Oct. 1, 1957 J. J. MEYERS 2,808,122

CONSTRUCTION FOR DAMPENING ENGINE NOISE

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Fig. 1

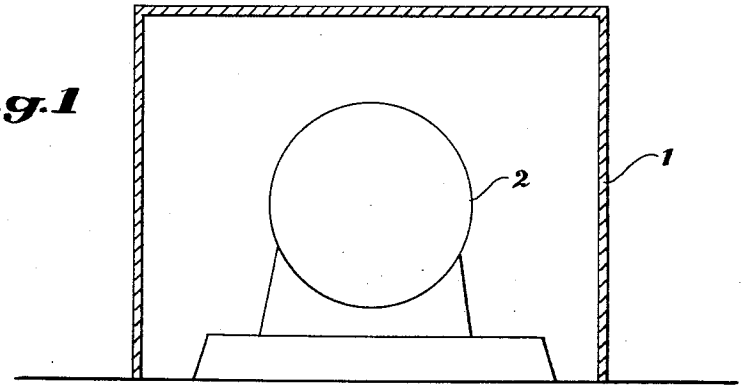


Fig. 2

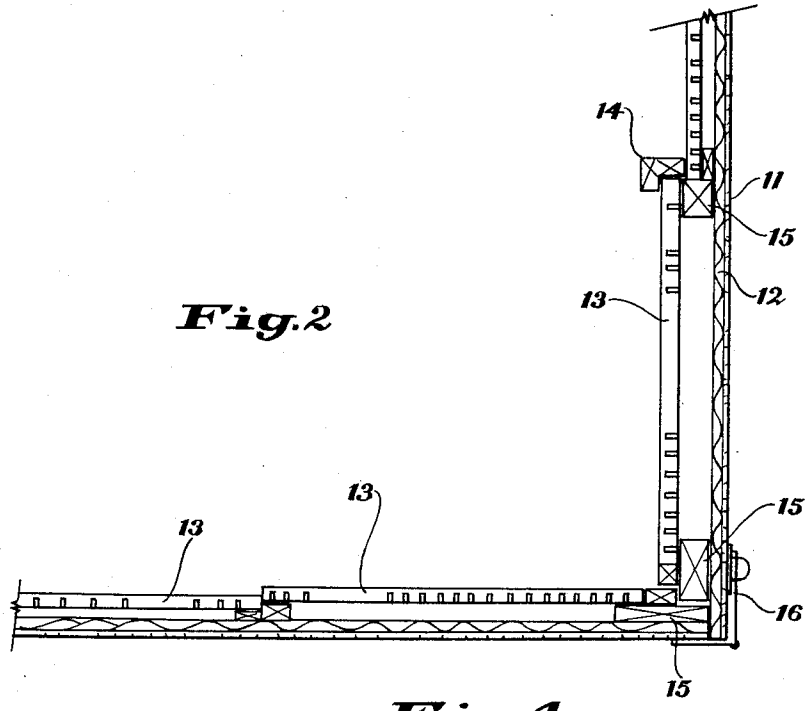


Fig. 4

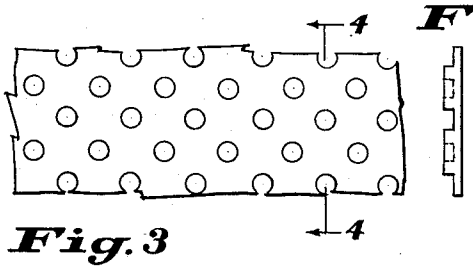


Fig. 3

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CONSTRUCTION FOR DAMPENING ENGINE NOISE

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3 Claims. (Cl. 181—33)

This invention relates to a construction adapted to the dampening of disturbing noise such as engine noise by constructing walls enclosing the source of the noise in the form of a multiplicity of cells in accordance with the sounds which are to be reduced in intensity.

The operation of certain types of machines produces noises which may be disturbing and disagreeable to many individuals. One type of machine which is especially objectionable noisewise is the Jordan engine employed in paper mill operations. Other types of machinery the operation of which may produce disturbing noises are generators, saw mills, hammer mills, punch presses, rolling mills, ball mills, and the like. Machinery of that nature located in the vicinity of residential areas may interfere with the peaceful enjoyment of property by the residents thereof and the noise so produced may even be considered a nuisance in many instances.

Previously sound absorbing materials consisting ordinarily of some type of fibrous material have been employed to act as a sound dampener usually without regard to the frequencies of the sound encountered. In many cases sound absorbing material has been employed in the walls of the building itself rather than by surrounding the machine responsible for the noise with a sound absorbing hood or walls immediately surrounding the noise producing machine.

