July 3, 1956 A. G. BODINE, JR 2,752,908

PISTON CARRIED DETONATION SUPPRESSION MEANS FOR INTERNAL COMBUSTION ENGINES

Original Filed July 2, 1954 2 Sheets-Sheet 1

FIG. 1

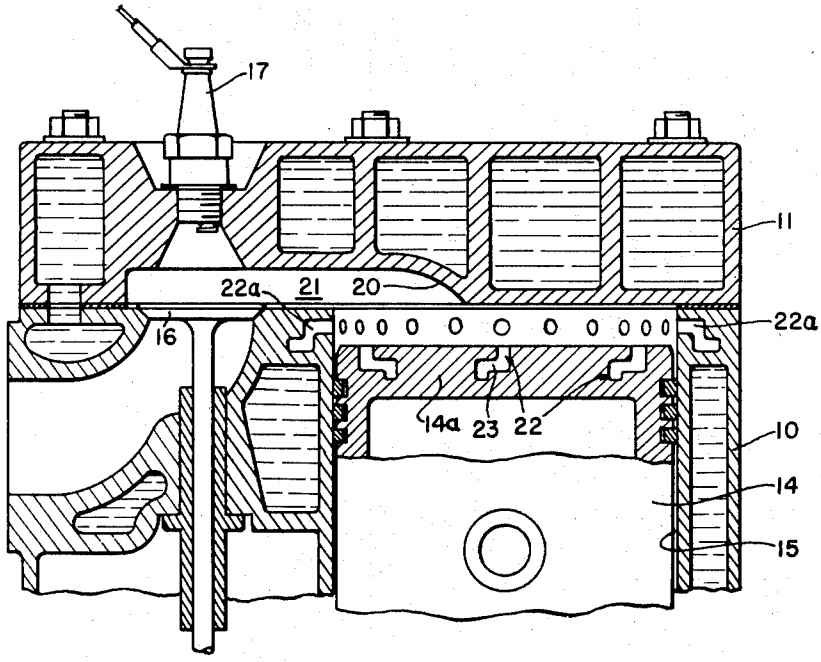


FIG. 3

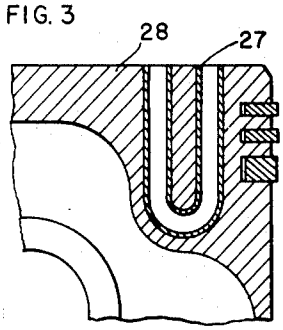
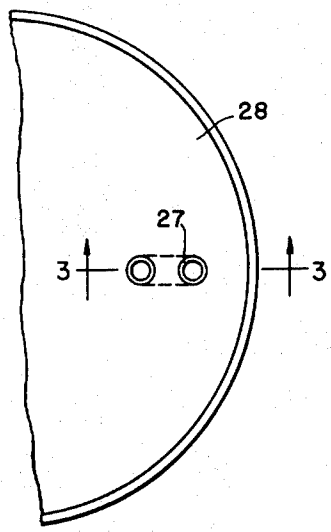


