GenRad

GR 1390-B Random-Noise Generator

Includes GR 1390-P2

Form 1390-0100-Q

Instruction Manual

GenRad

WARRANTY

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GR 1390-B Random-Noise Generator

Includes GR 1390-P2

Form 1390-0100-Q

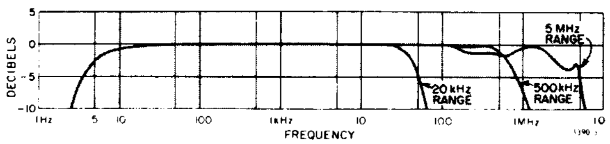
Concord, Massachusetts, U.S.A. 01742
August, 1977
ID-5968

SPECIFICATIONS

Frequency Range: 5 Hz to 5 MHz.
Output: VOLTAGE: Max open-circuit output is at least 3 V for 20-kHz range, 2 V for 500-kHz range, and 1 V for 5-MHz range. IMPEDANCE: Source impedance for max output is approx 900 Ω. Output is taken from a 2500-Ω potentiometer. Source impedance for attenuated output is 200 Ω. One output terminal is grounded.
Spectrum: See spectrum-level curves and following table. Note: Spectrum level is shown with constant-Hz-bandwidth analysis, "white" noise being ideally flat. (Pink noise would slope down at 10 dB per decade.)

Range	Typical Spectrum Level (with 1-V rms output)	Spectrum Level Uniformity *
20 kHz	5 mV for 1-Hz band	within ±1 dB, 20 Hz to 20 kHz
500 kHz	1.2 mV for 1-Hz band	within ±3 dB, 20 Hz to 500 kHz
5 MHz	0.6 mV for 1 Hz band	within ±3 dB, 20 Hz to 500 kHz within ±8 dB, 500 kHz to 5 MHz

* Noise energy also beyond these limits. Level is down 3 dB at 5 Hz.



Typical spectrum-level characteristics.

Waveform: Noise source has good normal, or Gaussian, distribution of amplitudes for ranges of the frequency spectrum that are narrow compared with the band selected. Over wide ranges the distribution is less symmetrical because of dissymmetry introduced by the gas tube. Some clipping occurs on the 500-kHz and 5-MHz ranges.

Voltmeter: Rectifier-type averaging meter measures output. It is calibrated to read rms value of noise.

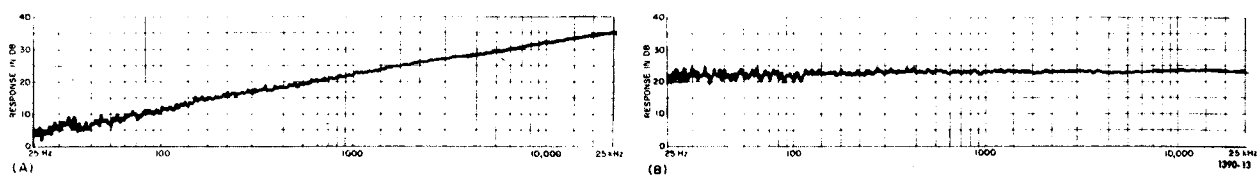
Attenuator: Multiplying factors of 1.0, 0.1, 0.01, 0.001, and 0.0001. Accurate to ±3% to 100 kHz, within ±10% to 5 MHz.

Available: Rack-adaptor set (19x7 in.); 1390-P2 PINK-NOISE FILTER.

Power: 105 to 125 or 210 to 250 V, 50 to 400 Hz, 50 W.

Mechanical: Convertible bench cabinet. DIMENSIONS (wxhxd): Bench, 12.75x7.5x9.75 in. (324x191x248 mm). WEIGHT: 12 lb (5.5 kg) net, 16 lb (7.5 kg) shipping.

Description	Catalog Number
1390-B Random-Noise Generator	
115-V Model	**1390-9702**
230-V Model	**1390-9703**
Rack Adaptor Set (7 in.)	**0480-9842**



(A) Output (white noise) of the 1390-B Random-Noise Generator and
(B) output (pink noise) after filtering by the 1390-P2 Pink-Noise Filter, as measured by a one-third-octave band analyzer.

1390-P2 Pink-Noise Filter

Frequency Response: Sloping −3 dB per octave from 20 Hz to 20 kHz, −6 dB per octave above 20 kHz. Output voltage is approx −5 dB with respect to the input voltage at 20 Hz and −35 dB at 20 kHz. It lies within 1 dB of the straight line connecting these two points on a graph of output in decibels vs log frequency.

Over-all Output Level: When the filter is used with the random-noise generator set for the 20-kHz range, the output voltage of the filter is approx 30 dB below its input, and the voltage level in each one-third-octave band is approx 17 dB below that. Thus, when the output meter of the generator indicates 3 V, the output of the filter is approx 0.1 V, and the level in each one-third-octave band is approx 15 mV.

Input Impedance: The filter should be driven from a source whose impedance is 1 kΩ or less. Input impedance is variable from 6.5 kΩ + load resistance at zero frequency to 6.7 kΩ at high frequencies.

Output Impedance: The filter should not be operated into a load of less than 20 kΩ. Internal output impedance is variable from 6.5 kΩ + source resistance at low frequencies to approx 200 Ω at high frequencies.

Max Input Voltage: 15 V rms.

Terminals: Input terminals are recessed banana pins on ¾-in. spacing at rear of unit. Output terminals are jack-top binding posts with ¾-in. spacing.

Mechanical: Plug-in unit housing. DIMENSIONS (wxhxd): 1.38x5x2.87 in. (35x127x73 mm). WEIGHT: 6 oz (0.2 kg) net, 4 lb (1.9 kg) shipping.

Description	Catalog Number
1390-P2 Pink-Noise Filter	**1390-9602**

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NOTE
Hz (hertz) = cps

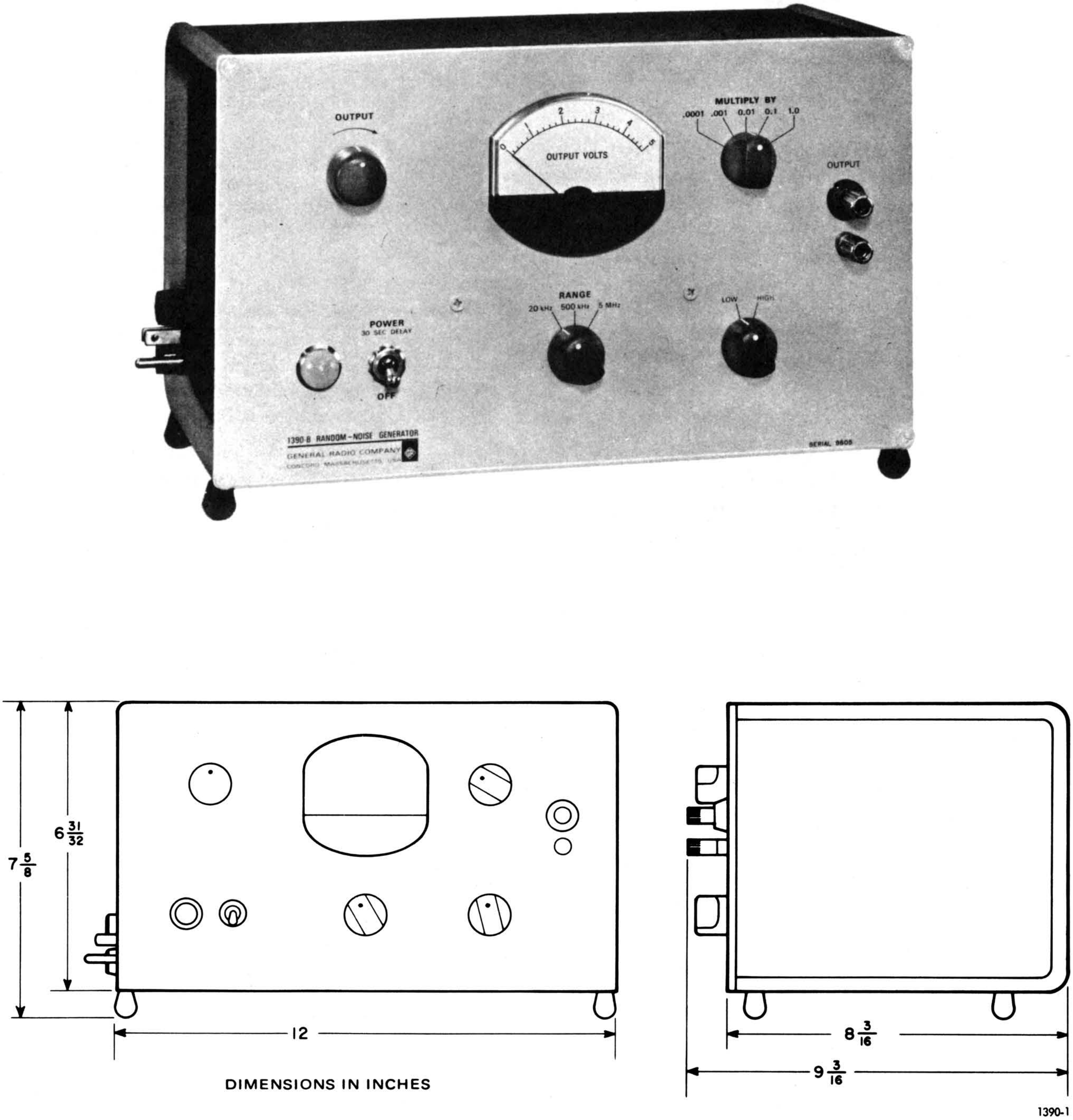

Figure 1. Type 1390-B Random-Noise Generator. (See Section 3 for different mounting arrangements).

WARNING
If disassembly or servicing is necessary, it should be performed only by qualified personnel familiar with the electrical shock hazards inherent to the high-voltage circuits inside the cabinet.

Section 1
INTRODUCTION

1.1 PURPOSE. The Type 1390-B Random-Noise Generator (Figure 1) provides a high level of electrical noise at its output terminals. This type of signal is useful in room acoustic measurements, loudspeaker and microphone tests, psychoacoustic tests, filter tests, cross-talk measurements for multichannel carrier systems, calibration checks on recording systems, modulation of signal generators and test oscillators, tests of rms response of meters, observation of resonance in systems, electrical averaging of resonant responses, and comparisons of effective band width. A pair of these generators can be used as signal sources for demonstration of various degrees of correlation, possible errors of random sampling, and other concepts of statistical theory.

1.2 DESCRIPTION.

1.2.1 CONNECTIONS. Two jack-top binding posts, used as output terminals, are provided on the panel of the Type 1390-B Random-Noise Generator.

1.2.2 CONTROLS. The following controls are on the panel of the Type 1390-B Random-Noise Generator:

Name	Description	Positions	Use
RANGE	3-position rotary selector switch	20 kc, 500 kc, 5 Mc	Selects network used for shaping noise spectrum
POWER	2-position toggle switch	OFF, POWER	Energizes instrument.
None	2-position rotary selector switch	LOW, HIGH	In LOW position, introduces a 10:1 resistance pad after gas-tube noise source to reduce effect of amplitude limitations of amplifier and to reduce noise field radiated by the instrument.
OUTPUT	Continuous rotary control		Varies output voltage.
OUTPUT VOLTS	Rectifier-type, averaging voltmeter		Indicates rms value of noise at output terminals.
MULTIPLY BY	5-position rotary selector switch	0.0001, 0.001, 0.01, 0.1, 1.0	Attenuates output voltage.

Section 2

THEORY OF OPERATION

2.1 GENERAL. (See Figure 2.) The Type 1390-B Random-Noise Generator uses a gas-discharge tube as its noise source. A transverse magnetic field is applied to the tube to eliminate the oscillations usually associated with a gas discharge and to increase the noise level at high frequencies[1]. The noise output from the gas tube is amplified in a two-stage amplifier. Between the first and second stages the noise spectrum is shaped in one of three different ways, depending on the setting of the RANGE switch. At the 20-kc position, a low-pass filter is inserted, which has a gradual roll-off above 30 kc, with the audio range to 20 kc uniform in spectrum level. At the 500-kc setting, a low-pass filter is inserted, which rolls off above 500 kc. At the 5-Mc setting, a peaking network is used. This network approximately compensates for the drop in noise output from the gas tube at high frequencies, so that a reasonably good spectrum is obtainable to 5 Mc.

2.2 OUTPUT VOLTAGE. The maximum open-circuit output voltage on the 20-kc band is at least 3 volts, on the 500-kc band at least 2 volts, and on the 5-Mc band at least 1 volt. This corresponds to a relatively high noise level, since the output impedance at maximum output is only about 900 ohms. This level can be expressed in terms of the resistance noise corresponding to 900 ohms at room temperature. The rms voltage in a one-cycle band due to thermal agitation in a 900-ohm resistor at room temperature is about 3.8×10^{-9} volt. The level from the Type 1390-B Random-Noise Generator is about five millivolts for a one-cycle band when there is a total output voltage of one volt on the 20-kc band. This level, then, is about 1,300,000 times the corresponding voltage for resistance noise, or about 122 decibels above resistance noise at the same impedance level.

