SURVEY OF CITY NOISE

G. L. BONVALLET
Armour Research Foundation of Illinois Institute of Technology, Chicago

A survey of city noise has been in progress in Chicago for over two years. The program covers noise of transportation vehicles, and noise in traffic lanes, industrial, and residential areas. The study is sponsored by Armour Research Foundation of Illinois Institute of Technology and the Greater Chicago Noise Reduction Council, and has the cooperation of the City of Chicago and the National Noise Abatement Council.

The work was undertaken as a public service and to stimulate further interest in the subject. Not only has the noise problem become more acute with the passing of time, but the public has become reconciled to noise as a necessary condition of present-day living. Furthermore, good methods of simply, rapidly, and reliably measuring industrial noise have not been available to the engineer. Equipment is available for measuring sound intensity, but acousticians agree that there is little correlation between sound levels, which are a measure of the physical condition in the medium, and loudness as adjudged by the human ear. It is hoped, therefore, that the results of the survey will create interest in further work, and will, in addition, establish a preliminary basis for tolerable noise levels which will be useful in writing or revising anti-noise legislation.

A study of city noise was made in New York City in 1930.* The results of this work were far-reaching and beneficial. Other surveys on a smaller scale have been made by a number of workers.

An important part of the present study has been that of taking octave band levels in addition to over-all levels. The over-all level is that indicated by a standard sound meter which responds to the entire audible spectrum within the limitations of the meter. The octave band levels are those read on the sound meter which has been modified by switching in various band pass filters. The meter then indicates the level within the particular band. The bands referred to in this paper are one octave wide.

Many acoustical measurements of mechanical noises have indicated the unreliability of the single over-all measurement to represent the objectionable degree of the noise. It is well known that levels in the various octave bands are more valuable in describing the noise than the single over-all level. As a result of numerous listening judgments on noises similar to these, it has been found that the loudness and objectionable nature of such noises could be correlated better with one of the octave measurements, such as the 400-800 cps band,

* *City Noise*, published by the Noise Abatement Commission of the City of New York, The Academy Press, New York, 1930.

than with the single over-all level. This particular band represents a good compromise between lower frequency octave levels with high energy content and higher octave band levels with reduced energy, because of the absorption by intervening structures and air.

Noise of Vehicles

The phase of the survey concerned with noise of common transportation vehicles was started first because vehicle and traffic noise was believed to be more objectionable and more prevalent than industrial noise. The work has been completed, and with curves and tables is rather comprehensively reported in the *Journal of the Acoustical Society of America,* Vol. 22, Number 2, March 1950.

Inside vehicles, the highest average levels were measured in subway cars. These were 95 db over-all and 91 db in the 400-800 cps band. All measurements are on the flat network. The lowest average levels were 85 db over-all in a new "L" car and 68 db in the 400-800 cps band measured in a relatively new seven-passenger sedan. Levels for such vehicles as old "L" cars, old street cars, trolley buses, PCC cars, motor buses, and suburban steam and electric railroad cars were between these maximum and minimum values.

Outside vehicles, the noise was measured at 20 feet in all cases except for railroad trains, in which case a distance of 100 feet was believed to be more practical for the purpose. The highest average levels were for subway trains and the levels were 94 db over-all and 87 db in the 400-800 cps band. The lowest average over-all level was 79 db for trolley buses. The lowest average level in the 400-800 cps band was 66 db for automobiles.

Traffic Noise

Although traffic noise generally is more intense than industrial noise, in many cases it may be adjudged less objectionable. This follows because: (a) the public may tolerate public transportation noise on the incorrect basis that it cannot be reduced, and (b) vehicle noise, aside from automobile horns, squealing brakes, and clanging street car gongs, when close to a listener, increases slowly as the vehicle approaches and then decreases. Industrial noise, on the other hand, often changes abruptly. Generally it stops and starts suddenly and may be objectionable because of its characteristic quality which identifies it as a forging hammer, steam exhaust blast, a traveling crane, a whistle, metal handling, or the like.

Measurements have been made at intersections and in thoroughfares to ascertain levels due to traffic. Insufficient data have been taken for a complete picture of the range of over-all and octave band levels. Based on the meager data, the over-all levels ranged from about 65 to 85 db, and the levels in the 400-800 cps band from 45 to 70 db. These figures are for places where a reasonable amount of city traffic, such as automobiles, trucks, and mass transportation vehicles, passes.

