

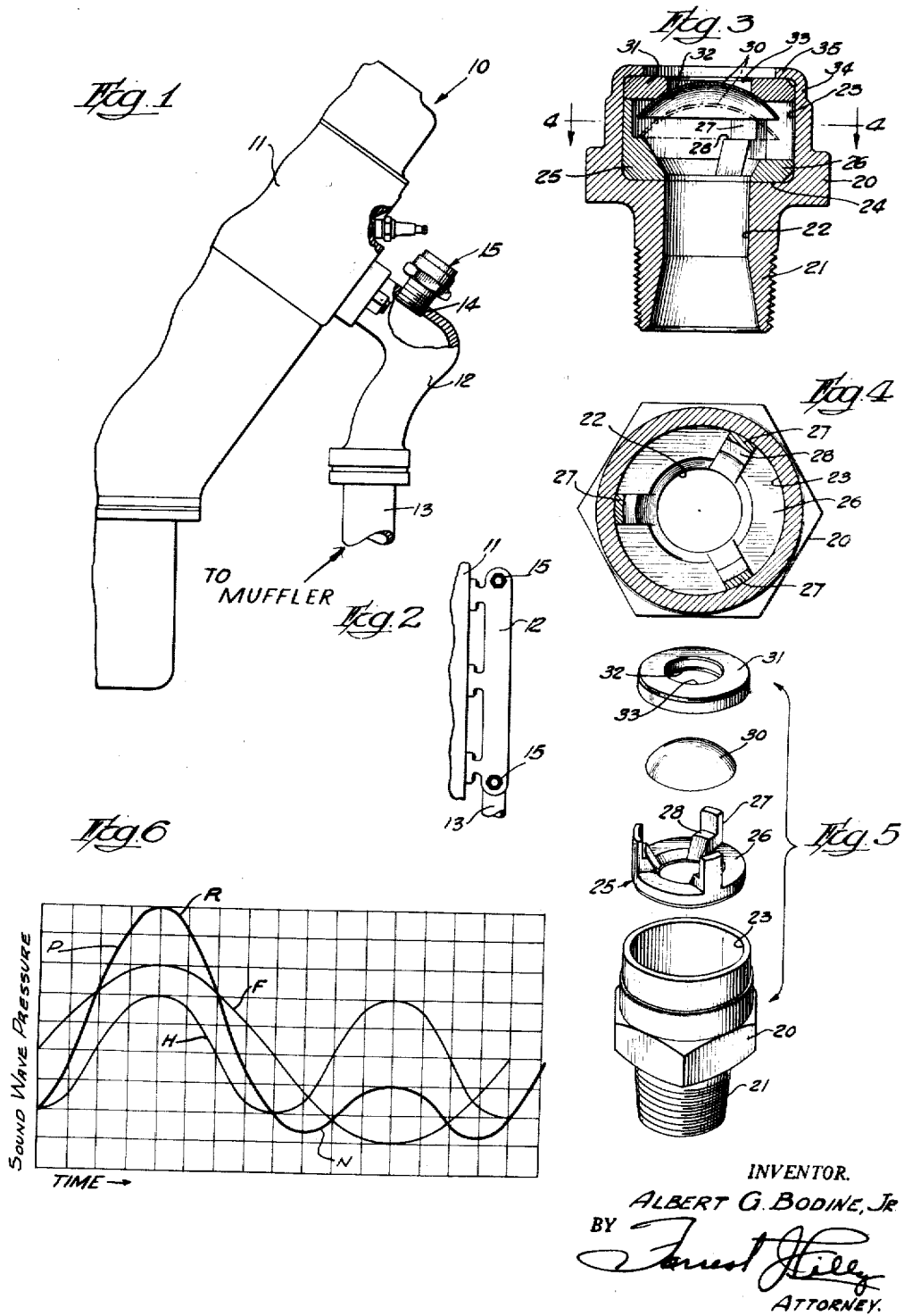
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SONIC ENGINE EXHAUST COMBUSTOR

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SONIC ENGINE EXHAUST COMBUSTOR

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1 Claim. (Cl. 60—30)

This invention relates generally to systems for completing the combustion of exhaust gases from automotive engines.

It has now been determined that a large and important fraction of "smog" consists of incompletely burned hydrocarbon fuel exhausted by automotive engines. Numerous proposals have been made for completion of the combustion of such fuels, including the broad concept of admitting air to the exhaust manifold through a negative pressure responsive check valve in order to complete the combustion, but nothing of sufficient merit or practicability has so far emerged. Those prior systems which admit air through a negative pressure responsive check valve use valves which open in response to that negative pressure which follows the surge of gases through the exhaust system upon each opening of an exhaust valve. Such valves do not operate in response to or in phase with the sonic wave pattern in the exhaust system and do not create the sonic wave pattern characteristic of the present invention, as presently to be described.