2.3 CHARACTERISTICS OF NOISE OUTPUT. As shown in Figure 3, no regular pattern appears in the output waveform; it is characterized by randomness rather than by regularity. Noise is therefore described by statistical means,[2] and is characterized by its distribution of instantaneous amplitudes and by its frequency spectrum.

A random noise is often defined as a noise that has a "normal" or "Gaussian" distribution of amplitudes. This concept is illustrated by the following simple experiment performed with the noise generator.

Set the noise generator to the 20-kc band and to maximum output. Connect a small capacitor (about 1000 pf) across the output. Suddenly disconnect the capacitor. Measure its voltage with an electrometer or

[1] J. D. Cobine and J. R. Curry, "Electrical Noise Generators", Proc. IRE, Vol. 35, No. 9, September 1947, pp. 875-879.

[2] S. O. Rice, "Mathematical Analysis of Random Noise", Bell System Technical Journal, Vol. 23, No. 3, July 1944, pp. 282-332; Vol. 24, No. 1, January 1945, pp. 46-156.

A. van der Ziel, Noise, New York, Prentice-Hall, Inc., 1954.

W. B. Davenport, Jr. and W. L. Root, An Introduction to the Theory of Random Signals and Noise, New York, McGraw-Hill, 1958.

W. R. Bennett, Electrical Noise, New York, McGraw-Hill, 1960.

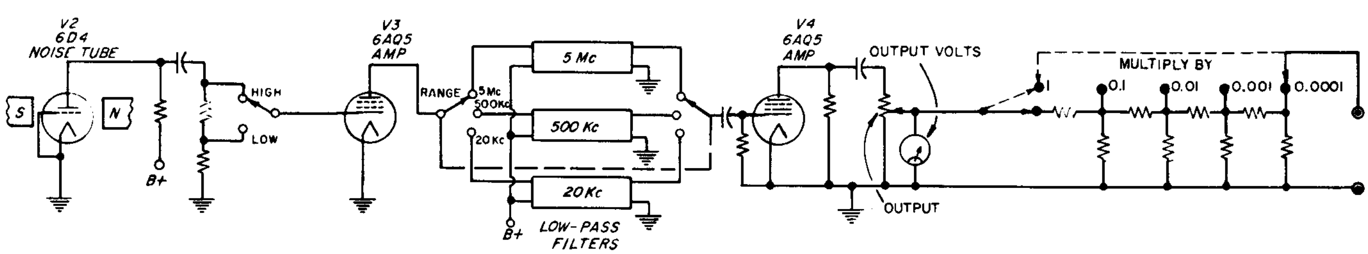

Figure 2. Elementary Circuit Diagram.

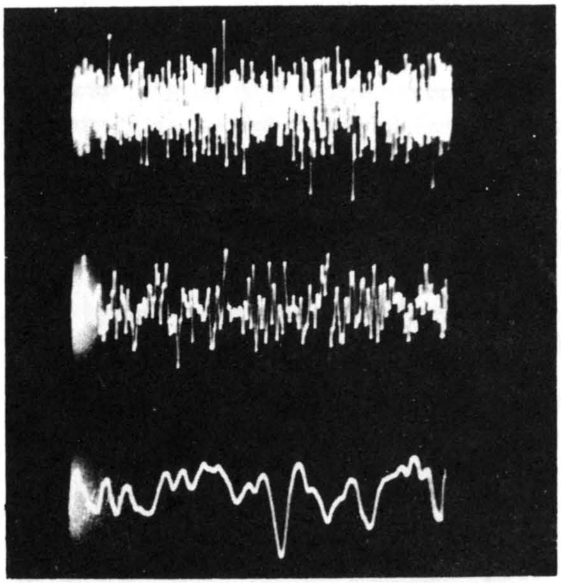

Figure 3. Oscillograms of Three Different Samples of the Output Voltage Wave. (A single sweep was used for each. Middle trace is at four times, and lower trace 20 times sweep speed of upper trace.)

its charge with a ballistic galvanometer. Record this value, which is the instantaneous amplitude of the noise voltage at the time the capacitor is disconnected. A series of these values can be obtained, and a graph prepared, with instantaneous amplitude versus the percentage of time during which any amplitude is exceeded. A large number of amplitudes must be determined in this way before a reliable distribution results. Two or three hundred observations are usually sufficient to show the trend for demonstration purposes, while several thousand will give a reliable curve for the important part of the range. Because of the large number of observations required, automatic apparatus is helpful in making these determinations.[3]

Figure 4 illustrates a chart made up after 400 observations. This chart shows the fraction of observations in each interval of 0.2 volt. It is seen that most of the observations were relatively low values, although some relatively high values were observed. These results are also shown in a qualitative way in the oscillograms in Figure 3.

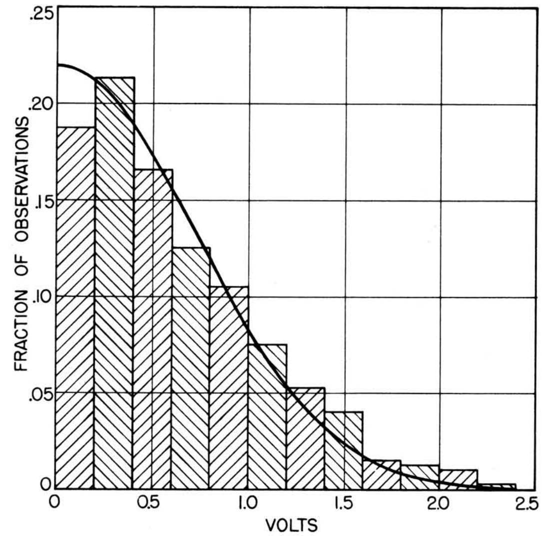

Figure 4. Results of Voltage-Sampling Experiment. (Continuous curve is a normal probability distribution curve adjusted according to r-m-s value of noise voltage and size of intervals used in plot.)

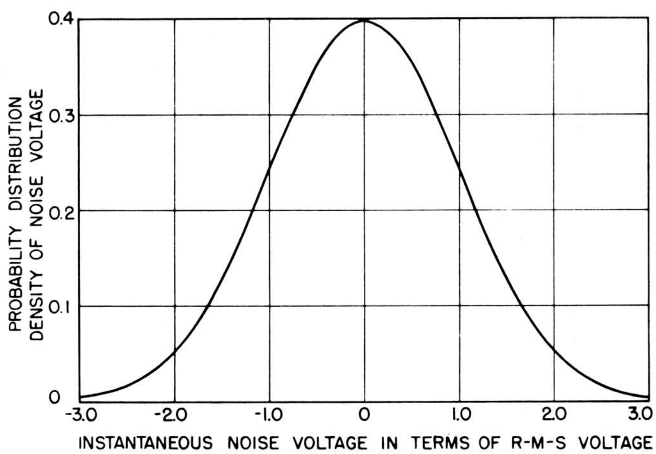

Figure 5.
Normal Distribution Curve of True Random Noise.

The normal (Gaussian or Laplacian) distribution curve is also shown in Figure 4. It has been adjusted according to the computed r-m-s value of the data (the standard deviation) and the size of the interval used in plotting the data. The experimental data fit the normal curve very closely. Departures from the normal curve are almost entirely the result of so few observations. Had more observations been made, the result would have been even closer to the expected values.[3]

In Figure 5, the probability that a voltage between two limits will be observed is given by the area under the normal curve between those two limits. Ex-

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[3] McKnudtzon, "Experimental Study of Statistical Characteristics of Filtered Random Noise", Technical Report No. 115, M.I.T. Research Laboratory of Electronics, July 15, 1949.

L. W. Orr, "Wide-Band Amplitude Distribution Analysis of Voltage Sources", Review of Scientific Instruments, Vol. 25, No. 9, Sept., 1954, pp. 894-898.

pressed in other terms, if the output voltage is observed over long periods of time, the fraction of the total time that the voltage is between the two voltage limits is given by the corresponding area under the probability curve.[4] For example, the instantaneous voltage magnitude will be no more than one-tenth the r-m-s value for about eight percent of the time, and will be greater than three times the rms value only about 0.26 percent of the time.

2.4 DEPARTURES OF OUTPUT FROM TRUE RANDOMNESS. The curve in Figure 5 is a theoretical curve and is symmetrical about the origin. The noise of the generator has a similar distribution, but is somewhat asymmetrical because of the gas tube. In addition, the inherent amplitude limitations of the vacuum-tube amplifiers limit the distribution curve at high levels. Clipping is most serious on the 500-kc and 5-Mc ranges. When a narrow-band filter is used at the output, the distribution becomes more nearly random.

2.5 FREQUENCY SPECTRUM OF NOISE. The meaning of the term "frequency spectrum of noise" is illustrated in the following experiment. If a wave analyzer, such as the Type 1900-A, set to a 50-cps bandwidth, is used to analyze the output of the noise generator, a fluctuating meter reading will be observed at any setting of the analyzer. If an average value of this reading is taken over a period of time, this average value is an estimate of the level in that 50-cycle-wide band. This level, determined on any ranges of the noise generator, is essentially independent of the frequency setting of the Type 1900-A Wave Analyzer. Thus the spectrum in this region is uniform. The relative spectrum on the noise can be determined by the use of suitable analyzers to cover the full range of the principal energy regions of the noise. A typical result of such an analysis is shown in Figure 6 for the three bands of the Type 1390-B Random Noise Generator. When the spectrum is uniform over a broad band, as shown in Figure 6, it is commonly called "white noise". The "whiteness" always applies to a definite band only. For example, if the noise spectrum is uniform from 100 to 500 kc, the noise is referred to as white in that band.

It is customary to adjust the measured value of analyzed noise to that corresponding to an ideal filter of one-cycle band width. Since noise voltage increases as the square root of the band width, the value determined on the Type 1900-A Wave Analyzer is then divided by $\sqrt{\frac{50 \text{ cycles}}{1 \text{ cycle}}}$ to obtain what is called "spectral voltage density". This can be defined as the

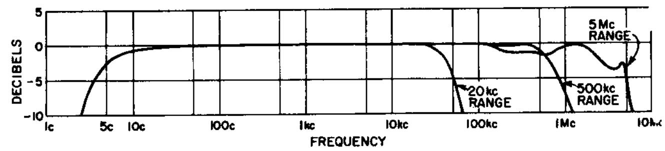

Figure 6. Typical Spectrum Level Characteristics for Type 1390-B Random-Noise Generator.

rms voltage corresponding to the energy contained within a band one cycle per second wide.

NOTE

"Spectral voltage density", although a convenient term, is sometimes not used because most work on noise deals with energy level. The transfer from one to the other requires a knowledge of the impedance level in the circuit. It should be remembered that separate noise signals add on an energy basis and that the noise energy increases directly with the noise bandwidth, while the noise voltage increases as the square root of the bandwidth. Furthermore, the concept used here assumes a uniform density of the noise signal over the band of the analyzer. It should not be used for discrete components.

2.6 ANALYSIS OF NOISE BY CONSTANT-PERCENTAGE ANALYZERS. If the output of the Type 1390-B Random-Noise Generator is analyzed by a Type 1564-A Sound and Vibration Analyzer, the results will be similar to those shown in Figure 7. Here the indicated level increases 10 decibels for each decade increase in frequency. This result can be understood by realizing that this analyzer has a bandwidth that is essentially a constant percentage of the center frequency. For example, at 5 kc the effective band width for noise is about 160 cps, and at 500 cps is about 16 cps.

2.7 TYPE 1390-P2 PINK-NOISE FILTER.

2.7.1 DESCRIPTION. The Type 1390-P2 Pink-Noise Filter (Figure 8) converts the electrical noise output

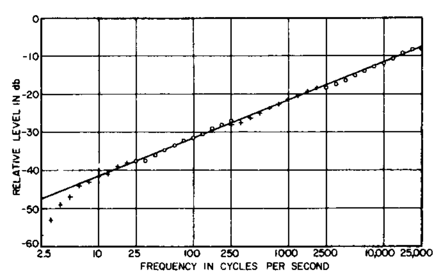

Figure 7. Results of Analysis of Noise-Generator Output Voltage by a Type 1564-A Analyzer. (Straight line drawn at slope of 10 db per frequency decade.)

[4] E. R. Neinburg and T. F. Rogers, "Amplitude Distribution Analyzer", Radio-Electronic Engineering, Vol. 46, No. 6, December 1951, pp. 8-10.

of the Type 1390-B Random-Noise Generator to "pink noise" (constant energy per octave) which facilitates measurements with constant-percentage-bandwidth analyzers. It is designed to plug into the output binding posts of the Type 1390-B Random-Noise Generator, but can also be used at any point in a system where this filter characteristic is needed. The filter is an RC low-pass filter with a slope of -3 db per octave from 20 cycles to 20 kc and a slope of -6 db at higher frequencies (See Figure 9). For shielding, the case of the filter is grounded to the LO input and output terminals. Figure 10 is a schematic diagram of the filter. The input terminals of the Type 1390-P2 Filter are recessed plugs at the rear and the output terminals are binding posts on the front.

