American Research on Acoustics.

By ALAN E. MUNBY.

THE Wallace Sabine laboratory of acoustics, a photograph of which is here reproduced (Fig. 1) is situated at Geneva, Illinois. It is a three-story building of brick and concrete specially erected for its purpose and forms a unique design, consisting of two structures under one roof, an inner room or sound chamber completely insulated from an outer shell. Figs. 2 and 3 show a plan and section of the building, the main feature of which is the sound chamber 27 ft. by 19 ft. and 19 ft. 10 ins. high. Here the original intensity of the sound is measured. The walls of this chamber are of 18-inch brick coated with cement outside and with wood fibre plaster inside, and the room as shown in the section has a separate concrete foundation. From this room half-way up

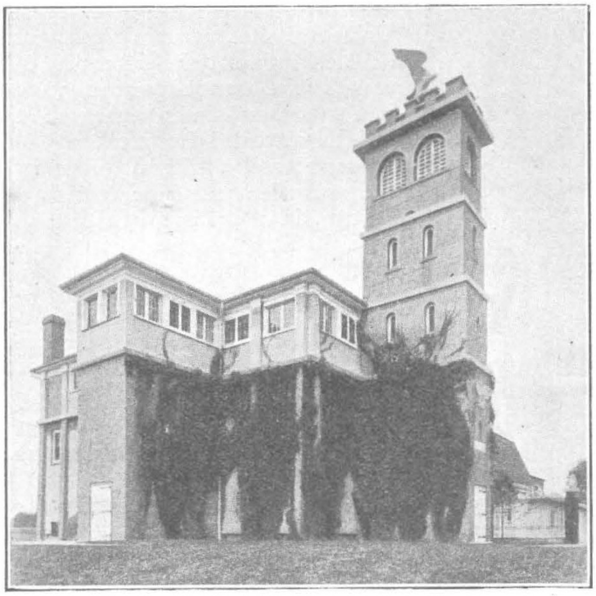

FIG. 1.—Riverbank laboratories, Geneva, Illinois.

its walls three small testing chambers are provided furnished with heavy steel doors to exclude sound completely. Materials to be tested are placed across these chambers, when the doors are opened to admit sound from an organ in the sound chamber. The organ is a complete 73 pipe instrument giving all the tones of the musical scale from C 64 to C 4096. It is operated electrically by the observer, who notes the time before a sound becomes inaudible in the test chamber. To ensure equality of sound distribution in the sound chamber a large steel reflector mounted on a central shaft is made to revolve in the room on a vertical axis. The main work, up to the late Prof. Sabine's death, has been connected with the calibration of the sound chamber and its instruments. This laborious undertaking completed, the activities of the laboratory should rapidly command a wider interest.

The present director of the laboratory, Prof. Paul E. Sabine, has recently published the results of an investigation on the nature and reduction of noises as occurring in business offices. Scarcely anything has been done in the way of investigation on the subject of noise, though the topic is obviously of wide interest. Prof. Sabine begins by pointing out that the sound-absorbing qualities of any material vary widely with pitch, and instead of attempting to apply data obtained for musical sounds, he wisely deals with the matter *de novo*, taking the actual sources of sound, such as the click of a typewriter, as the source for experimental purposes. A distinction is drawn between sounds in the open air and those in which reflection takes place, as in a room, from the point of view of the effect of the noise of one operator upon another. All but two or three per cent. of sound waves falling on a hard plaster wall are reflected, and in an experiment cited there were found to be 500 reflections before a given sound reached final decay. It would seem, therefore, that as much absorption as possible by walls and ceilings should be aimed at to prevent these reflections.

An important point brought out by these investigations is that the absorption efficiency of a given material for both musical sound and noise is greater when the material is employed in small units. In discussing practical measures Prof. Sabine alludes to linings of felt for walls, covered with some fabric, to light porous tiles and plaster, citing a plaster recently developed which is a much better absorber than ordinary plaster. He even makes a distinction between painted and unpainted walls, the general tendency of paints being to fill up a porous surface and thus decrease sound absorption, and numerical data are given showing the relative value of various surfaces in absorbing the sound of a typewriter. In these experiments the difference of power of absorption of a given material for various sounds, though existing, was found to be small.

