Sound Reinforcement for Banquet Halls, Ballrooms and Conference Rooms*

G. E. HORN, P. G. TANDY AND PERCY WILSON

Percy Wilson & Partners, Audio Consultants, Oxford, England

This paper describes some problems encountered in remodelling the system of sound reinforcement which had been installed at a hotel and had proved to be embarrassingly faulty. It includes what is thought to be a new approach to certain types of loudspeaker.

The origin of this research, and of this paper, goes back to the annual meeting in 1965 of one of the leading property organizations in Great Britain. This was held in what was then the most recently built hotel in London, which prided itself, and rightly, on the up-to-date electronic equipment that had been installed. The hotel was opened at the end of September, 1965. The meeting was held early in December, by the company which owned it. At that meeting, at which one of the authors of this paper was present, the chairman could not use the microphone because the system howled.

This system was not unusual. It was indeed typical of those that had been installed in other hotels and conference rooms, and on what was thought 10 years ago to be most advanced professional advice. (A more recently built hotel in London was provided with a similar system. It, too, howled).

The chairman consequently called in the assistance of our British Consortium, not only in regard to the particular room concerned in his own unfortunate experience, but also in other rooms where the specified installations had resulted in both similar and other distressing problems. These all had to be solved within a few months before two major events for which the hotel had been booked became due: the annual general meeting of the largest British company, at which an attendance of 1,000 shareholders could be expected; and the celebrations connected with the World Cup for Football. Both events would be made or marred by the sound system and therefore the hotel's prestige and future success were in balance.

There was also a problem concerning a restaurant in the hotel where a cabaret was in regular service. The audio installation there, as specified, was exceedingly primitive. Conditions even for the opening of the hotel by Prince Philip had been far from satisfactory. The Chairman had at once realized that expert audio advice was needed to rectify the specifications.

We make this preliminary statement because it has become quite clear, in our experience, that the recommendations of general architects on the planning of audio equipment are usually 10 to 20 years out of date. In all such cases, the services of competent audio consultants should be sought throughout the development of the plans, during the installation, and whenever alterations are required.

A recent problem at the same hotel emphasises this point. In the restaurant referred to earlier we had eventually arranged for the installation of a sound reinforcement system which entirely fulfilled the criteria to be discussed presently. After some six months of successful operation, it was decided for decor reasons to lower a section of the false ceiling. We were not consulted. It seemed a minor thing but the effect was to reduce the

* Presented October 23, 1968 at the 35th Convention of the Audio Engineering Society, New York

Fig. 1. Roof restaurant at Royal Garden Hotel, showing one of the bidirectional loudspeakers fixed to the ceiling in place of units behind the circular grilles in the ceiling.

feedback margin by about 10 dB, and we learned, almost by chance, that the system had become prone to howling, which it had not been previously. Fortunately we were able, when called in, to remedy this. But we should have been called in before the modification was made.

We determined, in the light of these facts, to construct a new technique for sound reinforcement in public halls. So we set about, first of all, to decide on the fundamental requirements. Before discussing these, however, we should like to comment negatively on a system which has been much favored in recent years. This is to install a number of small loudspeaker units operating through the ceiling of a large hall. In some quite limited circumstances, this can be useful. As a general device for large halls we find it hopeless. In many circumstances it causes howling. But even when that does not occur, confusion of sound in the auditorium is usual. There are roughly circular areas where some semblance of articulation is feasible from the cone of sound. If these overlap, then phase confusion occurs at the overlapping areas. If they don't, there are regions of comparative silence. The trouble is accentuated when the loudspeaker units are spaced 3 in. or more above a false ceiling, as was the case in the restaurant to which we have referred.

The sound distribution in fact was ineffective and muddy, even though more units had been added until eventually 27 units were used! It made the use of a microphone impossible unless the loudspeaker units in the immediate vicinity were switched off. We scrapped the loudspeaker system entirely and substituted an alternative. This consisted of 3 wedge-shaped bi-directional speakers fixed to the ceiling over apertures that had been made for some of the original units. They covered the whole area satisfactorily without confusion of sound, and enabled microphones to be used in the room without risk of howling. A picture of the room showing a wedge speaker and one of the abandoned units, which had operated through circular grilles with a series of ¼ in. holes, is shown in Fig. 1.

A second independent system was added for use when a cabaret was in operation, so as to reinforce the voices of the artists and yet make the sound appear to emanate from them, wherever the listener was seated in the room. For this we used a criss-cross directional arrangement consisting of two highly efficient bass units hidden away behind a false fluted wall; and two multicellular horns on top of the fluted wall. This is shown in Fig. 2. (The furniture down below had been temporarily placed where the cabaret artists normally perform). The system was successful beyond our hopes, as was proved in an accidental way. We had included a reverberation unit in the microphone channel. It was disposed on a platform near the musicians, so that the amount of reverberation could be varied by them. On the occasion in question the unit was accidentally kicked, and the microphone and amplifier had to be hastily switched off. It was only then that the audience realized that there had been any reinforcement in operation.

We mention this incident, thus early in this paper, because it well illustrates the value of one principle of reinforcement which we have come to regard as fundamental, even though it appears to be contrary to previous, and indeed to many currrent, ideas about public address (P.A.) systems. This principle is that if the loudspeaker can be heard as such, then the system is faulty. Only the person talking, the singer, or the band should be heard: the sound reinforcement should only serve to step up the audibility, without degrading the quality.