FIG. 2



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FIG. 5

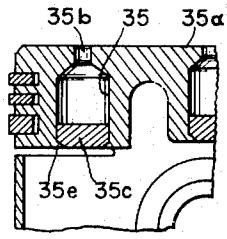


FIG. 4

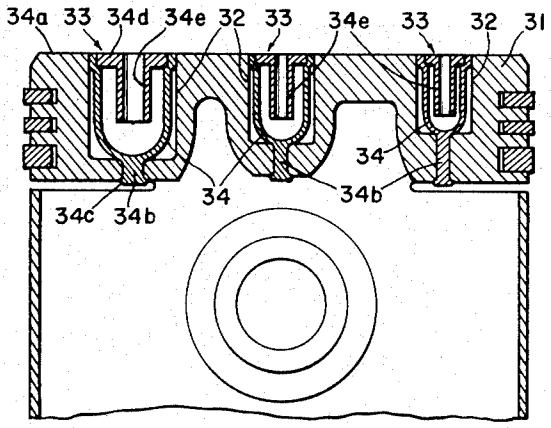


FIG. 6

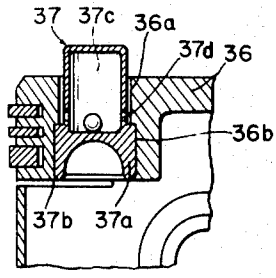


FIG. 8

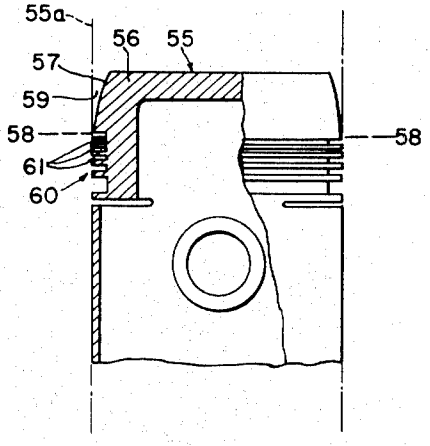
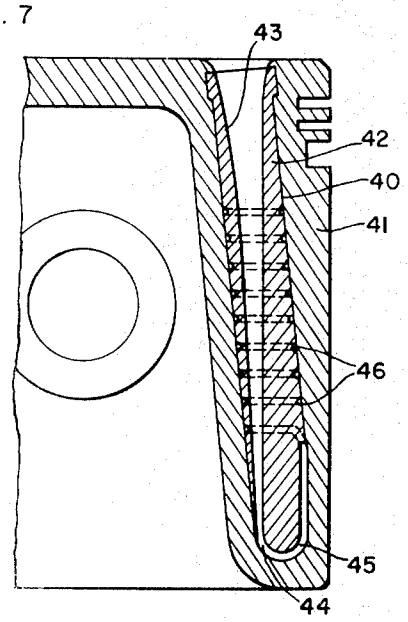


FIG. 7



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United States Patent Office

2,752,908

Patented July 3, 1956

2,752,908

PISTON CARRIED DETONATION SUPPRESSION MEANS FOR INTERNAL COMBUSTION ENGINES

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Application October 24, 1951, Serial No. 252,818, which is a division of application Serial No. 234,688, July 2, 1951, now Patent No. 2,573,536, dated October 30, 1951. Divided and this application December 6, 1955, Serial No. 551,263

3 Claims. (Cl. 123—191)

This invention relates generally to internal combustion engines and to means for suppressing irregular burning and detonation of fuel-air mixture therein. The invention is based on my discovery that detonation in combustion engines involves acoustic phenomena and can be alleviated by means of certain acoustic apparatus used in combination with the combustion chamber.

The present application is a division of my copending application Ser. No. 252,818, filed October 24, 1951, entitled Engine Detonation Control by Acoustic Methods and Apparatus which was a division of my earlier application Ser. No. 234,688, filed July 2, 1951, entitled Engine Detonation Control by Acoustic Methods and Apparatus (now Patent No. 2,573,536), which last mentioned case was in turn a continuation-in-part of my prior application Ser. No. 760,914, filed July 14, 1947, entitled Method and Means for Suppressing Detonation in Internal Combustion Engines, now abandoned. Reference is also made to the following applications filed as divisions hereof: Detonation Spoilers for Internal Combustion Engines, Ser. No. 578,472, filed April 16, 1956; Horn Type Detonation Attenuation Means for Internal Combustion Engines, Ser. No. 578,473, filed April 16, 1956; Self-Cleaning Detonation Attenuation Means for Internal Combustion Engines, Ser. No. 578,474, filed April 16, 1956; Helmholtz Resonator Detonation Attenuation Means for Internal Combustion Engines, Ser. No. 578,475, filed April 16, 1956; and Detonation Suppression Helmholtz Resonators for Internal Combustion Engines, Ser. No. 578,476.