Prof. Sabine has made a separate and special investigation of the absorption of sound by rigid walls and finds that the refraction effect on the passage of the sound into the new medium is of only trifling importance. His experiments have recently been further extended to tests upon artificial aids to hearing. He classifies the types of instruments commonly used and describes investigations to measure the difference of times during which residual sound may be heard with and without a particular instrument as a measure of the increase in loudness produced by that instrument. His results are illustrated graphically. It was observed that the highest tones in every case were less loud with instruments than without, suggesting that the short wave lengths enter the small cavity of the external ear better than do the air columns of instruments. With certain instruments also the lowest tone (frequency 128) was less well heard than without their aid. Prof. Sabine does not consider the prospects of improvements in alleviating extreme deafness to be good, but points the way by reference to the amplification of telephone currents by the thermionic tube, and he suggests a joint attack on the problem by physicists and physiologists.

Another series of experiments on sound-proof partitions has recently been conducted by Mr. F. R. Watson, also of Illinois University, which are described in Bulletin No. 127 of the University. The results

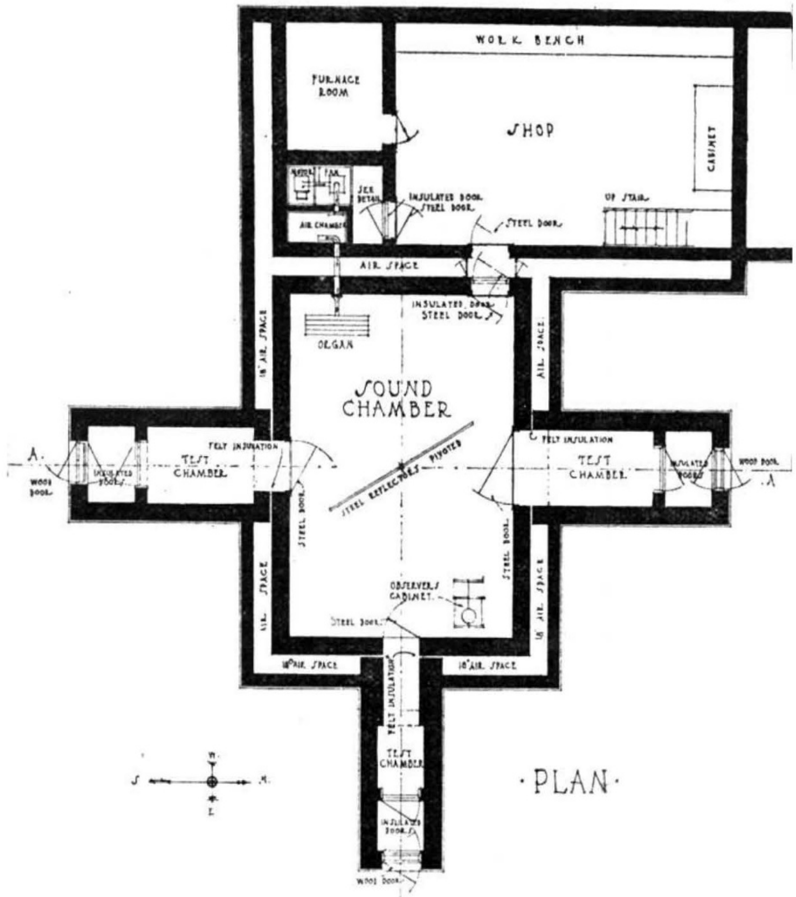

FIG. 2.—Plan of Acoustic Research Building.

have led to conclusions somewhat at variance with generally accepted ideas.

