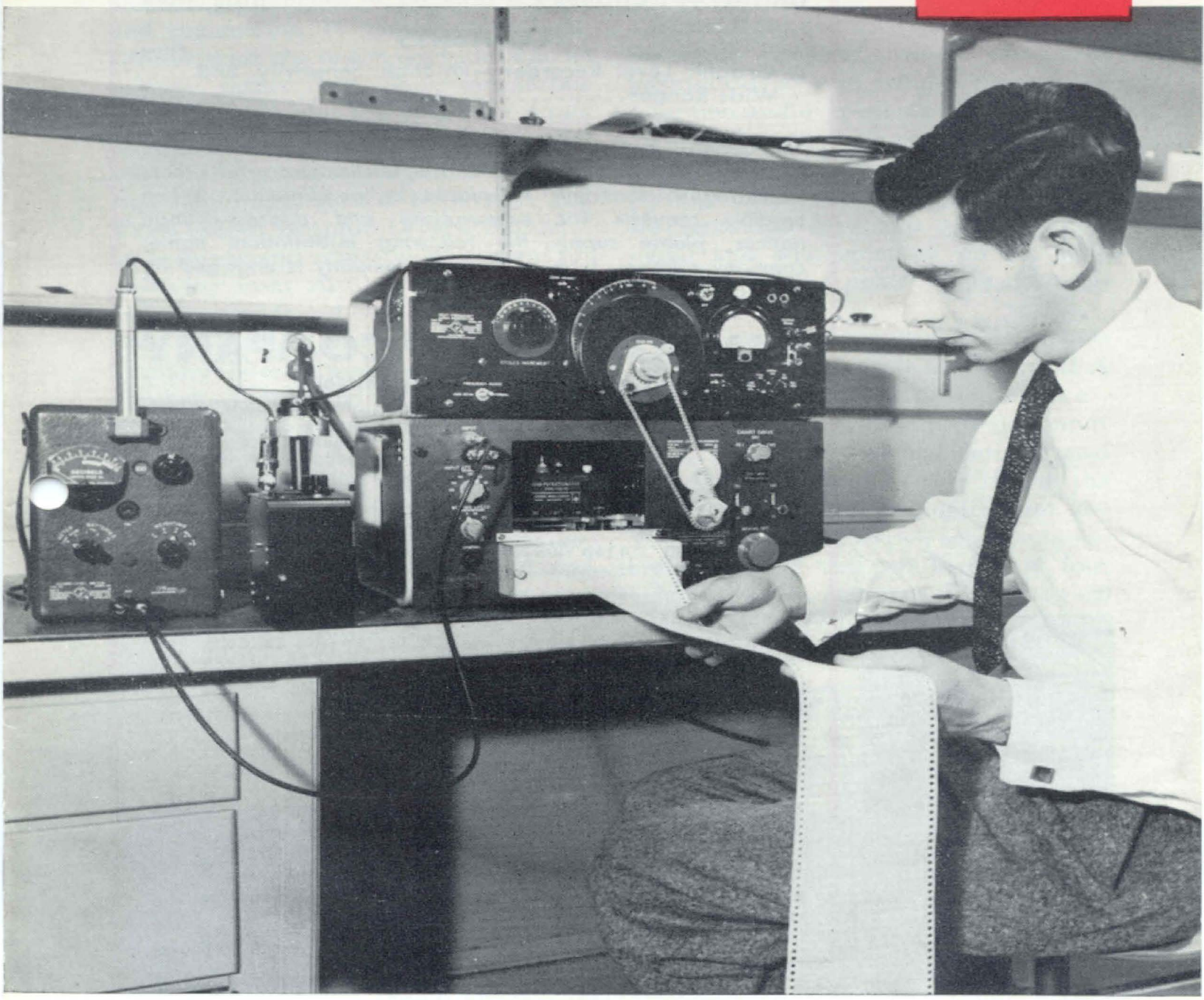
THE GENERAL RADIO

# EXPERIMENTER



VOLUME 33 No. 6 JUNE, 1959

## IN THIS ISSUE

Graphic Level Recorder

THE GENERAL RADIO

# EXPERIMENTER



*Published Monthly by the General Radio Company*

VOLUME 33 • NUMBER 6 JUNE, 1959

## CONTENTS

Page

A Graphic Level Recorder with High Sensitivity and Wide Ranges . . . . . 3

*The General Radio EXPERIMENTER is mailed without charge each month to engineers, scientists, technicians, and others interested in electronic techniques in measurement. When sending requests for subscriptions and address-change notices, please supply the following information: name, company address, type of business company is engaged in, and title or position of individual.*

## GENERAL RADIO COMPANY

**West Concord, Massachusetts**

*Telephone:* (Concord) *EMerson 9-4400;* (Boston) *CLearwater 9-8900*

**NEW YORK:** Broad Avenue at Linden, Ridgefield, New Jersey
*Telephone — N. Y., WOrth 4-2722*
*N. J., WHitney 3-3140*

**CHICAGO:** 6605 West North Avenue, Oak Park, Illinois
*Telephone — VIllage 8-9400*

**PHILADELPHIA:** 1150 York Road, Abington, Pennsylvania
*Telephone — HAncock 4-7419*

**WASHINGTON:** 8055 13th St., Silver Spring, Maryland
*Telephone — JUniper 5-1088*

**LOS ANGELES:** 1000 North Seward St., Los Angeles 38, Calif.
*Telephone — HOllywood 9-6201*

**SAN FRANCISCO:** 1186 Los Altos Ave., Los Altos, Calif.
*Telephone — WHitecliff 8-8233*

**CANADA:** 99 Floral Parkway, Toronto 15, Ontario
*Telephone — CHerry 6-2171*

**REPAIR SERVICES**

**EAST COAST:** General Radio Co., Service Dept., 22 Baker Avenue, West Concord, Mass.
*Telephone — Concord, EMerson 9-4400*
*Boston, CLearwater 9-8900*

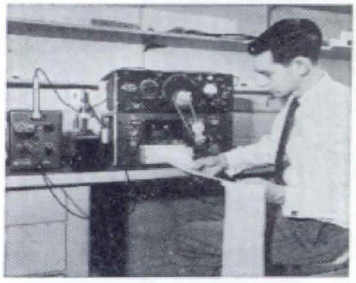
**NEW YORK:** General Radio Co., Service Dept., Broad Ave. at Linden, Ridgefield, New Jersey
*Telephone — N. Y., WOrth 4-2722*
*N. J., WHitney 3-3140*

**MIDWEST:** General Radio Co., Service Dept., 6605 West North Ave., Oak Park, Illinois
*Telephone — VIllage 8-9400*

**WEST COAST:** Western Instrument Co., 826 North Victory Boulevard, Burbank, Calif.
*Telephone — VIctoria 9-3013*

**CANADA:** Bayly Engineering, Ltd., First St., Ajax, Ontario
*Telephone — Toronto EMpire 2-3741*

### COVER



The new General Radio Graphic Level Recorder plotting automatically the frequency response of an earphone. The earphone is driven by the Type 1304-B Beat-Frequency Audio Generator and is coupled to the Type 1551-P1 Condenser Microphone System through a standard ASA coupler. The output of the Condenser Microphone System is fed to the Type 1551-B Sound Level Meter, which drives the recorder.

