Sir Humphry Davy, his mother being a niece of that distinguished scientist, the inventor of the miner's safety lamp. Educated at Marlborough, Cambridge, and St. Bartholomew's Hospital School, he has gone from honour to

Royal College of Physicians of London.

He holds honorary degrees from Oxford, Pennsylvania, Durham, Glasgow, Edinburgh, Bristol, Birmingham, Jefferson, Padua, Dublin, and Bordeaux.

As an author, he is known the world over for his works on "Diseases of the Liver," "Old Age," "Clinical Lectures." With his predecessor in the Regius Chair of Physic, the late Sir Clifford Allbutt, he was joint editor of a System of Medicine in eleven volumes, and just

was at Oxford.

In 1926, he was awarded the Gold Medal of the British Medical Association, "in recognition of his scientific work and of his distinguished services to the profession and to the Association.

Hospital Service Department Notes

THE REDUCTION OF NOISE IN HOSPITALS

By Harvey Agnew, M.D.,

Secretary, Department of Hospital Service, Canadian Medical Association

Toronto

Every advance in civilization seems to create or be accompanied by undesired complications. The introduction of industrial machinery caused a social upheaval and the motor car created new problems in law enforcement. We are very proud of our beautiful, well-constructed new hospitals, which are such a tremendous advance upon their predecessors; yet it is to be regretted that so many of them are proving to be veritable "loud speakers," amplifying every sound and transmitting it to the farthest corner of the building. This annoyance, this *bête noir* of the administrator, is due in large part to the modern fireproof type of construction, wherein the rigid framework of steel, tile, or concrete permits the undiminished transmission of sound. Reflection from the hard fireproof floors and transmission by the greatly increased plumbing now considered essential to hospital efficiency augment this effect. It is the purpose of this article to consider some of the factors involved, and to suggest means of amelioration or eradication of this source of irritation.

The effect of noise on a sleeping individual has been studied by Laird in the sleep laboratory at the Colgate Psychological Laboratory. Although not awakened by the noise of a passing truck, a sleeper may be so disturbed that his systolic blood pressure may rise 20 mm. and special galvanometers show a decided increase in muscular tension. The wearing, exhausting effect on the nervous system of the constant repetition of sound is now scientifically recognized. Were the effects not so indirectly manifest, were the results more easily traceable to their source, there is little doubt but that infinitely greater effort would be made than at present to eliminate preventable noise from our daily life, to turn off the jazz when we are trying to think or talk, to demand noiseless typewriters, and to gain a larger measure of that thought-clarifying silence upon which we insist when sinking a putt, drawing the target-trigger, or loosing the feathered shaft. And if desirable for the well, how essential for the sick that we preserve that "Silence which, like a poultice, comes to heal the blows of sound."

The Behaviour of Sound

Sound waves travel at the rate of 1100 feet per second. In an enclosed building they almost immediately impinge upon some surface and are then either reflected or absorbed, depending upon the nature of the surface struck. In an empty room, the surfaces of which are composed of hard smooth flooring and plaster, the waves are reflected back and forth so rapidly that a ringing sound or rumble is produced. With this *reverberation* we are all familiar from hearing it in empty houses, tunnels, or empty auditoria. The term *echo,* on the other hand, is applied to a more or less delayed reflection from a single surface which thus retains many recognizable characteristics of the initial sound.

Acoustical engineers have investigated most thoroughly this phenomenon of reverberation, and various building and surfacing materials have been studied and evaluated on the basis of their content of "units of absorption". It is this factor of absorption which eliminates reverberation from furnished rooms and makes it a much easier task to speak or to listen in a fully occupied auditorium than in an empty one. By knowing the degree of absorption of various materials entering into the construction or the furnishing of a room, the amount of absorption of a standard sound in any room can be determined.

SOUND ABSORPTION VALUES

The Coefficient of Sound Absorption, calculated on the basis of sound reflection.

