ENGINEERING DEPARTMENT

GENERAL RADIO COMPANY

CAMBRIDGE A, MASSACHUSETTS

REPRINT NO. A-12 1938

Reprinted from Journal of the Society of Motion Picture Engineers, Vol. XXX (April, 1938), No. 4.

THE SOUND-LEVEL METER IN THE MOTION PICTURE INDUSTRY

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Although sound-level meters have been commercially available for some time, it is only within the past year that they have attained their present high degree of popularity. One of the main reasons for this sudden acceptance by industry is, doubtless, the availability of new and improved models combining convenience of operation, low weight, and, in some cases, low price.

Probably few industries have as many important uses for a sound-level meter as the motion picture industry. Noise meters, as they were formerly called, have long been used for measuring the noise-levels in studios and theaters, the sounds made by various mechanical and electrical devices such as ventilators, cameras, projectors, arc lights, *etc.*, and for checking the volume of reproduction and the background noise-level from reproducing systems. Recent improvements in microphones, however, have made possible sound-level meters having reasonably smooth frequency characteristics, so that such instruments, unlike the earlier noise meters, are suitable not only for measuring complex noises, but are also quite satisfactory for many kinds of single-frequency measurements. Naturally, this has expanded the usefulness of the sound-level meter to include measurements of the overall frequency response of reproducing systems and variations in frequency response throughout a theater or auditorium.[1]

One of the newest sound-level meters is the General Radio Type *759-A*, which incorporates many features hitherto unavailable in even the most expensive instruments (Fig. 1). Aside from meeting the tentative specifications of the American Standards Association, the design of this new instrument stresses portability and convenience of operation, which characteristics are of utmost importance to the user. Among its many features are a non-directional sound-cell microphone, a high-gain stabilized amplifier, the absence of all battery adjustments, a practically linear decibel meter, and a simple system for resetting the calibration.

To mention the features in more detail, the sound-cell microphone provides a rugged and sensitive sound pick-up device with a smooth, nearly flat frequency response over the important frequency range, practically free from directional effects. Such a device is unaffected by ordinary changes of temperature and humidity, and even unusually low temperatures produce only a small change of sensitivity, for which correction can easily be made, if desirable.

In the interests of convenience the microphone is mounted upon a folding bracket on the top of the sound-level meter, and turns down into a compartment

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* Presented at the Fall, 1937, Meeting at New York, N. Y.; received October 1, 1937.

** General Radio Company, Cambridge, Mass.

cast in the panel when not in use. This makes it unnecessary to unwind any cables or plug in the microphone each time a measurement is made, since, under normal conditions of use, the microphone is always connected directly to the instrument. Provision is made, however, for removing the microphone from the sound-level meter and using it on a cable, for the few applications where such an arrangement is desirable. A special cable and tripod are available for this purpose.

The amplifier circuit itself is of the resistance-capacitance coupled type, using pentodes. By proper design of the screen-supply circuits an unusually high degree of stability of gain has been achieved, so that it is seldom necessary to reset

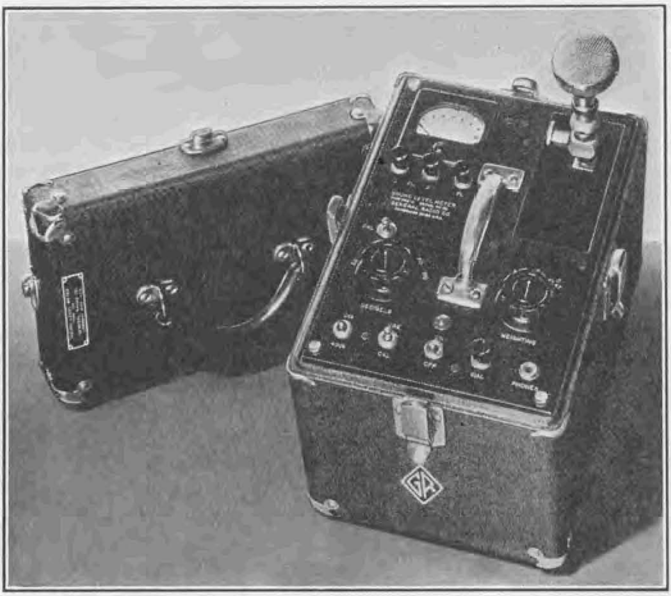

FIG. 1. Type *759-A* sound-level meter.

the calibration control as the batteries wear out. Another feature of the amplifier circuit is the extremely low battery drain, the total plate current being only 2 milliamperes. Naturally, this allows the use of very small batteries. Also, an amplifier circuit of this type requires no transformers or other heavy components.