# A GRAPHIC LEVEL RECORDER WITH HIGH SENSITIVITY AND WIDE RANGES

A graphic level recorder has a wide variety of uses in electronics, acoustics, and other branches of physical science and engineering. It records on a logarithmic scale the rms magnitude of an ac voltage, rather than the instantaneous value and can plot the output of an ac device as a function either of time or of some other parameter that can be made time dependent, such as frequency. The TYPE 1521-A Graphic Level Recorder,* an accurate and versatile instrument for recording from 20 c to 200 kc, has an input sensitivity of one millivolt. It has been designed to meet the requirements of many different applications and has a number of outstanding electrical, mechanical, and operational features.

In this recorder, a high-speed servomechanism of novel design positions an input potentiometer and a pen to produce an ink trace on rectilinear paper. Potentiometers for ranges of 20, 40, and 80 db are available and can be interchanged easily and quickly.

An additional feature is an accessory linear potentiometer, which converts the instrument from a level recorder to a general-purpose dc recorder with adjustable zero level and 0.8-volt full-scale sensitivity.

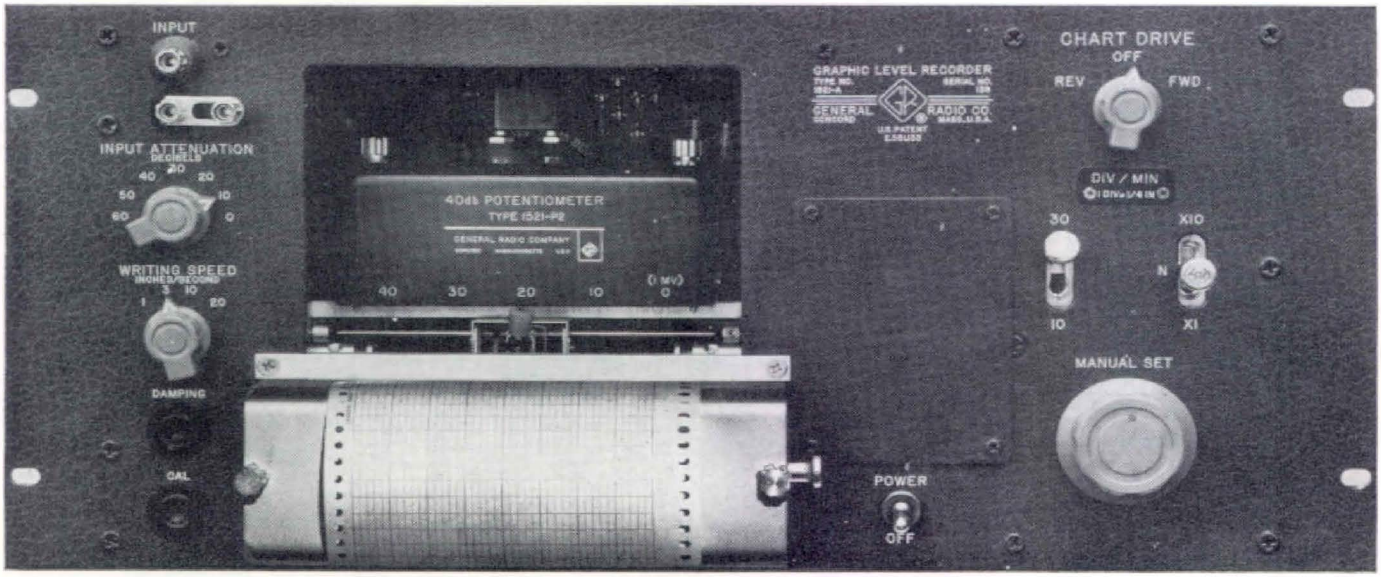
Transistors are used throughout the electronic circuitry, which eliminates warm-up delay and reduces power consumption and over-all size.

Controls are simple and have been reduced to a minimum: input amplitude, writing speed, and paper speed. These are separated into two groups: input signal and writing speed on the left-hand side of the panel; chart drive on the right.

The input and writing speed controls can be seen at the left of Figure 1. A constant impedance calibrated input attenuator is used to adjust the input level. The input terminal can be used with the low terminal either tied to the instrument chassis or floating for dc. The writing speed switch sets the maximum speed of the pen to one of four values from 1 inch per second to 20 inches per second, which, on the 80-db range, corresponds to 400 db per second.

*A completely new design based upon the Model SL-4 Recorder of Sound Apparatus Co.; U. S. Patent 2,581,133, now owned by General Radio Company.

**Figure 1. Panel view of the Graphic Level Recorder with 40-db potentiometer and CTP-505 Chart Paper installed.**



An adjustable damping control is also provided to allow setting of the overshoot for step inputs. This control is normally set for a 1-db overshoot at the maximum writing speed. A calibration control is also provided for setting the gain of the recorder in conjunction with an external ac reference voltage, so that the recorder will plot absolute level.

Four chart speeds are available with the motor supplied with the instrument: 2.5 in/min, 7.5 in/min, 25 in/min, and 75 in/min. Speed changes are easily made while the motor is running by means of two gear-shift levers shown at the right of Figure 1. A neutral position is also provided. The chart paper can be driven either forward or backward or controlled manually. By the use of a different motor, which is easily interchangeable (see the price table, page 12), these speeds can be reduced by a factor of 60. Chart paper is easily installed. Paper width is 5 inches and has a 4-inch recording range.

The recorder plots rms voltage level *vs.* time for frequencies between 20 and 200,000 cycles per second. Accessories are available to couple the chart drive to the dial of the TYPE 1304-B Beat-Frequency Audio Generator, the TYPE 1554-A Sound and Vibration Analyzer, or the TYPE 760-B Sound Analyzer to produce a plot of level *vs.* frequency. Chart paper with frequency scales is available for use with each of these instruments.

When coupled to the Beat-Frequency Audio Generator, the recorder produces plots having a true logarithmic frequency scale and is ideal for plotting the frequency response of analyzers, recording systems, networks, filters, and equalizers, as well as of loudspeakers, microphones, earphones, vibration pickups, and other transducers.

The combination of the recorder and either the TYPE 1554-A Sound and Vibration Analyzer[1] or the TYPE 760-B Sound Analyzer makes possible the automatic analysis of sound spectra and complex waveforms. When the network or device under test is excited by the TYPE 1390-A Random Noise Generator, a continuous spectrum response of that network to white noise can be plotted.

The high writing speed available with the 80-db potentiometer permits the recorder to be used for the measurement of reverberation time as short as approximately 0.5 second.

The wide range of paper speed facilitates long-period studies of the noise produced by traffic, office machinery, industrial processes, and potential hearing damage environments, as well as the measurement of short-duration transients.

## PRINCIPLES OF OPERATION

The TYPE 1521-A Graphic Level Recorder utilizes a null-seeking servo system, which positions the pen on the chart paper.

The block diagram of the servo loop is shown in Figure 2. The input signal is applied through the input attenuator to the logarithmic potentiometer. The output of the potentiometer is amplified

[1]To be described in a forthcoming issue of the *Experimenter*.