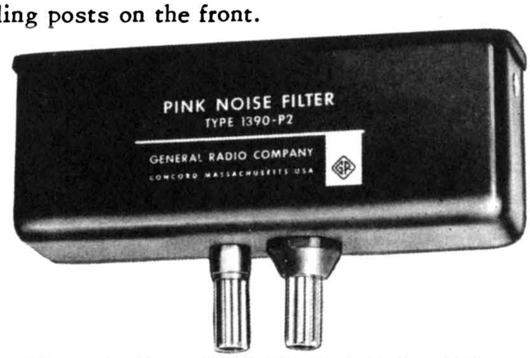

Figure 8. Type 1390-P2 Pink-Noise Filter.

2.7.2 USE WITH THE TYPE 1390-B RANDOM-NOISE GENERATOR. Plug the Type 1390-P2 Pink-Noise Filter into the output terminals of the Type 1390-B Random-Noise Generator. The impedance of the load connected to the output terminals of the filter should not be less than 20 kilohms.

On the Random-Noise Generator, set the RANGE switch to 20 kc, the LOW-HIGH switch to HIGH, and the MULTIPLY BY switch to 1.0. The output of the Pink-Noise Filter will be approximately 30 db below its input and the level in each one-third-octave band will be approximately 17 db below that. Thus, when the output meter of the Random-Noise Generator indicates 3 volts, the output of the filter will be approximately 0.1 volt and the level in each one-third-octave band will be approximately 15 millivolts.

2.7.3 USE IN OTHER APPLICATIONS. When the Type 1390-P2 Pink-Noise Filter is used in a system at some point other than the output terminals of the Random-Noise Generator, the input source to the filter should have an impedance of less than 1 kilohm. Input connections can be made with clip leads or Type 274-MB Double Plugs to the recessed input terminals. The impedance of the load connected to the output terminals should not be less than 20 kilohms.

2.7.4 FREQUENCY-RESPONSE MEASUREMENTS. In many acoustical systems, frequency response measurements made with a sine-wave tone source are difficult to interpret because of the large amplitude fluc-

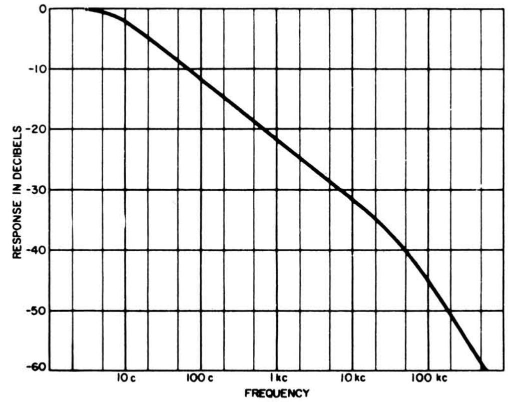

Figure 9. Typical frequency response of the Type 1390-P2 Pink-Noise Filter.

tuations that may occur. When the measurements are made by effectively averaging the data over a narrow range of frequencies, response curve is considerably smoother and much easier to use. In the past, "warble tones" have been used for this purpose. A more convenient method, however, is to use pink-noise as the tone source and a constant-percentage-bandwidth analyzer (such as the Type 1564-A Sound and Vibration Analyzer) with one-third octave bandwidth as the frequency-determining element in the receiving system.[5] The results of these frequency-response measurements can be conveniently recorded on the Type 1521 Graphic Level Recorder.[6]

2.7.5 USE AS A NOISE SIMULATOR. Some noises that occur in nature are closer in spectral characteristics to pink noise than to white noise. This is true, for instance, of the low-frequency noise in semiconductors and of some acoustical background noises. To simulate electrical signals generated in such cases, it is convenient to use pink noise.

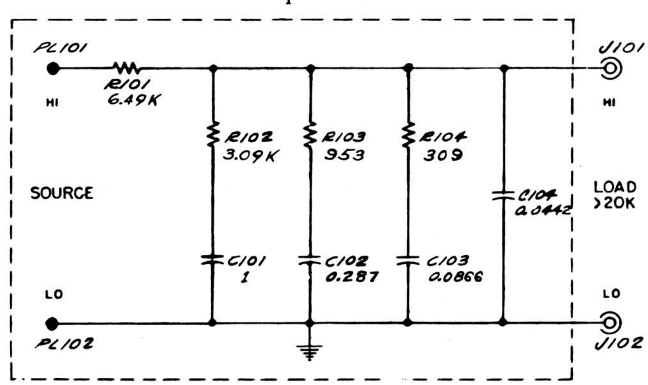

Figure 10. Schematic diagram of the Pink-Noise Filter.

[5] "A New Analyzer for Sound and Vibration", *General Radio Experimenter*, Volume 33, Number 12, December, 1959.

[6] "A Graphic Level Recorder with High Sensitivity and Wide Ranges", *General Radio Experimenter*, Volume 33, Number 6, June, 1959.

Section 3
INSTALLATION

3.1 BENCH MOUNTING. To set the instrument in a tilted position (shown in inset of Figure 1), simply pull each front leg down as far as possible and then turn the leg so that its notch faces the back of the instrument.

To restore the leg to its retracted position, turn it to release the catch and push the leg up.

3.2 RELAY-RACK MOUNTING. Type 480-P412 Panel Extensions are available to adapt the Type 1390-B Random-Noise Generator for relay-rack mounting. To mount the Type 1390-B Random-Noise Generator in a relay rack, first attach the two panel extensions to the instrument. Remove the two screws in the upper and lower corners on one side of the panel. These screws fasten the panel to the aluminum end frames. Place one of the extensions in the front of the panel so that the corner holes on the plate line up with those on the instrument and replace the two screws.

Attach the second extension on the other side of the instrument panel in the same manner. The instrument can then be mounted in a standard 19-inch relay rack.

3.3 CONNECTION TO POWER SUPPLY. Connect the Type 1390-B to a source of power as indicated by the legend at the input socket at the rear of the instrument, using the power cord provided. While instruments are normally supplied for 115-volt operation, the power transformer can be reconnected for 230-volt service (see schematic diagram, Figure 12). When changing connections, be sure to replace line fuses with those of current rating for the new input voltage (refer to Parts List). Appropriate measures should be taken so that the legend indicates the new input voltage. On instruments changed from 230 to 115 volts, this simply means removal of the 230-v nameplate; a 115-v legend is marked beneath. For instruments changed to 230 volts, a nameplate (Type 5590-1664) may be ordered from General Radio.

Section 4
OPERATING PROCEDURE

4.1 START-UP. Turn the POWER switch on. After 30 seconds, when the heater of the Type 6D4 thyratron tube has warmed up, plate voltage is applied by an internal time-delay relay. (Simultaneous application of heater and plate voltage would shorten the useful life of the thyratron tube and increase the drift in noise-output level on warm-up.)

4.2 FREQUENCY CONTROL. The RANGE switch selects the network used for shaping the noise spectrum. Markings indicate the upper frequency limits for which the noise spectrum is reasonably uniform.

4.3 OUTPUT CONTROL. Output controls are a switch for selecting LOW or HIGH output, an OUTPUT level control, and an output attenuator. In the LOW position, the switch introduces a 10:1 resistance pad after the gas-tube noise source. This reduces the effect of the unavoidable amplitude limitations of the vacuum-tube amplifier and also reduces the noise field radiated externally by the instrument. To keep hum and microphonics to a minimum, however, it is generally advisable to operate the instrument in the HIGH position.

The OUTPUT level control is a continuous-type control that is used to vary the output voltage from a very low value to maximum for either setting of the output switch.

The MULTIPLY BY switch is used to provide low output levels. It has multiplying factors of 1.0, 0.1, 0.01, 0.001, and 0.0001.

4.4 VOLTMETER. A rectifier-type, averaging meter measures the output voltage. It is calibrated to indicate the rms value of the noise. When the MULTIPLY BY switch is at 1.0, the meter indicates directly the open-circuit voltage at the output terminals. In the other positions of the MULTIPLY BY switch, the open-circuit output voltage is the product of the meter reading and the multiplier reading.

The spectral voltage density of the noise at a given frequency is the r-m-s voltage corresponding to the energy contained within a band 1-cps wide centered on that frequency. The typical spectral voltage density at 1 kc with one volt output is approximately as follows:

(a) 20-kc band: 5 millivolts for one-cycle band.
(b) 500-kc band: 1.2 millivolts for one-cycle band.
(c) 5-Mc band: 0.6 millivolt for one-cycle band.

When an accurate value is desired at any frequency, it should be measured. The values given are intended only as a guide.

4.5 LOAD. The output is taken from a 2500-ohm potentiometer, and one output terminal is grounded. For a truly resistive load with the MULTIPLY BY switch at 1.0, the apparent source impedance is zero when a reading of the voltmeter is taken with the load connected, since the voltmeter reads the voltage across the load. As the output control is varied from the maximum to the minimum setting, the actual source impedance varies from about 900 ohms to nearly zero. When the MULTIPLY BY switch is in any position other than 1.0, the source impedance is 200 ohms.

A load that is not independent of frequency will affect the frequency spectrum of the output noise. For example, a capacitor shunted across the output terminals will decrease the level of the high-frequency noise more than it decreases the level of the noise at low frequencies. The voltmeter is then less indicative of the spectrum level than it is for a resistive load.

4.6 HUM. The hum level is usually more than 40 db below the over-all noise level in the HIGH output position. This hum level is sufficiently low so that for most applications there is no effect from hum, even when an analyzer with a narrow band is used for analysis. The relative hum level in the HIGH output position is lower than that in the LOW position.

4.7 APPLICATIONS.

4.7.1 GENERAL. Some applications of a noise generator depend on its amplitude distribution characteristics (Figures 4 and 5.) For example, the amplitude distribution is similar to that of speech, music, and many other sounds or electrical disturbances that occur naturally[7], while the amplitude distribution of a sine

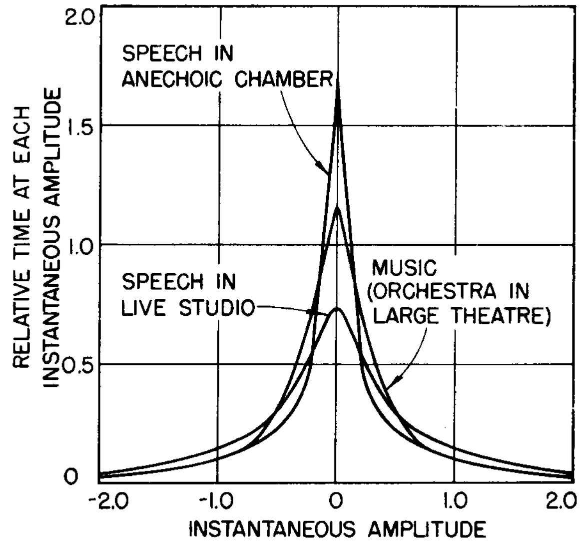

Figure 11a. Amplitude Distribution Curves for Various Sounds. (Curves labeled "Speech" are for particular cases of sounds produced from readings of printed matter[5]; curve labeled "Music" is an analysis of an orchestral selection made in a large theater[5].

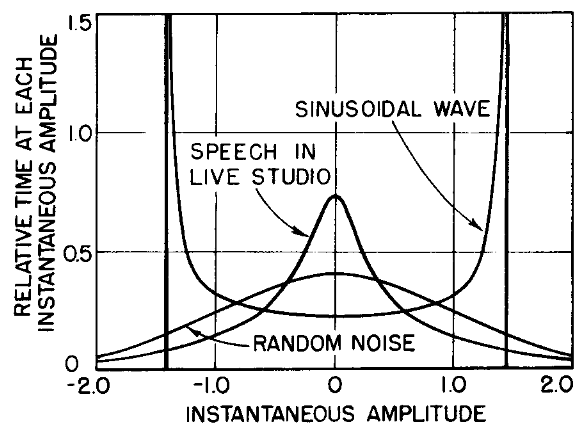

Figure 11b. Distribution Curves of a Single Sinusoidal Wave and a Random Noise.

wave is entirely different. These similarities and differences can be seen by comparison of the distributions of Figure 11. Because of this characteristic, random noise is an important signal for psychoacoustic tests. Psychoacoustic tests include masking or interference tests, loudness measurements, determination of critical bandwidths, and audiometric tests. The techniques used in making such tests are discussed in the various numbers of the Journal of the Acoustical Society

[7] H. K. Dunn and S. D. White, "Statistical Measurements on Conversational Speech", Journal of the Acoustical Society of America, Vol. 11, No. 3, January 1940, pp. 278-288.

W. B. Davenport, Jr. "A Study of Speech Probability Distributions", M.I.T. Laboratory of Electronics, Technical Report No. 148, August 25, 1950.

of America (for which there are two comprehensive indexes available) and in various psychological journals. A useful bibliography for these applications is S. S. Stevens, J. G. S. Loring, and Dorothy Cohen, Bibliography on Hearing, Harvard University Press, Cambridge, 1955, particularly those references listed in Sections 139 (p. 571), 157 (p. 573) and 222-228 (pp. 579 f).

