
British Standard Code of practice for
**Planning and installation
of sound systems**

(Formerly CP 327 : Part 3)

Code de bonne pratique pour la planification et l'installation des systèmes acoustiques

Leitfaden für die Planung und Einrichtung von Tonaufnahme- und -wiedergabesystemen

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This code of practice represents a standard of good practice and takes the form of recommendations. Compliance with it does not confer immunity from relevant legal obligations.

Foreword

This British Standard code of practice has been prepared under the direction of the Electronic Equipment Standards Committee and is a revision of CP 327 'Telecommunication facilities in buildings' Part 3 'Sound distribution systems' published in 1964, which is now withdrawn.

This code seeks to establish criteria for good performance and to ensure a desirable quality of reproduction, but as performance is in many important respects assessable only by subjective means, professional advice should be sought by a prospective user at an early stage in the planning of an installation.

This code is not applicable to concert halls, large theatres, cinemas, etc. where the most effective reproduction of sound is a primary objective. In these cases the most advanced multi-channel systems are likely to be used.

These systems are in the province of specialists who, in addition to the design of the sound reproduction system, should have a measure of control over the design and construction of the building itself, as far as its acoustic properties are concerned. The operation of such systems is generally in the hands of technicians.

Cathedrals and large churches, where reverberation presents difficult problems, are not dealt with in this code. In these cases the aim of the sound system is to produce high intelligibility of speech, a high degree of naturalness and the illusion that the sound is emanating from the speaker himself. In most cases a complete solution is not always possible, however time delay techniques described in BS 5428 : Part 8 may alleviate particular acoustic problems.

British Standard Code of practice for

Planning and installation of sound systems

Section one. General

1. Scope

This code gives guidance on the design, construction, use and maintenance of sound distribution systems for installation in buildings and outdoor stadia.

NOTE. The titles of the publications referred to in this code are listed on the inside back cover.

2. Definitions

For the purposes of this code the definitions given in BS 4727 : Part 1 and BS 661 apply, together with the following definitions and explanation of terms.

2.1 acoustic feedback and howl-round. The energizing of a microphone connected to an input by the acoustic output of a loudspeaker of the same sound reproduction system. As the effect increases so does the distortion, which may become intolerable, and eventually the system may oscillate continuously at some frequency, usually audible, at which the microphone to loudspeaker gain exceeds the loss in the feedback path. The system is then said to 'howl-round'.

2.2 channel. A signal path between input and output of a system.

NOTE. Although, for example, on a stereophonic disc, there is only one stylus tracing one groove, the cartridge has two outputs each connected to one of two channels designed to be independent, feeding separate amplifiers and loudspeakers.

2.3 decibel (dB). A ratio of powers, voltages or sound pressure levels.

NOTE. These can be conveniently expressed in terms of the logarithms of the ratios as follows:

- (a) ratio of two powers P_1 and P_2 (in dB) is $10 \log_{10} P_1 / P_2$;
- (b) ratio of two voltages V_1 and V_2 (in dB) is $20 \log_{10} V_1 / V_2$;
- (c) ratio of two sound pressures p_1 and p_2 (in dB) is $20 \log_{10} p_1 / p_2$.

If p_2 is equal to the standard reference sound pressure (20 μPa), the ratio of a sound pressure, p , to this standard (in dB) is called the sound pressure level.

2.4 matching. The correct coupling of a source to a load (e.g. a record playing unit to an amplifier, or an amplifier to a loudspeaker system). Correct matching enables units to work together satisfactorily. It does not necessarily imply maximum power transfer between units.

2.5 user control. A device, usually operated manually, for varying some characteristic that may require

adjustment during the normal functioning of the equipment.

2.6 pre-set control. A device for varying some characteristic of the equipment, the use of which is not required during the normal functioning of the equipment.

NOTE. Such controls are used only for setting up the equipment and are usually arranged to be inaccessible to unauthorized persons.

2.7 screened wiring. Wiring in which the insulated conductor or conductors are enclosed within a continuous conducting screen that should be earthed and sheathed with insulating material.

