Sept. 17, 1940. E. E. WILSON 2,214,894

RESONATOR SILENCER

Filed Dec. 12, 1936 2 Sheets-Sheet 1

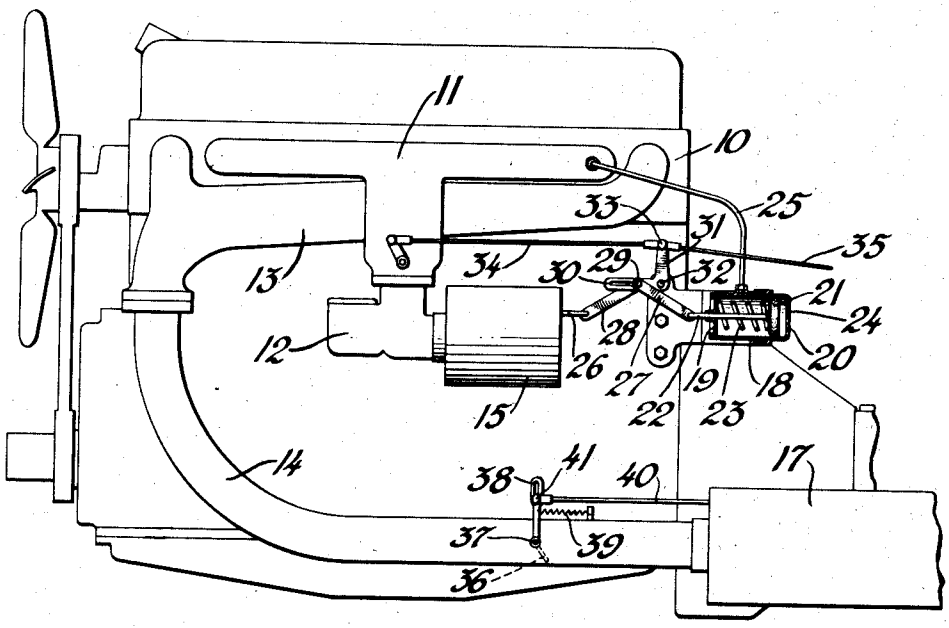

Fig. 1

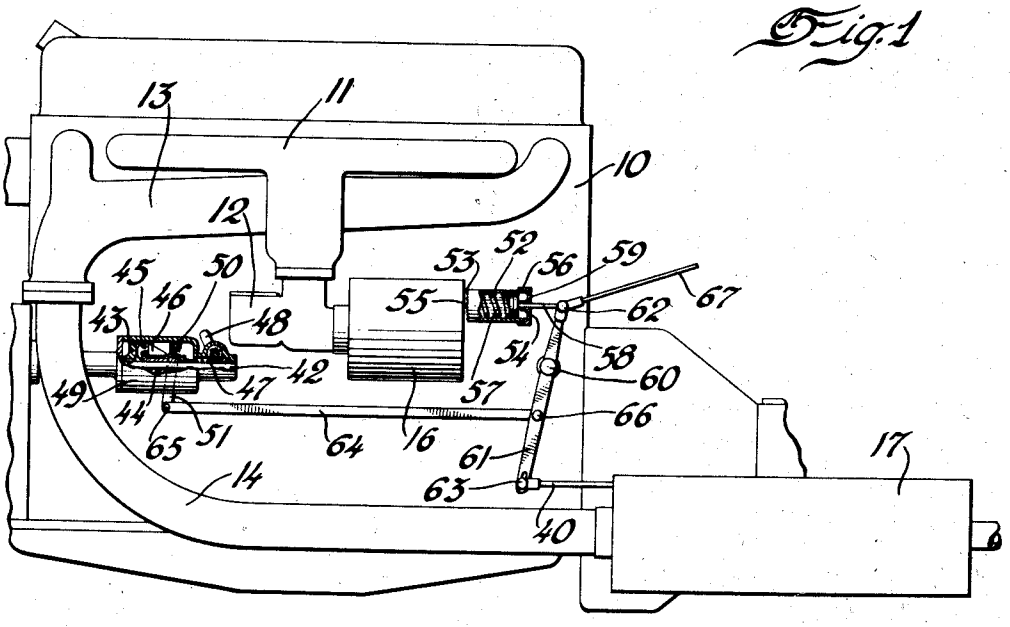

Fig. 2

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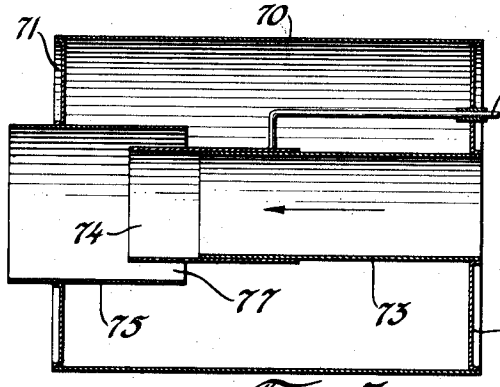