The present invention is based on the fact that detonation in an engine combustion chamber produces sound waves, a large part of which rise to high amplitude at resonant frequencies of the chamber, and on my discovery that the sound waves produce the various well-known and harmful manifestations of detonation. According to my basic invention, I inhibit or attenuate these harmful effects by interfering with or attenuating the high amplitude detonation-induced sound waves, and this is done by use in connection with the combustion chamber of acoustic attenuation means made responsive to the frequencies at which the detonation induced sound waves build up to high amplitudes.

The acoustic detonation attenuation means of the present invention is capable of being used in either the combustion chamber head wall or in the head wall of the piston, but comprises configurations particularly well-adapted for incorporation in the head wall of the piston. Various disclosed embodiments of the invention hence have in common the advantage of susceptibility to piston mounting, and hence the common advantage that they may be incorporated in conventional engines without modification of the combustion chamber head wall, and require only substitution of pistons provided with the special acoustic attenuator configurations of the invention.

A general object of the invention is the provision of

simple and effective acoustic attenuator means for the combustion chambers of internal combustion engines, particularly, if not necessarily, adapted for incorporation in the head of the piston of the engine.

Further objects are concerned with simple attenuator configurations of substantial effectiveness, simplicity and low cost.

The acoustic attenuators of the invention will be best understood by referring immediately to the following detailed description of several illustrative embodiments thereof, reference for this purpose being had to the accompanying drawings, in which:

Fig. 1 is a vertical transverse section through an internal combustion engine showing certain detonation sound wave attenuator configurations in accordance with the invention;

Fig. 2 is a top plane view of a portion of an engine piston equipped with a form of the present invention;

Fig. 3 is a detailed section taken on line 3—3 of Fig. 2;

Fig. 4 is a vertical medial section through the upper portion of a piston showing another embodiment of the invention;

Fig. 5 is a vertical detailed section through a portion of the top end of a piston showing another form of the invention;

Fig. 6 is a view similar to Fig. 5 showing another form of the invention;

Fig. 7 is a fragmentary vertical section through a piston showing another form of the invention; and

Fig. 8 shows a piston, partly in elevation and partly in section, showing still another form of the invention.

With reference first to Fig. 1, there is shown an illustrative L-head engine comprised of a water-cooled block **10**, a water-cooled head **11** fastened to block **10**, a piston **14** working in cylinder **15** in block **10**, an exhaust valve **16**, and a spark plug **17**. It will be understood that an intake valve (not shown) will be located along-side exhaust valve **16**, such valve being understood to be in front of the plane of the drawing. Block **10** and head **11** are shown with more or less conventional cooling jackets, and head **11** has an inner combustion chamber wall **20**, enclosing a combustion chamber space **21** over the cylinder and valve, as shown. A plurality of "spoiler" cavities or resonant absorbers **22** are formed in the upper or head wall **14***a* of piston **14**, and as here shown, additional spoiler cavities **22***a* may, if desired, be sunk in the upper end portion of the cylinder. Straight spoiler cavities were disclosed and claimed in my aforesaid patent No. 2,573,536, and functioning and effect of spoiler cavities in combating detonation was there set forth in full. As was there explained, such spoiler cavities are effective to absorb sound wave frequencies in the combustion chamber to which they have a resonant response; and it will be further understood that the spoilers such as illustrated, formed with closed inner ends, comprise quarter wavelength pipe resonators having a frequency selective attenuative response to sound waves whose wavelength is four times the depth of the cavities.

The characteristic novel feature of the present invention is that the quarter-wavelength resonant absorbers or spoilers **22** are not straight throughout their full lengths, but are provided with laterally extending intermediate sections **23**, so that the inner end portions of the cavities are laterally offset from the entrance ends thereof. By this arrangement, the interior end portions of the cavities are substantially shielded from the heat produced within the combustion chamber. In this connection, it is found in practice that carbon tends to accumulate on surfaces which are in a certain intermediate heat range, and that surfaces maintained at either a relatively high temperature, or at a relatively low temperature, will not accumulate carbon. This is believed to be due to the fact that certain varnishes

are produced in the combustion process. These varnishes are capable of adhering to combustion chamber wall surfaces within a certain heat range, so providing conditions favorable to an accumulation of carbon. Both above and below such heat range, the varnishes do not appear on the combustion chamber surfaces and the carbon does not deposit. The embodiment of Fig. 1 will be seen to be one means providing offset shielding from radiation for keeping the inner end portions of the resonant cavities at an operation temperature below that for which carbon will deposit.

