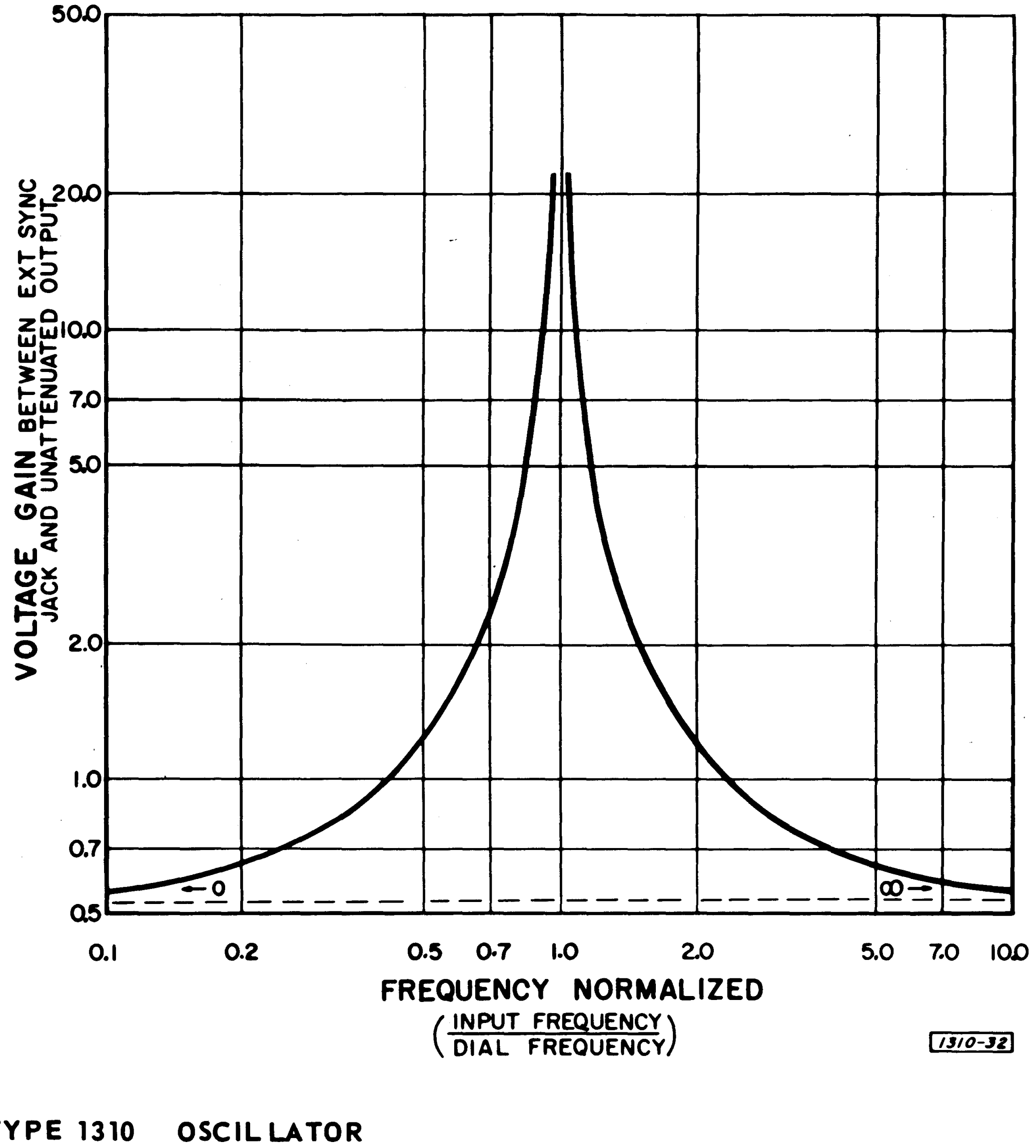
The *input impedance* of the EXT SYNC jack is 27 kΩ at all frequencies except the synchronizing frequency. At the synchronizing frequency the impedance, in general, is complex and can vary over a wide range including negative values because the jack is also a source at the synchronizing frequency.

Since the jack is a simultaneous source and input, care should be taken to insure the sync output voltage does not interfere with the drive source. The high output impedance of the EXT SYNC jack makes it easy to minimize the sync output signal. For example if the jack is fed from a 600-ohm source, less than 20 mV will appear across the source.

3.3.4 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. The intrinsic selectivity or Q of this filter is constant and determined only by the RC Wien network.

The voltage gain between the EXT SYNC jack and the OUTPUT terminals is constant at any frequency except the frequency of oscillation, regardless of the amplitude of the incoming signals. The curve may be used directly to determine the amplitude of any frequency component in the oscillator output if the amplitude of the input is known.



3.3 SYNCHRONIZATION JACK continued

For example, we wish to determine the reduction in the harmonic content of a 1-volt, 1-kc signal which has approximately 10% (0.1V) second-harmonic distortion. The signal is applied to the EXT SYNC jack of the Type 1310 ; the output of the Type 1310 is 20 volts and, from the graph, the gain at the second harmonic is approximately 1.2.

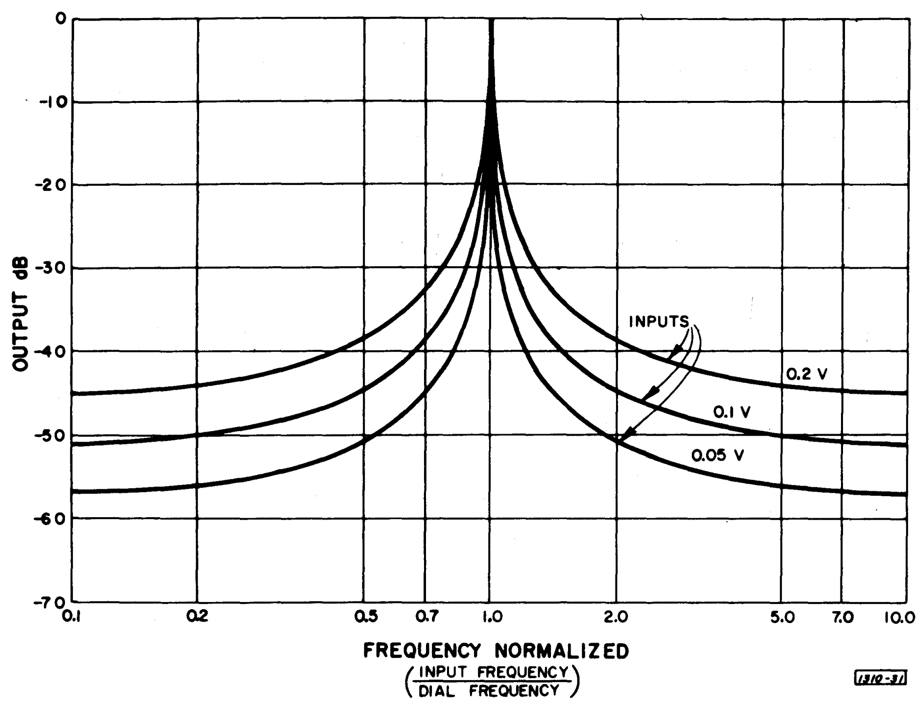
$$\text{distortion, in } \% = \frac{\text{amplitude of harmonics}}{\text{total amplitude}} \times 100 = \frac{1.2 \times 0.1}{20} \times 100 = 0.6\%$$

If the amplitude of the external signal is reduced to 0.5 V (0.05 V harmonic content), the distortion at the output of the Type 1310 becomes:

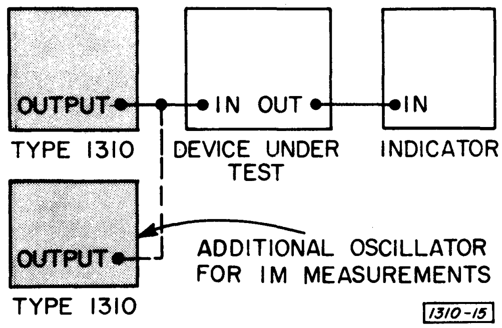
$$\frac{0.05 \times 1.2}{20} = 0.30\%$$

In general, it is not possible to reduce the distortion below the level normally present in the oscillator and little would be gained in the preceeding example by reducing the input to less than 0.25 volts.

Often the amplitude of a frequency component relative to the amplitude of the frequency of oscillation is of greater interest than the absolute amplitude. The figure shows this response for three different input amplitudes. Notice that the apparent selectivity or Q in this relative response is a function of the input amplitude. This is because the output at the frequency of oscillation remains constant while the output at other frequencies varies with the input amplitude.



3.4 APPLICATIONS



Response measurements. Constant output over a wide frequency range facilitates frequency-response measurements.

Distortion measurements. Low hum and low distortion make it very useful for amplifier distortion measurements.

AM and IM measurements. Low noise levels close to the fundamental allow amplitude modulation in magnetic recordings and intermodulation products in any device to be measured with ease.

3.4.1 SIGNAL SOURCE WITHOUT LINE-FREQUENCY BEATS

Beat frequency elimination. The ability to lock onto any external signals is useful. Often it is desirable to make measurements or to have a source at the line frequency or some multiple of the line frequency. A free-running oscillator may beat with the line frequency, but when the oscillator is locked to the line or its harmonics, there will be no beat and the phase can be adjusted with the FREQUENCY dial to minimize the other effects of pickups.

3.4.2 SLAVED OSCILLATORS

Slaving. Because the EXT SYNC jack is simultaneously an input and an output connector, two or more oscillators can be synchronized if their EXT SYNC jacks are connected together. Oscillators connected in this manner will operate at the same frequency or multiples of the same frequency and can be made to differ in phase (180° ± 75°) by adjustment of the FREQUENCY dials within the lock range.

3.4 APPLICATIONS continued

3.4.3 WAVEFORM SYNTHESIZER

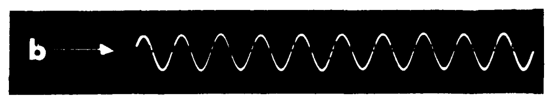
Fourier synthesis. The ability to lock onto harmonics lends the oscillator to interesting applications such as the Fourier synthesis of waveforms.

In the example shown, a square wave is synthesized by locking the oscillators on the sucessive odd harmonics present in the original square wave. Any waveform can be synthesized in this manner, provided a source of the necessary harmonics is available and the Fourier coefficients are known.

All sync inputs are paralleled and connected to an oscilloscope's square-wave calibrator output.

Original 1-kHz square wave from oscilloscope.

Fifth harmonic which, like the output of all the oscillators, is sinusoidal.



Synthesized square wave. The five outputs are adjusted for phase coherence and are summed in the ratio of their respective Fourier coefficients.

1310-8

3.4.4 ACCURATE FREQUENCY SOURCE WITH CLEAN, HIGH, SHORTABLE OUTPUT

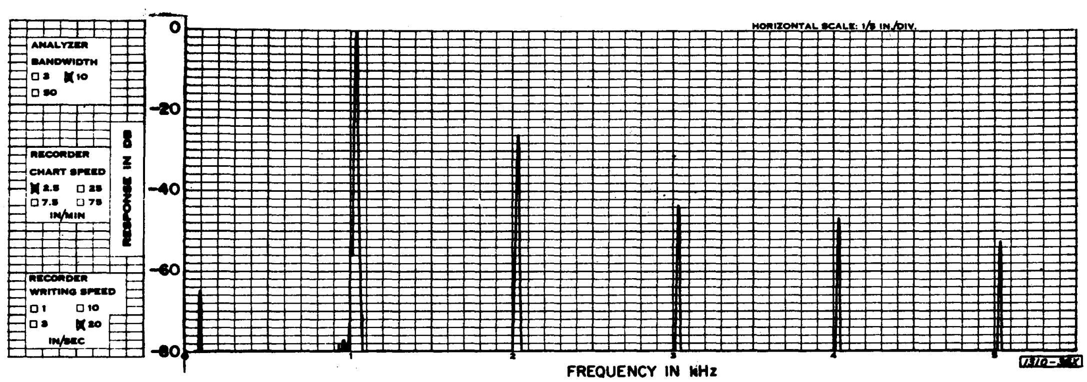
One obvious application for the sync capability is to lock one or more oscillators to a reference frequency for higher accuracy and greater long-term stability. With the oscillator synchronized, its accuracy and long-term stability will be identical with the reference; short-term stability or jitter will be the same as if the oscillator were free-running.

A Type 1310 can lock to the output of a Type 1161-A7C Coherent Decade Frequency Synthesizer, used as a reference-frequency source. The oscillator increases the 2-volt output of the synthesizer and reduces the already low harmonic content for a precision frequency modulation experiment. The frequency of 31.063 kHz, when used to modulate an fm generator, produces a null in the carrier for a ±75.000 -kHz frequency deviation.

