May 31, 1932. R. B. BOURNE 1,860,569

ENGINE OSCILLATION CONTROLLER

Filed May 1, 1929 2 Sheets-Sheet 1

Fig. 1.

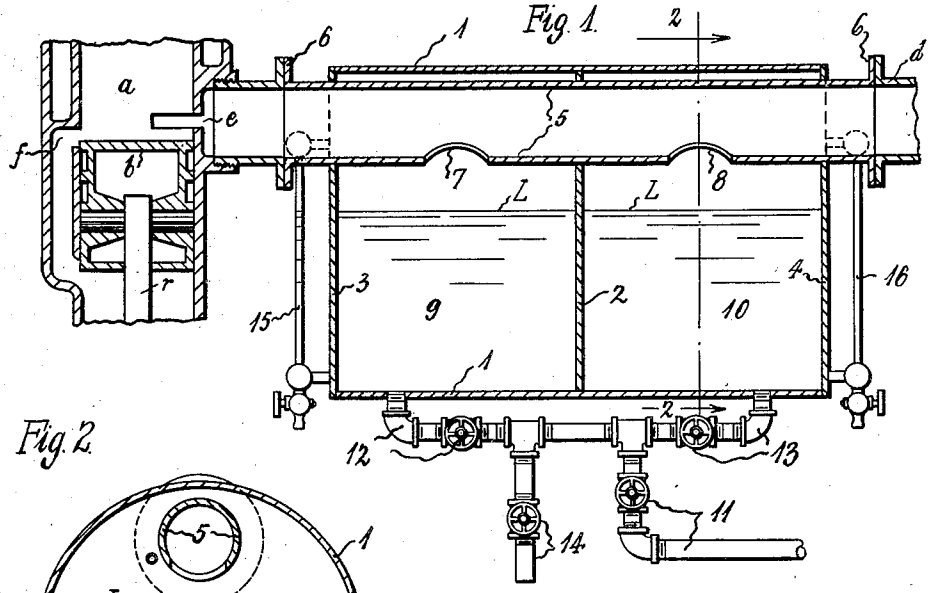


Fig. 2.

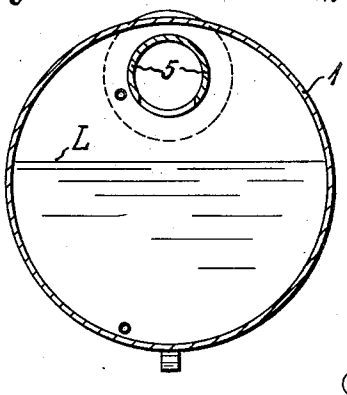


Fig. 3.

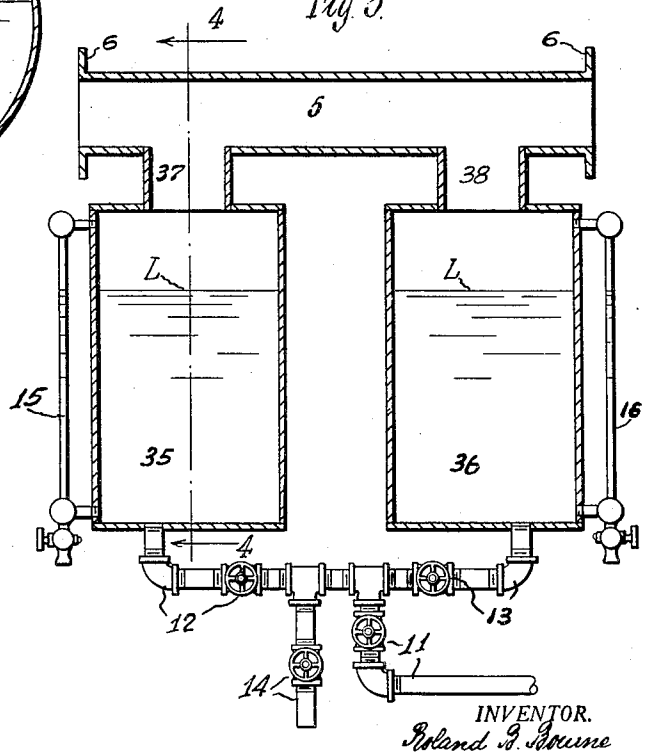
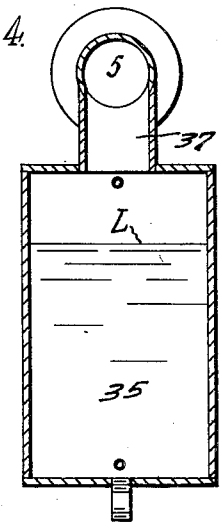


