sound towards the rear of the hall. This method has been successful in the Festival Hall, where the reflector suspended over the orchestra (and which weighs 12 tons) has maintained the definition over the whole auditorium.

Although these main criteria for the design of a concert hall can now be regarded as fairly well established, they are, except for reverberation time, all qualitative in character, and there is an obvious need for much more quantitative work.

Turning now to design problems for speech in auditoria, we are on more solid ground. The major single advance in recent years has been the work of Haas[1], who investigated the effect of a single echo on the audibility of speech. Extensions of his work made possible a quite reliable criterion[4] for the transient response of an auditorium. This criterion indicates how a room shape should be designed to ensure that the reflected and reverberant sound gives the maximum intelligibility and naturalness, although there is still need for far more knowledge on the actual behaviour of rooms.

But it is in its application to speech reinforcement systems that the Haas work has so far proved most useful, in two ways. First, a single echo (that is, a delayed reproduction of the original sound, usually coming from a different direction) when delayed behind the original sound by 5–25 msec. has to be about 10 db. greater in intensity to be heard as loudly as the original sound, and at lesser intensities is not detectable as a separate source ; secondly, at greater time-delays, Haas determined how loud such an echo can be before it begins to interfere with the speech. For example, an echo of intensity 3 db. lower than that of the original sound is not heard as an obtrusive echo until it is more than 60 msec. behind the original sound.

The applications to speech reinforcement systems are obvious. In a simple system employing only one loudspeaker, this loudspeaker should be placed so that the sound from it arrives 5–25 msec. after the sound from the human speaker. The loudspeaker sound can then be up to, say, 7 db. greater than the original sound without being heard as a separate source. In large auditoria where a single loudspeaker is not sufficient, the same effect can be maintained by using electrical delays. Thus in St. Paul's Cathedral the loudspeakers installed down the nave are delayed by time intervals corresponding to the path differences between the pulpit and the listener plus 5–25 msec., so that all the sound appears to be coming from the pulpit. The second Haas result can be used to ensure (by suitable directivity of the loudspeakers) that the sound travelling back towards the source is at a sufficiently low intensity to avoid interference.

An interesting further application of this work, although not yet tried in practice, would be in debating chambers and other similar auditoria where the original sound might come from anywhere in the floor area. Thus we can envisage a rectangular chamber split into a number of zones each with its own microphone and loudspeaker. When speech is coming from one zone, the loudspeakers in all other zones are automatically switched to have the proper time delays and amplitudes so that the sound received at any point conforms to the Haas criteria.

One more development in speech reinforcement systems should be mentioned. It has been noted that to maintain intelligibility in the presence of reverberation it is necessary for the intensity of the direct sound to be greater than that of the reverberant sound. Now, with an ordinary loudspeaker radiating more-or-less equally in all directions, the intensity of the direct sound has fallen, due to the inverse square law, below the intensity of the reverberant sound at quite a short distance away. But if we use a directional loudspeaker so that most of the energy is radiated towards the listeners, although, of course, the inverse square law still operates, the intensity of the reverberant sound is so much less that the loudspeaker is effective over a greater distance. This is most conveniently done using a vertical line-source which in the vertical plane is sharply directional, producing a main lobe perpendicular to the line and several subsidiary, negligible lobes. At St. Paul's such a line source, 11 ft. long, placed close to the pulpit is effective over the whole dome area (110 ft. in diameter) in spite of the very long reverberation time.

In conclusion, reverting to concert halls, as our knowledge of the desirable acoustical characteristics increases it may become possible to use electronic aids for music as well as speech. For example, in any large modern concert hall it is difficult to get a long enough reverberation time (by having a large volume and a small amount of absorption) without the risk of serious echoes. It might be possible to introduce artificial reverberation by electronic means which would be indistinguishable from natural reverberation and which, possibly, could be altered to suit the particular type of music being played. But this development is some way in the future.

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[1] Haas, H., *Acustica*, **1**, 2 (1951).
[2] Parkin, P. H., and Taylor, P. H., *Wireless World*, **58**, 2 and 3 (1952); see also *Nature*, **169**, 214 (1952).
[3] Parkin, P. H., and Allen, W. A., Purkis, H. J., and Scholes, W. E., *Acustica*, **3**, 1 (1953); see also *Nature*, **168**, 264 (1951).
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OBITUARY

Dr. C. E. Walker

Dr. Charles Edward Walker died at his home in Brighton on June 6 at the age of eighty-two. He was educated at St. George's College, Weybridge, and studied medicine at St. George's Hospital, London, where he was assistant medical registrar ; he qualified M.R.C.S., L.R.C.P. London, in 1909. After holding a demonstratorship in zoology at the Royal College of Science, South Kensington, he went to Liverpool as assistant director of cancer research and honorary lecturer in cytology to the Liverpool School of Tropical Medicine. He obtained the degree of M.Sc. Liverpool in 1909, and of D.Sc. in 1911 ; afterwards he went to Glasgow as director of research at the Royal Cancer Hospital. Dr. Walker served in the R.A.M.C. with the rank of major in the First World War in France, Gallipoli and the Middle East. He returned to the University of Liverpool in 1919 as lecturer in histology and associate professor of cytology. He held this appointment until his retirement in 1937.

