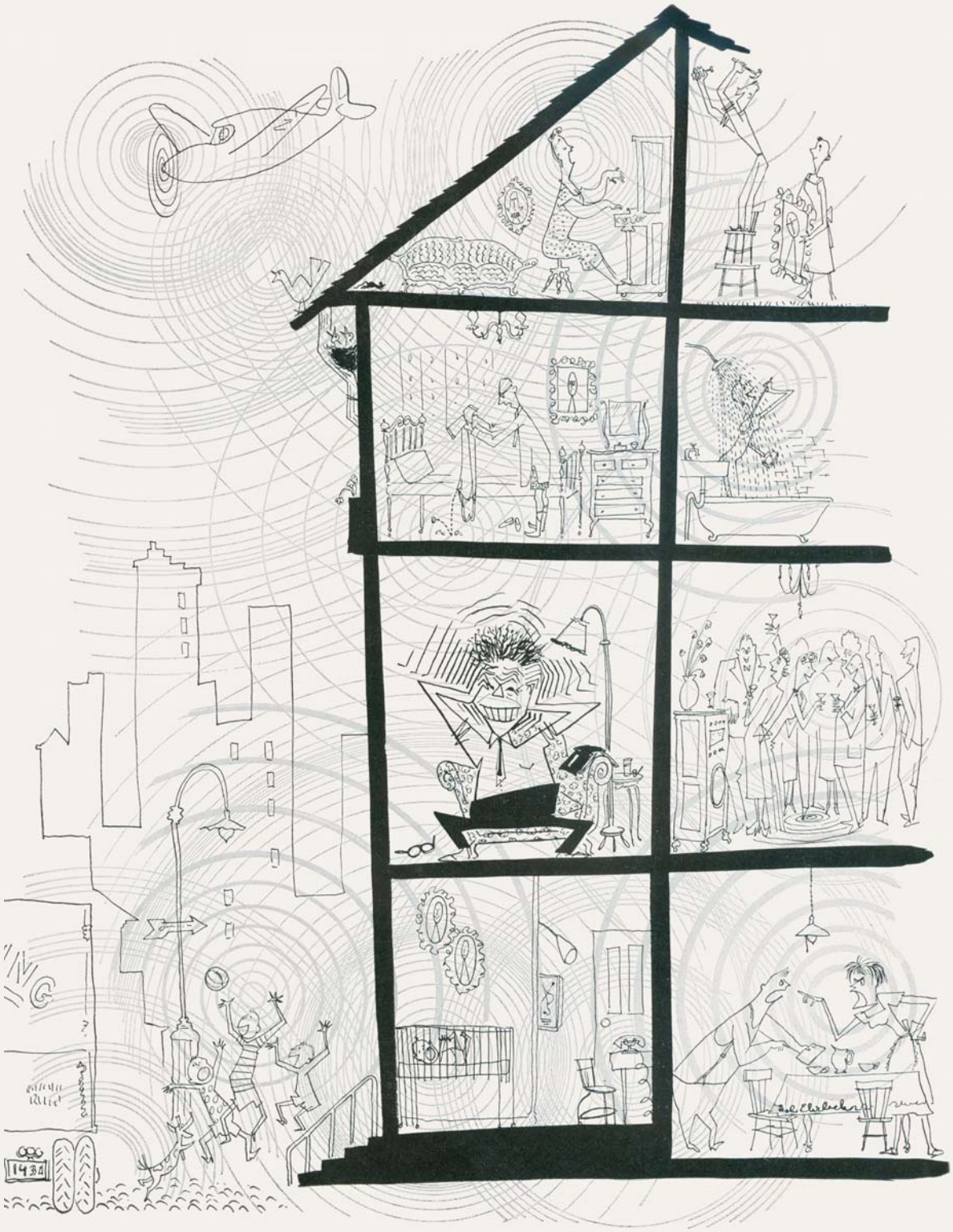
From the archives

(July 1949, pages 18–22)

Editor's note: On 15 September 2014, Leo Beranek celebrated his 100th birthday. When we proposed to reprint this 65-year-old article, Leo's reply was, "Everything in the article is valid today, so it can be reprinted with no embarrassment," and Bill Cavanaugh's introductory remarks attest to that. We hope you will enjoy reading this article as much as we enjoy presenting it.



Comments from William J. Cavanaugh, Natick, Massachusetts, November 2014

I am pleased to comment on Leo Beranek's farsighted overview of the state of acoustical design and construction in the US. In December 1949 I was a fourth-year student in MIT's five-year architectural degree program and had just completed a course in architectural acoustics taught by Leo's colleague Richard Bolt, director of MIT's Acoustics Laboratory. I have known Leo ever since.