Fig. 3

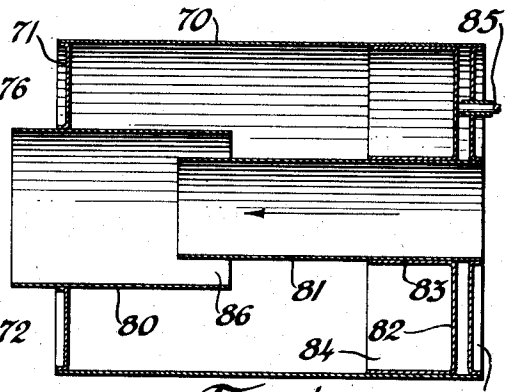

Fig. 4

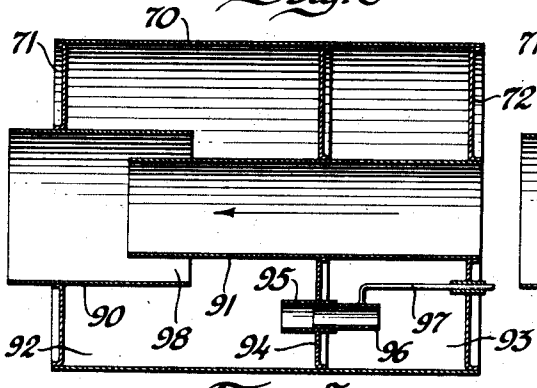

Fig. 5

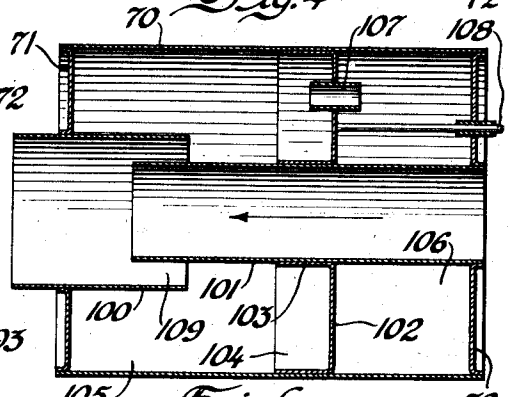

Fig. 6

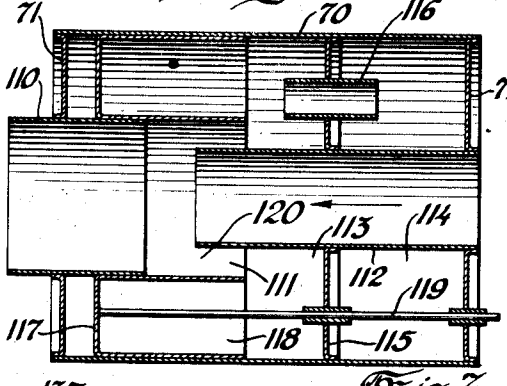

Fig. 7

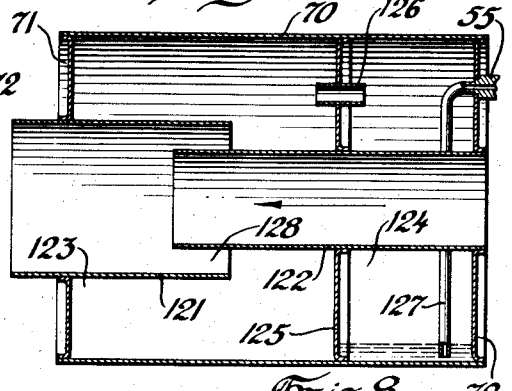

Fig. 8

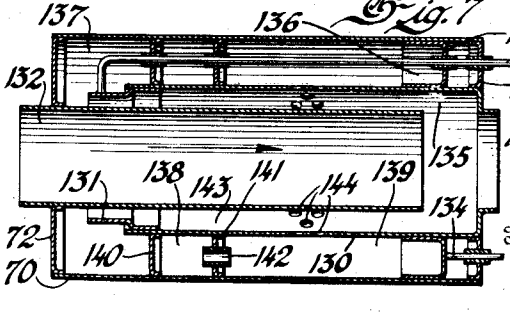

Fig. 9

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UNITED STATES PATENT OFFICE

2,214,894

RESONATOR SILENCER

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Application December 12, 1936, Serial No. 115,470

8 Claims. (Cl. 123—198)

To attenuate the objectionable sound waves which occur in the intake and exhaust systems of internal combustion engines, resonator silencers, such as those disclosed in my prior applications Serial Nos. 470,700 and 633,265 which were filed on July 25, 1930 and September 15, 1932, respectively, are now commonly used. However, because the natural frequencies of the resonators incorporated in these silencers are fixed and objectionable sound waves of different frequencies may occur in the intake or exhaust system of an internal combustion engine when it is operating at different speeds but not simultaneously, it is frequently necessary, in order to attenuate all of the objectionable sound waves which occur in the intake or exhaust system of an internal combustion engine, to provide in it one or more resonators which are operative only when the engine is operating at some speed or speeds and another or other resonators which are operative only when the engine is operating at another speed or other speeds.

The principal object of this invention is to provide an internal combustion engine with a resonator silencer in which it is not necessary, in order to attenuate all of the objectionable sound waves which occur in the intake or exhaust system of the engine to which the silencer is applied, to provide in the silencer any resonators which are not operative simultaneously and thus to minimize the number of resonators in the silencer.

