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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

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NOISE STEPS OUT

NOISE AND ITS REDUCTION are receiving a rapidly increasing amount of attention from industry. A more-than-ordinary interest in the subject has been evident for some years, but, because the available information was incomplete and confusing, and because noise-measuring instruments were not standardized, industrial noise measurements seldom got out of the research laboratory and into the production department.

The adoption of the A.S.A. Standards,[1] covering terminology, methods,

[1] See "American Tentative Standards for Noise Measurement," Bulletin Z24.2–1936 and "American Tentative Standards for Sound-Level Meters for Measurement of Noise and Other Sounds," Bulletin Z24.3–1936, published by the American Standards Association.

FIGURE 1. The sound-level meter and vibration pickup were used very effectively in locating, and minimizing the effect of, vibration in the machine shown here

Photo, courtesy New England Screw Company

and instruments, resulted in several standardized instruments being placed on the market, all of which give identical results in the majority of applications. These standardized instruments have made it possible to use the decibel as a measure of sound level with the same confidence that one uses the volt and the ampere in measuring electrical quantities. Consequently, industry can now apply noise specifications and tests to both design and production, and is rapidly taking advantage of the opportunity.

SURVEY

The General Radio TYPE 759-A Sound-Level Meter, an accurate, portable instrument which includes even the optional features listed in the A. S. A. Standards, found immediate acceptance. A recently - completed survey[2] shows this instrument in a wide variety of applications, many of which were not contemplated when the instrument was designed.

The results of this survey have been classified and are summed up in the chart shown on the opposite page.

By referring to the diagram, it will be seen that the applications break down into three major fields and the percentage figures given represent the present distribution of the General Radio TYPE 759-A Sound-Level Meter.

1. The Appliance Field 35%
2. The Electrical and Acoustical Field.................. 28%
3. The Industrial Field (which requires the vibration and sound analysis of heavy machinery).................. 21%

[2]July 1, 1937.

It is interesting to note that sound surveys in buildings, streets, and plants, the applications which one ordinarily thinks of when a noise meter is mentioned, are in the minority and involve only 10% of the total number of instruments.

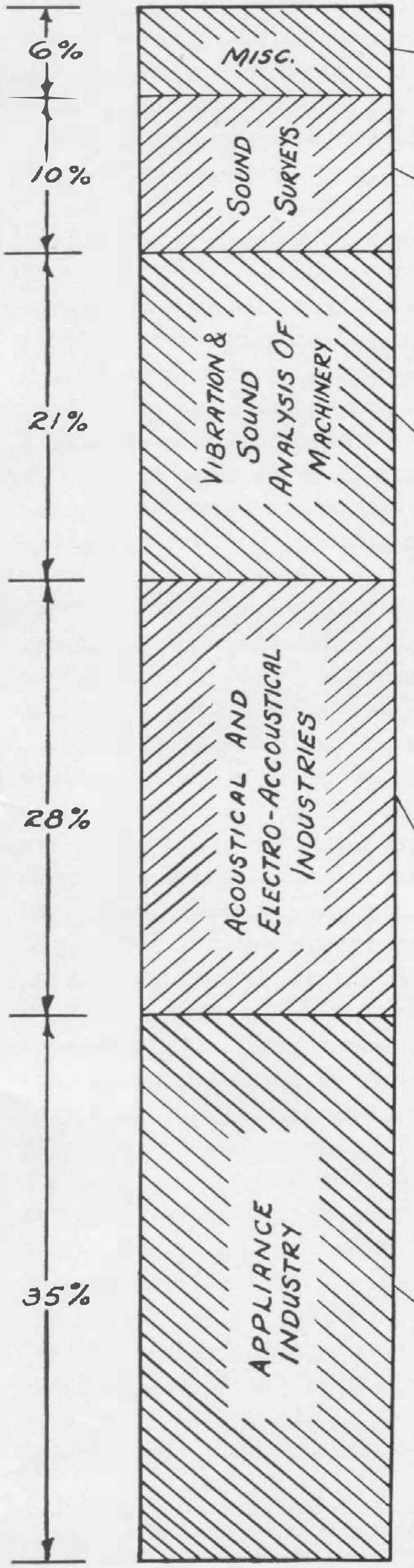
THE APPLIANCE FIELD

In the sale of household appliances, noise is a factor which is becoming of increasing importance, and it is not surprising that sound-level meters are more widely used in this industry than in any other.

