The GENERAL RADIO
EXPERIMENTER

ELECTRICAL MEASUREMENTS
TECHNIQUE AND ITS INDUSTRIAL APPLICATIONS

VOL. XI Nos. 2 and 3 JULY-AUGUST, 1936

QUIET, PLEASE

● "HOW QUIETLY IT RUNS!" We often hear this comment regarding the most popular makes of all mechanical devices ranging from automobiles and refrigerators down to the cheapest of gadgets. In fact, we have reached the stage where we take it for granted that the products of the better known manufacturers will give entirely satisfactory performance, and often the deciding factor between various makes is only the quietness with which the equipment operates.

The psychological and physiological effects of noise have been the subject of a considerable amount of analytical study.[1] Qualitatively, everyone recognizes their existence through personal experience with noisy appliances in the home as well as in the office and factory.[2] To meet the demand for quietness, manufacturers have not only designed mechanical equipment to operate quietly, but have tried to deaden any remaining sounds through the use of sound-absorbing and -insulating materials.

This interest in the reduction of noise has created a need for measuring instruments and has fostered an entirely new industrial application of science, commercial noise measurement. Many types of sound measuring equipment involving various principles of operation have been developed in order to provide industry with definite and reproducible readings to act as a basis of comparison between different sounds. Many of the early methods involved matching an audible tone with the measured sound.[3] This arrangement, however, relied upon the ear and the judgment of the operator, both of which are rather variable factors. The need for simpler and more reliable equipment rapidly brought forth a large number of various "noise meters" or "sound level meters" which indicated directly on a meter the total sound level, giving a reading totally

ALSO IN THIS ISSUE: A General Purpose Amplifier, page 6.

PLEASE NOTIFY US PROMPTLY WHEN YOU CHANGE YOUR ADDRESS

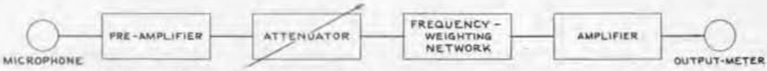

FIGURE 1. Functional diagram of a system for measuring sound level

independent of the judgment or hearing capacity of the operator.

Basically, a noise meter, or sound level meter, as they are now more generally called, consists of a microphone, an amplifier, and some sort of indicating meter which will respond to the audio-frequency voltages obtained from the amplifier. This system is shown in Figure 1. Since the human ear does not respond equally to all frequencies, it is desirable to adjust the over-all frequency response of the sound-measuring equipment to approximate that of the human ear. Also, since a wide range of sound levels must be measured, the amplifier gain should be adjustable, or suitable attenuators should be incorporated into the circuit, so that a reasonable deflection can be obtained on the indicating meter at all levels within the range of the equipment. Practically all modern sound level meters operate on the same principle and differ mainly in details of design.

Because of the relatively high price of some of the first complete outfits on the market, many manufacturers of mechanical devices used merely assemblies of standard microphones, amplifiers, and power-level-indicator meters which provided approximate measurements at but a fraction of the original cost for the equipment.[4] This method gave useful results for measuring differences in noise level, but was not convenient for absolute measurements because of the frequent and inconvenient calibration procedure necessary for such work. Unfortunately, some of the first sound level meters shared this same disadvantage.

Early types of sound-measuring equipment gave manufacturers of mechanical devices and acoustical materials a convenient means for comparing their products with those of other makes and, except in a few border-line cases, the readings obtained actually showed which product was the best from a standpoint of quietness. Lack of standardization, however, made it impossible to compare readings made with different types of meters because of their differing characteristics. This was of no great importance at first, but when it began to seem desirable to incorporate noise level data in purchase specifications, and when manufacturers began to advertise the low decibel ratings of their products, the need for standardization became obvious. Unless the type of noise meter and the conditions under which the measurements were made were carefully specified in each case, the noise ratings were practically valueless, since it was impossible to duplicate the readings or to compare them satisfactorily with the ratings of other manufacturers.