Open window (no reflection and accepted as standard for comparison)	1.0
Heavy velour curtains	.5 – 1.0
Acoustical tiles of fibre, felt or mineral products	.45– .74
Heavy rugs	.30 up
Acoustical plasters	.30
Carpets	.15– .29
Poor absorbents of sound:	
Varnished or waxed hardwood	.03
Linoleum	.03
Ordinary plaster	.025
Concrete	.015
Terrazzo or marble	.01

The *coefficient of absorption* of various substances has been established on a simple basis. A wide open window from which there is naturally no reflection of sound produced from within has perfect absorption, from the viewpoint of reflection back into the room, and hence an open window is said to have a coefficient of 1 (one unit absorption per square foot of surface). Heavy velour curtains hanging in deep folds absorb sounds well, even up to complete absorption, and so have coefficients ranging from 0.50 to 1.0 units per square foot of surface covered. (The degree of absorption of hangings and draperies refers to sound *reflection,* not sound *transmission.*) Carpets have fair absorption, ranging from 0.15 to 0.29 units per square foot. Thick rugs may have still higher values. On the other hand, varnished wood and linoleum are both low in absorption, the coefficient being 0.03. The index for concrete is 0.015 and for terrazzo and marble, 0.01. Ordinary smooth plaster has the low coefficient of 0.025 to 0.034, and in fact, plaster walls and ceilings are said to reflect a higher percentage of sound waves than a mirror does of light!

For the statistically minded it may be interesting to note that acoustical engineers, in working out the absorption of sound in churches and auditoria, estimate that each person in the audience has an absorption value of 4.7 units; each church pew (seat), 0.2 units and, if upholstered, 1.0 to 2.5 units. Balconies offer special problems to auditorium designers. For instance, a low, deep balcony may not provide enough ingress for sounds from the stage. A balcony with a high, flat, or dome ceiling beneath it may develop a pocket reverberation beneath it affecting all auditors sitting under the balcony. The best balcony from an acoustic standpoint has a ceiling beneath it which slopes down slightly from the front to the back.

OVERCOMING NOISE IN HOSPITALS

Architects are now paying more attention to special features designed to minimize sound conduction. *Stair wells* and *elevator shafts* are enclosed and are frequently placed upon a side corridor. Much attention has been paid to the *corridors* themselves. The long open "tunnel," stretching perhaps hundreds of feet from one end of the building to the other, is now broken at frequent intervals by self-closing doors which have proved to be of definite assistance in confining sounds to one unit. One frequently sees cross-beams across the corridor ceiling; this construction feature, which is much more commonly noted in hotels, helps to break sound waves travelling along the ceiling. One well-known architect prefers to have room doors set back from the corridor line (frequently in pairs), so as to break conduction along the side walls. Specially prepared ceilings are frequently used in corridors. Preparations of fibre, perforated metal, and special acoustic plaster are frequently used. These will be discussed later.

The *corridor and room floors* require special consideration. Terrazzo is meeting with increased favour on account of its cleanliness and its durability, but it is undoubtedly more noisy than either battleship linoleum or rubber. True, linoleum absorbs very little sound and reflects most of the sound waves striking it, but it has the advantage that it deadens the sound of footsteps, instead of amplifying them as terrazzo does. Traffic sounds constitute a large proportion of private room sound grievances. Cinder concrete floor fill is quieter than ordinary concrete. One large western hospital used "Aerocrete" as a floor fill. This is made with a specially prepared cement which breaks up the water added in the mixing process into its component gases, thus rendering the concrete spongy and light and, therefore, increasing its sound and heat insulation value.

The maternity wing needs careful consideration. The *caseroom,* and the *nursery* as well, should be sound-isolated, not only from the rest of the hospital but also from the rooms of the maternity patients. Such provision also applies,

although to a lesser extent, to the pædiatric ward. In all wards, the *utility rooms* and the *diet kitchens* should be so guarded by self-closing doors or by location "around the corner" that sound transmission is minimized. This is sometimes difficult, for the tendency to-day is to bring these services as close as possible to the patient in order to conserve the nurses' energy. For a similar reason, the *nurses' station* must be wisely placed. The nurse must be in a position to oversee the entire ward or corridor, but conversation, rattling of charts and other noises which emanate from this room can be reduced by glass enclosures, by care in selecting chart holders and tables, (giving preference to rubber mounts), and by arranging a rest room at some less prominent point wherein special nurses and others may sit when not serving their patients.

Much annoyance is caused by loud buzzers or bells on the *signal system,* by persistent ringing of unnecessarily loud telephones, and by old style "bumpy" steam radiation. A defect frequently noticed in the newer fire-proof hotels in smaller towns and in many hospitals is that plumbing and other sounds from the next room are transmitted through the walls with irritating clarity. Wall insulation costs money but it is well worth the expense. Enough sound may be transmitted from room to room through non-insulated steam or water pipes to nullify completely the effect of expensive ceiling, wall and door treatment. A new plumbing silencer, designed to eliminate "water hammer," has recently been perfected. It is surprising how much sound is transmitted through transoms, ventilators, and even keyholes. Sounds transmitted through ventilators may be reduced by covering the openings into the rooms with a "baffle", lined with good sound absorbing material such as acousti-celotex. All *heavy motors* and other *noisy machinery* subject to vibration should be mounted on insulated foundations.