The appliance industry is made up of manufacturers of such equipment as fans, small motors, vacuum cleaners, washing machines, oil burners, refrigerators, clocks, and air conditioning equipment. Since the market served is highly competitive, the salesman finds the sound-level meter invaluable as a means of proving to his customers that his products are superior. If, on the other hand, he finds his products faulty in this respect, it becomes the task of the factory engineers to design and produce quiet equipment.

The demand for convenient and accurate sound-measuring equipment comes from three different sources: first, the salesman; second, the research and development engineer; and third, the production department.

Since in this field the object is to reduce noise to the absolute minimum, the sounds to be measured are of extremely low intensity. Despite the difficulties of measuring sounds that are practically inaudible to the human ear, the General Radio TYPE 759-A Sound-Level Meter has been found entirely suitable for both laboratory and production measurements.



1. Production testing of grinding wheels.
2. Location of steam leaks.
3. Study of vibrations of aircraft fuselage, wing structures, and propellers.

1. Comparing noise level of various suburban and residential districts.
2. Measurement of office noises and effectiveness of sound installation.
3. Reducing noise of motor installations.
4. Study of office and plant noises and determination of ideal working conditions.

1. Measurements of vibration in vacuum pumps.
2. Study of the effect of mufflers on blower noises.
3. Measurement of noise produced by pneumatic drills.
4. Effect of silencing devices.
5. Measurement of high-speed transmission noise and vibration for both spur and helical gears.
6. Study of turret lathe noise.
7. Comparison of canvas and leather belt noise.
8. Study and elimination of noise in coil winding machines.
9. Production and experimental noise tests of both large and small electric motors.
10. Measurement of tractor noises.
11. With automobiles and other machinery for studying the effect of different fuels, cooling systems, manifolding, mufflers, and transmission gears.
12. Design of acoustic engine hoods.
13. Noise in automobile bodies.

1. Frequency analysis and measurement of sound patterns of foghorns and other signaling devices.
2. Measuring effectiveness of sound insulating material used in ships, automobiles, buildings, and aircraft cabins.
3. Intensity measurements and frequency analysis of aircraft noises both in flight and on ground.
4. Sound absorption measurements.
5. Electronic musical instrument research.
6. The effect of various treatments in deadening mechanical vibration.
7. Studying bank vault noises in order to determine standards governing burglar alarm systems.
8. Study of insulation values of various types of floor treatments for the reduction of impact noise.
9. For the measurement of sound distribution patterns and for frequency analysis in theaters, auditoriums, and other public address installations.
10. Measurement of noise level produced by movie projectors.
11. Frequency response for speaker combinations, radio receivers, and phonographs.
12. Susceptibility of radio to inductive interference and setting limits and standards.
13. Measurement of noise at loudspeaker of radio receivers or phonographs caused by hum and mechanical vibration — and determination of signal-to-noise ratio.
14. Measurement of reverberation time.

1. Sound and vibration analysis of air conditioning equipment.
2. Routine noise tests on new air conditioning installment.
3. For making noise studies and comparing equipment so that noise standards can be set up, governing air conditioning equipment, water pumps, refrigerators, oil burners, clocks, cream separators, horns, bells, and washing machines, fans, and other appliances.
4. Measurement and elimination of noise in postage stamp equipment meters.

Figure 2. This chart shows the distribution of General Radio sound-level meters in various fields of application. At the right are listed the main uses in each field

THE ACOUSTICAL AND ELECTRO-ACOUSTICAL FIELDS

In acoustics, the sound-level meter is used mainly for experiment and research. Phonograph noises, however, are measured as a production test. The radio manufacturers are using the instrument for checking the frequency response of loudspeakers, for measuring background and internal noises of radios, and for checking the susceptibility of receivers to inductive interference. Acoustical engineers are using the sound-level meter for checking frequency response and obtaining sound distribution patterns in theaters,[3] auditoriums, and out-of-door sound equipment installations. In the research laboratory the instrument is being used for the study of various types of sound-absorbing materials and determining their effectiveness in reducing sound and vibration in automobiles, buildings, ships, and aircraft cabins.

