(*11*) A house phone or other means of communication between projection room, auditorium, and manager's office.

(*12*) No film other than that actually in projectors or being threaded. This requires, of course, that there be an adjoining room for rewinding, inspection, and storage.

(*13*) One or more qualified projectionists, who shall not be minors. (NBFU, Sec. 217.) To operate a projection room with minimum fire hazard and first-class screen results requires that at least two projectionists be on duty at all times. Large theaters using more than two projectors, spotlights, effect machines, *etc.*, in the projection room must have more men in proportion to the additional equipment.

This outline covers only what must be in the projection room proper. Even for the one-man room, there is need for adjoining space to accommodate rectifying equipment, shipping cans, a complete stock of supplies and spare parts, oil cans, tools and test equipment not ordinarily used during a performance, a work-bench with vise, clothes lockers, books, records, and any other items necessary to the operation of the projection room, but which need not and should not be inside the projection room proper.

FACTORS AFFECTING SOUND QUALITY IN THEATERS

ADOLPH GOODMAN

During the past ten years a great deal of technical progress has been achieved in recording technic, and in recording and reproducing apparatus, so that today these advances should be reflected in greater entertainment value of the motion picture. In spite of such improvements there is much to be desired in the final presentation in theaters, mainly because there is a lack of proper coördination between the various phases that go to make up the ultimate sound as heard by the audience.

In this discussion, we shall point out the factors that must be considered and how they affect each other from the standpoint of the presentation in the theater. Assuming that the sound-track on the film is a faithful record of the original sounds, final results that the theater patrons hear depend upon the following five important, closely related factors:

(*1*) The sound-reproducing system.
(*2*) The theater acoustic condition.
(*3*) The screen.
(*4*) The adjustments of the sound system.
(*5*) The operation and maintenance of the sound system.

The Sound-Reproducing System.—It is fundamentally important that the sound-reproducing system be adequate, since it is through this medium that the audience is expected to hear sounds as the studio directors and technicians originally conceived them. It is well known that inadequate sound reproduction can ruin an otherwise excellent picture, while sound properly reproduced adds greatly to the entertainment value of the motion picture action.

In the early days, equipments having output power up to 10 or 12 watts were considered satisfactory, while in many instances the power available was as low as 1 or 2 watts. Modern presentation of sound motion pictures requires considerably increased power for proper dramatic effects, and it is not unusual for the larger theaters to use as much as 150 watts of undistorted power. Even greater power is needed for showing pictures such as Disney's *Fantasia* for creation of effects designed to stimulate the audience.

Realism in sound effects adds tremendously to the appeal of the screen action. Earthquake and warfare scenes must have sound accompaniment loud enough to make the audience feel that they are actual spectators at the scene of action. Thus, the small theaters as well as the large ones need apparatus having many times the power considered adequate in the past.

The Society of Motion Picture Engineers and the Academy of Motion Picture Arts and Sciences have studied the requirements for adequate theater sound equipment to meet the needs of modern pictures, and the following specifications represent the results of these studies:

(*1*) Volume range of 50 to 60 db.

(*2*) Amplifier capacity in accordance with recommendations of Academy of Motion Picture Arts and Sciences. (See *Research Council Bull.*, June 19, 1940.)

(*3*) Frequency response of 50 to at least 8000 cycles, with provision for extension to 10,000 cycles.

(*4*) Stage loud speaker system should have a high degree of efficiency, so that the required amplifier capacity need not be too great. The loud speaker system should have proper angular distribution so that all frequencies can be properly distributed throughout the theater.

(*5*) The sound-head should have a "flutter" content imperceptible to the ear.

(6) The equipment should be easy to install and operate. Necessary operating controls should be accessible.

(7) Components of apparatus should be easily accessible for maintenance and service operations.

(8) Adequate emergency provisions should be incorporated.

(9) Provision should be made for addition of apparatus that may be required in the future due to advancements in the art.

Theater Acoustics.—Regardless of how well sound is reproduced by the stage speakers, the theater acoustics greatly influence the final result. If a theater is properly designed acoustically, it will allow the sound to arrive at the listeners' ears with naturalness and realism. If the theater has any acoustic defects, the sound may be so changed in character that it arrives at the listeners' ears harsh, distorted, and very unsatisfactory.

In view of the technical progress that has been made in both recording and reproducing apparatus, it is more important than ever before that careful consideration be given to the acoustic design of the theater. This is necessary in order to take full advantage of the ability of modern equipment to give a faithful reproduction of the original sound.

Some of the more common defects found in auditoriums that are detrimental to good reproduction are high reverberation-time, echo, resonance, and extraneous noise from auxiliary equipment, or noises from sources outside the theater. Many of these can be overcome or eliminated by proper consideration of such problems in the original design. Specifically, attention should be given to the shape and size of the theater, the location and frequency characteristics of absorbent materials, and the insulation of walls and air-conditioning ducts to minimize the transmission of noise to the auditorium proper.