Of course, a generation of vocalists now use the loudspeaker as a producer rather than as a reinforcement of sound; and for them there are no rules which can apply. It is in any case a difficult doctrine. The artist wants to hear his or her voice come back from the loudspeaker. If that does not occur then the impression is created

Fig. 2. Roof restaurant, showing false fluted wall with multicellular horn on top.

that the microphone is not working. Sound engineers must try to persuade artists that this is all wrong. If artists can hear themselves in that way, then the apparatus is either faulty or the sound level is fixed too high.

When once this fundamental criterion is appreciated the effect of good sound reinforcement on realism can be fantastic. Perhaps this conclusion corresponds to the criticism of the distaff side in the home that their spouses always play records at too high a volume level. This is the first important distinction we would make between modern sound reinforcement systems and the older P.A. systems.

The second is equally significant. It is that the sound as reinforced should always and everywhere appear to come from the direction in which the original sound is produced. Thus, realism is destroyed if one hears the voice of the chairman of a meeting proceeding from above one's head or behind one's back. This criterion at once negatives most systems of distributed ceiling or wall-fixed loudspeakers. The loudspeaker in use must be behind and fairly close to the chairman, or other original sound source. This means that only one, or perhaps two (e.g. stereophonically placed) loudspeakers should be in operation at the same time.

This conclusion creates two very difficult problems. In the first place, it increases the risk of feedback from the loudspeaker to the microphone, which is just in front of the chairman. Secondly, it poses questions about the sound distribution and carriage throughout the auditorium. Obviously, the ideal is that the sound level, as reinforced, should not vary appreciably as one walks about in the hall. One should not have one's ears blasted when close to the loudspeaker, and straining above deafness at the other end of the hall.

It was this difficulty, one supposes, that was responsible for the system of distributed low-pressure sound sources throughout the auditorium, despite the disadvantages of phase differences and time delays. That system, we think, save in exceptional and limited circumstances in which the limitations are fully appreciated, is now virtually dead. We would only use it as a minor expedient to fill out small gaps in a major system.

These considerations inevitably led us to develop what in Britain is known as a line-source loudspeaker of special characteristics. In America such speakers are known as column loudspeakers, but this name is far too general and undescriptive. So in this paper we shall continue to refer to the type as "line-source" because this designation does describe its characteristics.

This type of loudspeaker was first developed in Britain in about 1933 for use in P.A. at the White City Sports Stadium in London, and later in certain London theatres. Its first champion was Paul H. Taylor, Managing Director of Pamphonic Reproducers Ltd. After the war, in consultation with P. H. Parkin, head of the Acoustic Section of the Building Research Board, his company installed a highly sophisticated type of line-source speaker in St. Paul's Cathedral in London. The principles involved are described in an illuminating lecture which Mr. Taylor gave to the British Sound Recording Association on 18th January 1963.[1]

[1] Published in *British Kinematography* (March 1964). See also British Patent No. 817,899 (1956/1959).

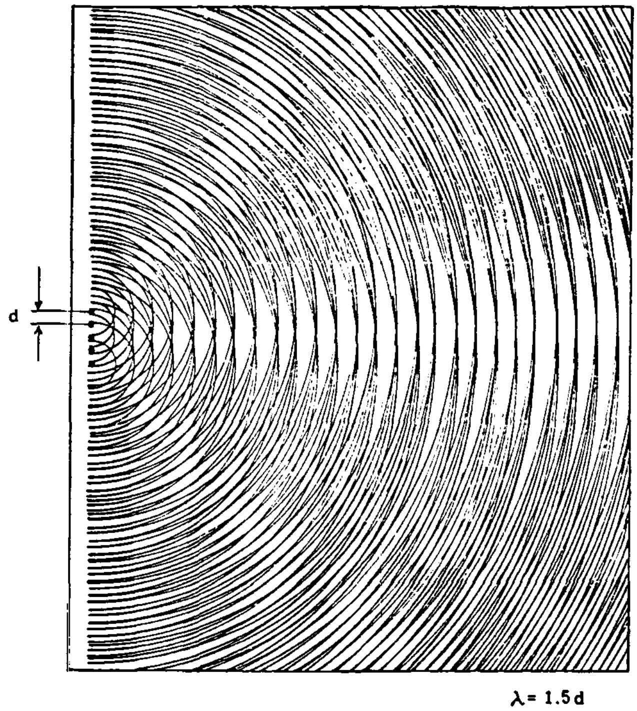

Fig. 3. Main and secondary beams from a line-source speaker (following Taylor).

The account showed that by arranging loudspeaker units in vertical line connection, it is possible to secure a highly directional distribution, though unfortunately there are small side lobes which can be troublesome. These are illustrated in Fig. 3 which is reproduced from Taylor's paper.

Our problem was to reduce the magnitude of these side lobes and at the same time to produce a controlled pattern of the forward distribution. We needed a fan-like pattern, wide laterally and restricted vertically, much like the light pattern in an automobile fog-lamp. We also needed a cylindrical wavefront. But alas, all previous descriptions had suggested that to obtain a frequency range down to 50 Hz, a line-source speaker would have to be about 18 ft long, which was impossible for our applications.