Many early types of noise meters[5] read directly in decibels above the average threshold of hearing at 1000 cycles (approximately 0.45 millibar) and contained a single weighting network giving an over-all frequency response not greatly different, throughout the most important parts of the range, from the low level characteristic specified in the new standards. There was, nevertheless, no general agreement among manufacturers and users of noise meters regarding reference levels and frequency characteristics. The various levels constituted only a minor annoyance, since it was possible to compare readings taken with respect to one level with readings referred to another level by merely adding or subtracting a fixed number of decibels. For instance, another common reference level at that time was 1 millibar, which is approximately 7 decibels higher than the average threshold of hearing. A meter calibrated in this manner read 7 decibels less on any given sound, providing, of course, that the instruments were alike in other respects.

Unfortunately, however, two different makes of meters were seldom alike in other characteristics. Any appreciable differences in frequency characteristics produced variations in readings for which it was almost impossible to compensate. Furthermore, practically all of the microphones used had pronounced directional properties, that is, their response at various frequencies depended upon the direction from which the sound was coming. In some applications, it was possible to point the microphone at the source of the noise, thus minimizing directional errors, but for measuring sound in automobiles, airplanes, etc., this was impossible, since the sound was coming from all directions.

As a consequence noise measurements made with different types of meters could be compared only very roughly, if at all. This situation was, of course, well understood by both manufacturers and users of noise meters, but was the cause of considerable confusion among consumers.

As a result of this situation, the American Standards Association, at the request of the Acoustical Society of America, undertook to develop a set of standards for noise measurements and for sound level meters.[6] Practically all companies interested in sound level measurements, either as manufacturers or as users of the equipment, were represented on the co-operating committees, and a set of tentative standards has recently been approved. The rapidity with which the new standards are being adopted indicates the general desire to clarify the sound-measuring situation. Apparently no serious difficulties are being encountered in meeting the important points in the new standards and, accordingly, it should be possible to compare the readings made with the new sound level meters with a satisfactory degree of accuracy.

The most important of the standards adopted by the committee concern (1) frequency characteristic, (2) reference level, and (3) indicating instrument characteristics. Furthermore, standard methods were specified for determining the degree to which any instrument complied with the standard specifications.

The frequency characteristic specified for all noise meters is that shown in Figure 2, Curve A. If more than one frequency response is provided, that of Curve B or a flat response or both may be used.

The reference level adopted is 10^{-16} watts per square centimeter at 1000 cycles in a free progressive wave.

The dynamic characteristics of the indicating instrument are so specified that the difference in indication obtained between short, transient sounds and steady sounds approximates the effect on the ear. Even before the tentative standards were finally approved, their influence was already noticeable, particularly in regard to reference level, and the reference point finally approved by the committee, namely, 10^{-16} watts per square centimeter at 1000 cycles per second, was rapidly

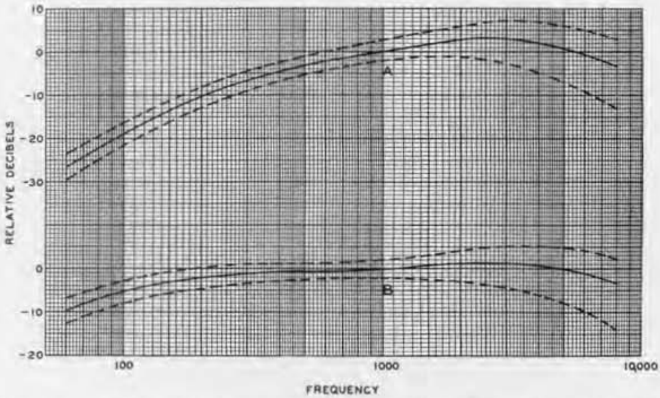

FIGURE 2. Frequency characteristics specified by the A.S.A. Curves A and B are respectively the so-called 40 db and 70 db equal-loudness contours modified to take account of the differences between random and normal free-field thresholds. Allowable tolerances are shown by the broken lines. These same tolerances are allowed on a flat characteristic

adopted for general use. To co-operate in the standardization, the General Radio Company modified its noise meter and announced the TYPE 559-B.[7] This instrument used the new reference level, which meant that for any given sound it read 7 decibels higher than the earlier model. At the same time, the sensitivity of the instrument was increased appreciably. The changes were, however, of a minor nature and the earlier models could be converted to the later type.