2.8 graphic equalizer. A device for adjusting the frequency response of a sound system providing individual adjustment of the gain in several frequency bands. It is normally included in a channel immediately prior to the power amplifier.

NOTE. The term derives from the usual arrangement of sliding controls that give a visual approximation to the frequency response for which the equalizer is set.

2.9 parametric equalizer. A device for adjusting the frequency response of a sound system by providing for increased and decreased gain at the extremes of the frequency range (bass and treble) together, possibly, with provision for increased or decreased gain over one or more central range of frequencies, the range and centre frequency being adjustable separately.

NOTE. Hybrid arrangements incorporating a graphic equalizer within a complex parametric equalizer are obtainable.

2.10 mixer. A specialized preamplifier with comprehensive control facilities allowing input signals from several sources to be combined.

2.11 sound power level. The power of a sound (in dB) relative to 10^{-12} W.

2.12 sound pressure level. The sound pressure expressed as a level (in dB) relative to 20 μPa .

NOTE. If the sound pressure level is measured with an instrument having a particular frequency response, known as 'A-weighting', the measured sound pressure level is expressed in dBA.

This weighting allows for certain characteristics of human hearing. The following table shows typical A-weighted sound pressure levels associated with certain familiar types of sound. These figures are given as a guide only and are subject to wide deviations.

Type of sound	Typical A-weighted sound pressure level
A jet aircraft taking off at approximately 25 m distance	125
A pneumatic drill at approximately 1 m distance	100
Busy road traffic at approximately 5 m distance from the kerbside	75
Conversational speech at 1 m	60
In a quiet living room (background)	40
Broadcasting studio (background)	25

2.13 bias compensation. A means to counteract the force (due to friction between the stylus and the disc) acting towards the centre of the turntable in a pick-up arm playing a disc record.

3. Exchange of information

3.1 General. The initial and ultimate requirements of the building should be ascertained as accurately as possible by consultation between the client, the architect, the consultant and the contractor. On the basis of this information, plans should be prepared showing:

- (a) details of the installation proposed;
- (b) the accommodation required for the equipment;
- (c) the chases, ducts and conduits, etc. required for the wiring (see 3.5).

3.2 Approval of installation. Approval of the installation proposed should be obtained from the client, and from any public or other authority who may be concerned.

3.3 Power supply. It is advisable to provide a mains power supply substantially free from electrical interference. This supply should not be shared with other equipment, especially motor-driven or thyristor-controlled equipment.

3.4 Accommodation. The location of equipment, microphones, loudspeakers, etc. should be agreed between the parties concerned so that the required accommodation can be reserved at an early stage.

3.5 Cabling plan. A cabling plan should be agreed in collaboration with those responsible for other services to enable the architect to specify the necessary ducts, chases, sleeves, etc. before building operations commence. Segregation from other services may be essential and therefore should be considered at this stage.

3.6 External lines. Wayleaves should be obtained for any lines that run outside the client's property. If external lines cross, or are in close proximity to, electric power or British Telecom lines, safety of the installation should be cleared with the appropriate authority.

3.7 Completion of installation. When a complex installation is completed, the following information should be supplied to the client.

- (a) Drawings indicating the position of the various items of equipment.
- (b) Diagrams showing the routing of all cables and wires together with their sizes, junction boxes and distribution cases.
- (c) Drawings showing the electrical interconnections of the various items of equipment.

(d) Maintenance handbooks for the various items of equipment.

(e) A schedule of recommended spare parts.

4. Time schedule

4.1 Ordering equipment. As the equipment may have to be specially manufactured, it should be ordered at an early date to ensure its availability at the appropriate time for installation.

4.2 Installation of equipment. Work may commence on the installation of the equipment at any stage of the building work provided that all of this work in the actual room, including decoration, is finished and that the room is dry. Electric light and power should be available at the commencement of installation.

Work of other contractors likely to give rise to dust, e.g. concrete mixing, should not be carried out in the immediate vicinity after installation of the equipment has begun.