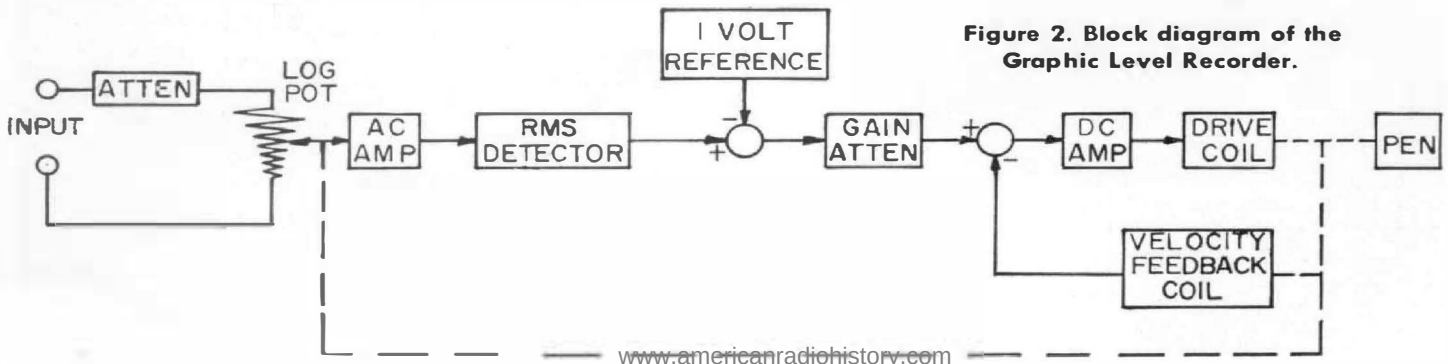



**Figure 2. Block diagram of the Graphic Level Recorder.**

and then rectified to produce a dc voltage proportional to the rms level of the ac input voltage. This dc voltage is compared with a 1-volt reference voltage, and their difference, which is the error signal, is used ultimately to position the drive coil.

#### Input Circuit and AC Amplifier

The input attenuator has a 60-db range in 10-db steps. It provides a constant 10,000-ohm input impedance, which can be increased, at corresponding sacrifice in sensitivity, by the addition of a resistor in series with the input. The sensitivity will, however, still be greater than that usually encountered in recorders of this type. The 10,000-ohm resistance of the potentiometer is a compromise between the desire for a high input impedance, the wire size required for the potentiometer, and the loading effects of the ac amplifier.

The ac amplifier consists of an emitter-follower input, four stages of gain, and a phase-inverter stage for driving the detector circuit. The high input impedance of the emitter follower minimizes its loading effect on the potentiometer. The gain of the amplifier is approximately 1000. It can be set to exactly 1000 in terms of an external ac reference voltage when it is desired to measure absolute level. Since the input attenuator is calibrated, the reference voltage can have any value between 1 mv and 10 volts. The gain of the amplifier is stabilized by a sufficient amount of inverse feedback to insure its stability of calibration. A regulated power supply is used to minimize the effects of line-voltage variations. The dynamic range of the amplifier is 15 db, which allows faithful reproduction of input signals with a peak-to-rms ratio of 5:1 — a feature of considerable importance in the recording of noise.

#### Detector

The detector has a quasi-rms response,[2] which closely approximates true rms for commonly encountered waveforms. The output is within 0.25 db of true rms for sine waves, multiple sine waves, square waves, and noise.

Since the output of the potentiometer is linear in db rather than in volts, the change in input voltage to the detector is significantly different for increasing and decreasing input signals. For example, a 10-db increase would momentarily produce 3.16 volts, a change of 2.16 volts from its normal 1-volt value, compared with 0.316 volt, or a change of −0.684 volt, for a 10-db decrease. In order to maintain comparable step responses in the two directions for these vastly differing signals, diode limiters are incorporated at the output of the detector. The level of limiting is set to produce similar transient responses for increasing or decreasing levels.

[2]E. E. Gross, "Improved Performance Plus a New Look for the Sound-Level Meter," *General Radio Experimenter*, Vol. 32, No. 17, October, 1958.

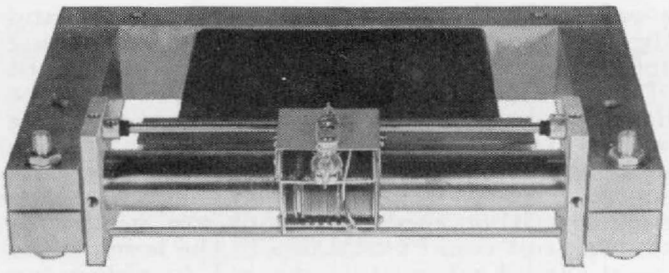


**Figure 3. View of the magnetic structure and pen motor.**

#### Pen Drive Circuit

The output of the detector is compared by emitter followers to a 1-volt dc reference obtained from the regulated 18-volt supply. An attenuator (gain switch) which changes the loop-gain according to the potentiometer used is located immediately after the emitter followers. A velocity-feedback signal (see below) is also injected at this point. The sum of the error voltage and the velocity feedback voltage is then amplified by a push-pull dc amplifier, which is drift compensated by means of negative feedback. Two power transistors are used to produce current through the drive coil or servo motor.

The servo motor consists of a center-tapped coil wound on a lightweight lucite form, which is positioned in the uniform magnetic field produced by a large Alnico permanent magnet. The magnetic structure and coil are shown in Figure 3. The interaction between the current in the coil and the field from the permanent magnet results in a force to move the coil in a direction to reduce the error voltage. When the coil is correctly positioned, the error voltage and the current in the coil become zero, and there is no further force on the coil. The coil will remain in this position as long as the input voltage remains constant because of the electrical restoring force produced on the coil for any slight movement about the correct null position. Full current flows through the coil for a displacement only a $\frac{1}{32}$ inch from the true null, resulting in a high degree of static accuracy. Because the pen and potentiometer wiper arm are located directly on the coil structure, there is no possibility of backlash, or dead zone, between movements of the servo motor and corresponding movements of the potentiometer and pen. Since the servo motor has a straight-line movement, the resulting recording is truly rectilinear.

#### Velocity Feedback

A second winding on the drive coil structure generates a voltage proportional to the coil velocity. This damping voltage is fed back around the drive coil through the dc amplifier to reduce the time constant of the drive-coil circuit. As a result, an adequate degree of stabilization can be obtained consistent with

