THE General Radio EXPERIMENTER

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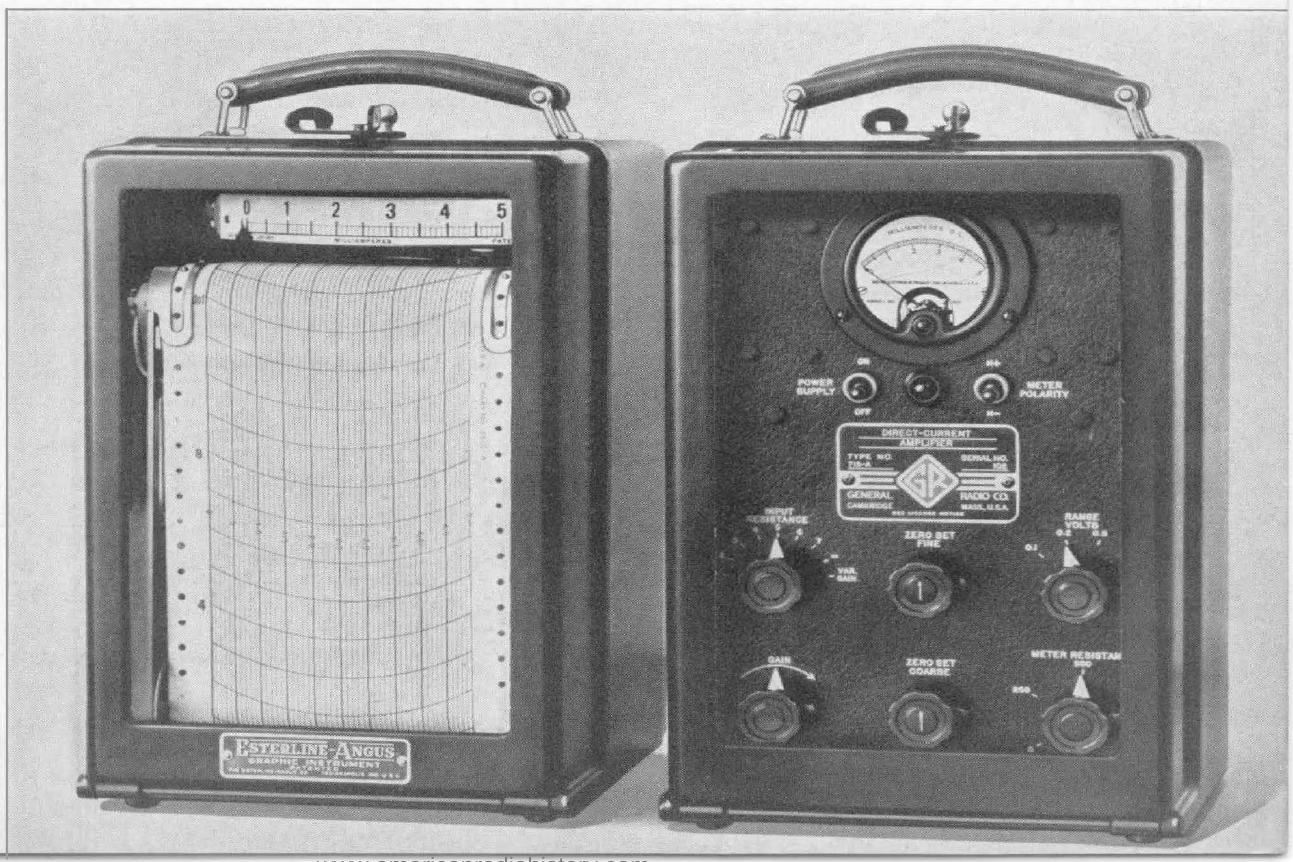
ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

Also IN THIS ISSUE

A-C OPERATED DIRECT-CURRENT AMPLIFIER FOR INDUSTRIAL USE

● **THE MAIN FUNCTION** of a direct-current amplifier is effectively to increase the sensitivity of direct-current indicating or recording instruments. Used with indicating instruments, it makes possible the use of rugged instruments for indicating small voltages and currents instead of the delicate, high sensitivity instruments which would otherwise be required. Recorders,

FIGURE 1. TYPE 715-A Direct-Current Amplifier and Esterline-Angus 5-milliampere recorder. The amplifier can be obtained in a case to match the recorder as shown here, or in a walnut cabinet as shown on page 3. A relay-rack mounting to hold both the amplifier and the recorder is also available.



because of the higher power required to operate them, cannot be used on weak currents and voltages without an amplifier. The amplifier, therefore, extends the use of these instruments to fields formerly beyond their scope, permitting continuous records of sound level, light intensity, frequency, and other phenomena easily converted to weak direct currents.

An additional use of the d-c amplifier is in automatic control circuits where, instead of being used to operate an indicating or recording instrument, the amplifier output actuates relays to control the original phenomenon or to perform some other function.

While "direct-coupled," "zero-frequency," or "direct-current" amplifiers are by no means new, various difficulties have previously prevented entirely satisfactory performance. Battery operation was once considered essential, and usually one set of heavy and expensive batteries was used for each tube. Such complications naturally limited the use of the equipment to applications where the desired results could be secured in no other way.

In the amplifier here described, operation from the alternating-current power line has been achieved with *no loss in stability* and with complete freedom from fluctuations due to line voltage variations within reasonable limits. Several features are incorporated involving principles and apparatus which have only become available in comparatively recent times. In particular, the use of degeneration, to stabilize the amplifier gain and to improve the linearity of response, and the use of voltage regulating transformers and tubes are important. Figure 2 is a schematic circuit diagram with power supply omitted.

The operation of the instrument is exceptionally simple, and for continuous recording it can be run for weeks without attention, except for a daily check of the zero adjustment which takes perhaps a half minute. The tubes will have a life expectancy of better than 3000 hours (120 days) when continuously used, and the deterioration of other parts is negligible.

One of the most important uses of the amplifier is in recording work. Full-scale output of the amplifier has, therefore, been made 5 milliamperes to operate an Esterline-Angus High-Sensitivity Graphic Instrument which requires 5 milliamperes for full-scale deflection. This output can be obtained for input voltages of 0.1, 0.2, 0.5, and 1.0 volt. A panel meter which is in series with the recorder indicates the output current in milliamperes.

