

# Research on a Device for Reducing Noise

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## ABSTRACT

The purpose of this research study is to describe a new device for reducing noise based on the principles of sound refraction and interference, which can effectively reduce noise from highway and railroad traffic. This device has a back sound barrier panel that effectively reduces sound when the system is used on an existing sound barrier. In a test at the proving ground of the Bridgestone Corporation, the device with a back barrier of glass fiber reduced the noise emanating from an 11-ton truck by 5 to 6 dB(A).

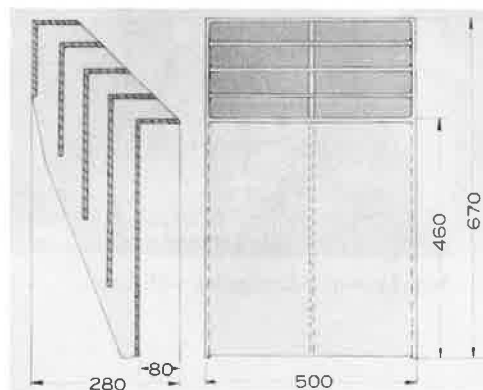


FIGURE 1 Construction of device.

## PRINCIPLE AND EFFECT

This study is concerned with a new type of device for reducing noise based on the principles of sound refraction and interference. The device can effectively reduce the effect of noise emanating from highway and railroad traffic.

In order to reduce noise, it has been common practice to provide a noise barrier between the sound source and the receiver for the purpose of intercepting the propagation of the sound wave that causes the noise or to construct a barrier to completely surround and shield the noise source. However, the former is limited in its effectiveness to insulate the sound, whereas the latter requires additional devices for heat dissipation or ventilation, and hence becomes complex in construction, thereby making it difficult to install and make effective.

To overcome such disadvantages, attempts have been made to construct a high wall along a railroad or a highway. Such a high wall, however, obscures sunlight from nearby houses and blocks the passenger's field of vision; therefore, the wall has its own disadvantages.

Based on a consideration of these points, this study is concerned with the development of a device for reducing noise using the principles of sound refraction and interference.

## DEVICE

The interference principle of the sound-reduction device is shown in Figure 1. On the right-hand side of the figure is the front elevation view from the sound source. The sound enters along the upper edge. The left-hand side shows a cross-sectional view of the device; shown are the hollow rectangular chambers located at right angles to each other, which are progressively longer from top to bottom.

The sound emanating from the source passes through the chambers and is refracted. It lags in phase compared with the sound passing over the top of the device. The device interferes with the two sounds, thus providing a region where the sound is reduced.

The underlying principle for this patented device is described by referring to Figures 2-5. The photographs show the sound distribution produced both in the absence and in the presence of the sound-reduction device. These photographs have been taken by using a special photographic method.

## Analysis of Sound Pressure

In Figures 2 and 3 the brighter area represents the area where the sound pressure is higher (i.e., louder).

Figure 2 shows the distribution of a 1/3 octave band noise that has a center frequency of 2,000 Hz. The noise is emitted from noise source (1) in the absence of the patented sound-reduction device.

Figure 3 shows the distribution of a 1/3 octave band noise that has a center frequency of 2,000 Hz. The noise is emitted from noise source (1) and is refracted by the device (2). Area A represents sound that has been emitted from the source (1) that has passed over the top of the device (2). Area B represents sound that has passed and is delayed in phase

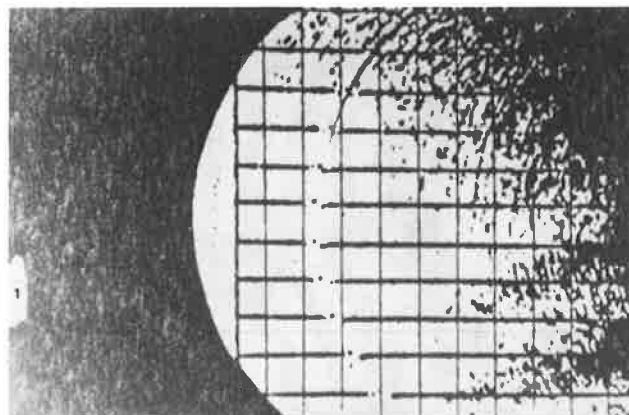


FIGURE 2 Sound pressure distribution without device.