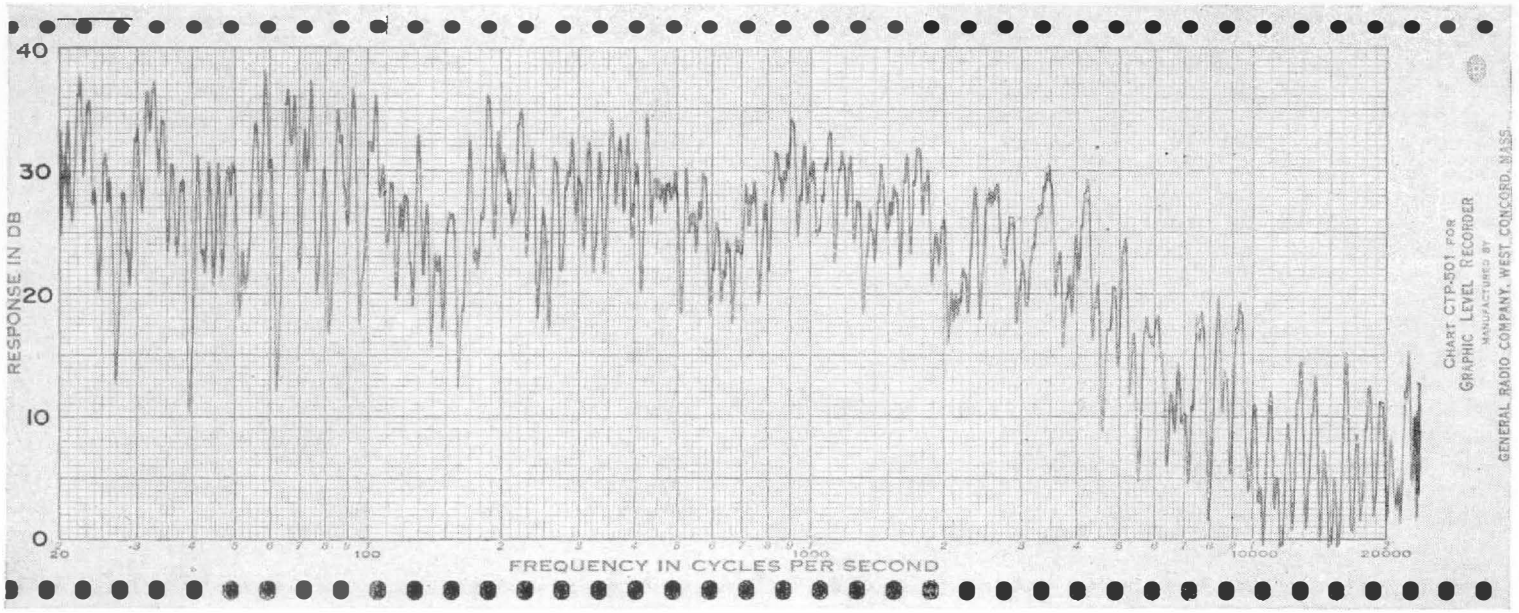
a reasonable bandwidth of the pen servo and the desired static accuracy. Slower writing speeds are obtained by increasing the amount of damping voltage. Since the output from the detector is limited, an increase in damping voltage results in a decrease in both the pen servo bandwidth and the maximum writing speed (saturation velocity of the pen). The slower writing speed positions are useful for filtering out rapid variations in the level of the input signal when it is desired to obtain an average value of these variations.

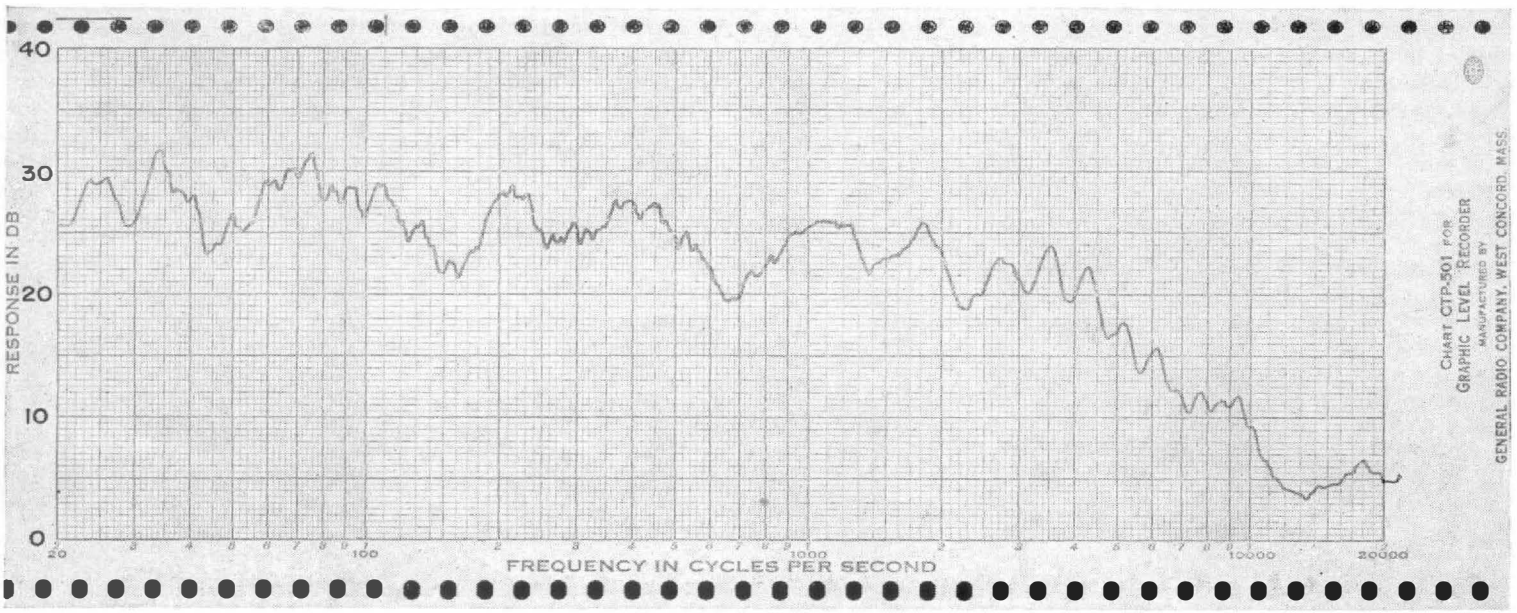
Figure 4 shows a plot of the frequency response of a public address system installed in a large auditorium as recorded with both maximum and minimum settings of the writing-speed control. The bandwidth of the pen servo is approximately 0-10 cps in the 20-inch per second writing speed position and decreases in approximately the same ratio as the writing speeds marked on the control. Because of the limitation in maximum velocity, the servo bandwidth is a function of amplitude. The writing speeds indicated on the control are only approximate and represent a coil velocity obtained when the dc amplifier is saturated. As such, they should be used only as an indication of the upper limit of the capabilities of the recorder to follow changes in the level of the input signal.

### Logarithmic Potentiometers

The potentiometers have shaped winding forms and are tapped for the connection of padding resistors to obtain an accurate logarithmic function. Since the same size wire is used throughout the length of the potentiometer, a high degree of resolution is maintained for all positions of the slider. The rated accuracy of the potentiometers is 1% full scale, but that of the 20-db and 40-db potentiometers is usually better than 0.5% of full scale. Life tests on these potentiometers have indicated that, with periodic application of proper lubricants, a

**Figure 4. Records of the frequency response of a public address system, taken with (*top*) maximum writing speed and (*below*) minimum writing speed.**



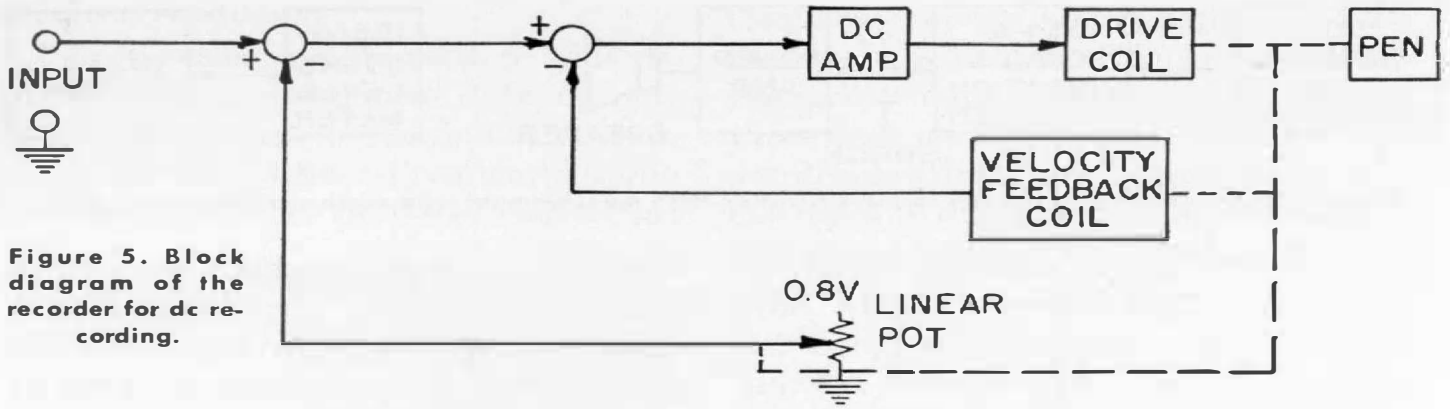



**Figure 5. Block diagram of the recorder for dc recording.**

life of many millions of cycles can be expected.