The advantages of this accrue from the output characteristics of the oscillator:

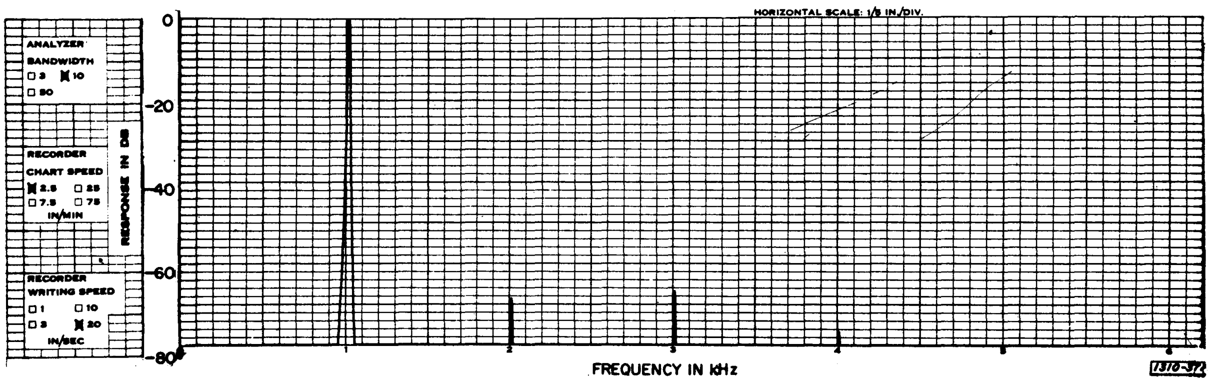
Distortion and hum reduction. The frequency selectivity of the synchronized oscillator reduces distortion and hum in the reference source.

For example, the figure below is the spectrum of a 1-kHz, sinusoidal frequency, derived by division from a crystal oscillator (Not from the above mentioned synthesizer).



3.4 APPLICATIONS continued

The next figure is the spectrum of the output of a Type 1310 Oscillator synchronized to the 1-kHz frequency on the opposite page. Note the significant reduction in distortion, noise, and hum.



Frequency multiplication. The harmonic content of the reference can be used for precise frequency multiplication since the oscillator can be synchronized to the harmonics. The accuracy and long-term stability of the submultiple reference are maintained and the oscillator output is, of course, sinusoidal. This technique can be used with most signals because harmonics are usually present or can be easily generated.

Amplification. Less than a volt into the high-impedance EXT SYNC jack produces a full 20-volt open-circuit, or 160-mW into 600 ohms, output.

Isolation. The oscillator isolates and protects the reference source from short circuits and nonlinear loads.

Amplitude stabilization. The output has the same long-term amplitude stability as the normal unsynchronized output and is thus free from changes in the output level of the reference source.

Level control. The oscillator provides adjustable output levels which are kept constant automatically with changes in frequency.

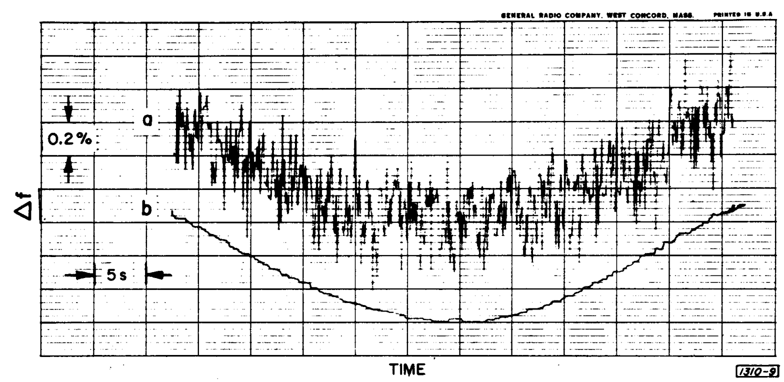
3.4.5 TRACKING, NARROW-BAND FILTER

Jitter or incidental fm reduction.* Although the short-term stability or jitter of the synchronized oscillator can not be better than when it is free-running, it canbe better than the source to which it is synchronized. In this respect it behaves as a phase-locked oscillator or automatic-phase-control (APC) oscillator.** Or, to express it differently, it behaves as a tracking, narrow-band filter to reduce short-term instability.

The selectivity of the filter is a function of the input sync signal, and the tracking mechanism has a time constant in the order of one second. The effective bandwidth to small frequency perturbations or small fm deviations is related to the lock range as it is in conventional APC oscillators; i.e., the lock range is the 3-dB cutoff frequency of an equivalent low-pass filter.

Since the lock range is a linear function of the sync-signal amplitude, the effective bandwidth is also the same function of the amplitude. For example, if a 1-volt signal is used to synchronize the oscillator at 100 kHz and provides a ±3% lock range, the oscillator will have a 3-dB bandwidth of 3 kHz (3% of 100 kHz) to perturbations in frequency. Thus frequency deviations in the 100-kHz source at a 3-kHz rate will be reduced 3 dB in the oscillator output.

The figure shows one example of jitter reduction:



a. Output frequency of a drifting 10-Hz, jittery source.

b. Output frequency of an oscillator synchronized to the 10-Hz source. Note the cycle-to-cycle change in frequency has been greatly reduced, yet the relatively long-term change of about 1% has been faithfully tracked.

The low frequency used in this example was chosen for convenience in making the graphic recordings. A reduction in jitter or fm can be made at any frequency within the range of the oscillator (2 Hz to 2 MHz). The ability to track drift, however, is still limited by the one-second time constant of the thermistor (paragraph 3.3.3).

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* See D.D.Weiner and B.J.Leon, "The Quasi-Stationary Response of Linear Systems to Modulated Waveforms," *Proceedings of the IEEE*, Vol 53, June 1965, pp 564 to 575 and references.

** Harold T. McAleer, "A New Look at the Phase Locked Oscillator," *Proceedings of the IRE*, Vol 47, pp 1137 to 1143, June 1959 (GR Reprint No. A-79).

3.4 APPLICATIONS continued

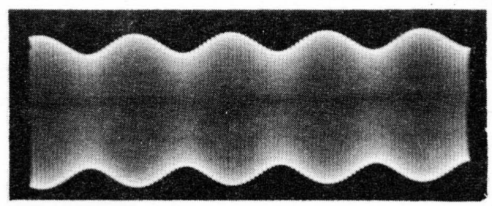
Incidental am reduction. Just as the oscillator can be used to reduce jitter or fm in a signal, it can also be used to reduce am. This is a natural consequence of the oscillator's similarity to a high-Q filter. The amplitude modulation on any signal to which a Type 1310 is synchronized is reduced to the extent that the modulation sidebands fall outside the passband of the oscillator.

The reduction can be calculated from the graph on page 16. For example, we wish to determine the reduction in amplitude modulation of a 0.1-volt, 10-kc signal which has 10% amplitude modulation at 1 kHz (5% or 0.005 V in each side band). The signal is applied to the EXT SYNC jack of the Type 1310 ; the output of the Type 1310 is 20 volts and, from the graph, the gain at 9 kHz and at 11 kHz is 8.5.

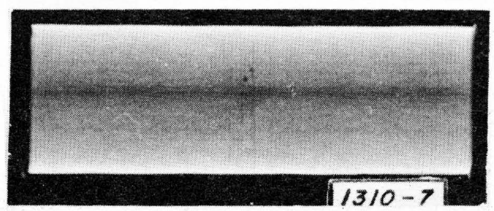
$$\text{am, in } \% = \frac{\text{amplitude of side bands}}{\text{total amplitude}} \times 100 = \frac{(8.5 \times 0.005) + (8.5 \times 0.005)}{20} \times 100 = 0.425\%$$

The figures show one example of am reduction:

10-kHz signal modulated at 500Hz applied to EXT SYNC jack.



Reduction in am in the output of the oscillator locked to the signal above.



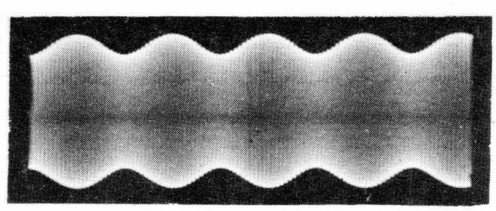
3.4.6 AMPLITUDE-MODULATED OSCILLATOR

Amplitude modulation. If the oscillator is operated outside of the lock range, the sync signal will beat with the oscillator frequency and produce an audio-frequency, amplitude-modulated output. The modulation will be approximately sinusoidal for modulation levels up to about 10%.

This arrangement is not ideal, but it does provide amplitude-modulated signals in the audio range where normally they are not conveniently obtainable. Modulated outputs of this type can be used to measure the effects of incidental am on other measurements and to provide a modulated source to reduce meter-friction errors in ac measurements.

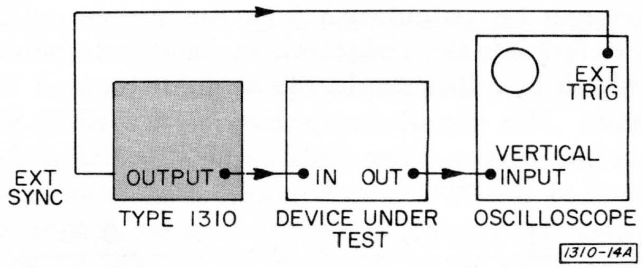
The figure shows one example of amplitude modulation:

10-kHz output of an oscillator modulated at 500Hz by a 9.5-kHz signal applied to the EXT SYNC jack.

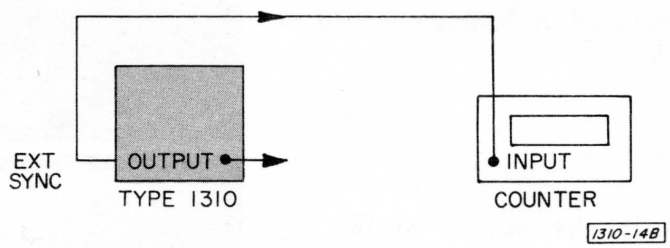


3.4.7 OUTPUT SYNC

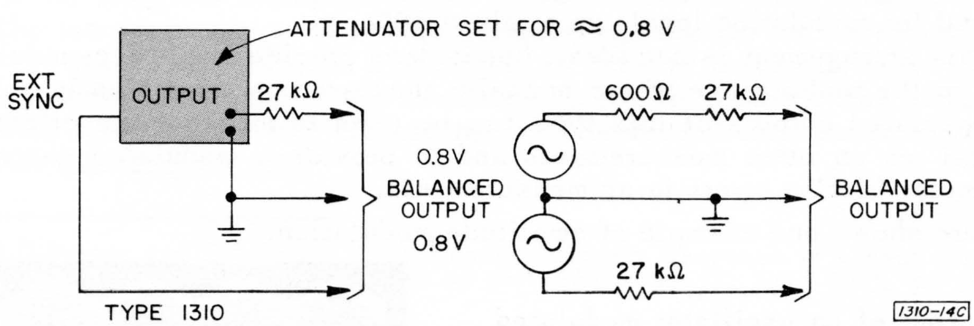
Oscilloscope trigger. Since the sync output is independent of the output level, it can be used to trigger an oscilloscope in applications where the oscillator output is often varied, thereby eliminating frequent readjustment of the oscilloscope trigger circuits.



Counter trigger. A counter can be driven from the EXT SYNC jack when more precise adjustment of frequency is desired or when the front-panel output is not sufficient to trigger the counter.



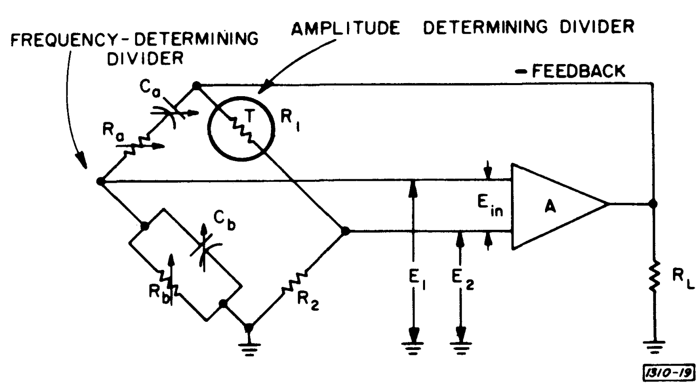
Balanced output. The output sync signal is 180° out-of-phase with the front-panel output, which makes it possible to obtain a high-impedance output, balanced with respect to ground, to drive push-pull circuits. The degree of balance is conveniently set with the LEVEL control.



SECTION 4

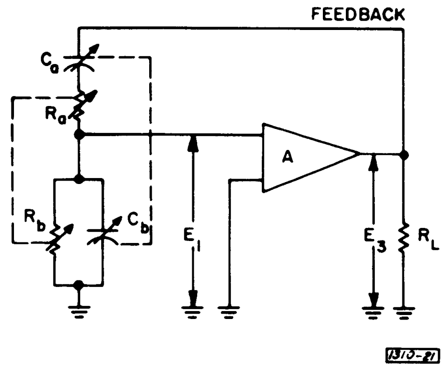
PRINCIPLES OF OPERATION

4.1 BRIDGE



A Wien bridge consists of two parts, a frequency-determining impedance divider which provides positive feedback to sustain oscillation and an amplitude-determining resistive divider which provides negative feedback to stabilize amplitude.