The input resistance can be varied by powers of 10 between 100 ohms and 10 megohms, the operating value being selected by means of a panel switch. An open circuit position is also provided which connects the grid of the first tube directly to the input terminals; and, in addition, an input potentiometer with R-C smoothing filter can be switched in so that the input voltage can be adjusted to any desired value. The input resistance for this position is 150,000 ohms, approximately.

Although the instrument should be considered as a voltage operated device, its extreme sensitivity as a current amplifier should be noted. One-tenth of a volt input will give a full-scale deflection in the five-milliampere output circuit. A current of only 0.01 microampere passed through the 10-megohm input resistance will provide this one-tenth volt input.

(Continued on page 4)

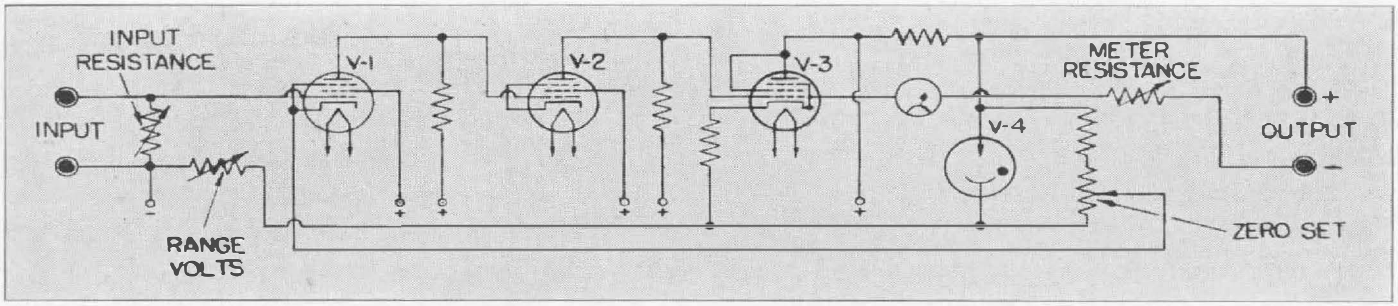


FIGURE 2. Schematic diagram of the TYPE 715-A Direct-Current Amplifier.

The amplifier consists of three stages in cascade, the first two being pentodes, the last a triode. For degeneration to be applied, it is necessary to have an odd number of phase reversals. The simplest arrangement is to use an odd number of amplifier stages. The total output current of the final stage is passed through a resistance placed in series with the cathode-grid circuit of the first tube. By adjustment of this resistance, the effective gain of the amplifier may be set at a desired value, which, when a specified voltage is applied to the input terminals, will result in the desired output current. This degeneration resistance is in the form of preadjusted resistors selected by the RANGE switch.

A bias control (ZERO SET) is provided whose normal setting would bring the output current to zero for zero input voltage. In some cases, however, use may be made of the adjustment as an offset zero, to cancel a portion, or all, of a steady input voltage so that the instrument responds to *changes* from this steady value.

In the schematic diagram, certain connections are indicated for supply voltages, but for simplicity the voltage dividers are not shown. Actually, the first two stages operate on individual voltage dividers giving a high degree of isolation from the common plate supply and, in particular, from the last stage.

The steady plate current of the output stage is removed from the output by the use of a bridge-type output circuit having a glow-tube regulator as one arm. A portion of the steady voltage across the glow tube is utilized for bias adjustment. No direct stabilization of the plate voltage supply is required. However, since an increase in plate voltage would result in some unbalance in the output bridge which is not entirely compensated by the increased bias applied through the degenerative resistance, a voltage proportional to plate voltage is fed into the first grid circuit in reverse phase. By factory adjustment of the magnitude of this voltage, compensation of plate voltage supply changes over a wide range is attained. (The network for this is not indicated in the schematic diagram.)

After the amplifier has been made stable in the ordinary sense, a new source of difficulty appears which would cause no trouble in amplifiers which are not direct-coupled. It can be shown that a temperature change of the cathode of the *first* tube is equivalent to a small change in bias. In an amplifier of the usual type no effect on performance would be observed, but in the direct-coupled amplifier an immediate change in output is noted, as a shift in the "zero" position of the output meter or recorder. To overcome this, it is necessary to stabilize carefully the operating voltage applied to the heater of the first tube. A ballast lamp has sufficient range of control to apparently give satisfactory results, but its large thermal lag renders it ineffective for rapid changes in heater supply voltage. Consequently a regulating transformer is used to overcome the effects of sudden changes, while the ballast lamp overcomes any residual slow variations. When properly adjusted, this combination gives a stable zero over a line voltage range of from 100 to 130 volts.

FIGURE 3. The TYPE 715-A Direct-Current Amplifier in walnut cabinet.

APPLICATIONS

A particular application, which was kept in mind during development of the amplifier, is that of recording the frequency indications of a Type 834-A Electronic Frequency Meter. By adjustment of the amplifier gain, full-scale readings on the recorder can be made to agree with full-scale readings of the frequency meter, for each range. By use of an offset zero in the amplifier an expanded record of *changes* in frequency over a portion of the normal range can be obtained. Since many quantities can be observed through frequency changes, this combination can be applied to many problems such as frequency drift in radio transmitters and crystal oscillators, and radio-meteorograph observations.

In conjunction with the Type 759-A Sound-Level Meter a continuous record can be made of average noise or sound levels over long periods of time. This is especially important in noise survey studies of offices, factories, broadcasting studios, and city streets.

Owing to the high input resistance of the amplifier, it can be used in the recording and measurement of hydrogen ion concentration with low-resistance electrodes.

Comparatively weak radio telegraph signals can be recorded on tape recorders by use of a small oxide rectifier (if a direct-current signal voltage is not otherwise available), the direct-current amplifier, and the recorder. In such applications the amplifier output can be utilized to operate relays, counters, or other devices as well as a signal recorder.

The direct-current amplifier and recorder can be operated directly from the output of a photronic cell. A number of applications are then possible, since the illumination of the photronic cell can be made to vary in accordance with such a large number of factors.