A primary object of the present invention is the provision of a novel and improved system for periodically admitting air for completion of combustion to the exhaust manifold system via a special check valve made responsive to sonic wave phenomena in the exhaust system, and the operation of which valve modifies the normal sonic wave pattern in the exhaust system in such a way as to markedly improve completion of combustion.

According to the invention, the manifold is equipped with one or more negative pressure responsive air intake check valves, which are made to be frequency responsive to open and close in response to negative pressure half cycles of the sound wave pattern developed in the exhaust system. Considering first the idealized frequency sinusoidal sound wave developed in the exhaust system by the engine exhaust, a negative pressure responsive air intake check valve, assumed to be responsive to the frequency of the wave, would admit air to the system during each negative pressure half cycle, with the effect that the negative pressure half cycle is flattened. The effect is to introduce into the wave a strong second harmonic content. The positive half cycle of the resulting wave pattern is highly peaked. In order to assure effective valve action in consonance with the resultant complex sound wave pattern in the exhaust system, I make the intake check valve frequency responsive to the resultant sound wave pattern, i. e., that resulting from the normal exhaust system sound wave, modified by the second harmonic owing to air admitted by the check valve. It has been stated that the positive half cycle of the resultant wave is peaked owing to the operation of the sonically responsive check valve. I have found that a positively peaked sound wave is highly conducive to fuel combustion, and accordingly, I have created conditions under which unburned fuel in the exhaust gases may be most effectively consumed. In operation, the check valve thus opens on each negative half cycle of the sound wave,

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and closes during the positive half cycle. The small quantity of intaken air admixes with the exhaust gases in the manifold, and consumes a substantial quantity of unburned hydrocarbons during the immediate following peaked positive half cycle of the wave. Owing to the vigorous burning induced by the peaked sound wave, there is little or no carry over of air from one positive half cycle to the next, each charge intaken during a negative half cycle of the wave reacting substantially completely during the immediately following positive half cycle. Under these conditions, there is no material cooling of the exhaust gases by the introduced air. The making of the check valve frequency responsive to the wave pattern will be explained hereinafter.

The invention will be more fully understood from the following detailed description of a present illustrative embodiment of the invention, in which:

Fig. 1 is a fragmentary view of an automotive engine equipped with an exhaust manifold and intake check valve in accordance with the invention;

Fig. 2 is a plan view of the exhaust manifold of Fig. 1;

Fig. 3 is a vertical medial section through a form of air intake valve in accordance with the invention;

Fig. 4 is a section taken on line 4—4 of Fig. 3;

Fig. 5 is an exploded view of the components of the check valve of the invention; and

Fig. 6 is a diagram showing sonic wave patterns induced in the exhaust system by the invention.

In the drawings, numeral 10 designates a portion of a V-type internal combustion engine, a cylinder head thereof being indicated at 11, and the usual exhaust manifold at 12. Coupled to and extending from the bottom of the exhaust manifold is fragmentarily illustrated conventional exhaust pipe 13. Mounted in suitable threaded ports 14 in the wall of manifold 12 are one or more air intake check valves 15. As here illustratively shown, there is one such intake valve 15 at each end of the top wall 12a of the manifold.

The construction of a preferred illustrative check valve 15 is shown in Figs. 3—5. A valve body 20 has a threaded tubular stem 21 for installation in port 14, and the bore 22 through this stem meets enlarged cylindrical valve chamber 23 at shoulder 24. Seated in the bottom of chamber 23, on shoulder 24, is a valve stop member 25 comprising annulus 26 fitted closely inside chamber 23 and seating on shoulder 24. A plurality of valve guide elements 27 project upwardly from annulus 26, and have intermediate steps 28 forming limit stops for the valve element. The valve element comprises a thin domed shell 30 receivable with good clearance between the upper portions of the guide members 27, and adapted to engage, in the open position thereof, against steps or stops 28. Contained within chamber 23, guides 27, and resting on the upper ends of the latter, is valve seat ring 31, having seat 32 for the valve element, and port 33. The cylindrical outer wall portion 34 of the valve body is turned over seat ring 31, as indicated at 35.

Owing to exhaust pressure in the manifold, the valve element 30 stands normally in its upper, closed position, seated on ring 31. The valve element 30 is relatively light in weight, being composed of thin steel (such as stainless steel) and, generally stated, is movable in response to the sound wave pattern in the exhaust system. It is important that this valve member be light, and move in phase with the sound pressure wave in the exhaust system.