4.3 Installation of loudspeakers, receivers and equipment for the reproduction of recordings. Loudspeakers, receivers, etc. should be installed as late as possible to minimize risk of damage and loss, and in any event not until the building work and preferably the decoration work in their immediate vicinity have been completed. It is essential to protect the equipment from dust and moisture until all construction and decoration work are complete.

In many instances it may not be possible to determine the positions and type of loudspeakers required until an acoustic survey has been made in the completed building. In others, sufficient information may be obtained by performing an acoustic survey when only the carcass of the building has been completed. This may not determine precisely the position of each loudspeaker, although it will generally afford sufficient information to determine where the necessary cabling should be run.

4.4 Wiring. Wiring in ducts, conduits and chases should be carried out at a late stage of building construction. The ducts, etc. should be dried out before wiring is begun. Surface wiring should be installed immediately prior to the final decoration.

Where sound installation is likely to be used for emergency communication purposes, the cables should have additional protection or be of a fire and damage resistant type, e.g. mineral insulated copper sheathed (MICS).

Section two. Equipment and materials

5. Sound system equipment

5.1 Specifications. The components of a sound distribution system should be specified in accordance with BS 5428.

5.2 Socket outlets and plugs. Socket outlets and plugs should comply with the relevant British Standards. (See also BS 5428 : Section 5.3.)

5.3 Quality of materials. The quality of materials and finishes, and the performance of all components, apparatus and equipment should be adequate to satisfy the recommendations given in section sixteen. They should also ensure satisfactory operation of the system throughout the life of the building or the period for which the installation is designed.

5.4 Fire and explosion risk. The provision of sound system equipment in any potentially explosive or flammable atmosphere should be avoided. If it is necessary to install sound system equipment in such a situation, the recommendations given in CP 1003 should be observed.

5.5 Climatic conditions. It is essential to ensure that all equipment will withstand any climatic conditions that may be encountered in transit, storage and use. Precautions to be taken during transit and storage should be clearly defined in the system specification and communicated to the appropriate persons.

6. Assembly and mounting of apparatus

6.1 General. All equipment should be designed for continuous operation. It should be robustly made and be permanently and securely installed in such a manner as to ensure convenient access for maintenance. Entry by unauthorized persons should be guarded against and locks should be fitted where necessary. Where the equipment is provided with an additional protective enclosure, it is important to ensure that:

- (a) the equipment is adequately ventilated to prevent overheating and moisture condensation;
- (b) there is some form of visual indication when the equipment is working that is not obscured by the enclosure.

All controls of the pre-set type should be either mounted behind cover plates that can only be removed with a tool or designed for adjustment only with a tool, e.g. a screw-driver. The operational controls required for normal use should be as few as possible, and all should have positive stops of adequate strength to withstand rough usage.

6.2 Simple installations. When only radio, either from an incorporated receiver or from a broadcast relay service, or a combination of radio, disc and tape reproduction is required, and few loudspeakers are to be connected, the radio receiver, disc playing desk, tape equipment and associated amplifier equipment may be conveniently mounted in a cabinet together with the controls. The cabinet may also include one of the loudspeakers.

Generally, such cabinets are not permanently fixed, and all their external connections are made by means of flexible cables, plugs and sockets. The sockets should be so positioned as to keep flexible cable lengths to a minimum and to avoid causing obstruction.

6.3 Comprehensive installations. When the amount of equipment cannot be accommodated in a cabinet as described in 6.2, the apparatus should be mounted on racks or in metal cubicles. The racks or cubicles should be arranged to take panels of a uniform width. The method of mounting equipment on racks depends upon the quantity of apparatus to be mounted, the need for ventilation and the accommodation available, bearing in mind that operational controls should be mounted at a height that can be reached conveniently. Racks or cubicles should be accommodated in a central control room that may be shared with other telecommunication equipment. The external finish of the metalwork should be durable.

