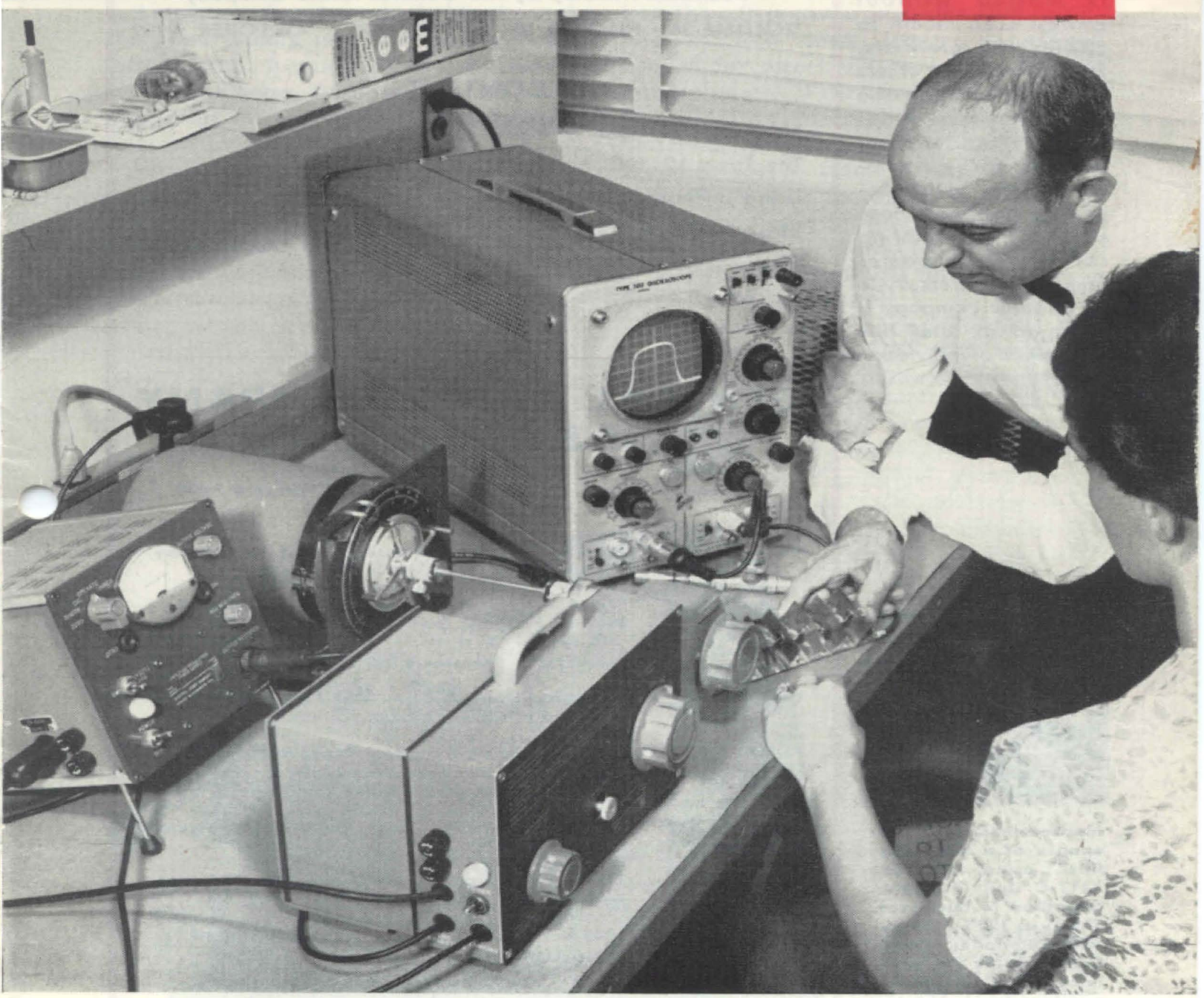
THE GENERAL RADIO EXPERIMENTER



VOLUME 36 No. 10 OCTOBER, 1962

IN THIS ISSUE

New

Octave-Band Analyzer
Unit Oscillator
Photoelectric Pickoff

THE GENERAL RADIO

EXPERIMENTER

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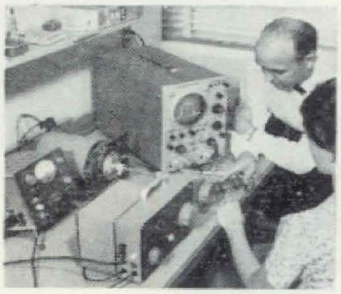

Measurement of the response of a band-pass filter, using the Type 1211-C Unit Oscillator, described in this issue. The Type 1263-B Amplitude-Regulating Power Supply holds the oscillator output voltage at a constant level. The test frequency is swept by means of the Type 1750-A Sweep Drive to produce the response curve on an oscilloscope screen.

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NEW, COMPACT, OCTAVE-BAND ANALYZER

OPERATES DIRECTLY FROM PIEZOELECTRIC MICROPHONE

An octave-band analysis has become the most widely used method of determining the frequency distribution of acoustical noise, because it yields, with minimum effort, sufficient information to solve most noise problems.

Most octave-band filter sets are fairly cumbersome and operate from the output of a sound-level meter, which serves as an acoustic pickup and high-impedance preamplifier. In field applications this arrangement is often inconvenient, owing to the necessity of handling two instruments. The new TYPE 1558 Octave-Band Noise Analyzer, weighing less than 9 pounds, includes the amplification and high input impedance needed for direct use with piezoelectric microphones. With its accessory TYPE 1560-P4 PZT Microphone Assembly, it indicates directly octave-band sound-pressure levels from 44 to 150 db *re* 2×10^{-4} μbar, a range that is adequate for the majority of uses. When the analyzer is operated from the output of a sound-level meter, however, lower levels can be measured.

The new analyzer is available in two models. The TYPE 1558-A is designed to meet the requirements of the current

Figure 1. View of the Type 1558-A Octave-Band Noise Analyzer with the Type 1560-P4 PZT Microphone Assembly.

ASA Specification for octave-band filter sets (Z24.10 1953) in all respects. The TYPE 1558-AP has bands centered at the ASA preferred frequencies for acoustical measurements (S1.6-1960).[1] Ten one-octave bands are included in each model together with an all-pass, or flat, characteristic. In addition, the A-model has a low-pass filter at 75 cps.

The electrical circuits are designed to reduce extraneous signals. Microphonics are held at a minimum through the use of transistors, rather than vacuum tubes, and pickup from external magnetic fields is avoided by RC-active filters, which contain no inductors.

The TYPE 1558 Octave-Band Noise Analyzer has a built-in, feedback-type calibration system for a simple check of the over-all electrical system. A dial setting renders the instrument direct reading in db *re* 2×10^{-4} μbar for piezoelectric microphones ranging in sensitivity from -52 to -62 db *re* one volt/μbar. Power is supplied by rechargeable nickel-cadmium batteries.

