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Sound Reinforcing Systems

ARTHUR W. SCHNEIDER*

A discussion of a variety of problems that arise in the installation of these systems in large halls.

SOUND REINFORCING is not, in the strict sense of the word, public address. It is an electro-acoustic system of amplifying and converting sounds into acoustic energy in such a fashion as to aid the original sound and to permit comfortable listening. A sound reinforcing system is not a reproducer of sound, nor is it a producer of sound. Fundamentally, the approach to a sound reinforcing system and the analysis of a sound reinforcing problem depends on sound reproducers and sound producers.

A sound reproducer is something which picks up a sound, amplifies it, and reproduces it so that the sound is as near to the original as possible. In this process no latitude should be taken by the engineer or the user to modify the original sound, even though this modification may make the sound more pleasing. In a case where latitude is taken to modify the nature of the original sound, then the instrument is no longer a reproducer of sound but becomes a producer of sound. For instance, Hammond organs and electric guitars are essentially producers of sound, whereas broadcast studios, transmitters, and radio receivers are essentially reproducing networks.

A sound reinforcing system, however, is neither one of these, but a combination of both in view of the fact that it is necessary to add to the original sound so that the original sound plus the amplified sound will make it sound to the auditor as if it were all original sound. Therefore, in the perfect sound reinforcing system, this blending of the amplified sound plus the original sound gives the auditor a feeling of comfortable listening without his realizing that amplification is being made.

From these statements it is readily seen that the art of sound reinforcing is applicable primarily to large halls and outdoor places of entertainment. It is also interesting to note that the art of sound reinforcing is relatively young. It has originated since the advent of the microphone, loudspeaker, and amplifier. As a matter of fact, to the writer's knowledge, no outstanding installations of sound reinforcing systems were in use prior to 1931. Our forefathers were able to get around this fact by developing people with high acoustic output, and we cherish the memories of such porducers of sound as Caruso and William Jennings Bryan. Now, through the efforts of sound engineers, we have developed a crop of singers who croon and politicians who whisper into KB2C's.

System Requirements

Let us now consider the requirements of the so-called perfect sound reinforcing system, or at least the requirements of a system that would fill all the desired and ideal functions. The first requirement is for a system to amplify all sounds on the stage regardless of where these sounds originate, and to amplify them with sufficient intensity for the audience to hear comfortably before feedback occurs. Feedback, of course, occurs when the sound returning to the microphone from the loudspeaker is equal to the original sounds. The second requirement of the perfect sound reinforcing system is that all sounds be amplified and reproduced equally insofar as the frequency response is concerned. The third requirement is that the wave form characteristics of the sound be preserved, that is, that the reproduced sounds be relatively free from distortion. The fourth requirement is that the illusion be preserved. This, of course, is a most important factor when it comes to show business. The basic reason for people going to theaters is to lose themselves in the illusion of what is going on, and surely the illusion would not be preserved if the sounds appeared to come from any spot other than where they are produced. The last requirement of a sound reinforcing system—one without which an otherwise good system will cease to be good—concerns the acoustics of the hall in which the system is to be installed and the attention of the design engineer to these acoustic problems.

It is not possible to install a perfect sound reinforcing system for many reasons, and numerous compromises must be effected. In order to get sufficient amplification before feedback, the characteristics of the microphones should be such as to limit their range of pickup to the area in which the sounds are being produced. In general, directional microphones are needed with normal pickup from the stage side and little from the audience side. These go a long way toward increasing the maximum usable gain.