The potentiometers are positioned on the mounting shelf by means of two pins, which mate with corresponding holes in the shelf. Input connections to the potentiometer are made by means of a shielded cable which plugs into the top of the potentiometer case. Pins, located at the rear of the case, prevent the potentiometer from being seated unless the gain switch is in the correct position. This switch can be operated through the opening in the front of the instrument.

### DC Recording

The TYPE 1521-A Graphic Level Recorder can be converted into a dc recorder with a 1-kilohm input impedance and an 0.8-volt full-scale sensitivity by use of the linear potentiometer (TYPE 1521-P4). Figure 5 is a block diagram of the recorder servo loop for dc recording. The necessary circuit changes are accomplished by means of the gain switch and one plug. Since the ac amplifier cannot be used for dc recording, the sensitivity of the recorder is considerably reduced. The input impedance is limited to 1 kilohm because of the collector leakage current of the input transistors. This impedance can be increased by a factor of 10 if the effects of leakage current are included in the zero adjustment of the recorder.

A zero adjustment is provided on the front of the linear potentiometer to allow the operator to set the zero position to any point on the chart paper. The servo bandwidth is not affected by the change to a dc recorder.

## ACCESSORIES AVAILABLE

(See price list, page 12)

### Potentiometers

The 40-db potentiometer is supplied, and the 20-db, 80-db, and linear potentiometers are available as accessories.

### Motors

Accessory motors (50-cycle and 60-cycle) are available for slow-speed chart drive. These motors produce chart speeds of 2.5 to 75 inches/hour, a reduction by a factor of 60 from the speeds available with the standard motors.

### Drive and Link Units

The 1521-P10 Drive Unit is designed to couple the recorder to all external oscillators or analyzers. Separate link units are required on the various external instruments for coupling the drive unit to the instrument dial shaft. By means of a cam-operated clutch, the recorder paper position and the oscillator or analyzer setting can be made completely independent of one another. Limit stop switches allow the operator to set the limit of travel of the drive unit. A slip clutch also is provided to protect the oscillator or analyzer.

The recorder can be used for time-base measurements without removal of the drive unit. To do this, the drive unit clutch is decoupled, and the limit switches are shorted out with a toggle switch behind the panel.

Link units are available for driving the dials of the following General Radio instruments: TYPE 1304-B Beat-Frequency Audio Generator, TYPE 760-B Sound Analyzer, and TYPE 1554-A Sound and Vibration Analyzer.

### Charts

Four types of chart paper are available:

CTP-505 is supplied and is designed for recording level *vs.* time or for dc recording.

CTP-501 is designed for use with the TYPE 1304-B Beat-Frequency Audio Generator.

CTP-516 is designed for use with the TYPE 760-B Sound Analyzer.

CTP-554 is designed for use with the TYPE 1554-A Sound and Vibration Analyzer.

## APPLICATIONS

### Level *vs.* Time

The TYPE 1521-A Graphic Level Recorder can be used in conjunction with a TYPE 1551-B Sound-Level Meter to yield permanent records of sound level as a function of time. Rapid changes in the sound level can be filtered out, when desirable, through the use of one of the slow writing speeds.

Continuous recordings can be made for periods from 16 minutes to 8 hours with the standard motor or from 16

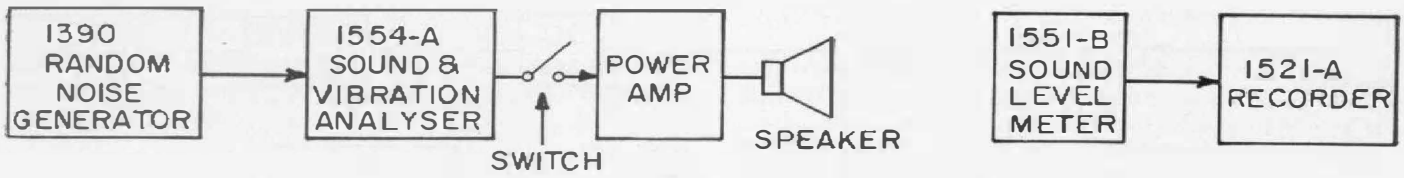


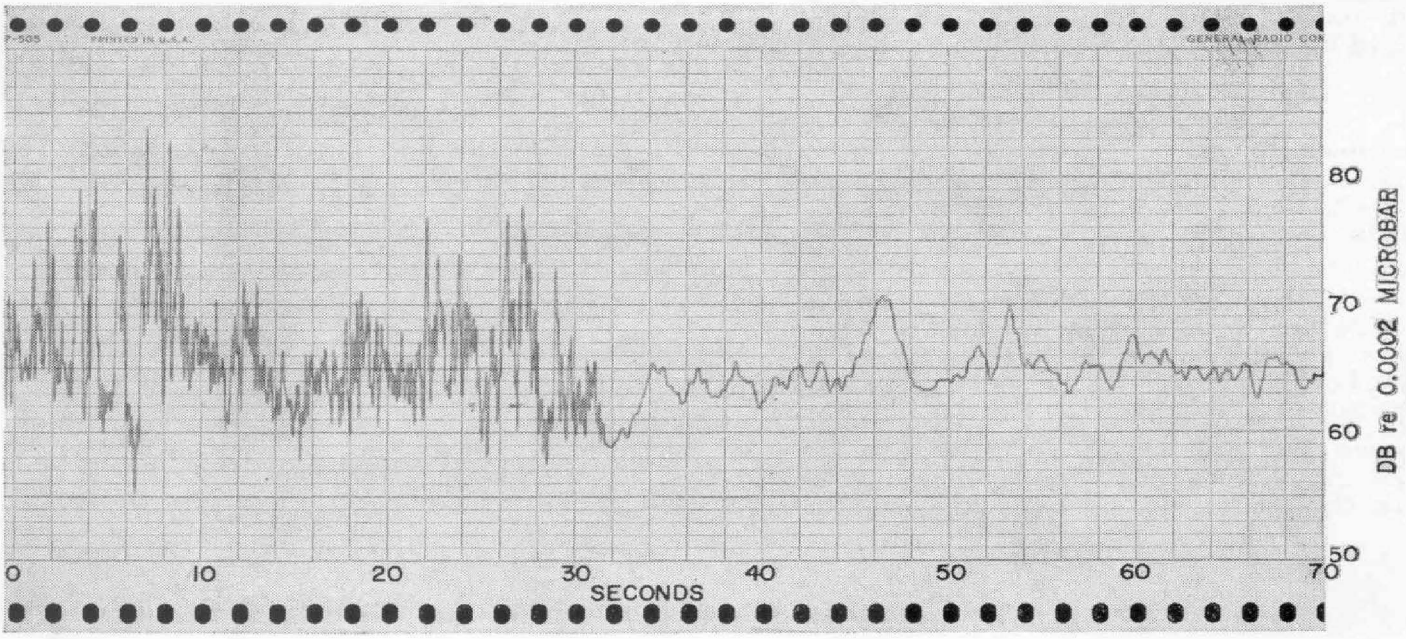

**Figure 7. Block diagram of system for reverberation-time measurement with narrow-band noise source.**

hours to 480 hours with the -P20 or -P21 Motors. The recorder can be calibrated to read in absolute sound pressure level with the sound-level meter attenuator switch in the CAL position. A typical plot of noise in a cafeteria with the recorder on both fast and slow writing speed positions is shown in Figure 6.