Switches should be provided to enable the maintenance engineer to isolate any faulty section of the equipment, so facilitating maintenance and avoiding danger. The switching arrangements should enable the equipment not being serviced to continue in use.

6.4 Accommodation of equipment. Accommodation provided for all equipment, portable items and accessories, and its immediate surroundings should be kept clean, dry and at a moderate, equable temperature.

Suitable provision should be made for the safe storage of discs and tapes, portable microphones and maintenance spares, such as cartridges, styli and special components, and also for plans, drawings and maintenance records.

Where a control desk is provided (see 25.2), such accommodation may be conveniently incorporated in it.

Section three. Design

7. General considerations

7.1 General. Sound distribution systems are of two kinds. In the first (sound reproduction systems) sounds occurring at one place are reproduced in another place or places.

In the second (sound reinforcement systems) the sounds are reproduced near their place of occurrence, so as to reach a larger audience or to be heard at a greater distance or both. In the first kind, the original sounds may be reproduced at once or they may be recorded, e.g. on magnetic tape, and reproduced at some later time.

Such recordings contain the reverberation characteristics of the place in which they were made, and therefore the reverberation characteristics of the place in which the sound is reproduced are additive to these. Furthermore, the loudness of the reproduction often differs from that of the original. These causes have subjective effects on the listener. Also, the two ears of the listener give him directional information, which is not exploited when sound is reproduced over a single channel even if spaced loudspeakers are used. This last defect can be largely overcome by using a number of separate microphone-loudspeaker channels, suitably adjusted and arranged in space, e.g. stereophonic reproduction.

7.2 Stereophonic reproduction. Stereophonic reproduction should be used where the most pleasing reproduction of music is desired. This can be provided from a disc or tape recording. These systems need to be laid out by experts, but some general information on them is given in later sections. Difficulties can arise when the space is too large for one group of loudspeakers to provide adequately the level of sound required.

7.3 Classification of systems. The systems covered by this code may be divided into three main types, which are characterized by both the listening conditions and the desired effects. In a large system it is possible to provide, from the same source, different types for different places.

Type 1 systems aim at the highest possible quality of reproduction. This type is not usually justified unless the audience is expected to be critically interested in the programme for its own sake and not merely as a background. It is essential that the listening conditions are acoustically very good. It is also essential that the inputs to this system are of adequately high quality because any defects may sound more objectionable. Signal quality from an a.m. broadcast receiver, for example, may cause the reproduction from this system to sound worse than that obtained from a type 2 system using similar inputs.

Type 2 systems are those most commonly used. The effect desired is intelligible and natural sounding speech, and music of a quality that the average listener considers pleasant. It is desirable that the listening conditions are either already fairly good acoustically, or can be made so by acoustic treatment of an acceptable kind.

Type 3 systems aim mainly at the reproduction of speech of good intelligibility but not necessarily a high degree of naturalness. Music, if reproduced at all, would be of an acceptable quality but not necessarily of artistic merit. Where acoustic conditions are bad, e.g. because noise levels are high or reverberation excessive, this system should provide results that are the best that can be achieved in the conditions available.

7.4 Infra-red systems. Systems using infra-red links have the advantage of not requiring direct cable connections.

7.5 Sound reinforcement difficulties. In a sound reinforcement system of any of the previously described types, a limit to the amplification is set by the acoustical coupling between the loudspeakers and microphones. These components should therefore be selected with great care, since certain characteristics are of particular importance in this application, as is shown in later sections. Close-talking microphones, preferably of the noise-cancelling type, allow the greatest amplification. When they cannot be used, e.g. where it is not possible to ensure that the user maintains the appropriate speaking distance, directional microphones and loudspeakers are desirable, both as free from colouration as possible, and carefully positioned and oriented. In addition, the acoustical treatment of buildings can lessen the reflection of sound from loudspeakers to microphones. As a last resort, frequency shift equipment may provide a worthwhile improvement (see BS 5428 : Part 8).

