Proceedings

of the

Radio Club of America

Incorporated

February, 1936

Volume 13, No. 1

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11 West 42nd Street + + New York City

The Radio Club of America, Inc.

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PROCEEDINGS
of the
RADIO CLUB OF AMERICA

Volume 13 February, 1936 No. 1

SOUNDPROOFING APARTMENT HOUSES FOR RADIO

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Delivered before the Radio Club of America
February 13, 1936

INTRODUCTION

One man's music may be another man's noise. A delightful radio program in my apartment is transformed into a nuisance by simply leaking into the next apartment. It is apparent that the psychological factors are also very important in dealing with sound control problems.

SOUND PROOFING DEFINED

In this short discussion we shall confine our remarks very largely to the objective and physical aspects. The term "sound proofing" has been used for a great many years. The exact meaning is somewhat indefinite and in some cases confusing. Consequently, let us use the two terms "sound insulation" and "sound absorption". Both terms indicate the reduction of the transmission of sound from one point to another, but the respective means for accomplishing this are different. Heavy walls, ceiling, and floor act as good insulators of a sound source in a room in reducing the transmission of sound to a point outside. Sound absorption applied to the interior surfaces cause a lowering of the acoustic intensity and hence adds to the reduction in the transmission of sound. It is apparent, then, that "insulation" and "absorption" are both means for sound proofing.

SCOPE

We shall further limit this paper to radio loud speakers as a sound source. Among the other sources of sound in an apartment house are the following:

Musical instruments; piano; violin; drums, etc.
Singing and speaking voices; Shouting voices, crying of children, barking of dogs, etc.
Footfalls; jumping; dancing, etc.
Rumbling of toys, bicycles, wagons, etc.

Sewing machines - Vacuum cleaners - Typewriters
Electric fans - Refrigerators - Kitchen aids-
Alarm clocks

Doors, windows, awnings. Elevators, dumb waiters, incinerators. Steam radiators and steam pipes. Water pipes and plumbing equipment.

BUILDING DEVELOPMENT

In this list of sources of sound there are many which have been added within the last generation. The type of building has gradually changed during this period. In the place of massive brick or stone walls we now have thin, flexible walls. In the place of relatively soft thick lime plaster on wood lath we have hard gypsum plaster on metal lath. For wood floors we often find concrete and tile. For the wood doors in wood bucks we now have metal clad doors in metal bucks.

Practically all modern developments are improvements in heating, sanitation and fireproofing. It is evident, however, that these developments have in each case contributed to the magnification and transmission of noise. The public is beginning to recognize this deplorable condition.

OUR NEXT DEVELOPMENT

We, as engineers, tenants, or owners are confronted with the necessity of quieting the modern apartment house, without giving up the improvements in sanitation, ventilation, heating, and fireproofing. It is also desirable to impose less restrictions on the activity of tenants without annoyance to others.

PURPOSE OF THIS PAPER

It is no secret that very little has been done in sound proofing apartment houses. One of the purposes of this paper is to stimulate interest in noise abatement and insulation in apartment houses. Furthermore, as radio engineers, we are anxious that the radio shall not become a nuisance due to improper operation and lack of acoustic control. Hence, a second purpose is to indicate some of the factors which determine when the radio is truly a nuisance due to loudness. A third purpose is to indicate certain improvements which can be made in apartments to provide more soundproofing.

AUDITORY CHART

In the last analysis a noise becomes a nuisance only when it can be heard. When the intensity and frequency of a sound falls within the hearing range it can be indicated on the auditory chart. (Fig 1-D) This chart is now generally accepted as the standard for average hearing. The pitch or frequency extends from 25 cycles per second on the left to 17,000 on the right. The intensity and loudness extend vertically. The horizontal straight lines correspond to physical strength or power of the sound in air. The family of curved lines in-

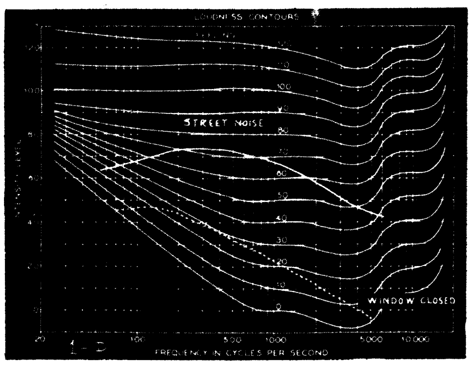


Figure 1-D

dicate contours of equal loudness as sensed by the average ear. For example, a 200 cycle tone whose intensity is 60 will be sensed as only 50 in loudness. The zero loudness corresponds to minimum audibility for each frequency. Hence the 200 cycle tone would have to be reduced only 37 decibels in order that it be placed at zero loudness which is the threshold of audibility. If on the other hand the tone has a pitch of 1000 cycles with an intensity level of 60 it would be sensed as 60 in loudness. This is 60 decibels above minimum audibility It will be noted that at only two points do loudness and intensity level have the same numerical value, namely, 1000 cycles and 5000 to 6000 except for the contours marked 110 and 120 where the equivalence occurs at 6500 and 7500 respectively.