Loudspeakers

On the speaker side, a directional unit is required so that the sounds produced can be directed into the audience area with a minimum of sound being returned to the microphone. However, a directional horn to cover the low end of the spectrum is impractical because of its size. Fortunately, this limitation is not serious in view of the fact that most sounds below 150 cps produced in the theater are of a sufficient intensity as not to require much sound reinforcing. Therefore, you will find that in most sound reinforcing systems the emphasis is laid on those frequencies extending upward from the fundamental of the male voice. At the high-frequency end of the spectrum, some compromises have to be effected in the loudspeaker design. Selection is limited, in view of the fact

* *General Manager, Commercial Radio-Sound Corp., 231 E. 47th St., New York 17, N. Y.*

that best-known over-all reproducers of sound are of the cone type, which is not readily adaptable to a directional loudspeaker. The loudspeakers on the high end should be of the cellular type, giving a uniform distribution to the high-frequency sounds. The microphones should have a directional characteristic pattern that limits the pickup to the area in which the sounds are being produced. However, in a good sound reinforcing system it is best that the microphone be concealed, inasmuch as it is not desirable to advertise the fact that the sound is being amplified, because this in turn would spoil the illusion. Therefore, it is necessary to conceal microphones in footlights and similar places, which results in a compromise in quality, directional characteristics, and scope of pickup.

If microphones are concealed for reasons of illusion, it is necessary that the speakers be concealed also if a good illusion is to be preserved from an audience standpoint. However, in connection with the speakers, their concealment is not the only consideration when it comes to illusion. It is necessary to have the speaker within a reasonable distance of the sound-producing source and located in such a manner as to make it appear to the auditor that the sound is actually coming from the sound-producing device and not from the loudspeaker. In general, the difference in the path length between the actual sound and the sound coming from the loudspeaker should not be greater than 60 to 80 feet. If this distance is greater than 80 feet, the auditor perceives that the sound is not actually coming from the producer of the sound, but from another spot. As this distance is increased, this realization becomes more acute. Compromises have to be affected in this particular category to a much greater degree than in any phase of sound reinforcing.

It is only with the distinct help of the architect in connection with the design that illusion can be preserved. Complete cooperation between the sound engineer and the architect is a matter of great importance. To date, too few architects have realized the problems of the sound engineer and have given too much attention to the appearance of the halls rather than to utilitarian value. After all, if a room is designed so that it is impossible to see or to hear properly, then it has little use as a meeting hall or a theater. The two fundamentals of a good auditorium are good vision and good hearing. Once these two objectives are obtained, then specification for fancy chandeliers, paintings, and other decorative elements lose their importance.

One example of a wonderful illusion was in the "Great Waltz," a show at the Center Theater back in 1933. The size of the proscenium was cut down considerably, and in the center of this there was a large emblem of the double eagle. It was behind this emblem that the sound reinforcing horns were placed. In all parts of the theater, it appeared as though the sound were coming from the actual singers and orchestra.

The frequency response of the amplifier, microphones, and speaker is an important phase of sound reinforcing. Too much emphasis has been laid on the range of the system rather than the smoothness of response. It is much better to have a system with a limited range and a close tolerance of the output over this range than one with an extended range and large variation in the output over the range.

When feedback occurs, it occurs at the frequency at which the system peaks. If there is a large peak at some particular point, feedback will occur even though the average energy content over the entire frequency range is relatively small. Therefore, you can see that if amplifiers, speakers, and microphones were absolutely flat in their response, all portions of the spectrum would be reproducing equally before feedback would occur. The integrated energy over the spectrum, which is the sensation we actually hear, would be far greater; therefore, a compromise is necessary to pick equipment which will give maximum response and a balance between gain and response.

In the realm of distortion, compromises for economical reasons are generally the limiting factor, but the amplifier capacity required to take care of peak conditions should be possibly ten times the average power required. For example, if a sound system requires an average power of 50 watts, its peak capacity should be 500 watts. From an economical standpoint, it is not always practical to install an amplifier of this capacity.

Typical Examples

One of the larger and more recent sound reinforcing systems is installed at the Lewisohn Stadium of the C.C.N.Y. During the summer, the New York Philharmonic Orchestra—through Stadium Concerts, Inc.—gives concerts to audiences ranging up to twenty thousand people. The stage is approximately 100 ft. wide and 60 ft. deep, and the roof is about 60 ft. above the stage. In the roof, along the leading edge, are installed five RCA twin-power speakers, each of them directed in such a manner

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Employment Register

EMPLOYMENT OPPORTUNITIES may be listed here at no charge to industry or to members of the Society. For insertion in this column, brief announcements should be in the hands of the Secretary, Audio Engineering Society, Box F, Oceanside, N. Y. before the first of the month preceding the date of issue. Replies to box numbers should be addressed to AUDIO ENGINEERING, 342 Madison Ave., New York 17, N. Y.