These include:

(a) Variations in daylight, as, for instance, in a manufacturing plant.

(b) Variations in artificial light brought about by dust or smoke in the air.

(c) Amount and duration of sunshine.

Since the amplifier and recorder actually constitute a calibrated recording voltmeter and, through the use of known input resistances, a recording milliammeter or microammeter, records of direct-current voltage or current variations can be obtained directly, opening up many applications where these observable quantities may be made responsive to many factors.

For some applications, the amplifier may serve in place of sensitive direct-current galvanometers. Using a one-megohm input resistance, the amplifier has a sensitivity of the order of 0.0004 microampere for one-fifth of a division on the meter scale, comparing with a good grade of galvanometer having a sensitivity of 0.0005 microampere per mm. at 1 meter. The indicating meter on the panel of the amplifier gives a high-speed response where the galvanometer has roughly a 10-second period.

A survey of the conditions of use should be made before the suitability of the amplifier to any given application can be established. Particular attention must be paid to the conditions of grounding and to voltages developed between the amplifier input terminals and ground. In applications involving rectified voltages or currents, attention must be given to the waveform of the input voltage, because of possible overloading on peaks on waveforms giving small average values. — J. K. Clapp

SPECIFICATIONS

Range: The instrument is provided with four calibrated ranges, selected by means of a switch, giving 5 milliamperes linear output in the recorder circuit of 1000 ohms, for input voltages of 0.1, 0.2, 0.5, and 1.0 volt applied at the input terminals with either polarity. The gain is best expressed as a transconductance; the maximum value is 50,000 micromhos.

Accuracy: As a calibrated voltmeter, the accuracy of calibration is approximately 1%, this accuracy being maintained over considerable periods of time.

Input Circuit: Means are provided for selecting any one of a number of input resistances, so that the instrument not only has an adjustable input resistance, but can serve as a calibrated millivoltmeter or microammeter. The input resistances range in powers of 10 from 100 ohms to 10 megohms. Short-circuit and open-circuit positions are also supplied on the selector switch.

For those applications where relative values only are of interest and where the voltage available exceeds 1 volt, one of the switch positions connects the input to a variable gain control, so that the voltage applied to the first grid can be adjusted to any desired value. The input resistance for this position is 150,000 ohms approximately.

Output: The output circuit is designed to operate a 5-milliampere meter mounted on the panel and an external meter or device such as the Esterline-Angus 5-milliampere recorder, and is provided with a manually adjusted compensating resistance. The compensating resistance is adjusted to allow for the resistance of the external device, so that the instrument always works into a normal resistance of 1000 ohms. Although the instrument functions perfectly when operating into resistances from 0 to 2000 ohms, its calibration is affected slightly if the total impedance deviates materially from the 1000-ohm value.

Power Supply: The instrument is intended for operation directly from 105-125 or 210-250 volts, 60-cycle mains. Other voltages or other frequencies can be supplied on special order only.

Power Input: The power drawn from the 60-cycle mains is approximately 35 watts. No batteries of any kind are employed.

Vacuum Tubes: The tubes furnished with the instrument are: two type 6J7-G, one 6F6-G, one 6X5-G, one VR-105-30, one 4A1.

Mounting: The amplifier is mounted in a cast metal case identical with that used on the Esterline-Angus recorder, or in walnut cabinet, as desired.

Dimensions: Type 715-AM, (height) 15¼ x (width) 9 x (length) 8½ inches, over-all; Type 715-AE, (height) 15 x (width) 8½ x (length) 8¾ inches, over-all.

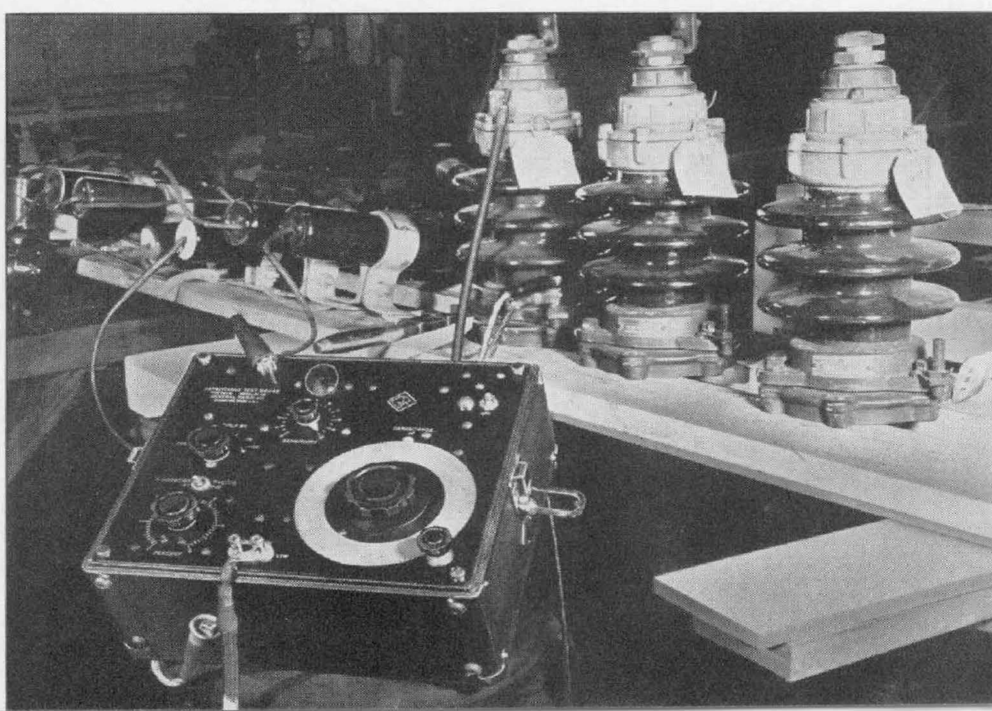
Net Weight: With Esterline-Angus case, 26¼ pounds; with walnut cabinet, 23 pounds.

Type		*Code Word*	*Price*
715-AE	In Esterline-Angus case	ASIDE	$250.00
715-AM	In walnut cabinet	ALOFT	225.00

This instrument is manufactured and sold under patents of the American Telephone and Telegraph Company, solely for utilization in research, investigation, measurement, testing, instruction and development work in pure and applied science, including industrial and engineering fields.