To attain this object, I provide a silencer with a resonator whose natural frequency may be varied and means for varying the natural frequency of the resonator in accordance with variations in the frequency of objectionable sound waves which occur in the intake or exhaust system of the engine to which the silencer is applied. To render the natural frequency of the resonator variable, the acoustical conductivity of its neck or necks or any of them and/or the volume of its chamber or chambers or any of them may be made adjustable. To adjust the acoustical conductivity of the neck or necks and/or the volume of the chamber or chambers a manually adjusted instrumentality and/or any instrumentality whose movement affects or is affected by variations in the speed of the engine may be employed.

For a better understanding of the objects and nature of this invention, reference is made to the following specification in which there are described the embodiments of my invention which are illustrated in the accompanying drawings.

In the accompanying drawings:

Figures 1 and 2 show internal combustion engines equipped with resonator intake and exhaust silencers in accordance with this invention.

Figures 3 to 9 are longitudinal sections through resonator silencers in accordance with this invention.

The internal combustion engines 10 which are shown in Figures 1 and 2 are equipped with intake manifolds 11 to which there are connected carburetors 12 and exhaust manifolds 13 to which there are connected exhaust pipes 14. To the air intake tube of the carburetor of the engine shown in Figure 1, there is connected a resonator silencer 15 of the type shown in Figures 3 to 7 and 9. To the air intake tube of the carburetor of the engine shown in Figure 2, there is connected a resonator silencer 16 of the type shown in Figure 8. To the exhaust pipe of each of the engines shown in Figures 1 and 2, there is connected a resonator silencer 17 which includes a unit of the type shown in Figures 3 to 7 and 9.