One object of my invention is to provide a sound absorbing construction governed by the principal frequencies of the noise which is to be dampened. Another object of my invention is to provide a soundproofing construction which can, if desired, be employed to immediately surround the noise producing machine. A further object of my invention is to provide a noise reducing construction using acoustical tile of a type which is readily available from commercial sources. Other objects of my invention will appear herein.

In its broadest aspects my invention comprises surrounding the noise producing machine or engine with a wall construction designed to accord with the principal frequencies of the sound which is to be reduced. In order to determine the desired structure for the sound reducing walls a spectrum of the noise from the offending machine is first taken. The surrounding walls are then designed and constructed to correspond to the offending frequencies as will be more fully described.

I have found that if the containing walls surrounding the noise producing machine or machines are composed of a plurality of cells having dead air spaces of volumes related to the noise producing frequencies the inner construction of which walls are of acoustical tile the holes of which open only to the dead air spaces of the cells the presence of these cells in the containing walls dampen or absorb the offensive sound waves and diminish or eliminate the noise produced by the noise producing machine. The volume of the air space in the various

cells to be employed are determined in accordance with the formula:

$$F=\frac{C}{2\pi}\sqrt{\frac{NA}{V(L+\Delta L)}}$$

in which formula F is one important frequency of the noise in cycles per second; C is the velocity of sound in air (1100 feet per second at 70° F.); N is the number of holes in the perforated board or tile which will be open to the dead air space of the cell; A equals the area of each perforation in square feet; V is the volume of the air space of the cell in cubic feet: L equals the depth of each hole in feet and ΔL is 1.7×the radius of each hole in feet. The dimensions of the cells are chosen so that no one of their dimensions is in excess of one half a wave length of the incident sound which is to be attenuated.

The accompanying drawings illustrate the construction which is employed for surrounding a noise producing machine, in this case a Jordan machine. Fig. 1 is an end elevation view of the Jordan machine **2** surrounded by containing walls the construction of the walls not being shown in detail. Fig. 2 is a view in section of wall construction in accordance with my invention. The walls surrounding the noise producing machine are made up of a series of cells the volume of dead air space of these cells being determined by the offending frequencies of the noise. The number of each size of cell employed is determined by the percentage of total noise which occurs in each frequency band for which the cells are being employed, and the various cell sizes are dispersed uniformly on all surfaces of the sound enclosure. As shown in Fig. 2 one type of cell employed requires an air space of definite size which is large whereas other offending frequencies require cells having air spaces of less volume.

The walls as shown in Fig. 2 consist of an outer layer which in this case is ¼" asbestos board designated **11** applied over ½" plywood board designated **12**. The outer layer may, however, be of any suitable construction such as plywood sandwiched between stainless steel layers or some other desired construction. Seals are preferably provided where pipes or other connections pass through the enclosure and between the enclosure and the floor. Such seals may be sponge rubber, etc. However, with this resonant type sound cancellation enclosure it has been found that a considerable amount of sound leakage surface can be permitted without detrimental effects. The inner walls are made up of fiber glass acoustical tile **13** which conveniently may come in units of 12" x 12" x ¾" or many other sizes. This tile is used with the perforation side facing the dead air space and the unbroken side toward the noise producing engine. The unbroken side may be covered by a moisture-proof layer such as of rubber or plastic. The sides of the air spaces instead of fiber glass acoustical tile may be any type of wall or fiber board carrying holes of a satisfactory depth. For instance, materials sold under the trade names: "Celotex," "Masonite," "Insulite," "Johns-Mansville" and the like may be used provided that the material is penetrated by holes.

A true resonate cell will peak very sharply at its specific design frequency having little sound attenuation benefits on either side of this frequency. However, if a layer of sound diffusing media is incorporated at the inlet to the throat of the resonator channel the sound waves are diffused and a broadened frequency band attenuation effect is achieved from the resonator. By using commercial acoustical tile having perforations which extend only part way through the tile, the impunched material remaining at the end of each perforation

channel acts as the required diffusion layer within the channel throat. Further, if a tile is used wherein the perforation does penetrate the entire tile thickness, then this same effect can be achieved by filling the resonator volume very loosely with materials such as low density fiber glass, glass silk, etc. Further this filled resonator can also be used in conjunction with tiles not punched all the way through to achieve still broader attenuation effects relative to the sound frequency scale. The air spaces of the walls are spaced by means of furring strips **15** of varying thickness to accommodate the cells to the different frequencies, which are met with. These furring strips may be any suitable material such as metal or plastic.

The sections illustrated in Fig. 2 are held together by means of battens **14** and the sides and top of the containing structure are made in sections for quick removal which sections may be secured by hasps **16**. Fig. 3 illustrates the perforated side of acoustical tile or other board used for the inner walls and Fig. 4 is a sectional view taken on line **4—4** of Fig. 3 to illustrate tile construction.