Operation of the system is as follows: The engine exhaust into and through the manifold and exhaust pipe by shock excitation, generates a sonic wave therein whose fundamental frequency is governed by manifold and ex-

haust pipe dimensions and exhaust gas temperature. The fundamental frequency sonic pressure wave thus generated is represented at F in Fig. 6. The valve element 30 of each of check valves 15 is held closed by positive exhaust gas pressure. Negative wave pressure in the manifold will cause the valve 30 to unseat and admit air. Such admission of air, as previously described, flattens the negative half cycle of the fundamental frequency wave, which distortion generates a second harmonic wave component as represented at H in Fig. 6. The fundamental F and second harmonic H combine to produce the resultant wave pattern R, characterized by a peaked positive half cycle P, and a flattened negative half cycle N.

Air taken in through the valve during the negative pressure half cycle N reacts vigorously with unconsumed hydrocarbons during the peaked positive half cycle P. As before stated, such a peaked sound wave has been discovered to greatly promote fuel combustion. The theory of fuel combustion in presence of sound waves is an involved subject, and only partially understood by authorities. No attempt need be made to set forth such theory herein, but it is a demonstrated fact that fuel combustion is accelerated and particularly excited by peaked positive waves resulting from harmonic content. The air taken in during the negative half cycle is thereby substantially completely consumed on the next succeeding positive half cycle in reacting with previously unburned hydrocarbons. The amount of this intaken air on each negative half cycle may be small, so that no material cooling effect takes place such as would retard the combustion. It is an important concept of the invention that, on each negative half cycle of the sonic wave, a small amount of air is taken in through the check valve, and substantially completely used in an accelerated combustion reaction during, and by virtue of, the next succeeding peaked positive half cycle.

As mentioned earlier herein, one concept of the invention is the provision of an air intake check valve that is frequency responsive to the complex wave pattern resulting from the combination of the fundamental with its harmonic content, so that the valve will unfailingly open during the negative half cycle of the wave pattern, and close during the positive half cycle thereof. It must move in step with the sound pressure wave, without material phase lag. The illustrative valve described hereinabove is made responsive to this sound wave pattern by adjustment of the acoustic mass reactance of its movable valve element relative to the product of the area of its orifice and the pressure differential across it. Thus, f , the optimum response frequency, is given by the ratio of the average cyclic pressure to the acoustic mass reactance of the valve element. In symbolic terms,

$$f = \frac{A \Delta p}{X_1}$$

where X_1 is equivalent acoustic mass reactance, A is the effective area of the valve orifice, and Δp is the pressure differential across the orifice. Following this theory, those skilled in the acoustics art will readily understand the proportioning of the valve for frequency response to the wave pattern developed in a given engine exhaust system.

One illustrative embodiment of the invention has now been described, but it will be understood that various modifications are possible within the scope of the invention. For example, while I have here shown the air intake check valves mounted in the manifold, they may be located at any place in the exhaust system where the sound wave is strong. The location should not, of course, be in the region of the muffler, where the sound wave is attenuated, and ineffective to operate the valve properly. But the valve can be located in the exhaust pipe downstream from the manifold, so long as it opens into the exhaust system at a point where the sound wave is strong enough to operate it. Various modified forms of intake valve conforming to the sonic response requirements heretofore given are also possible within the scope of the invention.

I claim:

In combination with an automotive engine exhaust system comprising an exhaust manifold, and an exhaust pipe and muffler wherein a sonic pressure wave is generated by engine exhaust, means for completing combustion of unburned fuel in the exhaust system comprising an air intake check valve opening into said exhaust system at a point therein substantially spaced upstream from said muffler where said sonic pressure wave is substantially unattenuated, said check valve having a movable valve element for opening and closing said valve in step and in phase with negative and positive half-cycles, respectively, of said sonic pressure wave, so as to cause intake of air during said negative half-cycles and resulting reduction in the amplitude of said negative half-cycles, thereby superimposing on said sonic pressure wave a second harmonic, yielding a complex resultant wave characterized by peaked positive pressure half-cycles and flattened negative pressure half-cycles, said movable valve element being frequency responsive to said complex resultant wave to open and close during and by virtue of said flattened negative pressure half-cycle and to remain closed during said peaked positive pressure half-cycle, whereby air charges admitted during the negative pressure half-cycles of the sonic wave react with unburned fuel in the exhaust system during and by virtue of the peaked positive pressure half-cycles of the sonic wave.

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