Sound Insulation of Wall and Floor Constructions

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Prepared by the Staff of the Sound Section

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Prepared by the Staff of the Sound Section*

The data obtained at the National Bureau of Standards on the sound transmission of door, wall, and floor constructions are summarized. The results in Report BMS17 (1939) and its two Supplements (1940 and 1947) are included, together with later results up to March 1954. The general principles of sound insulation are discussed, and the factors governing the transmission of airborne and impact sound in structures are examined. The importance of choosing suitably quiet locations for buildings is stressed, and the best use of the quieter rooms of a building is urged. The merits of suspended ceilings, floating floors, staggered studs, and other types of sound-insulating construction are discussed. A brief description of the measuring technique is given.

1. Introduction

In the design and construction of office buildings, apartment buildings, and row houses, as well as detached singlefamily houses, attention has to be given to sound insulation in party walls, partition walls, and exterior walls. Prevention of the transmission of speech sounds originating within the building is necessary for privacy. Outside noises have greatly increased during the past few years in many localities because of heavier vehicular traffic, including busses and trucks. In addition, more electrical and mechanical equipment is being used, which increases the amount of noise produced within the building. There is a continuing need for good sound insulation in structures.

Lightweight construction has been used to an increasing extent in recent years. The measurements given in this Report show that, generally speaking, more sound is transmitted through lightweight structures. By careful design in such cases, however, good sound insulation can be achieved, although it is more difficult to obtain than in the case of a heavier (e.g., masonry) construction.

To aid in obtaining the necessary data for the design of structures that would have a satisfactory degree of sound insulation, the National Bureau of Standards in 1922 constructed equipment by means of which measurements could be made of the sound insulation of different types of constructions. A large number of different types of partitions and floor structures have been tested. These tests have been made on constructions ranging from heavy masonry to glass and thin fiberboards, on customary types of wall and floor structures, and on modifications of the customary types. A large portion of this work has been made possible by the cooperation of manufacturers of building materials [1 to 6].[1,2] This report contains the results of measurements of all constructions tested that are likely to be of interest in any type of building.

The problem of sound insulation is a very difficult one, as there are many unknown factors. It is often difficult to predict whether or not a partition will be a good sound insulator, and it is generally impossible to predict the numerical value of the transmission loss with any degree of certainty. As a result of the sound-transmission measurements that have been made, it is possible to make a more intelligent estimate than heretofore. There still remain, however, many elements of uncertainty. Before presenting the numerical results of the measurements of various constructions, the general principles of securing quiet buildings will be discussed.

2. Location of Building

When planning a building in which it is desired to keep the noise level as low as possible, one of the first things that should be considered is location. The requirements of some buildings, such as hospitals, schoolhouses, courthouses, etc., are such that they should not be located on streets where the noise level is high unless extra precautions are taken to insulate the building against external noise. If it becomes necessary to locate such a building on a noisy street, either the windows should be eliminated and artificial illumination

*The original edition of Report BMS17, published in 1939 and the first Supplement, published in 1940, were prepared by V. L. Chrisler. The second Supplement, published in 1947, was prepared by A. London. The present Report was prepared mainly by S. Edelman and R. V. Waterhouse, and by H. J. Leinbach, Jr., who undertook the tedious task of checking earlier data and assembling the tabulated material.

[1] Figures in brackets indicate the literature references at the end of this paper.

[2] These publications are out of print but may be available for reference use in the leading public, scientific, educational, and Government depositary libraries.

provided or double windows should be used and precautions taken to eliminate any leakage of sound around the windows. In either case, mechanical ventilation must be specified.

Where a building is located close to railway lines, subways, elevated railways, or streets where heavy trucks are passing, it is frequently necessary to use special precautions to prevent vibrations being transmitted through the foundation into the structure. This is an important problem [7], but no attempt will be made to discuss it in this report.

3. Location of Rooms Within a Building

Many of the more difficult problems of sound insulation can be avoided if care is taken as to the location of rooms within a building. For instance, in some Government buildings there are one or two courtrooms or hearing rooms where a low noise level is desired and a large number of other rooms used for purposes where the noise level is relatively high, for example, rooms in which typewriters and other office equipment are to be used. Frequently, a building of this type has an interior court. Under these conditions, it might be possible to locate the courtroom, hearing rooms, and private offices areound the interior court. In the past many buildings have been designed so that rooms facing on a court were the least desirable. From the standpoint of sound insulation, however, these rooms should be the most desirable, as it is generally possible to have the noise level in these rooms much lower than in rooms facing on the street. It must be emphasized, however, that one room located on such an interior court may destroy the quiet of all other rooms located on the court if this room is a source of noise.

Similar considerations apply to the location of rooms within dwellings, and the architect can often make a house more comfortable by suitable location of sleeping quarters, for example, with respect to the prevalent sources of noise.

A type of noise that is very disturbing and often difficult to eliminate is that from machinery. Frequently the mistake is made of locating machinery on some of the upper floors and then locating a room directly below in which a low noise level is desired. It is true that it is generally possible to place such machinery on specially designed machine bases that will eliminate most of the noise in the room below. However, if the locations of the two rooms were reversed the problem would be much simpler.

4. Factors That Control the Transmission of Sound Through Walls and Floors

Noise may be transmitted by the following means:

1. As airborne sound through openings, such as open windows or doors, cracks around doors, windows, water pipes, conduits, or the ducts of ventilating systems, etc.
2. By vibration of the structure.
3. As airborne sound through wall structures.

The method of preventing the transmission of sound by the first means is quite evident, but not always easy to carry out. However, cracks can be reduced to a minimum, and where a high degree of sound insulation is desired, windows should be eliminated wherever possible. Ventilating ducts present a serious problem, but by inserting a properly designed acoustic filter in the duct, most of the noise can be eliminated.

Prevention of sound transmission by the second means should be taken into consideration when the building is designed. Some materials do not transmit vibration as readily as others, and this difference in the materials can sometimes be used to advantage. One of the most common methods is the use of a nonhomogeneous structure, or when possible, the complete separation of the two parts of the structure. This problem is discussed further in section 7.

The airborne sound transmission through walls is more easily studied in the laboratory than sound transmission by the other methods. To understand this action, let us consider some of the factors that control the transmission of sound through a panel. Let us consider how sound passes through a sheet of window glass. The sound energy is transmitted to one side of the glass by air. The impact of the successive sound waves upon the glass causes it to be set in motion like a diaphragm, and because of this motion, energy is transmitted to the air on the opposite side. The amount of energy transmitted through the glass depends upon the amplitude of vibration of the glass. This in turn depends primarily upon four things—the initial energy striking the glass, the mass of the glass, the stiffness of the glass, and the method by which the edges of the glass are held, especially as it affects the damping of the motions of the glass. When the sound consists primarily of a single frequency there is a possibility that the diaphragm may be in resonance with this frequency. In this case a very large part of the sound energy may be transmitted. Normally the resonance frequency of any part of a building is much lower than the frequencies of ordinary sounds, and hence this condition is not generally of importance.

5. Homogeneous Walls

From work that has been done in the laboratory on homogeneous walls of various types, it has been determined that the weight of the wall per unit area is the most important factor in determining its sound insulation. Of secondary importance are the nature of the material and the manner in which it is fastened at the edges. There is a rather popular misconception that fiberboard and sheet lead have special properties as sound insulators. Actually, if only the sound insulating properties of the materials by themselves are considered, a sheet of steel is a slightly better sound insulator than a sheet of lead or fiberboard of the same weight per square foot because of the greater stiffness of the steel, but the difference is not usually great enough to be of practical value. In small panels the manner of clamping the edges is of importance, but for a large panel, the manner in which the edges are held makes but little difference in its value as a sound insulator.

However, attention should be called to the fact that the sound-insulation factor (transmission loss in decibels) for homogeneous walls is not directly proportional to the weight per unit area, but increases less rapidly than this factor, actually being proportional to the logarithm of the weight per unit area. This means that a high degree of sound insulation cannot be obtained in a homogeneous wall unless the wall is made exceedingly heavy.

6. Nonhomogeneous Walls

It is found that the insulating value of a wall of given weight can be increased considerably if the wall is broken up into two or more layers. The surface on which the sound strikes is set in vibration, but the energy from this surface has to be transferred to the next layer and then to the other side. By a proper combination of materials this energy transfer may be made quite small, and the smaller this transfer, the better the wall is as a sound insulator. When a wall is thus broken up into layers, the problem becomes more complicated, and it is more difficult to predict what the transmission loss will be.

6.1. Lath and Plaster Walls

A wood-stud partition, with either wood, metal, or gypsum lath, is an example of a construction for which it is difficult to predict the transmission loss. Many factors affect the sound insulation of such a structure. With walls of ordinary stud construction we have two plaster diaphragms which are on opposite sides of the partition and have common supports, where they are attached to the studs. Sound energy can then be transferred by two different paths from one side of the partition to the other. The energy of vibration of the plaster on one side can be transferred either to the studs and then across to the plaster on the other side by solid conduction, or it can be transferred to the air between the two plaster surfaces and then from the air to the second plaster surface. By experiment, it has been shown, for usual plaster construction on wood studs, that most of the energy is transferred through the studs and only a very small proportion through the air. Keeping this in mind, we may draw a general conclusion. The stiffer the stud, which is the common support for the two surfaces, the smaller the amplitude of vibration, hence, the better the sound insulation.

Another way to reduce sound transmission is to reduce the coupling between the wall covering and the stud. When gypsum lath was first introduced the usual method of attaching it to the studs was by nailing. This gave a rigid attachment to the studs, which was undesirable from the standpoint of sound insulation. An improvement occurs if the gypsum lath is attached to the studs with a spring clip, which allows some relative movement between the lath and the stud. Other methods of accomplishing the same result have been tried, for example, using a large-headed nail driven between the pieces of gypsum lath instead of through them. Neither the nail nor the clip forms a rigid fastening between the gypsum lath and stud. Hence, a wall constructed in this manner proved to be a better sound insulator than one with the gypsum lath nailed in the usual manner.

As in ordinary wood-stud construction, most of the sound is transmitted through the stud, attempts have been made to improve such a partition by using separate studding for the two sides. This staggered-stud construction always shows some improvement over a single stud, but not as much as one might expect, because considerable energy is transmitted through the common connections at the ceiling and floor.

There is a rather general misconception that the sound-insulation value of an ordinary plaster wall can be greatly increased by using some kind of filling material between the studs. Although such a filler is usually advantageous as a heat insulator, the same cannot be said of it as a sound insulator. In many cases the empty air space is acoustically the better construction. For lighter partitions a filler may be of advantage, but even here much depends upon its nature and properties. If the filler packs down so that it becomes rather solid, it will act as a tie between the two surfaces and frequently do more harm than good. If it is a material that is fairly elastic, so that it stays in contact with the surface layer of the partition and exerts some pressure, and if it has considerable internal friction, it may materially damp the vibration of the partition surface and thus improve the sound insulation of the partition.

6.2. Masonry Walls and Floors

For heavy building construction, such as load-bearing walls, a double wall will increase the sound insulation, but the fillers that have been tried seem to be of little value. However, with a masonry wall satisfactory sound insulation can be obtained in other ways, which often give better results than a double wall.

In most cases it is customary to apply the plaster directly to the masonry. In this case, the wall becomes a solid unit, and its weight is the most important factor. If only 3- or 4-in. tiles are used, there is not sufficient weight to give satisfactory sound insulation in most cases. The problem then is one of attaching the plaster surfaces to the masonry core so as to secure as much sound insulation as possible.

To find the effect of keeping the plaster surface as independent of the masonry as possible, wood furring strips were tied to a 4-in. tile wall with wires that had been embedded in the mortar joints. Waterproofed paper was nailed to these furring strips, and metal lath and plaster were then applied (fig. 1). The object of using paper was to prevent the plaster from pushing through the metal lath and bonding to the masonry core. It was found that this type of wall was slightly better than an 8-in. brick wall, although it weighed approximately only one-third as much. The method of attaching the furring strips is of minor importance. There are several patented methods of attaching furring strips, but it is believed that for this type of wall construction there is little difference in the sound-insulation values of these systems as long as the plaster surface is held away from the masonry, not making direct contact at any point.

It was also found that the sound insulation of a masonry floor could be greatly improved by using a floating flooring and a suspended ceiling (fig. 2). The method of attaching the nailing strips is probably of secondary importance, as in the case of furring strips attached to masonry walls. For the suspended ceiling, rigid hangers should not be used. Any flexible supports, such as springs or wires, which do not give a rigid connection, should be satisfactory.

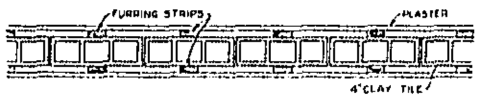


FIGURE 1. *Masonry wall with furred-out plaster.*

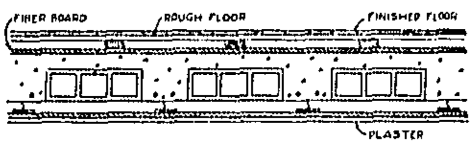


FIGURE 2. *Floating floor and suspended ceiling.*

7. Impact Noises and Methods of Isolating Them

Noises caused by impact, such as walking or the moving of furniture, or by a direct transfer of vibration from machines and musical instruments, such as pianos, radios, etc., are more difficult to insulate than airborne noise. These noises are also more difficult to study in the laboratory due to the limitation in size of test models. For measuring the impact noise transmission loss of constructions, special machines are used to produce a standard impact noise. The one used at the Bureau is shown in figure 3. It consists of a set of five rods, which are raised in succession by a set of cams. One rod is allowed to fall every sixth of a second. On a wood floor it is quite noisy—so much so that it is rather difficult to hold a conversation in the room. With a floor built of wood joists there is some reduction of the noise transmitted through the floor panel, but the transmitted noise is still decidedly annoying. Some contractors build a floating floor by laying a rough flooring upon the joists, upon this a layer of fiberboard, and upon the fiberboard a finish floor, which is nailed through the fiberboard to the rough floor. This form of construction was tested by the impact machine to determine whether such a structure was better, but it was found that the same percentage of sound energy was transmitted (within experimental error) as without the layer of fiberboard.

In another experiment a rough subflooring was laid, upon which was placed the fiberboard. On the fiberboard were laid nailing strips to which the finish floor was nailed. It is believed that the method of fastening these nailing strips is not of great importance. The strips can be nailed every 3 or 4 ft or held in position by various arrangements of straps. This same result can be accomplished by the use of springs or small metal chairs containing felt. For airborne noises such structures are quite satisfactory. Under usual conditions, a conversation carried on in an ordinary tone of voice is not audible through them. For impact noises, however, such structures are rather disappointing. They are slightly better than the usual wood structure, but footsteps can be easily heard through them.

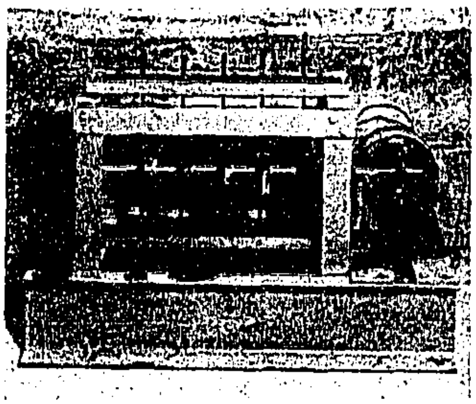


FIGURE 3. *Machine for producing impact sounds.*

The next attempt to improve such structures consisted of separating the ceiling and floor joists. This gave about the same result as the single set of joists and floating floor, although not quite as satisfactory. A floating floor was then added. This combination gave the best results that were obtained with wood joists.

Another type of floor which was studied was masonry. When impacts were applied directly to the masonry floor, the noise in the room below was practically as loud as in the room where the machine was located. A floating floor was then built, resulting in decided improvement. Finally, a suspended ceiling was added and this gave the best result (fig. 2).

For impact noises this construction was not as good as for airborne noises, but it was a decided improvement over masonry slab. The noise from the impact machine was distinctly audible, but not loud enough to be very noticeable if two people were talking in the room. The results in this case were more satisfactory than for wood joists.

In the foregoing discussion only the difference between the noise levels in the rooms above and below the floor panel has been considered. By changing the floor covering, the noise level in both rooms may be greatly reduced, although the airborne sound-transmission loss may not be changed much.

For noises that originate from impacts on the floor, the floor covering acts somewhat in the nature of a shock absorber. Hence, the softer and more yielding the floor covering, the less the amount of energy transferred to the floor to be radiated as noise. For instance, the noise produced by walking on a floor covered with rubber or cork tiles is somewhat less than that produced when walking on bare concrete, and that produced when walking on a heavy carpet is very much less.

The amount of noise generated also depends upon the type of object that strikes the floor. As two extremes, let us consider the leather heel of a shoe with an iron clip on the bottom versus a rubber heel. The impact of these two kinds of heels on a concrete floor will produce a noise level having a difference of several decibels. If the floor covering consists of rubber or cork tiles, the difference in the noise levels produced by these two types of heels is smaller. If we use a still softer material for a floor covering, such as a heavy carpet, the difference in the noise levels produced by the two types of heels becomes negligible. Considerable sound energy may be transmitted through the legs of a piano or radio into the floor. This can be partly eliminated by putting the legs of the piano or radio in caster cups and then putting rubber between the caster cups and the floor. Vibrations from machinery that are carried into a building structure and cause noise throughout the building may be largely eliminated in a somewhat similar manner. In this case a resilient mounting, having a considerable amount of internal damping, is placed between the machine and the building structure.

8. Effect of Openings and Methods of Computing Results

In the foregoing discussion, the fact that all rooms have either doors or windows or both has been ignored. A window or a door in a partition will frequently transmit more sound than the rest of the partition, although sealed around the edges so that it is airtight; hence, it may be useless to do anything to the partition to improve its sound insulation as long as the door or window remains in the partition.

To bring out this point, it will be necessary to discuss rather briefly how to compute the total sound transmitted through a wall composed of several elements having different coefficients of transmission and the manner in which these results are usually expressed.

First, let us consider the usual manner of expressing values of sound insulation and why they are expressed in that way. In most cases, we are interested in the effect of sound upon the human ear; therefore, an attempt has been made to express the results so that they are approximately proportional to what the ear hears. It has been found that the ear does not respond in proportion to the energy of the sound. As the energy of a sound increases steadily, the sensation of loudness fails to keep pace with it. There appears to be in the ear a regulating or protective mechanism, which, like the well-known mechanism of the eye, protects the organ against excessive stimulation. Experiment shows that the loudness sensation is approximately proportional to the logarithm of the sound energy, that is, energies proportional to 10, 100, and 1,000 would produce in the ear effects proportional to 1, 2, and 3, respectively.