STREET NOISE

One of the factors which influence the acoustic level at which the radio is adjusted is the noise level in the listening room. Among other sources the most universal is street noise. An average curve for the intensity in the street is indicated by the solid line, on the auditory chart. If the listener comes into the room next to the street with the window closed the intensity drops to the dotted line due to the attenuation of the outside wall and closed window. It is characteristic that the high frequencies are reduced much more than the low frequencies. It is quite usual in city apartments to have a noise level of 30 to 40 decibels under these conditions. It is clear that the area below the dotted line is subtracted from the total area which represents the full hearing range.

RADIO CHARACTERISTICS

In "1-A" is shown representative characteristics for the midget and high fidelity radio sets complete. It will be noted that the range of the high fidelity is almost an octave lower and extends almost an octave higher than that of the midget. These curves are placed at a level between 70 and 80 decibels which is a very comfortable loudness assuming that no abnormal noise is present. Due to the limited frequency range it is quite usual for a radio listener to adjust the loudness of the midget set for any individual

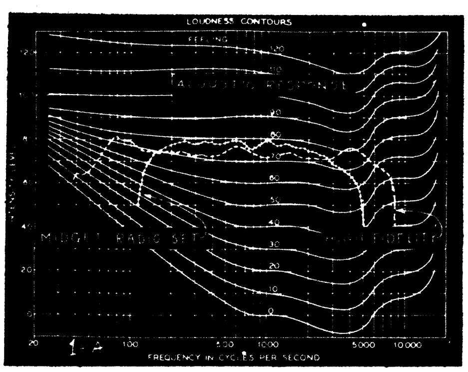


Figure 1-A

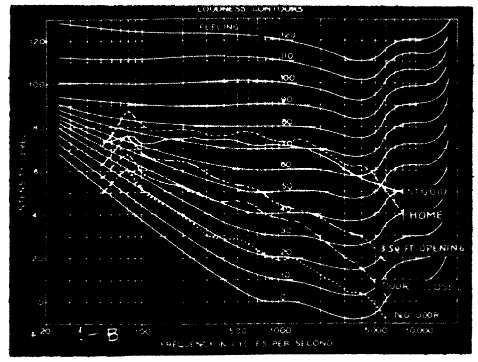


Figure 1-B

middle range tone to a higher level than that for the high fidelity set.

TRANSMISSION THROUGH WALLS AND DOORS

In Fig. 1-B is shown a solid curve which represents an average spectrum of sound of a studio program.

After reproduction the curve becomes the dashed line marked "HOME". The absolute acoustic levels are, of course, assumed. The "STUDIO" curve might actually be much higher as in the case of an orchestra or it might be lower as in the case of a singing voice up close to the microphone. The radio program may be adjusted in level at the will of the listener as best suits his particular hearing conditions.

The "dash-dot-dot" curve corresponds to the resulting curve of the sound spectrum after transmission to the air in the adjacent room when the door (or window) is opened about 6 inches to give a net area of 3 square feet. These curves apply to average apartments which are furnished, providing from 50 to 100 sabines of absorption. When the door (or window) is closed the transmitted curve drops to a lower level as indicated. If the door is removed entirely leaving a continuous wall the curve drops to the dotted curve marked "NO DOOR".