We realized at once that we had 3 variables in a line-source design: a. the number of units and their geographical distribution; b. signal voltage distribution to the units; and c. frequency distribution to the units. By laborious empirical research, we were fortunately successful in securing the balance we needed. We now have a line-source speaker system, of no more than 5 ft 6 in. in length, which has a 50 W rms power-handling capacity and a range from 30 Hz (without frequency doubling) up to over 10 kHz. Its distribution over most of the range is in a fan 20° vertically and 120° horizontally, with a 20 dB drop outside those limits. But these dimensions are under control.

At this stage our associate, Professor G. L. Wilson, of State College, Pa., became aware of what we were doing. He informed us that our conclusions were consistent with the modern theory of transducer sources. We had, in fact, stumbled empirically into the techniques of the Dolph-Tschebyscheff polynomial analysis of shaded arrays, such as are analysed in Chapter 11 of Dr. Alber's *Underwater Acoustics Handbook* (Pennsylvania

State University Press). But we had a significant advantage over that theoretical analysis, which referred to point sources of defined frequency. Our sources were small loudspeaker units, and we found that the directional qualities we desired could be secured over an extended frequency range but systematic adjustment of the three variables mentioned above.

Theoretical explanation of these results is not available. It should be noted, however, that the theoretical picture in Fig. 3 is based on a specific distance apart of the point sources. We have used elliptical L.S. units so that the effective distance apart should vary with frequency. For this reason, we have, fortunately, been able to devise some rules of design, in addition to those specified by Mr. Taylor. Thus, we know how to secure a fan-like distribution and even how to reduce the side-lobes to such an extent that their influence becomes negligible. Our major problem was to extend the response in the bass without increasing the length beyond about 6 ft, and without reducing substantially the power-handling capacity, which previous theory (e.g. as to binomial arrays) had forecast. Our first prototypes only functioned satisfactorily down to about 80 Hz. This, of course, was amply sufficient for speech reinforcement, but hardly good enough for music.

Fig. 4. Line-source speaker with central full-range unit. There are six elliptical units above and six below, arranged in a dihedral pattern with three to a side. These are fed differentially.

We therefore devised a method of combining the line-source technique with two modern techniques of rear loading. The results exceeded our hopes. Our latest 5 ft 6 in. line-source speakers go smoothly down to below 30 Hz without observable frequency doubling. Moreover, even 4 ft speakers can be designed to go down to 60 Hz, from which frequency they tail off until 40 Hz is only just audible. It is still not possible to hold the directional characteristic constant in the bottom 1½ octaves, but this has little operational significance.

A picture of the 5 ft 6 in. speaker is shown in Fig. 4. The middle bulge accommodates a wide-range 12 in. diameter unit, which also has a central subsidiary treble cone. Where only speech reinforcement is required only tweeters were put. Above and below, spaced in a dihedral pattern, are 3 + 3 elliptical units, differentially fed both as to signal frequency and signal amplitude; there are 12 such units in all. We found that signal inputs of these units as well as their positioning relative to the position of the 12 in. unit made a significant difference to the shape of the wavefront.

We were fortunate in that one of the members of our Consortium could hear even slight phase differences when the prototype speaker was fed with pink noise. To him a shift of ½ in. in the position of the 12 in. unit relative to the ellipticals was detectable. Such a facility always saves a lot of time in analysis and design. It was specially valuable in this case because we had found ordinary methods of measurement to be inadequate, even anechoic chamber measurement. To verify the conclusions of this colleague a special but rather laborious system was devised.

In a garden in Oxford, some distance from traffic noise and even from inhabited residences, a telegraph pole was erected. From one of the arms of this a microphone was slung so that it could be swung through an arc. Underneath, flat on the ground, the loudspeaker was placed, and its orientation could, of course, be varied. At dead of night (but not indeed as in *Ruddigore*, "When the night wind howls in the chimney cowls, and the bat in the moonlight flies") various signals were fed to the loudspeaker, picked up by the microphone at various angles, measured and plotted.

By this simple means the speaker characteristics could be determined. Thus, a series of line-source designs of prescribed characteristics was prepared. None is available for the general commercial market. All are kept on file, so to speak, to meet specific requirements. One type was used for the Hall of Christ Church, the largest College in Oxford University; another for the canteens of Morris Motors; a third for the Conference and Ballroom of the hotel already mentioned (the Royal Garden Hotel); four others for the Ballroom and Great Room of Grosvenor House in Park Lane, London, where as many as 2,000 guests may be accommodated for a conference or dinner party; and recently an entirely different outdoor type for a sports stadium in the north of London, where previous systems had excited threats of legal injunctions from residents in the neighborhood on account of objectionable noise. The problem there has been to contain an adequate volume of sound reinforcement within the area of the stadium but with a sharp drop outside. The fan-like beam, suitably directed, has succeeded even here.

