

April 10, 1934.

R. B. BOURNE
SOUND ATTENUATING DEVICE

1,954,516

Original Filed Oct. 19, 1931

Fig. 1.

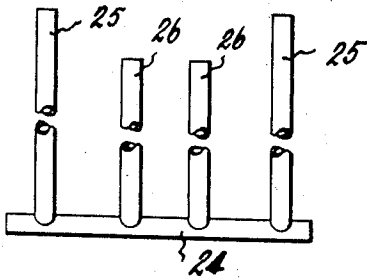


Fig. 2.

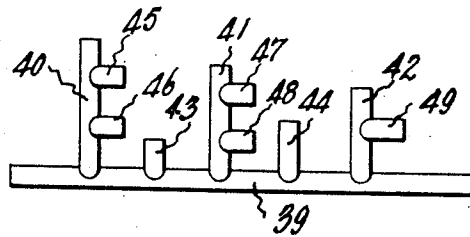


Fig. 4.

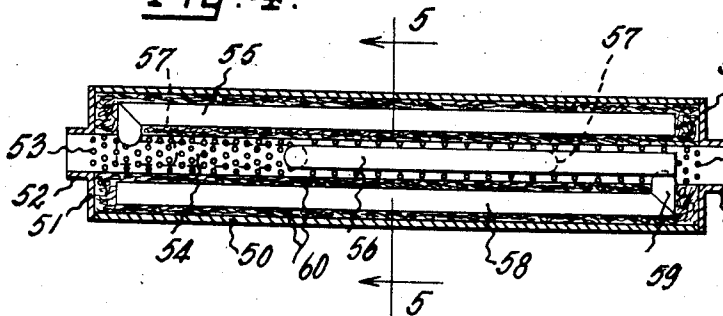


Fig. 5.

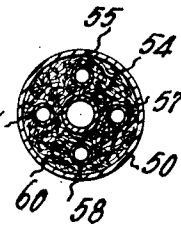
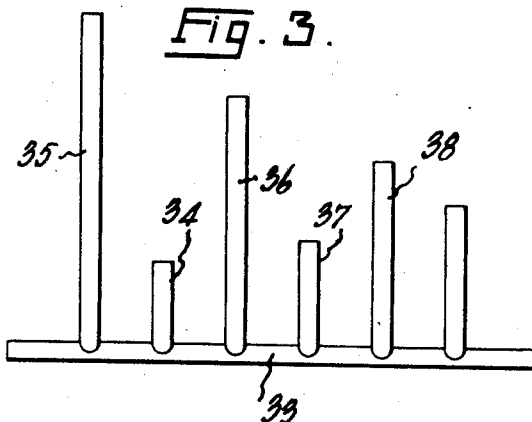


Fig. 3.



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UNITED STATES PATENT OFFICE

1,954,516

SOUND ATTENUATING DEVICE

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Original application October 19, 1931, Serial No.
569,711. Divided and this application Septem-
ber 22, 1932, Serial No. 634,326

6 Claims. (Cl. 181—0.5)

The present invention relates to devices for silencing sounds which are ordinarily present in conduits such as pipes and the like. Such sounds, particularly those incident to the exhausts of internal combustion engines, are generally extremely complex in character. That is to say, these sounds are made up of a great number of component sounds of different frequencies. In some cases the sound spectrum may extend more or less continuously from the lower to the upper limit of audibility.

One object of the invention is to provide a commercially practical device for attenuating sound waves over a wide range of frequencies. A further object is to provide a silencing device having a wide attenuation range which will impose practically no back pressure upon the system. A further object is to provide a device of this general character which will be compact in its overall dimensions. A further object is to provide a device of this general character in which the necessity for closely and accurately spaced walls is eliminated, thereby resulting in a decrease in the cost of manufacture. A further object is to provide a device of this general character which is inexpensive in its construction.

For the purpose of this specification, the sound spectrum is divided roughly into two groups: sounds of high frequency, which are most efficiently attenuated by the use of dissipative materials; and sounds of low frequency, which are most easily attenuated by the use of reactive side branches.

Acoustic friction devices for attenuating high frequencies may be placed in series with reactive devices for attenuating low frequencies. Such a combination, while very effective in sound attenuation, is generally commercially unwieldy and expensive. It has been found that satisfactory attenuation of both high and low frequencies may be accomplished by combining the separate means therefor in one device, simple of construction and cheap to build.