The analyzer joins the growing family of GR instruments packaged in the flip-tilt cabinet.

USES

Speech-Interference Level

The reactions of individuals to noise depend on many factors. Among these is the amplitude-frequency characteristic of the noise. It is well known, for example, that high sound-pressure levels in the octave bands 600–1200, 1200–2400, and 2400–4800 cps interfere with speech communication. The average of the band levels in db for these three bands is called speech-interference level, and for satisfactory intelligibility of difficult speech material this level should not exceed the values given in Table 1. Where speech cannot be heard, not only does efficiency suffer, but the danger of accidents is increased because shouted warnings may not be understood.

[1]Also specified by ISO Recommendation 402 and German Standard DIN45-401.

TABLE 1.

Speech-Interference Levels (db)

Distance (Feet)	Voice Level			
	Normal	Raised	Very Loud	Shouting
0.5	71	77	83	89
1	65	71	77	83
2	59	65	71	77
3	55	61	67	73
4	53	59	65	71
5	51	57	63	69
6	49	55	61	67
12	43	49	55	61
24	37	43	49	55

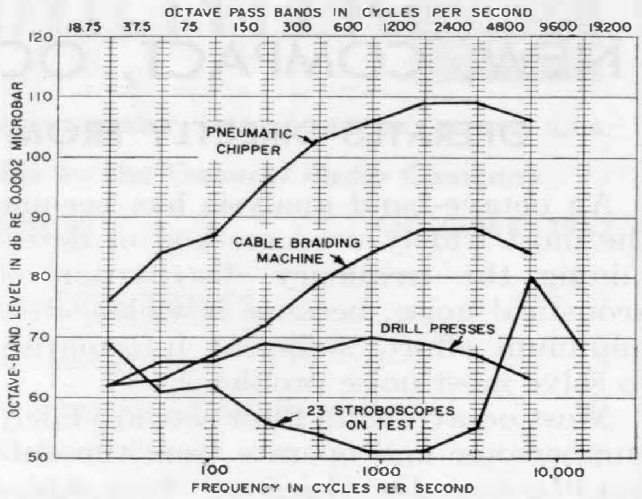


Figure 2. Typical octave-band pressure levels encountered in industry.

Hearing-Damage Risk

The TYPE 1558 Octave-Band Noise Analyzer is particularly suitable for determining the probability of hearing loss due to noise exposure. The noise spectra produced by several industrial activities are shown in Figure 2. While there are no standard methods for assessing the possibility of hearing damage in terms of octave-band analyses, it is generally accepted that the octave-band pressure level in any of the bands from 300 to 4800 cps should not exceed 85 db for daily exposure over a period of years. Thus, ear protection was prescribed for operators of the pneumatic chipper and cable-braiding machine of Figure 2.

Many organizations conduct periodic hearing tests and maintain records of noise exposure of their employees. Such a program is recommended wherever employees are exposed to high-level noise. A guide to recommended procedures is available.[2]

Office Noise

Difficulty in hearing speech can result in poor office efficiency. An octave-band analysis taken in an office allows the noise to be rated by use of a noise-criterion (NC) rating. Like speech-interference level, an NC level attempts to evaluate the noise environment by a single number. Figure 3 and Table 2

[2] "A Guide for Conservation of Hearing in Industry," Subcommittee on Noise of the Committee on Conservation of Hearing, American Academy of Ophthalmology and Otolaryngology. Available from the Research Center, Subcommittee on Noise of the American Academy of Ophthalmology and Otolaryngology, 327 S. Alvarado Street, Los Angeles 57, California.

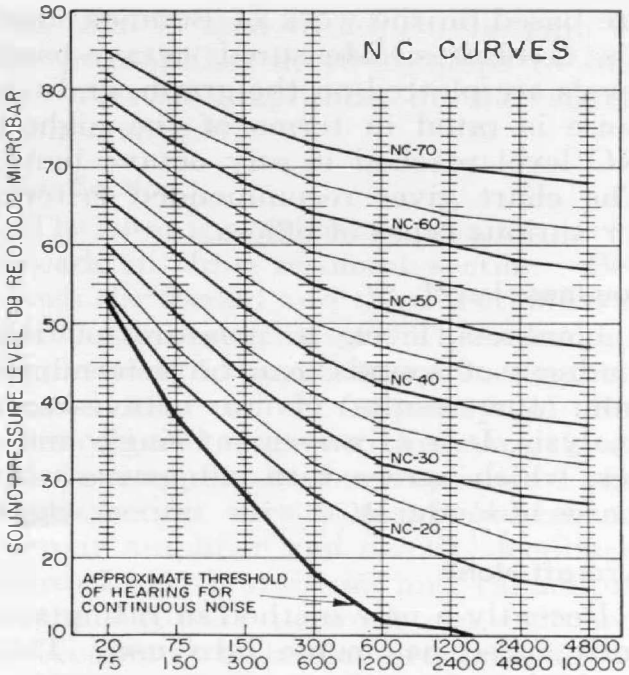


Figure 3. Curves for use with Table 2 in determining the permissible sound-pressure levels in eight octave bands.

TABLE 2. RECOMMENDED NOISE CRITERIA FOR OFFICES

Noise measurements made for the purpose of judging the satisfactoriness of the noise in an office by comparison with these criteria should be performed with the office in normal operation, but with no one talking at the particular desk or conference table where speech communication is desired (i.e., where the measurement is being made). Background noise with the office unoccupied should be lower, say by 5 to 10 units.

NC Curve of Figure 3	Communication Environment	Typical Applications
NC-20 to NC-30	Very quiet office — telephone use satisfactory — suitable for large conferences.	Executive offices and conference rooms for 50 people.
NC-30 to NC-35	"Quiet" office; satisfactory for conferences at a 15-ft table; normal voice 10 to 30 ft; telephone use satisfactory.	Private or semi-private offices, reception rooms, and small conference rooms for 20 people.
NC-35 to NC-40	Satisfactory for conferences at a 6- to 8-ft table; telephone use satisfactory; normal voice 6 to 12 ft.	Medium-sized offices and industrial business offices.
NC-40 to NC-50	Satisfactory for conferences at a 4- to 5-ft table; telephone use occasionally slightly difficult; normal voice 3 to 6 ft; raised voice 6 to 12 ft.	Large engineering and drafting rooms, etc.
NC-50 to NC-55	Unsatisfactory for conferences of more than two or three people; telephone use slightly difficult; normal voice 1 to 2 ft; raised voice 3 to 6 ft.	Secretarial areas (typing), accounting areas (business machines), blueprint rooms, etc.
Above NC-55	"Very noisy"; office environment unsatisfactory; telephone use difficult.	Not recommended for any type of office.

are based on the work of Beranek[3] and his associates. Measured octave-band levels are plotted on the graph, and the noise is rated in terms of the highest NC level reached in any octave band. The chart gives recommended criteria for various types of offices.

Loudness Level

Loudness level, a measure of the loudness of sounds, can be determined from the results of an octave-band analysis. It is a convenient single number, which agrees with subjective estimates of loudness.