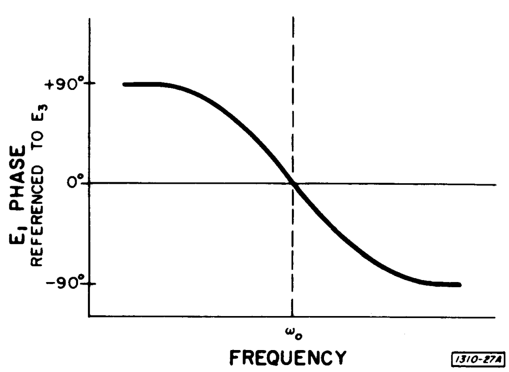
4.1.1. FREQUENCY

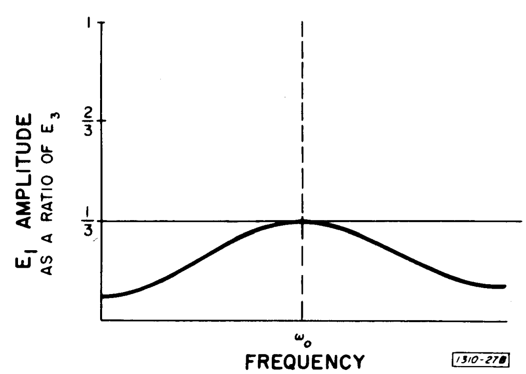


The operating frequency, f_o, of a Wien-bridge oscillator depends on the values of the components in the impedance divider:

$$f_o = \frac{1}{2\pi\sqrt{R_aC_aR_bC_b}} \quad ; \text{ since } \omega = 2\pi f \text{ then } \omega_o = \frac{1}{\sqrt{R_aC_aR_bC_b}}$$

In the Type 1310 , R_a is made equal to R_b and C_a is made equal to C_b. R_a and R_b consist of six pairs of resistors selected by the range switch. Stable, low-temperature-coefficient, metal-film resistors are used on all ranges except the lowest where glass-sealed carbon resistors are used. C_a and C_b consist of two variable, air capacitors ganged together and controlled by the frequency dial.





The transfer function (gain and phase shift) of the frequency divider is:

$$\frac{E_1}{E_3} = \frac{1}{3 + j\left(\frac{\omega}{\omega_o} - \frac{\omega_o}{\omega}\right)}$$

At the operating frequency, $\omega = \omega_o$, therefore: $\frac{E_1}{E_3} = \frac{1}{3}$

4.1 BRIDGE continued

This means that at the operating frequency of the oscillator, one-third of the signal applied to the divider appears at the input to the amplifier.

To sustain oscillations in any oscillator, a loop gain of unity is necessary, i.e., the gain from any one point in the circuit, around the loop and back to that same point, must be equal to one. Thus:

$$G_L = G_A \times \frac{E_1}{E_3} = 1$$

loop gain — amplifier gain — divider gain

Or:

$$G_A = \frac{G_L}{E_1 / E_3} = \frac{1}{1/3} = 3$$

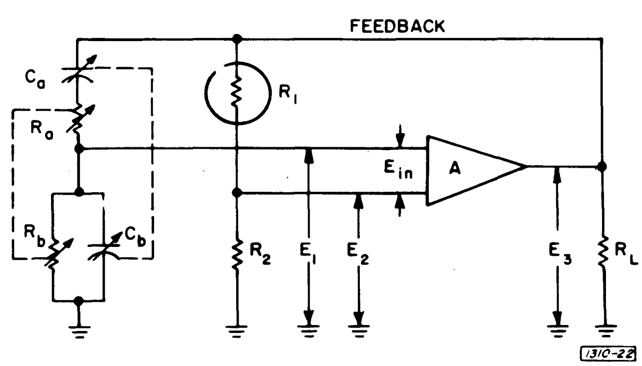
The amplifier, then, must have a gain of 3 to preserve unity gain in the loop and therefore to sustain oscillation at ω_o.

4.1.2 AMPLITUDE STABILIZATION

Under ideal conditions, the only requirement for stable oscillations is a constant loop gain of 1, i.e., if the amplifier gain and impedance divider gain remained constant with changes in frequency, circuit parameters, and environment, only the frequency-determining impedance divider would be necessary.

However, changes in frequency and environment affect the gain, phase, and terminal impedance of the amplifier and slight unbalances in C and R affect the gain (voltage ratio) of the divider. These factors change the loop gain and would cause the oscillator amplitude to increase or decrease.

For example, if these anomalies resulted in a momentary decrease in E_3, E_1 would decrease, further decreasing E_3, and so on until the amplitude became zero. Conversely, if E_3 were to *increase* momentarily, E_1 would increase, further increasing E_3 until the amplifier saturated. This latter case can be easily demonstrated by removing the thermistor, R107, and monitoring the output. The output will be square waves instead of sine waves and will not necessarily be at the frequency indicated on the dial.



To overcome this problem with a single divider, a second divider, R_1 and R_2, is added. The output, E_3, of this divider takes the place of the input ground reference and the input to the amplifier is now the difference between the output of the two dividers (E_2 is *negative* feedback and if it increases, E_3 decreases). Note that the amplifier is across the bridge as is the detector/amplifier of any bridge.

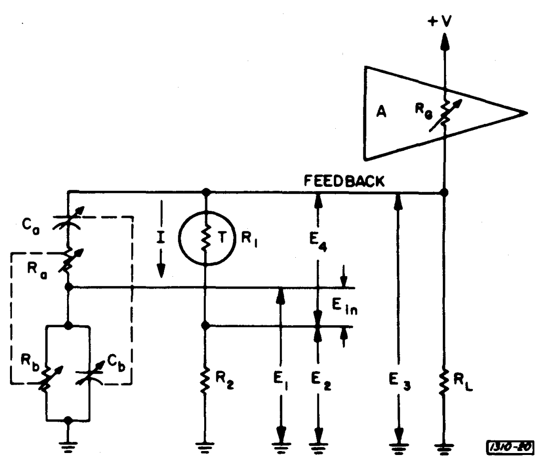
The transfer function of the resistance divider is the simple voltage ratio:

$$\frac{E_2}{E_3} = \frac{R_2}{R_1 + R_2}$$

The loop gain is now: $G_L = G_A \left(\frac{E_1}{E_3} - \frac{E_2}{E_3}\right)$ or =

$$G_L = G_A \left[\frac{1}{3 + j\left(\frac{\omega}{\omega_o} - \frac{\omega_o}{\omega}\right)} - \frac{R_2}{R_1 + R_2} \right]$$

and must still be equal to 1 for stable amplitude.



In order to stabilize E_3 with changes in frequency and amplifier gain, a negative-temperature-coefficient thermistor is used for R_1. An ordinary resistor is linear, its resistance remains essentially constant as the current through it changes. But the thermistor used in the Type 1310 is non linear, its resistance *decreases* as the current through it *increases*.

To explain the action of the thermistor, the amplifier is shown as a current source with a certain current-delivering capability (represented by the constant voltage, +V, and a resistor, R_g).

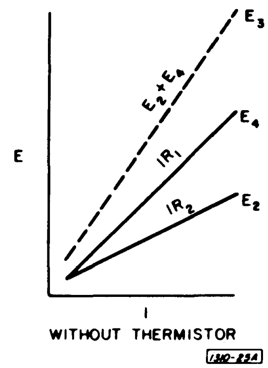
4.1 BRIDGE continued

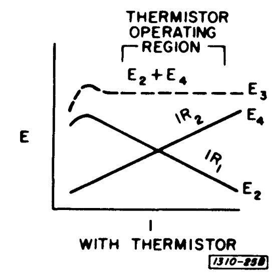
Note that the same voltage, E_3, is across all three legs (impedance divider, resistance divider, and R_L),:

$$E_3 = E_2 + E_4$$

$$E_2 = IR_2$$

$$E_4 = IR_1$$

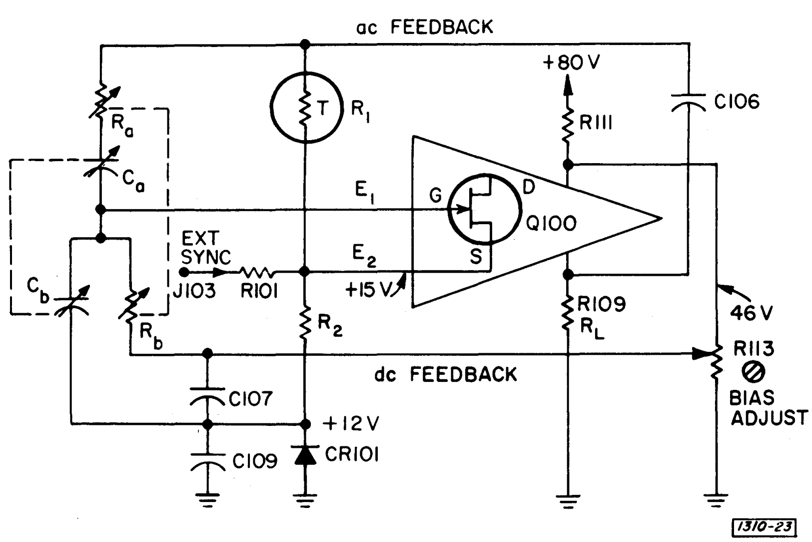




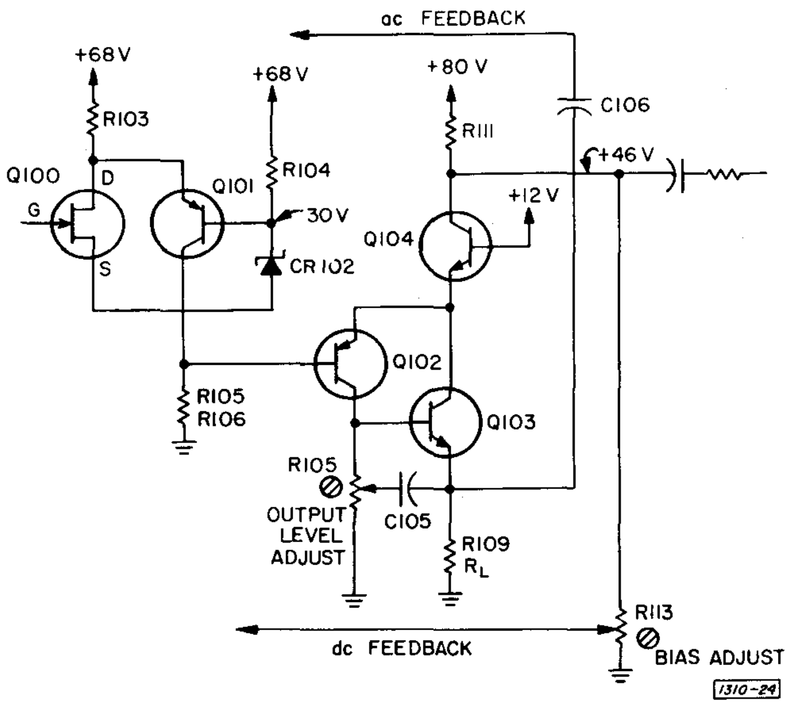
When an ordinary resistor is used for R_1, the voltage drops across R_1 and R_2 change in direct proportion to the current through them, which, in turn, changes in direct proportion to the gain (current-delivering capability) of the amplifier. In the above graph, the result of increasing current, I, is shown. Since E_3 is the sum of E_2 and E_4, E_3 rises linearly as the gain of the amplifier rises.

When a thermistor is used for R_1, and its resistance characteristic is chosen so that the slope of its IR drop is equal to the slope of the IR_2 drop but of opposite sign, E_3 remains constant with changes in amplifier *gain.*

4.2 AMPLIFIER



The differential input stage is a field-effect Transistor (FET, Q100. The positive feedback voltage E_1, from the bridge is applied to the gate (G) and the negative feedback voltage, E_2, is applied to the source (S). The bridge is returned to ac ground via C107, CR101 and C109.