A slight modification of this logarithmic scale has come into general use to measure sound energy and the amount of noise reduction. It is called the decibel scale. This scale merely multiplies the numbers of the logarithmic scale by 10. The unit of this scale, the decibel, is a rather convenient unit as it is approximately the smallest change in energy that the average ear can detect. For this reason this unit has frequently been called a sensation unit.

The decibel scale is suitable for measuring ratios of sound intensity. To measure absolute noise levels the zero value is assigned to a definite level, i. e., a level of 20 decibels corresponds to an energy 100 times that corresponding to the zero value.

To understand a little more clearly what is meant by different sound energies in decibels, and how much this energy may be reduced by a structure, figure 4 should be referred to. This has been made up from the results of various noise measurements and gives an approximate idea of the value of different noise levels in decibels.

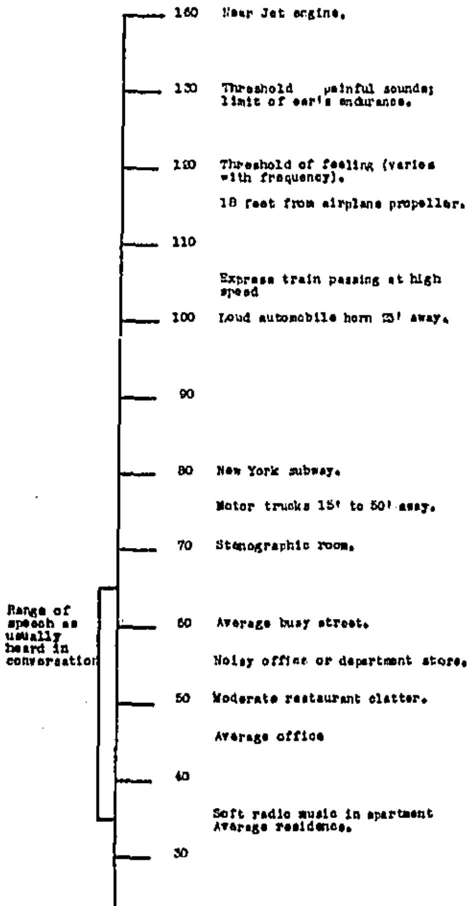


FIGURE 4. *Decibel scale of sound intensities.*

It can be shown [7] that if E_1 is the energy level of the noise outside of a room and E_2 the energy level in the room,

$$E_1/E_2=A/(\tau_1 s_1+\tau_2 s_2+\tau_3 s_3). \tag{1}$$

where A is the total absorption in the room, s_1, s_2, s_3, etc., are the areas of the various portions of the walls, such as walls, windows, etc., and τ_1, τ_2, τ_3, are their respective coefficients of sound transmission or acoustic transmittivity, that is, the fraction of the incident sound energy that is transmitted through the panel. The value of 10 $\log_{10} 1/\tau$ is called the transmission loss in decibels. The denominator $(\tau_1 s_1+\tau_2 s_2+\ldots)$ is termed the total transmittance and will be represented by T. Equation (1) can be rewritten

$$E_1/E_2=A/T. \tag{2}$$

The noise-reduction factor in decibels, which is the difference between the noise level outside a room and the noise level in the room, is equal to

$$10\ (\log_{10}E_1-\log_{10}E_2)=10\log_{10}E_1/E_2=10\log_{10}A/T. \tag{3}$$

To illustrate the use of these formulas and show the detrimental effect of doors and windows, let us consider the case of a brick masonry building containing a single room. The walls are of 8-in. brick and the roof a 6-in. reinforced-concrete slab. The total absorption in the room, which has been acoustically treated, is assumed to be 400 units. It is assumed also that the foundations and floor are built in such a manner that the amount of sound that enters the room through the floor is negligible. Assuming usual values for the transmission losses through the various parts, we may tabulate the separate items as follows:

Material	Areas, s	Transmission loss	τ	τs
	ft^2	db		
8-in. brick walls, plus plaster	1,200	54	0.0000010	0.0048
6-in. concrete roof slab, plus plaster	600	50	.000010	.0060
Windows	150	28	.0016	.24
Door	21	35	.00032	.0067
Total transmittance, T, equals	......	....	....	0.2575

Noise-reduction factor (in decibels) $=10\log_{10}(A/T)=10\log_{10}(400/0.285)=31.9$ db.

From column five in the above table it may be noted that the windows admit many times the amount of sound admitted by all of the wall and ceiling structures, and that the door admits more noise than either the walls or ceiling.

If one window is open so that there is 1 ft^2 of open window, the transmission loss through an opening like this is zero, hence $\tau=1$ and $\tau s=1$. In other words, an opening of 1 ft^2 would transmit four times the sound energy that is transmitted by the entire structure with closed windows.

The noise reduction factor with the partly opened windows is diminished to 25.0 db.

Frequently, the question arises as to how such a computation would be made in the case of an apartment room where one side is exposed to street noise with adjoining rooms on two sides, and the fourth side adjacent to a corridor.

Let us assume the case of a rectangular room, the width of which facing on the street is 10 ft, the length 12 ft, and the height 9 ft. Also, let us assume that the outer wall is of brick 13 in. thick, with one window 3 ft by 5 ft, and that the interior walls are 4-in. clay tile plastered on both sides, having one door 3 ft by 7 ft, entering from the corridor. Assume the street noise to be 80 db, the peak noises caused by loud talking and laughter in the room on one side to be 75 db, the peak noise in the other room to be 60 db, and in the corridor, 60 db. We shall neglect all sound coming through the floor or ceiling. The total absorption by carpet, draperies, furniture, etc., will be considered as 70 units. The absorption is computed as outlined in reference [5].

If the noise-reduction factor for each wall is computed as before, the following is obtained:

EXTERIOR WALLS

Material	Areas, s	Transmission loss	τ	τs
	ft^2	db		
13-in. brick wall, plus plaster on one side	75	57	0.0000020	0.00015
Window	15	28	.0016	.0240
Total transmittance, T, equals				0.0242

Noise-reduction factor (in decibels) = 10 $\log_{10}$ (A/T) = 10 $\log_{10}(70/0.0242)$ = 34.6 db.

WALL BETWEEN ROOMS

Material	Areas, s	Transmission loss	τ	τs
	ft^2	db		
4-in. clay tile wall, plus plaster on both sides	108	44.0	0.000040	0.00432
Total transmittance, T, equals				0.0043

Noise-reduction factor (in decibels) = 10 $\log_{10}(70/0.0043)$ = 42.1 db.

WALL BETWEEN ROOM AND CORRIDOR

Material	Areas, s	Transmission loss	τ	τs
	ft^2	db		
4-in. clay tile wall, plus plaster on both sides	69	44.0	0.000040	0.0028
Door	21	35.0	.00032	.0067
Total transmittance, T, equals				0.0095

Noise-reduction factor (in decibels) = 10 $\log_{10}(70/0.0095)$ = 38.7 db.

The noise in the room caused by street noise only would be 80.0−34.6=45.4 db. That from the noisiest room would be 75−42.1=32.9 db. That from the quietest room, 60−42.1=17.9 db. And that from the corridor, 60−38.7=21.3 db.

The approximate peak noise level can be obtained as follows:

$$\begin{aligned}
\text{Antilog}_{10}(45.4/10) &= 34{,}700\\
\text{Antilog}_{10}(32.9/10) &= 1{,}950\\
\text{Antilog}_{10}(17.9/10) &= 60\\
\text{Antilog}_{10}(21.3/10) &= 140\\
\hline
 & 36{,}850
\end{aligned}$$

$$10 \log_{10} 36{,}850 = 45.7 \text{ db.}$$

In other words, the street noise, because of the poor insulation of the window, is the predominating noise, but it may not be the most annoying one, as the intermittent noise resulting from loud talking and laughing may be more disturbing than a steady noise. Furthermore, with a level of 32.9 db it should be possible to understand a large portion of any conversation carried on in the adjoining room.

The values given for transmission losses are approximate for doors and windows, and are used merely to illustrate the fact that with a door or window in a wall it may be impractical to attempt to make the rest of the wall a good sound insulator, inasmuch as a small opening, such as a crack under a door, will greatly reduce the sound insulation. The same is true of ducts or any other opening that may connect two rooms.

In eq (3) the total absorption comes in the numerator, hence the noise level can be reduced by increasing the total absorption in the room. Generally, however, this reduction is not large, being of the order of about 5 db for a treated room. This means that the introduction of absorbent material to reduce the noise level caused by noises originating outside of the room is of little value, because a much greater reduction can generally be obtained at less cost by increasing the sound insulation of the boundaries of the room. This does not mean that sound-absorbent materials are of no value, for they are necessary to keep down the noise level resulting from noises originating in the room. Absorbent material prevents corridors from acting as speaking tubes and transmitting sound from one room to another when the doors are open. Other illustrations could be given of the value of sound absorption, but the fact should be emphasized that sound absorption cannot take the place of sound insulation.

9. Masking Effect

There remains one other important question, namely, what should be the transmission loss of a partition to give satisfactory results?

It has often been stated that a certain type of partition built in one place has been very satisfactory, yet the same type of partition used in another place is not satisfactory. It is believed that in these cases the conditions of local noise are entirely different, hence the apparent failure in one case. Whether a partition is satisfactory or not depends on what is heard through it. What one hears through a partition depends upon the amount of general noise in the locality as well as upon the noise level in the adjacent room and the *transmission loss of the partition.*

For example, in the country or in a place where the general noise level is very low, it might be possible to hear almost everything that occurs in an adjoining room, but if this same building were in a downtown district where the noise level is high, comparatively little would be heard from the adjoining room. In other words, there is a masking effect because of the presence of other noises, and this should be taken into consideration. This masking effect is much the same as if the listener were partly deaf, as his threshold of hearing is slightly raised.

In what is considered a quiet room this masking may raise the threshold of hearing as much as 5 or 10 db, and in an ordinary business office as much as 10 or 20 db. In a noisy shop or factory this masking effect is considerably greater.

10. Maximum Tolerable Noise Levels

A more practical way to choose a type of partition is to consider the tolerable noise level in a room. From a knowledge of this and the noise level existing on the other side of the partition, the partition required to reduce the noise to the desired level can be chosen. [7, p. 241]

There is little information regarding tolerable noise levels, but Knudsen and Harris [7, p. 221] make the following recommendations:

Recommended acceptable average noise levels in unoccupied rooms [1]	
	db
Radio, recording, and television studios	25 to 30
Music rooms	30 to 35
Legitimate theaters	30 to 35
Hospitals	35 to 40
Motion picture theaters, auditoriums	35 to 40
Churches	35 to 40
Apartments, hotels, homes	35 to 45
Classrooms, lecture rooms	35 to 40
Conference rooms, small offices	40 to 45
Court rooms	40 to 45
Private offices	40 to 45
Libraries	40 to 45
Large public offices, banks, stores, etc.	45 to 55
Restaurants	50 to 55

[1] The levels given in this table are weighted, that is, they are the levels measured with a standard sound-level meter incorporating a 40-db frequency-weighting network.

Attention is called to the fact that the above levels are seldom found in practice.

11. Details of Measurement of Sound-Transmission Loss

Figure 5 shows the test rooms in which were obtained the results given in this report. S is the source room, measuring 12 by 9¾ by 9½ ft; its foundation and walls are separate from those of the rest of the building. The rooms are built of reinforced concrete, the walls being 6 in. to 10 in. thick. R_2 is a receiving room, measuring 16 by 12 by 8¾ ft, and the wall panels tested are placed in the opening between rooms S and R_2. The openings in the two rooms are of different sizes, that in the source room being 72 by 90 in., and that in the receiving room R_2, 60 by 78 in. The adjacent walls of rooms S and R_2 are separated by an airspace of 3 in.

The measurements on floors were made with the floor panels placed in the opening between source room S and receiving room R_1. This opening measures 72 by 90 in., and the dimensions of room R_1 are 13 by 12¾ by 10 ft.

The sound source in room S usually consisted of several loudspeakers mounted on all sides of a wooden cabinet. The cabinet was situated near the middle of the room and was rotated. The sound signals consisted of warble tones, the bandwidths used being generally about ±20 percent at 128 and 192 cps and ±10 percent at the higher frequencies.

To measure the sound levels, various techniques have been used, generally with several microphones in each room. Currently, six microphones are used in each room, randomly spaced. Rooms S, R_1, and R_2 are quite reverberant, the wall surface being bare concrete.

Further details of the measuring techniques are given in [4, 8].

For panels 234 to 236, 309, 310, 435, 436, 612, and 613, the sound-transmission loss is given at frequencies of 125, 175, 250, 350, 500, 700, 1,000, 2,000, and 4,000 cps. The change to these new round-

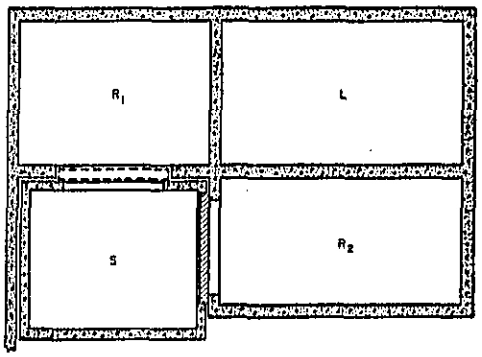


FIGURE 5. *Vertical section of NBS sound-transmission rooms.*

number frequencies from the older frequencies based on powers of 2 was made in order to simplify the measuring technique. Because most building constructions do not show sharp resonance peaks in the sound-transmission loss, it is believed that the results obtained at the new frequencies are not significantly different from those that would have been obtained at the old frequencies.

The sound-transmission loss figures in this publication are rounded off to integral numbers of decibels. Where the averages given in earlier publications differ from the averages obtained from these rounded-off figures, the former are used.

12. Numbering of Panels

For panels numbered below 224 and (in their respective classes) below 304, 420, 510, 602, and 709, the weight is given for the complete panel, including the outer frame. However, beginning with the panel numbers given above, the weight is given for the panel alone, without the frame. In most cases, this refinement causes no significant change.

The dimensions given for thicknesses of plaster are nominal, having been set by strips of wood along the edge of the panel or in the center of the panel. The plaster thicknesses given include the finish, or white, coat; all panels with plaster shown in this publication were finished in this way, with the exception of panel 604, which had no white coat. In metal lath panels, the thickness of the plaster given includes the thickness of the metal lath.

Certain dimensions of wood studs, (e. g., 2 by 4 inch studs), joists, and furring strips are nominal, the actual dimensions being some ⅜'' less than the nominal dimensions.

The results for panels 25, 26, 60 to 182, 201 to 223, 301 to 303, 401 to 419, 501 to 509, 601, and 701 to 708 were published in BMS 17 and its supplements. The results for panels 224 to 235, 304 to 312, 420 to 437, 510 to 528, 602 to 608, 709, 710, and 801 to 805 have not been previously published.

For panels tested after 1940, a new system of panel numbering was used. Under the new system, each panel is numbered in one of the following groups:

WALLS	
Panel	Description
1 to 182	Panels tested before 1940.
201 to 299	Wood studs or steel studs.
301 to 399	Brick. Cinder and concrete block. Clay tile. Glass brick. Gypsum tile. Terra cotta.
401 to 499	Clips and special nails.
501 to 599	Solid plaster with studs. Studless plaster partitions.
601 to 699	Doors. Single layers of material. Wood fiber blocks.
FLOORS	
1 to 182	Panels tested before 1940.
701 to 799	Wood joists or steel joists.
801 to 899	Concrete slab. Concrete and tile combinations. Flat arch concrete.
901 to 999	Miscellaneous floors.

13. References

[1] E. A. Eckhardt and V. L. Chrisler, Transmission and absorption of sound by some building materials, BS Sci. Pap. **21**, 37 (1926) S526.

[2] V. L. Chrisler, Transmission of sound through building materials, BS Sci. Pap. **22**, 227 (1927–28) S552.

[3] V. L. Chrisler and W. F. Snyder, Transmission of sound through wall and floor structures, BS J. Research **2**, 541 (1929) RP48.

[4] V. L. Chrisler, and W. F. Snyder, Recent sound transmission measurements at the National Bureau of Standards, J. Research NBS **14**, 749 (1935) RP800.

[5] P. R. Heyl and V. L. Chrisler, Architectural acoustics, NBS Circular **418** (1938).

[6] E. Buckingham, Theory and interpretation of experiments on the transmission of sound through partition walls, BS Sci. Pap. **20**, 193 (1925) S506.

[7] Vern O. Knudsen and Cyril M. Harris, Acoustical designing in architecture (John Wiley & Sons, Inc., New York, N. Y., 1950).

[8] Leo L. Beranek, Acoustic measurements, p. 870–887 (John Wiley & Sons, Inc., New York, N. Y., 1949).