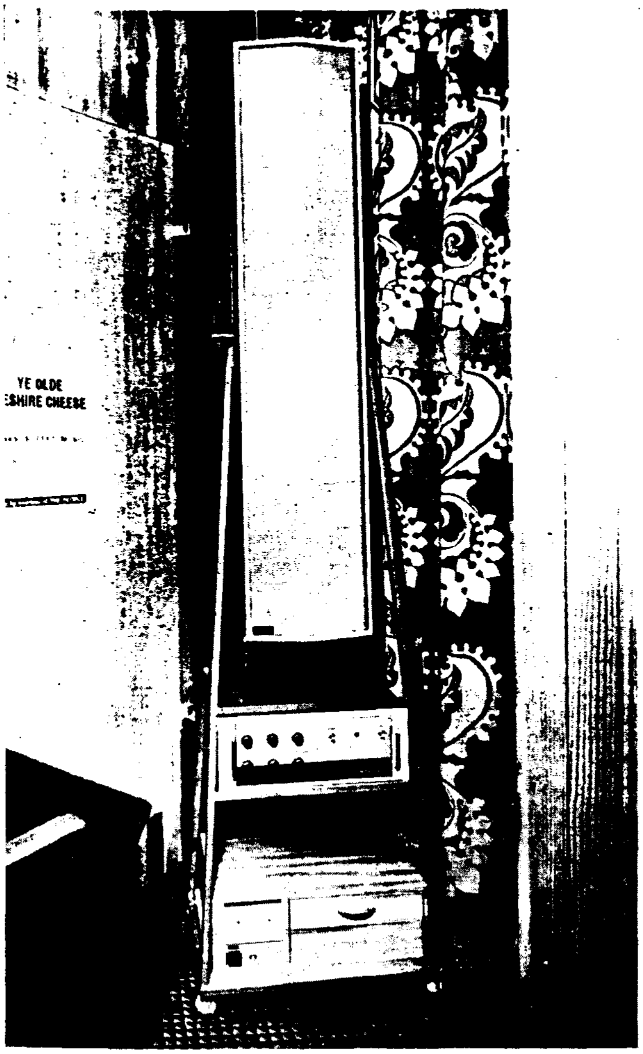

Fig. 5. Line-source speaker and amplifier on trolley.

A particularly valuable type is shown in Fig. 5. It is transportable on a trolley on which is also mounted a 30 W rms amplifier and a box for microphones, leads, etc. It is thus selfcontained and can be set up for operation in a couple of minutes. It has proved of great service in smaller conference rooms, and of course it is also available as a stand-by in case of failure of major equipment. So far (over 2 years) this has not occurred.

To secure the desired results each system has to be "tailor-made" to suit the conditions that have been disclosed by initial tests, using the prototype speakers for assessment. In this connection, it may be noted that our tests in many modern halls have suggested that one can no longer rely absolutely on the Sabine reverberation formulae. The conditions of selective reflection and absorption are significantly altered by the propagation characteristics of these loudspeakers. Thus, we found the acoustical conditions to be very tricky in the Palace Suite at the Royal Garden Hotel where the World Cup celebrations were to be held. We tried, at first, to use the highly directional microphones developed by Electro-voice Inc., but we were defeated by the fact that at each selected pickup point the reflected sound was greater than the direct sound. All the walls are reflective and most of the absorption is in the ceiling.

A picture of this suite is given in Fig. 6, a photograph taken just before the annual general meeting of Imperial Chemical Industries in 1966. The loudspeakers in the corners are the primitive speakers that had been installed before we were called in. They proved to be inadequate, causing confusion of sound in the suite, and with a pronounced resonance at 3 kHz. The intention had been that all four speakers, one in each corner, should be in operation at the same time, for each one was unable to carry the length of the room. No wonder confusion resulted.

We scrapped them and substituted our own line-source speakers at strategic points. The result was that an I.C.I. Director reported that at the annual general meeting, when he had deliberately stationed himself at the far end of the suite, he was able to hear the words of the chairman quite distinctly without even realizing that sound reinforcement was in operation. The loudspeaker can be seen just off-center behind the chairman's desk. In spite of this proximity there was no howling.

The audio problem in this suite, incidentally, had been complicated by the fact that housed in the ceiling there was a 40-ton soundproof partition which could be brought down to divide the suite into two unequal portions. Thus, we had to devise a system operable either for the suite as a whole or for two independent suites; and the conditions specified in this paper had to be satisfied in whatever position the customer chose to put his rostrum, platform or high table. We found that six of the line-source speakers were needed, one at each end (as shown in Fig. 6) and two on each of the longer walls. With one exception, only one loudspeaker was working at any time. The exception was when the high table for a dinner party was arranged along one of the long walls of the full suite. In that case, the two loudspeakers mounted on that wall were brought into operation. Since two independent channels were provided to cater for the case when the suite was divided, it is possible, when two speakers are needed, as just mentioned, to operate the system in stereo.

On the right of the picture in Fig. 6 the kitchens were situated, and above them a press gallery extending the full length of that longer wall of the suite. By opening a

Fig. 6. Palace Suite at Royal Garden Hotel showing original, elementary line-source speaker (four units) in the corner, and the new long-range line-source speaker (Fig. 4) behind the Chairman's desk.