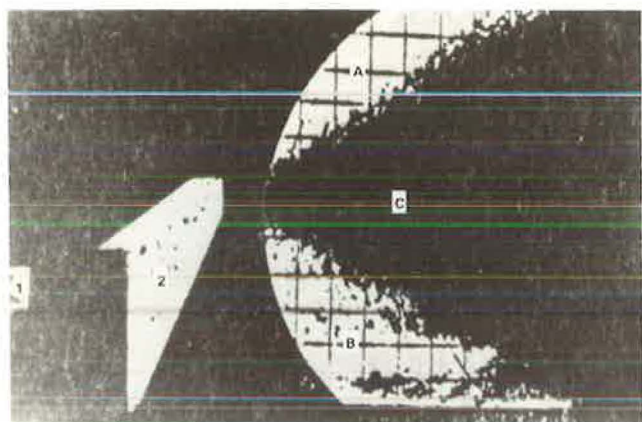


FIGURE 3 Sound pressure distribution with device.

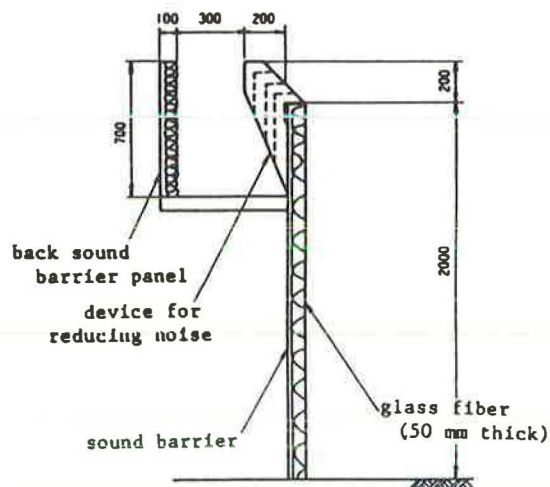


FIGURE 6 Cross section of sound-reduction system.

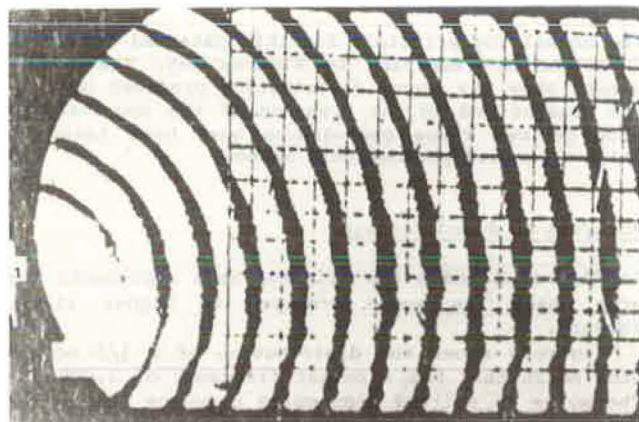


FIGURE 4 Sound wave without device.

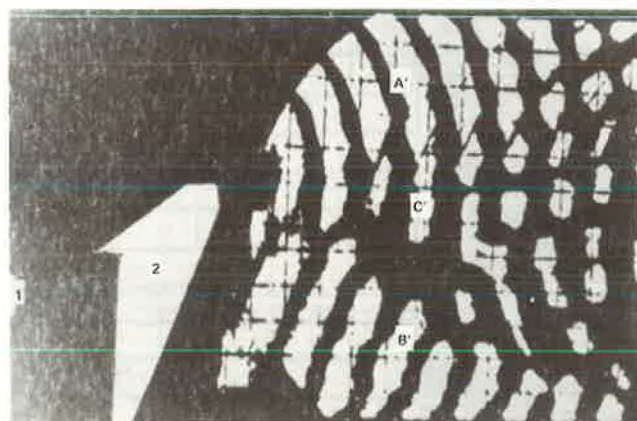


FIGURE 5 Sound wave with device.

as it passes through the chambers. Figure 3 shows that the device produces a low sound pressure area C between the two high sound pressure areas (A and B).

#### Analysis of Sound Wave Density

In Figures 4 and 5 the brighter areas represent sound waves of higher density.

Figure 4 shows the sound wave of a pure tone, which has a frequency of 2,000 Hz. The noise is emitted from the noise source (1) in the absence of the device. [The sound waves spread like ripples (concentric rings) in a pond after a stone has been thrown.]

Figure 5 shows the sound wave of a pure tone, which has a frequency of 2,000 Hz. The noise is emitted from the noise source (1) in the presence of the device (2). Figure 4 shows the pure tone emitted from the noise source (1) and propagated in a spherical wave without phase lag. The presence of the device in Figure 5, however, causes a sound wave B', which passes through the chambers and is propagated in a plane wave, to refract in a downward direction; this sound wave is delayed in phase compared with sound A', which has passed over the top of the device and is propagated in a spherical wave. As a result, the sound wave in region C' (located between sound A' and B') becomes a nonuniform wave, as shown in Figure 5. The nonuniform sound wave in region C' represents a destructive interference phenomenon. This phenomenon is produced between the direct sound wave A' passing over the top of the device and diffracted into the sound shadow behind the device, and the sound wave B' passing through the chambers of the device and refracted and delayed in phase. As a result the sound reduced in region C' is produced, as shown in Figure 5. The volume of the sound reduced in region C' due to the interference between sound B' and sound A' is determined by the size of the device, the difference in length between the chambers of the device, and the position of the noise source.