Other applications depend on the various possible frequency spectra of noise. The frequency spectrum is independent of the amplitude distribution, in the sense that a normal distribution of amplitudes is possible with any frequency spectrum - flat, broad, narrow, sloping, or peaked. Systems that affect one characteristic, however, may also affect the other. For example, nonlinear clipping affects both the amplitude distribution and the frequency spectrum. Linear filter networks used on purely random noise do not affect the randomness but alter the frequency characteristic and correspondingly the time scale. Linear filter networks used after clipped noise alter the frequency spectrum and also tend to make the noise more nearly random.

4.7.2 ELECTROACOUSTIC TESTS. The Type 1390-B Random-Noise Generator is a useful signal source for many types of electroacoustic tests, including loudspeaker-response tests. Some useful discussions of these tests using a noise source are given in the following: Leo. L. Beranek, Acoustic Measurements, New York, John Wiley and Sons, 1949, pp. 639-640, 665 f, 697-702; and RMA Standard SE-103, Speakers for Sound Equipment, April 1949, p. 6, Standard Test Signal BA.

Other General Radio instruments useful in electroacoustic tests are the Type 1551 Sound-Level Meter, the Type 1551-P1 Condenser Microphone System the Type 1558 Octave–Band Noise Analyzer, the Type 1564–A Sound and Vibration Analyzer, and the Type 1521 Graphic Level Recorder.

4.7.3 ROOM ACOUSTICS TESTS. The noise generator is a useful signal source for many types of tests in room acoustics. These include reverberation tests, panel (wall and floor) transmission measurements, measurement of space irregularities, and measurement of steady-state signal transmission. For details, consult the following: Leo. L. Beranek, Acoustic Measurements, New York, John Wiley and Sons, 1949, pp. 804 ff, 826 f, 831 and 883.

The Type 1551-C Sound-Level Meter, the Types 1550-A and 1558-A Octave-Band Analyzers, the Type 1564-A Sound and Vibration Analyzer, and the Type 1521 Graphic Level Recorder are useful elements in the over-all set-up for these tests.

4.7.4 STATISTICAL DEMONSTRATIONS. The properties of noise that concern the amplitude-time relationship are usually described by statistical means[2]. (Refer to paragraph 2.3.)

Random-noise generators can be used to demonstrate some concepts of statistical theory. The equipment and methods for demonstrating various degrees of correlation and possible errors of random sampling are described by J. C. R. Licklider and E. Dzendolet, "Oscillographic Scatterplots Illustrating Various Degrees of Correlation", Science, January 30, 1948, Vol. 107, No. 2770, pp. 121-124.

4.7.5 NOISE AT HIGH FREQUENCIES. The noise generator can be used to modulate an r-f carrier when a noise signal is desired at a frequency above 5Mc. A crystal diode modulator[8] is a suitable instrument for wide-band modulation, and the Type 1363 VHF Unit Oscillators[9] and the Type 1362 UHF Unit Oscillators are suitable rf oscillators covering the range from 65 to 920 Mc.

Because of the two sidebands that result from the standard modulation techniques, the noise band can be made to extend over a 10-Mc range, 5 Mc on each side of the carrier. For some applications it may be desirable to use a suppressed-carrier or balanced-type modulator (see Terman, Radio Engineering Handbook, New York, McGraw-Hill Book Co., 1943, pp. 551-553). It is also possible to use a series of carriers and modulators to combine to give a much broader band of noise than 10 Mc.

Some signal generators and oscillators include modulating circuits, so that an external source such as the Type 1390-B Random-Noise Generator can be used to modulate the signal. Instruments of this type are the Types 1003 and 1026 Standard Signal Generators. For these generators the modulation produced is limited to the audio range and to about 5 to 10 percent rms noise modulation, with peaks much higher. When a wider frequency band is desired, an external modulator should be used as described above.

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[8] Byers, W. F., "An Amplitude Modulator for Video Frequencies", General Radio Experimenter, March 1950, Vol. 24, No. 10, pp. 6-8.

[9] E. Karplus, "V-H-F and U-H-F Unit Oscillators", General Radio Experimenter, May 1950, Vol. 24, No. 12, pp. 7-11.

4.7.6 VERY HIGH NOISE LEVELS. When noise levels even higher than those provided by the Type 1390-B Random-Noise Generator are desired, an amplifier should be used.

4.7.7 INTERFERENCE TESTS. Since noise is a common form of interfering or disturbing signal or signal that limits the threshold of detectability, the noise generator can be used to check receivers, communication systems, and detection systems for susceptibility to interference. It can also be used as a training aid for operators who must communicate through interference.

4.7.8 OVER-ALL CALIBRATION TESTS. The noise generator can be used as an over-all calibration device because of the wide frequency range available at the output. This calibration signal can be particularly useful in audio systems that involve a recording technique, and its use can frequently simplify the calibration procedure when an analyzer forms part of the system.[10]

For example, when a magnetic tape recorder is used to record a signal to be measured on playback, reference signals must be recorded before and after the unknown signal is recorded. These reference signals permit one to fix levels and to determine response characteristics, which can vary from time to time depending on the condition of the tape and the machine. These reference signals are usually a series of tones at various points in the frequency range of interest. The noise generator, due to the broad frequency band, permits the use of a more versatile reference signal. Thus a useful set of reference signals would be a burst of noise of about one-half minute duration and a burst of a 400-cycle tone of about the same length. These two signals would permit the determination of frequency response, signal-to-noise ratio, harmonic distortion (at one level and one frequency), and flutter.

To determine the frequency response by use of a noise signal, perform the following operations:

1. Set the noise generator to the 20-kc range. Connect it to the input of the system under test, at such a level that the r-m-s input is at least 14 decibels below the sine-wave overload point.

2. Make a frequency spectrum analysis of the input noise signal and of the output noise signal from the device under test. The relative level of input and output as a function of frequency is then the frequency response of the device under test, unless spurious signals are present in the output of the device.

3. Test for spurious signals by making an analysis of the output with no input signal applied.

When these measurements are made, the input and output must be analyzed by analyzers of the same effective bandwidth. The bandwidth of the analyzer should also be appreciably smaller than the bandwidth of the device under test. Furthermore, the ultimate attenuation of the analyzer should be much greater than variation in response that one expects to measure, so that it will not limit the observed response. Distortion and background noise in the device under test will also limit the range of variation in response that can be measured by this method, and it is therefore important to select the proper level for input signal.

4.7.9 ANALYSIS OF NOISE. In the course of measurements with a noise generator, it is often necessary to make a frequency spectrum analysis of noise. The Type 1900-A Wave Analyzer, the Types 1558-A and 1558-AP Octave-Band Noise Analyzers, and the Type 1564-A Sound and Vibration Analyzer are useful accessories for this analysis in the audio-frequency range. The results of noise analyses by these different analyzers cannot be compared directly; the results must be modified because of the different bandwidths. Refer to paragraph 2.5 for a discussion of the frequency spectrum of noise.

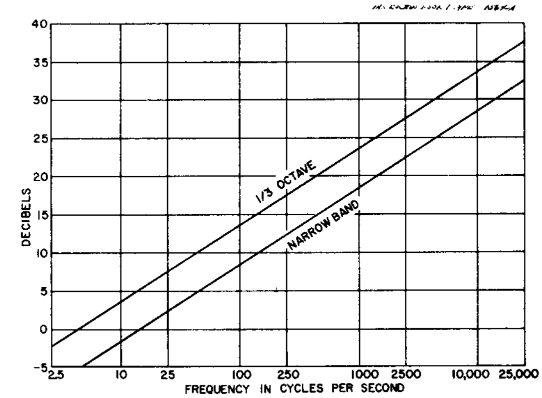

Figure 12. Decibels to Be Subtracted from Type 1564-A Reading to Obtain Spectral-Density Level.

The bandwidths of the Octave-Band Noise Analyzers increase in cycles directly with the mean frequency of the band. For that reason, a noise signal that is uniform in spectral-energy density over the frequency range will give higher-level readings for the higher-frequency bands than for the lower-frequency bands. The following table shows the values to be subtracted from the readings of the analyzer to obtain the spectral-density levels.

[10] S. S. Stevens, J. P. Egan, and G. A. Miller, "Methods of Measuring Speech Spectra", Journal of the Acoustical Society of America, Vol. 19, No. 5, September 1947, pp. 771-780.

Type 1558-A Band	DB to be sub-tracted	Type 1558-AP Band Center freq.	DB to be sub-tracted
18.75-37.5	13	31.5	13.5
37.5-75	16	63	16.5
75-150	19	125	19.5
150-350	22	250	22.5
350-600	25	500	25.5
600-1200	28	1,000	28.5
1200-2400	31	2,000	31.5
2400-4800	34	4,000	34.5
4800-9600	37	8,000	37.5
9600-19,200	40	16,000	40.5
LP 7.5	18		

The effective bandwidth of the Type 1564-A Sound and Vibration Analyzer increases with increase in the frequency to which the analyzer is tuned. The graph in Figure 12 shows the value in decibels that must be subtracted from the reading of the analyzer to obtain the spectral-density level. This value is determined on the basis of initial calibration of the instrument by a sine-wave signal.

The corrections for spectral density level for the Type 1900-A Wave Analyzer are independent of the center frequency to which it is tuned but do depend on the bandwidth used. For the 3-cycle bandwidth subtract 3.7 db; 10-cycle, subtract 9 db; 50-cycle, subtract 15.9 db to obtain the spectral density level. (These correction numbers take into account the metering characteristic as well as the bandwidth.)

4.7.10 FREQUENCY RESPONSE MEASUREMENT. The noise generator can be used in place of the usual sine-wave generator for measuring the response of circuits and systems. In this application the selective characteristics of generator and detector are reversed from those ordinarily used in point-by-point measurements; the wide-band noise source and a selective detector replace the single-frequency source and wide-band detector. For speech and music circuits, this technique provides a much closer approximation to operating conditions than does the older system. This approach is particularly useful in testing recording systems.[10] (Refer to paragraph 4.7.8.) The usual sweeping sinusodial tests are sometimes inconvenient because of the problem of determining the recorded frequency during playback. This problem is eliminated by a recorded noise signal that is analyzed on playback.

Because of its broad frequency spectrum, noise is often used to avoid the marked resonance effects that can occur when vibrations in mechanical structures and acoustical systems are measured. The use of noise as a source in measuring the reverberation characteristics of rooms and the transmission characteristics of building structures results in a type of electrical averaging of the characteristics, provided a reasonably broad band is used. This averaging often simplifies the comparison of the characteristics of different structures.

The noise generator is useful in response measurements on loudspeaker systems in rooms.[11] The electrically averaged response can be used to determine the optimum characteristic for equalizing networks, to set the relative levels of woofer and tweeter units, and to adjust levels of multiple-speaker units installed in different locations in a large hall.

4.7.11 RESONANCE TESTS. Because of its broad frequency spectrum, noise can sometimes simplify the search for resonant conditions in a system.[12] The resonance produces a peak in the frequency spectrum, which can be observed in oscillographic displays.

4.7.12 OTHER USES. The noise generator can also be used in crosstalk measurements[13], for masking crosstalk in multichannel communication systems[14], to drive vibrators in component testing[15], for noise factor comparison tests[16], or distortion measurements[17].

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11 L. L. Beranek, Acoustic Measurements, New York, John Wiley, 1949, pp. 665-668 and 697-702.

12 Emory Cook, "White-Noise Testing Methods", Audio Engineering, Vol. 34, No. 3, March 1950, pp. 13-15.

13 J. P. Vasseur, "Les foisceaux hertziers a courants porteurs devant les recommandations du C.C.I.F.", Annales de Radioelectricite, Vol. 9, No. 35, January 1954, pp. 47-82 and EIA Standard RS-252, "Base band Characteristics of the Microwave Radio and Multiplex Equipment," October, 1961.

14 A. J. Aikens and C. S. Thaeler, "Noise and Crosstalk on N1 Carrier Systems", Electrical Engineering, Vol. 72, No. 12, December 1953, pp. 1075-1080.

15 J. Robbins, "Standardized White Noise Tests", Electronic Industries & Tele-Tech, Vol 16, No. 2, February, 1957, pp. 68-69.

S. H. Crandall, ed., Random Vibration, Cambridge, Massachusetts, The Technology Press of MIT, 1958.

16 IRE "Standards on Electron Devices: Methods of Measuring Noise", Proceedings of the IRE, Vol. 41, No. 7, July 1953, pp. 891-896.

17 A. P. G. Peterson, "Intermodulation Distortion," 1957 IRE National Convention Record, Vol. 5, Part 7, March, 1957, pp 51-58.

J. S. Murray and J. M. Richards, "Non-linearity Distortion Measurements," Wireless World, Vol. 69, No. 4, April, 1963, pp 161-165.

Section 5
SERVICE AND MAINTENANCE

5.1 SERVICE. The product 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.

5.2 MINIMUM-PERFORMANCE STANDARDS.

5.2.1 Equipment Required.

A true-rms ac voltmeter, such as the Hewlett-Packard Model 3400 or equivalent, is required for the following minimum-performance tests. (A 776-A BNC-to 274 Patch Cord can be used to connect the Model 3400 Voltmeter to the 1390-B.)