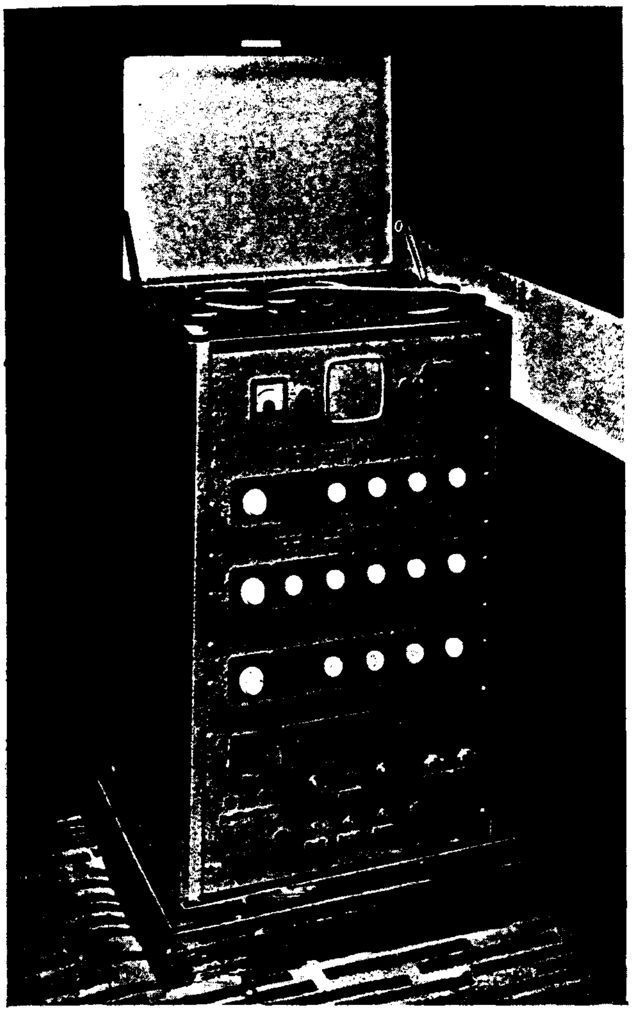

Fig. 7. Superseded console, showing jumper panel on top and rotary knob control panel on face. Behind is a white table which extends the whole length of the press gallery, and beyond that a movable partition. When this is removed, activities in Palace Suite may be viewed from the gallery.

series of sliding partitions the events in the suite could be overlooked from the gallery in which, of course, the apparatus for controlling the versatile system of lighting was also situated. There, too, were the two audio control consoles. One glance at these, when we were called in, persuaded us that they must be scrapped. The contractors had put them in, following a design made, we were told, by American consultants for another London luxury hotel. They were clearly the result of trying to do a complicated job too cheaply. The contractors were not in any way to blame. They had just made a tender in a competitive market on specifications drawn up by architects and décor consultants who were not knowledgeable in audio.

Figure 7 gives a picture of one of these consoles. It was placed well away from the partition on the right above the white table. It was therefore impossible for an operator to see what was going on in the suite below. On top of the console, under the hinged lid, were 20 sockets from microphone points in the suite, and 10 sockets connected to preamplifier inputs. The gain controls of these preamplifiers were the rotary knobs placed lower down on the front face of the console. By this means any microphone point could be connected to the preamplifier by a jumper lead on the top panel. The fatuity of the arrangement was that the jumpers, which were all preset at the start of a function, were in the most accessible positions, but the gain controls, which had to be operated during the course of the function and often in a very subdued light, were inaccessible. Fumbling was bound to occur, and it did occur.

Multiple rotary controls, which seem to be in almost universal use in P.A. equipment, are unsuitable for applications of this kind. Only linear or quadrant faders such as are used by broadcasting and recording companies are good enough; and they must be significantly placed so as to avoid fumbling, especially towards the close of a session when the operator is probably tired.

It is our firm belief that to date not nearly enough attention has been paid by architects, décor specialists and contractors to the fundamental psychological and physiological factors that affect the operator. There is not enough logical thinking in advance. This is fully borne out by the responses of the working electrician operators we have questioned. On the basis of their answers, we designed a pair of desk control units let into the white table close to the partition that separated the press gallery and the suite. (Fig. 8). We did *not* complicate them by including jumper plugs and sockets or even loudspeaker switches: these were catered for close by, again in a straightforward logical arrangement. But we did include group mixing facilities, prefade monitoring facilities and a VU meter so as to assist the operator in positive fashion when he was controlling an important function. No hitch has ever occurred, even when there have been as many as 30 microphones in service at any important event. Curious, is it not, that V.I.P.'s think they suffer a loss of prestige unless a personal microphone is allotted to them, to be switched in only when the appropriate occasion arises—if it ever does!

We have suggested above that in our opinion faults in design and installation may often be attributed to architects and décor experts rather than to contractors who have to submit competitive tenders for carrying out the work. This is indeed borne out by the welcome which contractors gave to our Consortium. All desired to have a reputable body of consultants, *acting for the clients*, who could hold an even balance.

Subsequent to the successful completion of the assignment at the Royal Garden Hotel, we were invited to

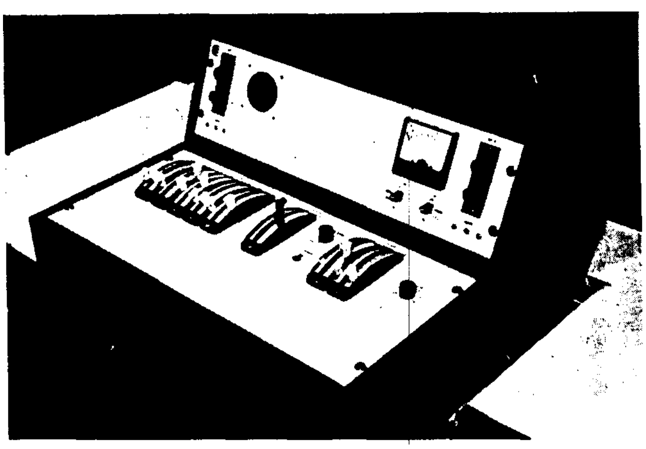

Fig. 8. New control console, as let into the white table so that operator can view the proceedings in the suite when controlling.