Each of the silencers shown in Figures 3 to 9 includes a cylindrical shell 70 with heads 71 and 72 secured over its ends and a duct through which gases may pass through the silencer. The duct is coaxial with the shell 70 and consists of two tubes of which one extends into and is sufficiently smaller than the other that the overlapping portions of the tubes are separated by an annular aperture. One of the tubes is secured in each of the heads 71 and 72. The shell 70, its heads 71 and 72 and the tubes define a compartment which communicates with the duct defined by the tubes through the aperture between the overlapping portions of the tubes.

The smaller of the tubes which define the duct of the silencer shown in Figure 3 consists of two partly telescoped tubular elements 73 and 74, of which the former is secured in the head 72 and terminates short of the larger tube 75. The tubular element 74 extends beyond the inner end of the tubular element 73 into the inner end of the tube 75 and may be shifted back and forth lengthwise of the silencer to vary the overlap between the tubes 73—74 and 75. To shift the tubular element 74, there is provided a rod 76 which extends through a guide in the head 72 and whose inner end is secured to the tubular element.

The compartment defined by the shell 70, its heads 71 and 72 and the tubes 73—74 and 75 con-

stitutes the chamber and the annular aperture 77 between the tubes 73—74 and 75 the neck of a simple resonator. The volume of the chamber is, of course, fixed, but the acoustical conductivity of the neck and, thus, the natural frequency of the resonator, may be varied by shifting the tubular element 74.

Within the compartment defined by the shell 70, its heads 71 and 72 and the tubes 80 and 81 which define the duct of the silencer shown in Figure 4, there is disposed a false head 82 which encircles the tube 81 and may be shifted lengthwise of the silencer. On the inner and outer edges of the false head 82, there are formed annular flanges 83 and 84 which fit snugly around the tube 81 and within the shell 70, respectively. To shift the false head 82, there is provided a rod 85 which extends through a guide in the head 72 and whose inner end is secured to the false head.

The compartment defined by the shell 70, its head 71, the false head 82 and the tubes 80 and 81 constitutes the chamber and the annular aperture 86 between the tubes 80 and 81 the neck of a simple resonator. The acoustical conductivity of the neck is, of course, fixed but the volume of the chamber and, thus, the natural frequency of the resonator, may be varied by shifting the false head 82.

The compartment defined by the shell 70, its heads 71 and 72 and the tubes 90 and 91 which define the duct of the silencer shown in Figure 5 is divided lengthwise into two chambers 92 and 93 by an annular partition 94 which encircles the tube 91 and is secured to it and the shell. Through the partition 94, there extends a tube which consists of two partly telescoped tubular elements 95 and 96 and interconnects the chambers 92 and 93. The tubular element 95 is secured in the partition 94 and the tubular element 96 may be shifted lengthwise of the tubular element 95 to vary the effective length of the tube 95—96. To shift the tubular element 96, there is provided a rod 97 which extends through a guide in the head 72 and whose inner end is secured to the tubular element 96.

The chambers 92 and 93 constitute the chambers and the tube 95—96 and the annular aperture 98 between the tubes 90 and 91 the necks of a compound resonator. The volumes of the chambers and the acoustical conductivity of the neck 98 are, of course, fixed but the acoustical conductivity of the neck 95—96 and, thus, the natural frequencies of the resonator, may be varied by shifting the tubular element 96.

Within the compartment defined by the shell 70, its heads 71 and 72 and the tubes 100 and 101 which define the duct of the silencer shown in Figure 6, there is disposed a partition 102 which encircles the tube 101 and may be shifted lengthwise of the silencer. On the inner and outer edges of the partition 102, there are formed annular flanges 103 and 104 which fit snugly around the tube 101 and within the shell 70, respectively. The partition 102 divides the compartment defined by the shell 70, its heads and the tubes 100 and 101 into two chambers 105 and 106 which are interconnected by a tube 107 which extends through the partition. To shift the partition 102, there is provided a rod 108 which extends through a guide in the head 72 and whose inner end is secured to the partition.