The first part of "Design for acoustics" states the problem. Using a series of personal experiences in apartment living—effectively illustrated on the facing page—Leo shows the complexity of acoustical design issues in a typical multifamily dwelling. The sounds in one's own apartment are generally desirable sounds, whereas those from adjacent neighbors, from floors above and below, or from outside the building are almost always objectionable. Thus noise controls must be specified and designed for in advance of construction. Today, acoustical design issues are orders of magnitude more complex and widespread than were anticipated in 1949.

The second part of "Design for acoustics," a series of recommendations for the US, is guided by the experience of governmental programs in Europe to replenish extensively bombed-out housing areas. Leo draws on his experience during World War II and on his own and colleagues' efforts at the Bolt and Beranek consulting and research partnership; started in 1948, it became Bolt, Beranek, and Newman Inc in 1953 (I joined BBN in 1954 and directed its architectural technologies division until 1970). Still working to implement his 1949 recommendations toward improved national standards and acoustical design guidelines, Leo was awarded the National Medal of Science at the White House in November 2003 "for his leadership, dedication, and contributions to the art and science of acoustics; for co-founding one of the world's foremost acoustical research and consulting firms; and for sustained contributions to scientific and civic organizations."

The discomforts of noise in working and living can be reduced only by a rational approach to acoustics problems when *building* houses and factories, writes the technical director of the Acoustics Laboratory at the Massachusetts Institute of Technology.

DESIGN FOR ACOUSTICS

by ***Leo L. Beranek***

In Rotterdam, Holland there is a three-story apartment house, about one block long, with forty-eight apartments. Except for a noticeable difference in types of windows, the general construction appears orthodox. But this building is a large, realistic field laboratory for studying the best possible methods of quieting and heating apartment buildings. Construction details differ from apartment to apartment. Each wall and each floor is, in effect, a test panel.

This is one of the few rational approaches to the improvement of acoustics in buildings. Bold in its conception, the program under which this apartment house was built sets out to establish standards of apartment house design based on the experience of the forty-eight families who will live in the building over a period of years. At the same time comparisons of the acoustic value of the many different floor and ceiling constructions in the building will result in the selection of alternate structures suitable for meeting the standards established.

We in the United States know what it means to have a lack of suitable national standards of acoustic design. Lax building codes have permitted speculative builders to construct apartments and row houses with acoustically transparent walls and resonant floors. As a friend described it, "In 1941 my wife and I moved into a brand new apartment building that was advertised as 'modern in every respect.' However, 'modern' didn't mean freedom from noise. The family living overhead had no carpets. If the husband spilled his change when removing his trousers, we felt we could count it as it rolled to a stop. We always shared in the piano playing of one of

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the other tenants. Fortunately, our neighbors are not abnormally noisy people, but some tenants are not so lucky. They tell of continual family bickering in the adjoining apartments and of the strain it puts on them—both in having to listen to it and in realizing how quiet they themselves must be not to constitute a nuisance to someone else." A man's home has often been referred to as his castle but some of these castles are nothing more than acoustic torture chambers!

Objectionable Noises

Noise from highways and airlanes has also blighted many housing areas which would otherwise be assets to our cities. The postwar increase in traffic has only accentuated this problem. For example, on the highway between Worcester, Massachusetts and Boston house after house is marked for sale. Recently I was startled to see one house, partially framed and not even weather tight, up for sale. Inquiry revealed that these houses were being sold because of noise. As one owner said, "Sometimes I awaken during the night with the terrified feeling that a big truck is driving through our bedroom." Another, on being questioned, said, "The man who sold us this house lied. He said that there was never any truck noise after 11 p.m. However, instead of decreasing after midnight the truck noise increased. Now they have put a new hard top on the road and last winter many drivers equipped their cars with snow tires. The result is our family never gets a decent night's sleep. We paid $16,000 for this house in 1946 and now we shall be fortunate if we can get $10,000 for it. I don't know what we shall do next because we shall have lost our entire savings."

The builder of the partially completed house said, "The people on this street have so thoroughly discouraged me about the noise problem that I just stopped building and shall sell the house for whatever I can get."

The highway is by no means the only enemy of public comfort in our cities. Anyone who has lived near an airport realizes the effect of airplane noise on the nearby community. In addition the airport noise problem has been a major deterrent to widespread private flying. The noise has made it necessary to locate flying fields for from residential areas. Potential owners of airplanes do not feel it worthwhile to drive ten miles to a private airport, in order to fly a distance of fifty miles to a neighboring town.

Is the situation any better in the factory or office? Perhaps so. The extensive advertising by acoustical materials manufacturers and the growing strength of labor unions have made management more noise conscious. While acoustical tile, placed on the ceiling of a factory space, may alleviate the noise situation somewhat, acoustic comfort is usually not obtained for those people in the vicinity of a noisy machine. Noise should be reduced at the source. Simple precautions taken in designing a machine will often make the difference between an intolerable and a passable noise situation.