Sound, on striking an object, is reflected, absorbed, or transmitted, and usually all three results occur. In any particular case a definite amount of energy has to be got rid of in these ways, and for sound-proofing one may aim chiefly at reflection or absorption. When sound waves in one medium encounter another medium having a different density, the progression of the waves is disturbed, a certain amount of reflection takes place, some of the energy is absorbed, that is, converted into heat, while the amount transmitted through the medium will depend on its thickness and properties, such as porosity and rigidity.

In practice the materials used to separate rooms or buildings are usually of a complex character, and their rigidity will depend not only on their nature and thickness, but on the area of the separating wall. Hence the problem of assessing sound transmission is a very complex one. The author of the bulletin cited directs attention to the very detrimental effect as regards sound insulation of even small apertures caused by ill-fitting doors or by ventilators; he also makes a distinction between sounds due to air waves striking a separating medium and vibrations such as those caused by machinery, the former best resisted by heavy and rigid walling, the latter by arranging for absorption of the vibrations by beds of sand or like loose material.

From a useful résumé of previous experiments on sound transmission, the conclusion is drawn that rigidity is a deciding factor in sound prevention, and some experiments recently conducted by Prof. P. E. Sabine are cited which showed that a plate of glass three-sixteenths of an inch thick transmitted less sound than two glass plates with a sheet of celluloid sealed between them of the same total thickness. A series of tests made at the Music Building, Chicago, in 1895, is quoted, which tends to show that an air space between materials forming the two sides of a partition is of much less value for sound prevention than is commonly supposed, and that benefits which accrue from such space are almost wholly negatived by the inevitable connexion at intervals for structural reasons between the two sides.

In Mr. Watson's experiments use was made of the Rayleigh disc resonator, which admits of much more accurate and comparable results than are possible by aural comparisons adopted by many earlier experimenters. A very large number of materials were tested, and these were in all cases of satisfactory area—

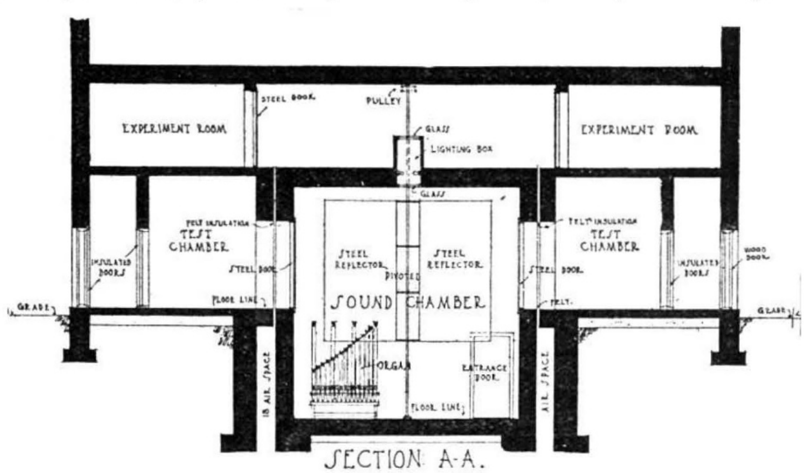

FIG. 3.—Section of Acoustic Research Building.

at least 3 ft. by 5 ft. An adjustable organ pipe blown at constant pressure formed the source of sound placed at the focus of a 5 ft. parabolic reflector facing the partition to be tested in the manner shown in

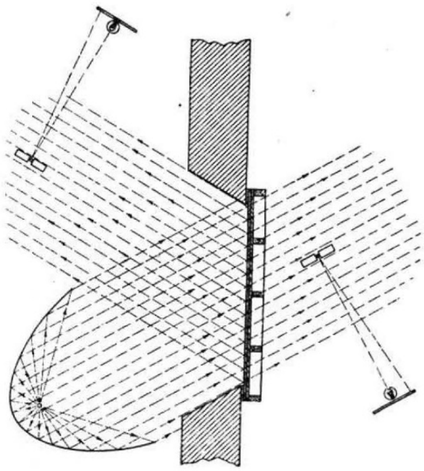

FIG. 4.—Diagram of apparatus for testing transmission and reflection of sound.