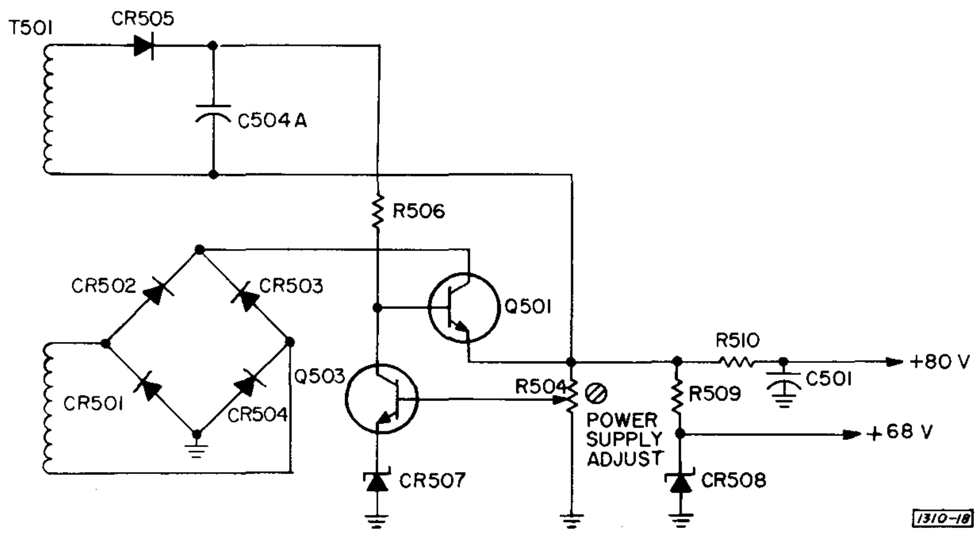


The drain (D) current of Q100 is applied to a grounded-base amplifier, Q101. Dc bias for Q100 is maintained at +15 volts by a divider, R104 and CR102. The amplified signal is taken from the collector and applied to the base of Q102 in a common-emitter connection.

The output of Q102 is taken from the collector and applied to the base of an emitter-follower, Q103. The output of Q103 is taken across R109 (R_L) which is connected through C106 to the top of the bridge and forms the ac paths for the impedance divider and resistance divider described earlier.

The collector current of Q103 drives the grounded-base stage, Q104, whose output appears across R111 and is applied through the attenuator to the OUTPUT terminal J101. Dc negative feedback is used around the entire direct-coupled amplifier to maintain stable dc-operating conditions. This feedback path is from the collector of Q104, through R113 which controls the magnitude of the feedback to the gate (G) Q100.

4.3 POWER SUPPLY



The power supply contains two regulators which provide two outputs: +80 volts B+, and +68 volts B+.

The B+ supply consists of a full-wave bridge rectifier (CR501 through CR504), a series regulator (Q501), and an amplifier-comparator (Q503). The +80-volt output is taken from the emitter of Q501 through a decoupling network, R510 and C501. Error voltage from the center arm of R504 is applied to the base of the comparator, Q503, whose bias is set by a 68-volt Zener diode, CR507. The comparator amplifies and inverts the error voltage and applies it to the base of the series regulator to maintain a constant, low-ripple, +80-volt output.

The +68-volt output is taken from the center of a divider, R509 and CR508, connected to the +80-volt supply. CR508 is a 68-volt Zener diode which maintains a constant output.

4.4 SYNCHRONIZATION

The method used to synchronize the oscillator is commonly called injection locking and is the same mechanism that causes some oscillators to beat with the power-line frequency or to lock with it. It is an old phenomenon and has been frequently discussed in the literature.*

Injection locking is a natural extension of the normal oscillator operation and, except for an isolating resistance and capacitance, is dependent only upon the proper operation of the oscillator. The naturalness of the extension is apparent when it is realized that normal operation is, in fact, only an amplitude-regulated, frequency-selective regeneration of noise sources within the oscillator. Synchronization is an amplitude-regulated, frequency-selective regeneration of an externally applied signal.

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* W.A.Edson, *Vacuum-Tube Oscillators*, John Wiley & Sons, Inc., New York, Chapter 13; 1953.
P.R.Aigrain and E.M.Williams, "Pseudo-synchronization in Amplitude Stabilized Oscillators," *Proceedings of the IRE*, Vol. 36, pp 800-801; June, 1948.
Robert Adler, "A Study of Locking Phenomena in Oscillators," *Proceedings of the IRE*, Vol. 34, pp 351-357; June, 1946.
Marcel J.E.Golay, "Normalized Equations of the Regenerative Oscillator-Noise, Phase Locking and Pulling," *Proceedings of the IEEE*, Vol. 52, pp 1311-1330; November, 1964.

SECTION 5 SERVICE AND MAINTENANCE

5.1 WARRANTY

We warrant that each new instrument 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, district 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 page), 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 district office, requesting a Returned Matexial 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 ROUTINE MAINTENANCE

None required.

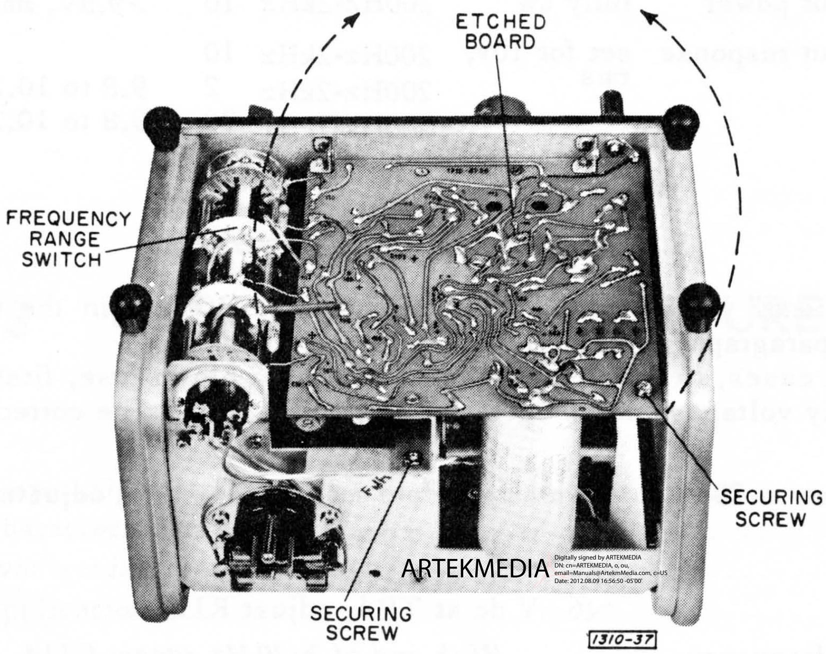
5.4 COVER REMOVAL

Turn the two knurled nuts on the rear of the cover counterclockwise and pull the cover straight back and off.

5.5 PILOT LAMP REPLACEMENT

The pilot lamp and lens form an integral assembly that should last the life of the instrument. However, it can be removed by cutting the plastic retaining band and pushing the lamp assembly out from the rear. To replace the lamp assembly, insert it from the front, install a new retaining band with the beveled edge toward the front, and push it all the way in to the panel.

5.6 ACCESS TO ETCHED-BOARD COMPONENTS.



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.

5.7 MINIMUM PERFORMANCE SPECIFICATIONS

The following specifications are recommended for incoming inspection or periodic operational checks. Detailed procedures are given in the Calibration Procedure, paragraph 5.10.

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

5.7 MINIUM PERFORMANCE SPECIFICATIONS continued

Calibration Procedure Step	*Check*	*OUTPUT LEVEL Setting*	*FREQUENCY Range Setting*	*FREQUENCY Dial Setting*	*Specifications*
5.10.4	Output level	fully cw	200Hz-2kHz	10	>20V, rms
5.10.5	Frequency	fully cw	each	10	±3% of indicated value
5.10.6	Distortion	fully cw	20Hz-200Hz	5	< 0.25%
		fully cw	2kHz-20kHz	5	< 0.25%
5.10.7	Hum	fully cw	200Hz-2kHz	10	< 0.02%
5.10.8	Sync output	—	200Hz-2kHz	10	≥ 0.8V, rms
5.10.9	Output power	fully cw	200Hz-2kHz	10	>9.8V, rms into 600-Ω load
5.10.9	Output response	set for 10v, rms	200Hz-2kHz	10	
			200Hz-2kHz	2	9.8 to 10.2V, rms
			200Hz-2kHz	20	9.8 to 10.2V, rms

5.8 TROUBLE-SHOOTING NOTES

Additional troubleshooting information is contained in the Calibration Procedure, paragraph 5.10, and on the schematic page.

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.

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

+80-V B+	+80 V dc at TPB, adjust R504
+68-V B+	+68 V dc at C502
Dc bias	+46 V dc at TPA, adjust R113

Inaccurate frequency .... *High end of 2–20* Hz *range:* C114.

200kHz-2MHz range: C102 misadjusted, refer to paragraph 5.10.5 for adjustment procedure.

One range only: R_a or R_b for that range.

Lower ranges: Dirt, grease, or high humidity may have affected R_a or R_b, frequency will be too high.

All ranges: C_a or C_b or improper frequency adjustments, refer to paragraph 5.10.5 for adjustment procedure.

Excessive distortion .... Output level improper, adjust R108 for minimum distortion (about 20.5V, rms, at OUTPUT terminal, voltage must be over 20V and R108 must not be adjusted to either of its extremes).

Dc bias improper, adjust R113 for +46V at TPA.

5.8 TROUBLE-SHOOTING NOTES continued

Excessive hum .... Power supply not regulating properly and one or more of the voltages contain excessive ripple:

Supply	*Check Point*	*Dc Value*	*Maximum Ripple*
+80V B+	TPB	+80 V	10mv, p-to-p
+68V B+	C502	+68 V	1mv, p-to-p

Poor response .... (Output varies with frequency) R107 (thermistor) or grossly improper frequency adjustments, refer to paragraph 5.10.5 adjustment procedure.

Instability or excessive noise... CR102 (select for low noise), C104, or Q104. Dust between plates of C101 or wiper dirty or otherwise making poor contact.

5.9 AMPLIFIER OPEN-LOOP TESTING

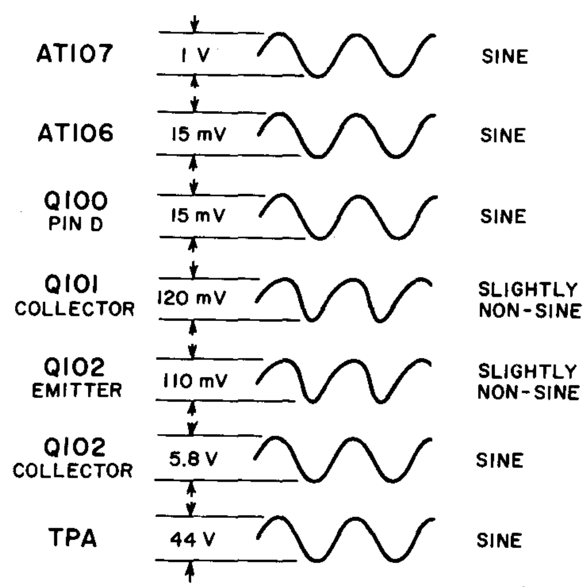
The oscillator uses a large amount of feedback so that trouble at one point will manifest itself at most other points and no clear idea of where the trouble originates is possible. In these cases, open-loop testing is recommended; i.e., testing the amplifier alone, without feedback:

a. Unsolder the lead to AT110 on the etched board and unsolder one end of the thermistor, R107 to open the ac feedback path.

b. Set the controls as follows:
FREQUENCY range 2kHz-20kHz
FREQUENCY dial 2 (2kHz)
LEVEL control .... fully cw

c. Apply a 1-V, p-to-p, 1kHz signal to the EXT SYNC jack, J103.

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



13108-2

5.10 CALIBRATION PROCEDURE

5.10.1 INTRODUCTION

This procedure can be used for troubleshooting or calibration.

If used for troubleshooting, 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 1310 Oscillator incorporates the high reliability one would expect of conservatively designed, semiconductor circuits and routine calibrations are unnecessary.

5.10.2 EQUIPMENT REQUIRED

The following equipment is required for a complete calibration of the Type 1310 Oscillator. The specifications given for the equipment are those necessary for the calibration of the Type 1310 and are not necessarily those of the recommended equipment.

Metered, adjustable autotransformer

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

Electronic voltmeter

Voltage: 40 to 80V, dc; 0.8 to 25V, rms, 20 Hz to 2 MHz, ±2% accuracy.
Impedance: 100 kΩ or greater.
The Type 1806 Electronic Voltmeter is recommended

Digital frequency meter (counter)

Frequency: 2 Hz to 2 MHz, ±0.1% accuracy.
Sensitivity: 1 to 25V, rms.
Impedance: 100 kΩ or greater.
The Type 1191 Counter is recommended.

5.10 CALIBRATION PROCEDURE continued

Oscilloscope

Bandwidth: 2 Hz to 2 MHz (-3 dB points)
Sensitivity: 1 to 25V, rms.
Impedance: 100Ω or greater.

Wave Analyzer

Frequency: 50 Hz to 150 kHz.
Sensitivity: 20 mV to 25V, rms.
Impedance: 100 kΩ or greater.

Test Oscillator

Frequency: 1 kHz.
Amplitude: 1 V, rms, into 25 kΩ.
The Type 1210, 1310, or 1311 Oscillator is recommended.