Aircraft Noise

Recently a new method of rating aircraft noise has come into use.[4] This method rates the annoyance value rather than the loudness of a sound. The octave-band levels are weighted in a manner to give good correlation with listener judgment of the "noisiness" of both reciprocating-engine and jet aircraft as they pass overhead.

Vehicle Noise

Vehicle noise, especially truck noise, has become a serious problem on city streets and in residential areas. Some work has been done by truck manufacturers to ameliorate this situation, and there is now in effect an Automobile Manufacturers Association Specification which requires that noise levels be measured with an octave-band noise analyzer.

Vibration

Although the trend in vibration analysis is toward the use of an analyzer with narrower bands, such as the General Radio TYPE 1554-A Sound and Vibration Analyzer,[5] the TYPE 1558 Octave-Band Noise Analyzer with its low-frequency octave bands may also be found useful. The high input impedance of the octave-band noise analyzer permits direct connection of a piezoelectric vibration pickup.

Acoustical Characteristics of Structures

The sound transmission loss of walls, partitions, and floors can be determined with the octave-band noise analyzer and a wide-band sound source such as the General Radio TYPE 1390-B Random-Noise Generator.[6]

[3] Leo L. Beranek, "Criteria for Noise in Buildings," *Noise Control*, Vol 3, No. 1, pp 19-27, January, 1957.

[4] K. D. Kryter, "Scaling Human Reactions to the Sound from Aircraft," *Journal of the Acoustical Society of America*, Vol 31, Number 11, pp 1415 to 1429, November, 1959.

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

[6] A. P. G. Peterson, "A New Generator of Random Electrical Noise," *General Radio Experimenter*, 34, 1, January, 1960.

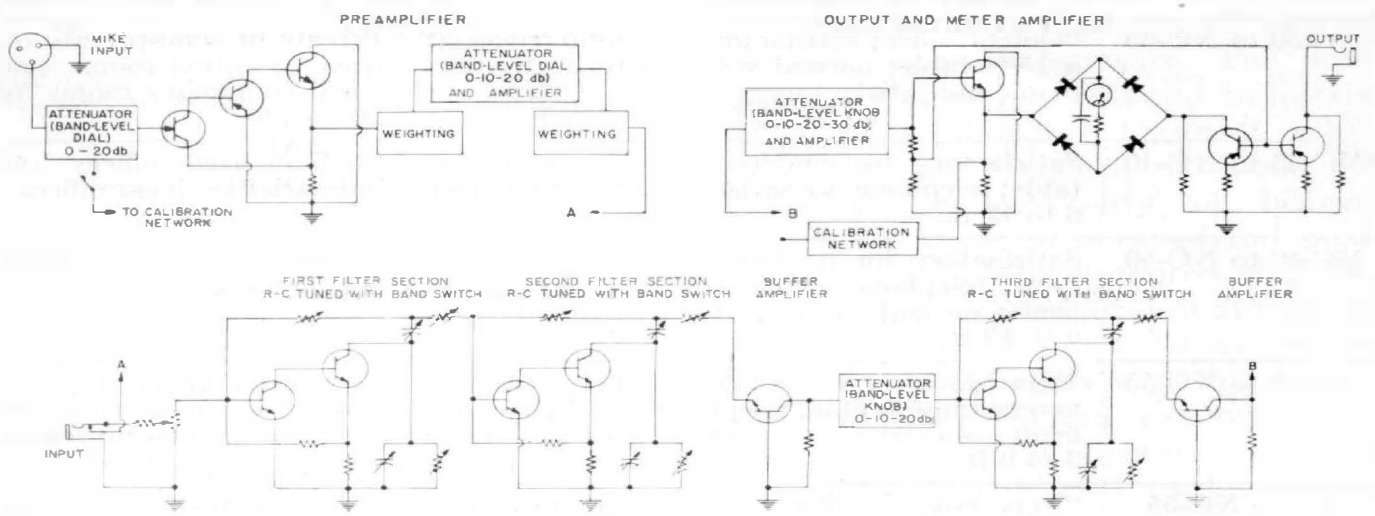


Figure 4. Schematic diagram of the Octave-Band Noise Analyzer.

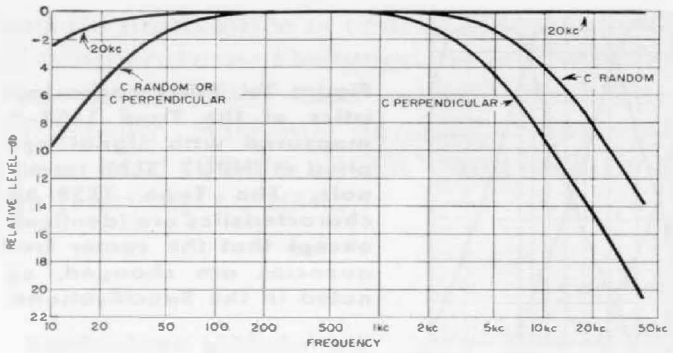


Figure 5. Frequency response characteristics of the preamplifier.

Non-Acoustical Uses

The TYPE 1558 Octave-Band Noise Analyzer can be used for purposes other than acoustical noise analysis. It is useful for measuring the electrical noise spectra generated by amplifiers, tape recorders, and other electronic devices. It can also function as a tuned voltmeter or a selective amplifier.

CIRCUIT

The TYPE 1558 Octave-Band Noise Analyzer consists of a high-impedance microphone preamplifier, a tunable filter having a noise bandwidth of one octave, an output amplifier, and a level indicator. An elementary schematic diagram is shown in Figure 4.

Preamplifier Section

The preamplifier section includes an input attenuator, a high-input-impedance, unity-gain amplifier, a weighting network, and a second attenuator and amplifier. It has a maximum mid-frequency voltage gain of 20 db, and its amplitude-frequency characteristic can be set by means of an internal switch to be either essentially flat from 20 cps to 20 kc or C-weighted (see Figure 5). Both attenuators in this section are controlled by the large outer dial of the coaxial BAND LEVEL control. This dial is used to adjust the gain of the preamplifier in 10-db steps to suit the over-all amplitude of the signal being analyzed.

Filter Section

The filter is synthesized as an isolated cascade of three resonant sections. Between the second and third sections is a 20-db step attenuator. The resonant frequencies of the sections are staggered around the center frequency of the selected band to give a Butterworth, or "maximally flat," characteristic. Each filter section uses a highly stabilized current amplifier and an RC feedback network. Both resistors and capacitors in the feedback network are switched in a manner which allows each capacitor set to be used for two bands. Figure 6 is a functional diagram of a single section.

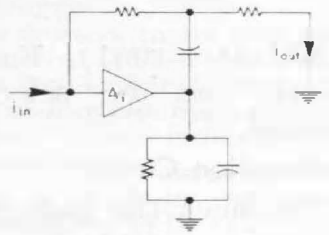


Figure 6. Functional diagram of a single section of the filter.