7.6 Stand-by facilities. Failure of the system in some installations may have serious consequences, and some method of quickly restoring the service may be necessary; the time delay for this will depend on the application. Spares of some or all of the units of the equipment should be provided either to physically replace defective units or be arranged so that they can be switched on manually or automatically. The whole equipment may be duplicated and both sets of equipment operated simultaneously or with one set on stand-by for changeover in the event of a fault. The method adopted depends on the importance attached to system reliability, the speed of resumption of service and on the economic considerations.

7.7 Induction loops. The provision of audio-frequency induction loops for use with hearing aids fitted with induction loop pick-up coils should always be considered. Field strength requirements for such loops are specified in BS 6083 : Part 4.

NOTE. The operation of these systems in the UK is governed by Home Office Regulation BR 34 under which they have to be licensed when used in public places.

7.8 Preferred matching values for interconnection.

The preferred matching values for the equipment listed below are given in the following publications.

- (a) D.C. power supply voltages, see clause 4 of BS 5428 : Part 10 : 1979.
- (b) Phantom feeding, see BS 5428 : Section 5.3.
- (c) Connectors, see BS 5428 : Section 5.2.
- (d) Line amplifiers, input and output impedances and levels, see clause 10 of BS 5428 : Part 10 : 1979.

(e) Microphones, output impedances and levels, see clause 11 of BS 5428 : Part 10 : 1979, for professional types and clause 12 of BS 5428 : Part 10 : 1979 for PA and domestic types.

(f) Disc record playing unit, output impedance and level, see clause 13 of BS 5428 : Part 10 : 1979.

(g) Tuners, output impedances and levels, see clause 14 of BS 5428 : Part 10 : 1979.

(h) Tape recording and reproducing, impedances and input and output levels, see clause 16 of BS 5428 : Part 10 : 1979.

(i) Loudspeakers, impedance, see 18.1 of BS 5428 : Part 10 : 1979. For constant voltage, see 18.2.2 of BS 5428 : Part 10 : 1979.

(j) Headphones, impedance, see clause 19 of BS 5428 : Part 10 : 1979.

(k) Auxiliary units, impedance, see clause 20 of BS 5428 : Part 10 : 1979.

8. Applications

8.1 General. Sound distribution systems are used for the following purposes.

- (a) Sound reinforcement of speech, music, e.g. for stage performances.
- (b) Reproduction of recordings. The material may be recorded in various ways, e.g. on disc records or magnetic tape.
- (c) Reproduction of broadcasts, e.g. radio broadcast programmes from either a local radio receiver or a broadcast relay system.
- (d) Announcements: sound distribution from one or more microphones for staff location, paging, giving information, etc.
- (e) Artificial signals. These may be of various kinds, e.g. time signals, process control signals and emergency signals.
- (f) Simultaneous translation, e.g. a congress system.
- (g) Audio-frequency induction loop systems or other systems for the hard of hearing. A separate amplifier may be required to supply the induction loop.

These facilities may be required in the types of building listed in 8.2 to 8.10. In each case the appropriate type of system, as defined in 7.3, is given. A single system would normally give all the facilities in one building by switching, e.g. music may be given in a factory but not in the associated offices, while announcements may be common to both. An example of an extensive sound system for a large department store is shown in figure 1.

8.2 Educational establishments, halls and assembly rooms

8.2.1 General. In educational establishments, halls and assembly rooms where the reproduction is of direct interest to the audience, a sound system is used for:

- (a) sound reinforcement of speech, music and stage performances;
- (b) reproduction of music;
- (c) reproduction of broadcasts;
- (d) announcements;
- (e) artificial signals, e.g. for time signals and class-changing.