Fig. 9. Ballroom at Grosvenor House, showing control booth at far left.

Fig. 10. Great Room at Grosvenor House, showing balcony all around.

make recommendations for an even more elaborate system at Grosvenor House. There, not only is there a large ballroom (Fig. 9) which, with its large foyer, can also be used for banquets and conferences; there is also a much bigger room, with gallery all round, known as the Great Room. (Fig. 10). This, we understand is the largest hotel conference room/banquet hall/exhibition room in Britain. It can accommodate over 1,500 people for dinner at circular tables each seating 10 to 12; and there is still adequate space left over to provide for a band and a small dancing floor. A large foyer has recently been added. Even so, it was proposed that the two rooms should have a two-way audio link, so that what was happening in one room could, at will, be relayed to the other.

The existing audio facilities, although installed in 1962, had only been designed for very limited functions and little forethought had been given to expansion; so it was readily agreed that the best course would be to abandon them. For instance, the amplifiers and control panels, on the rack principle, were situated in little rooms yards away from the areas they served. Supervision leading to instant control was impossible. Moreover, the power-handling capacity of the line-source speakers that were in use was so small, and their design so primitive, that as many as 10 of them distributed in pillars round the Great Room had to be brought into operation to secure full coverage. The result was painful distortion.

We decided on using at least four 50 W rms solid state amplifiers in the Great Room, and 2 such amplifiers for the Ballroom. The system in each case should be controlled from preamplifier and mixer consoles housed in specially constructed glass-faced booths which should overlook the service areas. We budgeted for as many as 56 microphone points in the Great Room and 34 in the Ballroom, connected to jumper sockets on accessible panels in the respective booths.

We also decided that in each case the amplifying system should be a twin-channel arrangement, but with suitable blending mixers so that by a very simple control the service could have mono, dual mono, or stereo. A speaker-switching panel was devised and superimposed upon a plan of the room showing the location of each loudspeaker, so as to facilitate both a pre-determined plan or even an instant switch-over (Fig. 11).

Our principal objectives were those described earlier in this paper, namely that:

1. On no occasion should more than two loudspeaker systems be functioning at any one time, though switching to alternatives could be done at a few seconds notice;
2. The sound, as reinforced, should always appear to come from the source of the original sound, wherever one was listening;
3. All the loudspeakers in operation should be adequate to deal with the signal input without distortion;
4. There should be no obvious difference in volume level as one walked about the room;
5. Similarly, it should not be obvious that sound reinforcement was in operation.

The last two conditions were particularly difficult. Yet we managed to construct speaker systems to fulfill them, at any rate to the extent that no more than a 6 dB difference in level is found in the Great Room between a measuring point close to the loudspeaker system and a

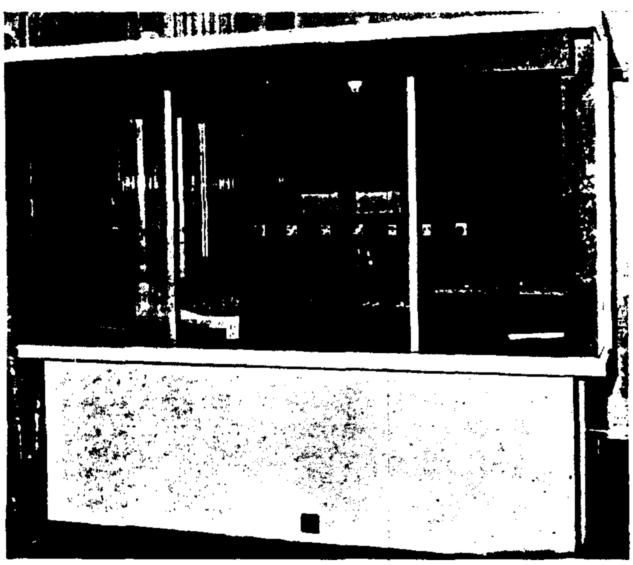

Fig. 11. Inside the control booth for the ballroom, showing loudspeaker switching panel **(left)**, control desk **(center)**, and microphone jumper panel **(right)**.

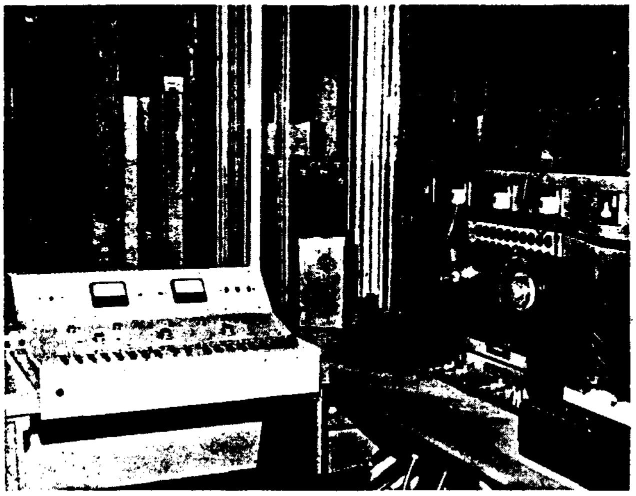

Fig. 12. Details of the control desk in the ballroom.

point at the farther end of the room. A major problem we had to face was that of phase difference, lest we might become involved in designing a time-delay device. Fortunately this has not occurred. For any much larger auditorium, e.g. for the new Free Trade Hall in Manchester, we think it would. But "sufficient unto the day is the evil thereof."