#### FIELD TESTS

Tests of this device were carried out at the Bridge-

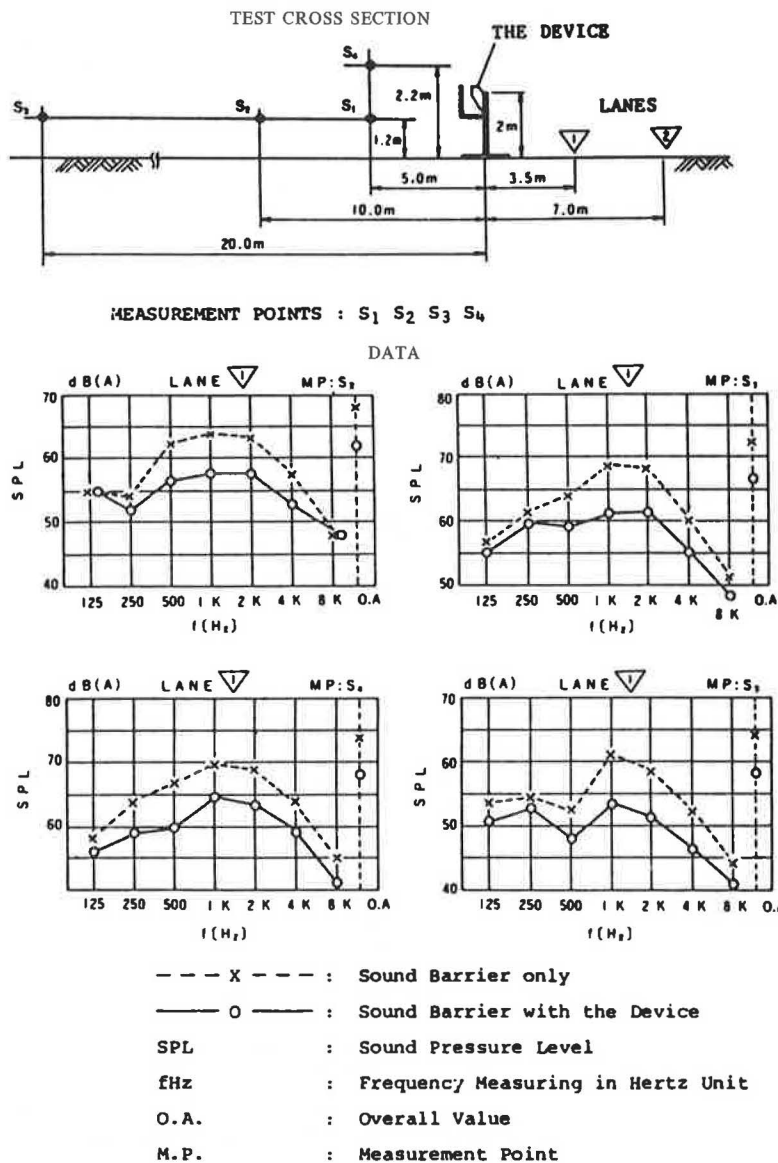


FIGURE 7 Data on frequency analysis at different measurement points.

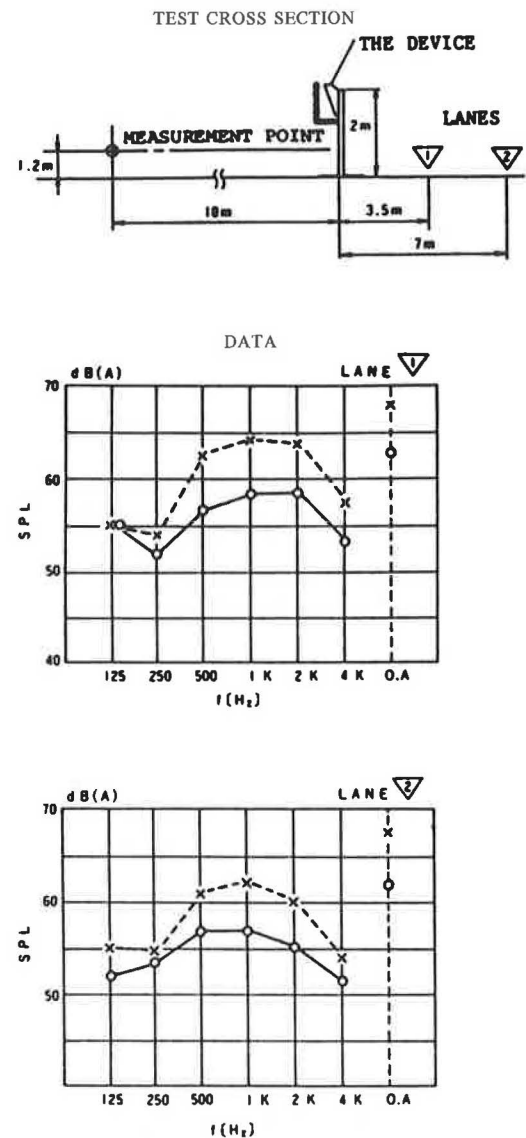


FIGURE 8 Data of frequency analysis for different lanes.