If enough acoustically absorbent material, suitably disposed, is used, it is possible to secure satisfactory attenuation of even very low frequency sound waves. By employing reactive side branches in combination with acoustic absorbent material, the length of the main conduit and consequently the back pressure is greatly reduced and makes possible commercial embodiments possessing the further advantages of small size, light weight and a high degree of sound attenuation.

The present application is a division of my prior

application Serial No. 569,711, filed October 19, 1931.

Referring to the drawing,

Figs. 1, 2, and 3 are diagrammatic views illustrating the acoustic principles of three species of my invention;

Fig. 4 is a central longitudinal section through a form of the invention embodying the acoustic principles illustrated in Fig. 1; and

Fig. 5 is a section on line 5—5 of Fig. 4.

The use of closed conduits or tubes as acoustic side branches on a main acoustic channel for attenuating sound waves of certain frequencies passing therethrough is old in the art. A single such side branch may be expected to offer attenuation to those frequencies for which the side branch is resonant,—that is, since a closed pipe resonates to frequencies for which it is an odd number of quarter wave lengths long, these frequencies and those immediately above and below it will suffer attenuation. The sharpness of the resonance curve depends upon the relation of the diameter of the side branch tube to that of the main conduit, as well as on the dissipation present in the resonator. The attenuation falls off on either side of the resonant frequency. Since the problem presented is one of attenuating a continuous band of frequencies, it becomes possible to accomplish this by providing a number of closed tubes of different lengths, suitably disposed along the main sound conduit, these lengths being so chosen that the attenuation bands for the various side branches will over-lap each other.

Since I am not interested in obtaining pass bands but rather a continuous attenuation band, it is not only not necessary to obtain a matching of impedances between sections of a filter but desirable to secure mismatching, since a certain amount of attenuation is thereby possible. This attenuation is due to reflection losses. In practice the length of the longest side branch is determined by the lowest frequency it is desired to attenuate. In some cases, where the frequencies to be attenuated are very low, the length of the side branch is necessarily excessive. It has been found that no appreciable diminution of attenuation is suffered by bending the tubular member back upon itself. This feature permits of a more compact arrangement of tubes.

In Fig. 1 the main channel 24 has disposed along its length the side branches 25 and 26. The side branches 25 are equal in length and are at opposite ends of the channel. Between these are disposed the side branches 26, also equal in length but shorter than the side branches 25. In

Fig. 3, we have the main channel 33 with a plurality of unequal closed tubular side branches disposed along its length but in such a manner that the shorter side branches act not only as efficient attenuators for those frequencies for which they are resonant, but also act as acoustic loading on the main channel for frequencies much lower than those for which they are resonant. For instance, the side branch 34, placed between the side branches 35 and 36, acts to load the main channel 33 and thus simulates a greater length between the junction points of said side branches 35 and 36. This loading, in reality, effects a rotation of phase. Similarly side branch 37 loads the main channel 33 between the side branches 36 and 38.

The principle of phase rotation by loading may be also applied to side branches. In Fig. 2, the main channel 39 is furnished with tubular side branches 40, 41 and 42, and also with intermediate short branches 43 and 44 which act to load the main channel 39. Side branch 40, itself, is acoustically lengthened by the presence of the sub-side branch tubes 45 and 46. Similarly, side branch 41 is acoustically lengthened by the loading action of 47 and 48. Side branch 42 has been shown as provided with but one sub-side branch 49. This feature makes possible the compact assembly of various side branch tubes for commercial embodiments of the invention. This acoustic loading may be also accomplished by the use of suitable volumetric side branches.

The upper limit of attenuation attainable is represented by the shortest practicable side branch. To obtain attenuation for higher frequencies, use is made of the sound absorptive properties of certain materials. The use of soft porous materials for absorbing sound is well known. Ducts and channels lined with felt, for instance, will absorb sound waves of medium to high frequencies passing therethrough. The amount of attenuation obtainable depends upon the amount of material used, its disposition, its quality, and the frequency of the sound to be attenuated. Most such materials attenuate most efficiently at frequencies of the order of 1500 cycles per second. Since attenuation by absorption is not particularly selective, this offers a means for preventing transmission through conduits of a very wide band of frequencies which lie above the point of feasible attenuation by reactive devices.