PANEL 181. *Heavy wooden door, approximately 2½ in. thick; special hardware; rubber gasket around sides and top; drop felt at bottom of door.*

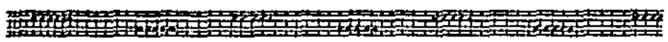
PANEL 182. *Approximately the same as panel 181.*

PANEL 612. *Wooden door 2¾ in. thick; 3 by 7 ft, with double-frame construction, frames insulated from each other with hair felt; 3- by 7-ft surface of the door formed of ½-in. hardwood panels; door hung in split frame with felt insert, mounted in 12-in. brick wall. Two tubular gaskets gave a double seal around both sides and at top of door, with two drop felts at bottom of door.*

PANEL 613. *Same as panel 612, but with edges of door plastered to frame on both sides.*

PANEL 605

PANEL 605. *Single sheet of 2-in. glass fiberboard.*
PANEL 93. *Single sheet of 0.025-in. aluminum.*
PANEL 94. *Single sheet of 0.03-in. galvanized iron.*
PANEL 95. *Single sheet of ¼-in. three-ply plywood.*
PANEL 96. *Single sheet of ¾-in. three-ply plywood.*
PANEL 98. *Single sheet of ½-in. wood fiberboard.*
PANEL 101. *Single sheet of heavy wrapping paper.*
PANEL 102. *Single sheet of ⅛-in. double-strength glass.*
PANEL 103. *Single sheet of ¼-in. plate glass.*
PANEL 106. *Single sheet of 7/16-in. cane fiberboard.*
PANEL 110. *Single sheet of ⅛-in. lead.*
PANEL 111. *Single sheet of 1/16-in. lead.*



PANEL 601

PANEL 601. *7/16-in. fiberboard; on each side ⅜-in. fiberboard strips 4 in. wide, spaced 21¾ in. on centers and staggered 10⅞ in. on centers, 0.34-in. fiberboard surfaces; entire unit glued together; panel thickness 1⅞ in.*

PANEL 606 PANEL 607

PANEL 606. *Fluted sheet of 18-gauge steel stiffened at edges by 2- by 4-in. wood strips; joints sealed.*

PANEL 607. *1½-in. mineral wool; on one side a fluted 18-gauge steel sheet; on the other side a flat 18-gauge steel sheet; panel stiffened by a 2- by 8-in. wood beam set horizontally across the center of the flat steel sheet, but not fastened to it; joints caulked.*

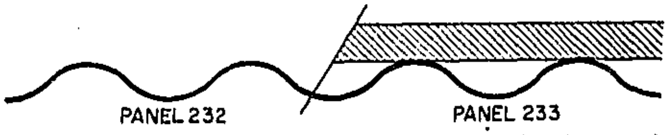
TABLE 1. *Sound-transmission loss*—DOORS

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
											lb/ft²		
181	23	26	26	28	29	30	26	33	33	28	-------	-------	1937
182	30	30	30	29	24	25	26	37	36	30	12.5	-------	1939
[a] 612	29	33	33	32	36	34	34	41	40	35	6.8	F62	1954
[a] 613	32	38	38	35	39	38	42	49	53	40	-------	F62	1954

TABLE 2. *Sound-transmission loss*—WALLS

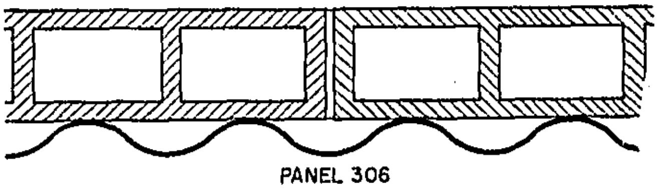
Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
SINGLE LAYERS OF MATERIAL													
											lb/ft²		
605	27	25	23	25	27	29	34	30	41	30	5.3	F47	1950
[b] 93	-------	-------	18	-------	13	-------	18	23	[c] 25	[d] 16	0.35	-------	1928
[b] 94	-------	-------	25	-------	20	-------	29	35	[c] 32	[d] 25	1.2	-------	1928
[b] 95	-------	-------	19	-------	18	-------	22	27	[c] 26	[d] 20	.52	-------	1928
[b] 96	-------	-------	21	-------	21	-------	26	26	[c] 22	[d] 22	.73	-------	1928
[b] 98	-------	-------	22	-------	20	-------	24	21	[c] 27	[d] 22	.75	-------	1928
[b] 101	-------	-------	1	-------	2	-------	2	3	[c] 4	[d] 2	.016	-------	1928
[b] 102	-------	-------	26	-------	27	-------	31	33	[c] 29	[d] 28	1.6	-------	1928
[b] 103	-------	-------	33	-------	31	-------	34	34	[c] 32	[d] 32	3.5	-------	1928
[b] 106	-------	-------	22	-------	17	-------	23	27	[c] 25	[d] 21	.06	-------	1928
[b] 110	-------	-------	31	-------	27	-------	38	44	[c] 33	[d] 32	8.2	-------	1928
[b] 111	-------	-------	32	-------	33	-------	32	32	[c] 32	[d] 32	3.9	-------	1928
FIBERBOARD PARTITION													
601	21	24	22	22	25	31	35	43	47	30	3.8	F17	1944
FLUTED STEEL PANELS													
606	30	20	20	21	22	17	30	28	31	24	4.4	F52	1951
607	36	30	25	36	37	42	46	44	44	38	7.8	F52	1951

[a] Results obtained for frequencies of 125, 175, 250, 350, 500, 700, 1,000, 2,000, and 4,000 cps (averages obtained for 125 to 4,000 cps).
[b] Panel size 40 by 21½ in.
[c] Results obtained at 3,100 cps instead of 4,096 cps.
[d] Averages obtained for 256, 512, and 1,024 cps.



PANEL 232. *Corrugated asbestos board bolted to a 2- by 8-in. stiffening beam set horizontally across the center of the panel: braced at top and bottom by asphalt strips; joints sealed.*

PANEL 233. *Same as panel 232, except that the corrugated asbestos board was backed by a 1 3/16-in. uncorrugated board, composed of 13/16 in. of organic material covered on both sides by 3/16-in. asbestos fiberboard. Joints closed by 1- by 1-in. furring, and all joints sealed.*

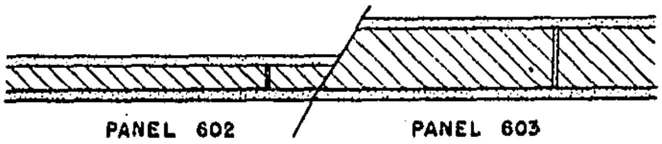


PANEL 306. *Corrugated asbestos board bolted onto a 2- by 8-in. stiffening beam set horizontally across the center of the panel; asbestos board backed directly by a 3-in. terra cotta wall; openings and joints filled.*

PANEL 146. *3-in. wood fiberboard laid in sanded gypsum plaster mortar; on each side ½ in. of sanded gypsum plaster.*

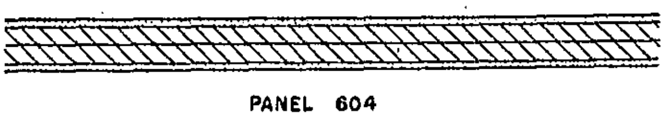
PANEL 147A. *3-in. wood fiberboard laid in sanded gypsum plaster mortar; when the mortar had set, 1-in. wood fiberboard was nailed to the one surface; on each side ½ in. of sanded gypsum plaster.*

PANEL 147B. *Same as panel 147A, except that sisal-kraft paper was placed between the 1-in. wood fiberboard and the 3-in. wood fiberboard, thus preventing any mortar penetrating through the joints of the 1-in. wood fiberboard and bonding it to the 3-in. wood fiberboard.*



PANEL 602. *2- by 24- by 48-in. wood fiberboards; on each side ¾ in. of sanded gypsum plaster.*

PANEL 603. *5- by 24- by 48-in. wood fiberboards; on each side ¾ in. of sanded gypsum plaster.*



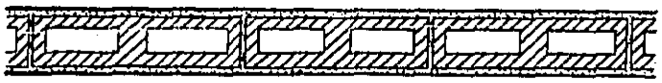
PANEL 604. *3- by 22½- by 85-in. wood fiberboards containing a vertical wax-paper vapor seal in the center; on each side ¾ in. of sanded gypsum plaster.*

TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
CORRUGATED ASBESTOS BOARD ON WOOD STUDS													
232	33	29	31	34	33	33	33	42	39	34	*lb/ft*² 7.0	F52	1951
233	40	36	33	38	40	43	46	45	42	40	10.4	F52	1951
CORRUGATED ASBESTOS BOARD AND TERRA COTTA													
306	41	40	33	35	35	38	41	47	45	39	26.3	F52	1951
WOOD FIBERBOARDS													
146	26	32	32	32	33	35	32	38	53	35	------	------	1934
147A	33	33	36	36	38	44	45	47	63	42	23.5	------	1934
147B	32	40	40	44	46	50	51	52	70	47	------	------	1934
602	31	33	25	31	31	29	32	41	42	33	16.0	F36	1947
603	26	34	33	36	34	35	38	42	49	36	28.0	F36	1947
604	32	33	30	33	35	35	36	42	52	36	20.9	F41	1949

PANEL 139 & 144 PANEL 145

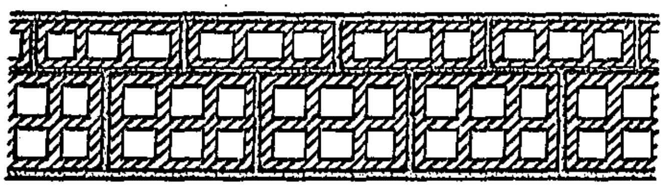
PANEL 308. *12-in. wall made of hollow 8- by 8- by 12-in. and 8- by 4- by 16-in. concrete blocks.*
PANEL 139. *4- by 8- by 16-in. hollow cinder blocks; on each side $\frac{5}{8}$ in. of sanded gypsum plaster.*
PANEL 144. *4- by 8- by 16-in. hollow cinder blocks; on each side $\frac{5}{8}$ in. of sanded gypsum plaster.*
PANEL 145. *3- by 8- by 16-in. hollow cinder blocks; on each side $\frac{5}{8}$ in. of sanded gypsum plaster.*



PANEL 173A

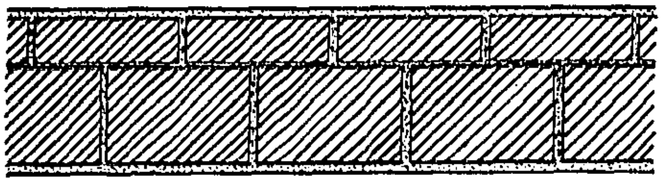
PANEL 173A. *4- by 8- by 16-in. porous, two-cell hollow tile made of pumice and portland cement; on each side ½ in. of sanded gypsum plaster.*
PANEL 173B. *Same as panel 173A, but plastered on one side only.*
PANEL 173C. *Same as panel 173A, but not plastered. (The poor sound-insulating properties of this panel were caused by the large number of pores extending through the walls of the tiles.)*
PANEL 311. *12-in. porous hollow tile made of pumice and portland cement.*
PANEL 312. *Same as panel 311, except for ½ in. of sanded gypsum plaster on one side.*

PANEL 155. *Partition of 3¾- by 4⅞- by 8-in. glass bricks.*



PANEL 60

PANEL 60. *3¾- by 12- by 12-in. and 8- by 12- by 12-in. hollow clay tile; end construction; on each side $\frac{5}{8}$ in. of sanded gypsum plaster.*



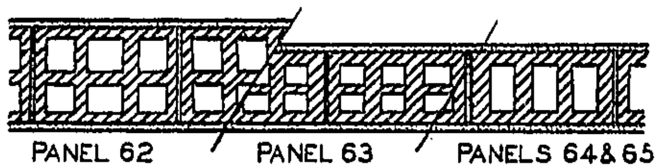
PANEL 61

PANEL 61. *3¾- by 5- by 12-in. and 8- by 5- by 12-in. load-bearing hollow clay tile; side construction; on each side $\frac{5}{8}$ in. of sanded gypsum plaster.*

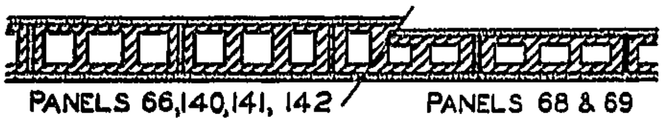
TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
CONCRETE AND CINDER BLOCKS													
											lb/ft²		
308	47	49	43	43	46	50	53	54	56	49	70	F52	1952
139	30	-------	30	-------	38	-------	48	53	59	†39	20.7	-------	1931
144	36	37	37	41	44	47	51	55	62	46	35.8	-------	1932
145	34	36	36	40	42	45	51	57	64	45	32.2	-------	1932
HOLLOW TILE													
173A	32	32	34	34	36	36	39	42	52	37	25.3	-------	1939
173B	31	27	27	36	35	33	36	40	47	35	20.4	-------	1939
173C	8	8	5	7	9	12	14	18	17	11	15.5	-------	1939
311	13	17	16	20	22	19	20	25	30	20	38.7	-------	1939
312	34	41	40	40	43	44	45	50	59	44	43.2	-------	1939
GLASS BRICK													
155	30	36	35	39	40	45	49	49	43	41	-------	-------	1936
HOLLOW CLAY TILE													
60	-------	-------	49	-------	46	-------	37	55	*54	†42	65.0	-------	1926
61	-------	-------	49	-------	46	-------	49	53	*52	†48	66.0	-------	1927

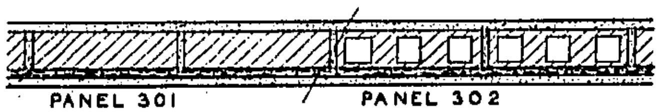
* Results obtained at 3,100 cps instead of 4,096 cps.
† Averages obtained for 256, 512, and 1,024 cps.



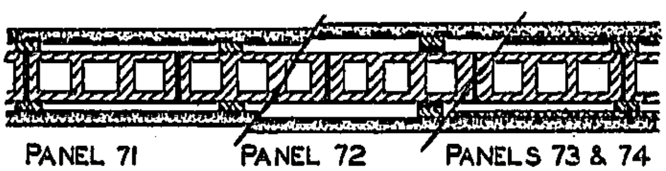
PANEL 62. *8- by 12- by 12-in. six-cell load-bearing hollow clay tile; on each side ⅝-in. of sanded gypsum plaster.*
PANEL 63. *6- by 12- by 12-in. six-cell load-bearing hollow clay tile; on each side ⅝ in. of sanded gypsum plaster.*
PANEL 64. *6- by 12- by 12-in. medium-burned, three-cell hollow clay tile; on each side ⅝ in. of sanded gypsum plaster.*
PANEL 65. *6- by 12- by 12-in. soft three-cell hollow clay tile; on each side ⅝ in. of sanded gypsum plaster.*



PANEL 66. *4- by 12- by 12-in. three-cell hollow clay tile; on each side ⅝ in. of sanded gypsum plaster.*
PANEL 140. *4- by 12- by 12-in. porous hollow clay tile; on each side ⅝ in. of sanded gypsum plaster.*
PANEL 141. *4- by 12- by 12-in. hollow clay column-covering tile with 1-in. shells; on each side ⅝ in. of sanded gypsum plaster.*
PANEL 142. *4- by 12- by 12-in. hollow clay tile; on each side ⅝ in. of sanded gypsum plaster.*
PANEL 68. *3- by 12- by 12-in. three-cell hollow clay tile; on each side ⅝ in. of sanded gypsum plaster.*
PANEL 69. *Built as nearly like panel 68 as possible.*
PANEL 303. *4- by 12- by 12-in. hollow clay tile with 1- in. shells (similar to panels 141 and 142); on each side ⅝ in. of gypsum vermiculite plaster.*



PANEL 302. *3-in. hollow clay tile laid in portland cement; ⅝ in. of sprayed fibrous acoustic material on one side; on each outer surface ⅝ in. of sanded gypsum plaster (see also results for panel 301, page 19.)*



PANEL 71. *4- by 12- by 12-in. three-cell hollow clay tile; on each side 1¼-in. furring strips 12 in. on centers, tar paper, expanded-metal lath, and ⅞ in. of sanded gypsum plaster.*
PANEL 72. *4- by 12- by 12-in. three-cell hollow clay tile; on each side ½-in. flax felt pads 12 in. on centers, ¾-in. furring strips placed over the felt pads, tar paper, expanded-metal lath, and ⅞ in. of sanded gypsum plaster.*
PANEL 73. *4- by 12- by 12-in. three-cell hollow clay tile; on each side 1¼-in. furring strips 12 in. on centers, dense wood fiberboard, and ⅝ in. of sanded gypsum plaster.*
PANEL 74. *4- by 12- by 12-in. three-cell hollow clay tile; on each side 13/16-in. wood furring strips 16 in. on centers, ½-in. wood fiberboard, and ½-in. of sanded gypsum plaster.*

TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second) 128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096	Weight	Test number	Year of test
HOLLOW CLAY TILE—Continued													
											lb/ft²		
62	-------	-------	44	-------	44	-------	49	58	[h] 53	[i] 46	48.0	-------	1926
63	-------	-------	39	-------	42	-------	47	54	[h] 55	[i] 42	39.0	-------	1927
64	-------	-------	41	-------	37	-------	45	52	[h] 53	[i] 41	37.0	-------	1927
65	-------	-------	41	-------	42	-------	44	50	[h] 46	[i] 42	37.0	-------	1927
66	-------	-------	41	-------	40	-------	42	50	[h] 47	[i] 41	29.0	-------	1927
140	31	-------	31	-------	36	-------	47	50	58	[i] 38	27.5	-------	1931
141	30	-------	35	-------	44	-------	52	56	65	[i] 44	37.5	-------	1931
142	33	-------	33	-------	42	-------	46	49	62	[i] 40	33.4	-------	1931
68	-------	-------	41	-------	39	-------	43	51	[h] 51	[i] 40	28.0	-------	1927
69	-------	-------	42	-------	41	-------	44	50	[h] 50	[i] 42	28.0	-------	1927
303	29	34	38	35	36	36	39	48	51	38	25.2	-------	1941
302	38	34	29	35	34	38	44	57	63	41	20.6	-------	1941
71	-------	-------	56	-------	53	-------	57	58	[j] 64	[i] 55	34.0	-------	1927
72	-------	-------	56	-------	52	-------	53	60	[j] 70	[i] 54	34.0	-------	1927
73	-------	-------	55	-------	53	-------	57	60	[j] 70	[i] 55	28.0	-------	1927
74	-------	[j] 56	52	-------	52	-------	61	61	[j] 62	[i] 55	34.0	-------	1928

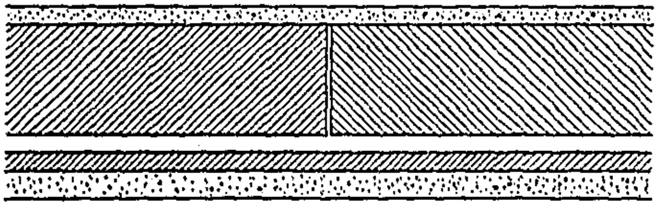
[h] Results obtained at 3,100 cps instead of 4,096 cps.
[i] Averages obtained for 256, 512, and 1,024 cps.
[j] Results obtained at 165 and 3,100 cps instead of 192 and 4,096 cps.

PANEL 75

PANEL 75. *Double partition of 3- by 12- by 12-in. hollow clay tile spaced 1¼ in. between sides; 1-in. flax fiberboard butted tight was placed in the space between the tile.*

PANEL 304 PANEL 305

PANEL 304. *3-in. hollow gypsum blocks cemented together with ⅜-in. mortar joints; on each side ½ in. of sanded gypsum plaster.*
PANEL 161. *3- by 12- by 30-in. gypsum tile; on each side ½ in. of sanded gypsum plaster.*
PANEL 309. *Same as panel 304.*
PANEL 305. *Same as panel 304, except 4-in. gypsum blocks were used.*
PANEL 301. *3-in. gypsum tile laid in portland cement; ½ in. of sprayed fibrous acoustic materia. on one side; ½ in. of sanded gypsum plaster on each outer surface (see drawing of panel 301, and also of panel 302, page 16.)*



PANEL 310

PANEL 310. *3- by 12- by 30-in. hollow gypsum blocks; on one side ½-in. sanded gypsum plaster; on the other side, a slotted channel system held ½-in gypsum lath covered by ½ in. of sanded gypsum plaster.*

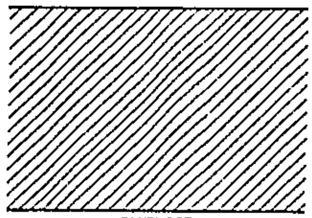
PANEL 138

PANEL 138. *3- by 12- by 30-in. gypsum tile; on one side ½ in. of sanded gypsum plaster; on the other side, spring clips held expanded-metal lath which held ¾ in. of sanded gypsum plaster.*

TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
HOLLOW CLAY TILE—Continued													
											lb/ft²		
75	-------	-------	55	-------	51	-------	51	66	[l] 73	[m] 52	50. 0	-------	1927
HOLLOW GYPSUM TILE													
304	38	34	34	38	36	39	42	48	45	39	21. 8	F44	1950
101	29	31	36	38	36	37	42	47	47	38	21. 0	-------	1938
[k] 300	40	38	34	31	39	42	44	48	48	40	21. 1	F58	1953
305	37	42	42	41	38	42	45	49	49	43	23. 4	F44	1950
301	40	35	32	36	34	40	44	52	64	42	27. 5	-------	1941
[k] 310	38	36	35	42	47	50	51	56	58	46	26. 4	F57	1953
138	45	-------	44	-------	55	-------	59	62	80	[m] 53	-------	-------	1930

[k] Panels 300 and 310: Results obtained for frequencies 125, 175, 250, 350, 500, 700, 1,000, 2,000, and 4,000 cps (averages obtained for 125 to 4,000 cps).
[l] Results obtained at 3,100 cps instead of 4,096 cps.
[m] Averages obtained for 256, 512, and 1,024 cps.