A second application as a time-base recorder is in the measurement of reverberation time. Reverberation time is defined as the time required for a sound level to decay 60 db. In this measurement a sound source in a room is abruptly shut off and the decay of the sound level is recorded. The 80-db potentiometer often is used for these measurements, but, since background noise often prevents reverberation recording over even a 60-db range, the 40-db potentiometer may be equally useful.

The nature of the sound source used for these measurements may have some influence on the accuracy of the results. The use of a fixed-frequency source can result in errors in the measurement owing to standing waves set up in the room. These errors can be avoided to some extent if the oscillator frequency is varied slightly or warbled. A better solution is the use of a noise source and a narrow band filter. Figure 7 shows a diagram of such a setup using the TYPE 1390-A Random Noise Generator and the TYPE 1554-A Sound and Vibration Analyzer to feed a power amplifier and loudspeaker. The sound level is picked up by a TYPE 1551-B Sound-Level Meter and applied to the recorder. A wider dynamic range can be obtained if a second analyzer is used following the Sound-Level Meter. The maximum writing speed and chart speed should be used when making reverberation measurements. Reverberation time as small as 0.5 second can be measured adequately with this recorder. A typical reverberation measurement made in an auditorium is shown in Figure 8.

**Figure 6. Recording of noise level in a cafeteria with both fast and slow writing speeds and 40-db potentiometer.**



## Level vs. Frequency

The recorder can be used to plot directly frequency-response data of networks or systems in conjunction with the TYPE 1304-B Beat-Frequency Audio Generator. A TYPE 1521-P10 Drive Unit

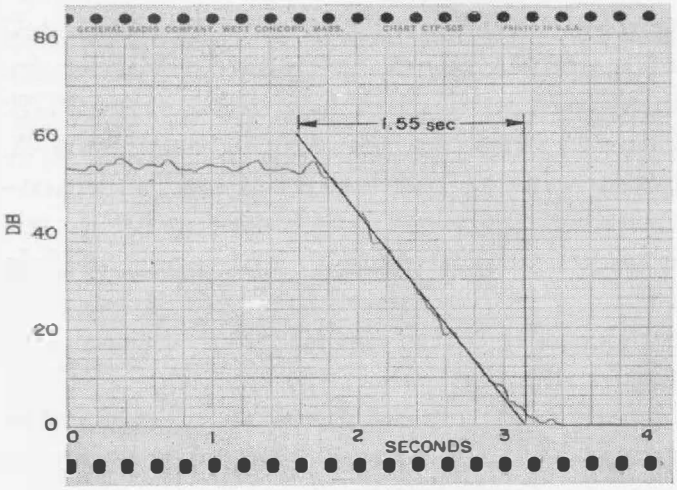



**Figure 8. Record of sound decay in an auditorium. Reverberation time is 1.55 seconds.**

and TYPE 1521-P11 Link Unit are required to couple the generator to the recorder. Since the change in frequency of the generator with respect to dial rotation is logarithmic, chart-paper motion will correspond to a logarithmic frequency change. Chart Paper CTP-501 has the logarithmic frequency calibration printed along the time axis over the three decades from 20 cps to 20 kc. The amplitude control of the generator and the input attenuator of the recorder can be used to obtain the desired 0-db reference level. If the input to the network or system under test must be maintained at some specified value, the 0-db reference level can then be adjusted by means of the input attenuator and "CAL" control on the recorder, provided that the minimum input signal to the recorder is 1 millivolt or greater. The chart paper and oscillator can be adjusted to the desired starting frequency by disengagement of the clutch on the drive unit. Figure 9 shows the generator-recorder combination.

This combination is ideal for measuring the frequency response of filters, attenuators, or other networks, as well as loudspeakers, microphones, or other transducers, and complete acoustic systems. A typical response of an adjustable notch filter is shown in Figure 10. The response of a condenser microphone mounted in an anechoic chamber is

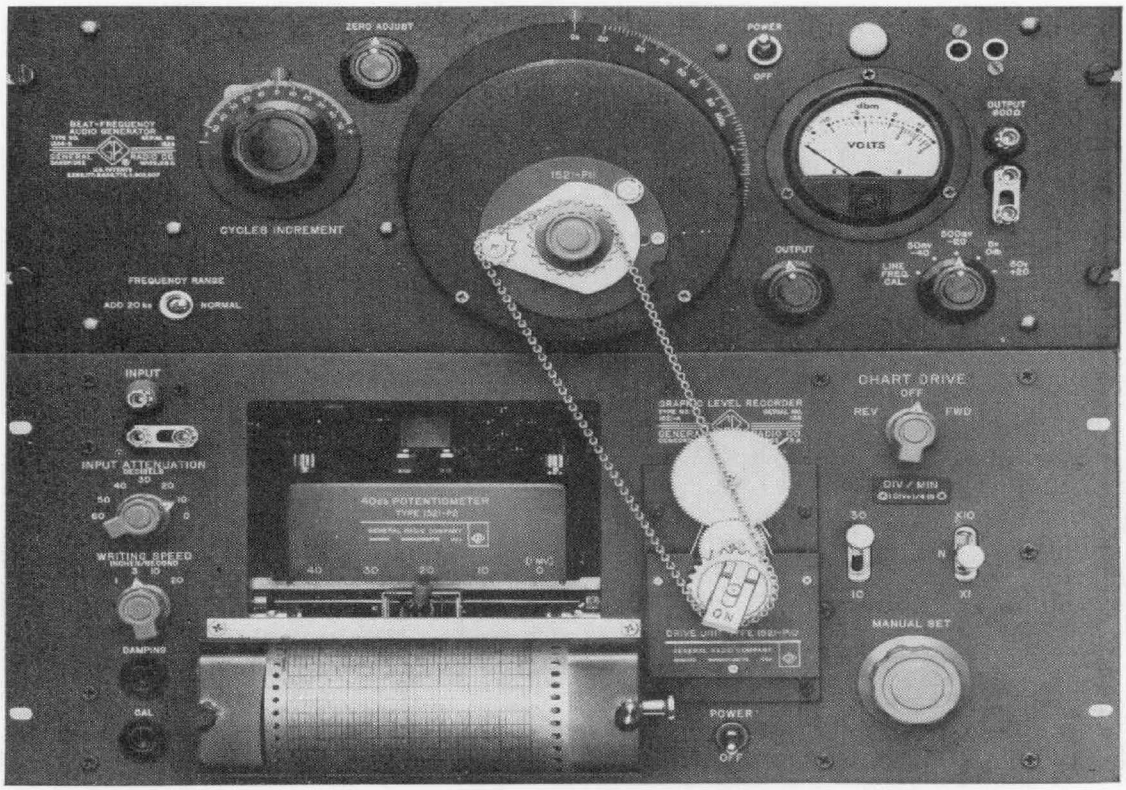



**Figure 9. View of the Graphic Level Recorder coupled to drive the Beat-Frequency Audio Generator for automatic recordings of amplitude vs. frequency.**