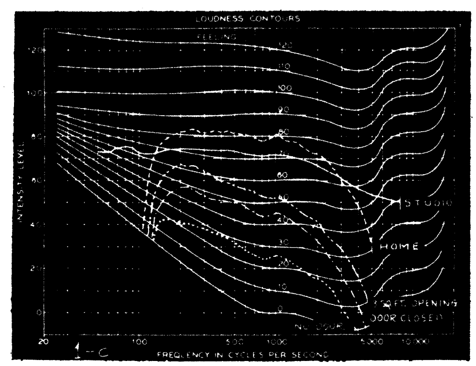


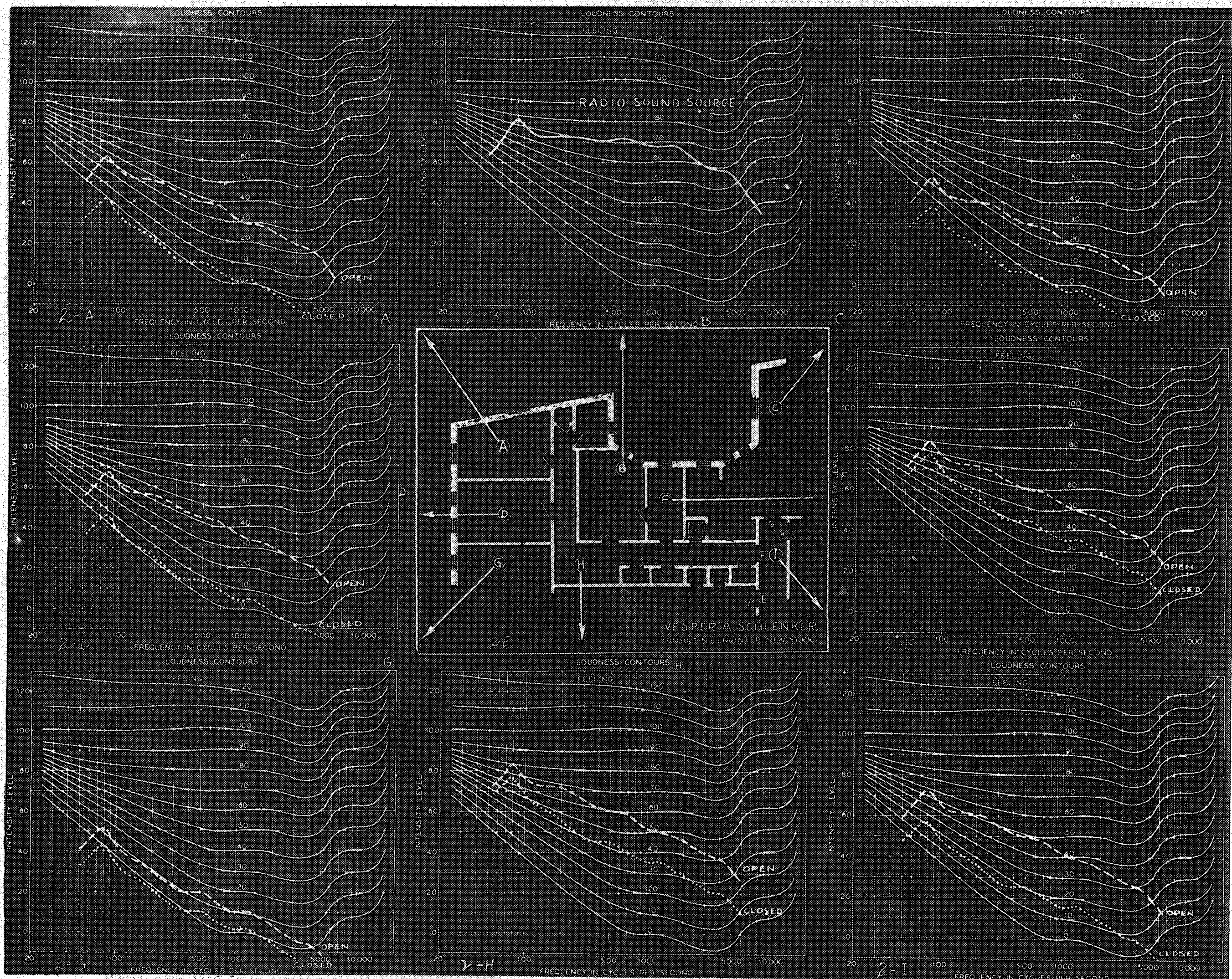
Figure 1-C

Figure 1-C include curves for a midget radio which correspond to the curves shown in the preceding figure. In the presence of 30 decibels of noise it will be noted that the frequency range of the midget is effectively reduced thereby impairing its quality much more than a corresponding condition for the high quality radio.

TRANSMISSION CHARACTERISTICS FOR AN AVERAGE APARTMENT

An average size apartment is shown in plan in Figure 2-E. The radio is located at position "B" near the double windows which look out over an open court. The acoustic spectrum of instrumental music is given in Figure 2-B as reproduced by a high fidelity radio set.