The House Jack Should Build

Now that we have stated the problem, what can we do about it? In the case of housing, we should certainly do well to follow the lead taken by our European neighbors. For example, the Building Research Station in Watford, Hertsfordshire, England has undertaken an extensive survey of noise conditions in London homes. Their study reveals the interesting results shown in the tables. Two of three tenants in apartment houses of the type found in the United States (brick veneer outer walls, simple wooden floors, and partitions) complain seriously of noise conditions. Those living in older style apartment houses with masonry partitions and heavy timber floors fare better. Here, the number of complaining tenants decreases to about one out of three.

The results of the British survey should be checked in the United States by instituting a program that would include a national survey of noise conditions in apartments and row houses. The survey alone would be of little value unless a program of building research were established which would lead to the development of economical building structures for producing the large reductions in noise level that obviously are necessary. The types of floor and wall structure given in the last line of the tables are those developed by the Building Research Station. Because of current American building practice few owners in the United States could afford such construction even though they might agree that it is desirable. Nevertheless, these constructions are currently being used in England. The Ministry of Works has prepared a Recommended Code for the Acoustics of Schools and Flats which practically requires their adoption. In fact, the English have constructed over one hundred thousand housing units (counting a single apartment suite as a housing unit) in accordance with this building code.

Experimental housing units, such as the large one in Rotterdam, would also be a necessary part of a national program in our country. How far studies of this type ought to be carried can be seen from an examination of the statistics of the Dutch experiment. In their special building they are testing thirty-eight floor con-

structions, classified into six different groups. One group, for example, includes floors of usual construction: timber joists, wood floor above, plaster ceiling below; prefabricated concrete slabs with metal joists; reinforced concrete slab, etc. A second group includes floors improved by a suspended ceiling. A third includes floors laid on a resilient mat, and so on. In addition, thirty-two different partition wall constructions, forty-five outer wall constructions, and twenty-two flat roof constructions are provided.

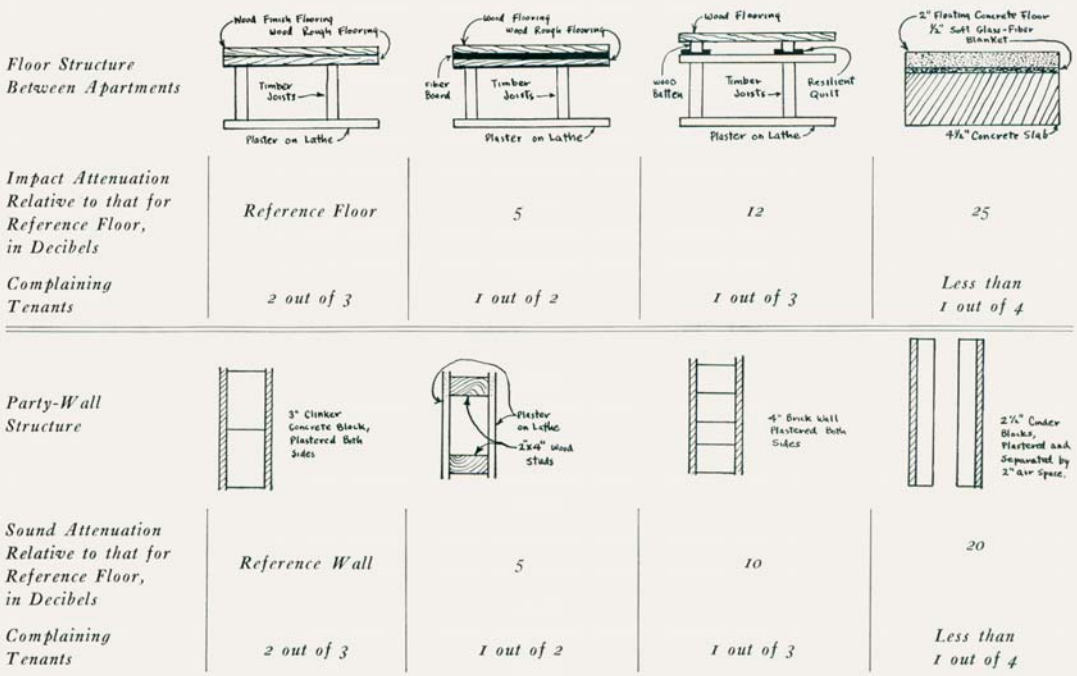
Establishing standards for building construction must not rest on acoustic considerations alone. Thought must also be given to such important items as thermal insulation, strength, stability, and fire hazard. In an effort to solve these problems from the standpoint of British needs, the Building Research Station has carried out a program that attempts to draw together the relevant information on these topics and to formulate standards.