The use of a ballast tube in the filament circuit and of the stabilized amplifier circuit makes all filament current or battery adjustments quite unnecessary. This is a great convenience, since it is not necessary to adjust any battery controls when putting the instrument into operation. Push-buttons are provided on the panel for indicating directly on the "Decibels" meter the condition of the batteries—a red line on the meter indicates when the batteries should be replaced. Accordingly, except for occasionally pushing the battery-test buttons to be sure that the voltages are sufficiently high to provide stable operation, it is never necessary to pay any attention to the batteries. When it does become necessary to change the batteries, the change is accomplished easily and quickly, since the battery-box cover is provided with spring contacts that automatically make the proper connections to the batteries when the cover is fitted in place.

The use of small batteries and an amplifier circuit requiring no transformers results in an unusually light instrument. The elimination of transformers also minimizes the possibility of inductive interference. The main panel and microphone housing are a single aluminum casting which is light but rigid. The whole instrument is housed in an "airplane-luggage" case made of light-weight plywood covered with leatherette and completely shielded electrostatically. The resulting instrument is small and light, and attractive in appearance.

Because of the high gain of the amplifier (approximately 140 db.) it is naturally necessary to make some provision for insulating the vacuum-tubes against mechanical shock in order to minimize microphonic pick-up in the tubes themselves. This is accomplished by special rubber bushings which support the complete amplifier assembly. All the heavier parts of the amplifier, such as by-pass condensers, *etc.*, have been mounted on this assembly, and the rubber mountings have an extremely low deflection rate for small deflections, thus providing a long natural period of oscillation for the sub-assembly. The rubber mountings are so designed, however, that the deflection rate increases rapidly as the deflection is increased, thus providing a snubbing action and making it impossible to damage the instrument in ordinary handling or jarring.

Convenience of operation has been considered of paramount importance in the design of the new sound-level meter. The main attenuator is adjustable in 10-db. steps, and, as previously mentioned, the indicating meter, which actually covers a range of 16 db., has a scale that is practically linear, which is achieved by the use of shaped pole-pieces. Three weighting networks are provided, in accordance with the A. S. A. standards, including the 40-db., 70-db., and flat networks. The first two of these networks are used for low-level and medium-level measurements, respectively, while the flat network is used generally for high-level measurements and for measuring frequency response. Fig. 1 shows the general appearance of the instrument. In particular, the arrangement of the panel, the clear lettering on the panel and on the meter scale, and the novel microphone mounting should be noted. All necessary operating instructions are fastened permanently inside the lid of the cabinet.

One extremely convenient feature of the new instrument is the method of resetting the calibration. Although the amplifier used in this device has an unusual degree of stability, it was not considered desirable to rely upon this factor entirely for maintaining the permanence of calibration. Accordingly, provision is made so that the amplifier gain may be reset quickly and easily at any time. The arrangement consists essentially of applying a voltage through an attenuator to the input of the amplifier. The magnitude of this voltage and the output of the amplifier are indicated alternately on the "Decibels" meter when the calibration button is pressed. If the readings are alike the gain is correct. If the readings are not alike a screw-driver control may be adjusted to reset the calibration to its factory value. Ordinarily the alternating voltage for making this test is obtained from commercial power lines, a connecting cord being provided for the purpose.

In the absence of a-c. power lines, however, an audio-frequency oscillator or other similar device may be used.

In order to test the sound-level meter under actual field conditions, a large number of measurements have been made, including most of the important problems to which the sound-level meter is applied (Fig. 2). The following information is not presented as an exhaustive survey of theater conditions, but merely to give an idea of conditions in what seems to be a typical suburban theater. The measurements were made in the University Theater at Cambridge, Mass., which has a seating capacity of about 2000 persons.

