Sound Reinforcement

—Martin Dickstein*

The elements that make up a sound reinforcement system have come a long way since the days of the cupped hand. But the present state of the art is merely a stopping point. Where do we go from here?

Back in the very, very old days, it was necessary to be within "earshot" of a sound's originating point. Earshot depended for the most part on the frequency characteristics, loudness, wind direction, surrounding noises, terrain or location of source and listener, just as it does today, whether the receiving device is an ear or mechanism. In those days, though, earshot distance actually meant to an ear. There was no way to preserve the sound for later listening, nor was there any way to extend the distance. If anyone wanted to hear the sound they had to be there, fairly close to the source. Attempts to increase the "throw" distance through the use of cupped hands or other horn-like devices helped the situation a little. In time, it was learned that sounds could be directed somewhat toward the listeners if the source was located in front of something such as a hill or structure. Carefully shaped and strategically placed vases in the proximity of performers, prevailing winds, and higher but closer seating areas were used in further attempts to permit more listeners to hear the sounds originating from the source.

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Through the many years that followed, more attempts were made to enlarge the listening area, but meeting halls, auditoria, concert halls, churches and ampitheaters had to be built to take advantage of natural acoustics to "spread the word." It was not until the availability of electronic amplification that something was done to substantially enlarge the listening area.

Recordings could now be made using a microphone which changed sound impulses to electrical impulses. These recordings could be played through speakers which distributed sound to listeners in a fairly good size area. When movies started to talk, though, a real need for "big sound" became apparent. Theaters could seat pretty big crowds to see the screens, but now it became necessary that all these people also be able to hear the voices, sounds, and music. Larger speakers, higher-output microphones, and more powerful amplifiers had to be developed. And they were.

This solved some problems but, as seems to happen in almost every field, created new ones.

As microphones came into use for addressing live audiences, methods had to be found to make the mikes smaller in order to avoid hiding the speaker or performer. Lapel microphones, lavaliers to hang around the neck, and button-hold mikes were designed to permit the speaker or singer free use of the hands during a performance. As sensitivity of microphones improved it became necessary to manufacture units with different pickup patterns so that some had very narrow cones of sensitivity, some could pick up through greater angles and some were made to be nonrestrictive, or omnidirectional.

Many types of microphones are now made for music, offering better frequency response in the bass range or high-frequency range or with smooth response through a very wide band of frequencies. Some distort sound less than others during loud, impact sounds. Others have pre-emphasis in the voice range built in. Still others are made to pick up through an extremely narrow angle but at a greater distance. Each microphone manufacturer today tries to cover a particular market or use with a variety of types and shapes especially designed and engineered for each application.

For locations where microphones are used near loudspeakers or in highly reverberant areas, the choice is a combination of narrow pickup angle, smooth frequency response and high front-to-rear rejection ratio to diminish the possibility of acoustic feedback. Today, microphones are made with these singular characteristics, combining those qualities that make them particularly suited for individual requirements, in almost all sizes and shapes and at almost any price.

Amplification

Many changes in the construction of microphones were caused by, and resulted in, changes made in the amplifier units developed to raise the minute power output of the microphone to the level necessary to drive a loudspeaker strongly enough to enlarge the listening area by a substantial amount. Early amplifier designs for power applications were made to match existing microphones and speakers. The desired power output was achieved first with existing tubes and components through the use of some known circuits, then with modified circuits and newly developed tubes, new ideas on impedance matching, energy transfer, interstage coupling and feedback.

Inherent tube and circuitry noise was slowly eliminated with the development of new materials for use in filaments, grids, resistors, and the resulting modifications in power supplies and filtering methods. Frequency response was broadened to provide smoother lows and more natural highs. Components were designed to withstand the heat developed by high-power tubes.

Mixing circuits were devised to offer greater possibilities for multi-source originations. Special filters were designed to compensate for recording characteristics. Mixer units were separated from the power chassis to permit the more delicate low-voltage circuitry to operate to its own best advantage without interference from tube heat and power transformers. Bridging circuitry and matching networks were calculated and engineered to permit flexibility of inputs. Power amplifiers could not be located at a distance from the mixing unit whenever desired without any appreciable loss of quality or energy.

Amplifiers were modified to reduce distortion, increase frequency response, provide higher power and take up less space. Preamplifier mixers were also modified to operate with a greater frequency range and lower noise and dis tortion level.

As power ratings of amplifiers were increased to provide greater audience coverage, constant-voltage output systems were devised to allow more and more speakers to be added without loss of level.

Separate mixer/amplifier units and packaged, or combined, mixer-amplifier equipments are now available from many manufacturers in various price ranges depending on the application.

With the arrival of stereophonic reproduction, mixers and amplifiers have been again redesigned to permit two and three channels to be available on units built to the same dimensions as previous mono equipment, and with a minimum of cross-channel interference.