Fig. 4, and a disc resonator was placed on either side of the partition to measure the transmitted and reflected sound. Fig. 5 shows a photograph of the apparatus in use, and the observer's box provided to prevent disturbance due to his presence. The general results of the tests confirm the views of earlier experimenters cited. Porosity results in absorption but a good deal of transmission, while rigidity results in large reflection; the reflection from hair felt, for example, being 6, while that from Sackett board of the same thickness is 42·7.

The effect of openings such as doors were also tested, and it was found that if the transmission through a 2-inch metal lath and plaster partition has an intensity represented by 0·93, a 2-inch well-fitted solid wood door with three-sixteenths of an inch clearance from the floor increased this to 7·3 and with half an inch clearance to 11·7, showing the importance of even very small apertures. As regards composite partitions, the author's conclusions are that the small gain in internal reflection at surfaces of different density is usually more than counterbalanced by the loss in total rigidity, and thus in reflecting power of the initial surface of contact. In practice, of course, too much reflection may be detrimental to the uses of the room in which the sound is generated, and as is pointed out, absorption must be the ultimate aim for the destruction of sound, which means its conversion into heat.

Sound-proofing is of special interest in the modern type of business building, where, in order to economise space and admit of adaptability for changes of tenancy, the constructural brick wall has been so largely replaced by the thin partition, and experiments of the type described should be of great value to architects who are responsible for specifying materials and construction. The present writer's experience is that a wall composed of Fletton bricks, which are very dense, is less effective in stopping sound than one composed of stock bricks, which are more porous and less regular.

It would be unwise to generalise too much from the experiments described; with floors, for example, the direct contact produces conditions different from those of a sound wave in air, and through a solid concrete floor every footfall may well be heard in the room below. Much further work on this subject is needed, and it is to be hoped that investigation in this country will supplement and extend what is being done elsewhere.

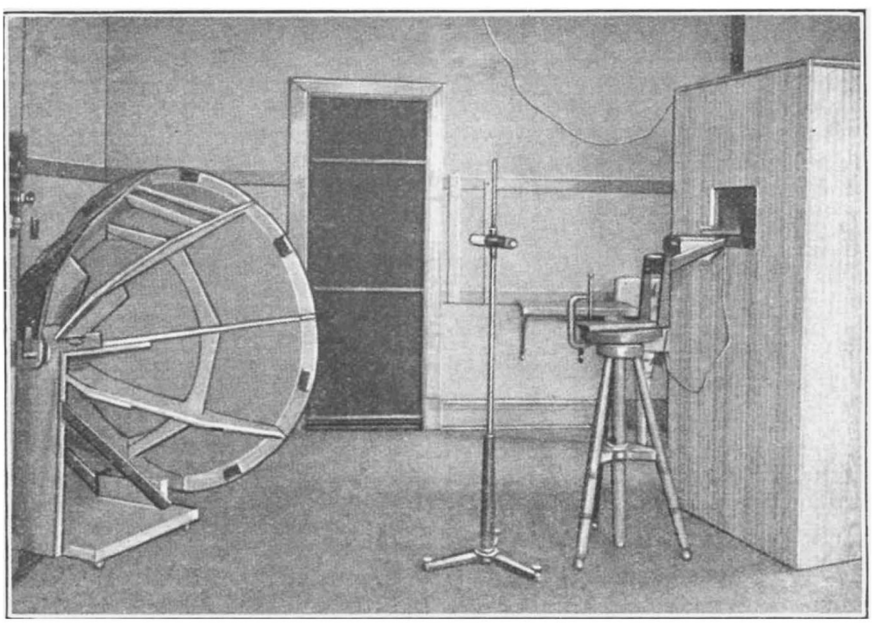

FIG. 5.—General view of apparatus.