Load resistors

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

5.10.3 POWER SUPPLY and BIAS VOLTAGES

Connect the Type 1310 to an ac line via a metered adjustable autotransformer and set the transformer for 115-V output. Set the Type 1310 controls as follows:

FREQUENCY range....... 200 Hz-2 kHz
FREQUENCY dial........ 10 (1 kHz)
LEVEL control........... fully cw

R504 **Power Supply.** Connect a voltmeter to TPB and adjust R504 for +80V, dc.

R113 **Bias.** Connect a voltmeter to TPA and adjust R113 for +46X, dc.

Ripple. Connect an oscilloscope to TPB and check 120-cycle ripple at 105, 115, and 125-V line; must be less than 10 mV, p-to-p (1-kHz signal must be less than 250 mV, p-to-p).

Allow a 30-minute warmup then recheck the adjustment of R504 and R113.

5.10.4 OUTPUT LEVEL

FREQUENCY range....... 200 Hz-2kHz
FREQUENCY dial........ 10 (1 kHz)
LEVEL control........... fully cw

R108 **Maximum output.** Connect a voltmeter to the OUTPUT terminal and adjust R108 for 20.5V, rms. The instrument should be on for at least 30 minutes before this adjustment is made.

LEVEL control operation. Vary the LEVEL control over its full range the output level must change smoothly. If it does not, the LEVEL potentiometer, R117, is noisy and should be replaced.

5.10.5 FREQUENCY

FREQUENCY range ...... 200 Hz-2 kHz
FREQUENCY dial .... 2(200 Hz)
LEVEL control .... fully cw

200-Hz mechanical adjustment. Connect a counter and a voltmeter to the EXT SYNC jack and set the FREQUENCY dial for a ten-period count of exactly 50 ms. Loosen the set screws on the FREQUENCY dial and position the dial on the shaft to read exactly 2 with a reading of 50 ms on the counter. Snug-up the set screws but don't tighten. Note the voltmeter reading.

C111 C112 **2 kHz, capacitor adjustments.** Set the FREQUENCY dial to exactly 20. Simultaneously adjust C111 and C112 for a counter frequency reading of exactly 2 kHz and the same voltmeter reading noted above.

The mechanical adjustment and capacitor adjustments interact; repeat until the measurements are correct and the voltmeter readings are equal at both ends of the dial.

Stability. Disconnect the voltmeter and connect an oscilloscope in its place. Rotate the FREQUENCY dial over the entire 200 Hz-2 kHz range; there must be no instability or other erratic operation. If there is, it is usually caused by the rotor wiper arm of the tuning capacitor, C101, or dust in C101. Disconnect the oscilloscope.

C102 **2-MHz adjustment.** Set the FREQUENCY range to 200 kHz-2 MHz and set the FREQUENCY dial to 20 (2 MHz). Adjust C102 for a counter frequency reading of exactly 2 MHz.

C114 **20-Hz adjustment.** Set the FREQUENCY range to 2 Hz-20 Hz and set the FREQUENCY dial to 20 (20-Hz). Adjust C114 for a counter 10-period reading of exactly 500 ms.

Frequency checks. Perform the following frequency checks:

5.10 CALIBRATION PROCEDURE continued

Range Setting	*Dial Setting*	*Counter Reading*	*Remarks*
*200Hz-2kHz	2 (200Hz)	Ten period 48.5 to 51.5 ms	*Mechanically position FREQUENCY dial
200Hz-2kHz	5 (500Hz)	Ten period 19.4 to 20.6 ms	
200Hz-2kHz	10 (1kHz)	Frequency: 970 to 1030 Hz	
200Hz-2kHz	15 (1.5kHz)	Frequency: 1455 to 1555 Hz	
*200Hz-2kHz	20 (2kHz)	Frequency: 1940 to 2060 Hz	*Adjust C111 and C112.
2kHz-20kHz	10 (10kHz)	Frequency: 9.7 to 10.3 kHz	
20kHz-200kHz	10 (100kHz)	Frequency: 97 to 103 kHz	
200kHz-2MHz	10 (1MHz)	Frequency: 0.97 to 1.03 MHz	
*200kHz-2MHz	20 (2MHz)	Frequency: 1.94 to 2.06 MHz	*Adjust C102
20Hz-2MHz	20 (200Hz)	Ten period 48.5 to 51.5 ms	
20Hz-200Hz	2 (20Hz)	Ten period 485 to 515 ms	
2Hz-20Hz	2 (2Hz)	Ten period 4850 to 5150 ms	
2Hz-20&z	10 (10Hz)	Ten period 970 to 1030 ms	
2Hz-20Hz	20 (20Hz)	Ten period 485 to 515 ms	*Adjust C114

*Adjusted earlier in this step.

5.10.6 DISTORTION

FREQUENCY range . . . . 20-200 Hz
FREQUENCY dial . . . . 5 (50 Hz)
LEVEL control . . . . fully cw

50 Hz. Disconnect the counter from the OUTPUT terminals and connect a wave analyzer in its place. Measure the second- and third-harmonic distortion (100 Hz and 150 Hz); total distortion must be less than 0.25%.

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

50 kHz. Change the FREQUENCY range to 20 kHz-200 kHz (50 kHz) and measure the second- and third-harmonic distortion (100 kHz and 150 kHz); total distortion must be less than 0.25%.

These measurements may also be made with a distortion meter.

5.10.7 HUM

FREQUENCY range . . . . 200 Hz-2 kHz
FREQUENCY dial . . . . 10 (1 kHz)
LEVEL control . . . . fully ccw

Open circuit hum. Keep the wave analyzer connected to the OUTPUT terminals and measure the hum at 60, 120, and 180 Hz; total hum must be less than 0.02%.

$$\text{total hum} = \sqrt{(\text{hum at 60 Hz})^2 + (\text{hum at 120 Hz})^2 + (\text{hum at 180 Hz})^2}$$

5.10.8 SYNCHRONIZATION

FREQUENCY range 200Hz-2kHz
FREQUENCY dial . . . . 10 (kHz)
LEVEL control . . . . fully cw

Sync in. Disconnect the wave analyzer from the OUTPUT terminals and connect a counter in its place. Connect the output of another oscillator (test oscillator) to the EXT SYNC jack and set the test oscillator for 1V, rms, of exactly 1 kHz.

Very slowly increase the FREQUENCY dial setting of the Type 1310 until it drops out of sync (counter reading changes from 1 kHz to some higher frequency). Reduce the output amplitude of the test oscillator to below 50 mV, rms, or turn its power switch off and note the counter reading (free-running frequency of the Type 1310); must be greater than 1030 Hz (1 kHz ±3%).

Sync out. Disconnect the test oscillator from the EXT SYNC jack and connect a voltmeter in its place. The sync out amplitude must be 0.8V, rms, or greater.

5.10.9 OUTPUT RESPONSE

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

FREQUENCY *Range Setting*	*Dial Setting*	*Output voltage, rms*
200Hz-2kHz	10 (1kHz)	> 9.8V
200Hz-2kHz	10 (1kHz)	Set LEVEL control for exactly 10V
200Hz-2kHz	2 (200Hz)	9.8 to 10.2V
200Hz-2kHz	20 (2kHz)	9.8 to 10.2V
2kHz-20kHz	20 (20kHz)	9.8 to 10.2V
20kHz-200kHz	20 (200kHz)	9.8 to 10.2V
20Hz-200Hz	2 (20Hz)	9.8 to 10.2V

5.11 SWITCH REMOVAL - REPLACEMENT.

5.11.1 REMOVAL.

To remove the knobs:

a. Set the controls full ccw (any position for frequency main tuning controls).
b. Hold the instrument securely and pull the knob off with fingers.

CAUTION

Do not use a screwdriver or other instrument to pry off the knob if it is tight, since this might mar or crack the dial. Do not lose the retention spring in the knob when the knob is removed. Do not attempt to further remove any parts of the frequency main tuning controls, since these controls must be calibrated at a GR service center when the control is reinstalled.

c. Remove the setscrew from the bushing; use a hex-socket key wrench.
d. Remove the bushing.

NOTE

If the knob and bushing are combined when the knob is removed, turn a machine tap a turn or two into the bushing on the dial for sufficient grip for easy separation of the knob.

e. If the switch is to be removed, remove the dress nut exposed after step d.

5.11.2 REPLACEMENT.

Install the switches by reversing the removal procedure and performing the following steps:

a. Make sure the control shafts are turned full ccw.
b. Install the dress nut, if applicable.
c. Install the bushing on the shaft; tighten the setscrew.

NOTE

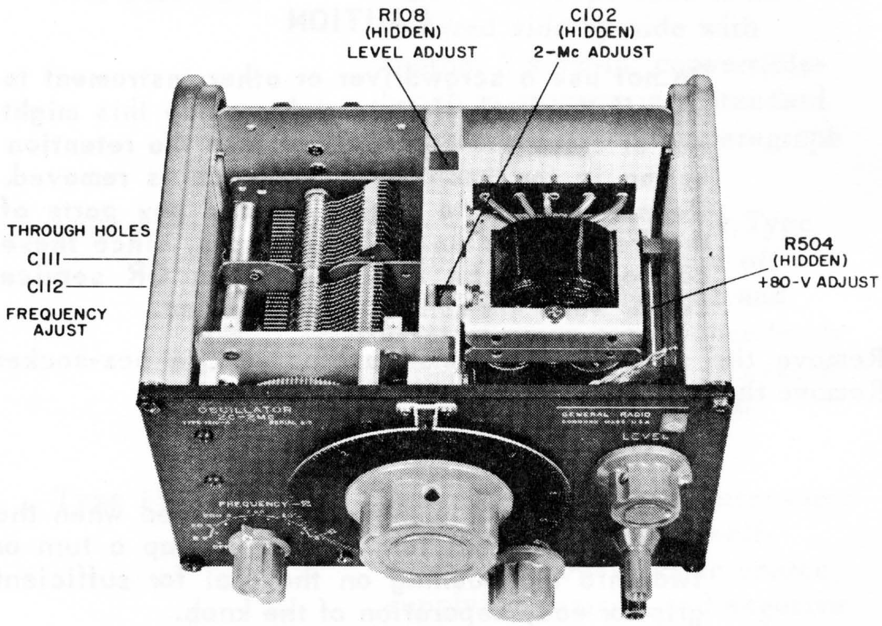
Make sure that the end of the shaft does not protrude through the bushing, or the knob won't seat properly.

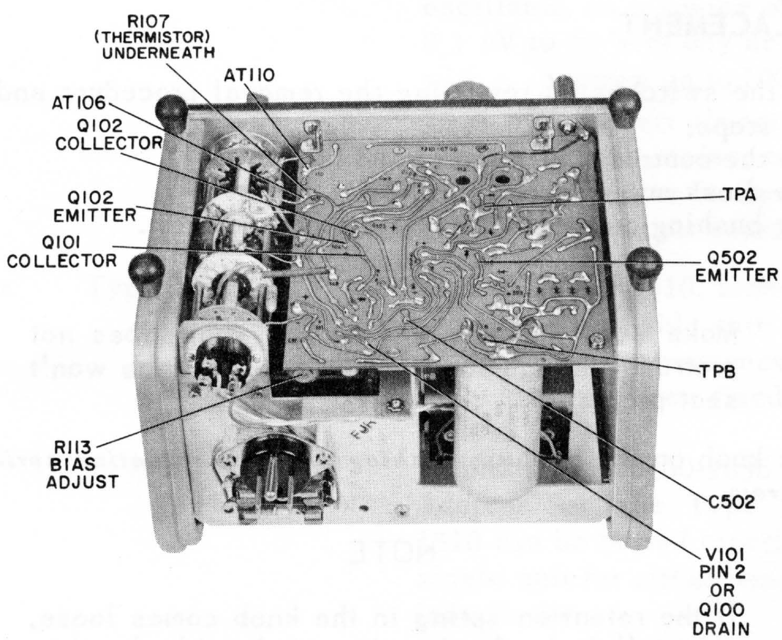
d. Install the knob on the bushing, *making sure the retention spring is opposite the setscrew.*

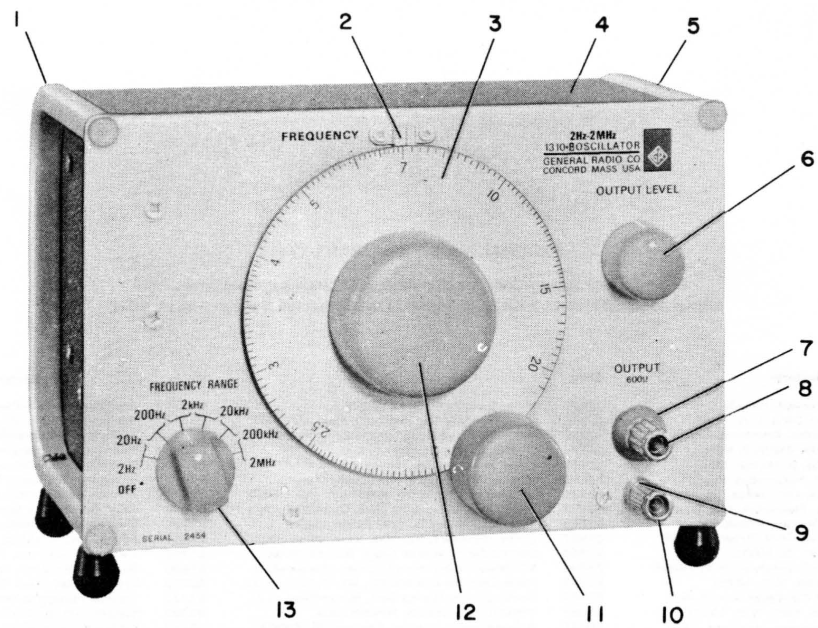
NOTE

If the retention spring in the knob comes loose, reinstall it in the interior notch with the thin flange set into the small slit in the wall of the knob.