5.2.2 OPEN-CIRCUIT OUTPUT-VOLTAGE TEST.

a. Connect the rms voltmeter to the OUTPUT terminals of the 1390-B.

b. Set the 1390-B as follows:

RANGE ------ 20 kHz
MULTIPLY BY ------ 1.0
LOW-HIGH ------ HIGH
OUTPUT ------ Fully clockwise
POWER ------ ON

c. Both the rms voltmeter and the panel voltmeter on the 1390-B should read 3.0 V or higher.

d. Change the RANGE switch to 500 kHz. The voltmeters should now read 2.0 V or higher.

e. Set the RANGE switch to 5 MHz. The voltmeters should now read 1.0 V or higher.

5.2.3 OUTPUT ATTENUATOR CHECK, 20 kHz.

a. Set the 1390-B as follows:

RANGE ------ 20 kHz
MULTIPLY BY ------ 1.0
LOW-HIGH ------ HIGH

b. Connect the rms voltmeter to the OUTPUT terminals of the 1390-B and set the OUTPUT control to give a reading of 2.0 V on the 1390-B meter. Note the reading of the rms voltmeter.

c. Set the MULTIPLY BY switch to 0.1 and reset the OUTPUT control for 2.0 V on the 1390-B meter. The rms voltmeter should now read 1/10, ±3% of the previous reading.

d. Repeat this check with the MULTIPLY BY switch at .01, .001, and .0001. The rms voltmeter readings should drop by a factor of 10, ±3% for each step.

5.2.4 OUTPUT ATTENUATOR CHECK, 5 MHz.

a. Set the 1390-B as follows:

RANGE ------ 5 MHz
MULTIPLY BY ------ 1.0
LOW-HIGH ------ HIGH

b. Set the OUTPUT control for a reading of 1.0 V on the 1390-B meter. Follow the procedure of para. 5.2.3 except allow a ±10% tolerance for each step.

5.2.5 HIGH-LOW CHECK.

a. Set the 1390-B as follows:

RANGE ------ 20 kHz
MULTIPLY BY ------ 1.0
LOW-HIGH ------ HIGH

b. With the rms voltmeter connected to the OUTPUT terminals on the 1390-B, set the OUTPUT control for a reading of 3.0 V on the rms voltmeter.

c. Change the HIGH-LOW switch to LOW. The 1390-B, hp3400 should both read between 0.3 and 0.6 V.

5.3 ACCESS TO COMPONENTS. To remove the shield, loosen the two fluted locking screws on the back of the instrument. These will unlock on the first turn, but should be loosened the maximum amount before the shield is removed. Pull the shield straight back from the panel.

5.4 PRELIMINARY CHECKS. If the noise generator is inoperative, make the following checks before removing the case. Make sure that the ac supply is plugged into a live power line, that the power switch is turned to the POWER position, that the output control is turned up, that the time-delay relay is operative, and that the fuses are not open.

5.5 TUBE REPLACEMENT. Since the vacuum tubes have a shorter life on the average than the other components used in the instrument, they should be tested if the instrument is still inoperative after the above checks have been made.

The Type 6D4 Gas Triode used as the noise source is aged and selected for uniformity of the noise spectrum and for good amplitude characteristics. If the tube has deteriorated and must be replaced, some selection among different tubes of this type may be necessary to find a satisfactory replacement. Use a tube by the same manufacturer.

5.6 HEATER VOLTAGE OF TYPE 6D4 GAS TUBE. The potentiometer at the rear of the chassis is for setting the heater voltage of the gas tube. Over certain ranges of heater voltage, some gas tubes will "sputter". The meter indication on the 20-kc range will often reveal this sputter. Under normal conditions, the meter reading fluctuates two or three percent. When sputtering occurs, the meter reading may fluctuate 10 percent or more. The sputtering is more easily detected by observation of the noise pattern on an oscilloscope or by ear with a good pair of earphones. The heater voltage should be set so that this sputtering does not occur. Some selection among tubes of this type may be necessary to find a tube that is free from sputtering.

5.7 VOLTAGE MEASUREMENTS. The adjacent tables give test voltages for aid in troubleshooting:

T1 TRANSFORMER MEASUREMENTS

Between Terminals	AC Volts
10 and 11	120
5 and 6	17
6 and 7	17
8 and 9	6.3

5.8 VOLTMETER CALIBRATION. To calibrate the voltmeter proceed as follows:

a. Remove all external connections from the Type 1390-B, including the power cable.

b. Zero the mechanical zero of the meter.

c. Set the OUTPUT control fully clockwise.

d. Set the MULTIPLY BY switch to 1.0.

e. Apply 3.0 volts at 1KC from the GR Type 1304-B or equivalent to the Type 1390-B output terminals. The meter must read upscale.

f. Adjust potentiometer R103 (Figure 10) to obtain a reading of 3.3 on the panel voltmeter.

g. Apply 3.0 volts at 500KC from an oscillator with low distortion, using open leads, to the Type 1390-B output terminals and observe that the meter reads between 3.2 and 3.4.

h. Apply 3.0 volts at 5Mc, using open leads, and observe that the meter reads between 3.0 and 3.6.

TABLE OF VOLTAGES

TUBE	PIN	VOLTS	TUBE	PIN	VOLTS
V1 (3-4)	2 7	13.4 6.3	V3 (6AQ5) (cont.)	6	150 (A) 150 (B) 110 (C)
V2 (6D4)	3 4 7	6.3 0 16.0	V4 (6AQ5)	1 2 3 to 4 5 6	0 13 6.3 ac 165 245
V3 (6AQ5)	1 2 3 4 5	0 5.5 20 13.4 230 (A) 215 (B) 45 (C)	V5 (115NO30T)	4 9	120 ac* 120 ac*

NOTES

Voltages are measured with a 20,000-ohms-per-volt voltmeter and are dc with respect to ground unless otherwise stated.

(A) S3 = 5 Mc

(B) S3 = 500 kc

(C) S3 = 20 kc

* Voltages are measured with a 1000Ω/volt rectifier meter, and are with respect to terminal 11 on transformer T1.

ELECTRICAL PARTS LIST

Ref Des	Description	GR Part No.	Fed Mfg Code	Mfg Part No.
CAPACITORS				
C1	Electrolytic, 25/25 μF 200 V	4450-3300	37942	104110G1S3C1X1
C2	Electrolytic, 50/25/25 μF 450 V	4450-0800	56289	D28936
C3	Electrolytic, 50/25/25 μF 450 V	4450-0800	56289	D28936
C4	Electrolytic, 1500/750/750 μF 25 V	4450-0700	90201	203828S10C10X2
C5	Ceramic, 1.0 pF ±10%	4400-0100	78488	GA, 1.0 pF ±10%
C6	Plastic, 47 μF ±10%	4860-5800	84411	663UW, 47 μF ±10%
C7	Electrolytic, 15 μF 300 V	4450-1600	37942	204009854C2X2
C8	Electrolytic, 50/25/25 μF, 450 V	4450-0800	56289	D28936
C9	Cap Cer Disc 680 pF ±5%	4404-1685	72982	831, 680 pF ±5%
C10	Cap Cer Disc, 470 pF ±10%	4404-1475	72982	831 470 pF ±10%
C11	Cap Cer Disc .0015 μF ±10%	4406-2158	72982	811, .0015 μF ±10%
C12	Cap Cer Disc, 300 pF ±10%	4404-1305	72982	831 300 pF ±10%
C13	Cap Cer Disc .0068 μF ±20%	4406-2689	72982	811, .0068 μF ±20%
C14	Trimmer, 5-20 pF	4910-0400	72982	TS2AN300, 5-20 pF
C15	Plastic, .33 μF ±10%	4860-5700	84411	620S033 MFPORM
C16	Electrolytic, 1500/750/750 μF 25 V	4450-0700	90201	203828S10C10X2
C17	Cap Cer Disc .0068 μF ±20%	4406-2689	72982	811, .0068 μF ±20%
C18	Ceramic, 50 pF ±10%	4400-4400	72982	315N750, 50 pF ±10%
C19	Ceramic, 50 pF ±10%	4400-4400	72982	315N750, 50 pF ±10%
C20	Ceramic, 50 pF ±10%	4400-4400	72982	315N750, 50 pF ±10%
C21	Mica, 470 μF, ±10%, 500 V	4660-5400	72136	CM15E, 470 pF
C100	Ceramic, 6.8 pF ±5%	4400-0680	78488	GA, 6.8 pF ±5%
C101	Electrolytic, 100 μF, 15 V	4450-2800	56289	D17872
C102	Electrolytic, 100 μF, 15 V	4450-2800	56289	D17872
DIODES				
D100	Diode, Type HP-5082-2800	6082-1034	28480	HP5082-2800
D101	Diode, Type HP-5082-2800	6082-1034	28480	HP5082-2800
RESISTORS				
R1	Power, 470 Ω ±5%	6640-1479	24655	6640-1479
R2	Power, 330 Ω ±5%	6640-1339	24655	6640-1339
R3	Power, 220 Ω ±5%	6640-1229	24655	6640-1229
R4	Composition, 5.1 kΩ ±10%	6110-2515	01121	RC32GF512J
R5	Composition, 10 kΩ ±10%	6120-3109	01121	HB, 10 kΩ ±10%
R6	Composition, 10 kΩ ±10%	6120-3109	01121	HB, 10 kΩ ±10%
R7	Composition, 56 Ω ±5%	6100-0565	01121	RC20GF560J
R8	Pot. Wirewound, 500 Ω, ±10%	6050-1100	12697	43WX, 500 Ω
R9	Composition, 150 kΩ ±5%	6100-4155	01121	RC20GF154J
R10	Composition, 16 kΩ ±5%	6100-3165	01121	RC20GF163J
R11	Composition, 330 Ω ±5%	6100-1335	01121	RC20GF331J
R12	Power, 100 Ω ±5%	6640-1105	75042	1 3/4A 12 AB, 100 Ω ±5%
R13	Composition, 2.2 kΩ ±5%	6100-2225	01121	RC20GF222J
R14	Composition, 56 Ω ±5%	6100-0565	01121	RC20GF560J
R15	Composition, 56 kΩ ±5%	6100-3565	01121	RC20GF563J
R16	Composition, 330 Ω ±5%	6100-1335	01121	RC20GF331J
R17	Composition, 68 Ω ±5%	6100-0685	01121	RC20GF680J
R18	Composition, 22 kΩ ±5%	6100-3225	01121	RC20GF223J
R19	Power, 2.2 kΩ ±5%	6640-2225	24655	6640-2225
R20	Composition, 470 kΩ ±5%	6100-4475	01121	RC20GF474J
R21	Composition, 56 Ω ±5%	6100-0565	01121	RC20GF560J
R22	Composition, 180 Ω ±5%	6100-1185	01121	RC20GF181J
R23	Composition, 150 Ω ±5%	6100-1155	01121	RC20GF151J
R24	Power, 15 kΩ ±5%	6660-3155	75042	AS-5, 15 kΩ ±5%
R25	Composition, 1 kΩ ±5%	6110-2109	01121	GB, 1 kΩ ±5%
R26	Composition, 1 kΩ ±5%	6100-2105	01121	RC20GF102J
R27	Composition, 220 Ω ±5%	6100-1225	01121	RC20GF221J
R28	Composition, 5.1 kΩ ±10%	6110-2515	01121	RC32GF512J
R32	Power, 1.5 Ω ±5%	6640-9155	24655	6640-9155
R33	Potentiometer, 2.5 kΩ ±10%	6000-0400	12697	53MS, 2.5 kΩ ±10%
R34	Wire Wound, 5.8 Ω ±10%	6760-9689	75042	BWH, 6.8 Ω ±10%
R35	Film, 2 kΩ ±1%	6350-1200	75042	CEB, 2 kΩ ±1%
R36	Film, 2 kΩ ±1%	6350-1200	75042	CEB, 2 kΩ ±1%
R37	Film, 2 kΩ ±1%	6350-1200	75042	CEB, 2 kΩ ±1%
R38	Film, 2 kΩ ±1%	6350-1200	75042	CEB, 2 kΩ ±1%
R39	Film, 2 kΩ ±1%	0700-3520	24655	0700-3520
R40	Film, 2 kΩ ±1%	0700-3520	24655	0700-3520
R41	Film, 2 kΩ ±1%	0700-3520	24655	0700-3520
R42	Film, 2 kΩ ±1%	0700-3510	24655	0700-3510
R100	Composition, 2.7 kΩ ±5%	6100-2275	01121	RC20GF272J
R101	Composition, 4.3 kΩ ±5%	6100-2435	01121	RC20GF432J
R102	Composition, 5.1 kΩ ±5%	6100-2515	01121	RC20GF512J
R103	Potentiometer, Composition, 5 kΩ ±20%	6040-0600	01121	FWC, 5 kΩ ±20%

ELECTRICAL PARTS LIST (cont)