THE VIBRATION AND SOUND ANALYSIS OF HEAVY MACHINERY

The use of the sound-level meter by manufacturers of heavy machinery such as aircraft motors, automobiles, marine Diesel motors, turbines, lathes, and other machine tools is the third major field for this instrument. The automobile and aircraft manufacturers were perhaps the first to recognize its importance and, as a result of sound studies, the noise factor has become one of their strongest selling and advertising points.

In many factories the size of the equipment to be tested requires that tests be conducted in large assembly and experimental rooms where the extraneous noise level is too high to permit accurate sound measurements. It is then necessary to resort to vibration rather than sound studies. The use of a vibration-sensitive element with the sound-level meter offers a satisfactory solution to this difficulty since vibration pickups are, in general, sensitive only to vibrations produced at the point under test, and errors produced by background noises become negligible. Since the vibration pickup localizes the measurement to one point, it becomes possible, when making tests on heavy machinery such as aircraft motors, Diesel motors, and the like, to measure vibration at such points as bearings, cylinders, gears, etc., and from these localized tests a complete vibration pattern of any machine can be obtained. With this information, points of maximum strain and points at which the maximum of noise occurs can be easily located.

After locating the vibration that is causing the objectionable sound, it is often necessary to locate the source of the vibration, which is, in many instances, in some part of the machine other than the part producing the objectionable noise. Since every part in a machine has a certain definite mass and

[3] H. H. Scott and L. E. Packard, "The Sound-Level Meter in the Motion Picture Industry," presented at the Fall Convention of the Society of Motion Picture Engineers, October, 1937. This paper will be published in a forthcoming issue of the Journal of the Society of Motion Picture Engineers.

FIGURE 3. Measuring the acoustical properties of a motion picture theater with the sound-level meter

period of vibration, resonant vibrations can occur, and the cause of these resonant vibrations cannot be located by a simple vibration amplitude analysis. To cope with this problem, industrial engineers have found it desirable in studying the machine to determine both the amplitude and the frequency of each component of the complex vibration.[4] With this complete frequency and amplitude information, and knowing the speeds of the various parts of the machinery, the engineer is equipped with the necessary information for locating the ultimate source of the undesirable frequency and, hence, for bringing about its elimination.

SOUND SURVEYS AND NOISE ELIMINATION IN FACTORIES, OFFICES, ETC.

The acoustical engineer in his daily work is confronted with problems of sound insulation and reduction, and vibration elimination in buildings, offices, factories, and homes. Although basic formulae which check to a remarkable degree of precision are available for calculating the effectiveness of various sound insulating materials, no practical check on the results of acoustical treatment or sound insulation can be had without the use of accurate sound-measuring equipment. The modern acoustical engineer is not satisfied in simply trying to reduce existing noise conditions in offices, plants, and homes, but is trying, by the use of sound-measuring and vibration-measuring equipment, to locate the source of the objectionable noise or vibration and to eliminate the cause rather than its effect.

[4] Discussion of the TYPE 759-A Sound-Level Meter used with the TYPE 636-A Wave Analyzer and Vibration Pickup, pages 15 and 16 of Bulletin 20, entitled "The Technique of Noise Measurement," published by the General Radio Company.

As was mentioned above in the discussion of sound measurements with heavy machinery, the scientific method of coping with noise and vibration problems is to analyze the situation, determining (1) the source of the noise, (2) the method of transmission, and (3) the manner in which the objectionable noise is excited. Having this information, a systematic procedure can be adopted for bringing about noise elimination. In many cases it has been found to be more economical to eliminate the noise at its source rather than at the point where it has been found bothersome; in others, the transmission medium has been changed; and, in still others, because of economic reasons, it has been found desirable simply to reduce the noise where it occurs. In any one case, however, to deal with the problem in the most economical manner, and to give the customer complete satisfaction, a complete survey must be made.

The uses of the sound-level meter to the acoustical engineer are (1) to obtain the information necessary to deal with the problem and (2) to demonstrate to the client the effectiveness of the treatment installed.

FIGURE 4. The washing machine is only one of the many home appliances which the sound-level meter has helped to make quieter

THE GENERAL RADIO TYPE 759-A SOUND-LEVEL METER

The General Radio Company has taken extreme care, in the design and construction of its new TYPE 759-A Sound-Level Meter,[5] to insure its ability to meet all present and future demands so that it can be considered a basic sound-measuring instrument. The acceptance of the instrument by industry has proved that it is a basic instrument and that its features have met with wide approval. It furnishes instantly readings of sound intensity directly in decibels over a range of from 24 to 130 decibels, and, because of its three frequency-weighting networks, its readings are indicative of the noise actually heard by the human ear. Two features which are probably the keynote to its success are its portability and its simplicity of operation. Weighing but 23½ pounds and being small in size, it is easily carried to the point of application, and it is so simple that it can be operated by any untrained employee.