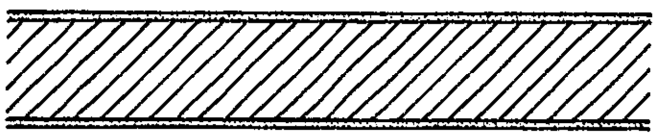


PANEL 307

PANEL 307. *12-in. brick wall.*

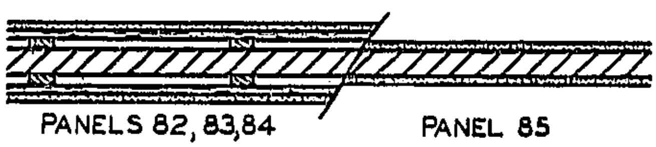
PANELS 25 & 26

PANEL 25. *4-in. brick; on each side 5/8 in. of sanded lime plaster.*
PANEL 26. *4-in. brick; on each side 5/8 in. of sanded gypsum plaster.*



PANELS 79, 80, 81

PANEL 79. *8-in. brick, poor workmanship; on each side 5/8 in. of sanded gypsum plaster.*
PANEL 80. *Same as panel 79, except workmanship was good.*
PANEL 81. *Same construction as panel 80.*



PANELS 82, 83, 84 PANEL 85

PANEL 82. *Brick laid on edge; on each side 13/16- by 2-in. furring strips wired to brick surface 16 in. on centers, 3/8-in. gypsum lath, and 1/2 in. of sanded gypsum plaster.*
PANEL 83. *Same as panel 82, except that the furring strips were nailed to plugs in the brick.*
PANEL 84. *Same as panel 83, except that 1/2-in. wood fiberboard was used in place of gypsum lath.*
PANEL 85. *Brick laid on edge; on each side 5/8 in. of sanded gypsum plaster.*

PANELS 526. 527

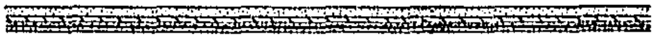
PANEL 526. *Expanded metal lath; on each side gypsum perlite plaster; panel thickness 2 in.*
PANEL 527. *Same as panel 526, except sanded gypsum plaster was used.*
PANEL 503. *Expanded-metal lath; on each side sanded gypsum plaster; panel thickness 2 in.*

TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
						BRICK							
											lb/ft²		
307	45	49	44	52	53	54	59	60	61	53	121	F52	1951
25	------	------	43	------	------	------	47	54	a 56	b 45	------	------	1926
26	------	------	46	------	------	------	49	58	a 61	b 48	------	------	1926
79	------	------	48	------	48	------	56	56	a 60	b 50	92.0	------	1927
80	------	------	48	------	49	------	57	59	a 70	b 51	97.0	------	1927
81	------	------	50	------	48	------	56	64	a 69	b 51	87.0	------	1928
82	------	------	52	------	47	------	56	54	a 58	b 52	36.5	------	1927
83	------	------	47	------	44	------	54	61	a 69	b 48	38.2	------	1927
84	------	------	49	------	50	------	60	56	a 58	b 53	33.3	------	1928
85	------	------	40	------	37	------	49	59	a 59	b 42	31.6	------	1928
					STUDLESS PLASTER—EXPANDED-METAL LATH CORE								
520	37	35	20	26	31	29	32	41	45	33	8.8	F51	1951
527	35	38	28	37	34	36	40	48	50	38	18.1	F51	1951
503	37	36	29	33	36	32	38	48	55	38	18.4	F20	1944

a Results obtained at 3,100 cps instead of 4,096 cps.
b Averages obtained at 256, 512, and 1,024 cps.

PANEL 504 PANEL 506

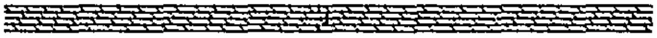


PANEL 520

PANEL 504. *3/8-in. gypsum lath; 13/16 in. of sanded gypsum plaster on each side; panel thickness 2 in.*
PANEL 506. *3/8-in. gypsum lath; 1 1/16 in. of sanded gypsum plaster on each side; panel thickness 2 1/2 in.*
PANEL 510. *3/8-in. gypsum lath; on each side 13/16 in. of sanded gypsum plaster.*
PANEL 511. *3/8-in. gypsum lath; on each side 1 1/16 in. of sanded gypsum plaster.*
PANEL 512. *3/8-in. gypsum lath; on each side 1 5/16 in. of sanded gypsum plaster.*
PANEL 516. *3/8-in. gypsum lath; on one side 3/4 in. of sanded gypsum plaster; on the other side 7/8 in. of sanded gypsum plaster.*
PANEL 517. *Same as panel 516, except plaster was gypsum perlite.*
PANEL 521. *1/2-in. gypsum lath; on each side 3/4 in. of gypsum perlite plaster.*
PANEL 520. *3/8-in. gypsum lath; on one side 3/4 in. of sanded gypsum plaster; on the other side scratch coat of sanded gypsum plaster, 1/8-in. heavy-gage quilted asphalt felt, and brown coat of sanded gypsum plaster to make the total thickness of the panel 1 3/4 in.*

PANEL 528

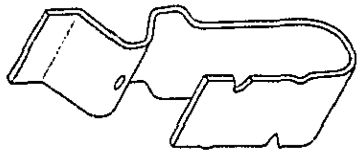
PANEL 528. *Two layers of 1/2-in. gypsum wallboard glued together to form a 1-in. layer; joints covered with wooden strips on each side.*



PANEL 522

PANEL 522. *Four layers of 1/2-in. gypsum wallboard glued together and fastened with sheet-metal screws; joints staggered as shown in drawing; surface joints covered with paper tape.*

PANEL 428



PANEL 428

PANEL 428. *Same as panel 522, except spring clips attached to one surface by sheet-metal screws; horizontal slotted channel 30 3/4 in. on centers attached to spring clips by sheet-metal screws; 1-in. gypsum wallboard unit (similar to one half of panel 522) attached to channels.*

TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
STUDLESS PLASTER—SINGLE GYPSUM LATH CORE													
											lb/ft²		
504	38	36	27	32	35	32	36	46	54	37	10. 8	F22	1944
506	38	32	32	32	35	36	39	40	55	39	10. 7	F21	1944
510	38	34	23	32	32	32	36	46	51	36	16. 1	F29	1946
511	39	30	37	39	36	36	40	48	54	40	20. 2	F30	1946
512	39	36	32	34	35	40	42	48	53	40	25. 4	F31	1946
516	38	35	28	32	32	34	36	46	49	37	16. 8	F30	1949
517	34	34	30	33	34	28	33	42	46	35	9. 0	F39	1949
521	32	38	36	37	34	34	31	41	47	37	10. 9	F43	1949
520	35	38	38	41	41	42	41	41	52	41	13. 9	F42	1949
STUDLESS PLASTER—GYPSUM WALLBOARD													
528	24	25	20	32	31	33	32	30	34	30	4. 5	-------	1942
522	28	35	32	37	34	36	40	38	40	37	8. 9	F43	1949
428	36	32	32	38	40	42	45	46	56	41	13. 4	F44	1950

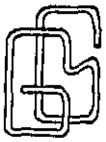
PANEL 515. *Two sheets of ½-in. gypsum lath clamped tightly together; on each side ⅝ in. of sanded gypsum plaster.*

PANEL 513. *Two sheets of ⅜-in. gypsum lath separated by ¼-in. felt pad spacers; on each side 13/16 in. of sanded gypsum plaster.*

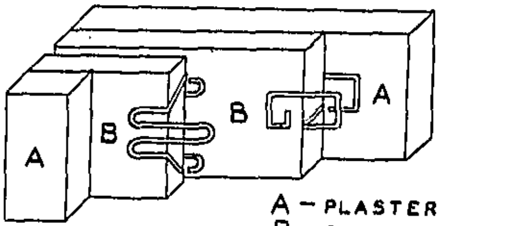
PANEL 514. *Same as panel 513, except that thickness of sanded gypsum plaster was ½ in. on one side and 1⅛ in. on the other side.*

PANEL 505

PANEL 505. *Two sheets of gypsum lath spaced ¼ in. apart with felt spacers; joints between lath covered with metal lath to prevent mortar from bonding two sides together; on each side ½ in. of sanded gypsum plaster.*



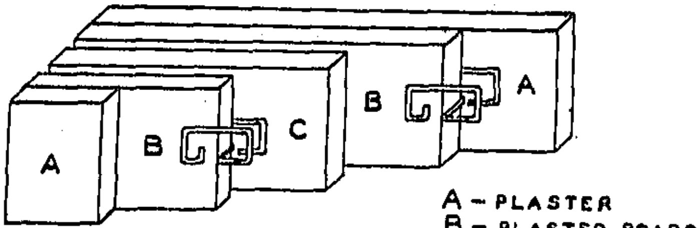
PANELS 507, 509



PANEL 507

PANEL 507. *½-in. and ⅜-in. gypsum laths, held together at vertical joints partly by clips of panel 416 (page 42), and partly by clip in sketch, with ¼-in. airspace between laths because of thickness of clips; ⅝ in. of sanded gypsum plaster on each side.*

PANEL 508. *Similar to panel 507, except that all clips were same as those of panel 416 (page 42); two sheets of ½-in. gypsum lath; ½ in. of sanded gypsum plaster on one side, 13/16 in. on the other side.*

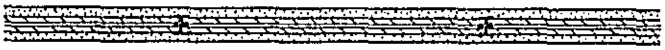


PANEL 509

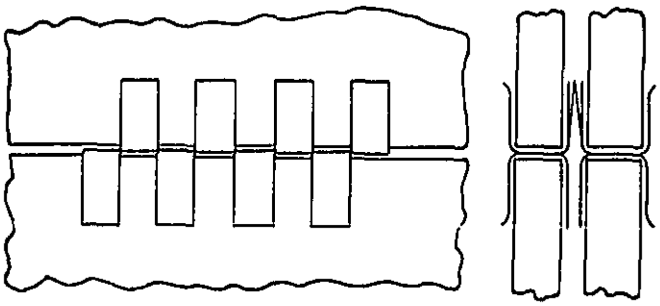
PANEL 509. *½-in. fiberboard held between ½-in. gypsum lath on one side and ⅜-in. gypsum lath on the other side by means of clips shown with panel 507; ¼-in. airspace between fiberboard and gypsum lath on each side; on outer surfaces ½ in. of sanded gypsum plaster.*

TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
STUDLESS PLASTER—DOUBLE GYPSUM LATH CORE													
											lb/ft²		
515	40	38	37	40	41	40	37	44	52	41	18.1	F34	1946
513	43	40	37	38	39	40	37	45	56	42	17.9	F32	1946
514	40	40	38	40	41	40	41	45	52	42	19.2	F33	1946
505	35	35	29	30	33	40	38	43	57	38	15.3	......	1941
507	31	32	32	36	38	41	40	50	62	40	12.0	F28	1945
508	34	35	35	38	40	44	40	50	60	42	13.6	F27	1945
509	36	41	41	44	47	49	48	53	62	47	15.9	F26	1945

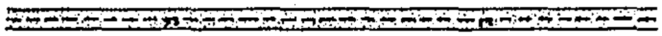


PANEL 430, 431



PANELS 430, 431

PANEL 430. *½-in. long-length gypsum lath on each side of ¼-in. airspace; ¾ in. of sanded gypsum plaster on outer surfaces; ¼-in. airspace set by double clip along joints of lath.*
PANEL 431. *Same as panel 430, except that airspace was ⅛ in. instead of ¼ in.*



PANEL 525

PANEL 525. *¾-in. cold-rolled steel channels 22 in. on centers; expanded-metal lath on one side; gypsum perlite plaster on both sides; panel thickness 1½ in.*

PANEL 154

PANEL 154. *¾-in. steel channels 16 in. on centers; paper-backed expanded-metal lath on one side; sanded gypsum plaster on both sides; panel thickness 2 in.*
PANEL 171A. *¾-in. steel channels 12 in. on centers; expanded-metal lath on one side; sanded gypsum plaster on both sides; panel thickness 2 in.*
PANEL 171B. *Same construction as panel 171A.*
PANEL 171C. *Same construction as panel 171A.*
PANEL 172. *Same as panel 171C, except thickness increased to 2½ in. by adding sanded gypsum plaster.*
PANEL 501. *¾-in. metal channels 16 in. on centers; expanded-metal lath on one side; vermiculite gypsum plaster on both sides; panel thickness 2 in.*
PANEL 502. *Same construction as panel 171A.*
PANEL 518. *¾-in. metal channels approximately 11 in. on centers; expanded-metal lath on one side; sanded gypsum plaster on both sides; panel thickness 2 in.*
PANEL 519. *Same as panel 518, except that gypsum perlite plaster was used.*
PANEL 523. *Same as panel 501, except sanded gypsum plaster was used.*

PANEL 524

PANEL 524. *Same as panel 523, except that in addition to the metal lath, a partial lath of 3.4-lb burial vault mesh 32 by 28¾ in. was placed on the opposite side of the channels directly in the center of the panel with the 32-in. dimension horizontal.*

PANEL 170

PANEL 170. *¾-in. steel channels 10 in. on centers; perforated gypsum lath on one side; sanded gypsum plaster on both sides; panel thickness 2 in.*

TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
STUDLESS PLASTER—DOUBLE GYPSUM LATH CORE													
											lb/ft²		
430	37	38	36	45	46	46	44	62	66	47	18.9	F46	1950
431	35	36	36	41	45	46	44	52	62	44	17.1	F49	1950
SOLID PLASTER WITH STEEL STUDS													
525	28	36	32	31	29	29	30	38	41	33	7.4	F48	1950
154	38	37	34	33	36	36	41	48	50	40	-------	-------	1936
171A	36	32	30	32	34	36	39	47	54	38	16.4	-------	1938
171B	29	30	26	30	30	34	37	46	54	35	17.7	-------	1938
171C	35	33	22	32	31	31	38	47	55	36	18.8	-------	1939
172	34	26	33	37	35	37	43	50	57	39	22.4	-------	1939
501	36	34	33	33	30	29	28	38	48	34	8.8	-------	1941
502	40	36	23	32	36	33	36	47	54	38	18.1	F19	1944
518	43	35	28	36	32	35	42	50	50	39	18.7	F39	1949
519	35	36	24	31	29	29	33	42	45	34	9.6	F39	1949
523	40	39	30	37	33	35	42	48	50	39	17.0	F45	1950
524	36	36	28	38	36	36	39	46	48	38	17.4	F45	1950
170	30	28	33	35	31	33	38	48	53	36	19.4	-------	1939

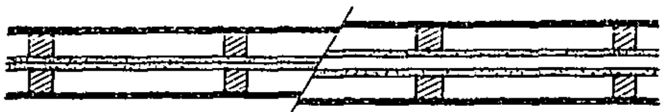
PANEL 211 / PANEL 212 / PANEL 214 / PANEL 215

PANEL 211. *1- by 3-in. wood studs 16 in. on centers; ¼-in. plywood glued to each side.*

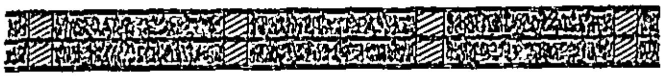
PANEL 212. *Same as panel 211, but with ½-in. gypsum wallboard nailed to both plywood surfaces.*

PANEL 214. *1- by 3-in. staggered wood studs, each set spaced 16 in. on centers and spaced 8 in. on centers with 1-in. offset from other set; ¼-in. plywood glued to both sides.*

PANEL 215. *Same as panel 214, but with ½-in. gypsum wallboard glued to both plywood surfaces.*



PANEL 216 / PANEL 218



PANEL 217

PANEL 216. *Two sets of 2- by 2-in. wood studs, each set spaced 16 in. on centers; two sheets of ½-in. gypsum wallboard inserted in 1-in. space between studs; ¼-in. plywood glued to studs on each outer side; panel thickness 4¼ in.*

PANEL 217. *Two sets of 2- by 2-in. wood studs, each set spaced 16 in. on centers; ¼-in. plywood inserted in ¼-in. space between studs; on each outer side ¼-in. plywood; paper-back mineral wool inserted in both airspaces; panel thickness 4 in.*

PANEL 218. *Two sets of 2- by 2-in. wood studs, each set spaced 16 in. on centers; ½-in. gypsum wallboards nailed to inside surface of each set of studs, leaving 1-in. airspace between gypsum wallboards; ¼-in. plywood glued to outer surfaces of studs.*

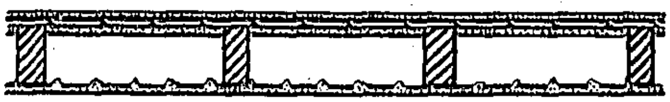
PANEL 179A / PANELS 179B,C / PANEL 179D

PANEL 179A. *2- by 4-in. wood studs 16 in. on centers; on each side ⅝-in. plywood with a light cotton fabric glued on one side, and a heavy cotton duck glued on the other.*

PANEL 179B. *Same as panel 179A, except that a 4-in. flameproofed cotton bat was placed in airspace between studs.*

PANEL 179C. *Same as panel 179B, except that a 1-in. flameproofed cotton bat was used in place of the 4-in. bat.*

PANEL 179D. *Same as panel 179A, except that 3½-in. strips of the 4-in. flameproofed cotton bats were tacked on each 3½-in. side of each wood stud (see drawing).*



PANEL 127

PANEL 127. *2- by 4-in. wood studs 16 in. on centers; on one side ½-in. wood fiberboard, and ½ in. sanded gypsum plaster on each side of the wood fiberboard; on the other side expanded metal lath and ⅞ in. of sanded gypsum plaster.*

TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
PLYWOOD ON WOOD STUDS													
											lb/ft²		
211	16	16	18	20	26	27	28	37	33	24	2.5	F10	1943
212	20	34	33	40	39	44	46	50	50	40	6.6	F11	1943
214	14	17	20	23	28	30	33	40	30	26	2.9	F12	1943
215	40	37	39	45	48	50	51	54	55	46	7.0	F13	1943
216	18	25	29	31	32	37	42	40	51	35	8.0	F15	1944
217	20	31	31	35	37	41	41	49	50	37	5.2	F16	1944
218	27	24	29	33	37	42	46	55	55	39	7.4	F18	1944
170A	15	20	28	33	29	34	38	43	40	31	4.6	-------	1940
170B	14	27	33	37	34	39	42	46	44	35	4.8	-------	1940
170C	15	24	28	37	31	38	43	49	46	35	4.6	-------	1940
170D	13	23	31	37	34	38	42	47	45	34	4.7	-------	1940
WOOD LATH AND EXPANDED-METAL LATH ON WOOD STUDS													
127	-------	[p] 45	45	-------	45	-------	48	58	[p] 50	[q] 40	20.9	-------	1928

[p] Results obtained at 165 and 3,100 cps instead of 192 and 4,096 cps, respectively.
[q] Averages obtained for 256, 512, and 1,024 cps.