★ Positions Open • Positions Wanted

★ **Radio and Television engineers.** Experienced in design of high frequency circuits such as FM tuners, TV boosters, and TV antennae. Salary commensurate with ability. Write giving full details. Mr. Stone, Talk-A-Phone Company, 1512 South Pulaski Road, Chicago 23, Illinois, Lawndale 1-8414.

★ **Wireman,** instrument, capable of building models and occasional short production runs of precision electronic devices. Must be able to work with minimum of supervision. Permanent; write giving salary expected, family status, availability. Box 1002.

★ **WANTED:** Signal Corps Center, Fort Monmouth, N. J. has openings in the following Civil Service positions:

Military Instructors—Microwave relay, radar, radio electronics, fixed station radio, central office techniques, teletype installation and maintenance, repeater and carrier, dial central office maintenance, theory of electricity. $3100–4600.

Electronic Engineers—Participate in design, development, modification, construction, and testing of electronic equipment—radio, radar, wire communications, instrumentation, sonar, etc. Responsibility depending upon experience and ability. $3100–6400.

Technical Writers—Write, edit, prepare technical publications, handbooks, circulars, instruction books, etc. Edit and revise scientific manuscripts on radio, radar, electronics, communications, and photography. Write instruction manuals on theory, operation, and maintenance of Signal Corps equipment; determine media and method of presentation of material; prepare charts, graphs, schematic diagrams etc. $3100–5400.

Applicants for any of these positions should write Chief, Civilian Personnel Branch, Signal Corps Center, Fort Monmouth, N. J., submitting a completed Standard Form 57, "Application for Federal Employment" (obtainable at any first or second class post office) for review before going to Fort Monmouth for a personal interview.

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as to give optimum coverage over the entire seating area, which extends over a radius of 140 deg. with a maximum projection distance of approximately 250 feet. Into this system is fed a total of 400 watts of audio energy, divided 100 watts into each of the three center speakers and 50 watts into each of the two outside speakers. Controls are provided on each loudspeaker amplifier to proportion the amount of energy into the speakers to give uniform distribution over the seating area. The average power required in this system is approximately 75 watts.

The input system is made up of 15 to 17 microphones arranged in six groups. A remote control is located some 250 feet from the stage, directly in audience area. The operator blends the amplified sound with the actual sound for the best results, which, in this case, means adding just enough of the amplified sound to permit comfortable listening without the audience realizing that the concert is being reinforced.

In this particular installation—as in many others—sounds from the orchestra are picked up with multiple microphones, and the results are mixed electrically to get a combined signal. This results in an electrical mix which, when added to the acoustic energy of the orchestra, makes it sound as though the whole orchestra were playing sufficiently loud so as not to require a sound reinforcing system. That, of course, is ideal. It was accomplished to a very high degree in this installation.

Another installation of note is located at the same college in the Great Hall. This installation was a most difficult one in view of the fact that the large, curved rear wall of the hall is a perfect reflector for sound originating on the stage, and when attempts are made to boost the acoustic output to the point where people can hear throughout the hall, the reflecting sounds cause loss of intelligibility. In this hall, the problem was corrected by installing a sound reinforcing system with a loudspeaker suspended on a single pendant support from the ceiling. Sounds originating from a relatively weak source are amplified through the loudspeaker, and its output is directed into the audience area with a minimum amount falling on the rear and side walls. In this way the intelligibility has been improved so that it is possible to hear and understand throughout the entire seating area. In the Great Hall the path-length difference between the orator and the loudspeaker is never greater than 60 feet in any part of the auditorium where amplified sound is received. Therefore, the illusion is remarkably good.