Fig. 4.



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Filed May 1, 1929 2 Sheets-Sheet 2

Fig. 5.

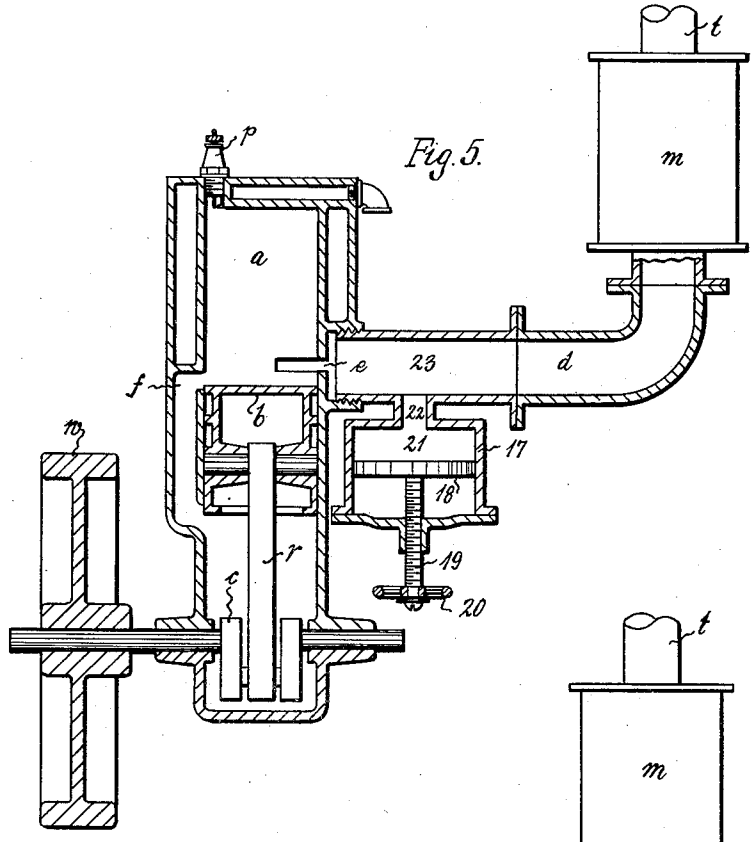


Fig. 6.

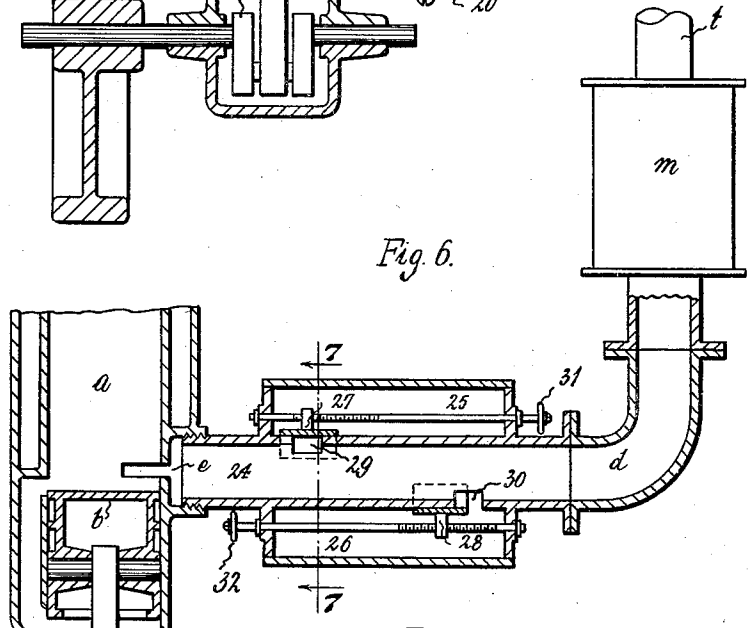
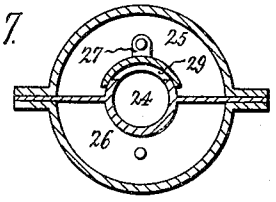