PANEL 208 PANEL 209

PANEL 208. *1⅛-in. wallboard nailed on one side only of 1⅝- by 8-in. wood stud. Wallboard consisted of ⅞-in. cane-fiber center covered on each side by ⅛-in. cement-asbestos layers.*

PANEL 209. *Similar to panel 208, except that the 1⅛-in. wallboard was on both sides of 1⅝- by 8-in. wood studs 44 in. on centers.*

PANEL 120 PANEL 123

PANEL 120. *2- by 4-in. wood studs 16 in. on centers; on each side ½-in. wood fiberboard, joints filled.*

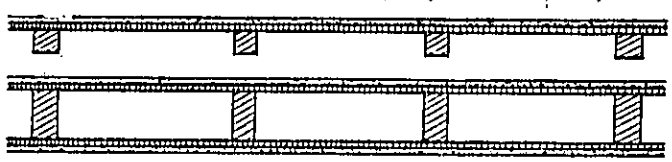
PANEL 123. *2- by 4-in. wood studs 16 in. on centers; on each side ½-in. wood fiberboard and ½ in. of sanded gypsum plaster.*

PANEL 206. *2- by 4-in. wood studs 16 in. on centers; ½-in. dense wood fiberboard on each side, with joints at studs.*

PANEL 207. *Similar to panel 206, except that ¾-in. wood fiberboard was used.*

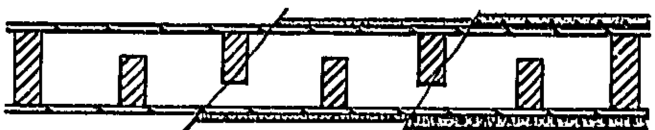
PANEL 210. *2- by 2-in. wood studs 16 in. on centers; on each side ½-in. fiberboard.*

PANEL 205. *2- by 4-in. wood studs 16 in. on centers; on each side ½-in. fiberboard and ½ in. of sanded gypsum plaster.*



PANEL 213

PANEL 213. *Same as panel 205, except that an auxiliary wall was added on one side only, with a 8½-in. airspace. The auxiliary wall consisted of 2- by 2-in. wood studs 16 in. on centers, ½ in. fiberboard, and ½ in. of sanded gypsum plaster.*

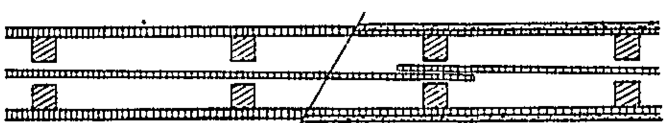


PANEL 124 PANEL 126 PANEL 125

PANEL 124. *Staggered 2- by 4-in. wood studs, each set spaced 16 in. on centers with studs of one set 8 in. on centers and projecting 2 in. on centers from other set; on each side ½-in. wood fiberboard, joints filled.*

PANEL 126. *Studs same as in panel 124; on each side ½-in. wood fiberboard and ½ in. of sanded gypsum plaster.*

PANEL 125. *Studs same as in panel 124; on each side ½-in. wood fiberboard, heavy corrugated paper, wire-reinforced, then sanded gypsum plaster.*



PANEL 219 PANEL 220

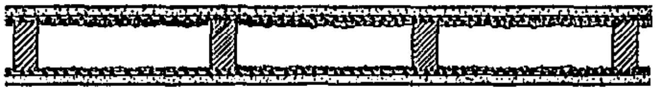
PANEL 219. *Two sets of 2- by 2-in. wood studs, each set 16 in. on centers; ½-in. fiberboard stood loose in 2-in. airspace between studs; on each side ¾-in. fiberboard; panel thickness 7 in.*

PANEL 220. *Similar to panel 219, with ¾-in. fiberboard replaced by ½-in. fiberboard and ½ in. of sanded gypsum plaster; panel thickness 7½ in.*

TABLE 2. *Sound-transmission loss*—WALLS—Continued

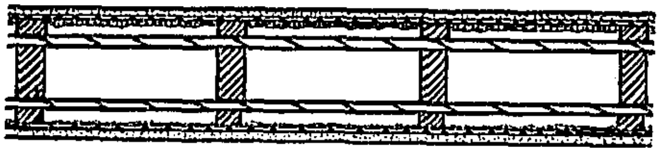
Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
FIBERBOARD ON WOOD STUDS													
											lb/ft^2		
208	21	23	24	28	28	28	23	40	38	28	-------	-------	1942
209	29	32	31	35	38	42	42	50	60	40	8.3	F14	1944
120	-------	[a] 28	29	-------	24	-------	30	48	[a] 51	[b] 29	5.1	-------	1928
123	-------	[a] 46	40	-------	47	-------	57	56	[a] 55	[b] 48	13.3	-------	1928
206	16	19	22	32	28	33	38	50	52	32	3.8	-------	1941
207	21	18	21	27	31	32	38	49	53	33	4.3	-------	1941
210	14	11	17	28	27	30	37	47	51	30	3.1	-------	1942
205	28	27	31	38	41	44	46	47	66	41	12.6	F1	1943
213	41	46	44	49	50	51	52	56	72	51	18.2	F1	1943
124	-------	[a] 34	30	-------	28	-------	42	50	[a] 60	[b] 33	4.0	-------	1928
126	-------	[a] 50	52	-------	49	-------	60	60	[a] 54	[b] 54	13.1	-------	1928
125	-------	[a] 52	53	-------	47	-------	54	58	[a] 63	[b] 51	16.1	-------	1928
219	28	29	28	39	40	43	48	62	68	43	6.2	-------	1941
220	42	48	48	51	49	51	55	54	73	52	14.3	-------	1941

[a] Results obtained at 165 and 3,100 cps instead of 192 and 4,096 cps.
[b] Averages obtained for 256, 512, and 1,024 cps.



PANELS 162, 163, 119

PANEL 162. *Wood studs; on each side ⅝-in. total thickness of wood lath and sanded lime plaster.*
PANEL 163. *Wood studs; on each side ⅝-in. total thickness of wood lath and sanded gypsum plaster.*
PANEL 119. *2- by 4-in. wood studs 16 in. on centers; on each side ⅞-in. total thickness of wood lath and sanded gypsum plaster.*
PANEL 201. *2- by 4-in. wood studs 16 in. on centers; on each side wood lath and ½ in. of sanded gypsum plaster.*



PANEL 86

PANEL 86. *2- by 4-in. wood studs 16 in. on centers; on each side ½-in. flax fiberboard, 1- by 2-in. wood furring strips 16 in. on centers, ⅞-in. total thickness of wood lath and gypsum plaster.*

PANELS 164 & 165

PANEL 164. *Wood studs; on each side expanded-metal lath and ¾ in. of sanded lime plaster.*
PANEL 165. *Wood studs; on each side expanded-metal lath and ¾ in. of sanded gypsum plaster.*
PANEL 228. *2- by 4-in. wood studs 16 in. on centers; on each side expanded-metal lath and ¾ in. of sanded gypsum plaster.*

PANEL 174

PANEL 174. *2- by 4-in. wood studs 16 in. on centers; on both sides expanded-metal lath with paper backing nailed to studs with special nail; ¾ in. of sanded gypsum plaster.*

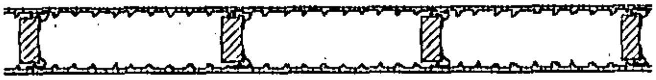
Table 2. *Sound-transmission loss*—walls—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
WOOD LATH ON WOOD STUDS													
											lb/ft²		
162	27	27	36	38	41	44	50	55	60	42	15.6	-------	1938
163	32	29	18	34	33	40	37	40	58	36	15.1	-------	1938
119	-------	[4] 38	40	-------	39	-------	44	49	[4] 59	[5] 41	17.4	-------	1928
201	35	32	24	37	34	32	37	45	61	38	17.1	F1	1942
86	-------	-------	42	-------	38	-------	45	54	[4] 62	[5] 42	14.7	-------	1927
EXPANDED-METAL LATH ON WOOD STUDS													
164	26	34	41	40	44	40	52	56	58	44	19.8	-------	1938
165	31	26	34	32	38	44	43	45	61	39	20.0	-------	1938
228	29	28	28	38	38	43	45	46	54	39	18.1	F43	1940
174	30	27	25	31	34	37	38	38	54	35	12.6	-------	1930

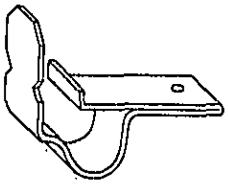
[4] Results obtained at 165 and 3,100 cps instead of 192 and 4,096 cps.
[5] Averages obtained for 256, 512, and 1,024 cps.

PANEL 175

PANEL 175. *Staggered 2- by 4-in. wood studs, each set spaced 16 in. on centers, with one set having the 3⅝-in. faces parallel to the wall surface; on each side expanded-metal lath and ¾ in. of sanded gypsum plaster.*

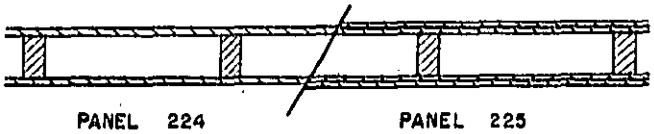


PANEL 425



PANELS 425, 710

PANEL 425. *2- by 4-in. wood studs 16 in. on centers; on each side, ¼-in. metal rod fastened vertically along each stud by spring clips 16 in. on centers, expanded-metal lath wire-tied to metal rod, and ⅞ in. of sanded gypsum plaster.*

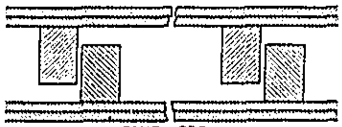


PANEL 224 PANEL 225

PANEL 224. *2- by 4-in. wood studs 16 in. on centers; on each side ½-in. gypsum wallboard; joints in wallboard filled and covered with paper tape.*

PANEL 234. *Same as panel 224.*

PANEL 225. *2- by 4-in. wood studs 16 in. on centers, on each side two layers of ⅜ in. gypsum wallboard cemented together; joints in outer wallboards filled and covered with paper tape.*



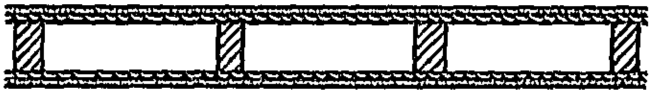
PANEL 235

PANEL 235. *Staggered 2- by 3-in. wood studs, each set spaced 16 in. on centers, ¼ in. apart from the other set and projecting 1 in.; on each side two layers of ½-in. gypsum wallboard, with the joints of one layer set vertically, and the other horizontally. The two layers of wallboard were cemented together and the outside joints sealed with tape.*

TABLE 2. *Sound-transmission loss*—WALLS—Continued

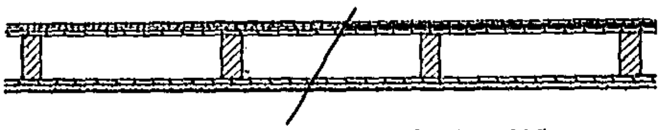
Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
EXPANDED-METAL LATH ON WOOD STUDS—Continued													
											lb/ft²		
175	44	47	47	48	47	50	50	52	63	50	10. 8	....	1939
425	47	50	48	51	52	54	54	51	61	52	10. 1	F43	1949
GYPSUM BOARD AND LATH ON WOOD STUDS													
224	20	22	27	35	37	39	43	48	43	35	5. 0	F37	1948
ª 234	22	23	28	32	33	41	44	46	39	34	5. 6	F54	1953
225	27	24	31	35	40	42	46	53	48	38	8. 2	F37	1948
ª 235	42	40	39	40	45	42	45	41	53	43	11. 0	F55	1953

ª Results for panels 234 and 235 obtained at frequencies of 125, 175, 250, 350, 500, 700, 1,000, 2,000, and 4,000 cps (averages obtained for 125 to 4,000 cps).



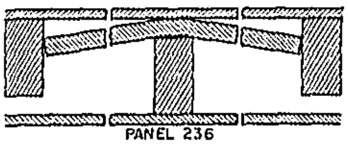
PANELS 148 & 149

PANEL 148. *2- by 4-in. wood studs 16 in. on centers; on both sides gypsum lath nailed to studs with nails approximately 6 in. apart, then ½ in. of sanded gypsum plaster.*
PANEL 149. *2- by 4-in. wood studs 16 in. on centers; on both sides gypsum lath held with special nails with large heads, the nails being driven between the sheets of gypsum lath, then ½ in. of sanded gypsum plaster.*
PANEL 202. *2- by 4-in. wood studs 16 in. on centers; on each side ⅜-in. gypsum lath and ½ in. of sanded gypsum plaster.*
PANEL 203. *Similar to panel 202, except the plaster used was ½ in. of vermiculite gypsum.*
PANEL 204. *2- by 4-in. wood studs 16 in. on centers, on each side ⅜ in. perforated gypsum lath and ½ in. of vermiculite gypsum plaster.*



PANEL 226 PANEL 227

PANEL 226. *2- by 4-in. wood studs 16 in. on centers; on each side ⅜-in. gypsum lath and sanded gypsum plaster with quilted asphalt felt, 1/16 in. thick, applied on one side only between scratch and brown coats of the gypsum plaster; ½ in. between outside surface and surface of lath.*
PANEL 227. *Same as panel 226, except that the felt was ¼ in. thick instead of 1/16 in. thick.*



PANEL 236

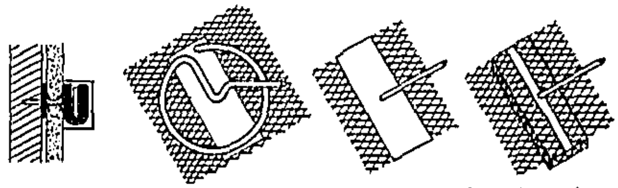
PANEL 236. *Staggered 2- by 4-in. wood studs, each set 16 in. on centers, with studs of one set 8 in. on centers and offset ¼ in. on centers from the corresponding studs of the other set; on one side only, 0.9-in. thick wood-fiber wool blanket stapled to outer surface of 2- by 4-in. wood studs; on each side ½-in. gypsum wallboard.*

TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
GYPSUM BOARD AND LATH ON WOOD STUDS—Continued													
											lb/ft²		
148	33	28	31	35	39	44	46	49	66	41	15.2	-------	1937
149	32	41	39	43	46	51	50	55	72	48	15.7	-------	1937
202	33	24	24	30	28	38	30	42	59	35	15.0	F1	1942
203	27	24	20	31	27	30	36	38	55	33	9.6	-------	1941
204	31	25	22	34	31	38	38	46	66	37	12.9	-------	1941
226	28	28	33	35	40	43	48	48	58	40	12.7	F42	1949
227	26	29	34	35	41	42	48	49	58	40	12.0	F42	1949
* 236	39	38	40	42	42	45	48	56	51	45	13.8	F60	1953

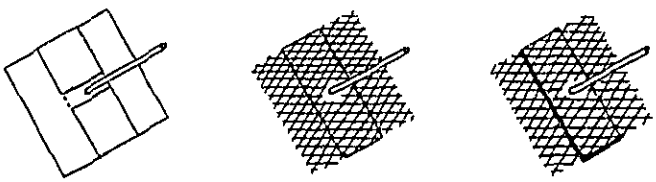
* Results for panel 236 obtained at frequencies of 125, 175, 250, 350, 500, 700, 1,000, 2,000, and 4,000 cps (averages obtained for 125 to 4,000 cps).