The curve of this spectrum drops to various levels at positions "A", "D", "H", and "F"., of the other



rooms of the apartment under two conditions--"all doors open" and "all doors closed" as noted on the corresponding numbered figures. The curves for "H" and "F" are approximately equal since there is only one door between them and the source. The rooms "A" and "D" have a much greater attenuation because there are two doors and a hall between. Taking 500 cycles per second for example, when the loudness in room "B" is 70 it is 60 at "H", 42 at "D", and 38 at "A", when all the doors are open. If, however, all the doors are closed the loudness drops to 43 at "H", 9 at "D", and 5 at "A". In the presence of a noise of 20 to 30 db. it is evident that the radio will be heard when the doors are open but not when the doors are closed. The adjacent room "F" will have a loudness of 60 with the door open and 42 with the door closed. Therefore, room "F" will not be a suitable bedroom while rooms "A" and "D" will be free from annoyance of the radio when the doors are closed. This illustrates the importance of arranging a room or hall between the living room and bedrooms.

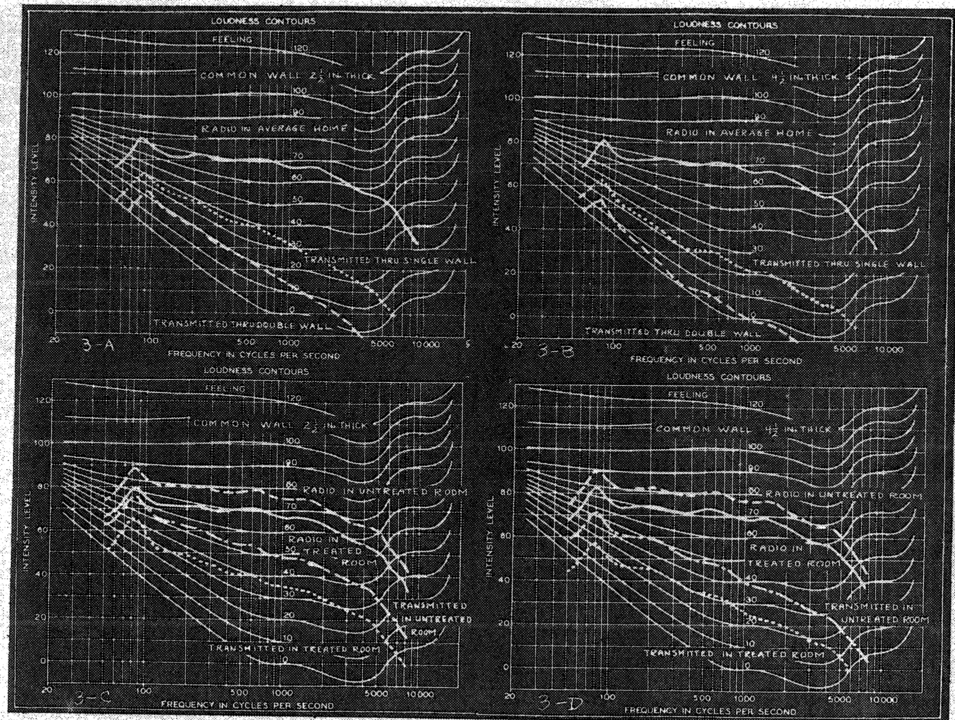
In like manner the loudness can be determined from the curves for the public hall "I", the east apartment "C" and the south apartment "G". In the case of "C", the sound travels through two windows and the open court. This attenuation is approximately equivalent to that for the path by way of the hall "I" and the entrance doors. In the case of apartment "G" the sound must travel through continuous walls. It will be noted, then, that in the presence of 20 to 30 db. of noise that neither apartment will be annoyed by the radio at "B" whether the windows and doors are opened or closed. This would not be true in the case of "C" if the intervening court were closed on all sides. In that event, the curves for "C" would be similar to those for "D". Open windows would then result in considerable annoyance from the radio.

DOUBLE WALLS AND FLOORS

The effect of different wall and floor construction is illustrated in Figure 3. The solid curve again represents the source. The dotted curves in 3-A indicate the spectra after transmission through single continuous walls about 2½ inches thick, constructed of gypsum tile and plaster. If now a second wall similar to the first is built providing an air space of 2 inches the attenuation is improved as is shown by the dashed curve. Figure 3-B gives the corresponding spectra for the 4½ inch wall, single and double. It is evident that in the presence of a noise loudness of 20 that the 4½ inch single wall will most probably be entirely satisfactory whereas the 2½ inch wall will permit too much transmission. It is also interesting to note that the double wall 2½ inches thick is only 6 db. lower in transmission than the single wall 4½ inch thick. It can be concluded that the double 4½ inch wall will be satisfactory even in the absence of masking noise for the given condition of 70 db. loudness of the source.