We constructed special prototypes, following the general principles already mentioned, and found that they worked satisfactorily in the Great Room. There was a minor snag in the Ballroom, where we found that direct reflection from ceiling-supporting pillars on the one hand, and large mirrors on the other, was causing a liability to feedback from two loudspeakers at the end of the room.

To complete this paper, and to be of service to other Consultants who may be presented with similar problems, we think it would be well to give some details of the type of control console we have found to be desirable.

It should, of course, have inputs from an adequate number of microphone points. Although we had planned for 56 such points in the Great Room to cater for all likely contingencies, to facilitate instant switching, and to avoid trailing cables in operation, we concluded that not more than 30 inputs were likely to be needed on even the most demanding occasion. In the Ballroom only 15 were likely. So we budgeted for a control desk with two groups of 8, that is, 16 inputs. This seems to be about the maximum that one operator can supervise. It was duplicated for the Great Room. (See Appendix and Figs. 12 and 13.)

Each input was provided with its own preamplifier and slider gain control. There is also a spring-loaded press button to transfer such input to a separate monitor amplifier and small loudspeaker or headphones. Each preamplifier, through its gain control, is connected to a mixer amplifier with group gain control and tone controls, and thence to the console output amplifier. Six outputs for other services are available, as well as the feed to major 50 W amplifiers.

Two distinct such systems, each with VU meter, are provided on each desk, giving the required facilities for stereophony or independent dual channel, as previously described. They are separately powered and fused.

One other novel feature should be mentioned. In our

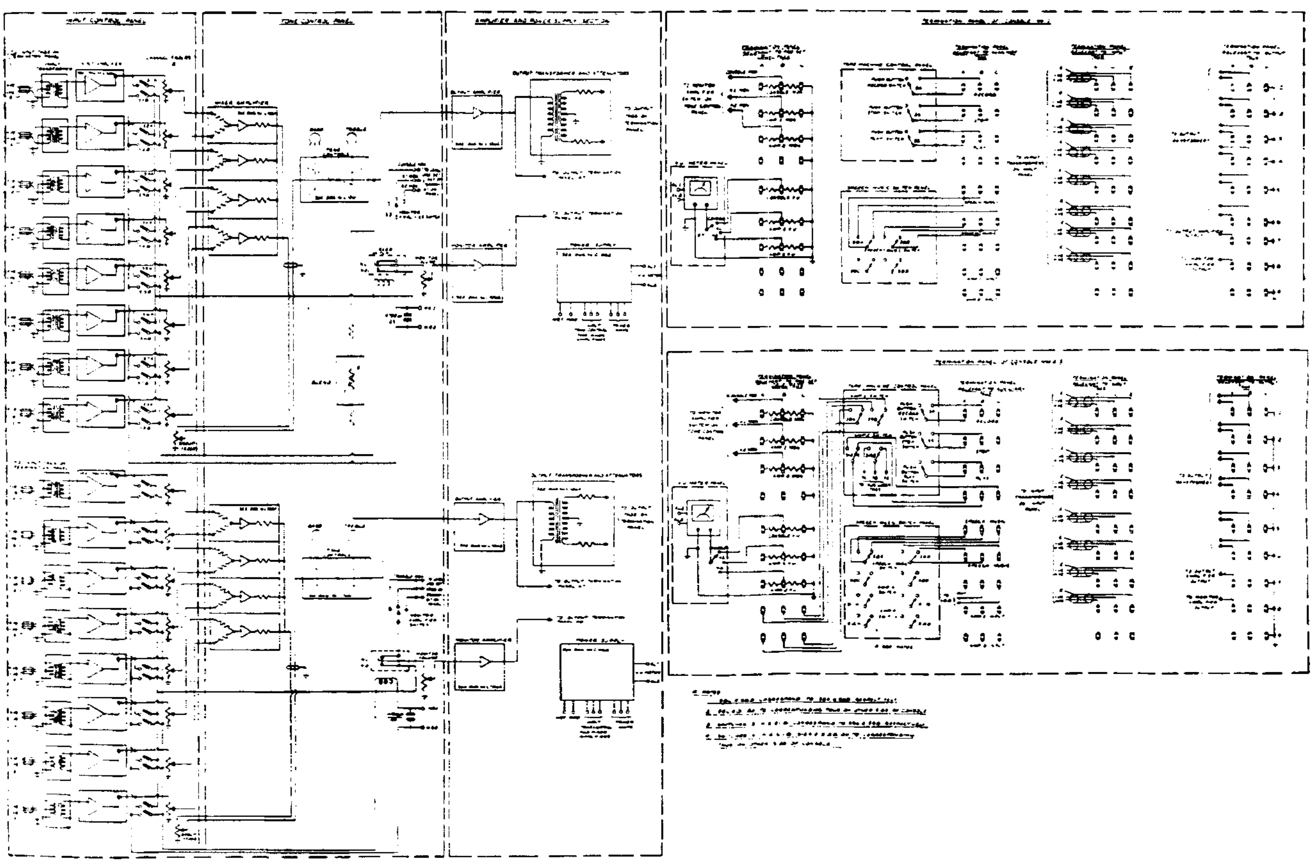

Fig. 13. Schematic of each control circuit for the ballroom shown in Fig. 9. There are two on each desk with a blend control between them and with outputs both to the main amplifiers and to the control booth in the other room.