A MODIFICATION OF THE CAPACITANCE TEST BRIDGE FOR MEASURING GROUNDED SAMPLES

● **A MODIFICATION** of the Type 740-B Capacitance Test Bridge is now available which has one of the test terminals grounded. This new model is extremely useful in the electrical manufacturing and electric power fields for capacitance and power-factor tests on insulators, cables, transformers, etc. A folder describing the new bridge (Type 740-BG) will be sent on request. Ask for Form 516-A.



AN ANALYZER FOR NOISE MEASUREMENT

USES OF NOISE ANALYSIS

A sound-frequency analysis is often a necessary step in the location and elimination of noise. While, for production tests and acceptance tests on most mechanical and electrical devices, a measurement of the loudness of the noise with the Type 759-A Sound-Level Meter provides all the necessary information, there are many problems in machine design and installation which cannot be solved without a knowledge of the frequencies of the various noise components.

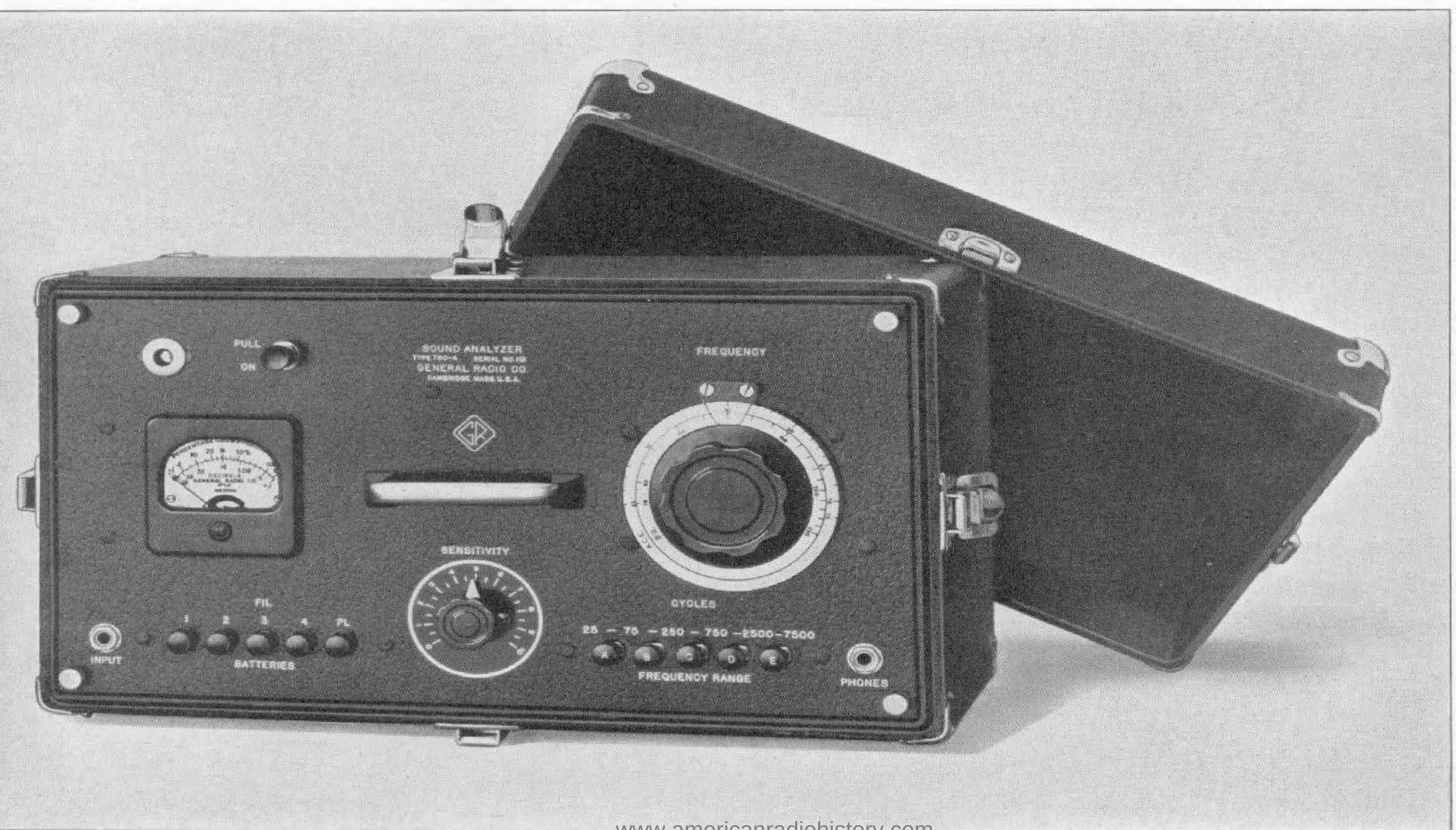
With this information, sources of noise components can be traced and their sources located. Machine parts, for instance, may tend to vibrate at their natural frequencies. These resonant frequencies can be calculated, and when one appears as a prominent component of the total noise, it usually is generated by the corresponding machine part.

TYPES OF NOISES

The noises generated by ordinary types of machinery may be divided into two general classes. The first includes sounds whose pitch corresponds to the fundamental frequency at which the machinery is operating or at some harmonically related frequency. Sounds in this class are characteristically harmonic in nature, and their frequency will vary with the speed of the machine. Many types of high-speed rotating machinery, such as centrifuges, dynamos, etc., produce sound almost entirely in Class One.

The second class of noise includes all of the so-called "unpitched" noises, which are usually generated by mechanical parts of a machine vibrating at or near their natural frequencies as a result of shock excitation. Such noise is in the form of a series of damped waves, which, although they may recur at regularly timed intervals depending upon the

Figure 1. View of the Type 760-A Sound Analyzer with cover removed.



machinery speed, consist essentially of components corresponding to the natural frequencies of the vibrating parts and bearing no definite harmonic relationship to the fundamental speed of the machine. The actual frequencies involved in such sounds are seldom clearly defined, since the effects of shock excitation and damping, as well as the movements of the various parts or the variation of forces impressed upon them, cause appreciable shifts of frequency. Sounds in Class Two are what are generally described as rattles or clashing sounds and are more often encountered in reciprocating machinery than in rotating machinery.