The chambers 105 and 106 constitute the chambers and the tube 107 and the annular aperture 109 between the tubes 100 and 101 the neck of a compound resonator. The acoustical conductivities of the necks are, of course, fixed but the volumes of the chambers and, thus, the natural frequencies of the resonator, may be varied by shifting the partition 102.

The larger of the tubes which define the duct of the silencer shown in Figure 7 consists of two partly telescoped tubular elements 110 and 111, of which the former is secured in the head 71 and terminates short of the smaller of the tubes 112. The tubular element 111 extends beyond the inner end of the tubular element 110 around the inner end of the tube 112 and may be shifted back and forth lengthwise of the silencer to vary the overlap between the tubes 110—111 and 112. The compartment defined by the shell 70, its heads 71 and 72 and the tubes 110—111 and 112 is divided lengthwise into two chambers 113 and 114 by an annular partition 115 which encircles the tube 112 and is secured to it and the shell. In the partition 115, there is secured a tube 116 which interconnects the chambers 113 and 114. Within the chamber 113, there is disposed a false head 117 which encircles the tubular element 110 and whose inner edge is joined to the outer end of the tubular element 111 and may be shifted with it lengthwise of the silencer. On the outer edge of the false head 117, there is formed an annular flange 118 which fits snugly within the shell 70. To shift the tubular element 111 and the false head 117, there is provided a rod 119 which extends through guides in the head 72 and the partition 115 and whose inner end is secured to the false head.

The chambers 113 and 114 constitute the chambers and the tube 116 and the annular aperture 120 between the tubes 110—111 and 112 the necks of a compound resonator. The volume of the chamber 114 and the acoustical conductivity of the neck 116 are, of course, fixed but the volume of the chamber 113 and the acoustical conductivity of the neck 120 and, thus, the natural frequencies of the resonator, may be varied by shifting the member 111—117—118.

The compartment defined by the shell 70, its heads 71 and 72 and the tubes 121 and 122 which define the duct of the silencer shown in Figure 8 is divided lengthwise into two chambers 123 and 124 by an annular partition 125 which encircles the smaller of the tubes and is secured to it and the shell. In the partition 125, there is secured a tube 126 which interconnects the chambers 123 and 124. Through the head 72, there extends into the chamber 124 a tube 127 which terminates near the lower side of the shell 70 and through which a liquid may be introduced into or withdrawn from the chamber 124.

The chambers 123 and 124 constitute the chambers and the tube 126 and the annular aperture 128 between the tubes 121 and 122 the necks of a compound resonator. The acoustical conductivities of the necks and the volume of the chamber 123 are, of course, fixed but the effective volume of the chamber 124 and, thus, the natural frequencies of the resonator, may be varied by introducing liquid into or withdrawing liquid from the chamber 124 through the tube 127.

The larger of the tubes which define the duct of the silencer shown in Figure 9 consists of two partly telescoped tubular elements 130 and 131 of which the former is secured in the head 71 and extends well beyond the inner end of and encircles the smaller of the tubes 132. Within the compartment defined by the shell 70, its heads 71 and 72 and the tubes 130—131 and 132, there

is disposed a false head 133 which encircles the tubular element 130 and may be shifted lengthwise of the silencer. To shift the false head 133, there is provided a rod 134 which extends through the head 71 and whose inner end is secured to the false head. On the inner and outer edges of the false head, there are formed annular flanges 135 and 136 which fit snugly around the tubular element 130 and within the shell 70, respectively. The compartment defined by the shell 70, its head 72, the false head 133 and the tubes 130—131 and 132 is divided lengthwise into three chambers 137, 138 and 139 by annular partitions 140 and 141 which encircle the tubular element 130 and are secured to it and the shell. The partition 140 is imperforate but there is secured in the partition 141 a tube 142 which connects the chamber 138 with the chamber 139 which communicates with the annular aperture 143 between the tubes 130—131 and 132 through orifices 144 in the tubular element 130 which may be partially or wholly covered by the flange 135 on the false head 133. The tubular element 131 of the tube 130—131, whose outer end is of smaller diameter than its inner end but of considerably larger diameter than the tube 132, extends beyond the tubular element 130 and may be shifted lengthwise of the silencer to vary the overlap between the tubes 130—131 and 132. To shift the tubular element 131, there is provided a rod 145 which extends through guides in the head 71, the false head 133 and the partitions 140 and 141 and whose inner end is secured to the tubular element 131.