PARTITIONS

The construction of *partitions* calls for some care. Few modern buildings show a real scientific effort to soundproof walls. Various substances, such as eelgrass, cork, and felt have been used with varying results. It is easier to achieve heat insulation than sound insulation. Powdered gypsum is one of the best fillers and has the advantage of being strongly fire-resisting, a feature due in part to the contained water of crystallization. A two-inch air space, if unbridged or unfilled, has been found quite satisfactory and, according to Professor Sabine, is equivalent in insulating power to a 6¾ inch solid brick wall. A four-inch air space has the insulation value of 10½ inches of solid masonry. "It appears that the problem of sound insulation in buildings is not a matter of damping acoustic waves in a medium, but of preventing the transfer of vibrations from one solid material to another." Ordinary walls transmit vibrations because of the connection between the surfaces. *The intervening space must not be bridged by anything rigid.* One writer emphasizes that even one nail driven through from side to side will set the other surface in vibration, as does the pin under the bridge of a violin.

CEILING AND WALL SURFACES

The treatment of the *ceiling* depends upon whether the building is an old one or is under construction. In new buildings transmission can be reduced by the use of specially "hung" ceilings, suspended from special hangers, the metal continuity of which is broken by felt pads. The moderate extra cost is more than compensated by the greater insulation obtained. This hung ceiling and the ceiling in old buildings may be coated with acoustical plaster or with one of the sound-absorbing materials now on the market, thus decreasing both the transmission and the reflection of sound.

Acoustical plasters are fairly rough and highly porous, being made of pumice particles bound with cement or gypsum. The absorption value is about 30 per cent. One of the best of these is "Dekoosto", a Canadian product composed of pumice, gypsum and a gas-forming chemical which fills the plaster with bubbles before it sets. (Fig. 1). Others are "Sabinite", also composed of pumice and gypsum, and "Akoustolith," in which the pumice is bound with cement. Ground coral was used with success in one recently constructed hospital in Ontario. Acoustical plaster must be carefully applied by experienced plasterers, as the pores on the surface are apt to be clogged if water is expressed by too much pressure in surfacing. It can be thoroughly cleaned and renewed only by brushing and spraying with acoustical paint, and this brushing may dislodge small flakes. Therefore, it is more popular for corridors and kitchens than for, say, caserooms.

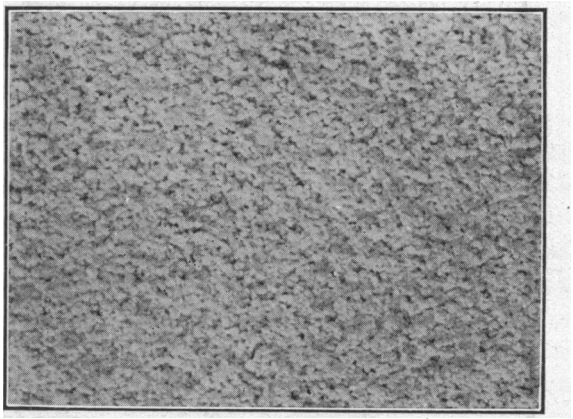

FIG. 1.—"DEKOOSTO" PLASTER
Composed of pumice, gypsum and a gas-forming ingredient which makes the plaster porous. Sound absorption value is approximately 30 per cent.