Ref Des	Description	GR Part No.	Fed Mfg Code	Mfg Part No.
MISCELLANEOUS				
F1	Fuse, 115 V	5330-1100	71400	MDL, 0.6 Amp
	Fuse, 230 V	5330-0800	71400	MDL, 0.3 Amp
F2	Fuse, 115 V	5330-1100	71400	MDL, 0.6 Amp
	Fuse, 230 V	5330-0800	71400	MDL, 0.3 Amp
J1	Binding Post	0938-3000	24655	0938-3000
J2	Binding Post	0938-3022	24655	0938-3022
L1	Inductors, 22 μH ±10%	4300-2600	99800	1537, 22 μH ±10%
L2	56000 μH ±10%	4300-6397	24759	CHM=56,000 μH
L3	Inductors, .5 mH	4290-4700	42498	R50, .5 mH
M1	Meter	5730-0920	24655	5730-0920
P1	Pilot Light	5600-0700	24454	MAZDA, 44
RX1	Rectifier	6081-1002	09213	1N3254
RX2	Rectifier	6081-1002	09213	1N3254
RX3	Rectifier	6081-1001	79089	1N3253
RX4	Rectifier	6081-1001	79089	1N3253
S1	Switch	7910-1300	04009	83053-SA
S2	Switch	7890-1800	76854	Type HC
S3	Switch	7890-1810	76854	Type HC
S4	Switch	7890-1820	76854	Type HC
T1	Transformer Power	0485-4970	24655	0485-4970
V1	Tube	8330-0300	70563	3-4
V2	Tube	8360-4500	24655	8360-4500
V3	Tube	8360-1500	24446	6AQ5
V4	Tube	8360-1500	24446	6AQ5
V5	Tube	8370-1100	70563	115N030T

MECHANICAL PARTS LIST

Name	Description	GR Part No.	Fed Mfg Code	Mfg Part No.
Etched Circuit Asm. Comp.		1390-2700	24655	1390-2700
Switch Assembly		1390-3040	24655	1390-3040
Power Cable		4200-0220	24655	4200-0220
Connector, Power Plug		4240-0210	24655	4240-0210
Dust Cover Assembly		4429-0400	24655	4429-0400
Feet, Black Neophrene		5260-0700	24655	5260-0700
End Frame Asm, Right		5310-4086	24655	5310-4086
End Frame Asm, Left		5310-4087	24655	5310-4087
Knob, Bar		5500-5321	24655	5500-5321
Knob, OUTPUT		5520-5321	24655	5520-5321
Pilot Light, Lens		5620-0800	72619	95-0975
Pilot Light Socket Asm.		7510-1930	24655	7510-1930
Fuse holder		5650-0100	71400	HKP-H