Recognizing, however, that a noise meter designed with the sole aim of meeting the new specifications would be little better than previous models as far as convenience, portability, freedom from maintenance difficulties, and similar considerations were concerned, the General Radio Company has for some time been working on an improved and unusual type of noise meter which is the result of careful study to determine exactly what type of sound-measuring device would best meet the needs of the greatest number of customers.

Mechanically the meter is arranged for maximum convenience, including the use of accessories such as a vibration pickup[8], with a minimum of operating controls. The type of microphone used — and its method of mounting — minimize directional effects. Batteries are carried inside the cabinet, yet the entire instrument is light in weight and easily portable.

Permanence of calibration over a wide range of battery voltages and a simple means of checking and resetting the sensitivity are features of the electrical design. A wide range of sound levels is covered. Provision for selecting any one of the three frequency characteristics specified by the A.S.A. assures its acceptance for all types of noise and sound measurement.

The last feature, and one of the most important, is low price.

The new TYPE 759-A Sound Level Meter will be completely described in next month's *Experimenter*.

— H. H. SCOTT

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4. See "Inexpensive Noise-Measuring Equipment," H. H. Scott, General Radio *Experimenter*, Vol. VII, No. 4; September 1932.

5. See "Commercial Noise Measurement," H. H. Scott, General Radio *Experimenter*, Vol. VII, No. 10; March 1933.

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8. See "Using the Noise Meter with a Vibration Pickup," H. H. Scott, General Radio *Experimenter*, Vol. IX, No. 11; April 1935.

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A GENERAL-PURPOSE AMPLIFIER

● **FEW INSTRUMENTS** are more useful in the communications laboratory than a high-gain portable amplifier. In addition to its use in increasing the sensitivity of bridge balances, there are an almost unlimited number of applications where a few extra decibels of gain are required. For maximum convenience, the general-purpose amplifier should be small, light, and readily portable and should have as high a maximum gain as is consistent with a good frequency characteristic. The output power should be sufficient for operating bridge detectors, such as a pair of phones or an oxide-rectifier voltmeter. It is also desirable that the maximum output voltage be sufficient for reasonable deflections on a cathode-ray oscillograph.

The new Type 814-A Amplifier is an excellent general-purpose instrument. Because of the use of 2-volt pentodes, the instrument, in spite of its high gain, has a very low battery drain, and will operate satisfactorily from small dry batteries, for which provision is made within the cabinet. The amplifier is of the resistance-capacitance coupled type, covering the range from 18 cycles to 10,000 cycles with a variation in gain of less than ±2 db, although the total gain, when operating into a high impedance circuit, is about 90 db. When operating into 20,000 ohms, which is approximately the impedance of an average headset at 1000 cycles, the gain is nearly 80 db. The amplifier is intended mainly for use with small input voltages (less than 0.5 volt), but a toggle switch on the panel allows the use of input voltages up to 5 volts without appreciable distortion. The gain is continuously adjustable by a tapered attenuator.

One unusual feature is the provision made for inserting a parallel resonant circuit in the grid circuit of the last stage in order to modify the frequency response of the amplifier. A jack is provided on the panel for connecting the resonant circuit. This arrangement provides extremely good selectivity at most bridge frequencies in the audible range, resulting in discrimination against harmonics and a greatly decreased noise level. Several standard filter units will be available.