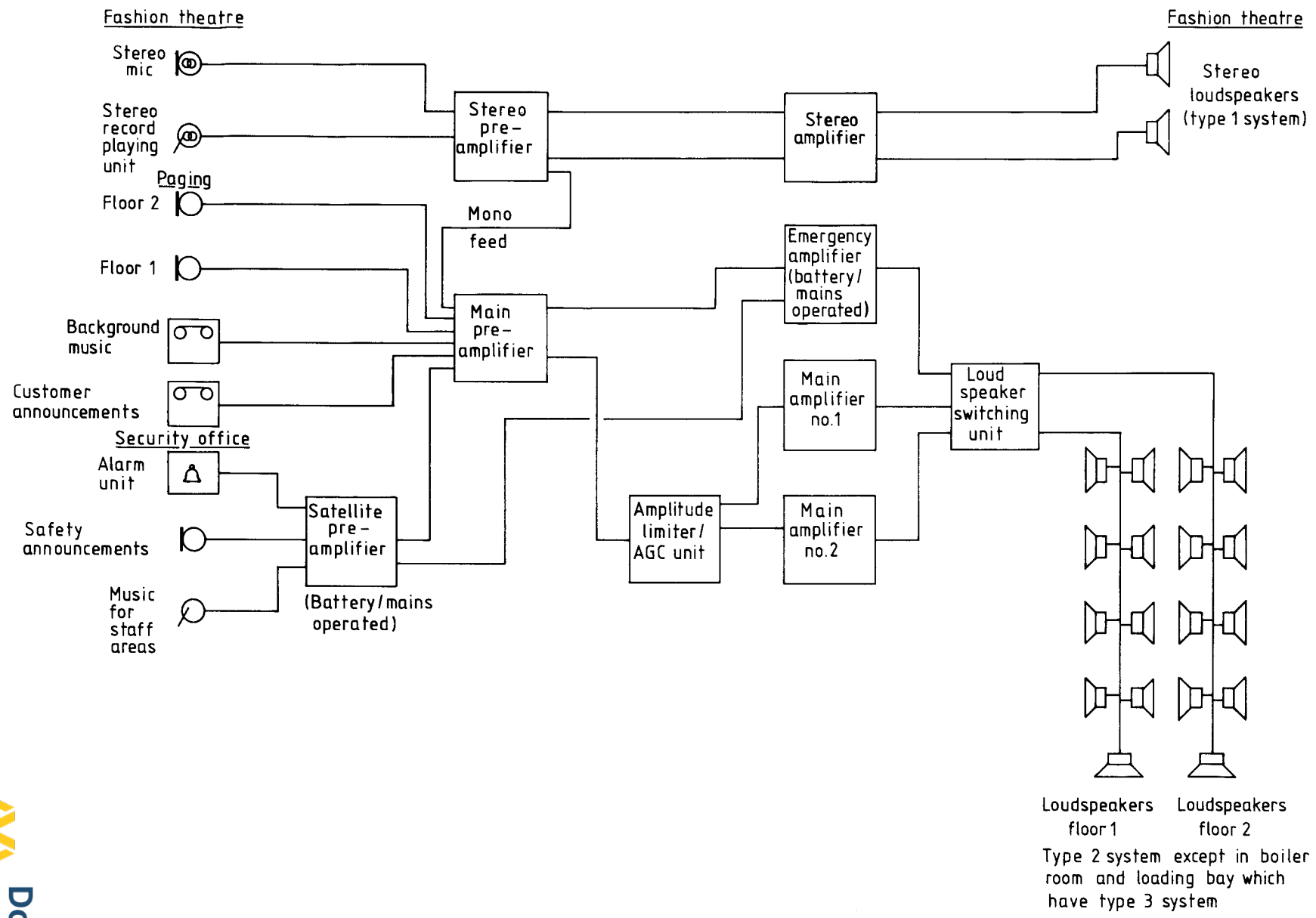


Figure 1. Block diagram of an extensive sound system for a large store

8.2.2 Normal system. The system normally used is type 2, but type 1 may be justified in rooms with good acoustics.

8.3 Places of worship

8.3.1 General. In places of worship where reproduction is of direct interest to the congregation, a sound system is used for:

- (a) sound reinforcement for pulpits and similar positions;
- (b) reproduction of recordings.

Many of the smaller churches, chapels, etc. may be classified with halls and assembly rooms, as they are acoustically similar to them.