FEDERAL SUPPLY CODE FOR MANUFACTURERS

From Defense Logistics Agency Microfiche

H4-2 SB 708-42 GSA-FSS H4-2

Ref FMC Column in Parts Lists

Code	Manufacturer
00136	McCoy Elctrns.,Mt.Holly Springs,PA 17065
00192	Jones Mfg.,Chicago,IL 60181
00194	Walsco Elctrns.,Los Angeles,CA 90018
00327	Welwyn Intntl.,Westlake,OH 44145
00434	Schweber Elctrns.,Westbury,NY 11590
00656	Aerovox.,New Bedford,MA 02745
00779	AMP Inc.,Harrisburg,PA 17105
01009	Alden Products.,Brockton,MA 02413
01121	Allen Bradley.,Milwaukee,WI 53204
01255	Litton Inds.,Beverly Hills,CA 90213
01281	TRW.,Lawndale,CA 90260
01295	TI.,Dallas,TX 75222
01526	GE.,Waynesboro,VA 22980
01930	Amerock.,Rockford,IL 61101
01963	Cherry Elctrc.,Waukegan,IL 60085
02111	Spectrol Elctrns.,City of Industry,CA 91745
02114	Ferroxcube.,Saugerties,NY 12477
02606	Fenwall Lab.,Morton Grove,IL 60053
02639	GE.,Schenectady,NY 12307
02660	Amphenol.,Broadview,IL 60153
02735	RCA.,Somerville,NJ 08876
02768	Fastex.,Desplains,IL 60016
03042	Carter Ink.,Cambridge,MA 02142
03508	GE.,Syracuse,NY 13201
03550	Vanguard Elctrns.,Inglewood,CA 90302
03636	Grayburne.,Yonkers,NY 10701
03877	Transitron Elctrns.,Wakefield,MA 01880
03888	KDI Pyrofilm.,Whippany,NJ 07981
03911	Clairex.,New York,NY 10001
04009	Arrow Hart.,Hartford,CT 06106
04643	Digitronics.,Albertson,NY 11507
04713	Motorola.,Phoenix,AZ 85008
04919	Component Mfg.,W.Bridgewater,MA 02379
05079	Tansistor Elctrns.,Bennington,VT 05201
05245	Corcom.,Chicago,IL 60639
05276	ITT Elctrns.,Pomona,CA 91766
05402	Controls Co.of Amer.,Melrose Pk,IL 60160
05574	Viking Inds.,Chatsworth,CA 91311
05624	Barber Colman.,Rockford,IL 61101
05748	Barnes Mfg.,Mansfield,OH 44901
05820	Wakefield Eng.,Wakefield,MA 01880
06383	Panduit.,Tinley Pk,IL 60477
06406	Truelove & Maclean.,Waterbury,CT 06708
06665	Precision Monolith.,Santa Clara,CA 95050
06743	Clevite.,Cleveland,OH 44110
06795	WLS Stamp.,Cleveland,OH 44104
06915	Richco Plstc.,Chicago,IL 60646
06928	Teledyne Kntcs.,Soland Bch,CA 92075
06978	Aladdin Elctrns.,Nashville,TN 37210
07047	Ross Milton.,Southampton,PA 18966
07126	Digitran.,Pasadena,CA 91105
07127	Eagle Signal.,Baraboo,WI 53913
07233	Cinch Graphik.,City of Industry,CA 91744
07261	Avnet.,Culver City,CA 90230
07263	Fairchild.,Mountain View,CA 94040
07387	Birtcher.,N.Los Angeles,CA 90032
07595	Amer.Semicond.,Arlington Hts,IL 60004
07699	Magnetic Core.,Newburgh,NY 12550
07707	USM Fastener.,Shelton,CT 06484
07828	Budine.,Bridgeport,CT 06605
07829	Bodine Elctrc.,Chicago,IL 60618
07910	Cont Device.,Hawthorne,CA 90250
07983	State Labs.,New York,NY 10003
07999	Borg Inst.,Delavan,WI 53115
08524	Deutsch Fastener.,Los Angeles,CA 90045
08556	Bell Elctrc.,Chicago,IL 60632
08730	Vemaline Prod.,Franklin Lakes,NJ 07417
09213	GE.,Buffalo,NY 14220
09353	C&K Components.,Watertown,MA 02172
09408	Star-Tronics.,Georgetown,MA 01830
09823	Burgess Battery.,Freeport,IL 61032
09856	Fenwal Elctrns.,Framingham,MA 01701
09922	Burndy.,Norwalk,CT 06852
10025	Glasseal Prod.,Linden,NJ 07036
10389	Chicago Switch.,Chicago,IL 60647
11236	CTS of Berne.,Berne,IN 46711
11599	Chandler Evans.,W.Hartford,CT 06101
11983	Nortronics.,Minneapolis,MN 55427
12040	National.,Santa Clara,CA 95051
12045	Elctrc Transistors.,Flushing,NY 11354
12498	Teledyne.,Mountain View,CA 94043
12617	Hamlin.,Lake Mills,WI 53551
12672	RCA.,Woodbridge,NJ 07095
12697	Clarostat.,Dover,NH 03820
12856	Micrometals.,City of Industry,CA 91744
12954	Dickson Elctrns.,Scottsdale,AZ 85252
12969	Unitrode.,Watertown,MA 02172
13094	Electrocraft.,Hopkins,MN 55343
13103	Thermalloy.,Dallas,TX 75234
13148	Vogue Inst.,Richmond Hill,NY 11418
13150	Vernitron.,Laconia,NH 03246
13327	Solitron Devices.,Tappan,NY 10983
13715	Fairchild.,San Rafael,CA 94903
13919	Burr Brown.,Tucson,AZ 85706
14010	Anadex Inst.,Van Nuys,CA 91406
14195	Elctrc Controls.,Wilton,CT 06897
14196	American Labs.,Fullerton,CA 92634
14332	Relton.,Arcadia,CA 91006
14433	ITT.,W.Palm Beach,FL 33402
14482	Watkins & Johnson.,Palo Alto,CA 94304
14608	Corbin.,Berlin,CT 06037
14655	Cornell Dubilier.,Newak,NJ 07101
14674	Corning Glass.,Corning,NY 14830
14749	Acopian.,Easton,PA 18042
14752	Electrocube.,San Gabriel,CA 91776
14889	R&G Sloan.,Sun Valley,CA 91352
14908	Elctrc Inst & Spclty.,Stoneham,MA 02180
14936	General Inst.,Hicksville,NY 11802
15238	ITT.,Lawrence,MA 08142
15476	Digital Equip.,Maynard,MA 01754
15605	Cutler Hammer.,Milwaukee,WI 53202
15782	Houston Inst.,Bellaire,TX 77401
15801	Fenwal Elctrns.,Framingham,MA 01701
15819	Sinclair & Rush.,St.Louis,MO 63111
16037	Spruce Pine Mica.,Spruce Pine,NC 28777
16068	Intntl Diode.,Jersey City,NJ 07304
16179	Ommi Spectra.,Farmington,MI 48024
16301	Astrolab.,Linden,NJ 07036
16352	Codi.,Fairlawn,NJ 07410
16485	Sterling Inst.,New Hyde Park,NY 11040
16636	Indiana General.,Oglesby,IL 61348
16758	Delco.,Kokomo,IN 46901
16950	Precision Dynamics.,Burbank,CA 91504
16952	Amer Micro Devices.,Summerville,SC 29483
17117	Elctrc Molding.,Woonsocket,RI 02895
17540	Mohawk Spring.,Schiller Park,IL 60176
17745	Angstrohm Precsn.,Hagerstown,MD 21740
17771	Singer.,Somerville,NJ 08876
17850	Zeltex.,Concord,CA 94520
17856	Siliconix.,Santa Clara,CA 95054
18324	Signetics.,Sunnyvale,CA 94086
18542	New Prod Eng.,Wabash,IN 46992
18677	Scanbe.,El Monte,CA 91731
18736	Computer Diode.,S.Fairlawn,NJ 07936
18795	Cycon.,Sunnyvale,CA 94086
18911	Durant.,Watertown,WI 53094
19178	Zero.,Monson,MA 01057
19209	GE.,Gainesville,FL 32601
19373	Eastron.,Haverhill,MA 01830
19396	Paktron.,Vienna,VA 22180
19617	Cabtron.,Chicago,IL 60622
19644	LRC Elctrns.,Horseheads,NY 14845
19701	Electra.,Independence,KS 67301
20093	Elect Inds.,Murray Hill,NJ 07974
20754	KMC.,Long Valley,NJ 07853
21335	Fafnir Bearing.,New Britian,CT 06050
21688	Raytheon.,Norwood,MA 02062
21759	Lenox Fugle.,Watchung,NJ 07060
22526	Berg Elctrcs.,New Cumberland,PA 17070
22589	Electro Space Fabrctrs.,Topton,PA 19562
22753	UID Elctrcs.,Hollywood,FL 33022
23338	Wavetek.,San Diego,CA 92112
23342	Avnet Elctrcs.,Franklin Park,IL 60131
23936	Pamotor.,Bulingham,CA 94010
24351	Indiana Gnrl Elctrc.,Keasby,NJ 08832
24355	Analog Devices.,Cambridge,MA 02142
24444	General Semicond.,Tempe,AZ 85281
24446	GE.,Schenectady,NY 12305
24454	GE.,Syracuse,NY 13201
24455	GE.,Cleveland,OH 44112
24602	EMC Technlgy.,Cherry Hill,NJ 08034
24655	Gen Rad.,Concord,MA 01742
24759	Lenox Fugle.,S.Plainfield,NJ 07080
25008	Vactite.,Berkeley,CA 94710
25289	EG&G.,Bedford,MA 01730
26601	Tri County Tube.,Nunda,NY 14517
26805	Omni Spectra.,Waltham,MA 02154
26806	American Zettler.,Costa Mesa,CA 92626
27014	National.,Santa Clara,CA 95051
27545	Hartford Universal Ball.,Rocky Hill,CT 06067
28480	HP.,Palo Alto,CA 94304
28520	Heyman Mfg.,Kenilworth,NJ 07033
28875	IMC Magnetics.,Rochester,NH 03867
28959	Hoffman Elctrcs.,El Monte,CA 91734
30043	Solid State Devices.,LaMirada,CA 90638
30646	Beckman Inst.,Cedar Grove,NJ 07009
30874	IBM.,Armonk,NY 10504
30985	Permag Magnetics.,Toledo,OH 43609
31019	Solid State Scntfc.,Montgomerville,PA 18936
31514	Standford Appld Engs.,Costa Mesa,CA 92626
31814	Analogic.,Wakefield,MA 01880
31951	Triridge.,Pittsburgh,PA 15231
32001	Jensen.,Chicago,IL 60638
33095	Spectrum Control.,Fairview,PA 16415
33173	GE.,Owensboro,KY 42301
34141	Koehler.,Marlboro,MA 01752
34156	Semicoa.,Costa Mesa,CA 92626
34333	Silicon Genrl.,Westminster,CA 92683
34335	Advanced Micro Devices.,Sunnyvale,CA 94086
34649	Intel.,Santa Clara,CA 95051
34677	Solitron Devices.,Jupiter,FL 33458
35929	Constanta.,Montreal,QUE,CAN
36462	National Ltd.,Montreal,QUE,CAN
37942	Mallory.,Indianapolis,IN 46206
38443	Marlin Rockwell.,Jamestown,NY 14701
39317	McGill Mfg.,Valpariso,IN 46383
40931	Honeywell.,Minneapolis,MN 55408
42190	Muter.,Chicago,IL 60638
42498	National.,Melrose,MA 02176
43334	New Departure-Hyatt.,Sandusky,OH 44870
43991	Norma Hoffman.,Stanford,CT 06904
49671	RCA.,New York,NY 10020
49956	Raytheon.,Waltham,MA 02154
50088	Mostek.,Carrollton,TX 75006
50101	GHZ Devices.,S.Chelmsford,MA 01824
50507	Micro Networks.,Worcester,MA 01606
50522	Monsanto.,Palo Alto,CA 94304
50721	Datel Systems.,Canton,MA 02021
51167	Aries Elctrcs.,Frenchtown,NJ 08825
51553	Diablo Systems.,Hayward,CA 94545
51642	Centre Eng.,State College,PA 16801
52648	Plessey.,Santa Ana,CA 92705
52676	SKF Inds.,Philadelphia,PA 19132
52763	Stettner Trush., Cazenovia, NY 13035
53021	Sangamo Elctrc.,Springfield,IL 62705
53184	Xciton.,Latham,NY 12110
53421	Tyton.,Milwaukee,WI 53209
54294	Shallcross.,Selina,NC 27576
54297	Assoc Prec Prod.,Huntsville,AL 35805
54715	Shure Bros.,Evanston,IL 60202
56289	Sprague.,North Adams,MA 01247
57771	Stimpson.,Bayport,NY 11705
58553	Superior Valve.,Washington,PA 15301
59730	Thomas & Betts.,Elizabeth,NJ 07207
59875	TRW.,Cleveland,OH 44117
60399	Torrington.,Torrington,CT 06790
61007	Townsend.,Braintree,MA 02184
61637	Union Carbide.,New York,NY 10017
61864	United Carr Fast.,Boston,MA
63060	Victoreen.,Cleveland,OH 44104
63743	Ward Leonard.,Mt.Vernon,NY 10550
65083	Westinghouse.,Bloomfield,NJ 07003
65092	Weston.,Newark,NJ 07114
70106	Acushnet Cap.,New Bedford,MA 02742
70109	Adams & Westlake.,Elkhart,IN 46514
70417	Chrysler.,Detroit,MI 48231
70485	Atlantic India Rubber.,Chicago,IL 60607
70563	Amperite.,Union City,NJ 07087
70611	Ark-Les Switch.,Watertown,MA 02172
70892	Bead Chain.,Bridgeport,CT 06605
70903	Belden.,Chicago,IL 60644
71126	Bronson.,Beacon Falls,CT 06403
71279	Cambridge Thermionic.,Cambridge,MA 02138
71294	Canfield.,Clifton Forge,VA 24422
71400	Bussmann.,St Louis,MO 63107
71450	CTS.,Elkhart,IN 46514
71468	Cannon.,Los Angeles,CA 90031
71482	Clare.,Chicago,IL 60645
71590	Centralab.,Milwaukee,WI 53212
71666	Continental Carbon.,New York,NY
71707	Coto Coil.,Providence,RI 02905
71729	Crescent Box.,Philadelphia,PA 19134
71744	Chicago Min Lamp.,Chicago,IL 60640
71785	Cinch.,Chicago,IL 60624
71823	Darnell.,Downey,CA 90241
72136	Electromotive.,Willimantic,CT 06226
72228	Continental Screw.,New Bedford,MA 02742
72259	Nytronics.,Berkeley Hts,NJ 07922
72619	Dialight.,Brooklyn,NY 11237
72699	General Inst.,Newark,NJ 07104
72765	Drake.,Chicago,IL 60631
72794	Dzus Fastener.,W.Islip,NY 11795
72825	Eby.,Philadelphia,PA 19144
72962	Elastic Stop Nut.,Union,NJ 07083
72982	Erie.,Erie,PA 16512
73445	Amperex Elctrcs.,Hicksville,NY 11801
73559	Carling Elctrc.,Hartford,CT 06110
73690	Elco Resistor.,New York,NY
73803	TI.,Attleboro,MA 02703
73899	JFD Elctrcs.,Brooklyn,NY 11219
73957	Groov-Pin.,Ridgefield,NJ 07657
74193	Heinemann.,Trenton,NJ 08602
74199	Quam Nichols.,Chicago,IL 60637
74445	Holo-Krome.,Hartford,CT 06110
74545	Hubbell.,Stratford,CT 06497
74861	Industrial Cndnsr.,Chicago,IL 60618
74868	Amphenol.,Danbury,CT 06810
74970	Johnson.,Waseca,MN 56093
75042	IRC(TRW).,Burlington,IA 52601
75376	Kurz Kasch.,Dayton,OH 45401
75382	Kuka.,Mt Vernon,NY 10551
75491	Lafayette.,Syosset,NY 11791
75608	Linden.,Providence,RI 02905
75915	Littelfuse.,Des Plains,IL 60016
76005	Lord Mfg.,Erie,PA 16512
76149	Mallory Elctrc.,Detroit,MI 48204
76241	Maurey.,Chicago,IL 60616
76381	3 M Co.,St.Paul,MN 55101
76385	Minor Rubber.,Bloomfield,NJ 07003
76487	Millen.,Malden,MA 02148
76545	Mueller Elctr.,Cleveland,OH 44114
76684	National Tube.,Pittsburg,PA
76854	Oak Inds.,Crystal Lake,IL 60014
77132	Dot Fastener.,Waterbury,CT 06720
77147	Patton MacGuyer.,Providence,RI 02905
77166	Pass Seymour.,Syracuse,NY 13209
77263	Pierce Roberts Rubber.,Trenton,NJ 08638
77315	Platt Bros.,Waterbury,CT 06720
77339	Positive Lockwasher.,Newark,NJ
77342	AMF.,Princeton,IN 47570
77542	Ray-o-Vac.,Madison,WI 53703
77630	TRW.,Camden,NJ 08103
77638	General Inst.,Brooklyn,NY 11211
78189	Shakeproof.,Elgin,IL 60120
78277	Sigma Inst.,Braintree,MA 02184
78429	Airco Speer.,St Marys,PA 15867
78488	Stackpole.,St Marys,PA 15867
78553	Tinnerman.,Cleveland,OH
78711	Telephonics.,Huntington,NY 11743
79089	RCA.,Harrison,NJ 07029
79136	Waldes Kohinoor.,New York,NY 11101
79497	Western Rubber.,Goshen,IN 46526
79725	Wiremold.,Hartford,CT 06110
79727	Continental Wirt.,Philadelphia,PA 19101
79840	Mallory Controls.,Frankfort,IN 46041
79963	Zierick.,Mt Kisco,NY 10549
80009	Tektronix.,Beaverton,OR 97005
80030	Prestole Fastener.,Toledo,OH 43605
80048	Vickers.,St Louis,MO 63166
80103	Lambda.,Melville,NY 11746
80183	Sprague.,N.Adams,MA 01247
80211	Motorola.,Franklin Pk,IL 60131
80251	Formica.,Cincinnati,OH 45232
80258	Standard Oil.,Lafeyette,IN 47902
80294	Bourns Labs.,Riverside,CA 92506
80368	Sylvania.,New York,NY 10017
80431	Air Filter.,Milwaukee,WI 53218
80583	Hammarlund.,New York,NY 10010
80740	Beckman Inst.,Fullerton,CA 92634
80756	TRW Ramsey.,St Louis,MO 63166
80894	Pure Carbon.,St Marys,PA 15857
81030	Int'l Inst.,Orange,CT 06477
81073	Grayhill.,LaGrange,IL 60525
81143	Isolantite.,Stirling,NJ 07980
81312	Winchester.,Oakville,CT 06779
81349	Military Specifications
81350	Joint Army-Navy Specifications
81483	Int'l Rectifier.,El Segundo,CA 90245
81741	Chicago Lock.,Chicago,IL 60641
81831	Filtron.,Flushing,NY 11354
81840	Ledex.,Dayton,OH 45402
81860	Barry Wright.,Watertown,MA 02172
82219	Sylvania.,Emporium,PA 15834
82227	No.Amer Philips.,Cheshire,CT 06410
82273	IN Pattern & Model.,LaPort,IN 46350
82389	Switchcraft.,Chicago,IL 60630
82567	Reeves Hoffman.,Carlisle,PA 17013
82647	Metals & Controls.,Attleboro,MA 02703
82807	Milwaukee Resistor.,Milwaukee,WI 53204
82877	Rotron.,Woodstock,NY 12498
82901	IN General Magnet.,Valparaiso,IN 46383
83003	Varo.,Garland,TX 75040
83014	Hartwell.,Placentia,CA 92670
83033	Meissner.,Mt Carmel,IL 62863
83058	Carr Fastener.,Cambridge,MA 02142
83186	Victory Eng.,Springfield,NJ 07081
83259	Parker Seal.,Culver City,CA 90231
83330	H.H.Smith.,Brooklyn,NY 11207
83361	Bearing Spclty.,San Francisco,CA
83587	Solar Elctrc.,Warren,PA 16365
83594	Burroughs.,Plainfield,NJ 07061
83740	Union Carbide.,New York,NY 10017
83766	Mass Engrg.,Quincy,MA 02171
83781	National Elctrcs.,Geneva,IL 60134
84411	TRW.,Ogallala,NB 69153
84835	Lehigh Metals.,Cambridge,MA 02140
84970	Sarkes Tarzian.,Bloomington,IN 47401
84971	TA Mfg.,Los Angeles,CA 90039
85604	Kepco.,Flushing,NY 11352
86420	Payson Casters.,Gurnee,IL 60031
86577	Prec Metal Prod.,Stoneham,MA 02180
86684	RCA.,Harrison,NJ 07029
86687	REC.,New Rochelle,NY 10801
86800	Cont Elctrcs.,Brooklyn,NY 11222
88140	Cutler Hammer.,Lincoln,IL 62656
88204	GTE Sylvania.,Ipswitch,MA 01938
88219	Gould Nat Battery.,Trenton,NJ 08607
88419	Cornell Dubilier.,Fuquay Varina,NC 27526
88627	K&G Mfr.,New York,NY
89265	Potter & Brumfield.,Princeton,IN 47671
89482	Holtzer Cabot.,Boston,MA 02119
89665	United Transformer.,Chicago,IL
89870	Berkshire Transformer.,Kent,CT 06757
90201	Mallory Cap.,Indianapolis,IN 46206
90303	Mallory Bat.,Tarrytown,NY 10591
90634	Gulton Inds.,Metuchen,NJ 08840
90750	Westinghouse.,Boston,MA 02118
90952	Hardware Prod.,Reading,PA 19602
91032	Continental Wire.,York,PA 17405
91146	Cannon.,Salem,MA 01970
91210	Gerber.,Mishawaka,IN 46544
91293	Johanson.,Boonton,NJ 07005
91417	Harris.,Melbourne,FL 32901
91506	Augat Bros.,Attleboro,MA 02703
91598	Chandler.,Wethersfield,CT 06109
91637	Dale Elctrcs.,Columbus,NE 68601
91662	Elco.,Willow Grove,PA 19090
91719	General Inst.,Dallas,TX 75220
91836	Kings Elctrcs.,Tuckahoe,NY 11223
91916	Mephisto Tool.,Hudson,NY 12534
91929	Honeywell.,Freeport,IL 61032
92519	Electra Insul.,Woodside,NY 11377
92678	Edgerton Germeshuasen.,Boston,MA 02115
92702	IMC Magnetics.,Westbury,NY 11591
92739	Ampex.,Redwood City,CA 94063
92966	Hudson Lamp.,Kearny,NJ 07032
93332	Sylvania.,Woburn,MA 01801
93346	Amer Elctrcs Labs.,Lansdale,PA 19446
93618	R&C Mfg.,Ramsey,PA 16671
93916	Cramer.,New York,NY 10013
94144	Raytheon.,Quincy,MA 02169
94154	Wagner Elctrc.,Livingston,NJ 07039
94271	Weston.,Archibald,PA 18403
94322	Tel Labs.,Manchester,NH 03102
94589	Dickson.,Chicago,IL 60619
94696	Magnecraft.,Chicago,IL 60630
94800	Atlas Ind.,Brookline,NH 03033
95076	Garde.,Cumberland,RI 02864
95121	Quality Comp.,St Marys,PA 15857
95146	Alco Elctrcs.,Lawrence,MA 01843
95238	Continental Conn.,Woodside,NY 11377
95275	Vitramon.,Bridgeport,CT 06601
95348	Gordos.,Bloomfield,NJ 07003
95354	Methode.,Rolling Meadow,IL 60008
95794	Amer Brass.,Torrington,CT 06790
95987	Weckesser.,Chicago,IL 60646
96095	Aerovox Hi Q.,Olean,NY 14760
96341	Microwave Assoc.,Burlington,MA 01801
96906	Military Standards
97918	Linemaster Switch.,Woodstock,CT 06281
98291	Sealectro.,Mamaroneck,NY 10544
98474	Compar.,Burlingame,CA 94010
98821	North Hills.,Glen Cove,NY 11542
99017	Protective Closures.,Buffalo,NY 14207
99117	Metavac.,Flushing,NY 11358
99313	Varian.,Palo Alto,CA 94303
99378	Atlee.,Winchester,MA 01890
99800	Delevan;E.Aurora,NY 14052
99934	Renbrandt.,Boston,MA 02118
99942	Centralab.,Milwaukee,WI 53201