PANEL 401-412. *2- by 4-in. wood studs 16 in. on centers; on each side $\frac{3}{8}$-in. gypsum lath and $\frac{1}{2}$ in. of sanded gypsum plaster, lath held by special nails with resilient heads, nails being driven into the joints between pieces of lath.*



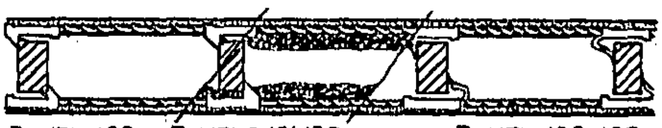
PANEL 401 PANEL 405 PANEL 406 PANEL 407

PANEL 401. *Head of nail imbedded in felt and covered with sheet iron; $\frac{1}{4}$-in. felt pad between stud and gypsum lath.*
PANEL 402. *Nail similar to that of 401; no felt pad between stud and perforated gypsum lath.*
PANEL 403. *Nail head consisting of a ring of steel rod integral with nail itself; similar to that of panel 405 but without cardboard; perforated gypsum lath used.*
PANEL 404. *Same as 403, except solid gypsum loth waz used.*
PANEL 405. *Nail head consisting of a ring of steel rod integral with nail itself; corrugated cardboard and expanded-metal lath strip applied to head of nail; gypsum board held snugly against the stud.*
PANEL 406. *Ordinary nail with head encased in expanded-metal lath square; metal lath girdling the expanded-metal lath square; gypsum lath snug against studs.*
PANEL 407. *Ordinary nail with head encased in corrugated cardboard, and expanded-metal lath square encompassing the cardboard but not touching nail; gypsum lath snug against studs.*



PANEL 408 PANEL 410 PANELS 411,412

PANEL 408. *Ordinary nail with head enclosed in corrugated cardboard, metal strap girdling the cardboard square but not in contact with nail; gypsum lath loose against studs, approximately $\frac{1}{32}$ in. of play.*
PANEL 409. *Nail similar to that of panel 401; gypsum lath snug against studs.*
PANEL 410. *Ordinary nail with head encased in thin cardboard, expanded-metal lath square over cardboard, which was highly compressed.*
PANEL 411. *Nail similar to that of panel 410, but head of nail was encased in felt and then covered by an expanded-metal lath square; lath snug against studs.*
PANEL 412. *Same nail as in panel 411; $\frac{1}{4}$-in. felt pad between stud and gypsum lath.*



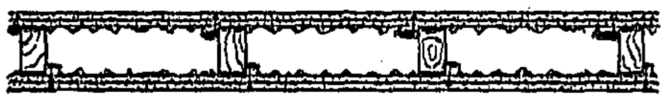
PANEL 153 PANELS 151,152 PANEL 150,167

PANEL 153. *2- by 4-in. wood studs 16 in. on centers; on each side gypsum lath attached to studs with stiff clips and covered by $\frac{5}{8}$ in. of sanded gypsum plaster.*
PANEL 151. *Similar to panel 153, except that $\frac{1}{2}$-in. felt was glued inside gypsum lath, and sanded gypsum plaster.*
PANEL 152. *Similar to panel 151, except that gypsum plaster was $\frac{1}{2}$ in. thick instead of $\frac{5}{8}$ in.*

PANEL 150. *2- by 4-in. wood studs 16 in. on centers; on both sides $\frac{3}{8}$-in. gypsum lath attached to studs by spring clips, then $\frac{1}{2}$ in. of gypsum plaster.*
PANEL 167. *2- by 4-in. wood studs 16 in. on centers; on both sides $\frac{3}{8}$-in. perforated gypsum lath attached to studs by spring clips, then $\frac{1}{2}$ in. of sanded gypsum plaster.*
PANEL 168. *Same as panel 167, except that the space between the studs was filled with glass wool packed to a density of $1\frac{1}{2}$ lb/ft^3.*

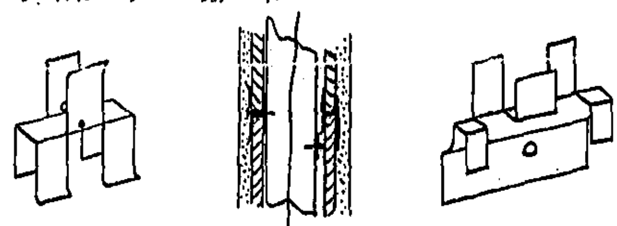
TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second) 128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096	Weight	Test number	Year of test
GYPSUM LATH HELD BY SPECIAL NAILS ON WOOD STUDS													
											lb/ft²		
401	19	30	34	38	39	44	46	52	63	41	13.6	-------	1941
402	29	36	34	38	40	43	46	50	66	42	15.8	-------	1941
403	23	29	30	36	39	39	41	48	62	39	15.0	-------	1941
404	23	25	33	36	37	43	43	44	62	38	14.5	-------	1942
405	27	26	34	38	39	42	43	44	61	39	15.2	F4	1943
406	31	31	31	36	39	43	45	48	62	40	14.8	F5	1943
407	29	33	32	36	40	46	45	50	63	41	14.4	F7	1943
408	34	31	32	39	40	45	45	51	64	42	14.8	F8	1943
409	31	33	35	36	39	44	47	50	64	42	15.2	F9	1943
410	31	32	33	41	42	47	48	48	65	43	13.6	F23	1944
411	32	33	31	37	41	47	48	50	66	43	14.3	F24	1944
412	36	38	37	42	45	51	53	54	68	47	14.0	F25	1944
GYPSUM LATH HELD BY STIFF CLIPS ON WOOD STUDS													
153	31	37	40	42	46	51	51	54	67	47	-------	-------	1937
151	30	38	40	45	47	57	61	60	70	50	-------	-------	1937
152	37	40	42	45	46	55	61	62	68	51	17.2	-------	1937
GYPSUM LATH HELD BY SPRING CLIPS ON WOOD STUDS													
150	51	42	48	48	50	56	56	48	66	52	-------	-------	1937
167	45	53	45	48	47	53	55	53	67	52	15.7	-------	1938
168	48	50	49	53	53	56	58	58	68	55	16.9	-------	1938



PANEL 176

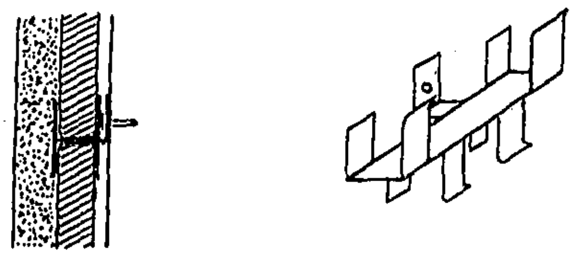
PANEL 176. *2- by 4-in. wood studs 16 in. on centers; on both sides perforated gypsum lath held by clips consisting of a coiled spring and a piece of heavy wire extending across the surface of the gypsum lath and interlocking with the adjoining clip; ½ in. of sanded gypsum plaster.*



PANEL 177 PANEL 178

PANEL 177. *2- by 4-in. wood studs 16 in. on centers; on each side ⅜-in. gypsum lath held by clip as shown in drawing, and ½ in. of sanded gypsum plaster. The nail went through the clip and gypsum lath near its edge, holding the lath and the clip firmly against the stud.*

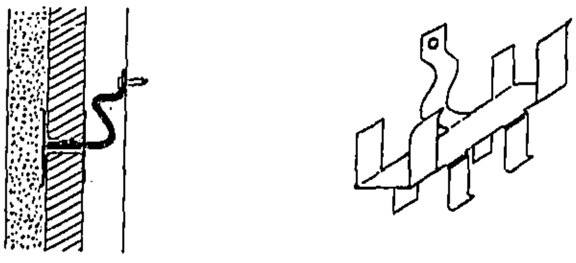
PANEL 178. *2- by 4-in. wood studs 16 in. on centers; on each side perforated gypsum lath attached to studs by means of clips shown in the drawing, and ½ in. of sanded gypsum plaster. The nail held only the back of the clip against the stud and allowed a small movement of the gypsum lath.*



PANEL 413

PANEL 413. *2- by 4-in. wood studs 16 in. on centers; on each side ⅜-in. gypsum lath held to studs by spring clips as shown in drawing, and ½ in. of sanded gypsum plaster.*

PANEL 415. *Similar to panel 413.*

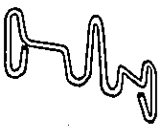


PANEL 414

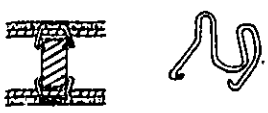
PANEL 414. *2- by 4-in. wood studs 16 in. on centers; on each side ⅜-in. gypsum lath held to studs by spring clip as shown in drawing, then ½ in. of sanded gypsum plaster. This clip was the same as that used in panel 413, except that a resilient member was introduced in the clip.*

TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
GYPSUM LATH HELD BY SPRING CLIPS ON WOOD STUDS—Continued													
											lb/ft[2]		
176	40	42	42	47	48	49	48	54	66	48	16.4	-------	1939
177	19	24	29	33	35	39	42	42	60	36	14.4	-------	1940
178	33	42	42	46	45	46	46	48	61	46	14.0	-------	1940
413	26	32	37	41	42	46	47	44	62	42	12.4	-------	1940
415	29	33	35	37	40	45	45	50	67	42	13.0	-------	1942
414	39	41	40	46	43	45	46	48	63	46	14.1	-------	1941



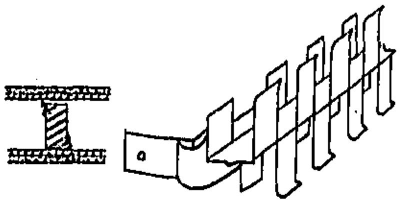
PANEL 416



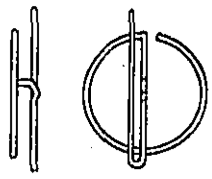
PANEL 417

PANEL 416. *2- by 4-in. wood studs 16 in. on centers; on each side ⅜-in. gypsum lath attached to stud by clip shown, then ½ in. of sanded gypsum plaster; clip nailed to stud by large-headed nail loosely driven into wood, giving a ⅜-in. airspace between the stud and the gypsum lath. The same clip was used for the vertical joints of the gypsum lath.*

PANEL 417. *2- by 4-in. wood studs 16 in. on centers; on each side ⅜-in. gypsum lath attached to stud by clip as shown, then ½ in. of sanded gypsum plaster; large-headed nails on each side of clip driven into stud before installation of gypsum lath gave a ⅜-in. airspace between the stud and gypsum lath.*

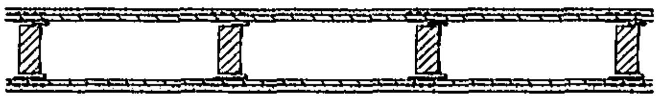


PANEL 418

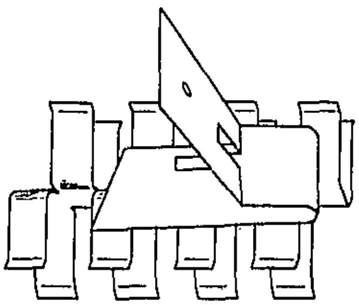


PANEL 419

PANEL 418, 419. *2- by 4-in. wood studs 16 in. on centers; on each side ⅜-in. gypsum lath held to studs by spring clips shown in drawings, then ½ in. of sanded gypsum plaster.*



PANELS 420, 421, 422, 423



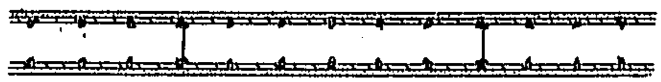
PANELS 420, 421, 422, 423, 709

PANEL 420 to 422. *2- by 4-in. wood studs 16 in. on centers; on each side ⅜-in. gypsum lath fastened to studs by spring clips, then ½ in. of sanded gypsum plaster. Panels 420, 421, and 422 were identical except for the length of the bent shank between the lath seat and the nailing strip of the spring clip. The black clip used on panel 420 was the most flexible, the red clip used on panel 422 was the stiffest, and the gray clip used on panel 421 was intermediate in stiffness.*

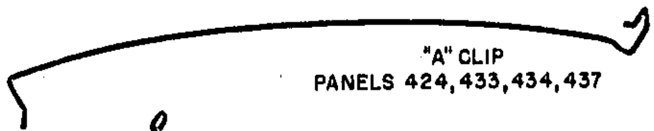
PANEL 423. *Same as panel 420, except that ⅜-in. perforated gypsum lath was used and the aggregate in the plaster was perlite.*

TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
GYPSUM LATH HELD BY SPRING CLIPS ON WOOD STUDS—Continued													
											lb/ft²		
416	37	38	39	40	42	45	45	49	66	44	14.9	F2	1943
417	29	38	38	42	40	47	44	49	66	44	15.5	F2	1943
418	41	44	42	44	45	48	48	49	62	47	14.3	F3	1943
419	37	33	37	44	44	48	48	52	63	45	15.1	F6	1943
420	46	44	49	56	54	57	57	50	62	52	13.1	F40	1949
421	43	48	45	56	54	57	57	49	50	52	13.1	F40	1949
422	45	45	46	56	54	57	58	48	62	52	13.1	F40	1949
423	38	40	45	52	54	56	56	51	64	51	11.9	F43	1949

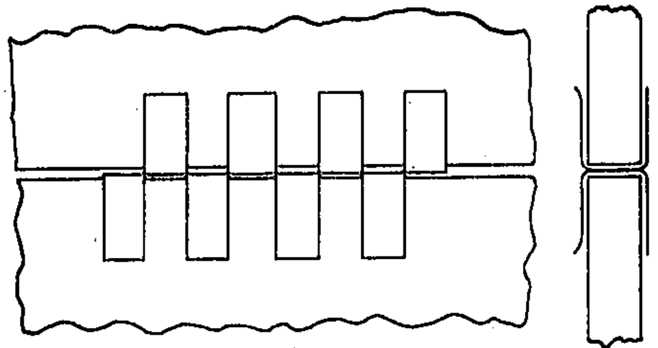


PANEL 424



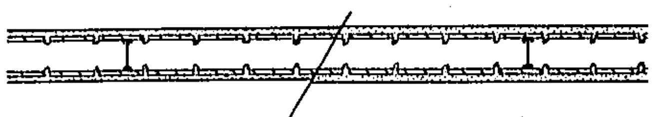
"A" CLIP
PANELS 424, 433, 434, 437

"B" CLIP
PANEL 433 ONLY



"D" CLIP
PANELS 424, 433, 434, 437

PANEL 424. *3¼-in. steel trusses used as studs 24 in. on centers and mounted vertically in metal tracks at top and bottom; on each side ⅜-in. perforated gypsum lath held to studs by "A" clips with edges of lath held together by "D" clips, then ½ in. of sanded gypsum plaster. The end of the "A" clip at the left in the drawing was wired to the metal track, and the other end was held by the steel truss; the clip held the gypsum lath in place. The adjacent piece of gypsum lath was then put in place, with the left-hand end of the "A" clip inserted in the right-hand side of the previous clip.*

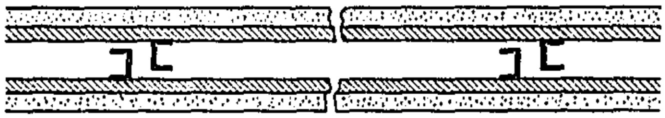


PANEL 434 PANEL 437

PANEL 434. *Same as panel 424, except that 2¼-in. trusses were used as studs 16 in. on centers.*
PANEL 437. *Same as panel 434, except that the plaster used was ⅝ in. of perlite gypsum.*
PANEL 433. *Same as panel 434, except that the left-hand side of the top "A" clip (panel 424) was held in place at the metal track by the eyelet end of the "B" clip, which was inserted into the track.*

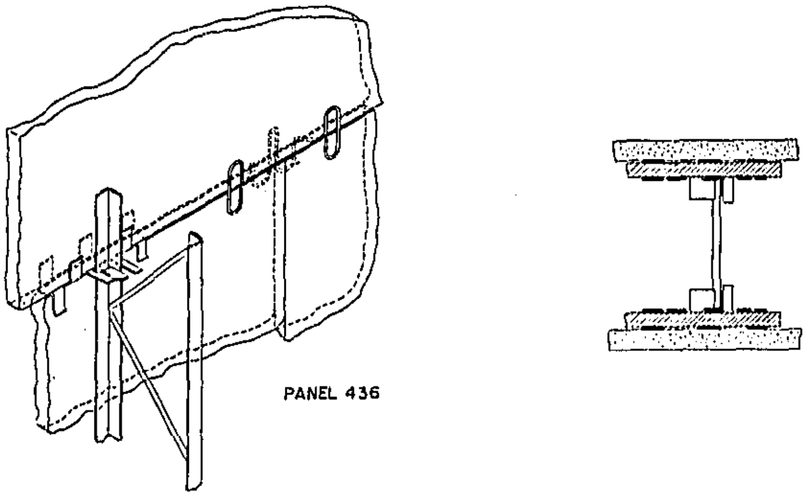
TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
GYPSUM LATH HELD BY SPRING CLIPS TO STEEL STUDS													
424	34	41	38	48	47	49	50	52	58	46	lb/ft² 15.7	F43	1949
434	33	35	34	42	41	45	48	45	54	42	13.0	F50	1951
437	26	30	34	40	43	43	44	40	49	39	11.7	F50	1951
433	46	34	36	42	45	47	47	47	48	44	14.8	F53	1951



PANEL 435

Panel 435. *Two sets of ¾-in. cold-rolled steel channels set apart ⅛ in. and offset ¼ in., each set 16 in. on centers; channels held at top by punched-out metal strip and at bottom by cork strips; on each side ⅜-in. gypsum lath and ½ in. of perlite gypsum plaster; gypsum lath held to studs by "A" clips (panel 424), and edges of lath held together by "D" clips (panel 424, page 44); gypsum lath held from studs of opposite side by ⅜-in. thick sponge-rubber dots.*

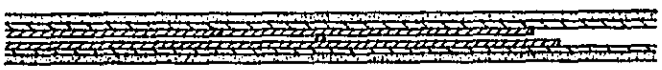


PANEL 436

Panel 436. *3¼-in. steel trusses used as studs 16 in. on centers; on each side ⅜-in. gypsum lath held by spring clips (see drawing) and ½ in. of sanded gypsum plaster; edges of lath held together by metal clips.*

PANEL 426

Panel 426. *One 1½-in. cold-rolled steel channel (corresponds to approximately 33 in. on centers) set vertically in center of panel, with horizontal 1½-in. cold-rolled steel channels 28¼ in. on centers wire-tied to vertical channels so that horizontal channels bridged 1½-in. airspace; on each side ½-in. long-length gypsum lath wire-tied to channels, ¾ in. of sanded gypsum plaster.*



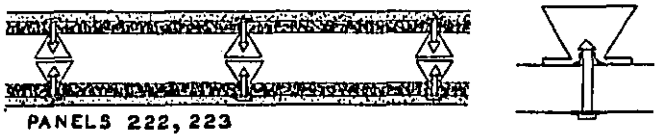
PANEL 427

Panel 427. *One ¾-in. cold-rolled steel channel set vertically in center (corresponds to approximately 33 in. on centers) horizontal ¾-in. cold-rolled steel channels 20 in. on centers wire-tied on each side of vertical channel, with horizontal channels on opposite sides of panel displaced about 6 in. vertically with respect to each other, making a 1½-in. airspace; on each side ½-in. long-length gypsum lath wire-tied to horizontal channels, and ¾ in. of sanded gypsum plaster.*

Table 2. *Sound-transmission loss*—walls—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
GYPSUM LATH HELD BY SPRING CLIPS TO STEEL STUDS—Continued													
											lb/ft²		
[a] 435	27	30	31	38	38	42	41	47	56	39	8. 6	F56	1953
[a] 436	35	35	33	42	48	50	49	45	53	43	13. 7	F59	1953
GYPSUM LATH HELD BY WIRE-TIES TO STEEL STUDS													
426	43	44	41	49	48	46	42	54	60	47	17. 3	F44	1949
427	43	40	46	52	51	51	45	58	67	51	17. 4	F44	1950

[a] Results obtained at frequencies of 125, 175, 250, 350, 500, 700, 1,000, 2,000, and 4,000 cps (averages obtained for 125 to 4,000 cps).