stone Corporation proving ground on February 2, 1982. The tests were conducted under the following conditions:

1. Sound barrier--2.0 m high, coated with 50-mm-thick glass fiber on the front face for the purpose of sound absorption (Figure 6),
2. Test car--11-ton truck (Mitsubishi Fuso),
3. Speed--100 km/h (63 mph), and
4. Distance between the device and the noise source--3.5 and 7 m (11.5 and 23 ft).

The results of the test indicated that

1. The noise of the truck was reduced 5 to 6 dB(A) when the device was applied;
2. A similar degree of sound reduction was recorded at measurement points  $S_1$  to  $S_4$  in the range of 500 Hz to 4 kHz, as shown in Figure 7; and
3. A similar effect was recorded when the truck ran along a different lane, as shown in Figure 8; thus the device functioned efficiently, even if the noise source was distant. (The test setup is shown in Figure 9.)



FIGURE 9 Test setup.



## CONCLUSIONS

Considerable reduction of sound can be expected when this device is used on existing sound barriers, without a big modification of the barriers. If new sound barriers are constructed, then the use of this device can contribute to the economical design of the sound barrier system by lowering the height and reducing the weight of the installation. This de-

vice, when combined with the back sound barrier panel that intercepts the refracted propagated noise, can effectively reduce the noise from sources such as railroads or highways.

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## Review of Federal Noise Emission Standards for Interstate Rail Carriers

ERIC STUSNICK

## ABSTRACT

The federal noise emission standards for interstate rail carriers, the most recent portion of which took effect on January 15, 1984, are reviewed. Some potential problems in carrying out various elements of these standards are described, and possible solutions to these problems are discussed.

The Noise Control Act of 1972 identified noise as a growing danger and declared that the policy of the United States was "to promote an environment for all Americans free from noise that jeopardizes their health and welfare." Included in the Act was the authorization to establish federal noise emission standards for products distributed in commerce, and the mandate for the U.S. Environmental Protection Agency (EPA) to coordinate federal activities in noise control. Section 17 of the Act specifically required EPA to promulgate standards and the U.S. Department of Transportation (DOT) to promulgate compliance regulations setting limits on "noise emission resulting from operation of the equipment and facilities of surface carriers engaged in interstate commerce by railroad." It further required that such regulations include noise emission standards that "reflect the degree of noise reduction achievable through the application of the best available technology, taking into account the cost of compliance."

In accordance with Section 17 of the Act, EPA issued final railroad noise emission standards on December 31, 1975. These standards applied to all railroad cars and all locomotives, except steam locomotives. On August 23, 1977, FRA published Railroad Noise Emission Compliance Regulations setting forth procedures for enforcing the EPA standards.

In June 1977 the Association of American Railroads (AAR), along with several railroad companies,

challenged the EPA regulation in the U.S. Court of Appeals on the basis that it did not include standards for all railroad equipment and facilities as required by the Noise Control Act. The concern of the railroad industry was that, lacking federal preemption of all railroad noise source regulations, there could develop a great variety of differing and inconsistent standards in every jurisdiction along the railroad's routes. In addition, local communities would not necessarily be bound by the protective requirement in the Noise Control Act for use of the "best available technology, taking into account the cost of compliance."

The judgment of the court was in favor of the railroad industry. As a result EPA published proposed noise regulations for additional railroad equipment and facilities in April 1979. These proposed regulations would have established federal standards for overall railroad facility and equipment noise, as well as specific standards for retarders, refrigerator cars, and car-coupling operations.

After an extended public comment period, EPA published final rules on January 4, 1980, establishing standards for noise from four specific sources, namely, switcher locomotives, retarders, car couplings, and locomotive load cell test stands. These new standards took effect on January 15, 1984.

Although at the time of preparation of this paper DOT had not yet promulgated compliance regulations for these new standards, draft regulations were in the process of being prepared.

## LOCOMOTIVE STANDARDS

The data in Table 1 summarize the standards for noise emission from all locomotives, except steam locomotives, operated or controlled by railroads within the continental United States.

The original standards, issued in 1975, differentiated among three different operating conditions:

1. Stationary at idle throttle setting,