With the wide use and acceptance of sound-measuring instruments, there is an increasing demand in industry for a definite standardized procedure for making sound measurements and it is probable that within the near future this will be made available. The development of the new standards is but the first step in a series of definite specifications covering sound measurements. The TYPE 759-A Sound-Level Meter, being designed to meet all of the requirements of the fundamental specifications, can be expected to take care of any future demands. —L. E. PACKARD

[5] For a description of the TYPE 759-A Sound-Level Meter, see Bulletin 20 and other publications of the General Radio Company.

BACKGROUND NOISE CORRECTIONS IN THE MEASUREMENT OF MACHINE NOISE

● **IN MANY PLANTS** soundproof rooms are either not available or not practical, and it is found necessary to make sound measurements under existing noise conditions. It is always advisable to reduce the level of extraneous noise as much as possible, but satisfactory sound measurements can usually be made, even under adverse conditions. Separate measurements are made of the background noise alone and the background plus the unknown noise. The difference of these readings is then taken and, from the chart of Figure 1, the correction in db for the background noise is determined. This correction is subtracted from the db reading obtained in the second measurement to obtain the level of the unknown noise.

Assume, for instance, that the problem is to measure the noise produced by a machine mounted in an assembly room or test room where an appreciable background noise level is present. The sound-level meter is placed in the desired test position, and a measurement is made of the general background noise without the machine running. An average measurement of the background noise in db will be sufficient although, if a widely fluctuating noise is present, it is often desirable to note the peak readings. As an example, let this reading be 72 db. The machine under test is then set in operation and, when it is operating at the desired conditions of load and speed, a second measurement is made of the total noise level. Let the result of this measurement be, say, 78 db. The difference between these two readings is then 6 db. Entering the chart of Figure 1 at 6 db, along the horizontal axis, we find the correction to be 1.25 db. This subtracted from the sound reading of 78 db gives a result of 76.75 db which is the true noise level of the machine itself.

To obtain this correction it is assumed that the power in the background noise and the power in the measured sound are added arithmetically by the sound-level meter. From the relation

$$db = 10 \log_{10} \frac{P_2}{P_1},$$

the power ratio corresponding to the 6 db difference is found to be 3.981. This means that the total noise is 3.981 times the background. The desired noise and the total noise level are therefore in the ratio of $\frac{3.981 - 1}{3.981}$ or .75, which corresponds to 1.25 db. The actual noise being measured is then 1.25 db lower than the reading of the sound-level meter.*

If actual sound-power levels corresponding to the db readings are desired, these can be calculated from the expression given above. An easier method is to refer to a set of decibel tables such as those published on pages 162 to 167 of the General Radio Company's Catalog J. A reading of 72 db, for instance, corresponds to a power ratio of 1.585×10^7. Since the reference level (corresponding to zero db) is 10^{-16} watts per square centimeter, sound-power level for 72 db is 1.585×10^{-9} watts per square centimeter.

—L. E. PACKARD

*A general expression for which the curve of FIGURE 1 can be calculated is
Error db $= \frac{1}{2} [d - 20 \log_{10} (2 \sinh \{0.1151\, d\})]$
where d is the difference in decibels between the two readings.