Multiple-Speaker Problems

One large reinforcing system, which for a while was almost a failure, was that part of the official World's Fair sound system at the Court of Peace. Approximately ninety thousand people were assembled in a "U" shaped area, surrounded on two sides by the exhibits of various nations and the tremendously large Federal Building which was the exhibit of the United States. The podium was erected on the steps of the Federal Building, and loudspeakers were at a level of about 150 ft., built behind grilles in the front of the building. Two RCA twin-power speakers were used, each being supplied with 100 watts of audio. At the last minute, just before the dedication, the radio director insisted that we install additional horns along the sides of the Court of Peace because he was afraid the people would not be able to hear distinctly. During the first part of the ceremony the people heard many confusing sounds, first from the nearest speaker and then from other speakers that covered the same area. After we were advised at the master control desk that this was happening, we cut off the side speakers and projected the sound only from the top of the Federal Building, and with far better results. This setup was never designed as a sound reinforcing system, but it was used that way on the opening day.

A makeshift and compromise sound reinforcing system is now in use at the General Assembly of the United Nations out at Flushing Meadow.[1] The term "compromise" is used in view of the fact that the nature of the room does not lend itself to a true sound reinforcing system. The room is fairly large but has a balcony which overhangs the first floor to a considerable degree. This overhang prevents any possibility of feeding sound from the main cluster of cellular horns which are directly over the podium. It was therefore necesary to put a number of small speakers on the ceiling underneath the balcony. In this area, which covers a depth of 20 to 30 rows of seats, there is a total of 66 loudspeakers because the ceiling is low and the area must be blanketed with low-level sound. Thus the auditors are not too conscious that the speaker is in their immediate vicinity. One other compromise was effected by putting an additional loudspeaker half way back from the podium, towards the rear wall, to cover the balcony exclusively. This speaker could be dispensed with if the delegates and press were attentive. However, the compromise, insofar as illusion is concerned, was made to permit those in the balcony area to hear all of the proceedings.

It must be borne in mind that these compromises are acceptable because it is not the prime intent of the United Nations to put on a show. The main purpose is to have the spoken word of the delegate heard by all in the seating area with 100 per cent intelligibility. To reach this condition, some compromises are acceptable.

Sound reinforcing systems for the ordinary broadcast are relatively simple. All that is necessary is to install one or two high-quality commercial loudspeakers in the approximate center of the proscenium and directed to cover the audience area. Very little trouble with feedback is encountered because the microphones are in close proximity to the sound to be picked up. For an orchestra, of course, no amplification is required because most broadcasts take place in relatively small halls.

In a television studio, the actor or the sound producing device is no longer relatively close to the microphone, because the latter must be kept out of the field of the camera. Consequently, it is not possible to locate loudspeakers where they previously were because of the feedback problem. The solution is to put a number of high-quality loudspeakers throughout the seating area. These speakers are connected to their own amplifier with separate gain control, and the amplifiers bridge the output of the audio system picking, being cut off only when the applause microphones are used. Experience by NBC at the International Theater has indicated that the type of

[1] A. W. Schneider, "Broadcast and Public Address Systems," AUDIO ENGINEERING, Aug. 1947.

speaker used is most important. It has been found impossible and impractical to get by with an inexpensive speaker. One is required which has an excellent and smooth high-frequency response so that the audience can understand every word. Part of the reaction upon the radio or television audience, as well as the sponsor, is the reaction of the audience in the theater. If the audience cannot understand what the actor is saying, a gag may be missed and the audience does not laugh when it is supposed to. Sponsors are prone to blame the sound reinforcing system for many an "egg" laid on a television program.

In the International Theater, a total of six twin-cone speakers are used to cover the balcony, and approximately four cover the orchestra floor. Illusion is compromised in this case, but illusion is not the primary intent. A compromise is possible because the programs are not intended primarily to entertain the people in the theater, but to entertain millions in their homes so they will go out and buy the products advertised by the sponsor.