SOUND ABSORPTION TREATMENT

The value of absorptive treatment for sound insulation is frequently assumed to be much greater than it actually is in practice. Figures 3-C and 3-D indicate the reduction in transmission for the 2½ inch and the 4½ inch walls previously considered. The solid curve indicates the average spectrum of sound in the room if it were heavily treated to prevent appreciable reverberation. The dashed curve represents the condition in the same room



due to noticeable reverberation when the interior has very little absorption, which results in a sound level of about 7 decibels higher or 77 db. The attenuation of the wall lowers this curve 30 db. but the reverberation of the receiving room raises it another 7 db. resulting in a level of 54.

On the other hand, if both rooms are heavily treated with absorption the resulting level will be approximately 40. Therefore, if both rooms are treated the insulation is 14 db. better than if both rooms are reverberant. Similar conditions are true for other types of walls.

FLOORS AND CEILINGS

The previous considerations of walls are equally true of floor and ceiling construction which corresponds in stiffness and mass. For example, a 4" concrete slab with a plastered ceiling underneath would have approximately the same characteristics as that shown for 3-B. If a metal lath and plaster ceiling were suspended below the slab the attenuation would. of course, be greater.

SOUND FROM IMPACTS

Since this discussion is limited to radio as a source of sound the serious disturbances resulting from percussion on the floor are not included in the preceding considerations. In other words, we are assuming that the transmission is from air to air.

VARIATIONS IN SPEECH INTENSITIES

In all the preceding characteristics the curves represent average values in intensity. In applying these charts to actual conditions it must be remembered that the variations from the average are usually plus or minus 10 db. and may be as much as plus or minus 20 db. This fact is effectively illustrated by a reproduction of an actual oscillographic photograph of speech picked up by the microphone about 18 inches from the speaker. The speech is separated into three traces recorded simultaneously. The upper trace are made up of frequencies below 500 cycles which include the fundamentals of the vowels. The center trace consist of frequencies between 500 and 2000 cycles which contain the harmonics and overtones of the vowels. The bottom trace record the essential frequencies of the consonants, which lie above 2000 cycles. This division of the frequency spectrum has been made in order to analyze the behavior of speech transmission in auditorium surveys where the effect of special acoustical treatments must be determined. In this record the deflections are proportional to the sound pressure impressed on the microphone. Hence a half deflection in pressure is 6 decibels below full amplitude. In like manner one fourth corresponds to 12 decibels below since the energy of the sound is proportional to the square of the pressure. For average English

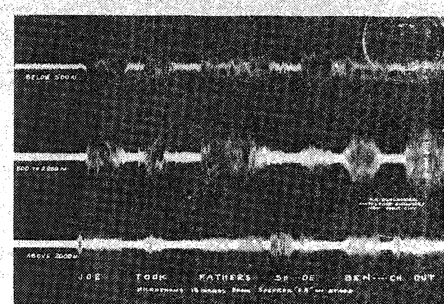


Figure 4

speech the consonants are 14 decibels below the level of the vowels. Of course, this relationship is widened when speech is transmitted through walls and openings as is illustrated in the preceding charts. This accounts in part for the very low articulation of speaking voices when heard through a wall or door. The other important factor is the parasitic reverberation and transients introduced by multiple reflections and vibration of the wall itself.

WINDOW VENTILATORS

It is quite evident from the preceding discussion that windows and doors should be kept closed. The outside noise must be effectively attenuated so that the noise level in the listening room is low as possible, certainly far below 40 db. This is important for comfortable listening and makes it possible for the listener to adjust the acoustic level of the radio output to a reasonably low level, not higher than 70 db. or 80 db. at most. If the radio is adjusted to higher levels the transmission to adjoining rooms and apartments will be raised