Fortunately, the present trend is toward coördination between acoustic treatment and the other functions of the auditorium such as lighting, decoration, air conditioning, *etc.* Thus the theater architect can carry out a definite decorative scheme and at the same time incorporate the necessary provisions to make the theater suitable from an acoustic standpoint.

Screen.—After the sound leaves the loud speaker system it must pass through the screen before reaching the audience. Just as the acoustic condition of the theater plays an important part in the final result, so does the screen influence the sound as heard by the listeners.

One of the improvements made in modern sound equipment is the

extension of the upper audio-frequency range. A poor screen will not allow the high-frequency tones to be transmitted with the proper intensity, resulting in a loss of brilliance of the music and lack of intelligibility of speech.

The sound-transmission properties of a screen depend upon several factors, the most important of which are the size and number of perforations per square-inch and the thickness of the screen material. If the holes are too small or the material is too thick, then the screen presents too high an acoustic impedance to permit good sound transmission.

Even though a screen may be satisfactory when first installed, it may adversely affect the sound transmission after a period of use. The perforations will gather dust, and eventually the hole diameters will be restricted, causing a reduction in high-frequency transmission. More frequently loss of transmission qualities are due to resurfacing the screen, in an attempt to improve the light-reflecting qualities. Any attempt to overcome such adverse conditions of the screen by recompensating the sound system to accentuate certain frequency bands results in ragged response and uncomfortable hearing conditions as far as the audience is concerned.

Adjustments of the Sound System.—While present-day theater sound apparatus is capable of reproducing with greater fidelity, the various components must be more carefully installed and adjusted than has heretofore been necessary. Low-level circuits should be carefully shielded and grounded to prevent the introduction of extraneous noises into the system. Correct power-transformer taps should be used, depending upon the line voltage. Voltages and currents in tubes, exciter lamps, and loud speaker fields should be checked to be sure they conform to specifications. In addition, the mechanical apparatus should be carefully inspected, oiled, and adjusted before any film is run. After these preliminary adjustments have been made, then the amplifier system should be set to conform to the frequency response characteristic set up for that particular system. Experience with a large number of installations has shown that the standard electrical characteristic will prove to be satisfactory in the vast majority of theaters.

To secure uniform frequency balance, proper distribution of high-frequency tones, and equalized volume levels in the various parts of the theater, it is necessary to pay special attention to the installation and adjustment of the stage loud speaker system. One of the most

satisfactory speaker set-ups is that in which the high frequencies are reproduced by a cellular type of horn and the low frequencies by some type of folded horn, with a suitable cross-over network to separate the two frequency bands properly. Since frequencies above 300 cycles become directional and beyond 2000 cycles have a beam effect, the positioning of the high-frequency horn is extremely critical in arriving at the best setting for uniform sound distribution. Also, the high-frequency horn must be properly set with respect to the low-frequency unit to obtain the correct phase relation between the sounds emanating from both sources. Usually, this dimension is specified by the manufacturer, but the actual relative positions are subject to slight variation in practice and must be checked during the tune-up process.

At present, the most satisfactory means for adjusting the balance and distribution in the auditorium is by use of the Academy Research Council Theater Sound Test-Reel and by careful listening tests in all parts of the theater. Since the test-reel contains selections of regular release prints from the various major Hollywood studios, once the equipment has been adjusted properly, it will reproduce the product of all studios with uniformly good quality.

Operation and Maintenance of the Sound System.—The preceding discussion pointed out how the condition of the theater and the equipment affects the sound reproduction. Of equal importance are the operation and maintenance of the sound system. Since the apparatus consists of delicate mechanical parts and sensitive electrical circuits, it must be kept in good condition at all times.

An important point in practical operation is the setting of the sound volume level for the auditorium to allow the audience to hear comfortably. It must be remembered that the frequency response of the human ear changes for different sound levels. When the response of the sound system is adjusted for proper balance between high and low frequencies for a certain optimal level in the auditorium, the pictures reproduced at this level are natural and pleasing. However, if the average level is increased or decreased, the sound quality changes appreciably and the balance is destroyed. Generally, if the level is set too low, the sound loses "screen presence," giving the impression that the actors are far behind the screen. If the level is too high, certain features of voice reproduction are overaccentuated and the sound becomes extremely irritating, (*e. g.*, excessively strong sibilants). Projectionists can determine the average

gain setting for their theaters that will give the most pleasing and understandable sound. Once this has been determined, there should be no necessity for "riding" the gain control during the showing of a picture.

Because of the many delicate adjustments that must be maintained it is extremely important that the equipment be inspected periodically. Quite often the quality of the sound will deteriorate slowly, but not enough to be noticed immediately. Such a condition can be checked quickly, provided the system is regularly adjusted, to be sure that it performs in accordance with the standards originally set for that particular type. Such inspections require the use of proper tools and test equipment, including electrical meters specially designed for the purpose, flutter indicator, and special test-films. Worn parts in the sound-heads should be replaced before they adversely affect the sound reproduction.