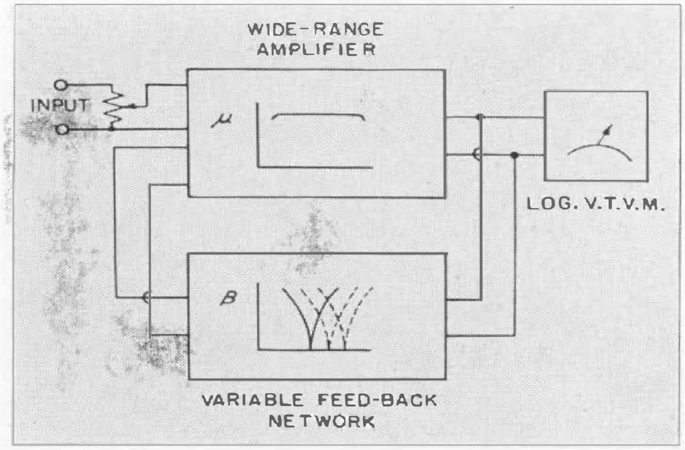


FIGURE 2. Functional block diagram showing the operation of the analyzer. In this circuit the output of an amplifier is fed back to the input in such a manner as to produce degenerative action and cancel the amplifier gain excepting at the frequencies within the pass band. To vary the tuning or the selectivity of this device only the feedback circuit itself need be adjusted, and no changes in the amplifier itself are required. The feedback network balances to a sharp null at a point corresponding to the peak in the pass band of the analyzer. Any variation in the balance frequency of the feedback network produces a corresponding change in the frequency to which the analyzer is tuned.

TYPES OF ANALYZERS

Analyzers hitherto available for separating noises into their component frequencies have been adaptations of instruments originally designed for other purposes. This limited their use to restricted fields. Heterodyne analyzers, for example, are completely satisfactory only when measuring Class-One noises having essentially constant pitch. Owing to their extremely sharp response and constant band width in cycles, they can seldom be used for measuring Class-Two noises. A band width variable in steps is somewhat more satisfactory, but is still subject to large errors. Tuned circuit analyzers have a characteristic nearer the ideal, but are cumbersome and expensive, and are usually not continuously adjustable. Unfortunately, this lack of satisfactory instruments has led many engineers to the conclusion that sound analysis is inherently difficult and unsatisfactory.

TYPE 760-A SOUND ANALYZER

A new analyzer, designed solely for sound and noise measurement, has been developed by the General Radio Company. This new instrument, TYPE 760-A Sound Analyzer, operates on different principles, and is far more satisfactory for analyzing the average noise than any device which has heretofore been generally available.

Briefly, the new instrument operates on the selective inverse-feedback principle,* as shown in Figure 2.

The use of this type of circuit has made possible a selectivity characteristic which is a constant-percentage function of the frequency to which the device is tuned. Most acoustical and sound engineers agree that this type of selectivity curve is ideal for the purpose of noise analysis. For measuring sounds of Class One, an analyzer of this type is relatively unaffected by even large changes in the fundamental speed of the machinery being tested, since any atten-

*H. H. Scott, "A New Type of Selective Circuit and Some Applications," *Proc. I.R.E.*, Vol. 26, No. 2, pp. 226-235; Feb. (1938).

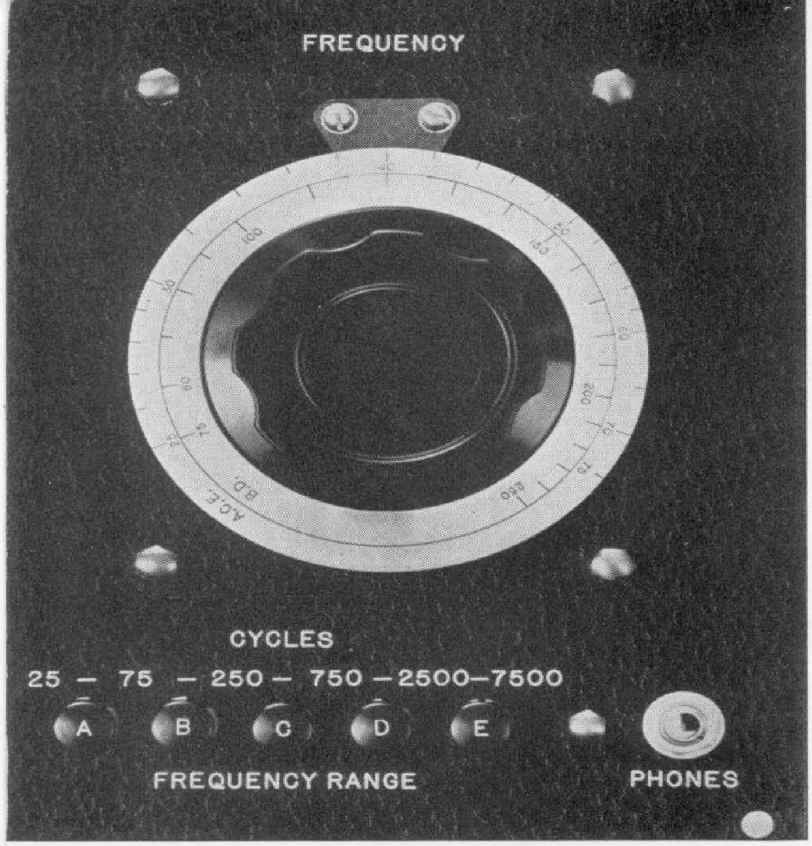


FIGURE 3. The tuning controls consist of a single dial and a row of push-button switches. The dial frequency span in cycles per second for each range is engraved above the corresponding push button, i.e., 25-75, 75-250, etc.

uation caused by such speed fluctuations is constant for the fundamental and all harmonics, so that their relative amplitudes are still measured correctly. For the unpitched sounds of Class Two, which usually cover bands of frequencies, the selectivity curve is sufficiently wide to give accurate readings.