Figure 7 shows the band-pass characteristic of the filters in the -A model. The -AP model has identical characteristics, but different center frequencies.

Output Amplifier and Meter Section

The output amplifier section consists of a 30-db step attenuator, an amplifier, a detector, and a meter. An isolating stage for the output terminals prevents any load from affecting the meter indication. The detector characteristic is 'quasi-rms[7] so that the meter indication is very closely rms for most types of signals.

The meter is identical to the one used in the TYPE 1551-C Sound-Level Meter[8] and therefore has the dynamic characteristics specified by ASA Specification for General Purpose Sound Level Meters

[7]E. E. Gross, "Improved Performance Plus a New Look for the Sound-Level Meter," *General Radio Experimenter*, 32, 10, October, 1958.

[8]E. E. Gross, "TYPE 1551-C Sound-Level Meter," *General Radio Experimenter*, 35, 8, August, 1961.

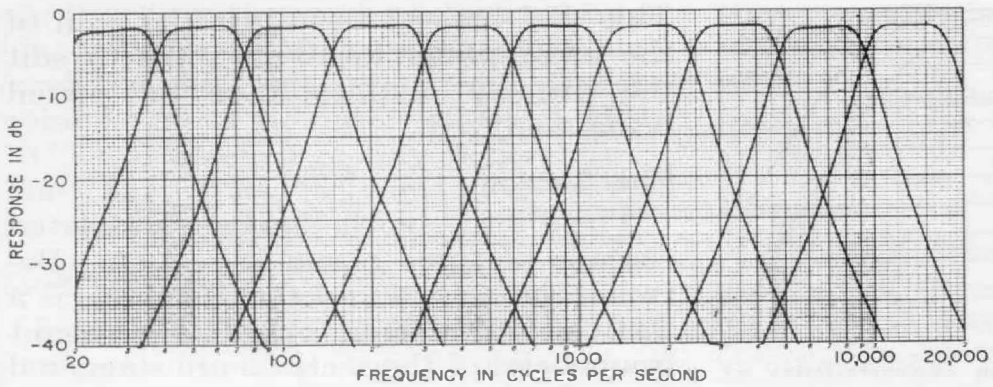


Figure 7a. Filter characteristics of the Type 1558-A measured with signal applied at INPUT (SLM) terminals. The Type 1558-AP characteristics are identical, except that the center frequencies are changed, as noted in the Specifications.

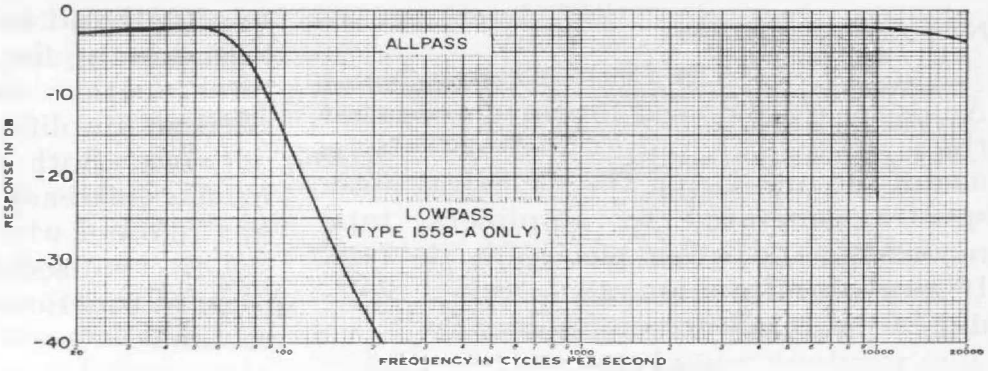


Figure 7b. Lowpass and allpass characteristics of the Analyzer.

(ASA S1.4-1961). Fast or slow meter speeds can be selected by a panel control.

Calibration Circuit

To check the gain of the analyzer, its output is switched to its input through a filter limiter and calibrated attenuator. When the gain is adjusted to equal the known attenuation of this feedback network, the system oscillates. The attenuation of the feedback network is adjustable by means of an internal control, which is calibrated in terms of microphone sensitivity.

Charging Circuit

The battery, a sealed nickel-cadmium unit, is charged through a simple half-wave rectifier and series resistor, which connect directly to the power line. During the charge period, the battery floats on the line. Neither side of the line is connected to the case nor to any other part of the instrument except the charging circuit.

[8]Ibid.

TYPE 1560-P4 PZT MICROPHONE ASSEMBLY

The TYPE 1560-P4 PZT Microphone Assembly was designed for use with the TYPE 1558 Octave-Band Noise Analyzer. The microphone is a PZT piezoelectric ceramic type, identical to that supplied with the TYPE 1551-C Sound-Level Meter and described in detail in a previous article.[8]

As shown in Figure 8, the frequency response of this microphone to sounds of random incidence is virtually flat to 8 kc. Its temperature coefficient of sensitivity is very low (−0.01 db/°C)

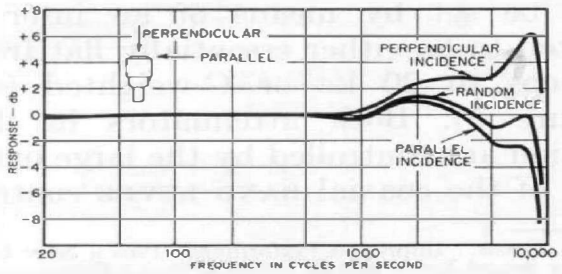


Figure 8. Response of the Type 1560-P4 PZT Microphone Assembly.

and its impedance is nearly independent of temperature. Designed to be durable and dependable, this microphone will withstand, without damage, temperatures of −30 to +95C and relative humidity up to 100%.

The microphone is mounted on one end of a flexible conduit. A detented swivel connector on the other end of the conduit plugs into a receptacle on the panel of the instrument.

— W. R. KUNDERT

SPECIFICATIONS

Bands: Type 1558-A

Lower Cutoff Frequency - cps	*Upper Cutoff Frequency - cps*	*Center Frequency*- cps*
18.75	37.5	26.5
37.5	75.0	53.0
75.0	150	106
150	300	212
300	600	424
600	1200	848
1200	2400	1696
2400	4800	3392
4800	9600	6784
9600	19,200	13,570
LP	75	
ALL PASS		

*Geometric Mean

For Type 1558-AP center frequencies are 31.5, 63, 125, 250, 500, 1000, 2000, 4000, 8000, 16,000.

Filter Characteristics*: Level at center frequency in bands from 37.5 to 9600 cps is uniform within 1 db. Maximum deviation from ALL PASS level at center frequency in any band is 1 db. For bands from 37.5 to 9600 response at nominal cutoff frequency is (3.5 ± 1) db below response at center frequency. Attenuation is at least 30 db at one-half the lower nominal cutoff frequency and twice the upper nominal cutoff frequency for all octave bands. Attenuation is at least 50 db at one-fourth the lower nominal cutoff frequency and four times the upper nominal cutoff frequency for all octave bands. The 75-cycle low-pass filter has at least 30-db attenuation at 200 cps and at least 50-db attenuation at 400 cps.