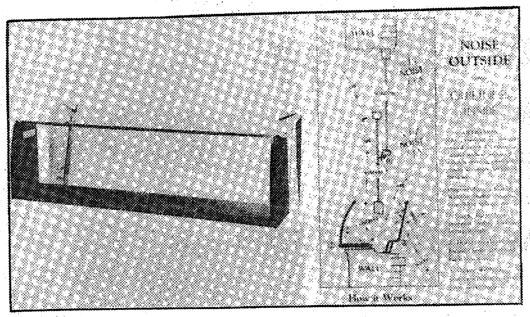


Figure 5

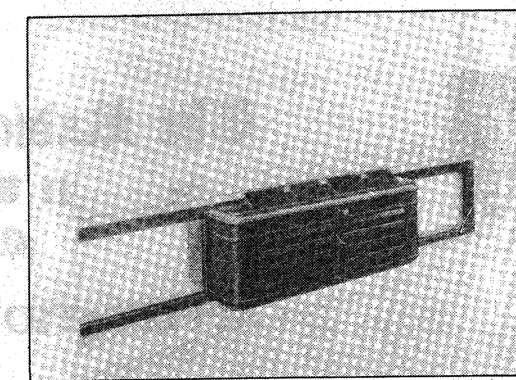


Figure 7

in a corresponding amount, thereby causing an annoyance to neighbors in spite of substantially built walls.

One of the first commercial window ventilators which was placed on the market for the expressed purpose of excluding the noise but not the air is shown in Figure 5. The explanation of its action is also given to show how the manufacturer relied on reflection to exclude the noise. It is fairly well appreciated now that only the higher frequencies have appreciable directional properties and hence this ventilator is effective where the noise has a substantial amount of its energy in the middle and high frequencies.

A much more efficient (and costly) window unit has been placed on the market in the last few years. Figure 6 shows a phantom view which illustrates how the air is brought in through a dust filter and sound absorbing path by an adjustible speed fan and electric motor. The louvers are also adjustible in direction and area of opening. The reduction of outside noise through this unit is approximately equal to that of the closed window, which usually falls between 15 and 25 decibels of reduction.

Later models offered by two leading manufacturers are illustrated in Figure 7 and 8. These units do not extend past the inside edge of the window sill and hence do not interfere with curtains or take up floor space. These units can easily be lifted out so that the windows may be cleaned in the usual manner.

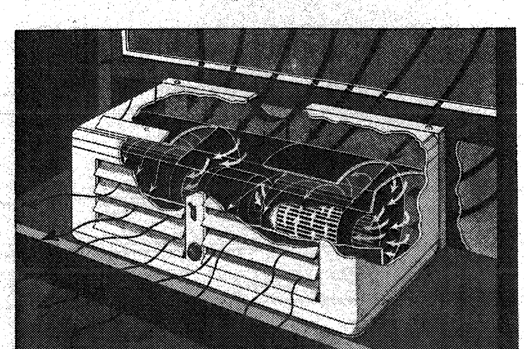


Figure 6

CONCLUSION

Some of the important factors for the improvement of the apartment house can be summarized as follows:

1. Provision for positively controlled ventilation with closed window conditions, acoustically.

2. Provision for double walls and suspended ceilings below double floors between apartments horizontally and vertically, respectively.

3. Elimination of closed courts or light walls.

4. Provision for acoustical treatment of all halls, both inside and outside of apartments.

5. Provision for vibration isolators under radio cabinets, pianos, etc.

6. Arrangement of rooms so that closets are situated between apartments along common walls.

From the standpoint of noise reduction it is always desirable to have all floors covered with carpets or rugs laid over heavy cushion fabric or mat. This provides acoustical absorption and also reduces the impact noises transmitted to the room below.

It is quite clear, then, that the owner, engineer and architect should include adequate provisions for sound proofing throughout all stages in the planning and building of a new apartment house.

Figure 8

No.....................

The Radio Club of America

11 West 42d Street

New York City

FOUNDED 1909

APPLICATION FOR MEMBERSHIP

TO THE BOARD OF DIRECTORS: ....19........

I hereby make application for membership in THE RADIO CLUB OF AMERICA, and agree, if elected, that I will be governed by the Constitution as long as I continue a member.

....
(Signature in ink)

NOTE—Applicants are urged to read extracts from the Constitution on the back of this blank.

Answer All Questions

NAME (Print in Block Letters) Mr...

Address—

* Home ☐ ....

* Business ☐ ....

* *Indicate by X address to which notices should be sent.*

General and technical education; degree held, schools or colleges attended:.......................

....

What radio or technical organization do you belong to? ....

....

What particular branch of the radio art are you interested in? ....

....

Date and place of birth...

Occupation ....

References:

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Do not fill in below this line

Receipt acknowledged ....Elected ....

Deferred ....Advised of election......................................

Remarks ....

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