SECTION 6 PARTS LIST and SCHEMATIC







MECHANICAL REPLACEABLE PARTS

Qty	Ref. No.	Name	Description	GR Part No.	FMC	Mfg. Part No.	Fed. Stock No.
1	1	End frame asm.	Left end frame asm.,	5310-3065	24655	5310-3065	
2			including foot, soft	5260-0700	24655	5260-0700	5340-738-6329
1	2	Indicator	Indicator, opaque	5460-1303	24655	5460-1303	
1	3	Dial asm.	Dial asm., FREQUENCY	1310-1500	24655	1310-1500	
1	4	Dust cover asm.	Dust cover asm.,	4429-1700	24655	4429-1700.	
2			including thumbscrew	7270-4800	24655	7270-4800	
1	5	End frame asm.	Right end frame asm.,	5310-3064	24655	5310-3064	
2			including foot, soft	5260-0700	24655	5260-0700	5340-738-6329
1	6	Knob asm.	Knob, OUTPUT LEVEL, including retainer 5220-5402	5520-5321	24655	5520-5321	
1	7	Insulator, binding post	Insulator	0938-7130	24655	0938-7130	
1	8	Binding post	Binding post, J101, OUTPUT	0938-3000	24655	0938-3000	
1	9	Spacer, binding post	Spacer	7800-0600	24655	7800-0600	5340-738-6516
1	10	Binding post	Binding post, J102, OUTPUT	0938-3022	24655	0938-3022	
1	11	Knob asm.	Knob, FREQUENCY, vernier, including retainer 5220-5401	5520-5420	24655	5520-5420	
1	12	Knob asm.	Knob, FREQUENCY, main tuning dial, including retainer 5220-5401	5520-5520	24655	5520-5520	
1	13	Knob asm.	Knob, FREQUENCY RANGE, including retainer 5220-5402	5500-5321	24655	5500-5321	
2		Screw (on voltage legend plate - rear panel)	Screw, binder hear, 3/16	7060-0400	24655	7060-0400	5305-929-9384
1		Plug asm.	Power plug asm., PL501	4240-0700	24655	4240-0700	5935-794-3012
MISCELLANEOUS							
1		Jack	Phone jack, J103	4260-1030	82389	#111	
1		Dress nut	Phone jack, dress, nut, 3/8-32, 9/16	5800-0805	24655	5800-0805	

FEDERAL MANUFACTURER'S CODE

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) as supplemented through August, 1968.

Code	Manufacturer
00192	Jones Mfg. Co, Chicago, Illinois
00194	Walsco Electronics Corp, L.A., Calif.
00434	Schweber Electronics, Westburg, L.I., N.Y.
00656	Aerovox Corp, New Bedford, Mass.
01009	Alden Products Co, Brockton, Mass.
01121	Allen-Bradley, Co, Milwaukee, Wisc.
01295	Texas Instruments, Inc, Dallas, Texas
02114	Ferroxcube Corp, Saugerties, N.Y. 12477
02606	Fenwal Lab Inc, Morton Grove, Ill.
02660	Amphenol Electron Corp, Broadview, Ill.
02768	Fastex, Des Plaines, Ill. 60016
03508	G.E. Semicon Prod, Syracuse, N.Y. 13201
03636	Grayburne, Yonkers, N.Y. 10701
03888	Pyrofilm Resistor Co, Cedar Knolls, N.J.
03911	Clairex Corp, New York, N.Y. 10001
04009	Arrow-Hart & Hegeman, Hartford, Conn. 06106
04713	Motorola, Phoenix, Ariz. 85008
05170	Engr'd Electronics, Santa Ana, Calif. 92702
05624	Barber-Colman Co, Rockford, Ill. 61101
05820	Wakefield Eng, Inc, Wakefield, Mass. 01880
07126	Digitron Co, Pasadena, Calif.
07127	Eagle Signal (E.W. Bliss Co), Baraboo, Wisc.
07261	Avnet Corp, Culver City, Calif. 90230
07263	Fairchild Camera, Mountain View, Calif.
07387	Birtcher Corp, No. Los Angeles, Calif.
07595	Amer Semicond, Arlington Hts, Ill. 60004
07828	Bodine Corp, Bridgeport, Conn. 06605
07829	Bodine Electric Co, Chicago, Ill. 60618
07910	Cont Device Corp, Hawthorne, Calif.
07983	State Labs Inc, N.Y., N.Y. 10003
07999	Borg Inst., Delavan, Wisc. 53115
08730	Vemaline Prod Co, Franklin Lakes, N.J.
09213	G.E. Semiconductor, Buffalo, N.Y.
09408	Star-Tronics Inc, Georgetown, Mass. 01830
09823	Burgess Battery Co, Freeport, Ill.
09922	Burndy Corp, Norwalk, Conn. 06852
11236	C.T.S. of Berne, Inc, Berne, Ind. 46711
11599	Chandler Evans Corp, W. Hartford, Conn.
12040	National Semiconductor, Danbury, Conn.
12498	Crystalonics, Cambridge, Mass. 02140
12672	RCA, Woodbridge, N.J.
12697	Clarostat Mfg Co, Inc, Dover, N.H. 03820
12954	Dickson Electronics, Scottsdale, Ariz.
13327	Solitron Devices, Tappan, N.Y. 10983
14433	ITT Semicondictors, W.Palm Beach, Fla.
14655	Cornell-Dubilier Electric Co, Newark, N.J.
14674	Corning Glass Works, Corning, N.Y.
14936	General Instrument Corp, Hicksville, N.Y.
15238	ITT, Semiconductor Div, Lawrence, Mass.
15605	Cutler-Hammer Inc, Milwaukee, Wisc. 53233
16037	Spruce Pine Mica Co, Spruce Pine, N.C.
17771	Singer Co, Diehl Div, Somerville, N.J.
19396	Illinois Tool Works, Pakton Div, Chicago, Ill.
19644	LRC Electronics, Horseheads, N.Y.
19701	Electra Mfg Co, Independence, Kansas 67301
21335	Fafnir Bearing Co, New Briton, Conn.
22753	UID Electronics Corp, Hollywood, Fla.
23342	Avnet Electronics Corp, Franklin Park, Ill.
24446	G.E., Schenectady, N.Y. 12305
24454	G.E., Electronics Comp, Syracuse, N.Y.
24455	G.E. (Lamp Div), Nela Park, Cleveland, Ohio
24655	General Radio Co, W. Concord, Mass. 01781
26806	American Zettlet Inc, Costa Mesa, Calif.
28520	Hayman Mfg Co, Kenilworth, N.J.
28959	Hoffman Electronics Corp, El Monte, Calif.
30874	I.B.M, Armonk, New York
32001	Jensen Mfg. Co, Chicago, Ill. 60638
33173	G.E. Comp, Owensboro, Ky. 42301
35929	Constanta Co, Mont. 19, Que.
37942	P.R. Mallory & Co Inc, Indianapolis, Ind.
38443	Marlin-Rockwell Corp, Jamestown, N.Y.
40931	Honeywell Inc, Minneapolis, Minn. 55408
42190	Muter Co, Chicago, Ill. 60638
42498	National Co, Inc, Melrose, Mass. 02176
43991	Norma-Hoffman, Stanford, Conn. 06904
49671	RCA, New York, N.Y. 10020
49956	Raytheon Mfg Co, Waltham, Mass. 02154
53021	Sangamo Electric Co, Springfield, Ill. 62705
54294	Shallcross Mfg Co, Selma, N.C.
54715	Shure Brothers, Inc, Evanston, Ill.
56289	Sprague Electric Co, N. Adams, Mass.
59730	Thomas and Betts Co, Elizabeth, N.J. 07207
59875	TRW Inc, (Accessories Div), Cleveland, Ohio
60399	Torrington Mfg Co, Torrington, Conn.
61637	Union Carbide Corp, New York, N.Y. 10017
61864	United-Carr Fastener Corp, Boston, Mass.
63060	Victoreen Instrument Co, Inc, Cleveland, O.
63743	Ward Leonard Electric Co, Mt. Vernon, N.Y.
65083	Westinghouse (Lamp Div), Bloomfield, N.J.
65092	Weston Instruments, Newark, N.J.
70485	Atlantic-India Rubber, Chicago, Ill. 60607
70563	Amperite Co, Union City, N.J. 07087
70903	Belden Mfg Co, Chicago, Ill. 60644
71126	Bronson, Homer D, Co, Beacon Falls, Conn.
71294	Canfield, H.O. Co, Clifton Forge, Va. 24422
71400	Bussman (McGraw Edison), St. Louis, Mo.
71468	ITT Cannon Elec, L.A., Calif. 90031
71590	Centralab, Inc, Milwaukee, Wisc, 53212
71666	Continental Carbon Co, Inc, New York, N.Y.
71707	Coto Coil Co Inc, Providence, R.I.
71744	Chicago Miniature Lamp Works, Chicago, Ill.
71785	Cinch Mfg Co, Chicago, Ill. 60624
71823	Darnell Corp, Ltd, Downey, Calif. 90241
72136	Electro Motive Mfg Co, Wilmington, Conn.
72259	Nytronics Inc, Berkeley Heights, N.J. 07922
72619	Dialight Co, Brooklyn, N.Y. 11237
72699	General Instr Corp, Newark, N.J. 07104
72765	Drake Mfg Co, Chicago, Ill. 60656
72825	Hugh H. Eby Inc, Philadelphia, Penn. 19144
72962	Elastic Stop Nut Corp, Union, N.J. 07083
72982	Erie Technological Products Inc, Erie, Penn.
73138	Beckman Inc, Fullerton, Calif. 92634
73445	Amperex Electronics Co, Hicksville, N.Y.
73559	Carling Electric Co, W.Hartford, Conn.
73690	Elco Resistor Co, New York, N.Y.
73899	JFD Electronics Corp, Brooklyn, N.Y.
74193	Heinemann Electric Co, Trenton, N.J.
74861	Industrial Condenser Corp, Chicago, Ill.
74970	E.F. Johnson Co, Waseca, Minn. 56093
75042	IRC Inc, Philadelphia, Penn. 19108
75382	Kulka Electric Corp, Mt. Vernon, N.Y.
75491	Lafayette Industrial Electronics, Jamica, N.Y.
75608	Linden and Co, Providence, R.I.
75915	Littelfuse, Inc, Des Plaines, Ill. 60016
76005	Lord Mfg Co, Erie, Penn. 16512
76149	Mallory Electric Corp, Detroit, Mich. 48204
76487	James Millen Mfg Co, Malden, Mass. 02148
76545	Mueller Electric Co, Cleveland, Ohio 44114
76684	National Tube Co, Pittsburg, Penn.
76854	Oak Mfg Co, Crystal Lake, Ill.
77147	Patton MacGuyer Co, Providence, R.I.
77166	Pass-Seymour, Syracuse, N.Y.
77263	Pierce Roberts Rubber Co, Trenton, N.J.
77339	Positive Lockwasher Co, Newark, N.J.
77542	Ray-O-Vac Co, Madison, Wisc.
77630	TRW, Electronic Comp, Camden, N.J. 08103
77638	General Instruments Corp, Brooklyn, N.Y.
78189	Shakeproof (Ill. Tool Works), Elgin, Ill. 60120
78277	Sigma Instruments Inc, S.Braintree, Mass.
78488	Stackpole Carbon Co, St. Marys, Penn.
78553	Tinnerman Products, Inc, Cleveland, Ohio
79089	RCA, Rec Tube & Semicond, Harrison, N.J.
79725	Wiremold Co, Hartford, Conn. 06110
79963	Zierick Mfg Co, New Rochelle, N.Y.
80030	Prestole Fastener, Toledo, Ohio
80048	Vickers Inc, St. Louis, Mo.
80131	Electronic Industries Assoc, Washington, D.C.
80183	Sprague Products Co, No. Adams, Mass.
80211	Motorola Inc, Franklin Park, Ill. 60131
80258	Standard Oil Co, Lafeyette, Ind.
80294	Bourns Inc, Riverside, Calif. 92506
80431	Air Filter Corp, Milwaukee, Wisc. 53218
80583	Hammarlund Co, Inc, New York, N.Y.
80740	Beckman Instruments, Inc, Fullerton, Calif.
81030	International Insturment, Orange, Conn.
81073	Grayhill Inc, LaGrange, Ill. 60525
81143	Isolantite Mfg Corp, Stirling, N.J. 07980
81349	Military Specifications
81350	Joint Army-Navy Specifications
81751	Columbus Electronics Corp, Yonkers, N.Y.
81831	Filtron Co, Flushing, L.I., N.Y. 11354
81840	Ledex Inc, Dayton, Ohio 45402
81860	Barry-Wright Corp, Watertown, Mass.
82219	Sylvania Elec Prod, Emporium, Penn.
82273	Indiana Pattern & Model Works, LaPort, Ind.
82389	Switchcraft Inc, Chicago, Ill. 60630
82647	Metals & Controls Inc, Attleboro, Mass.
82807	Milwaukee Resistor Co, Milwaukee, Wisc.
83033	Meissner Mfg, (Maguire Ind) Mt. Carmel, Ill.
83058	Carr Fastener Co, Cambridge, Mass.
83186	Victory Engineering, Springfield, N.J. 07081
83361	Bearing Specialty Co, San Francisco, Calif.
83587	Solar Electric Corp, Warren, Penn.
83740	Union Carbide Corp, New York, N.Y. 10017
83781	National Electronics Inc, Geneva, Ill.
84411	TRW Capacitor Div, Ogallala, Nebr.
84835	Lehigh Metal Prods, Cambridge, Mass. 02140
84971	TA Mfg Corp, Los Angeles, Calif.
86577	Precision Metal Prods, Stoneham, Mass. 02180
86684	RCA (Elect. Comp & Dev), Harrison, N.J.
86687	REC Corp, New Rochelle, N.Y. 10801
86800	Cont Electronics Corp, Brooklyn, N.Y. 11222
88140	Cutler-Hammer Inc, Lincoln, Ill.
88219	Gould Nat. Batteries Inc, Trenton, N.J.
88419	Cornell-Dubilier, Fuquay-Varina, N.C.
88627	K & G Mfg Co, New York, N.Y.
89482	Holtzer-Cabot Corp, Boston, Mass.
89665	United Transformer Co, Chicago, Ill.
90201	Mallory Capacitor Co, Indianapolis, Ind.
90750	Westinghouse Electric Corp, Boston, Mass.
90952	Hardware Products Co, Reading, Penn. 19602
91032	Continental Wire Corp, York, Penn. 17405
91146	ITT (Cannon Electric Inc), Salem, Mass.
91293	Johanson Mfg Co, Boonton, N.J. 07005
91506	Augat Inc, Attleboro, Mass. 02703
91598	Chandler Co, Wethersfield, Conn. 06109
91637	Dale Electronics Inc, Columbus, Nebr.
91662	Elco Corp, Willow Grove, Penn.
91719	General Instruments, Inc, Dallas, Texas
91929	Honeywell Inc, Freeport, Ill.
92519	Electra Insul Corp, Woodside, L.I., N.Y.
92678	E.G.&G., Boston, Mass.
93332	Sylvania Elect Prods, Inc, Woburn, Mass.
93916	Cramer Products Co, New York, N.Y. 10013
94144	Raytheon Co, Components Div, Quincy, Mass.
94154	Tung Sol Electric Inc, Newark, N.J.
95076	Garde Mfg Co, Cumberland, R.I.
95121	Quality Components Inc, St. Mary's, Penn.
95146	Alco Electronics Mfg Co, Lawrence, Mass.
95238	Continental Connector Corp, Woodside, N.Y.
95275	Vitramon, Inc, Bridgeport, Conn.
95354	Methode Mfg Co, Chicago, Ill.
95412	General Electric Co, Schenectady, N.Y.
95794	Anaconda Amer Brass Co, Torrington, Conn.
96095	Hi-Q Div. of Aerovox Corp, Orlean, N.Y.
96214	Texas Instruments Inc, Dallas, Texas 75209
96256	Thordarson-Meissner, Mt. Carmel, Ill.
96341	Microwave Associates Inc, Burlington, Mass.
96791	Amphenol Corp, Jonesville, Wisc, 53545
96906	Military Standards
98291	Sealectro Corp, Mamaroneck, N.Y. 10544
98474	Compar Inc, Burlingame, Calif.
98821	North Hills Electronics Inc, Glen Cove, N.Y.
99180	Transitron Electronics Corp, Melrose, Mass.
99313	Varian, Palo Alto, Calif. 94303
99378	Atlee Corp, Winchester, Mass. 01890
99800	Delevan Electronics Corp, E. Aurora, N.Y.