Sound-Pressure Level Range: 44 to 150 db above 0.0002 μbar in any band when the TYPE 1560-P4 PZT Microphone Assembly is used.

Inputs: Impedance at MIKE terminals is approximately 50 pf in parallel with 50 MΩ. It is intended for use with high-impedance transducers.

Impedance at INPUT (SLM) terminals is approximately 100 kΩ. Maximum input is 3 volts. Low-input terminal is connected to case. This input is intended for connection to the output of a sound-level meter.

Preamplifier Frequency Characteristics: Two frequency characteristics are available. These are C-weighting, which is specified by the American Standards Association (ASA S1.4-1961 SLM), and 20 kc, an essentially flat response.

Outputs: Open-circuit output is at least 1 volt for full-scale meter indication. Output impedance is 6000 ohms. Any load can be connected across the OUTPUT terminals.

Meter Response: FAST or SLOW meter response is selected by panel control. These characteristics are as specified in the American Standard Specification for General Purpose Sound Level Meters, ASA S1.4-1961. Meter indication is closely rms for most waveforms.

Internal Calibration: A built-in reference allows the gain of the analyzer to be calibrated for use with piezoelectric microphones having sensitivities from −52 to −62 db *re* 1 v/μbar. The absolute accuracy for ALL PASS is then ensured within 1 db over a wide range of atmospheric conditions.

Batteries: Two 9.6-volt rechargeable nickel-cadmium batteries (Gould Type 9.6V/450B) give 30 hours operation. They are recharged by connection to a 115-v (or 230-v) 25- to 60-cycle power line. Full charge takes about 14 hours.

Accessories Supplied: Carrying strap, power cord, shielded cable assembly.

Accessories Available: TYPE 1560-P4 PZT Microphone Assembly.

Dimensions: Flip-tilt case: length 10¼, height 9¼, depth 7¼ inches (260 by 235 by 185 mm), over-all, including handle.

Net Weight: 8¾ pounds (4 kg).

*Measured with signal applied at INPUT (SLM) terminals.

Type		*Code Word*	*Price*
1558-A	**Octave-Band Noise Analyzer**	ABATE	**$725.00**
1558-AP	**Octave-Band Noise Analyzer**	ALARM	**725.00**
1560-P4	**PZT Microphone Assembly**	NAVAL	**80.00**

U.S. Patent Nos. 3,012,197; 2,966,257; and D187,740.

THE TYPE 1211-C, AN IMPROVED UNIT OSCILLATOR

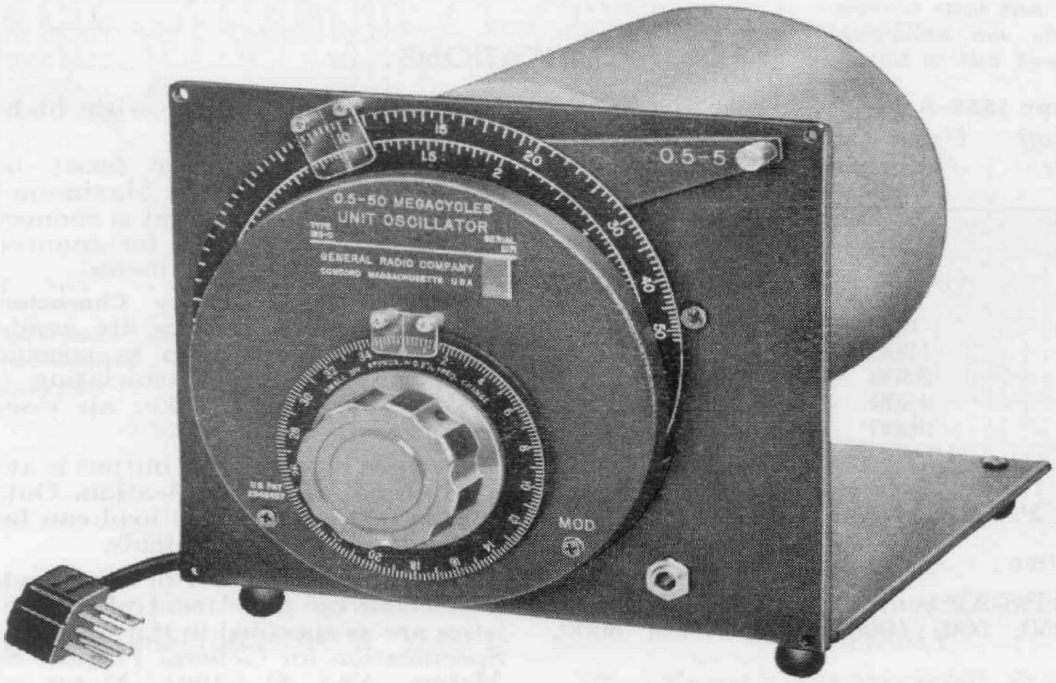


Figure 1. View of the Type 1211-C Unit Oscillator.

The TYPE 1211 Unit Oscillator,[1] 0.5 to 50 Mc, which was first announced in September, 1953, has now been modified as a first step in a program of Unit-Oscillator redesign which should make these popular rf power sources even more useful in the future. The characteristic L-shaped mounting panel of the Unit Oscillators and their open construction, which give excellent shielding and heat dissipation at a minimum price, have been retained, but the panel of the new oscillator, TYPE 1211-C, has been reduced to 7-inch height (four standard relay-rack units). Panel width is 8 inches, corresponding to one half relay-rack width, for mounting side by side in a relay rack with other GR half-rack instruments. Mounting in a relay rack is by means of simple, inexpensive adaptor panels (see Figure 2).

Frequency range, input power requirements, and output power remain es-

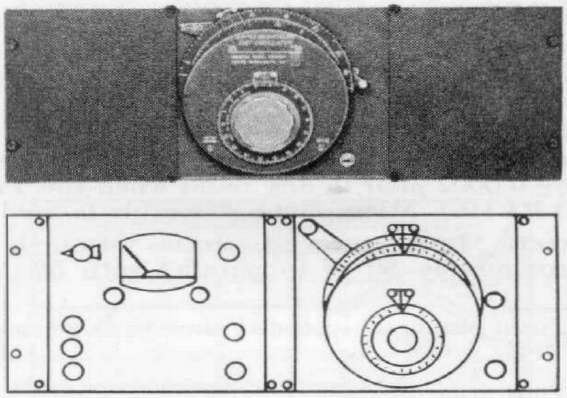


Figure 2. (*Top*) View of the oscillator with adaptor set installed for relay-rack mounting. (*Below*) Sketch showing arrangement of oscillator and amplitude-regulating power supply for relay-rack mounting.