The chambers 138, 139 and 137 constitute the chambers and the tube 142, the orifices 144 and the annular aperture 143 the necks of a complex resonator. The volumes of the chambers 138 and 137 and the acoustical conductivity of the neck 142 are, of course, fixed but the volume of the chamber 139 and/or the acoustical conductivities of the necks 144 and 143 and, thus, one or more of the natural frequencies of the resonator, may be varied by shifting the false head 133 and/or the tubular element 131.

The silencers shown in Figures 3 to 9 were designed for installation on an internal combustion engine in the manner in which the silencers 15 and 16 are installed on the engines shown in Figures 1 and 2, i. e., with the outer ends of the larger of the tubes (75, 80, 90, 100, 110—111, 121 and 130—131) which define their ducts connected to the air intake tube of the carburetor so that the air which enters the carburetor and cylinders of the engine flows through their ducts in the direction indicated by the arrows in the drawing. But any of the units shown in Figures 3 to 9 may be incorporated in a silencer installed on an engine in the manner in which the silencers 17 are installed on the engines shown in Figures 1 and 2 with its duct disposed so that the exhaust gases of the engine pass through it in the same direction as air passes through it when it is employed as an intake silencer.

In whichever manner the units shown in Figures 3 to 9 are to be installed the resonators will, of course, be so proportioned and dimensioned that when their adjustable elements are in one position they will respond to and attenuate by resonance objectionable sound waves of one or more frequencies which occur in the intake or exhaust system of the engine on which the units are to be installed while the engine is operating at some speed or speeds and when their adjustable elements are in another position or other positions they will respond to and attenuate by resonance objectionable sound waves of another frequency or other frequencies which occur in the intake or exhaust system of the engine while it is operating at another speed or other speeds.

To vary the natural frequencies of the units shown in Figures 3 to 7 and 9 the rods (76, 85, 97, 108, 119, 134 and 145) may be actuated manually and/or automatically to shift the adjustable elements of the units in accordance with the requirements. Automatic actuation of the rods may be effected by suitably connecting them to any element whose movement affects the speed of the engine, such as the throttle valve of the carburetor of the engine, to any element whose position is affected by changes in speed of the engine, such as an element whose position is affected by an engine actuated governor, by a solenoid which is energized by an engine operated generator or by changes in the pressure or rate of flow of fluid in any part of the intake system, the exhaust system, the lubricating system or the cooling system of the engine or to any two or more such elements. The rods 134 and 145 of the unit shown in Figure 9 may be actuated synchronously or non-synchronously by the same or different instrumentalities. The liquid employed to vary the effective volume of the chamber 124 of the unit shown in Figure 8 may be obtained from the cooling system or the lubricating system of the engine on which the unit is installed or from a supply provided especially for the purpose. Any suitable means actuated manually and/or automatically by elements such as those referred to above may be provided to introduce and withdraw and control the introduction and withdrawal of the liquid from the chamber 124 in accordance with the requirements.

Examples of the instrumentalities that may be employed to vary the natural frequencies of the units shown in Figures 3 to 9 are shown in Figures 1 and 2.

On the engine shown in Figure 1, there is mounted to the rear of the intake silencer 15 a horizontally disposed cylinder 18 whose ends are closed by heads 19 and 20. Within the cylinder 18, there is snugly fitted a piston 21 to which there is secured a rod 22 which extends through a stuffing box in the head 19. The portion of the piston rod 22 which is within the cylinder is encircled by a coiled spring 23 which urges the piston toward the head 20 in which there is a vent 24. The portion of the cylinder between the head 19 and the piston 21 is connected to the intake manifold 11 of the engine 10 by a tube 25.