PANELS 222, 223

PANEL 222. *Two special metal nailing studs back to back and held in position by top and bottom plates, 16 in. on centers; on each side 1-in. thick, 6-lb/ft³ density, glass-fiber board and paper-backed metal lath attached to studs by special nails, and ¾ in. of sanded gypsum plaster.*
PANEL 223. *Same as panel 222, except that the density of the glass-fiber board was 4½ lb/ft³.*

PANEL 143A　　PANEL 143B

PANEL 143A. *1½-in. steel channel 16 in. on centers for studs; on each side expanded-metal lath and ¾ in. of sanded gypsum plaster.*
PANEL 143B. *Same as panel 143A, except that space between studs and the expanded-metal lath was packed with mineral wool.*

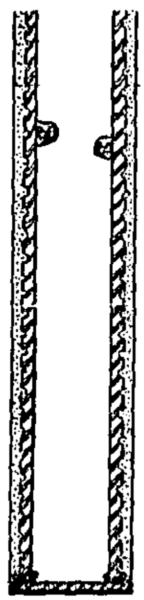
PANEL 166A　　PANEL 166B

PANEL 166A. *3¼-in. metal studs 16 in. on centers; on each side expanded-metal lath and ¾ in. of sanded gypsum plaster.*
PANEL 166B. *Same as panel 166A, except that the space between the studs was packed with mineral-wool bats to a density of 5.2 lb/ft³.*
PANEL 220. *3¼-in. steel trusses used as studs 16 in. on centers; on each side expanded-metal lath wire-tied to studs, and ¾ in. of sanded gypsum plaster.*

TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
GLASS-FIBER BOARD AND EXPANDED-METAL LATH ON STEEL STUDS													
222	44	47	50	53	53	58	58	58	68	54	*lb/ft²* -------	-------	1941
223	41	47	47	53	52	55	55	55	67	52	-------	-------	1941
EXPANDED-METAL LATH ON STEEL STUDS													
143A	18	-------	21	-------	27	-------	43	39	58	[y] 30	17.6	-------	1931
143B	26	-------	24	-------	37	-------	47	50	69	[y] 36	-------	-------	1931
166A	30	27	28	35	35	40	40	43	53	37	19.6	-------	1938
166B	34	35	31	34	40	38	39	40	52	38	21.1	-------	1938
229	40	34	29	41	37	42	40	48	53	40	19.1	F44	1960

[y] Averages for panels 143A and 143B obtained for frequencies 256, 512, and 1,024 cps.



PANELS 159,
160A - 160I

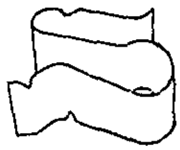
PANEL 159. *Panel A only: ¾-in. metal channels 12 in. on centers and stiffened by a 1-in. horizontal metal channel about halfway up the panel; expanded-metal lath and ¾-in. of sanded gypsum plaster.*

PANEL 160A to 160F. *Two panels similar to panel 159 placed back to back and resting on cork 1 in. thick; distance from face to face as given below: 160A, 10 in.; 160B, 8½ in.; 160C, 7 in.; 160D, 5½ in.; 160E, 4½ in.; 160F, 4⅜-in. braces at corners of panels were in contact with each other in panel 160F.*

PANEL 160G. *Same as panel 160E, except that 1-in. cork was replaced by 1-in. board.*
PANEL 160H. *Same as panel 160G, except that 1-in. board was replaced by concrete.*
PANEL 160I. *Same as panel 160H, except that the two panels were tied together at two points with a shoe made of ¾-in. channel iron, each point being approximately 18 in. in the horizontal direction from the center of the panel.*

PANEL 221. *Similar to panel 160A; in each section of panel, ¾-in. metal channels 12 in. on centers with ¾-in. horizontal stiffening channel about halfway up the panel; expanded-metal lath, and ¾-in. heat-insulating plaster; both sections rested on a 1½-in. cork base; panel thickness 5 in.*

PANEL 429

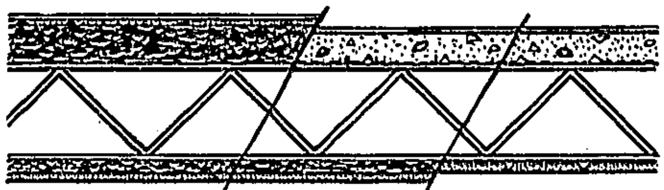


PANEL 429

PANEL 429. *3¼-in. steel trusses used as studs 10 in. on centers; on each side spring clips 10 in. on centers fastened to studs, ¾-in. metal rod wire-tied to clips, metal lath wire-tied to metal rods, and ¾-in. of sanded gypsum plaster.*

TABLE 2. *Sound-transmission loss*—WALLS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)										Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096			
EXPANDED-METAL LATH ON STEEL STUDS—Continued													
											lb/ft²		
159	27	31	29	33	35	36	33	32	44	33	8.1	-------	1938
160A	50	50	48	52	53	57	55	60	72	55	17.2	-------	1938
160B	49	51	46	52	53	57	54	58	72	55	17.2	-------	1938
160C	51	49	44	51	53	56	54	56	72	54	17.2	-------	1938
160D	43	49	45	50	52	56	51	61	73	53	17.2	-------	1938
160E	43	50	43	48	51	55	50	62	74	53	17.2	-------	1938
160F	44	49	43	46	47	52	49	57	72	51	17.2	-------	1938
160G	44	53	44	46	46	54	50	50	70	51	17.2	-------	1938
160H	46	46	44	43	48	51	46	49	60	48	17.2	-------	1938
160I	43	40	41	43	46	48	46	46	58	46	17.2	-------	1938
221	32	37	43	48	45	50	51	47	62	46	9.1	-------	1940
420	50	52	52	50	55	56	56	52	60	55	19.0	F44	1950



PANEL 137 PANEL 137A PANEL 137B

PANEL 137. *8-in. steel joists 20 in. on centers; on floor side 8-in. wood fiberboard clipped to joists, ½ in. of concrete, ¼-in. linoleum cemented to concrete; on ceiling side 1-in. wood fiberboard clipped to joist, ½ in. of sanded gypsum plaster.*

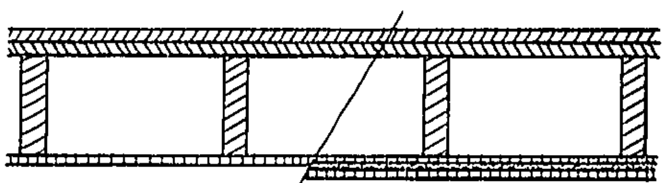
PANEL 137A. *Same joists and ceiling as panel 137; on floor side high-rib metal lath attached to joists, 2½ in. of concrete, ¼-in. linoleum cemented to concrete.*

PANEL 137B. *Same joists and floor as panel 137A; on ceiling side high-rib metal lath attached to joists, and sanded gypsum plaster with distance from underside of joists to surface of plaster being ¾ in.*

PANEL 136A PANEL 136B

PANEL 136A. *Steel floor section with flat top; on floor side 2 in. of concrete; on ceiling side a suspended ceiling of expanded-metal lath and ⅞ in. of sanded gypsum plaster; approximately 4-in. air space between the metal section and the plaster.*

PANEL 136B. *Same steel floor section and ceiling as in panel 136A; on floor side ½ in. of emulsified asphalt and 2½ in. of concrete.*



PANEL 707 PANEL 708

PANEL 707. *2- by 8-in. wood joists 16 in. on centers; ½-in. fiberboard ceiling; 1-in. pine subfloor and 1-in. pine finish floor.*

PANEL 708. *Same as panel 707, except ceiling was ½-in. fiberboard, ½ in. of sanded gypsum plaster, and ½-in. fiberboard surface.*

PANEL 130

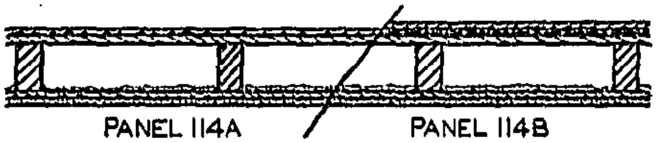
PANEL 130. *2- by 8-in. wood joists 16 in. on centers; on ceiling side expanded-metal lath and ⅞ in. of sanded gypsum plaster; on floor side 13/16-in. subfloor and 13/16-in. oak finish floor.*

PANEL 131. *Same as panel 130, except that 2- by 4-in. wood joists were used instead of 2- by 8-in. wood joists.*

TABLE 3. *Sound-transmission loss*—FLOORS

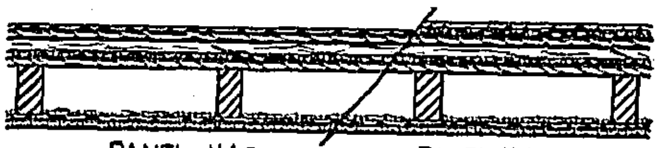
Panel number	Transmission loss (in decibels) at frequencies (cycles per second)											Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average 128 to 4,096	Tapping loss			
STEEL JOISTS														
											db	*lb/ft²*		
137	31	51	44	46	52	55	58	64	74	53	12	------	------	1934
137A	37	46	47	48	52	56	59	65	75	54	14	------	------	1935
137B	40	41	49	51	54	59	66	63	72	55	13	------	------	1935
STEEL SECTION														
136A	34	44	43	51	52	57	59	65	72	53	6	------	------	1932
136B	42	49	52	56	60	64	67	77	83	61	21	------	------	1932
WOOD JOISTS														
707	22	28	31	38	40	41	44	55	62	40	6	9.6	------	1941
708	31	23	30	40	40	44	47	56	68	42	11	15.8	------	1941
130	23	------	24	------	34	------	41	48	60	[a] 33	11	17.1	------	1930
131	22	------	36	------	45	------	48	56	65	[a] 43	12	18.8	------	1930

[a] Averages for panels 130 and 131 obtained for frequencies 256, 512, and 1,024 cps.



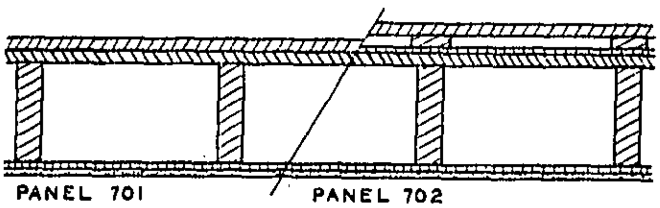
PANEL 114A. *2- by 4-in. wood joists 16 in. on centers; on ceiling side 7/8-in. total thickness of wood lath and sanded gypsum plaster; on floor side 3/4-in. subfloor and 13/16-in. oak finish floor.*

PANEL 114B. *Same as panel 114A, except that 1/2-in. wood fiberboard was placed between the subfloor and the finish floor.*



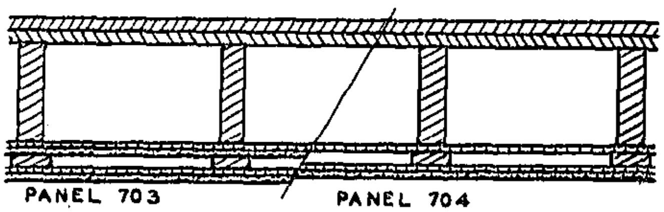
PANEL 114C. *Same as panel 114A, except that there was 3/4-in. subfloor, 1/2-in. wood fiberboard, and a floating floor consisting of 1- by 2-in. furring strips, 3/4-in. subfloor, and 13/16-in. oak finish floor.*

PANEL 114D. *Same as panel 114C, except that 1/2-in. wood fiberboard was inserted between subfloor and finish floor in the floating floor.*



PANEL 701. *2- by 8-in. wood joists 16 in. on centers; on ceiling side 1/2-in. fiberboard and 1/2 in. of sanded gypsum plaster; on floor side 1-in. pine subfloor and 1-in. pine finish floor.*

PANEL 702. *Same joists and ceiling as panel 701; on floor side 1-in. pine subfloor, 1/2-in. fiberboard, 1- by 3-in. furring strips 16 in. on centers, and 1-in. pine finish floor.*



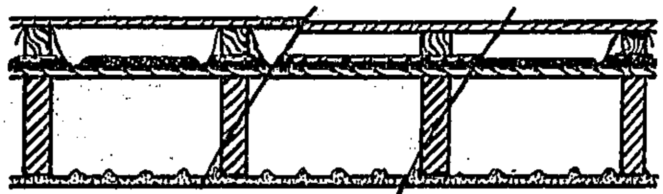
PANEL 703. *Same as panel 701, except that a second ceiling was added. The second ceiling consisted of 1- by 3-in. furring strips 16 in. on centers, 1/2-in. fiberboard, and 1/2 in. of sanded gypsum plaster.*

PANEL 704. *Same joists and floor as panel 701; ceiling was 1/2-in. fiberboard, 1- by 3-in. furring strips 16 in. on centers, 1/2-in. fiberboard, and 1/2 in. of sanded gypsum plaster.*

TABLE 3. *Sound-transmission loss*—FLOORS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)											Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average, 128 to 4,096	Tapping loss			
WOOD JOISTS—Continued														
											db	*lb/ft*²		
114A	------	[aa] 48	47	------	41	------	50	49	[aa] 47	[bb] 46	14	-------	-------	1928
114B	------	[aa] 48	48	------	41	------	50	49	[aa] 47	[bb] 46	14	-------	-------	1928
114C	------	[aa] 58	58	------	55	------	62	58	[aa] 57	[bb] 58	22	-------	-------	1928
114D	------	[aa] 58	60	------	54	------	63	59	[aa] 57	[bb] 59	22	-------	-------	1928
701	23	28	34	44	47	52	55	54	69	45	11	14.3	-------	1941
702	30	30	37	47	50	52	57	65	70	50	12	16.2	-------	1941
703	31	28	32	43	45	49	48	54	70	45	10	10.0	-------	1941
704	24	32	38	43	49	50	56	58	77	47	14	15.9	-------	1941

[aa] Results obtained at 165 and 3,100 cps instead of 192 and 4,096 cps.
[bb] Averages obtained for 256, 512, and 1,024.



PANELS 132A, 132C PANEL 133A PANEL 133B

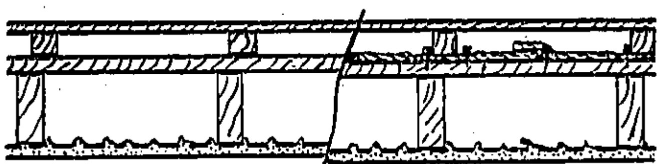
PANEL 132A. *2- by 8-in. wood joists 16 in. on centers; on ceiling side expanded-metal lath and ¾ in. of sanded gypsum plaster; on floor side 13/16-in. subfloor, 1-in. wood-fiber wool blanket, 2½- by 2½-in. hardpressed wood fiberboard squares spaced 16 in. on centers in each direction, 1¾- by 1¾-in. nailing strips held in place by metal straps, 13/16-in. oak finish floor.*

PANEL 132B. *This was a floor in an apartment house supposed to be constructed the same as panel 132A.*

PANEL 132C. *Same as panel 132A, except that wood-fiber wool blanket was ½ in. thick.*

PANEL 133A. *Same as panel 132C, except that ½-in. wood fiberboard was substituted for the 2½- by 2½-in. squares, and 1¾- by 1¾-in. nailing strips 16 in. on centers were attached by one nail at each end.*

PANEL 133B. *Same as panel 133A, except that the sheets of ½-in. wood fiberboard in the floor were replaced by strips of wood fiberboard 2½ in. wide and 16 in. on centers.*

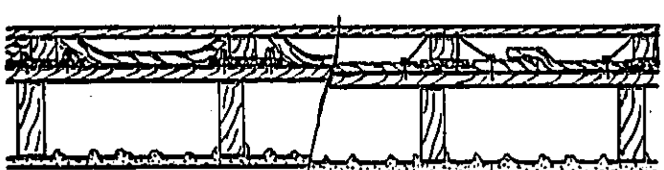


PANEL 180A PANELS 180B, C

PANEL 180A. *2- by 6-in. wood joists; on floor side a subfloor, 2- by 2-in. of furring strips 16 in. on centers and a hardwood finish floor; on ceiling side expanded-metal lath and ¾ in. of sanded gypsum plaster.*

PANEL 180B. *Same as panel 180A, except that ½-in. wood-fiber wool blanket was laid on the subfloor, and the 2- by 2-in. furring strips were attached with special clips.*

PANEL 180C. *Same as panel 180B, except the blanket was 1 in. thick.*



PANEL 180D PANELS 180E, F

PANEL 180D. *Same as panel 180A, except that ½-in. strips of wood fiberboard 8 in. wide were laid under the 2- by 2-in. wood furring, and the wood furring was attached to the wood fiberboard with special clips; strips of 1-in. wood-fiber wool blanket 16 in. wide were laid between the wood furring strips.*

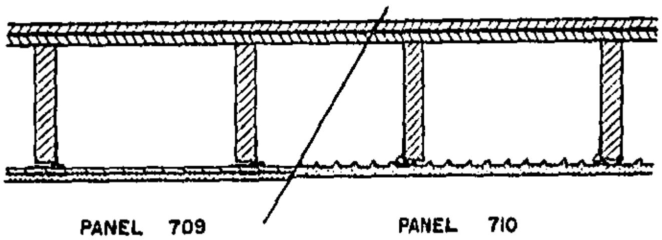
PANEL 180E. *Same as panel 180A, except that ½-in. wood-fiber wool blanket was laid on the subfloor, then ½- by 2½- by 2½-in. squares of wood fiberboard spaced 16 in. on centers in each direction, 2- by 2-in. wood furring held in position by metal strips, and hardwood finish floor.*

PANEL 180F. *Same as panel 180E, except wood-fiber wool blanket was 1 in. thick.*

TABLE 3. *Sound-transmission loss*—FLOORS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)											Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average 128 to 4,096	Tapping loss			
WOOD JOISTS—Continued														
											db	*lb/ft²*		
132A	32	------	35	------	40	------	57	68	80	[ee] 47	19	------	------	1931
132B	26	------	31	------	50	------	62	64	80	[ee] 48	------	------	------	1931
132C	26	------	30	------	48	------	56	70	80	[ee] 47	17	------	------	1930
133A	24	------	34	------	48	------	56	67	82	[ee] 46	15	10. 2	------	1931
133B	23	------	35	------	51	------	60	73	80	[ee] 49	20	------	------	1931
180A	35	23	24	32	34	30	42	50	62	38	10	16. 3	------	1938
180B	32	37	38	46	48	52	55	65	76	50	16	16. 6	------	1938
180C	35	38	37	48	49	52	55	64	75	50	19	16. 7	------	1938
180D	37	38	39	47	48	52	55	63	75	50	18	16. 7	------	1938
180E	32	32	33	41	44	49	52	60	72	46	13	16. 6	------	1938
180F	30	36	36	46	48	51	54	63	75	49	16	16. 7	------	1938

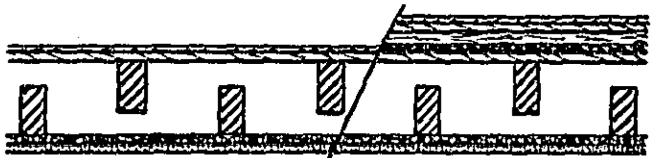
[ee] Averages obtained for frequencies 256, 512, and 1,024 cps.