The disassociation of mixer from amplifier has permitted the development of equipment specifically to solve some of the problems incurred in multi-input and high-level speaker output systems. Limiters and compressors have come into fairly extensive use to prevent sharp bursts of sound from distorting the quality of reproduction or damaging the equipment. In the same way, expanders to raise the level of the source sound automatically if it should fall below a predetermined point, are now common.

Most recently, equalizers of various types have been engineered to permit a greater opportunity to emphasize desired frequencies and eliminate undesired ones. In reverberant auditoria greater intelligibility can be realized by raising the relative importance of certain frequencies and diminishing the level of others, thus limiting the discrete ones causing the disturbing reverberation and, as a result, permitting higher levels of output in the desired ranges. Less sophisticated equalizers are available that operate on calculated curves at fewer, but carefully selected, frequencies from those units that are specifically designed to permit exceptionally sharp operation at a great number of frequencies.

In recent studies of acoustics and reverberation, it has been found that if output frequencies can be made slightly different from the original ones, by an amount insufficient to be heard, then feedback can be reduced. This will allow higher output levels. The result is the development of a frequency shifter which raises each input frequency

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by 5 Hertz at the output. Levels can then be increased as much as 3 dB, or more, for greater audience coverage.

Solid State

In most recent years, preamplifiers, amplifiers, compressors and even power supplies have undergone a most revolutionary change with development of the transistor. In its infancy, the transistor introduced its own sound characteristic when used in audio equipment. It also could not withstand the punishment that a tube could when something happened in the internal circuitry of the equipment or in the speaker lines. With further development, this device is now being used in almost all equipment. New circuitry has been devised to keep the transistor from breaking down in the event the equipment becomes defective, or if trouble develops in the output lines, or even if there is a sudden power surge. Transistors of various designs and internal structures have been developed for special applications and while some are still being made that cannot be handled without special precautions, for the most part, these tiny units have made such inroads that they have almost taken over completely.

Audio equipment can now be made smaller, lighter, with very good frequency and noise characteristics, but not yet quite at the same price as the tube equipment.

Since the heat developed by a transistor is much less than that given off by a tube of equivalent operation, more equipment can be mounted in smaller housings. Nevertheless, all transistor equipment should still be protected from being overheated by any tube units which may be used in the same system.

Speakers

As other units of a sound distribution system have changed, so did the speaker. Extremely bulky, inefficient loudspeakers with coil-generated fields changed to smaller, lighter, more efficient units with permanent magnets. Cone material changed along with the type of suspension of open ends. Frequency response improved, rattle was eliminated in better speakers during peaks, shapes of magnets changed as new materials were found to create stronger fields in a smaller space, and efficiency improved as less power was required to move the cone. Speakers, as with microphones, have been developed for different applications, with unique specifications of frequency response and smoothness, power ratings, angle of dispersion, efficiency and size. Smoothness of the response curve is desired to reduce feedback when used in the vicinity of open microphones. Concepts of speaker housings and their internal structure, front openings and sizes, dimensions and material have undergone study and modification to improve particular characteristics deemed necessary by the variety of applications.

A study was also made of the interaction of sound waves when speakers were located close together. It was found that a mounting of several speakers in a particular arrangement provides characteristics unique to that arrangement. A linear array, with speaker centers a definite distance apart, creates a "spotlight" effect with the vertical angle less than that of a single speaker alone. That angle decreases as the number of speakers increases.

Sound columns are now used in areas where reverberation time is high to direct the sound towards the audience and to decrease the wasted sound energy which would otherwise hit the ceiling or floor and create reflected, disturbing sound patterns. Straight line and curved speaker arrays, multiple speaker arrangements, filter networks and other concepts have sprung from the original theory in an effort to produce units that will suit an application range or fit a price category. Still, specially designed units are required when the circumstances are sufficiently unique to warrant this engineering, as for example tremendous audiences in large outdoor areas or music halls where highest fidelity is required at each seat.

As more and more equipment has been developed and produced in each phase of sound distribution systems, it has become obvious that standardization is required. Microphone output impedance must match preamplifier inputs, amplifier outputs must match speakers, preamplifier outputs and amplifier inputs, as well as those of intermediate equipment, must also match for proper operation of a complete system. Characteristics of equipment, depending on several variables, have to be defined at particular points of measurement.

Prognostications?

Now that all these concepts, systems, equipment and many of the standards have become accepted, tried and developed to meet a great variety of uses and conditions, have we gone as far as we can in sound reinforcement and public address? Can anything more be done to improve what is now available to compare with the strides in development up to now? Further miniaturization seems to be part of the answer.

Will mikes be made with mini-transmitters to eliminate the use of connecting cables altogether? Will receiver-amplifiers be further diminshed in size through the use of multi-function modules so that they can be located at each speaker instead of in central racks? Will speakers become smaller to permit them to be hidden entirely? Will new studies of acoustics, reverberation, sound transmission and dispersion create havoc with present standards? Or will future studies of the ear and its operation, the response of the brain and greater use of psychedelic sound provide the new incentives for the developments yet to come? It might prove interesting to live long enough to hear for ourselves.

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