latest design we have not provided separate inputs for record players, tape recorders, radio, or film devices. We have found it preferable to doctor each of these sources so that they appear to the control with the impedance and level characteristics of a standard microphone. They can be jumpered to any input, as all inputs are identical. The consequence of this is that such devices can be plugged in at any of the microphone points in the room, or of course in the control booth itself. This adds enormously to the versatility and flexibility of the system. As an example, if a discotheque should be in operation late into the night or small hours, the settings in the control booth may be preset and the whole function controlled from the record-player or tape deck at a suitable position in the hall itself.

We would wish, in conclusion, to add a grateful acknowledgement of the skilful assistance we have received from Mr. Arthur Radford, of Radford Audio Ltd., in the design and fabrication of the control consoles for the Grosvenor House project.

APPENDIX

Outline Specification for Control Desks at Grosvenor House

Inputs.—There are 16 inputs in two groups of 8, all identical sensitivity, 50–100 mV from 30–200 balanced line, and of good overload characteristics. The two sets of 8 arranged in left hand and right hand groups, fed from separate power supplies.

Mixing.—Each input amplifier terminates at a slider-type fader. From these the signals enter a common mixer amplifier (one for each group). This includes another slider control, (L and R adjacent to each other), the group fader, and a pair of bass and treble controls with the usual lift and cut arrangements. There is also a switched control: Speech/Music.

Outputs.—After the tone controls the signals in each group go to an output amplifier of low output impedance, and then via six parallel-connected output isolating attenuators to give a 4 dBm level with adequate overload capacity. These outputs to be free of ground, and the pads to be such that grounding or shorting any output will not affect any others. Two outputs from each group feed the main power amplifier. Two terminate in tip ring sleeve jacks. Two combine with the like output of the other group to give a pair of mono outputs with a blend control. A pair of VU meters, normally across the console output amplifiers, may be connected by key switches across either of the power amplifiers associated with that channel.

Monitors.—A pair of monitor amplifiers is provided in the form of a small stereo amplifier with its own power supply. These feed a pair of small loudspeakers in the control booths or stereo headphones via a tip ring sleeve switched jack. The input for the monitor amplifiers is selected by a key switch from the console output or either output amplifier (as with the VU meter). In addition, a spring-return push switch associated with each of the 16 input faders may disconnect the monitor amplifier from the switch bus and transfer it to the output of that channel amplifier so as to give prefade facilities.

Auxiliaries.—Console and monitor On/Off switches and lamps. Stop/start switch for a remote tape recorder. A means of linking two consoles together. Radio frequency filters and suppressors to avoid pick-up from other electrical equipment and from the language translation system, which operates in the 60 to 120 kHz range.

THE AUTHORS

Percy Wilson was born in Halifax, Yorkshire, England in 1893. Receiving a B.A. in mathematics with first class honors from Oxford in 1915 and an M.A. in 1918, he served as a Naval Instructor in the Royal Navy from 1915 to 1919. During the latter part of this period, he was Lecturer in Applied Mathematics at the Royal Naval Engineering College.

From 1919 to 1938 Mr. Wilson was an administrative offcer in the Ministry of Education after which he became Principal Assistant Secretary in charge of the Roads Department of the Ministry of Transport. As a hobby, he acted as Technical Adviser to the British magazine **The Gramophone** from 1924 to 1938. After his retirement from public service in 1953, Mr. Wilson became Technical Editor of that magazine. In 1966 he resigned from the magazine to become an acoustics and audio consultant.

Author of **Modern Gramophones and Electrical Reproducers** (1929) and **The Gramophone Handbook** (1957), Mr. Wilson is a member of the Audio Engineering Society and a Founder Member of the British Sound Recording Association.

•

Geoffrey E. Horn was born and educated in Oxford, England. He joined the Engineering Department of the British Post Office in 1938 and worked on Carrier Telephony and other telecommunications equipment. During World War II he served with the Wireless Branch of the Royal Air Force in the Far East.

Leaving the Post Office in 1950 Mr. Horn started a business which has come to specialise in the supply and installation of high quality domestic and commercial sound equipment.

Mr. Horn, who is 48, has contributed many articles and technical reports to British Audio Magazines.

•

Philip Geoffrey Tandy was born in Oxford, England in 1913 and sang for his early education in the Queen's College Choir, Oxford. He pursued further studies in mathematics and science, and obtained his amateur radio license in 1933, call sign G2DU which is still active. Mr. Tandy was with Pye's of Cambridge during the War working both in communications and Radar. He went into partnership with Geoffrey Horn in 1950 and has been busy with it ever since. Mr. Tandy has contributed technical reviews on High Fidelity equipment.