The initial noise-level in this theater—that is, with all air-conditioning and mechanical equipment shut off—is about 26 db. A loud street noise, such as a pneumatic drill, may raise the level to as high as 32 db., which, as will be noted later, is considerably below the normal noise-level within the theater when the air-

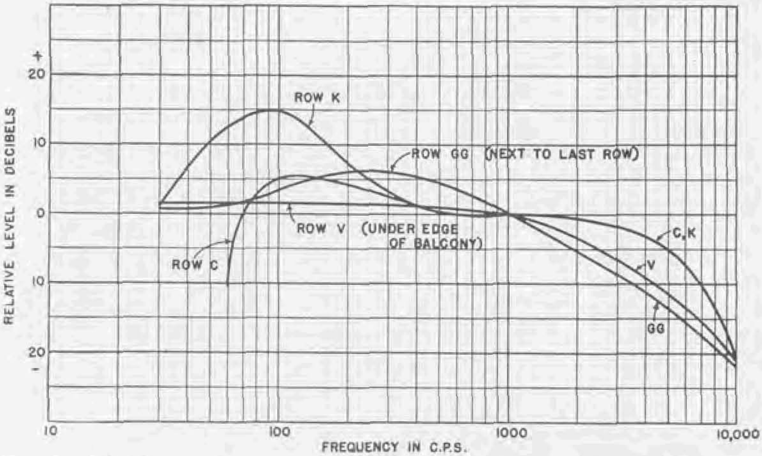

FIG. 2. Variations of frequency response in center seats of motion picture theater.

conditioning equipment is in operation. Accordingly, it appears that the theater is quite satisfactorily insulated from outside noises.

Turning on the air-conditioning equipment raises the noise-level in the theater by nearly 20 db. in some locations. For instance, in the front orchestra seats the total noise-level with the air-conditioning equipment in operation is approximately 45 db. The level, however, decreases toward the back of the theater, reaching a minimum of approximately 37 db. in the rear rows and 41 db. in the balcony.

Measurements made of the loudness of reproduced speech and music in this theater seem to be about average.[2] Speech sounds, for instance, were around 70 to 72 db., while music reaches 80 db. or higher. The background noise in the theater during the program, which includes, aside from the noises previously mentioned, the audience noise and the noise from the reproducing system, is approximately 54 db.

Frequency characteristics were taken at various positions in the theater in order to determine the changes in frequency response with location. Some of these data are shown in Fig. 2, which indicates clearly how the frequency response changes in the center of the theater between the front seats and the rear seats. The effect of the balcony upon the high frequencies is particularly noticeable and readily accounts for the decrease in articulation under the balcony.

Data such as these are invaluable to the theater owner or operator, since they show readily how well the various portions of the audience are actually hearing the reproduced sounds. As a result of such measurements it is frequently possible, by proper acoustical treatment or by changes or additions in the speakers or tweeters, to improve noticeably the quality of reproduction throughout the theater.

The data shown here were obtained by merely connecting a beat-frequency oscillator to the input of the amplifying equipment. Obviously, similar runs may be made when using a constant-frequency film in the projectors, thus obtaining an overall measure of the reproduction, including the optical equipment. No particular difficulties were encountered due to standing waves when making measurements at the higher frequencies, but there was some trouble from this source at the lower frequencies. Accordingly, it would be desirable, where extreme accuracy was warranted, to use a warble tone to minimize the effects of standing waves.

The authors wish to express their appreciation to Messrs. S. Sumner and C. W. Parshley for the use of the University Theater during these tests and to Mr. O. B. Asten of Electrical Research Products, Inc., for his coöperation in carrying out the tests.

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Wolf, S. K., and Sette, W. J.: "Progress in the Acoustics of Sound Recording and Reproduction for Motion Pictures," *Rev. Sci. Instr.*, **VII** (Sept., 1936), No. 9, p. 323. Note that the decibel ratings mentioned in these papers are referred to the threshold of audibility. The new sound-level meters use 10^{-16} watts per sq. cm. as reference level. Accordingly, for any given sound a new standard sound-level meter will read approximately 7 db. higher than if the measurement were referred to the threshold of audibility.