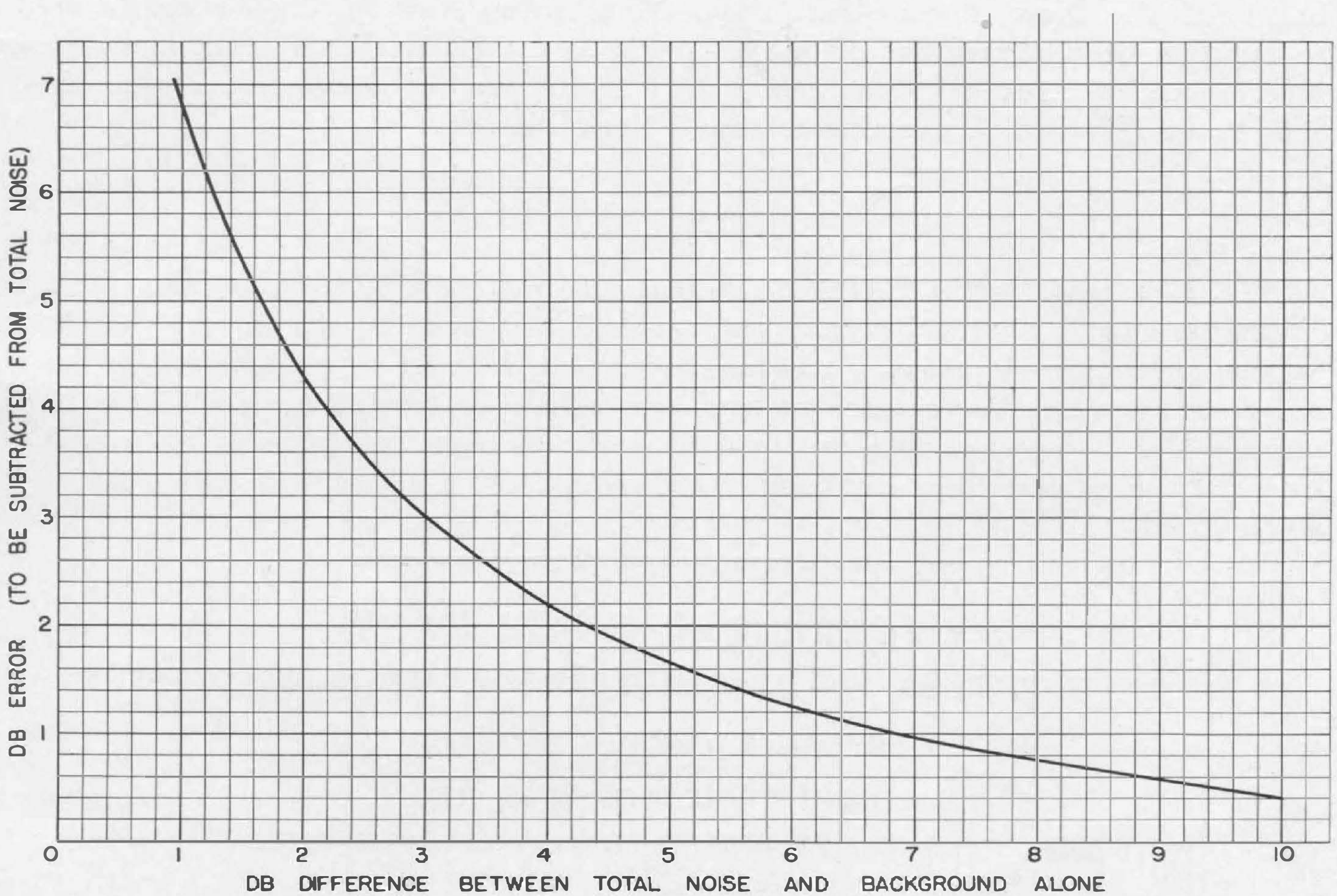


FIGURE 1. Background noise correction for sound-level measurements

MISCELLANY

MR. SMITH GOES TO HOLLYWOOD

To 988 General Radio customers on the Pacific Coast went, last month, cards announcing the opening of a Los Angeles engineering and sales office on December 1. Mr. Myron T. Smith, who takes over the new office, will be available for consultation concerning the application of General Radio instruments.

Mr. Smith has been in charge of our New York office since its establishment several years ago. Prior to that time he was a member of the factory engineering staff, coming to us shortly after graduation from the Massachusetts Institute of Technology with the Class of 1930.

In addition to engineering service, a stock of laboratory instruments and parts will be maintained in order to facilitate the prompt handling of orders in this area.

The address of the new office is 1000 North Seward Street, Los Angeles, and the telephone is Hollywood 6321.

MR. IRELAND TO NEW YORK

With the departure of Mr. Smith for the West Coast, Mr. Frederick Ireland takes charge of the New York office. Mr. Ireland has been a member of our engineering staff for several years, coming to us from Harvard University, where he was a member of the Class of 1933. Having spent a considerable amount of time at the New York office in the last few years, he is already well known to General Radio customers in the New York district.

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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