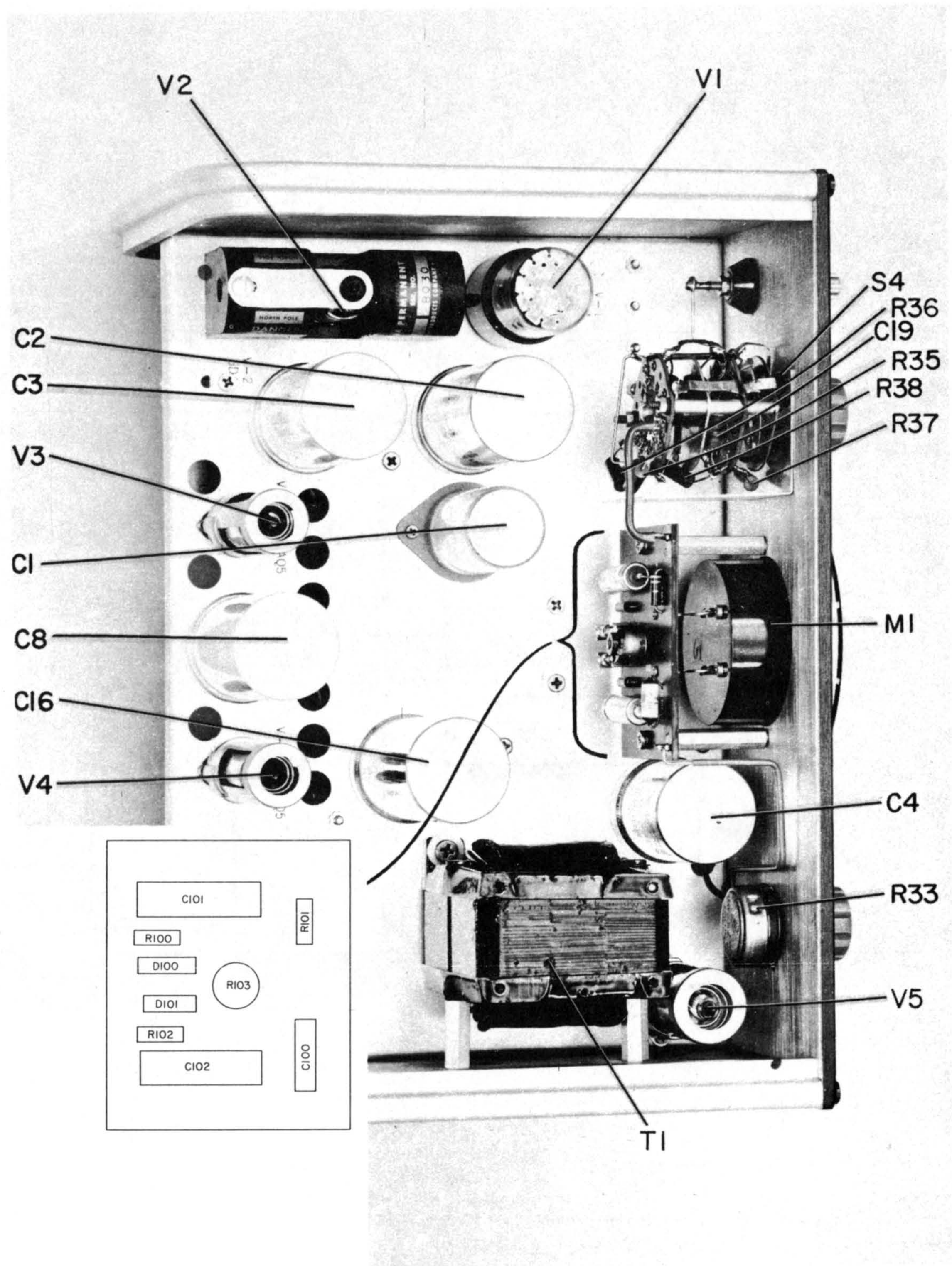


Figure 10. Top Interior View.

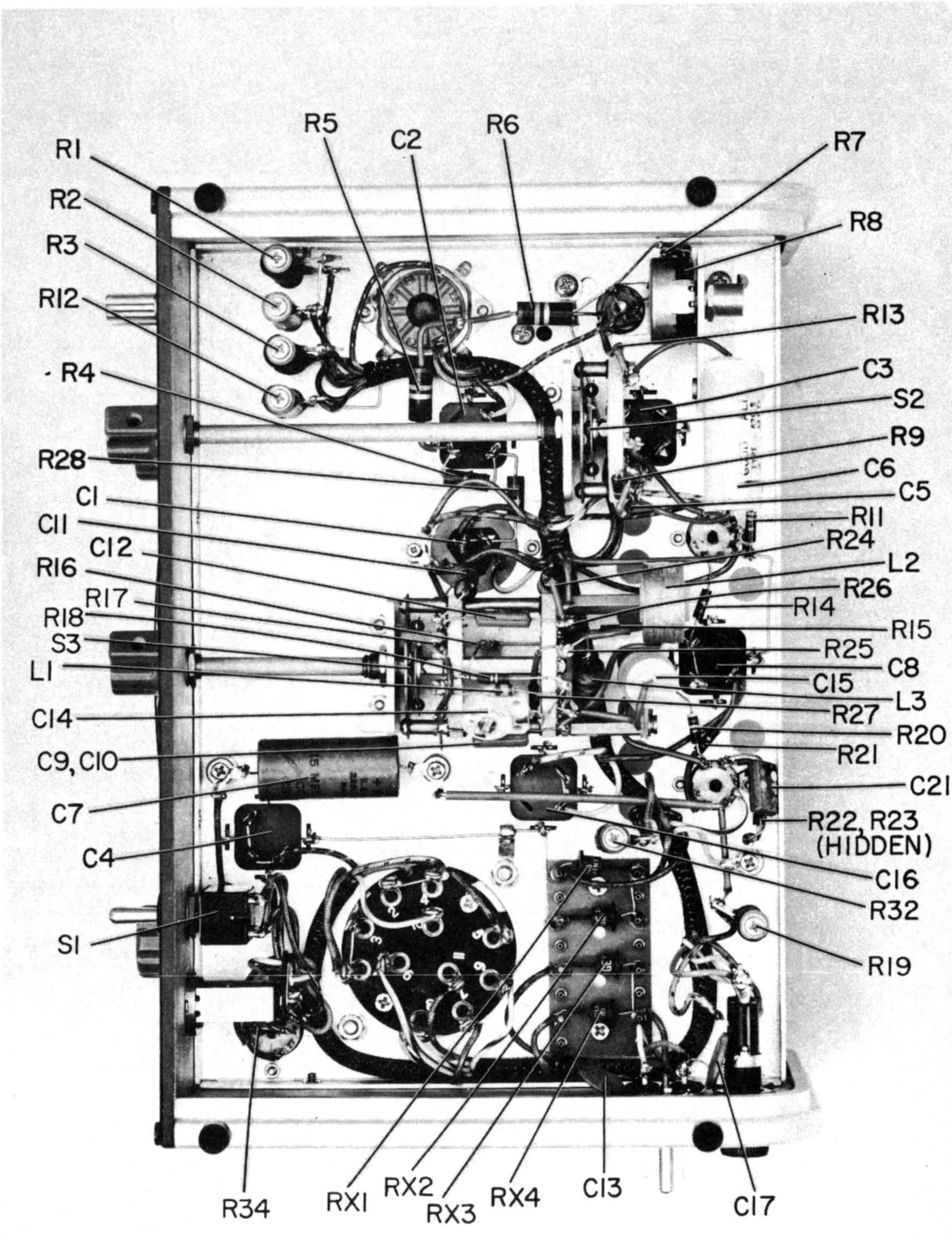
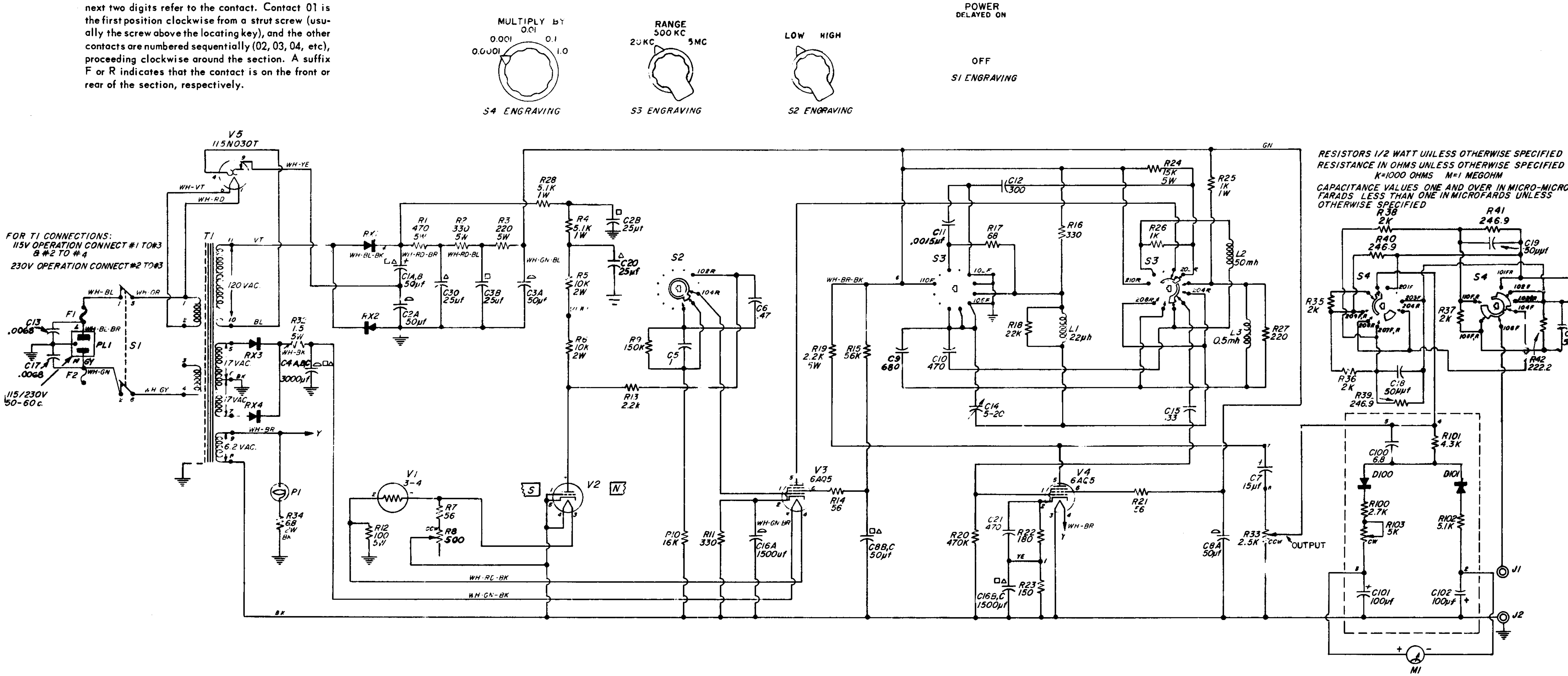


Figure 11. Bottom Interior View.

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.



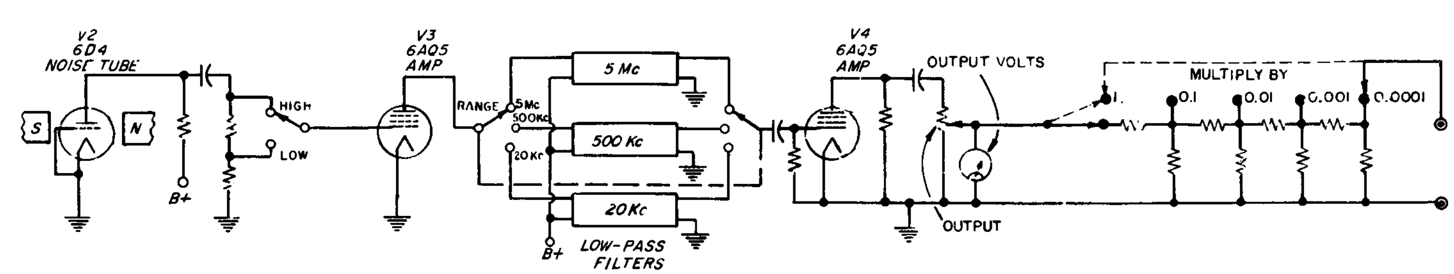


Figure 13. Schematic Wiring Diagram.