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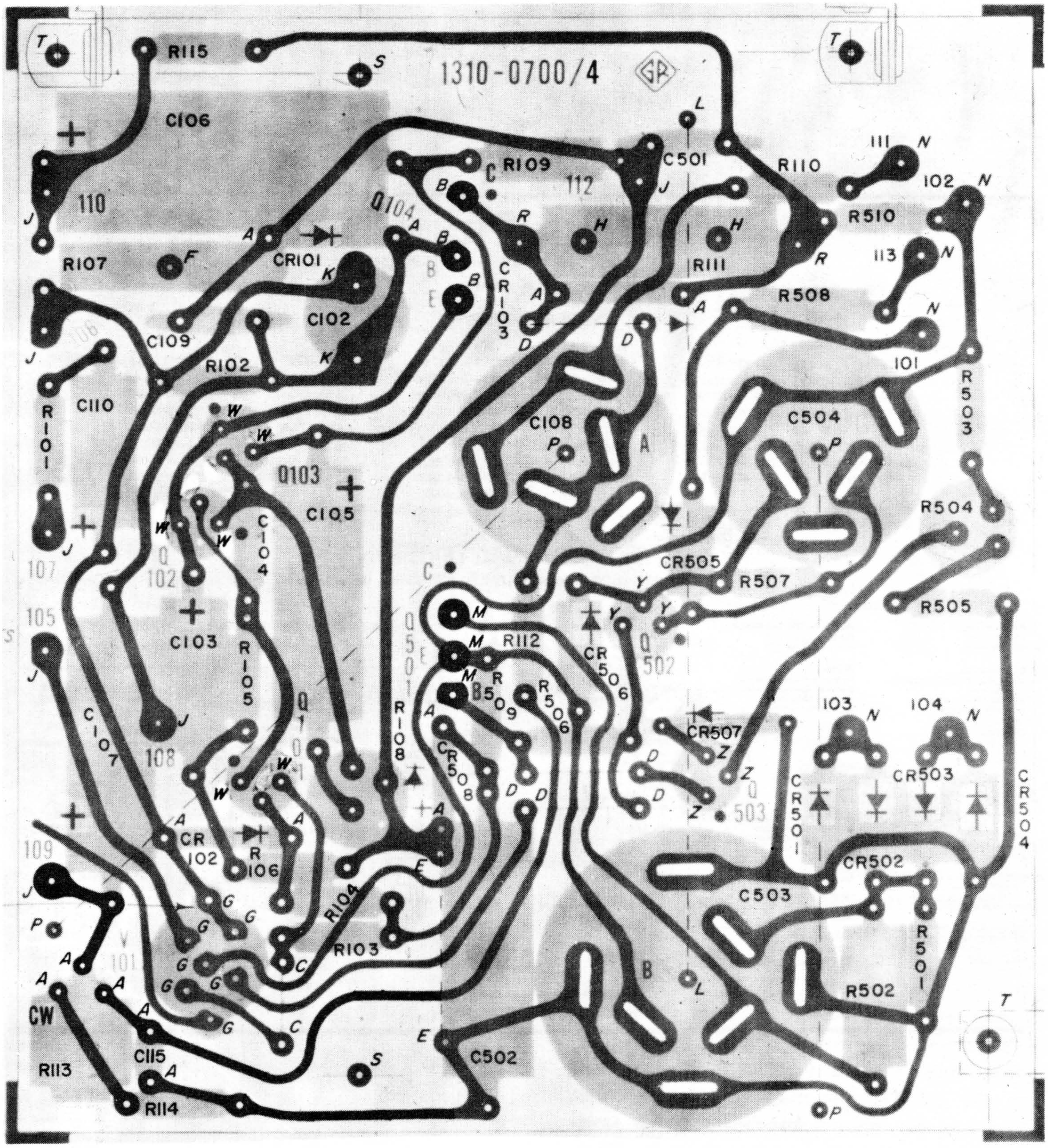
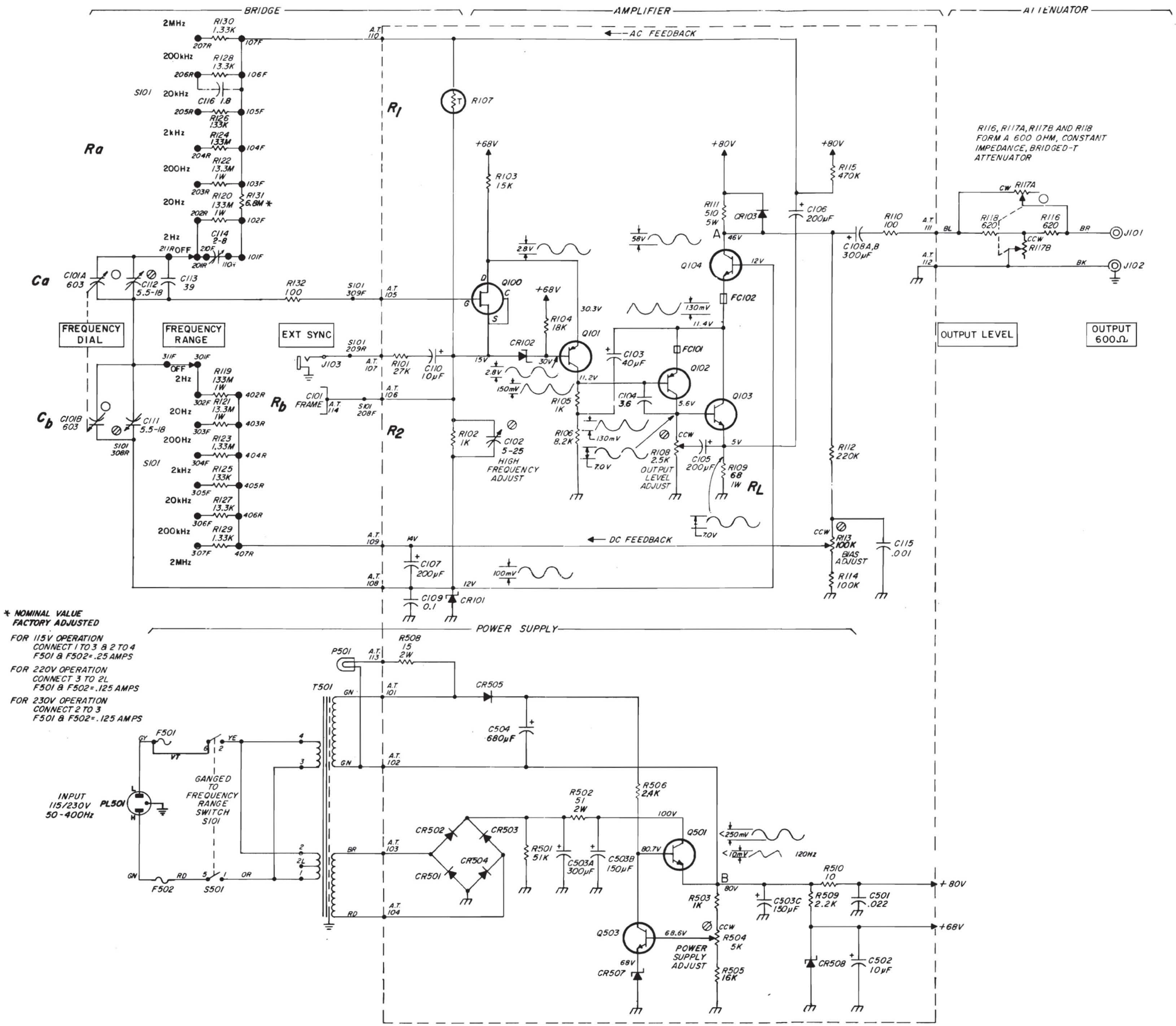


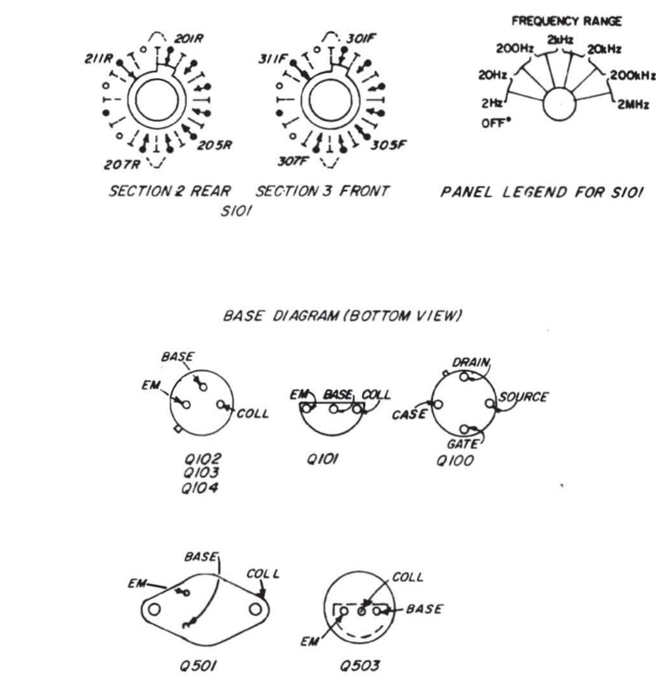
Etched board assembly, part number 1310-2710.