[1] A. G. Bousquet, "A Unit Oscillator for the 0.5- to 50-Mc Range," *General Radio Experimenter*, 28, 4, September, 1953.

sentially unchanged, but distortion has been reduced considerably. The 100-to-1 frequency range of this oscillator is covered in two 10-to-1 ranges, 0.5 to 5 Mc and 5 to 50 Mc. The required 100-to-1 variation in the LC product on each range is obtained by changing the inductance as well as the capacitance of the tuned circuit. The capacitance is varied from 20 to 800 pf (40-to-1), and simultaneously the inductance value is altered by sickle-shaped cores, mounted on the capacitor shaft (see Figure 3). One core is made of aluminum, the other of iron dust. As the frequency dial is

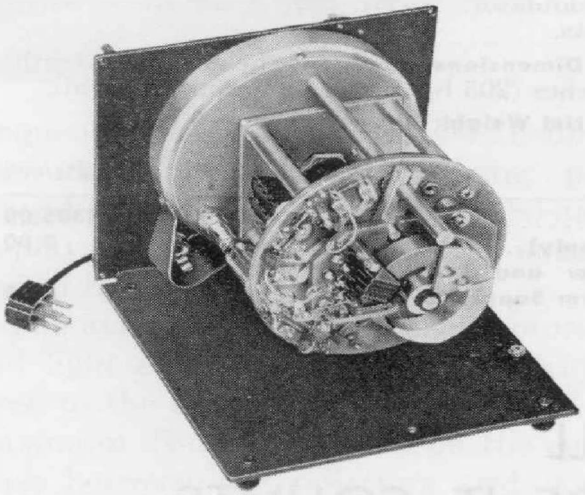


Figure 3. Rear view of the Unit Oscillator, with cover removed, showing tuned circuit inductors and sickle-shaped cores.

rotated, the active core material within the inductors varies smoothly from dust core for maximum inductance to a full aluminum core for minimum inductance. A 2.5-to-1 change in inductance is realized, from 125 to 50 μh for the 0.5- to 5-Mc range and from 1.25 to 0.5 μh for the 5- to 50-Mc range. The cores and the capacitor plates are shaped for logarithmic frequency change with angular rotation.

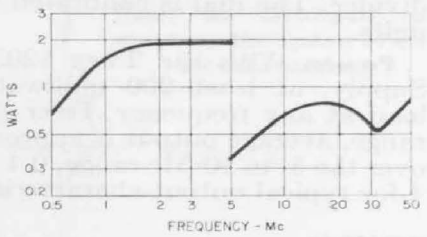


Figure 4. Typical output curves of the Type 1211-C Unit Oscillator.

Power output over the frequency range varies approximately as shown in Figure 4, when the inexpensive TYPE 1203-B Unit Power Supply is used. With the plate-regulated TYPE 1201-B Unit Regulated Power Supply, the output frequency as well as the output power is stabilized against line-voltage change, but output is reduced to about three quarters of that shown.

The frequency dial of the TYPE 1211-C Unit Oscillator can be swept back and forth mechanically by the TYPE 1750-A Sweep Drive,[2] the TYPE 908-P Synchronous Dial Drives, or the TYPE 908-R96 Dial Drive, and constant output over the frequency ranges can be obtained with the TYPE 1263-B Amplitude-Regulating Power Supply.[3] The combination of Unit Oscillator, Sweep or Dial Drive, and Amplitude-Regulating Power Supply is used for recording or for oscillographic display of frequency characteristics (see cover photograph). The TYPE 1263-B Amplitude-Regulating Power Supply will also be found useful for manual operation of the Unit Oscillator.

— E. KARPLUS

[2]W. F. Byers, "A New System for Automatic Data Display," *General Radio Experimenter*, 24, 11, April, 1955.

[3]W. F. Byers, "TYPE 1263-B Amplitude-Regulating Power Supply," *General Radio Experimenter*, 35, 9, September, 1961.

SPECIFICATIONS

FREQUENCY

Range: 0.5 to 50 Mc in two ranges.

Calibration Accuracy: ±2 percent at no load.

Warmup Drift: 0.4% ± 0.2%, largest at the high-frequency end of each range.

Controls: A two-position range switch, a six-inch dial with approximately logarithmic calibration, and a slow-motion dial to indicate frequency increments of 0.2 percent per dial division.

SPECIFICATIONS (Continued)

OUTPUT

System: Output available at a TYPE 874 Coaxial Connector (locking) at rear of instrument. Adjacent ground terminal also permits connection by TYPE 274-M Double Plug. Output is controlled by a 250-ohm resistive voltage divider. The dial is calibrated in 100 arbitrary units.

Power: With the TYPE 1203-B Unit Power Supply, at least 200 milliwatts into 50-ohm load at any frequency. Over the 0.5- to 5-Mc range, average output is approximately 1 watt; over the 5- to 50-Mc range, 0.4 watt. See Figure 4 for typical output characteristics.

GENERAL

Circuit: Hartley oscillator coupled directly to output. Capacitance and inductance are simultaneously changed for frequency variation.

Modulation: Plate modulation of 30% at audio frequencies can be produced by external source of 50 volts. Input impedance is about 8000 ohms. For amplitude modulation free from incidental fm, a TYPE 1000-P6 Crystal Diode Modulator can be used at carrier frequencies above 10 Mc.

Power Supply Requirements: 320 volts, 50 milliamperes, dc; 6.0 volts, 0.75 ampere, ac or dc. TYPE 1203-B Unit Power Supply, TYPE 1201-B Unit Regulated Power Supply, or TYPE 1263-B Amplitude-Regulating Power Supply is recommended.

Mounting: Oscillator on aluminum casting is shielded with a spun aluminum cover; assembly is mounted on an L-shaped panel and chassis. Adaptor panels for relay-rack mounting are available.

Accessories Supplied: TYPE 874-R22 Patch Cord, TYPE 874-Q2 Adaptor, telephone plug.

Other Accessories Available: TYPE 1750-A Sweep Drive, TYPE 908 Dial Drives, TYPE 874 Coaxial Elements, TYPE 1000-P6 Crystal Diode Modulator, TYPE 480 Relay-Rack Adaptor Sets.

Dimensions: Width 8, height 7½, depth 12 inches (205 by 192 by 305 mm), over-all.

Net Weight: 11½ pounds (5.5 kg).

Type		*Code Word*	*Price*
1211-C	**Unit Oscillator**	ATLAS	**$305.00**
480-P408	**Relay-rack Adaptor Set (for oscillator only)**	EXPANELJAG	**8.00**
480-P416	**Relay-rack Adaptor Set (for oscillator and Type 1263-B Amplitude-Regulating Power Supply)**	EXPANELNIT	**6.00**

U.S. Patent No. 2,548,457.