In order to utilize both types of attenuation in one device, several expedients may be employed. Fig. 4 shows one embodiment of such a device, comprising a shell 50 fitted with headers 51 and necks 52. Extending between the two necks 52 and supported thereby is a perforated metal conduit 53 which forms the main channel 54. Disposed along the length of said conduit 53, in this case with their respective coupling points at equal distances apart, are the four side branches 55, 56, 57 and 58. These side branches correspond acoustically to those shown in Fig. 1. They are disposed with their axes parallel to that of the main channel 54 and are connected thereto by means of necks 59. It will be seen that this disposition of the side branch tubes leaves considerable space between the shell 50 and the central tube 53. This space is filled with sound absorbing heat resisting material 60 which provides for the attenuation of the high frequencies. It will be noted that the four side branches are disposed angularly around the main tube 53, thus providing a compact assembly. In

order that the sound waves may have ample opportunity to penetrate all the sound absorbent material, the side branch tubes 55, 56, 57 and 58 are so disposed that the sum of the shortest peripheral distances between adjacent tubes is at least equal to the perimeter of the main conducting tube 53. This feature applies to all devices of this character. It is found in practice that the low frequency attenuation may be affected to a slight degree by using a perforated main conduit rather than a solid one. Careful designing, with respect to the kind of sound absorbing material used and number and size of perforations in the main conducting channel, however, makes it possible to obtain, in combination with the reactive side branches, satisfactory attenuation over as wide a frequency band as is desired. The presence of the sound absorbing material 60 which is packed around and between the various tubular members effectively prevents "shell noise" and also prevents metallic ringing of the interior parts of the silencer. It also confines most of the heat of exhaust gases to the interior of the silencer, an important feature in connection with interior installations.

It is obvious that many combinations using non-dissipative and dissipative side branches may be conceived and reduced to practical working embodiments. Without enumerating a large number of such arrangements, it is clear that the scope of the invention embraces many combinations not shown in detail, and I therefore do not limit myself to those exact embodiments depicted but claim additional and obvious embodiments suggestible to those skilled in the art.

What I claim is:

1. A silencer comprising a main conducting channel and a plurality of closed tubular side branches of unequal length acoustically coupled thereto at intervals along the length thereof, one or more relatively short side branch tubes being interposed between adjacent relatively long side branch tubes whereby the acoustic length of the main conducting channel between said relatively long side branch tubes is increased over its physical length, through an additional change of phase therein.

2. An acoustic wave filter having a main conducting channel, acoustic side branches disposed along the main channel, and a plurality of non-dissipative side branches of high fundamental natural period compared to the first-named side branches and interposed along the main channel between the first-named side branches, the second-named side branches serving to increase the acoustic length of the main channel as compared to its physical length.

3. In an acoustic wave filter, a main sound conducting channel, a plurality of tubular side branches, acoustically coupled thereto at intervals along the length thereof, and means associated with said tubular side branches for effecting an increase in their acoustic length, said means comprising one or more relatively short tubular sub-side branches acoustically coupled to said tubular side branches along the respective lengths thereof.

4. In an acoustic wave filter, having a main conducting channel and acoustic side branches coupled thereto at intervals along the length thereof, means for increasing the acoustic length of said main conducting channel between adjacent acoustic side branches, comprising one or more acoustic side branches coupled to said main conducting channel at points intermediate the

- first named side branches, whereby an additional change in phase is made to take place in said main conducting channel between said adjacent first mentioned side branches.
- 5 5. In a low-pass acoustic wave filter, means for lowering the first cut-off frequency comprising means for effecting additional progressive change of phase in the main conducting channel between sections thereof, comprising phase-shifting side branches coupled to said main conducting channel.
6. A silencer comprising a main conducting channel, a plurality of closed tubular side branches, wherein progressive wave motion takes place, acoustically coupled thereto at intervals along the length thereof, and one or more closed tubular sub-side branches, wherein progressive wave motion takes place, acoustically coupled to certain of said side branches at intervals along the lengths thereof.
- ROLAND B. BOURNE.
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| 15 | 90 |
| 20 | 95 |
| 25 | 100 |
| 30 | 105 |
| 35 | 110 |
| 40 | 115 |
| 45 | 120 |
| 50 | 125 |
| 55 | 130 |
| 60 | 135 |
| 65 | 140 |
| 70 | 145 |
| 75 | 150 |