The piston rod 22 is connected to the rod 26 by which the adjustable element of the silencer 15 is shifted by links 27 and 28 which are interconnected by a pivot 29 which is mounted so that it may slide in a slot 30 in the generally horizontally disposed arm of a bell crank 31 which is mounted on a pivot 32 which is mounted on the engine 10. The other arm of the bell crank 31 which is generally vertically disposed is connected to the linkage by which the throttle valve of the carburetor 12 is moved to change the speed of the engine by a pivot 33 which connects two elements (34 and 35) of the linkage.

To vary the natural frequency of the adjustable unit of the exhaust silencer of the engine which is shown in Figure 1 there is provided within the exhaust pipe 14 a vane 36 which is mounted on a shaft 37. To the shaft 37, there is secured an arm 38 which is biased to a position in which the vane 36 is disposed crosswise of the exhaust

pipe by a spring 39 and connected to the rod 40 by which the adjustable element of the adjustable unit of the exhaust silencer is shifted by a pivot 41.

On the engine shown in Figure 2, there is mounted a centrifugal governor in which there is included a shaft 42 which is driven by the engine at a speed proportional to the speed of the engine. The shaft 42 is encircled by a collar 43 which cannot rotate or slide with respect to the shaft and a collar 44 which can slide lengthwise of the shaft. To the collar 43, there are connected by pivots 45 which extend at right angles to the shaft 42 elements 46 with weighted arms which extend generally parallel to the shaft and hook-like arms which extend inwardly and engage the inner end of the collar 44. To hold the collar 44 in engagement with the hook-like arms of the elements 46, there is provided a spring 47 which encircles the shaft and may be adjusted by means of an arm 48. With the exception of the arm 48, the elements of the governor which have been referred to are enclosed within a housing 49 which carries a pivot 50 on which there is mounted an arm 51 which is connected to the collar 44 so that it is rocked on the pivot 50 when the collar 44 is shifted lengthwise of the shaft 42.

On the outer end of the intake silencer 16 of the engine which is shown in Figure 2, there is mounted a cylinder 52 whose ends are closed by heads 53 and 54. On the head 53, there is formed a nipple 55 through which the cylinder is connected to the tube 127. In the cylinder 52, there is snugly fitted a piston 56 which is urged toward the head 54 by a coiled spring 57. To the piston 56 there is secured a rod 58 which extends through a guide in the head 54 in which there is a vent 59. Sufficient oil or other suitable liquid to fill the cylinder 52, the tube 127 and the chamber 124 to above the level of the lower end of the tube 127 is introduced thereinto before the silencer is put into operation.

On a pivot 60 which is carried by the engine shown in Figure 2 there is mounted a lever 61 whose ends are connected, respectfully, by pivots 62 and 63 to the piston rod 58 and the rod 40 by which the adjustable element of the adjustable unit of the exhaust silencer 17 is shifted. To the lever 61, the arm 51 of the governor is connected by a link 64 and pivots 65 and 66. To the lever 61, there is also connected by the pivot 62 a manually actuated link 67.

When the engine shown in Figure 1 is operating, the position of the piston 21 will vary in accordance with variations in the pressure within the intake manifold 11, the position of the bell crank 31 will vary in accordance with variations in the position of the throttle valve of the carburetor 12 and the position of the vane 36 will vary in accordance with variations in the rate of discharge of exhaust gases from the engine. Variations in the position of the piston 21 and the bell crank 31 will, of course, shift the adjustable element of the intake silencer 15 and vary its natural frequency or frequencies in accordance with the requirements. Variations in position of the vane 36 will, of course, shift the adjustable element of the adjustable unit of the exhaust silencer 17 and vary its natural frequency or frequencies in accordance with the requirements.