Industrial Noise

Another phase of the survey concerns noise in industrial areas. Over a hundred different places in the many Chicago industrial zones were visited and data taken during the usual business hours. Measurements were taken from the sidewalk, street,

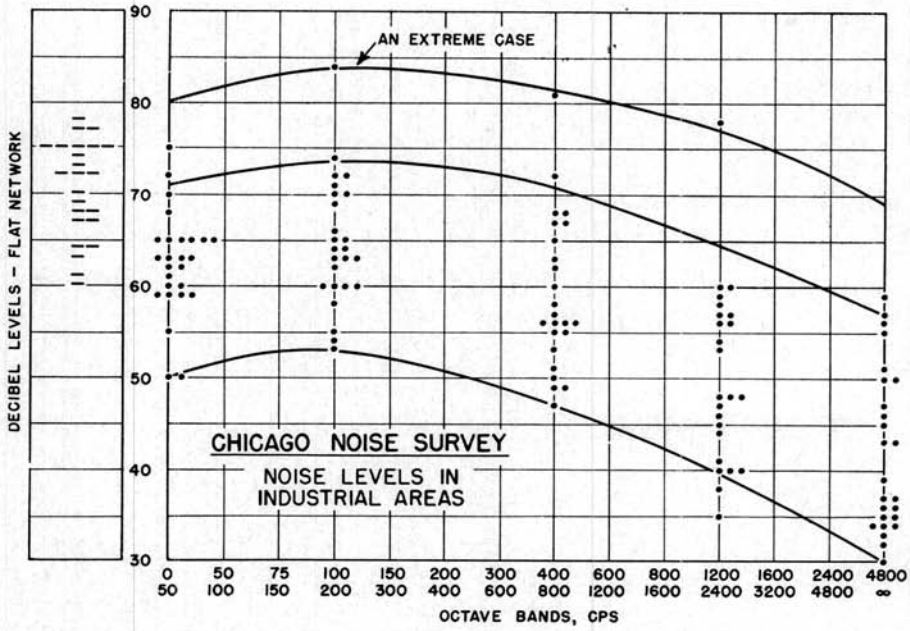

FIG. 1.—Data and curves of noise in industrial areas. Measurements (flat network) are on the sidewalk or street about 25 to 30 feet from buildings or plant boundaries and during usual daytime business hours.

or other public thoroughfare on the outside of each plant or industrial area. Distances generally were about 25 to 30 feet from a building or boundary. In many cases it was difficult to establish a meaningful sound level because of the intermittent nature of the noise. Information on whether the noise was above or below the general background noise also was noted.

Preliminary study of the data indicates a range in over-all levels of about 60 to 90 db. Measurements in the 400-800 cps octave band ranged from 45 to 80 db. Typical levels are shown in figure 1. This figure also shows the value of octave band data in describing the noise as compared to the single over-all level. Despite the incompleteness of these data, they have been used to make preliminary curves and draw preliminary conclusions. Figure 2 shows the distribution of noise levels measured in the 400-800 cps band. The curve shows that about 95 percent of the levels fall below 70 db. Assuming that these data are confirmed after complete analysis of the measurements, a preliminary conclusion might be drawn that 5 percent of the cases should be considered objectionably loud.

Figure 3 might be termed a preliminary limiting curve for industrial noise. It has the same general shape as industrial noise curves and passes through the previously mentioned 70 db level in the 400-800 cps band. It would define a noise spectrum such that industrial noise with higher components than those shown might be considered legally objectionable. Such measurements and curves require complete and careful analysis before conclusions can be made.

The study indicates one important observation even at the present stage. Industrial noise outside plants and factories is not so loud as it is reputed to be. The few factories that make intense noise probably have given a bad reputation to industry in general. Many cases were found where the plant noise could not be measured in the background of unidentifiable sounds or of transportation vehicle or traffic noise.

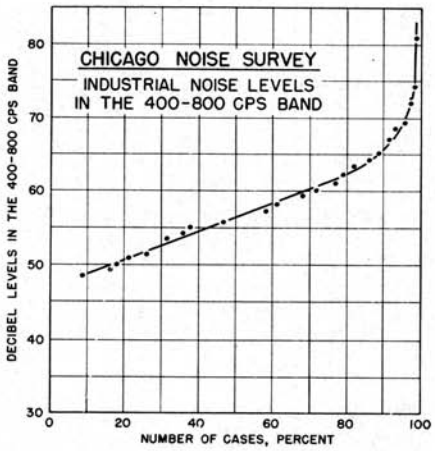

FIG. 2.—Curve showing the percentage distribution of industrial noise levels measured in the 400-800 cps band. From these data it can be seen that about 95% of the cases are below 70 db in the specified octave band.

RESIDENTIAL AREA NOISE

The data on residential noise are rather meager at the present time. The background levels are caused by industrial or traffic noise at different distances. Nearby vehicles, children at play, vendors, and other local sources generally do not contribute much to the ambient background, although they often are objectionable. Again, with incomplete analysis, the data indicate a range of from 50 to 80 db over-all and 35 to 70 db in the 400-800 cps band. As before, compromises are required in associating a single level with complicated noise conditions such as these.