In the case of the operation of a particular Jordan engine it was determined that the principal noise produced by that engine in processing paper pulp as shown by a spectrum of that noise was at frequencies of 260, 525 and 1,050 cycles per second. Thus it appeared that in accordance with my invention cells of 3 different sizes would be desirable in enclosing the Jordan engine to reduce the sound. The noise level resulting from the operation of the Jordan engine was markedly reduced by the construction shown and was particularly effective at the peak frequencies.

For the cells to dampen noise of 260 cycle frequency a 2½" depth was desirable. Where an acoustical tile was used having dimensions of 12" x 12" x ¾" the tile had 196 holes of 5/32" diameter and ⅝" depth. Using this material in construction leaves 168 acting holes facing the inside of the cavity. By substituting these values in the formula given the depth of the air spaces for cells to dampen 260 cycle noise was found to be 2.52".

The size of other cells was determined by inserting these values in the formula. With a 525 value for the frequency, the depth of air space in this case figured as approximately ⅝". For the frequency of 1,050 cycles cells having a dead air space of approximately 3/16" are indicated using the dimensions given for the cells which were constructed. If acoustical board or tile of different dimensions or different numbers or depths of holes or holes of different size are used the cell space would have to be figured out using those different dimensions.

By the use of hoods provided with cells having the calculated volumes of dead air space the noise and particularly the peak noises are definitely reduced to a substantial extent. Our invention may be employed in constructions in which each individual offending unit is enclosed with walls having cells of the described construction or the entire room where one or several of these machines are found may be enclosed incorporating the machines in one room having a wall construction consisting of cells of the type described to absorb the peak noises which issue therefrom.

I claim:

1. A cell adapted for use in sound inhibiting construction which comprises a sealed enclosure having on one side a sheet of acoustical material provided with perforations opening only to the dead air space of the cell and on the outer layer a sheet of solid material the air space of said cell conforming in volume to that which results from determining the same in the following formula using one of the principal frequencies of the sound to be inhibited;

$$F=\frac{C}{2\pi}\sqrt{\frac{NA}{V(L+\Delta L)}}$$

in which formula F=a sound frequency in cycles per second; C=the velocity of sound in air; N=the number of holes in the perforated material opening to the dead air space of the cell; A=the area of each perforation in square feet; V=the volume of air space of the cell in cubic feet; L=the depth of each hole in feet; $\Delta L=1.7\times$the radius of each hole in feet.

2. A noise minimizing construction to surround a noise-producing machine, the spectrum of the noise of which shows a plurality of principal noise producing frequencies, which comprises walls made up of a series of cells the length and width of which are accommodated to the dimensions of acoustical sheet material employed to form a portion of the wall construction which acoustical material is provided with perforations opening only into the cell, the inner and outer layers of the cells being so spaced as to provide volumes of air spaces in the cells corresponding to respective principal frequencies of the noise which volumes are determined in accordance with the formula:

$$F=\frac{C}{2\pi}\sqrt{\frac{NA}{V(L+\Delta L)}}$$

in which formula F=a principal frequency of the sound in cycles per second; C=the velocity of sound in air (1100 ft. per sec. at 70° F.); N=the number of holes in the perforated material which open to the dead air space of the cell; A=the area of each perforation in square feet; V=the volume of air space of the cell in cubic feet; L=the depth of each hole in feet; $\Delta L=1.7\times$ the radius of each hole in feet; the various cells being employed in approximately the percentage of the total noise identified with each principal frequency, the various cell sizes being dispersed uniformly throughout the sound enclosure.

3. A sound inhibiting construction to inhibit the noise produced by a Jordan engine, the spectrum of the noise of which shows the principal noise frequencies to be 260, 525, and 1050 cycles per second which comprises enclosing the engine with walls, of sealed cells enclosing dead air space, of three different sizes, the inner walls of the cells being of acoustical sheet material having perforations therein opening only onto the dead air space of the cell and the outer walls of the cells being of solid sheet material, the air spaces of the cells employed in such construction corresponding to that determined in accordance with the formula:

$$F=\frac{C}{2\pi}\sqrt{\frac{NA}{V(L+\Delta L)}}$$

in which formula F=a principal frequency of the sound in cycles per second; C=the velocity of sound in air (1100 ft. per sec. at 70° F.); N=the number of holes in the perforated material which open to the dead air space of the cell; A=the area of each perforation in square feet; V=the volume of air space of the cell in cubic feet; L=the depth of each hole in feet; $\Delta L=1.7\times$the radius of each hole in feet.

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