NOTE: The board is shown foil-side up. The number appearing on the foil side is *not* the part number. The dot on the foil at the transistor socket indicates the collector lead.



ANCHOR TERMINALS USED A.T. 101 THRU 114

NOTE UNLESS SPECIFIED	
1 POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE	5 RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
2 CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK	6 CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
3 REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM	7 ◯ KNOB CONTROL
	8 ⊘ SCREWDRIVER CONTROL
	9 AT ANCHOR TERMINAL
4 RESISTORS 1/2 WATT	10 TP TEST POINT



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.

Waveforms taken at 1KHz, maximum output.

Schematic of the Type 1310-B.

ELECTRICAL REPLACEABLE PARTS

	Ref. No.	Description		GR Part No.	FMC	Mfg. Part No.	Fed. Stock No.
CAPACITORS	C101	Variable air, 630 pF	main tuning	1210-4000	24655	1210-4000	
	C102	Trimmer, 5 to 25 pF		4910-1150	72982	557-050, U2PO	
	C103	Electrolytic, 40 µF +100-10% 6V		4450-3600	37942	20-40707S4	5910-952-0467
	C104	Ceramic, 5.6 pF ±5% 500V		4400-0560	78488	GA, 5.6 pF ±5%	
	C105	Electrolytic, 200 µF +100-10% 6V		4450-2610	37942	TT, 200 µF +100-10%	5910-945-1836
	C106	Electrolytic, 200 µF +100-10% 12V		4450-0400	37942	97679	5910-799-9281
	C107	Electrolytic, 200 µF +100-10% 6V		4450-2610	37942	TT, 200 µF +100-10%	5910-945-1836
	C108	Electrolytic, 300 µF +100-10% 75V		4450-5620	37942	20-222544990	5910-931-7040
	C109	Ceramic, 0.1 µF +80-20% 50V		4403-4100	80131	CC63, 0.1 µF +80-20%	5910-811-4788
	C110	Electrolytic, 10 µF +100-10% 25V		4450-3800	56289	30D106G025BB4M1	5910-952-8658
	C111	Trimmer, 5.5 to 18 pF 350V		4910-2041	72982	538-000, 5.5-18 pF	
	C112	Trimmer, 5.5 to 18 pF 350V		4910-2041	72982	538-000, 5.5-18 pF	
	C113	Mica, 39 pF ±5% 500V		4640-0200	72136	CM15D390J	
	C114	Trimmer, 2 to 8 pF 350V		4910-2042	72982	538-000, 2-8 pF	
	C115	Ceramic, 0.001 µF +80-20% 500V		4404-2109	72982	831, 0.001 µF +80-20%	5910-983-9994
	C116	Ceramic, 1.8 pF ±5% 500V		4400-0180	78488	GA, 1.8 pF ±5%	
	C501	Ceramic, 0.022 µF +80-20% 500V		4407-3229	72982	CC63, 0.022 µF +80-20%	5910-842-2961
	C502	Electrolytic, 10 µF +100-10% 150V		4450-3100	80183	D33610	5910-799-9287
	C503	Electrolytic, 300 µF x 150 µF x 150 µF +100-10% 150V		4450-5602	37942	20-22287991	5910-931-7039
	C504	Electrolytic, 680pF +100-10% 15 V		4450-6015	37942	TT, 680pF +100-10%	
DIODES	CR101	Type 1N759A		6083-1014	81349	1N759A	5961-846-9157
	CR102	Type 1N965B, selected for low noise		6083-1047	07910	1N965A	5961-877-6192
	CR103	Type 1N628		6082-1013	07910	1N628	5961-681-8162
	CR501	Type 1N3254		6081-1002	09213	1N3254	5961-082-3988
	CR502	Type 1N3254		6081-1002	09213	1N3254	5961-082-3988
	CR503	Type 1N3254		6081-1002	09213	1N3254	5961-082-3988
	CR504	Type 1N3254		6081-1002	09213	1N3254	5961-082-3988
	CR505	Type 1N3253		6081-1001	79089	1N3253	5961-814-4251
	CR506	Type 1N753A		6083-1006	07910	1N753A	5961-752-6121
	CR507	Type 1N981B		6083-1042	28959	1N981B	5961-892-0909
	CR508	Type 1N981B		6083-1042	28959	1N981B	5961-892-0909
FUSES	F501	For 115-V operation: 0.25A, 3AG, Slo-Blo		5330-0700	71400	MDL, 0.25 Amp.	5920-933-5435
		For 230-V operation: 0.125A, 3AG, Slo-Blo		5330-0450	71400	MDL, 0.125 Amp.	5920-284-9455
	F502	For 115-V operation: 0.25A, 3AG, Slo-Blo		5330-0700	71400	MDL, 0.25 Amp.	5920-933-5435
		For 230-V operation: 0.125A, 3AG, Slo-Blo		5330-0450	71400	MDL, 0.125 Amp.	5920-284-9455
JACKS	J101	Binding post assembly:	OUTPUT				
		1 binding post, red plastic top		4060-0400	24655	4060-0400	5940-951-9300
		2 insulators, red plastic		4130-0300	24655	4130-0300	
	J102	Binding post assembly:	OUTPUT ground				
		1 binding post, metal top		4060-1800	24655	4060-1800	5940-272-1464
		1 bushing		7800-0600	24655	7800-0600	5340-738-6516
	J103	Phone jack, two contact, Switchcraft Type 11	EXT SYNC				
LAMP	P501	Translucent monogram, 6V 200 mA, size T-1-3/4	pilot lamp	5600-1001	24655	5600-1001	6240-933-5816
PLUG	PL501	3-terminal power plug assembly		4240-0700	24655	4240-0700	5935-926-0635
TRANSISTORS	Q100	Type 2N4221		8210-1127	93916	2N4221	
	Q101	Type 2N2188		8210-1045	01295	2N2188	5960-065-5373
	Q102	Type 2N2188		8210-1045	01295	2N2188	5960-065-5373
	Q103	Type 2N2218		8210-1028	81349	2N2218	5960-059-4464
	Q104	GR TR-99 uses 5700-1010 heat sink		8210-1099	80221	SM-8321	5961-931-8245
	Q501	Type 2N2196		8210-1041	96214	2N2196	5961-903-1619
	Q503	Type 2N2714		8210-1047	24446	2N3414	5961-989-2749

ELECTRICAL REPLACEABLE PARTS continued

	Ref. No.	Description		GR Part No.	FMC	Mfg. Part No.	Fed. Stock No.
RESISTORS	R101	Composition, 27 kΩ ±5% 1/2w		6100-3275	01121	RC20GF273J	5905-279-3499
	R102	Composition, 1 kΩ ±5% 1/2w		6100-2105	01121	RC20GF102J	5905-195-6806
	R103	Composition, 15 kΩ ±5% 1/2w		6100-3155	01121	RC20GF153J	5905-279-2616
	R104	Composition, 18 kΩ ±5% 1/2w		6100-3185	01121	RC20GF183J	5905-279-3500
	R105	Composition, 1 kΩ ±5% 1/2w		6100-2105	01121	RC20GF102J	5905-195-6806
	R106	Composition, 8.2 kΩ ±5% 1/2w		6100-2825	01121	RC20GF822J	5905-299-1971
	R107	Thermistor		6740-2021	83186	51A16/GR	5905-933-8183
	R108	Potentiometer, composition, 2.5 kΩ ±20%		6040-0500	01121	FWC, 2.5 kΩ ±20%	5905-931-6868
	R109	Composition, 68Ω ±5% 1w		6110-0685	01121	RC32GF680J	5905-279-1733
	R110	Composition, 100 Ω ±5% 1/2w		6100-1105	01121	RC20GF101J	5905-190-8889
	R111	Wire-wound, 510 Ω ±5% 5w		6660-1515	80183	246E, 510 Ω ±5%	
	R112	Composition, 220 kΩ ±5% 1/2w		6100-4225	01121	RC20GF224J	5905-192-0667
	R113	Potentiometer, composition, 100 kΩ ±20%		6040-1000	01121	FWC, 100 kΩ ±20%	5905-958-7949
	R114	Compositon, 100 kΩ ±5% 1/2w		6100-4105	01121	RC20GF104J	5905-195-6761
	R115	Composition, 470 kΩ ±5% 1/2w		6100-4475	01121	RC20GF474J	5905-279-2515
	R116	Composition, 620 Ω ±5% 1/2w		6100-1625	01121	RC20GF621J	5905-279-1761
	R117	Attenuator potentiometer, uses 5530-1200 gray knob	LEVEL	6045-1070	01121	Type JJ	5905-931-6869
	R118	Composition, 620 Ω ±5% 1/2w		6100-1625	01121	RC20GF621J	5905-279-1761
	R119	Film, 133 MΩ ±1% 1w		6182-6133	03888	PT1000, 133 MΩ ±1%	
	R120	Film, 133 MΩ ±1% 1w		6182-6133	03888	PT1000, 133 MΩ ±1%	
	R121	Film, 13.3 MΩ ±1% 1w		6450-5133	75042	MDC, 13.3 MΩ ±1%	
	R122	Film, 13.3 MΩ ±1% 1w		6450-5133	75042	MDC, 13.3 MΩ ±1%	
	R123	Film, 1.33 MΩ ±1% 1/2w		6450-4133	75042	CEC-TO, 1.33 MΩ ±1%	
	R124	Film, 1.33 MΩ ±1% 1/2w		6450-4133	75042	CEC-TO, 1.33 MΩ ±1%	
	R125	Film, 133 kΩ ±1% 1/2w		6450-3133	75042	CEC-TO, 133 kΩ ±1%	
	R126	Film, 133 kΩ ±1% 1/2w		6450-3133	75042	CEC-TO, 133 kΩ ±1%	
	R127	Film, 13.3 kΩ ±1% 1/2w		6450-2133	75042	CEC-TO, 133 kΩ ±1%	
	R128	Film, 13.3 kΩ ±1% 1/2w		6450-2133	75042	CEC-TO, 13.3 kΩ ±1%	
	R129	Film, 1.33 kΩ ±1% 1/2w		6450-1133	75042	CEC-TO, 13.3 kΩ ±1%	
	R130	Film, 1.33 kΩ ±1% 1/2w		6450-1133	75042	CEC-TO, 1.33 kΩ ±1%	
	R131	Composition, 3.3 MΩ ±5% 1/2w		6100-5335	01121	RC20GF335J	5905-279-1883
	R132	Composition, 100 Ω ±5% 1/2w		6100-1105	01121	RC20GF101J	5905-190-8889
	R501	Composition, 51 kΩ ±5% 1/2w		6100-3515	01121	RC20GF513J	5905-279-3496
	R502	Composition, 51 Ω ±5% 2w		6120-0515	01121	RC42GF510J	5905-252-5425
	R503	Composition, 1 kΩ ±5% 1/2w		6100-2105	01121	RC20GF102J	5905-195-6806
	R504	Potentiometer, composition, 5 kΩ ±20%		6040-0600	01121	FWC, 5 K ±20%	5905-034-5374
	R505	Composition, 16 kΩ ±5% 1/2w		6100-3165	01121	RC20GF163J	5905-279-3501
	R506	Composition, 24kΩ ±5% 1/2 W		6100-2245	01121	RC20GF242J	5905-279-1877
	R508	Wire-wound, 15 Ω ±10% 2w		6760-0159	75042	BWH, 15 Ω ±10%	5905-988-3022
	R509	Composition, 2.2 kΩ ±5% 1/2w		6100-2225	01121	RC20GF222J	5905-279-1876
	R510	Composition, 10 Ω ±5% 1/2w		6100-0105	01121	RC20GF100J	5905-190-8883
SWITCHES	S101	Rotary, 7 position, 4 section uses 5500-0800 gray knob	FREQUENCY	7890-3970	76854	Type F	5930-931-6927
	S501	Power switch, part of S101	power				
TRANSFORMER	T501	Power transformer		0345-4140	24655	0345-4140	5950-931-6949
CHOKE	FC101/2	Ferrite Bead		5000-1250	02114	56-590-65/4B	

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