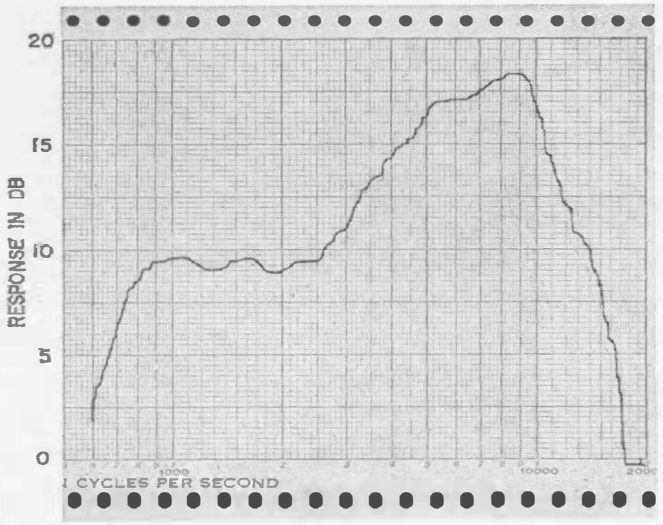



**Figure 11. Recorded response, for frequencies above 600 cycles, of a condenser microphone in an anechoic chamber. Plot includes the characteristics of the source.**

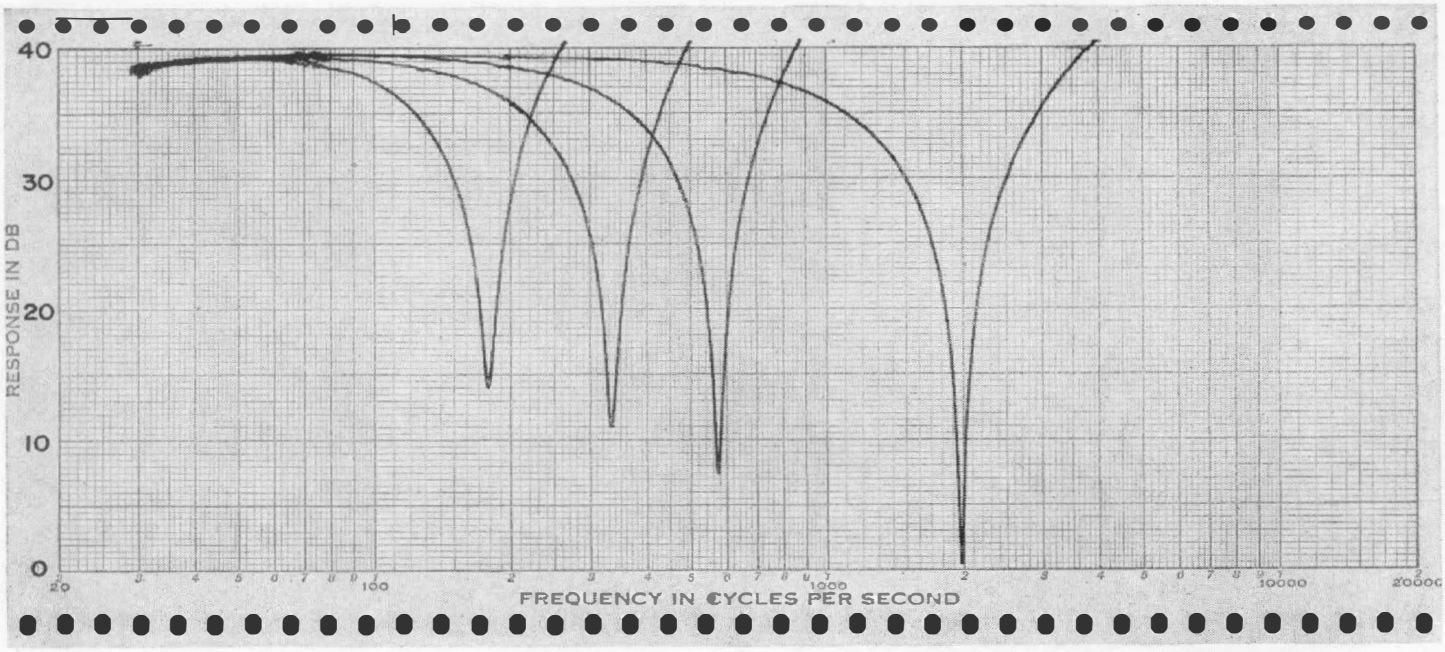
shown in Figure 11. The response of the public address system in an auditorium is shown in Figure 4.

The output voltage from the TYPE 1304-B Beat-Frequency Audio Generator is sufficiently constant with frequency (± .25 db) for most applications. In the calibration of a microphone where the sound source is a loudspeaker or where the device under test has a variable input impedance with frequency, it may be desirable to use a second TYPE 1521-A Graphic Level Recorder to maintain a constant sound pressure level or to vary the reference voltage to account for changes in the oscillator output voltage, as explained later.

## Frequency Analysis

A frequency analysis of a sound spectrum or the output of an electrical device can be made with the recorder in conjunction with either the TYPE 760-B Sound Analyzer or the TYPE 1554-A Sound and Vibration Analyzer. Connection between the analyzer and the recorder is made by the appropriate link unit in the same manner as with the audio generator. The chart paper for use with the analyzer (CTP-516) has three calibrated ½-decade segments properly spaced so a 2½-decade analysis can be made without stopping the recorder. The change in range can be accomplished during the blank portion of the dial. The TYPE 1554-A Analyzer does not have a continuously rotatable dial, and so the dial must be returned manually to the low end before the next range is plotted. However, the dial ranges are in 1-decade intervals, so that only three resettings are required to cover the range from 25 cps to 25,000 cps.

**Figure 10. Record of the transmission characteristic of an adjustable notch filter for four different frequency settings.**



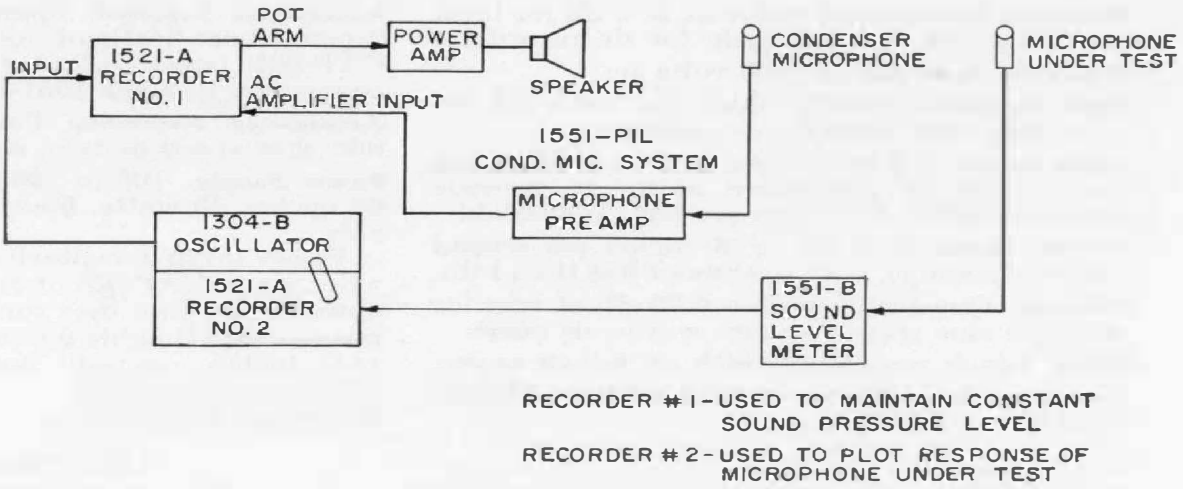



**Figure 12. Block diagram showing how two recorders can be used to maintain constant sound pressure level for the measurement of microphone characteristics.**