The new analyzer is shown in Figure 1. Many of its mechanical and electrical features are identical with those of the TYPE 759-A Sound-Level Meter. Both instruments are similar in appearance, light in weight, and easily portable. Other features common to both instruments are complete operation from self-contained batteries, the elimination of all battery adjustments, and low battery drain resulting in extremely long battery life. Like the sound-level meter, the analyzer contains no coils or inductances whatsoever and hence is totally unaffected by all ordinary magnetic fields.

TUNING

An outstanding feature of this analyzer is the tuning system, which consists entirely of resistors and condensers. The resistors are ganged together on a common shaft and provide a continuous adjustment of frequency. The condensers are switched by a push-button arrangement to change the frequency range covered by the ganged resistors.

The dial has a spread-out logarithmic frequency scale covering a range of slightly over three to one, and the range is shifted quickly and easily by means of the push-button switch. The dial can be rotated continuously, so that the entire range of the device may be covered in a minimum of time. The push-button switch also allows quick adjustment of the tuning from one extreme of the frequency range to the other.

SELECTIVITY

Figure 4 compares the selectivity curves of TYPE 760-A Sound Analyzer and a typical heterodyne analyzer at several points in the sound-frequency range. Expressed as a percentage of the frequency to which the analyzer is tuned, the pass band of the heterodyne analyzer is undesirably wide at low frequencies and unusably narrow at high frequencies. The new analyzer, however, has a constant percentage band width at all frequencies. For measuring Class-Two sounds or Class-One sounds of varying pitch, this type of characteristic is essential.

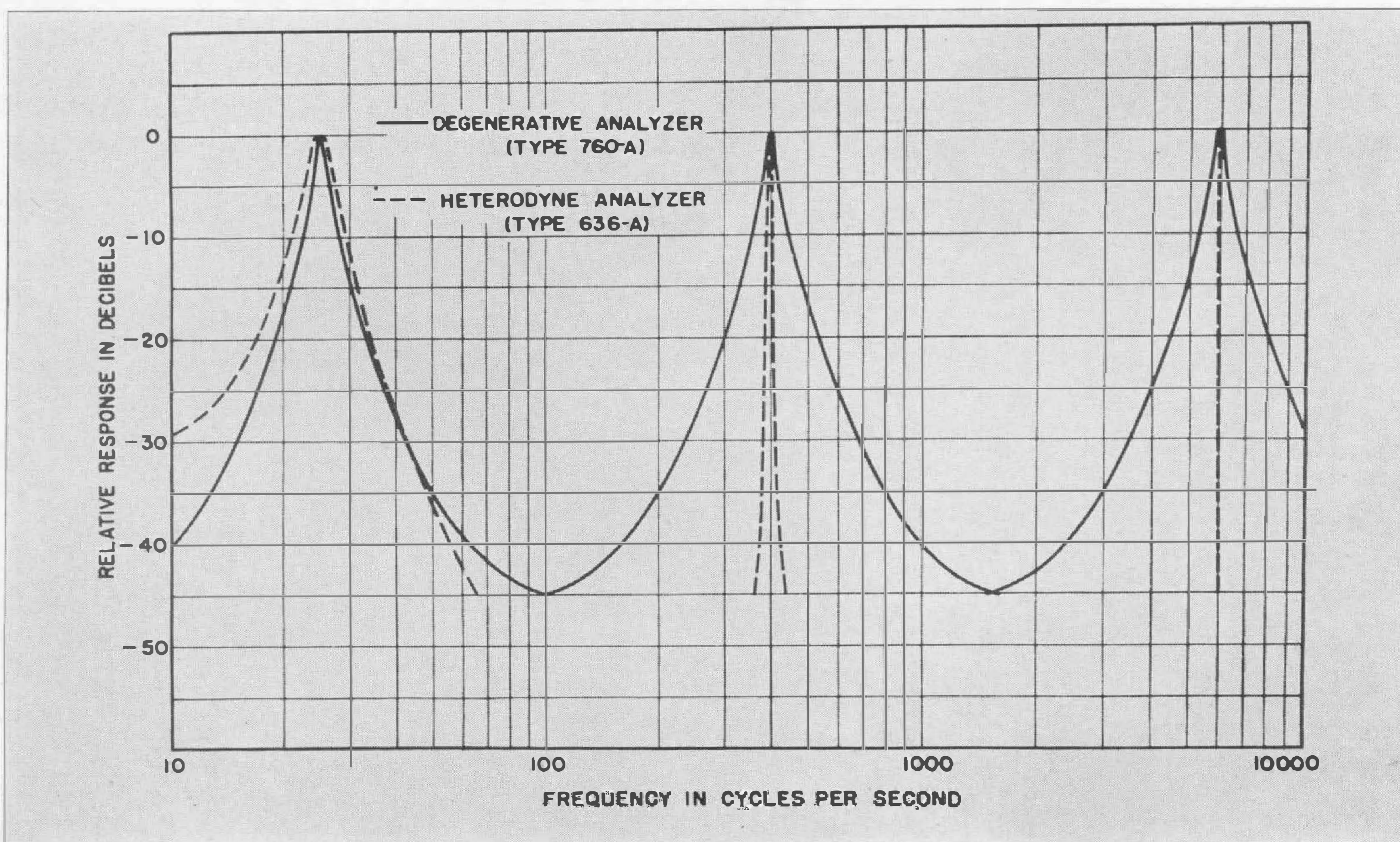
Examples of the errors occurring with different types of analyzers are shown in Figure 5. For purposes of simplification, it is assumed that, after the analyzer is tuned to a component, the frequency shifts by 1%, thus causing an amount of attenuation depending upon the selectivity curve of the analyzer. It will be noted that Curve A, for the TYPE 760-A

Sound Analyzer, shows a constant attenuation at all frequencies within its range. For a Class-One sound measured on this analyzer, therefore, small frequency shifts have no appreciable effect, while large frequency shifts provide an equal reduction of all components, so that they still remain in their proper relationship with one another. Curve B, however, illustrates what happens when a conventional type of heterodyne analyzer is used for this purpose. Under these conditions the error reaches 10 decibels at a frequency only a little above 300 cycles, and in that range from 1000 to 2000 cycles where the ear is most sensitive the response of the analyzer is down by 30 decibels, more or less. Obviously, under these conditions, these heterodyne analyzers will give results which are highly erroneous.