Dr. Walker's work, largely cytological, was published mainly in the form of contributions to the *Proceedings of the Royal Society*. He was also the author of several books on cytology, heredity, evolution, and the cancer problem. The present revival of interest in the Golgi apparatus naturally recalls his contributions to the subject. He was among the first, twenty-five years ago, to carry out deliberate experiments concerned with the importance of physico-chemical fixation artefacts in the usual tissue sections. His experiments were done with chemical models, employing microscope slides coated with films of mixtures of albumin, lecithin, peptone, together with olive oil and ground egg yolk. The slides were fixed and stained by procedures normally employed for the demonstration of the Golgi apparatus in tissue sections. Structures bearing a striking resemblance to the classical Golgi net were obtained, which led Walker to doubt the existence of the apparatus in the living cell. This work laid the foundations for the more recent investigations such as those of Palade and Claude.

Apart from his scientific publications, Dr. Walker was editor of *Shooting and Fishing* during 1897–1903, and author of "Shooting and Fishing on a Small Income". His tall upright figure, his monocle and his military bearing made him a notable figure in the medical school at Liverpool. His staff knew him as a courteous and kindly man. He skated and fenced. He was a skilful and intrepid yachtsman; in 1904 Mr. Justice Channell awarded him the Challenge Cup, the highest distinction of the Royal Cruising Club, for a single-handed cruise down channel to France and back in his 2-ton sloop *Thebe*.

His wife died last year and he is survived by a son and daughter. N. M. Hancox

NEWS and VIEWS

Physics in Queen Mary College, London: Prof. H. R. Robinson, F.R.S.

After having held the chair of physics at Queen Mary College, University of London, since 1930, Prof. H. R. Robinson is retiring at the end of the present session. His teaching and research work were greatly influenced by his association with Rutherford, first as a student and lecturer in the University of Manchester and later at Cambridge as the holder of the Moseley Research Studentship of the Royal Society. Prof. Robinson's scientific work has been largely concerned with radioactivity and X-rays. He developed with Rutherford the β-ray magnetic spectrometer, and has spent many years in the study of the application of X-ray methods to the elucidation of atomic structure and to the accurate determination of atomic constants. He has always had a special interest in the history of physics, which he regards as an essential part of the education of all serious physicists. During his long tenure of the chair of physics at Queen Mary College he has become well known to a wide circle through his services to the College and to the University of London. He became a member of the governing body of Queen Mary College in 1945 and vice-principal in 1946. He is a member of the Senate of the University of London and takes an active part in the work of several of its committees. He has also served on the Councils of the Royal Society and the Physical Society. His other interests are indicated by the fact that he has been for many years a member of the governing body of the Old Vic Theatre.

Dr. G. O. Jones

Dr. G. O. Jones, who is to succeed Prof. Robinson, has been reader in experimental physics at Queen Mary College since 1949. He graduated at Oxford in 1938 and worked under Sir John Townsend on high-frequency gas discharges and later at Sheffield under Prof. W. E. S. Turner on physical properties of glasses. He then joined Prof. F. E. Simon as a member of the U.K. Government atomic energy project, working mainly at the Clarendon Laboratory, Oxford, and also for short periods at the University of Birmingham and in the United States as a member of a Government mission. After the War, Dr. Jones was appointed as Nuffield Foundation Research Fellow at the Clarendon Laboratory under Prof. Simon. He prepared the detailed design and directed the construction of the large liquid-hydrogen plant serving the low-temperature department of the Laboratory. Later he worked on the properties of solid helium and of low-temperature glasses. During this period he was retained as a consultant by the Atomic Energy Research Establishment, Harwell. Since his appointment as reader at Queen Mary College, Dr. Jones has made new developments in the techniques of attaining low temperatures and has built up a research team working in the field of solid state and low-temperature physics. In this work high-pressure, magnetic, micro-wave and ultrasonic measurements are being employed in a number of investigations at temperatures down to those attainable with liquid helium. Dr. Jones is a member of the Papers Committee and also of the Low Temperature Group Committee of the Physical Society, and is a representative of the University of London on the governing body of the Sir John Cass College.

Mullard Research Laboratories

Mr. P. E. Trier and Mr. G. Knott have been appointed joint managers of the Mullard Research Laboratories. Mr. Trier, who graduated as a Wrangler in the Mathematical Tripos at Cambridge, was engaged at the Admiralty Signal and Radar Establishment during 1941–50. During the War he developed direction-finding techniques in the metre and centimetre regions. Later he was head of the V.H.F. Communications Group. He joined the Mullard Research Laboratories in 1950 as head of the Communications and Radar Division. In his present appointment, Mr. Trier will direct the Electronics Laboratory and be responsible for work in the fields of communications, radar, special circuit techniques, particle accelerators, special components and materials, valve applications, ultrasonics, and metal physics. Mr. Knott, sometime scholar of Clare College, Cambridge, commenced his career as physicist to the Calico Printers' Association in 1935. During 1937–40 he was engaged in research on X-ray crystallography in the University of Cambridge, and worked on molecular structure factors in relation to complex organic crystals. He is also the author of a number of publications on flash tubes and their use in high-speed photography. In 1940 Mr. Knott joined the Mullard Radio Valve Co., Ltd., first as development engineer on transmitting valves and later on V.H.F. valves. He was placed in charge of the Mullard Vacuum Physics Laboratory when it was formed in 1946. Mr. Knott will continue to direct the work of this laboratory in his new appointment, and will be responsible for V.H.F. valves, gas discharge tubes, and photo-electric devices.