USING A PHOTOCELL WHERE IT COUNTS

For those wishing to measure the speed of rotating objects and to present the results as a continuous digital display, we recommend the combination of the new TYPE 1536-A Photoelectric Pickoff and the TYPE 1150-A Digital Frequency Meter.[1]

The pickoff consists of a light source, an optical system, a photocell, an output cable, and a flexible linkage system. Light from the source is reflected, either by the rotating object or by reflective tape attached to it, back to the photocell, which sends electrical pulses to the

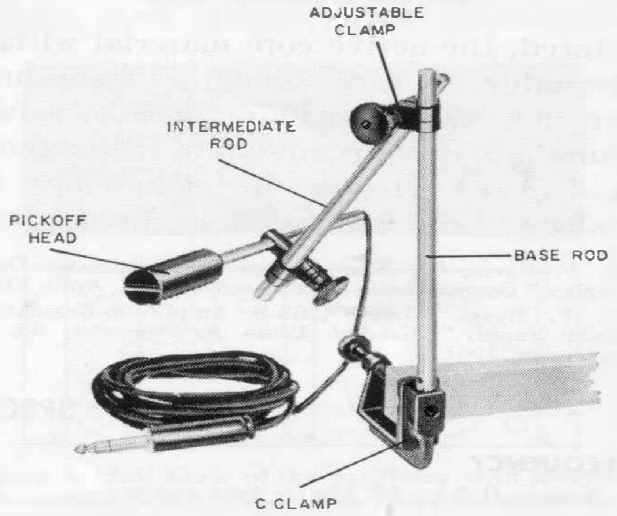


Figure 1. View of the Photoelectric Pickoff with component parts identified.

[1] R. W. Frank, J. K. Skilling, "A Five-Digit Solid-State Counter for Frequency Measurements to 220 kc," *General Radio Experimenter*, 36, 4, April, 1962.

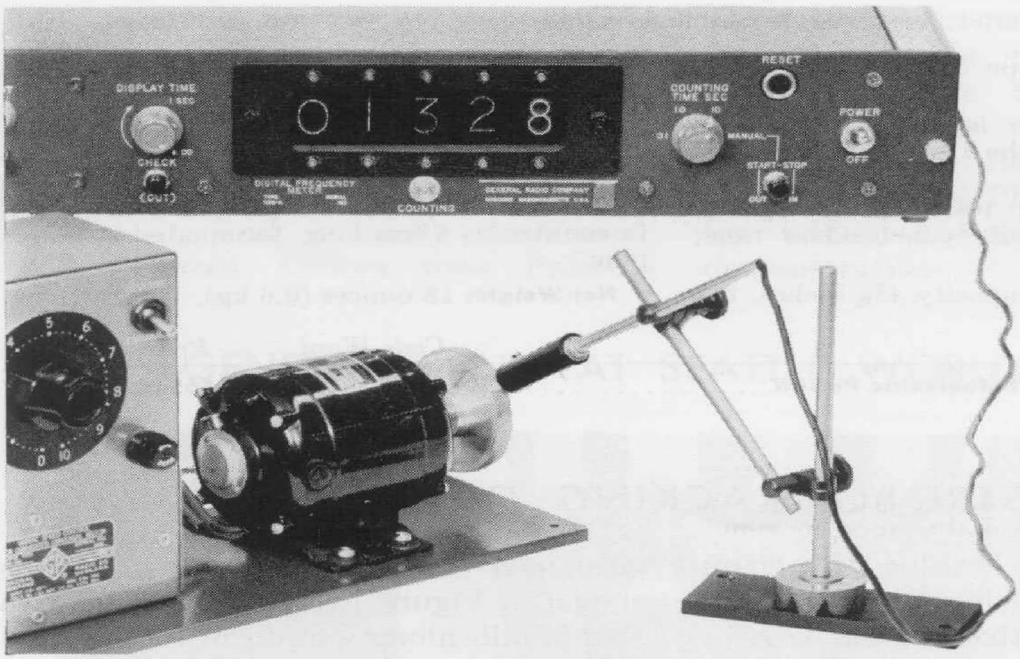


Figure 2. The Photoelectric Pickoff shown with the Type 1150-A Digital Frequency Meter (*top*), as arranged to measure the speed of an electric motor.

frequency meter. This instrument counts the number of pulses arriving per second (or 0.1 second or 10 seconds) and displays that number on an in-line digital readout.

The cylinder containing the photocell and light source must be placed fairly close to the object being observed. The maximum distance depends on the contrast between the reflective and nonreflective parts of the rotating object. The small size of the pickoff head and the double-jointed linkage assembly, mounted on either a C-clamp or a magnet (both supplied), permit the pickoff to be maneuvered close enough to out-of-the-way rotating parts.

With the counter set for a one-second gate (i.e., counting) period, the digital display will be in revolutions per second. For greater accuracy, the counting period can be set to 10 seconds, and the digital readout divided by 10. By obtaining more than one pulse per revolution (as, for instance, by attaching more than one reflecting strip to the rotating surface), one can increase the display possibilities: With six reflective strips and a 10-second counting period, the counter indicates rpm. If 60 strips can be attached, one can obtain a direct rpm statement once a second. As more strips are used, the pickoff must be placed nearer to the object.

Most machine speeds are well within the range of the pickoff-counter combination. The high-frequency limit of the counter is over 13 million rpm, so there is no problem from that quarter. The limiting factor is usually the capacitance of the cable connecting the pickoff to the counter. Under favorable conditions, speeds up to 100,000 rpm can be measured.

Two rolls of pressure-sensitive tape are supplied, one reflecting and one nonreflecting. The latter can be used with objects that are themselves highly reflective.

Uses of the TYPE 1536-A Photoelectric Pickoff cover almost all rotating machinery, but it is especially desirable for low-torque devices, to which mechanical contactors cannot be attached.

SPECIFICATIONS

Light Source: GE Type 327 bulb, 28 volts, 40 milliamperes.

Power Supply: Power is supplied for both lamp and photocell by the TYPE 1150-A Digital Frequency Meter.

Accessories Supplied: 10-ft roll of $\frac{3}{8}$-inch black tape; 10-ft roll of $\frac{3}{8}$-inch silver tape; carrying case.

Mounting: C-clamp (capacity $1\frac{5}{16}$ inches, flat or round) or $1\frac{1}{2}$-inch magnet, both supplied.

Dimensions: Pickoff head, $1\frac{1}{16}$-inch diameter, 2 inches long. Linkage consists of two $\frac{5}{16}$-inch-diameter stainless-steel rods, 6 and $6\frac{1}{4}$ inches long, connected by an adjustable clamp. Second clamp attaches pickoff assembly. Cable (pickoff to counter) is 8 feet long, terminated in phone plug.