As previously mentioned, attempts have been made to eliminate this difficulty by the use of several band widths, usually related by factors of ten. Curve C shows the result obtained with a typical analyzer having a 5-cycle band-pass characteristic with a sharp cut-off beyond that point. Curve D is a continuation of Curve C into the higher frequency range and shows the extreme attenuation obtained. Curve E represents the response of the same analyzer with a 50-cycle band width. Under normal operating conditions the error obtained with this analyzer would be indicated by Curves C and E. The large discrepancy falling at the cross-over frequency, in this case 500 cycles, should be noted. Under these conditions an error of 25 decibels occurs at this point, which is most serious for all sound-analysis work. If the 50-cycle band were used at lower frequencies in order to minimize this error, the selectivity would probably be insufficient to give satisfactory results, because even at 500 cycles the band width is 10% of the frequency to which this device is tuned.

Of course, the actual results obtained

FIGURE 4. Comparison of the selectivity curves of the TYPE 760-A Sound Analyzer and a typical heterodyne analyzer (TYPE 636-A) having a band width of one cycle.



with any given sound with the heterodyne types of analyzers may be better or worse than that shown in the diagram, depending upon the amount of frequency shift present in the sound being measured and the frequency-versus-time characteristics. The results in most cases would, however, be unpredictable, except through a series of elaborate measurements. The possibility of such serious errors is probably the main reason why the heterodyne type of analyzer has been abandoned for most purposes of sound analysis, excepting in those few cases where the machinery speed can be held within very close limits.

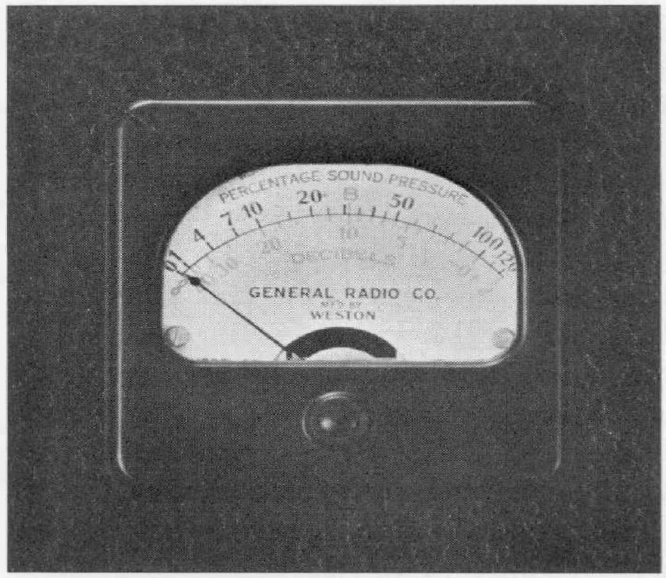


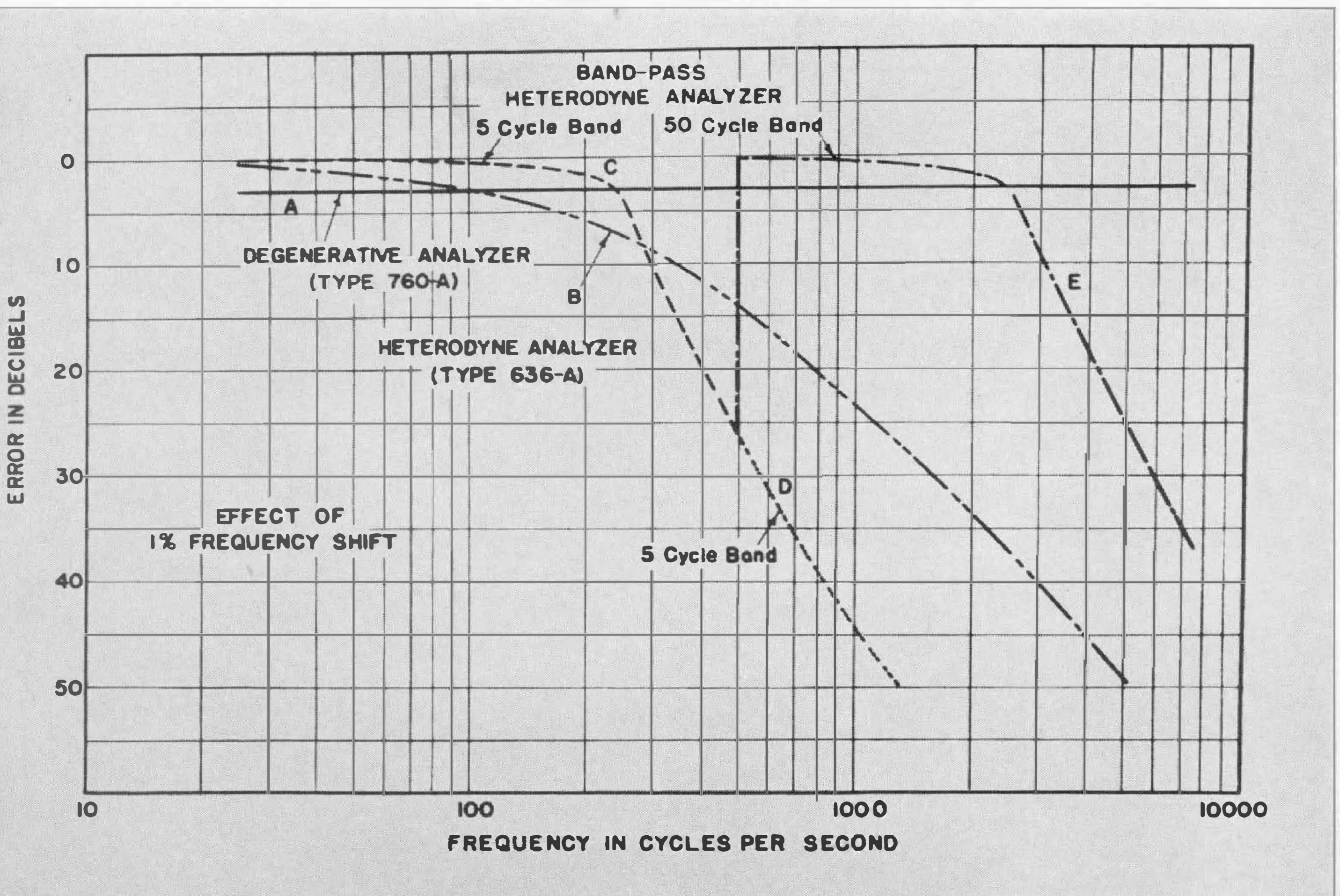
FIGURE 6. Meter scale of the TYPE 760-A Sound Analyzer.