## Miscellaneous

The TYPE 1521-A Graphic Level Recorder can be used to maintain constant sound pressure levels in a chamber when the frequency response of microphones is measured. The block diagram in Figure 12 shows the equipment required for this operation. The normal connection between the arm of the potentiometer and the input to the ac amplifier is opened by removal of a jumper on the rear of the etched circuit. The arm of the potentiometer is connected to the input of the power amplifier driving the loudspeaker, and the output of the condenser microphone pre-amplifier is connected into the ac amplifier in the recorder. The recorder will automatically position the potentiometer arm to maintain a constant output level from the condenser microphone. The range over which this correction can be made is the same as that of the potentiometer in the recorder. As long as the recorder is on scale, the sound pressure level will be maintained constant (assuming a flat response for the condenser microphone). The regulating recorder will plot the response of the loudspeaker system. A second TYPE 1521-A Recorder is necessary to plot the frequency of the microphone under test.

Small variations in the output level of an oscillator used for frequency response measurements can be corrected for by the use of an external reference which is a function of the oscillator output level and which can be generated by an external detector. This can be substituted for the internal fixed reference by the removal of a jumper on the back of the etched circuit.

## Acknowledgments

The design of the TYPE 1521-A Recorder resulted from the combined efforts of a number of people. Particular credit should be given to James J. Faran, Martin Basch, P. K. McElroy, and George Neagle. D. B. Sinclair and Arnold Peterson supplied numerous suggestions and followed the development with considerable interest and enthusiasm.

— M. C. HOLTJE
M. J. FITZMORRIS

## SPECIFICATIONS

**Input Frequency Range:** 20 cps to 200 kc, for level recording; servo bandwidth, dc to 10 cps.

**Input Range:** 0 to 40 db for level recording (20-db and 80-db potentiometers are also available); 0-0.8 volt (at 1000 ohms) full scale, for dc recording with zero input position adjustable over full scale.

**Accuracy:** Potentiometer balances within 0.5% of full scale.

**Maximum Sensitivity:** 1 millivolt at 0 db for level recording; 0.8 volt full scale for dc recording.

**Maximum Input Voltage:** 100 volts ac.

**Input Impedance:** 10,000 ohms for ac level recorder; 1000 ohms for dc recorder.

**Paper Speeds:** 2.5 inches per minute to 75 inches per minute. A slow-speed motor to provide speeds of 2.5 to 75 inches per hour is available.

**Writing Speed:** 1, 3, 10, or 20 inches per second (approximately), with overshoot less than 1 db.

**Detector:** Quasi-rms; within 0.25 db of rms for multiple sine waves, square waves, or noise.

**Chart:** 4-inch recording width on 5-inch paper.

**Transistor Complement:** 12-2N169A, 4-2N321, 2-2N301, 1-2N176.

**Accessories Supplied:** Spare fuses, power cord, 2 pens, 2-oz. bottle of ink, 40-db pot, 1 roll of CTP-505 paper, adaptor cable assembly for connection to TYPE 1551-B Sound-Level Meter.

**Accessories Available:** Potentiometers, charts, ink, slow-speed motors, and link units.

**Power Supply:** 105 to 125 (or 210 to 250) volts, 60 cycles, 35 watts. 50-cycle models are available.

Power input receptacle will accept either 2-wire (TYPE CAP-35) or 3-wire (TYPE CAP-15) power cord. Two-wire cord is supplied.

**Dimensions:** (Height) 9 x (width) 19½ x (depth) 14¼ inches, over-all. Available for bench or relay-rack mounting.

**Net Weight:** 50 pounds.

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| 1521-AR | Relay-Rack Model, for 60-cycle supply | AGENT | $995.00 |
| 1521-AM | Bench Model, for 60-cycle supply | ASTER | 995.00 |
| 1521-ARQ1 | Relay-Rack Model, for 50-cycle supply | AGENTRABID | 995.00 |
| 1521-AMQ1 | Bench Model, for 50-cycle supply | ASTERRABID | 995.00 |

Patent No. 2,581,133.

**POTENTIOMETERS FOR OTHER RANGES**

| | | | |
|---|---|---|---|
| 1521-P1 | 20-db Potentiometer | FACET | $ 55.00 |
| 1521-P3 | 80-db Potentiometer | FELON | 155.00 |
| 1521-P4 | Linear Potentiometer, for dc recording | FAUNA | 55.00 |

**CHARTS**

| | | | |
|---|---|---|---|
| CTP-501 | Calibrated 20 cps-20 kc, logarithmic, in 9 inches, repeating every 12 inches along time axis; for use with Type 1304-B Beat-Frequency Oscillator | LOGARCHART | $2.30* |
| CTP-505 | Linear time base, 1 division = ¼ inch; for ac or dc records as a function of time | LINALCHART | 2.30* |
| CTP-516 | Calibrated 25-7500 cps in ½-decade segments, spaced for continuous rotation of analyzer knob; for use with Type 760-B Sound Analyzer | SOUNDCHART | 2.30* |
| CTP-554 | Calibrated 25-25,000 cps along time axis; for use with Type 1554-A Sound and Vibration Analyzer | ANNALCHART | 2.30* |

Charts are 5 inches wide and have 8 major divisions on a 4-inch vertical scale with 40 total divisions (80 on CTP-501). Roll length 100 feet. All may be used with any potentiometer.

**INK (red)**

| | | | |
|---|---|---|---|
| 1521-409 | 2-ounce bottle | INKAL | $0.85* |
| 1521-409-2 | 16-ounce bottle | INKER | 3.00* |

*Subject to quantity discounts.

**MOTORS FOR LOWER CHART SPEED**

| | | | |
|---|---|---|---|
| 1521-P20 | (60 cycles) for paper speeds of 2.5-75 inches/hour | PASTY | $52.50 |
| 1521-P22 | (50 cycles) for paper speeds of 2.5-75 inches/hour | PERIL | 52.50 |

**DRIVE AND LINK UNITS FOR COUPLING TO OSCILLATOR AND ANALYZERS**

| | | | |
|---|---|---|---|
| 1521-P10 | Drive Unit to operate all link units | PUPIL | $72.00 |
| 1521-P11 | Link Unit for coupling to Type 1304-B or Type 1554-A | PRIOR | 18.00 |
| 1521-P12 | Link Unit for coupling to Type 760-B | PUPPY | 18.00 |

General Radio Company

PRINTED IN U.S.A.