Systems simulating the sound of church bells, carillons, etc. should be specific to these purposes and not associated with other sound distribution systems.

8.3.2 Normal system. The system normally used is type 2.

8.4 Factories, offices and department stores

8.4.1 General. In factories, offices and department stores a sound system is used for:

- (a) reproduction of music;
- (b) reproduction of broadcasts;
- (c) announcements;
- (d) artificial signals, e.g. for time and process control.

The quality of reproduction of records and broadcasts is only of secondary interest to the listeners who are engaged in other activities, but their attention may need to be drawn to the announcements and artificial signals by the use of higher sound levels.

8.4.2 Normal system. In factory areas with high noise levels or excessive reverberation or both, a type 3 system is normally used; for other applications a type 2 system is normally used.

Artificial signals can form part of the main system, but if they cause disturbing interruptions on the main system it may be preferable for those used for process control, etc. to have a simple system of their own. Canteens used as auditoria should have the same type of installation as halls and assembly rooms (see 8.2), and the use of a separate system is desirable.

8.5 Hotels and clubs

8.5.1 General. In hotels and clubs a sound system is used for:

- (a) sound reinforcement for banquet speeches, etc.;
- (b) reproduction of music;
- (c) reproduction of broadcasts;
- (d) announcements.

The audience is directly interested in the banquet speeches but only indirectly in the recordings or broadcasts, which are used as a background. For announcements, a higher sound level may be necessary to attract attention.

If a local performance is to be reproduced in other rooms, for entertainment rather than as a background, it is essential that the system is designed with this in mind.

8.5.2 Normal system. The system normally used is type 2.

8.6 Hospitals

8.6.1 General. In hospitals and similar institutions a sound system is used for:

- (a) reproduction of music;

- (b) reproduction of broadcasts;
- (c) live programmes;
- (d) announcements.

These places have special requirements that vary greatly with their function and size. It is essential that each installation is designed for the particular conditions but some general considerations are given in 8.6.2 and 8.6.3.

8.6.2 Announcements. A paging system for doctors, nurses, etc. may be required. This should be separate from that for the patients and can be a normal type 2 or type 3 system according to the conditions.

8.6.3 Main system. The principal purpose is a headphone service to the patients, but waiting rooms, nurses' rest rooms, etc. may also be served by loudspeakers. The main distribution is to bedside sockets to supply headphones, pillowphones, etc. for which a choice of programmes is desirable and for which individual volume controls are essential. The maximum volume should be such that the sound output from headphones not being worn is not disturbing to patients in adjacent beds, and the available output may need to be limited accordingly.

8.6.4 Normal system. The system normally used is type 2.

8.7 Airports

8.7.1 General. In airports and similar establishments a sound system is used for:

- (a) reproduction of music;
- (b) announcements.

The main interest is in the announcements, while music is used as a background. The noise level may be high and other acoustic conditions not very good. It is essential to design the system for maximum intelligibility, even at the expense of naturalness of reproduction.

8.7.2 Normal system. The system normally used is type 2 perhaps modified to type 3, with increased sound level for announcements.

8.8 Railway stations

8.8.1 General. In railway stations a sound system is used for:

- (a) reproduction of music;
- (b) announcements.

The main interest is in the announcements, while music is used as a background. The noise levels are high and have a wide range of variation: the amount of reverberation is often excessive. The area to be covered is usually so large that a number of spaced loudspeakers have to be used. The technical problems of the worst cases have not been completely solved, but by careful design an acceptable service can be provided. It is essential to design the system for maximum intelligibility, even at the expense of naturalness of reproduction.

8.8.2 Normal system. The system normally used is type 3.

8.9 Indoor sports stadia, swimming baths and exhibitions

8.9.1 General. In indoor sports stadia, swimming baths and exhibitions, a sound system is used for:

- (a) reproduction of music;
- (b) announcements.

The main interest is in the announcements, while music is used as a background. The noise levels are likely to be high and the reverberation is often excessive.