VOLTMETER

Another innovation is the logarithmic vacuum-tube voltmeter, which covers a range of 42 decibels with a spread-out decibel scale. The meter is calibrated in both decibels and percentage, so that readings may be conveniently taken in any desired units.

The shape of the meter deflection characteristic has been purposely adjusted to provide a higher degree of ac-

FIGURE 5. Error in indication of various types of analyzers for an arbitrary shift of 1% in the frequency of source under measurement.



curacy of reading at the higher levels, since it is the high-level components which are of most importance when analyzing a noise. Because of this meter characteristic no multiplier switch is required on the sound analyzer, a feature which makes rapid analyses possible and which eliminates many chances of error in recording data.

OTHER USES

As frequently happens with new instruments, many uses have been discovered for the sound analyzer in fields quite outside that for which it was designed. One of the most important of these is the use of the instrument as a tuned amplifier and null indicator in bridge balancing. The selectivity characteristics of the device are ideal for bridge-balancing purposes and provide, particularly at low frequencies, a degree of discrimination which has not hitherto been available in most bridge-balancing devices. Of particular importance is the fact that the analyzer is unaffected by 60-cycle pickup and hence may be used in the many applications involving measurements at this frequency.

The sensitivity of the circuit is such that an input voltage of a millivolt will provide a satisfactory deflection on the indicating meter. This is about equivalent to the sensitivity of a pair of head telephones at 1000 cycles, which corresponds with the resonant frequency of the phones and is nearly at the peak of efficiency of the human ear. Obviously, therefore, since the analyzer will operate at any frequency between 25 and 7500 cycles, it is far superior in sensitivity to a pair of telephones over the greater portion of the range.

The logarithmic voltmeter is a great convenience for bridge-balancing applications. If desired, a pair of head telephones may be plugged into the output of the analyzer to provide aural as well as visual balance. The same automatic gain control which is in the voltmeter circuit will then operate on the telephones, providing an acoustic shock absorber which effectively prevents disagreeable acoustic shock if the bridge is suddenly unbalanced.

The use of the TYPE 760-A Sound Analyzer for wave analysis is, of course, not restricted to acoustical applications. It is quite suitable for the analysis of audio-frequency electrical waves over a voltage range of 100:1.

— H. H. SCOTT

SPECIFICATIONS

Frequency Range: Calibrated directly in cycles from 25 to 7500. This total range is covered in five complete turns of the tuning knob, the ranges on the various dial rotations being 25 to 75, 75 to 250, 250 to 750, 750 to 2500, and 2500 to 7500 cycles. A push-button switch allows immediate change of the main control to any of these ranges.

Input Voltage: The analyzer will give usable indications on input voltages ranging from 1 millivolt to 10 volts. The meter scale is calibrated for reading directly component tones down to 1% of the sound pressure (or voltage) of the fundamental or loudest component. Accordingly, to make full use of this feature, the input voltage at the loudest component or fundamental should be 0.1 volt or higher.

Selectivity: The average selectivity is such that the relative attenuation is 3 db at 1% off the peak to which the analyzer is tuned. The attenuation is at least 35 db at twice the frequency to which the analyzer is tuned.

Circuit: The circuit consists of a three-stage amplifier made selective by the use of degeneration, and an approximately logarithmic vacuum-tube voltmeter circuit, which allows a range slightly in excess of 40 decibels, or 100 to 1, to be read on the meter scale.

Meter: The indicating meter is calibrated down to 1% of the fundamental or loudest component of the sound. A decibel scale is also included, extending to 40 decibels below the fundamental or loudest component.

Telephones: A jack is provided on the panel for plugging in a pair of head telephones, in order to listen to the actual component of the sound to which the instrument is tuned. This is also useful when using the analyzer as a bridge-balance indicator.

Tubes: Three 1H4G and one 1F7GV tubes are required. A neon regulator tube is also used. A complete set of tubes is supplied with the instrument.

Batteries: The batteries required are four Burgess No. F2BP 3-volt batteries, or the equivalent, and three Burgess No. Z30N 45-volt batteries, or the equivalent. A compartment is provided in the case of the analyzer for holding all batteries, and connections are automatically made to the batteries when the cover of this compartment is closed. A set of batteries is included in the price of the instrument.

Case: The analyzer is built into a shielded carrying case of airplane-luggage construction, covered with a durable black waterproof material and equipped with chromium-plated corners, clasps, etc. This case has been designed to combine durability with light weight and good appearance. When operating the analyzer, the cover is ordinarily removed. An additional handle is provided on the panel of the instrument for convenience in moving it about while it is in operation.

Dimensions: (Length) 15 x (width) 10 x (height) 11½ inches, over-all.

Net Weight: 37 pounds, with batteries; 30 pounds, without batteries.

Type		*Code Word*	*Price*
760-A		ATTAR	$260.00
Set of replacement batteries for above		ATTARADBAT	8.00

This instrument is manufactured and sold under patents of the American Telephone and Telegraph Company, solely for utilization in research, investigation, measurement, testing, instruction and development work in pure and applied science, including industrial and engineering fields.

Patent applied for.

MISCELLANY

● **A LIMITED NUMBER** of reprints is available of the article by D. B. Sinclair, entitled "Parallel Resonance Methods for Precise Measurements of High Impedances at Radio Frequencies." This article appeared in the December, 1938, issue of the *Proceedings of the I.R.E.*

● **AT A MEETING** of the student section A. I. E. E. at the University of Wisconsin on January 12, 1939, Martin A. Gilman of the General Radio engineering staff was the speaker. His subject: "Problems in Instrument Design."

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