While as stated above, the spoiler cavities shown in Fig. 1 may be located in either the head wall of the piston, or within the stationary wall structure definitive of the combustion chamber, I have found that the piston is in an advantageous location, permitting ready installation of the attenuator configurations without redesign of conventional combustion chambers, and operating entirely satisfactorily even though the piston is moving.

Figs. 2 and 3 show another form of acoustic attenuator in the form of half-wave pipe resonators 27 mounted in the piston top 28 (which of course constitutes one wall of the combustion chamber). As shown, the piston top 28 has cast therein a U-shaped tube 27, whose two open ends open through the top surface of the piston. The length of this U-tube is one-half the wavelength of the detonation sound wave to be combatted. In effect, within its frequency range, the U-tube functions for the purpose herein as two individual quarter-wave pipes. A pressure wave cycle of frequency to which the U-tube is tuned, generated by a detonation origin point in the flame and incident upon the piston in the region of the two ends of the U-tube, will cause it to resonate and thereby function as a resonant absorber. In my prior Patent No. 2,573,-536, I explained the occurrence of detonation induced resonant sound wave patterns within the combustion chamber, and the meaning of regions of high acoustic impedance within said patterns. The two ends of the U-tube 27 are preferably disposed to open to a common high impedance region of such an acoustic pattern. This double, or continuous passage type "spoiler" is relatively free of carbon accumulation problems.

Fig. 4 shows a modified piston 31 whose top is formed with cylindrical sockets 32 to receive Helmholtz resonators 33. These resonators each have a cylindrical body 34, rounded at the bottom, and formed at the upper end with an external annular flange 34*a* which snugly fits the socket 32, the body 34 being spaced from the piston structure excepting at its lower end. Heat conduction to the piston structure is thus reduced, and the resonator operates at a high temperature. At the bottom, body 34 is provided with a stem 34*b* extending down through the head of the piston, its lower end being riveted, as at 34*c*, to secure the resonator tightly in position. The resonator is provided with a top wall 34*d*, furnished with a downwardly extending tubular stem 34*e* which opens into the lower portion of body 34, this stem 34*e* being the neck of the resonator. The farthest inner end portion of the cavity of this resonator, where any carbon might tend to accumulate, will be seen to be the part which is turned toward the heat to give a condition of temperature substantially above the aforementioned range where carbon will deposit, with the result that carbon accumulation within the resonator is minimized or prevented.

Fig. 5 shows another modification of piston mounted Helmholtz resonator, the Helmholtz resonator being formed in this instance by a bore 35 extending upwardly through the top 35*a* of the piston nearly to the top surface thereof, and by a smaller bore 35*b* extending through the top surface of the piston, the latter forming the neck of the resonator. The bottom of the bore 35 is then closed by a plug 35*c*, which may be secured in place by peening as at 35*e*. The Helmholtz resonator in this form is of advantage in view of its simple nature and the ease with which it may be formed in a conventional piston structure.

Fig. 6 shows still another piston mounted Helmholtz resonator type of absorber. Here, the piston top 36 is formed with a bore 36*a* extending downwardly from its top surface, and an enlarged counterbore 36*b* extending upwardly from below. The Helmholtz resonator structure, indicated generally by numeral 37, includes a cylindrical base portion 37*a*, received in counterbore 36*b*, and secured in position by peening as at 37*b*. Extending upwardly from base portion 37*a* is a cylindrical chamber forming a resonator chamber 37*c*. As shown, the side walls of the chamber 37*c* are annularly spaced from the bore 36*a*, and the lower ends of the side walls are formed with a series of ports 37*d*, which ports constitute the mouth of the resonator. Enclosed within the chamber 37*c* is a steel ball 38. The resonator 37 functions in the usual manner to attenuate detonation frequency waves of frequency to which it is resonant. The chamber being exposed to the flame, carbon accumulation therewithin is minimized. In addition, the steel ball 38 is free to rattle about inside the chamber owing to the reciprocating motion of the piston, and this rattling ball has a scouring action on the inside surfaces of the chamber, tending to prevent carbon accumulation. In passing, it may be noted that the attenuator 37 is one of several disclosed types which has been arranged in sound transmissive communication with the combustion chamber by being positioned virtually inside the chamber.