Figure 1. Panel view of the Type 814-AM Amplifier

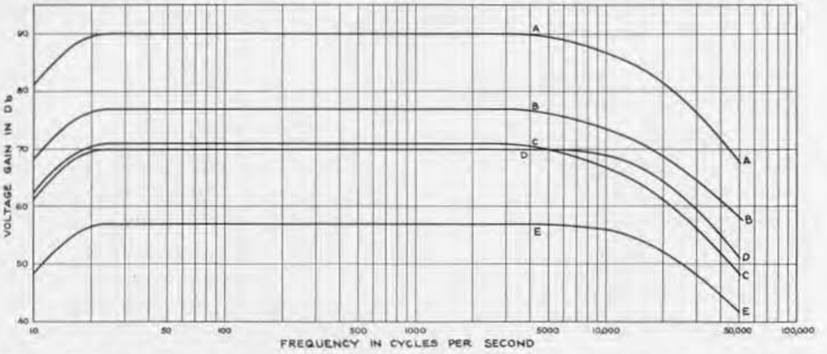

FIGURE 2. Frequency characteristics of TYPE 814-A Amplifier under various load conditions. Curves A and B were taken with loads of 1 megohm and 20,000 ohms respectively with the INPUT VOLTAGE switch in the LOW position. Curves D and E were taken with the same loads, but with the switch on HIGH. Curve C is the same as Curve B but with the GAIN control turned down 6 db

The new TYPE 814-A Amplifier is similar in appearance to the older TYPE 514-A, which has been on the market for several years and which has proved extremely popular in communications laboratories. The new instrument, however, provides practically twice the gain (in decibels) of the older unit, has a tapered volume control, and provision for tuning. The maximum output voltage from the new amplifier is also somewhat larger, being approximately 25 volts rms, which gives a very satisfactory deflection on the average cathode-ray oscillograph without noticeable distortion. In spite of the high gain of the new amplifier, the microphonic noises are actually less than in the older instrument, since the tube shelf has been cushioned in rubber.

The amplifier is supplied in two models, TYPE 814-AM, which is mounted in a walnut cabinet, and TYPE 814-AR, which is arranged for relay-rack mounting. The cabinet supplied on the TYPE 814-AM contains space for a complete set of batteries. The relay-rack mounting model has an extension on the right-hand side of the panel with provision for mounting a rectifier-type meter. A compartment is also provided on the back of this extension panel for holding a set of batteries. Both models have a rheostat for adjusting the filament voltage and a voltmeter which indicates filament and plate voltages.

— H. H. SCOTT

TYPE 814-A Amplifiers are available for immediate delivery. All vacuum tubes and batteries are included in the price.

Type		*Code Word*	*Price*
814-AM	Cabinet Model	APPLE	$97.50
814-AR	Relay-Rack Model	ALONE	97.50

MISCELLANY

MODULATION MONITORS

● **A NOTE** to broadcast station engineers: November first is the deadline for installing modulation monitors. We are still taking orders for the TYPE 731-A.

SALUTE

● **THE RCA REVIEW**, a quarterly devoted to contemporary developments in the field of radio communication, made its first appearance in July of this year. This journal is attractive in appearance and well printed. The articles in the first number cover many phases of radio communication. It is published by the RCA Institutes Technical Press, 75 Varick Street, New York City.

COVERAGE

● **APPROXIMATELY** 60 General Radio primary standards of frequency are in use in 18 countries including the United States. Russia alone has 8 of these.

CHANGE

● **BETWEEN** the engineering and production departments of active manufacturing companies there is usually a continual banter over design changes. The production superintendent dreams of the day when each new order will read "like last lot" and while awaiting the arrival of the fatal (used advisedly) day accuses (and with perhaps some justification) the design engineer of making changes for change's sake, but let him not forget the philosophy of Francis Bacon, who wrote, "That which man altereth not for the better, Time, the great innovator, altereth for the worse."

CIRCULATION

● **EXPERIMENTER** readers, domestic and foreign, number over 15,000. This is a larger circulation than that of any magazine in the radio field, with the exception of those published for amateurs and broadcast listeners.

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

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