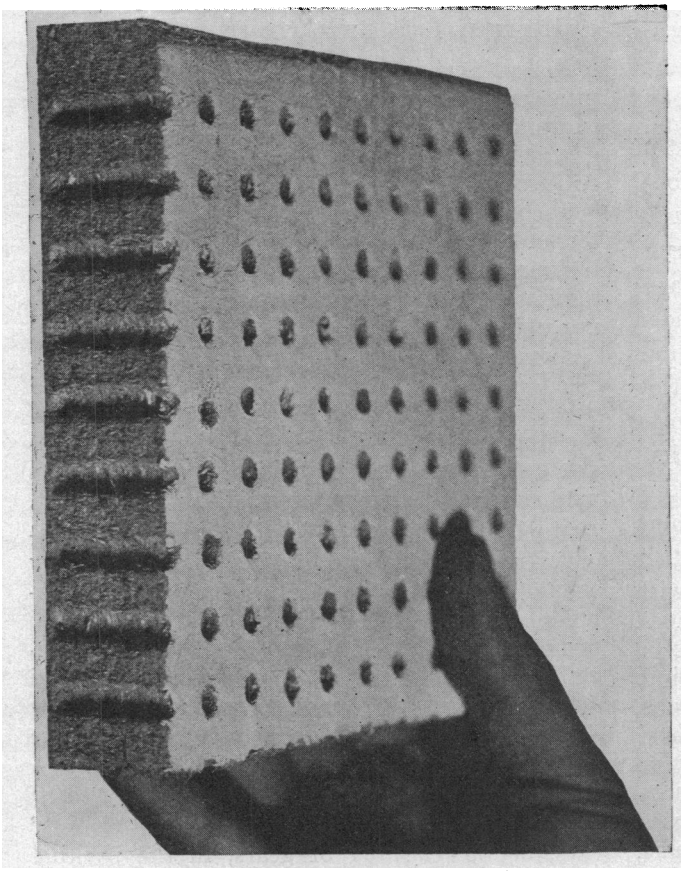

FIG. 2.—"ACOUSTI-CELOTEX"

A fibre tile made of compressed sugar cane. Sound waves enter holes and are broken up. Popular for ceilings of nurseries and corridors. Sound absorption value is from 47 to 70 per cent depending upon the tile thickness.

The organic acoustical products are made of *fibre, felt*, and other organic material. One of the best of these, "*Acousti-Celotex,*" is widely used in hospitals and broadcasting stations and comes as a perforated fibre tile made of compressed sugar cane. (Fig. 2). In the 1¼ inch thickness, the coefficient of absorption is 70 per cent; the ¾ inch thickness has a value of 47 per cent. (Thinner sheets of this product are used under linoleum and carpet.) Another is "Nashkote A," a hair and asbestos felt covered with muslin, with a one-inch felt; this has a coefficient of 45 per cent. "Nashkote B," which is covered with white oilcloth with pinhole perforations, has a coefficient of 64 per cent. As the method of determining coefficients varies in different laboratories, these percentages must be regarded as representing approximate relative values only. Other materials used in making these coverings are wood fibre, asbestos, and flax. Porous products, especially when organic, might be considered as likely breeding places for vermin. However, Neergaard comments upon this possibility in his studies and finds no report of such occurrence where modern methods of sound deadening have been used.

Another product is "J-M Sanacoustic Tile" which comes as a tile-shaped pan of metal containing a sound-absorbing pad of rock wool which has been substituted for the asbestos-goat-hair felt formerly used. (Fig. 3). The surface of these tiles is finished in baked enamel and is covered with small perforations. This is said to have an absorption value of 74 per cent (Sabine).

The maintenance and cleaning of these absorbent products must be considered. Rough plasters do harbour dust, but vacuum-brushing and spray-painting with special paint will renew the surface and, moreover, it is doubtful if there is much danger of cross-infection by this means. If there is any likelihood of the deeper recesses, either of the plaster or the other products, proving a source of cross-infection, rooms with ceilings of this material can be sealed and subjected to fume disinfection. Acoustic-celotex has a soft fibrous surface which cannot be washed, but which, F. R. Watson has demonstrated, can be painted without diminution of absorbent power, provided the holes are not filled. If soaked with water, it dries slowly with some danger of loosening. Nashkote B is more readily washed, having an oilcloth surface; it retains water longer when soaked, which may affect the cement binding it to the ceiling. Its replacement cost is low. Sanacoustic tile washes readily, is fireproof, and seems generally satisfactory.

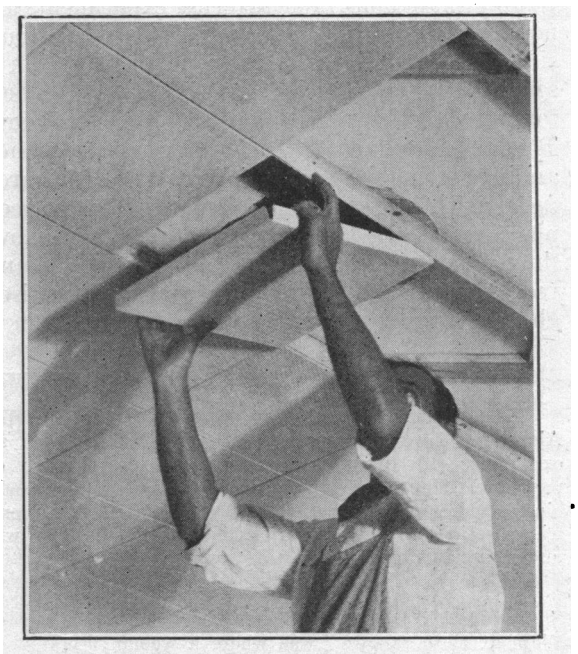

FIG. 3.—"SANACOUSTIC" TILE

A flat enamelled metal pan, finely perforated and filled with a sound absorbent rock wool material. The tiles clip into place on special metal supports. The absorption value is stated to be 74 per cent.