AUTOMOBILE HORNS

An investigation of automobile horns is being conducted as a part of the survey. It was felt that such a study was of value because of the necessity for horns on vehicles and the objectionable nature of some of them. It is necessary that a horn be louder than the ambient background noise and even loud enough to warn nearby motorists in totally enclosed automobiles operating at noisy high speeds. Such warning signals, therefore, are required to be comparatively intense sound sources. On the other hand, many such horns are unduly loud. It is believed that horns can be effective without being raucous despite their relatively high levels. The work in progress consists in part in measuring the levels and in investigating the overtone structures to determine the characteristics of pleasant and effective signals on the one hand and characteristics which are objectionable and which possibly identify the horns as dangerous because of their frightening effect.

Again it must be reported that the work is not yet completed and only a report of progress can be made here. The modern automobile for the last five years has employed horns in pairs. The present work is simplified because most of the automobiles now on the streets employ only about half a dozen types of horns. The fundamental tones of the two horns in the pair are usually a musical major third apart. The more

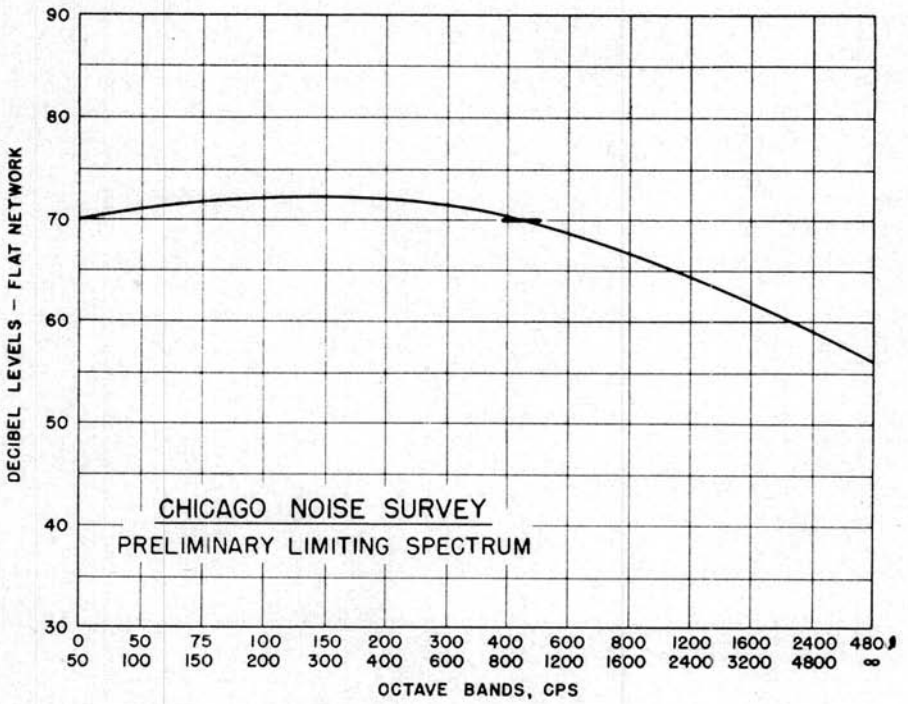

FIG. 3.—Curve showing a preliminary limiting spectrum. The curve is similar to others for industrial noise and passes through 70 db in the 400-800 cps band. Industrial noise data which are higher than this curve might characterize the source as legally objectionable.

pleasant sounding devices have harmonic overtones, whereas the objectionable sounding horns have inharmonic overtone structures.

Measured at three feet in front of the units, these horns have levels of from 105 to 125 db, so far as they have been measured. The fundamental tones for the different horns are in the range of about 150 to 400 cps.

An important feature of the work is that, in addition to the levels in decibels, the information in phons and sones also is being determined. There has been too little work done in the industrial field in the way of obtaining loudness and loudness levels. This has been due, at least in part, to the difficulty and the labor involved in determining these from decibel levels. As an example, the range of 105 to 125 decibels is a range in loudness level of approximately 125 to 140 phons and range in loudness of about 600 to 2000 sones.

It is desirable to define these units here. The loudness of a sound is the magnitude of sensation in the ear. It depends on sound pressure and on the frequency spectrum. The unit is the loudness unit or the sone. A 1000-cycle tone 40 db above the normal threshold has a loudness of one sone or 1000 millisones or loudness units. The loudness level of a sound is numerically equal to the sound pressure level in decibels of the simple 1000-cycle reference tone which

is judged to be equally loud. The unit of loudness level is the phon.

The program includes the processing of these horn noises in several ways, such as filtering the output to cut off at around 1000 cps. Again in a preliminary way, it has been found that such filtering removes a reasonable amount of the sound which is objectionable, and apparently does so without sacrificing the necessary warning characteristics.

Conclusion

The survey is proceeding at the present time with analysis of available data and with plans for the incomplete phases referred to above. Of more importance, further thought is being given to the problem of using these results beneficially. As the work becomes completed the results will be made available in the most useful way.