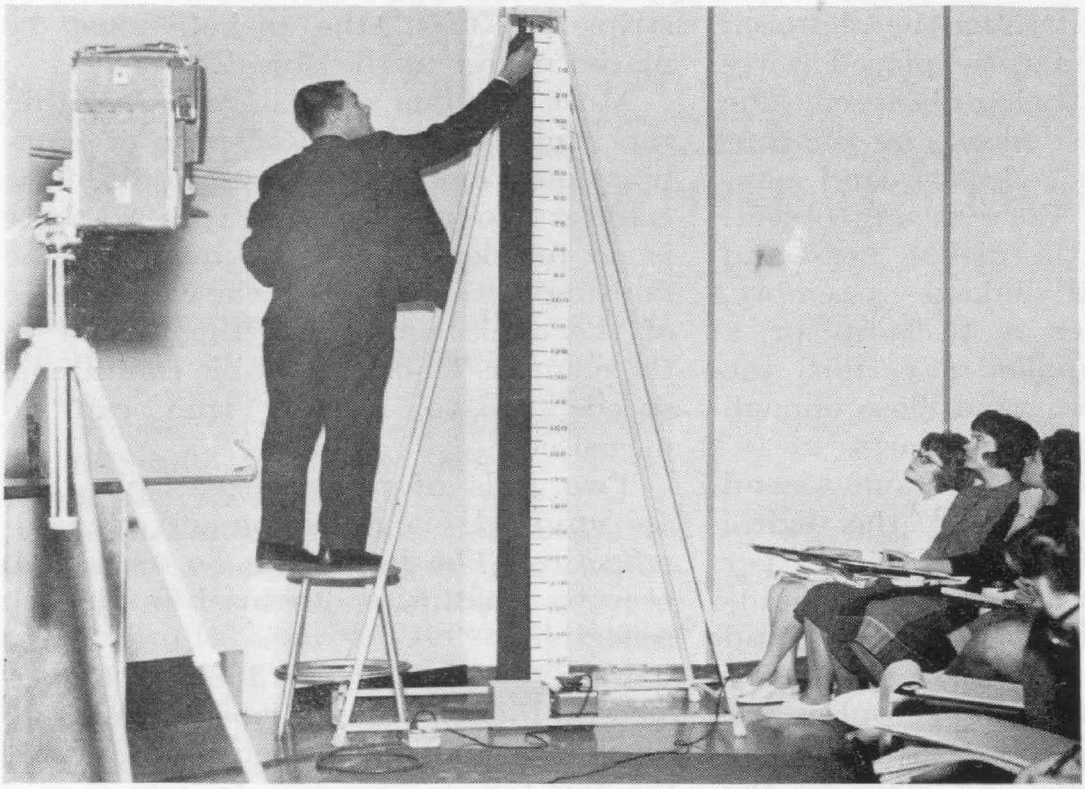
Net Weight: 18 ounces (0.6 kg).

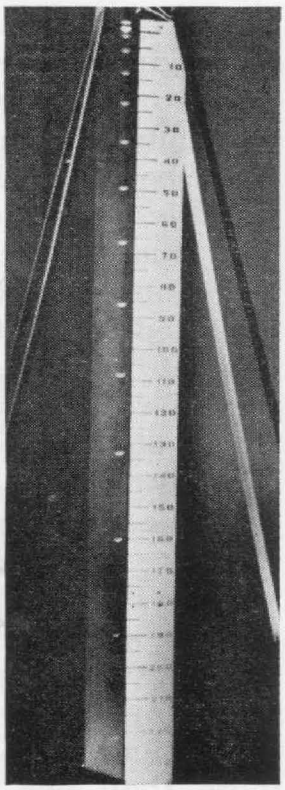
Type		*Code Word*	*Price*
1536-A	**Photoelectric Pickoff**.....	FOTOF	**$65.00**

STROBO-TRACKING GRAVITY

The constant acceleration of a freely falling object is nowhere more graphically demonstrated than at Los Angeles' Occidental College, where a TYPE 1531-A Strobotac® Electronic Stroboscope[1] is used in a classroom demonstration. As shown in Figure 1, a ball is dropped so that it falls along a uniformly calibrated scale. During its fall the ball is photographed by the light of the stroboscope, flashing at a constant rate. The result is the multiple-image photograph of Figure 2, in which the ball is shown at fixed

[1] M. J. Fitzmorris, C. J. Lahanas, and W. R. Thurston, "New Eyes for Modern Industry," *General Radio Experimenter*, 34, 9, September, 1960.





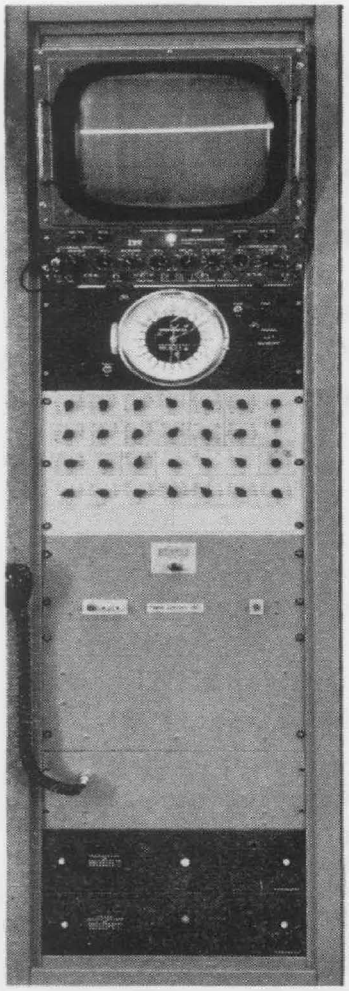
(*Left*) Figure 1. View of the classroom demonstration, with ball about to be dropped.
(*Right*) Figure 2. Photographic record of the travel of the ball.

time intervals on the way down. The widening gaps between images as the ball drops proves the rule of constant acceleration to even the most skeptical sophomore.

The setup at Occidental uses simple equipment, and is easily duplicated. The Polaroid camera uses Polaroid Type 46-L transparency film, and the transparency is projected for class analysis within two minutes after exposure.

Our thanks to Rex R. Nelson, Assistant Professor of Physics at Occidental, for telling us about his interesting demonstration.

GENERAL RADIO AT SEATTLE WORLD'S FAIR



(*Right*) Group of fairgoers listening attentively to the satellite-tracking demonstration. (*Left*) Close-up view of the center rack. The Syncronometer with its 24-hour clock face is near the top; the standard-frequency oscillator and frequency divider are at the base.

The accompanying photographs show the Transit Satellite Demonstration Tracking Station used in the U. S. Science Exhibit at the Seattle World's Fair. The frequency standard for the station is a General Radio TYPE 1113-A Standard-Frequency Oscillator, shown at the bottom of the center rack with its companion, the GR TYPE 1114-A Frequency Divider. A third member of

GR's frequency-measuring lineup, the TYPE 1103-B Syncronometer, is seen higher up in the same rack.

The 5-Mc output of the TYPE 1113-A is multiplied up into the UHF region for use as a local oscillator for precision doppler receivers. A multichannel tape recorder records satellite signals along with a 50-kc reference signal from a generator driven by the TYPE 1114-A Frequency Divider. The Syncronometer provides an accurate time display for audience and demonstrators, and serves as a time reference for recorded doppler data.

The satellite tracking demonstration is one of the most popular displays at the fair. The right-hand photograph shows a group of fairgoers paying earnest attention to a tracking demonstration. This demonstration was designed and built by the Applied Physics Laboratory at Johns Hopkins University.

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