In pursuing these studies the British Government has encouraged the development of alternative types of houses by providing the promoters of promising designs with facilities for carrying out trial constructions. One part of the procedure in dealing with a design for this purpose is to submit the plans and specifications to the Building Research Station for study. If the plans are promising, a license is granted. If changes are indicated, they are suggested to the promoter. When the prototype is erected it is examined and usually subjected to scientific tests after which a report is issued to the sponsoring agent in the government. An important point to be noted here is that the research side of building design is brought into touch with each practical design both before and after the erection of the prototype.

The new standards that are gradually evolving from the British studies are founded on information that is not yet common knowledge in the building industry. Hence, this close relationship between designers, research engineers, and promoters has disseminated new information at a surprisingly high rate. Other government agencies, such as the British National Physical Laboratory, also share in the study of new building structures. The Building Research Station acts as a coordinating center for all forms of scientific information leading to better housing. Consequently, it becomes the logical place to which designers and members of government agencies come when seeking information or standards for new construction.

Skyways and Highways

The noise problem presented by small flying fields is simpler to solve than are the complex difficulties of architectural acoustics. In the United States the combined efforts of the National Advisory Committee on Aeronautics and the Aeronautical Research Foundation



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of Cambridge, Massachusetts have led to designs of small aircraft that are suitably quiet for use in semicongested areas. These studies have revealed that, by increasing the number of blades on an airplane propeller and decreasing the tip speed, it is possible to reduce the noise levels produced by conventional small aircraft to values that are nearly inaudible except when one is within a few hundred feet of the airplane. This is done with little, if any, loss of performance. Also, the addition of a new type of crosswind landing gear has made the usual multistrip airfield plan unnecessary for small aircraft. In one public demonstration in Cambridge, Massachusetts it was shown that a strip of land, parallel to a public highway in a semicongested region, is a suitable landing field for small planes. People living in the vicinity of this flying strip were, in general, unaware of the landing and taking off of specially quieted airplanes. Special research in this direction, combining economy of design with quiet motive power, should be encouraged.

Traffic noise is the most difficult to solve of all our national noise problems. Actually, the problem is divided into three parts: first, we must determine the noise conditions that exist throughout various parts of typical leading cities; secondly, we must decide what maximum sound levels are acceptable in typical living areas; and finally, we must persuade city officials to prepare city codes and city regulations that govern the location of factories, highways, airstrips, and other sources of noise. It is difficult to find a good reason why our city administrations should not be as concerned with acoustic health as they are with plumbing, lighting, and heating problems. The potential home builder and architect should be able to inspect city maps prepared from surveys that indicate principal noise sources such as highways, railroads, airports, and factories. Building permits should be issued only if the home owner can demonstrate that he has located his house with respect to noise sources or treated it acoustically in a manner that will assure a reasonably satisfactory acoustic environment. Admittedly, this would be a radical departure in public planning, but a very worthwhile one.

Ordinances specifying maximum allowable noise levels near factories are already in force in a few cities. One difficulty in establishing permissible noise levels is the lack of suitable devices for measuring the noise. We need instruments that will evaluate noises in terms of both their loudness and their annoying effects. If such instruments were available, they would greatly expedite interpretation of noise ordinances in the courts. We in the United States have a long way to go, both legislatively and scientifically, before acoustic comfort joins the other comforts of home.

In summary, a plea is advanced that we encourage long range planning in the fields of building design, city planning, noise evaluation, and noise reduction. This planning should lead to the formation of a central building research station, financed perhaps by the combined building industries, for an initial ten-year period. The organization should be complete with a staff of scientists, engineers, and architects interested in the general problem of better housing. Out of this new station would come ideas for the future, which would combine the five essentials of building: structure, design, lighting, heating, and acoustics. This station could also draw up model building codes for use by local governing bodies. Also, airport codes, zoning codes, noise codes, and others, as related to acoustic comfort and health, could be formulated. All ideas could be tried on a full scale basis and exhibited to the building industry and to the general public.

Plans, of course, are easy to make but difficult to execute. In the case of building research, however, there is no reason why a long range plan could not be put into effect in this country at an early date. Government supported building is still needed to alleviate the long standing housing shortage. It would seem sensible to incorporate experimental construction for noise reduction into this building program. Of course, the cost would be slightly greater. In return, however, people would have a measure of acoustic privacy. In addition, the houses would be better constructed because almost every method used for sound isolation and control improves the heat insulation and the strength of the wall and floor elements.

We who pride ourselves on our advanced mode of living must take action to improve one of its most basic aspects. At this moment the improvement of American housing is a sadly neglected matter. ■