Fig. 7 shows a further piston mounted horn type attenuator, wherein a bore 40, extended downwardly through a body structure 41 of the piston, receives a plug 42 formed with a horn-shaped chamber 43. The throat of the horn opens through the inner end of the plug 42, as indicated at 44, to a groove 45 which communicates with a spiral groove 46 formed around the plug 42. The groove 45 and spiral groove 46 form a long attenuation passage communicating with the throat of the horn. This device as illustrated in Fig. 7 forms a convenient and easily made structure for carrying out the functions of the invention.

Fig. 8 shows a piston 55 whose upper end portion is configured to provide a horn type space between it and the cylinder wall, indicated in dot-dash lines at 55*a*. Thus, the top end portion 56 of the piston converges in an upward direction on an exponential function curve 57, in such manner that the cross-sectional area of the annular space between the piston and cylinder wall converges downwardly from the upper end of the piston to the plane 58 in the manner of an exponential type horn. This exponential "horn" passage 59 is reduced to a relatively small transverse dimension at the plane 58, something of the order of a few thousandths of an inch to a millimeter, and there communicates with an acoustic attenuator 60 in the nature of a plurality of fine grooves 61 formed in the periphery of the piston and arranged to communicate with the "throat" of the "horn."

It will be seen that detonation sound waves received by the mouth end of the "horn" passage or space 59 will travel down the same, without reflection, and will be dissipated by the attenuator 60. This form of the invention is of particular advantage, in that it may be carried into effect by a most simple modification of the piston structure. It has further advantage, in that the mouth of the "horn" 59 is located in the region of the various pressure anti-node zones of the acoustic patterns known to exist in the combustion chamber. It is important to note at this point that it is common to have a taper or "stepped" diameters, particularly to maintain dimensions in spite of a temperature gradient, for the top portions of pistons. However, unless the taper complies with acoustic laws and includes an attenuative region, the effects spoken of herein will not be accomplished.

It is of course necessary, as always, to have the passage length, width and taper and the volume provided by the grooves 61 in proportions which will give the necessary frequency band coverage. It is also possible to increase band coverage by increasing the proportion of the grooved region, or to accomplish attenuation by proper grooves alone, wherein the extended distribution of the

grooves results in a multi-orifice acoustic baffle operating as a broad band acoustic wave absorber.

It will be understood that the drawings and description are merely illustrative of certain specific embodiments of the invention, and that various changes in design, structure and arrangement may be made without departing from the spirit and scope of the appended claims.

I claim:

1. For use with an internal combustion engine having a combustion chamber and a cylinder opening into said chamber, a piston adapted for reciprocation in said cylinder, and a sound wave conduit in said piston having a half wavelength for the frequency of detonation sound waves produced in said chamber by combustion, the two ends of said conduit opening through the top of said piston closely adjacent to one another.

2. For use with an internal combustion engine having a combustion chamber and a cylinder opening into said

chamber, a piston adapted for reciprocation in said cylinder, and a sound wave conduit in said piston having a half wavelength for the frequency of detonation sound waves produced in said chamber by combustion, the two ends of said conduit opening through the top of said piston into a common region of high acoustic impedance within a resonant acoustic pattern produced in said combustion chamber by said detonation sound waves.

3. For use with an internal combustion engine having a cylinder and walls, including the top wall of a piston, defining a combustion chamber thereover, a sound wave conduit in said walls having a half wavelength for the frequency of detonation sound waves produced in said chamber by combustion, the two ends of said conduit opening into said combustion chamber in close proximiy to one another.

No references cited.