PANEL 709 PANEL 710

PANEL 709. *2- by 10-in. fir joists 16 in. on centers; on floor side pine subfloor, building paper, and 13/16-in. pine finish floor; on ceiling side spring clips (same as used in panels 420 to 423, page 42), ⅜-in. gypsum lath, and ½ in. of sanded gypsum plaster.*

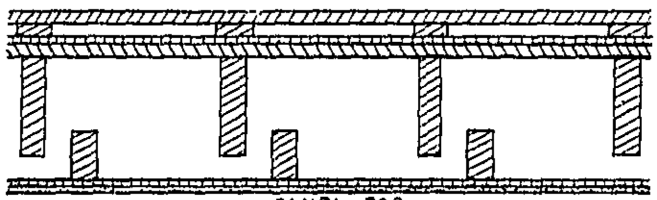
PANEL 710. *Joists and floor same as in panel 709; on ceiling side spring clips (same as in panel 425, page 34) held ¼-in. horizontal metal rods bearing expanded-metal lath and ¾ in. of sanded gypsum plaster.*



PANEL 115A PANEL 115B

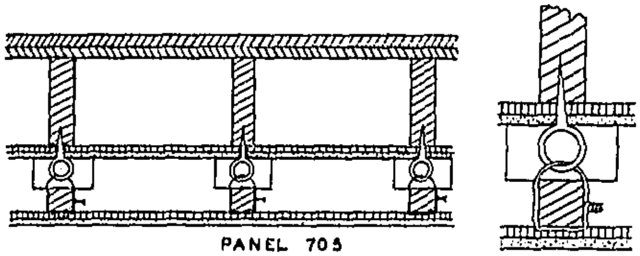
PANEL 115A. *Suspended ceiling with floor and ceiling, each using 2- by 4-in. wood studs 16 in. on centers, with the ceiling joists 2 in. lower and 4 in. on centers from the corresponding floor joists; on the ceiling side ½-in. wood fiberboard and ½ in. of sanded gypsum plaster; on the floor side ¾-in. subfloor and ¾-in. finish floor.*

PANEL 115B. *Same joists and ceiling as panel 115A; on floor side ¾-in. subfloor, ½-in. wood fiberboard, and a floating floor of 1- by 2-in. furring strips, ¾-in. subfloor, and ¾-in. oak finish floor.*



PANEL 706

PANEL 706. *2- by 8-in. wood floor joists 16 in. on centers, 2- by 4-in. wood ceiling joists 16 in. on centers, two by eights spaced 4 in. on centers from the two by fours; airspace between ceiling and floor sealed by two by tens at the edges of panel; on ceiling side ½-in. fiberboard and ½ in. of sanded gypsum plaster; on the floor side 1-in. pine subfloor, ½-in. fiberboard, 1- by 3-in. furring strips 16 in. on centers, 1-in. pine finish floor.*



PANEL 705

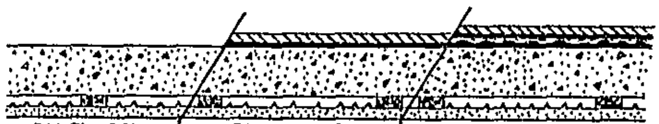
PANEL 705. *2- by 8-in. wood joists 16 in. on centers; on floor side 1-in. pine subfloor and 1-in. pine finish floor; on ceiling side ½-in. fiberboard and ½ in. of sanded gypsum plaster; then an additional ceiling of 2- by 2-in. wood joists 16 in. on centers, ½-in. fiberboard, and ½ in. of sanded gypsum plaster was suspended 4 in. below upper ceiling by screw eyes and wire loops 36 in. on centers; 5- by 5- by 2-in. fiberboard-block pads on each side of fastenings along two by twos to give 2-in. airspace between two by twos and first ceiling.*

TABLE 3. *Sound-transmission loss*—FLOORS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second) 128	192	256	384	512	768	1,024	2,048	4,096	Average 128 to 4,096	Tapping loss	Weight	Test number	Year of test
WOOD JOISTS—Continued														
											db	*lb/ft²*		
709	42	41	40	47	48	52	51	56	68	49	19	......	F43	1940
710	42	44	45	47	48	52	53	59	68	51	22	......	F44	1940
115A	......	dd 53	54	......	49	......	55	55	dd 55	** 53	22	12.6	......	1928
115B	......	dd 62	65	......	57	......	69	62	dd 65	** 64	30	16.1	......	1928
706	48	50	49	51	50	52	54	58	75	54	25	16.7	F1	1943
705	46	44	50	53	55	57	56	63	75	56	26	20.3	F1	1942

dd Results obtained at 165 and 3,100 cps instead of 192 and 4,096 cps.
** Averages obtained for 256, 512, and 1,024 cps.

PANEL 804. *4-in. reinforced concrete slab.*
PANEL 805. *Same as panel 804, except that on floor side was added 1½ in. of concrete containing an asphalt-water emulsion.*



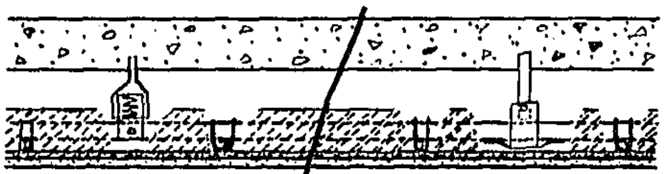
PANEL 801. *4-in. reinforced concrete slab; on ceiling side ¾-in. furring strips 14½ in. on centers, expanded-metal lath, and ⅞ in. of sanded gypsum plaster.*
PANEL 802. *Same as panel 801, with addition on floor side of approximately $\frac{3}{32}$ in. of mastic and ¾-in. parquet floor.*
PANEL 803. *Same as panel 801, with addition on floor side of approximately $\frac{3}{32}$ in. of mastic, ½-in. fiberboard, approximately $\frac{3}{32}$-in. of mastic and ¾-in. parquet floor.*

PANEL 116A. *4-in. concrete slab reinforced with ⅜-in. diameter round rods placed 9 in. on centers; on ceiling side $\frac{13}{16}$- by 2-in. furring strips 16 in. on centers, ½-in. wood fiberboard, and ½ in. of sanded gypsum plaster.*
PANEL 116B. *Same slab and ceiling as panel 116A; on floor side 1- by 2-in. furring strips, ¾-in. subfloor, and ¾-in. oak finish floor.*
PANEL 116C. *Same as panel 116B, except that ½-in. wood fiberboard was inserted under furring strips.*

TABLE 3. *Sound-transmission loss*—FLOORS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second)											Weight	Test number	Year of test
	128	192	256	384	512	768	1,024	2,048	4,096	Average 128 to 4,096	Tapping loss			
CONCRETE SLABS														
											db	*lb/ft²*		
804	37	33	36	44	45	50	52	60	67	47	2	53.4	F38	1948
805	38	38	40	44	49	52	56	66	72	51	8	63.9	F33	1948–9
801	39	38	39	39	39	40	42	50	60	43	5	62.2	F35	1947
802	43	44	44	43	44	48	52	58	66	49	8	65.7	F35	1947
803	41	42	39	44	44	45	50	62	69	48	17	67.0	F35	1947
116A	------	†† 51	55	------	59	------	56	53	†† 56	** 57	1	54.4	------	1928
116B	------	†† 59	57	------	55	------	68	65	†† 62	** 60	30	58.1	------	1928
116C	------	†† 58	58	------	50	------	66	67	†† 62	** 60	33	58.9	------	1928

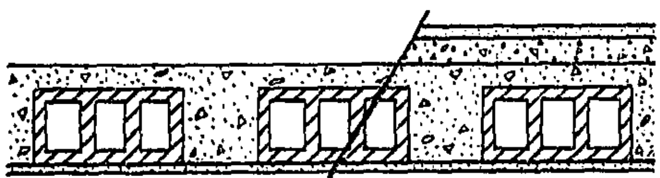
†† Results obtained at 165 and 3,100 cps instead of 192 and 4,096 cps.
** Averages obtained for 256, 512, and 1,024 cps.



PANEL 156. *4-in. concrete slab; on floor side special hangers spaced 24 in. on centers one way and 24 in. on centers the other way (these hangers consisted of two stirrups 1⅛ in. wide separated by a coiled spring and pieces of felt); connected to the hangers were 1½-in. metal channels 24 in. on centers; ¾-in. metal channels 16 in. on centers were attached at right angles to the 1½-in. metal channels; attached to the ¾-in. channels by metal clips were ⅜-in. gypsum lath, ¼ in. of gypsum plaster, and ½ in. of acoustic plaster (trowel finish). The edges of the gypsum lath were held by clips similar to the "D" clips of panels 424, 433, 434, and 437 (page 44). On the upper side of the gypsum lath was 3-in. ground cork.*

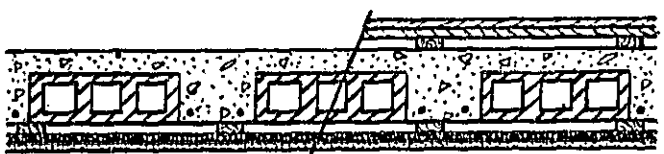
PANEL 158. *Same as panel 156, except 4-in. mineral wool used above gypsum lath.*

PANEL 157. *Similar to panel 156, except that 1½-in. channels rested on bent pieces of spring steel whose centers were held in stirrups attached to hangers; on top of the gypsum lath were 3 in. of ground scraps of gypsum wallboard and gypsum lath.*



PANEL 78A. *6- by 12- by 12-in. three-cell hollow tile 18 in. on centers and concrete between tile and to a thickness of 2 in. above the tile; on ceiling side ⅝ in. of sanded gypsum plaster.*

PANEL 78B. *Same as panel 78A, except 3 in. of cinder concrete and 1 in. of cement were added to floor side.*



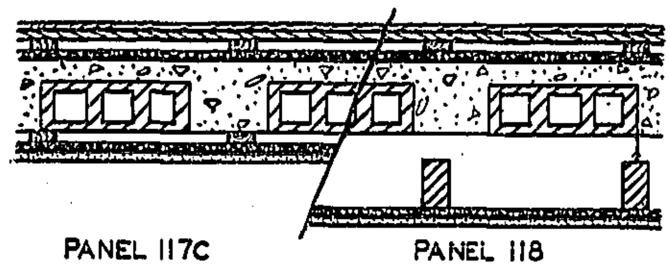
PANEL 117A. *4- by 12- by 12-in. three-cell hollow clay tile separated by 5 in. of concrete between the tiles; joints each reinforced by two ⅝-in. round rods; slab 6½ in. thick; on ceiling side were 13/16- by 2-in. furring strips 16 in. on centers, ½-in. wood fiberboard, ½ in. of sanded gypsum plaster.*

PANEL 117B. *Same as panel 117A, except that a floating floor was added consisting of 1- by 2-in. furring strips, ⅞-in. subfloor, and ⅞-in. oak finish floor.*

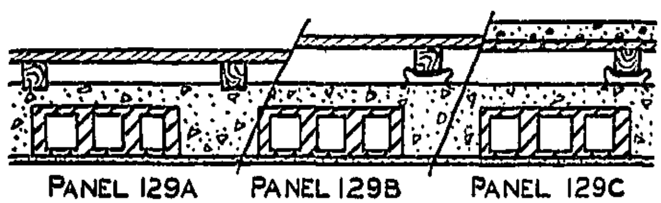
TABLE 3. *Sound-transmission loss*—FLOORS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second): 128	192	256	384	512	768	1,024	2,048	4,096	Average 128 to 4,096	Tapping loss	Weight	Test number	Year of test
CONCRETE SLABS—Continued														
											db	*lb/ft²*		
156	39	46	44	48	51	56	60	68	77	54	11	-------	-------	1930
158	37	46	47	50	51	57	60	69	77	55	12	-------	-------	1930
157	41	44	47	50	51	56	60	68	76	55	12	-------	-------	1930
COMBINATION TILE AND CONCRETE														
78A	------	------	51	------	47	------	50	60	[hh] 54	[ll] 49	-------	83	-------	1927
78B	------	------	52	------	48	------	50	55	[hh] 48	[ll] 50	-------	100	-------	1927
117A	------	[hh] 56	57	------	56	------	58	50.	[hh] 57	[ll] 57	5	69. 8	-------	1928
117B	------	[hh] 63	63	------	61	------	66	74	[hh] 67	[ll] 63	34	73. 5	-------	1928

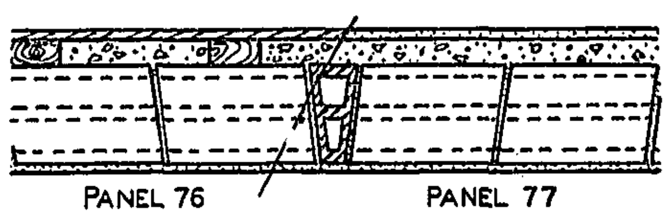
[hh] Results obtained at 105 and 3,100 cps instead of 192 and 4,096 cps.
[ll] Averages obtained for 256, 512, and 1,024 cps.



PANEL 117C. *Same as panel 117B (page 62), except that ½-in. wood fiberboard was added between masonry slab and floating floor.*
PANEL 118. *Same as panel 117C, except that the ceiling was suspended from the slab by means of wires; ceiling composed of 2- by 4-in. wood joists 16 in. on centers, ½-in. wood fiberboard, ½ in. of sanded gypsum plaster.*



PANEL 129A. *4- by 12- by 12-in. three-cell hollow clay tile (rows of tiles placed 6 in. apart) and concrete, panel 6 in. thick; on ceiling side ½ in. of sanded gypsum plaster; on floor side 2- by 2-in. furring strips 16 in. on center grouted into concrete and 13/16-in. oak finish floor.*
PANEL 129B. *Same as panel 129A, except that spring steel clips were inserted between the concrete and the furring strips.*
PANEL 129C. *Same as panel 129B, except that ½-in. gypsum lath was substituted for the oak floor and 1½ in. of gypsum cement was applied on top of the lath.*



PANEL 76. *8-in. four-cell tile; on ceiling side ⅝ in. of sanded gypsum plaster; on floor side 2- by 4-in. wood strips 16 in. on centers laid on the 3½-in. side and fastened to the top surface, and the space between the wood strips filled with cinder concrete, then ¾-in. maple finish floor.*
PANEL 77. *8-in. four-cell tile; on ceiling side ⅝ in. of sanded gypsum plaster; on floor side 2 in. of cinder concrete and 1 in. cement.*

TABLE 3. *Sound-transmission loss*—FLOORS—Continued

Panel number	Transmission loss (in decibels) at frequencies (cycles per second) 128	192	256	384	512	768	1,024	2,048	4,096	Average 128 to 4,096	Tapping loss	Weight	Test number	Year of test
COMBINATION TILE AND CONCRETE—Continued														
											db	*lb/ft²*		
117C	------	[jj] 64	70	------	63	------	64	69	[jj] 68	[kk] 66	35	74.2	------	1928
118	------	[jj] 68	68	------	66	------	72	>76	>[jj] 77	[kk] 69	51	72.8	------	1928
129A	36	------	38	------	39	------	47	54	55	[kk] 41	23	------	------	1930
129B	37	------	47	------	58	------	68	73	([ll])	[kk] 58	33	------	------	1930
129C	43	------	50	------	61	------	71	77	([ll])	[kk] 61	38	------	------	1930
FLAT ARCH														
												lb/ft²		
76	------	------	46	------	47	------	48	54	[mm] 54	[kk] 47	------	76	------	1927
77	------	------	47	------	47	------	47	50	[mm] 49	[kk] 47	------	85	------	1927

[jj] Results obtained at 165 and 3,100 cps instead of 192 and 4,096 cps.
[kk] Averages obtained for 256 and 1,024 cps.
[ll] Sound inaudible.
[mm] Results obtained at 3,100 cps instead of 4,096 cps.

14. Numerical Index of Test Panels

Panel	Page	Panel	Page	Panel	Page	Panel	Page
25	20	136B	52	182	10	422	42
26	20	137	52	201	32	423	42
60	14	137A	52	202	36	424	44
61	14	137B	52	203	36	425	34
62	16	138	18	204	36	426	46
63	16	139	14	205	30	427	46
64	16	140	16	206	30	428	22
65	16	141	16	207	30	429	50
66	16	142	16	208	30	430	26
68	16	143A	48	209	30	431	26
69	16	143B	48	210	30	433	44
71	16	144	14	211	28	434	44
72	16	145	14	212	28	435	46
73	16	146	12	213	30	436	46
74	16	147A	12	214	28	437	44
75	18	147B	12	215	28	501	26
76	64	148	36	216	28	502	26
77	64	149	36	217	28	503	20
78A	62	150	38	218	28	504	22
78B	62	151	38	219	30	505	24
79	20	152	38	220	30	506	22
80	20	153	38	221	50	507	24
81	20	154	26	222	48	508	24
82	20	155	14	223	48	509	24
83	20	156	62	224	34	510	22
84	20	157	62	225	34	511	22
85	20	158	62	226	36	512	22
86	30	159	50	227	36	513	24
93	10	160A	50	228	32	514	24
94	10	160B	50	229	48	515	24
95	10	160C	50	230—See 434	44	516	22
96	10	160D	50	231—See 437	44	517	22
98	10	160E	50	232	12	518	20
101	10	160F	50	233	12	519	26
102	10	160G	50	234	34	520	22
103	10	160H	50	235	34	521	22
106	10	160I	50	236	36	522	22
110	10	161	18	301	18	523	26
111	10	162	32	302	16	524	26
114A	54	163	32	303	16	525	26
114B	54	164	32	304	18	526	20
114C	54	165	32	305	18	527	20
114D	54	166A	48	306	12	528	22
115A	58	166B	48	307	20	601	10
115B	58	167	38	308	14	602	12
116A	60	168	38	309	18	603	12
116B	60	170	26	310	18	604	12
116C	60	171A	26	311	14	605	10
117A	62	171B	26	312	14	606	10
117B	62	171C	26	401	38	607	10
117C	64	172	26	402	38	612	10
118	64	173A	14	403	38	613	10
119	32	173B	14	404	38	701	54
120	30	173C	14	405	38	702	54
123	30	174	32	406	38	703	54
124	30	175	34	407	38	704	54
125	30	176	40	408	38	705	58
126	30	177	40	409	38	706	58
127	28	178	40	410	38	707	52
129A	64	179A	28	411	38	708	52
129B	64	179B	28	412	38	709	58
129C	64	179C	28	413	40	710	58
130	52	179D	28	414	40	801	60
131	52	180A	56	415	40	802	60
132A	56	180B	56	416	42	803	60
132B	56	180C	56	417	42	804	60
132C	56	180D	56	418	42	805	60
133A	56	180E	56	419	42		
133B	56	180F	56	420	42		
136A	52	181	10	421	42		

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