Its appearance may not be quite as pleasing as that of some other preparations when new.

PRIVATE ROOMS

While acoustical experts are directing most of their attention to general construction, noisy equipment, nurseries, and corridors, the *private room* itself is not being forgotten. Thick rugs help to overcome the noise amplified by terrazzo or hardwood floors; doors should be provided with door checks, or, if economy must be practised, at least with rubber bumpers, friction hinges, or rubber door knob guards. Door hooks are rapidly replacing the knob, so inconvenient to the scrubbed nurse or doctor, and the clicking latch is also fast disappearing. Sound-absorbing material may be used for the portable or other screens. Chairs and tables, not equipped with rubber tired casters, should have rubber shoes. If metal furniture be used, pieces should be selected in which the drawers do not bind. Rubber vases do not click on glass dresser tops, and composition trays make but little noise. Leather-upholstered chairs have practically no absorption value, but more absorbent coverings, cushions, and heavy draperies cannot be used here as they might be utilized in a private home. The rimming of lids of dressing jars with adhesive tape will eliminate one common source of ward noise.

To reduce the entry of street noises into hospitals situated on traffic arteries, experiments are now being conducted with reflectors placed outside of the window, on the window ledge, in a somewhat similar fashion to the draught reflectors frequently placed inside of the window. These are designed to reflect back and up sounds arising from the street below. Baffle boards faced with sound-absorbing material have been placed vertically four inches within the window, thus permitting ventilation and marked sound reduction, provided the window is not raised above the level of the baffle board.

HOSPITAL PERSONNEL AND OTHER FACTORS

Not all unnecessary sound production in a hospital can be attributed to the operation of its equipment. Anyone who has required hospital care knows that one of the most aggravating features from the viewpoint of the patient is the loud conversation, often accompanied with laughter, on the part of nurses and doctors. Laughter, especially, bothers many patients who cannot understand why anyone can be light-hearted and gay while *they* are sick. We, ourselves, are responsible for a great deal of this aggravation. The banging of a single door may awaken a dozen patients. The clatter of falling dishes, the flapping of blinds, the squeaking of stretchers, or the impact of hard heels assail the ears with endless repetition during the day and night.

Much can be accomplished by seeking the cooperation of tradesmen and others. Not only should notices be posted at the goods and ambulance entrances, but letters might be sent to firms ordinarily supplying the hospital, especially the coal dealers, to ambulance and taxi companies, to contractors on neighbouring new structures, to the fire department, and to the principals of neighbouring schools.

One most annoying feature, especially at night, is the warming up of doctors' and visitors' cars, or the clashing of gears, in the parking space which is so often right under the hospital windows. Not only are the ears thus assailed, but the nostrils are offended by the clouds of noxious fumes that are borne in through the open windows. In choosing a site, or in landscaping the grounds, the location of the parking space for doctors' and visitors' cars must be given much more careful consideration than in the past. Incidentally, a large Canadian hospital, which is seeking a new site, is considering the need of locating near an airport, realizing that this is the probable route whereby out-of-town patients will be transported in the future. This will introduce another noise factor without doubt and already complaints of this nature have been reported in other countries.

The following lines* from the pen of the Rev. Dr. Alexander Louis Fraser of Bathurst, N.B., depict an experience all too familiar to every practitioner of medicine. The physician to whom the practice of medicine is more than a livelihood or a scientific experiment, whose solicitude for his patient is his first thought, will understand and appreciate this sonnet:

IN A HOSPITAL

Soft-sandalled Death and I this very night
Were at close range; 'twas where a woman lay,
Young, mother of a boy, for just one day!
I saw at once 'twas but a losing fight.
Exhausted skill stood speechless at the sight,
While Hope and Fear alike were in suspense;
A soul was knocking at the door of sense,
Which viewlessly, at length, took its long flight.

How strange the world seemed then; its gold but dross;
A bursting bubble, Fame, when Death is nigh.
I sought the city square; the soul just gone,
Which left us far behind, found gain, not loss,
In its affinities beyond the sky—
A cock then gave its usual cry for dawn.

* People of the Street and Other Poems, by Alexander Louis Fraser. The Globe Press, Limited.