When the engine shown in Figure 2 is operating, centrifugal force causes the weighted arms of the elements 46 to move outwardly and to move the collar 44 toward the rear of the engine against the resistance of the spring 47. Variations in the position of the collar 44 will through the arm 51, the link 64, the lever 61 and the rods 58 and 40 shift the piston 56 and withdraw or introduce liquid into the chamber 124 of the intake silencer 16 and vary the position of the adjustable element of the adjustable unit of the exhaust silencer 17 and thus vary the natural frequencies of the intake silencer and the adjustable unit of the exhaust silencer in accordance with the requirements. However, at any time he desires, the operator of the vehicle in which the engine 10 is installed may manually regulate the natural frequencies of the intake silencer and the adjustable unit of the exhaust silencer by shifting the rod 67.

It will, of course, be understood that although I have described and illustrated my invention applied to the intake and exhaust systems of internal combustion engines, it is also applicable to other devices in which objectionable sound waves of different frequencies occur under different conditions.

I claim:

1. The combination, with a duct through which sound waves with different characteristics travel at different times, of means for attenuating sound waves which travel through the duct including a silencer and means for automatically varying attenuating characteristics of the silencer in accordance with variations in the characteristics of the sound waves which travel through the duct.

2. In an internal combustion engine, a duct which communicates with a cylinder of the engine and through which gases and objectionable sound waves of different frequencies travel while the engine is operating at different speeds, a resonator which is arranged as a branch of the duct and includes a chamber and an orifice through which the chamber communicates with the duct, and means by which the natural frequency of the resonator may be varied in accordance with variations in frequency of objectionable sound waves which travel through the duct including an element which occupies different positions at different speeds of the engine.

3. In an internal combustion engine, a duct which communicates with a cylinder of the engine and through which gases and objectionable sound waves of different frequencies travel while the engine is operating at different speeds, a resonator which is arranged as a branch of the duct and consists of a chamber and an orifice through which the chamber communicates with the duct, and means by which the natural frequency of the resonator may be varied in accordance with variations in frequency of objectionable sound waves which travel through the duct including an element whose position is affected by changes in the speed of the engine.

4. In an internal combustion engine, a duct which communicates with a cylinder of the engine and through which gases and objectionable sound waves of different frequencies travel while the engine is operating under different conditions, a resonator which is arranged as a branch of the duct and includes a chamber and an orifice through which the chamber communicates with the duct, and means for automatically varying the natural frequency of the resonator in accordance with changes in the engine operating conditions so that the resonator will attenuate by resonance sound waves of different frequencies under different engine operating conditions.

5. In a silencer, a shell, and a duct which extends through the shell and with it defines a compartment which encircles the duct, the duct including two tubes of which one extends into and is radially spaced from the other to define with it an aperture through which the compartment communicates with the duct, one of the tubes being adjustable lengthwise of the duct to vary the overlap between the tubes and thus the acoustical conductivity of the aperture through which the compartment communicates with the duct.

6. In a silencer, a shell, and a duct which extends through the shell and with it defines a compartment which encircles the duct, the duct including two tubes and an extension which is telescopically related to one of the tubes and encircles and is radially spaced from a portion of the other of the tubes to define with it an aperture through which the compartment communicates with the duct, the extension being adjustable lengthwise of the duct to vary the overlap between it and the tube of which it encircles a portion and thus the acoustical conductivity of the aperture through which the compartment communicates with the duct.

7. In a silencer, a shell, and a duct which extends through the shell and with it defines a compartment which encircles the duct, the duct including two tubes and an extension which is telescopically related to one of the tubes and is encircled by and radially spaced from a portion of the other of the tubes to define with it an aperture through which the compartment communicates with the duct, the extension being adjustable lengthwise of the duct to vary the overlap between it and the tube which encircles a portion of it and thus the acoustical conductivity of the aperture through which the compartment communicates with the duct.

8. In a silencer, a shell, a duct which extends through the shell and with it defines a compartment which encircles the duct, the duct including two tubes of which one extends into and is radially spaced from the other to define with it an aperture through which the compartment communicates with the duct, one of the tubes being adjustable lengthwise of the duct to vary the overlap between the tubes and thus the acoustical conductivity of the aperture through which the compartment communicates with the duct, and a partition which is carried by the tube which is adjustable lengthwise of the duct and extends from it to the shell so that it is moved lengthwise of the duct when the tube is adjusted.

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