Fig. 7.



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UNITED STATES PATENT OFFICE

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ENGINE OSCILLATION CONTROLLER

Application filed May 1, 1929. Serial No. 359,569.

This invention relates to devices for controlling the oscillations of mechanically energized gas columns—such as pressure or exhaust lines—coupled to an engine which produces oscillations in such a column that may unfavorably affect the output of the engine. In the particular example hereinafter described the apparatus is adapted for the controlling of the exhaust system of a two-cycle internal combustion engine.

The sudden discharge of the exhaust gases of such engines produces in the exhaust system, which represents a substantially kinetically energized gas column, a pressure wave or surge comprising a variety of constituent frequencies and traveling at the velocity of sound. A certain amount of the oscillating energy contained in the surge will escape at the mouth of the exhaust pipe and the remainder will, due to reflection, oscillate in the acoustic conductor formed by the cylinder volume and the column of gas in the exhaust pipe. This acoustic system resembles an organ pipe in having an air channel closed at one end by the cylinder head and terminating at the other end in the open air or a pit of relatively large volume, nearly equivalent to an open air termination. The reflected waves travel between these two terminal points. Though the oscillations may be of complex character, there will always be a predominant wave or frequency corresponding to the fundamental natural frequency or one of the higher harmonics of the acoustic conductor.

Any given installation comprising engine and exhaust pipe system has a predominant wave frequency determined by the conditions in the installation. The traveling distance of this wave is definite as well. From this it follows that the pressure fluctuations caused by the predominant frequency at the engine ports constitute a sequence of events in definite time relation to the other occurrences in those ports. This is also true if, as very likely, it be assumed that also stationary oscillations of predominant frequency take place in the system forming nodes and antinodes. However, this time relation will be changed as soon as the acoustic load of the system is altered by adding gas volumes in series or parallel to the exhaust pipe system. Such a change in load corresponds to a change of both predominant frequency and traveling distance irrespective of whether such air columns are added in the form of pipe extensions, also called series loads, or in the form of side branches, also called shunt loads. If this additional load is modified in such a way as to produce a coincidence of events near the ports favorable for the power output of the engine, the engine and its exhaust system may appropriately be spoken of as being "tuned".

The object of this invention is to provide means for tuning the exhaust system of an internal combustion engine in order to obtain more favorable pressure conditions at the exhaust and intake ports during the time of their opening and closing operation, finally resulting in a greater output of the engine. In two-cycle engines where the periods for exhaust and intake are comparatively very short, such means are particularly desirable and effective.

It is evident that the invention is by no means confined to the exhaust system of internal combustion engines, but will be applicable in all cases where gas columns are coupled to engines, be it the outlet or the inlet of the engine, and where such gas columns are liable to execute oscillations unfavorably affecting the output of the engine.

The invention aims at the accomplishment of its purpose by providing an acoustic, substantially reactive shunt load consisting of one or more insulated gas volumes practically realized by means of closed side chambers acoustically coupled to the main conduit through which the gases pass. I, preferably,

call such an arrangement an engine oscillation controller. According to this invention, the volume of the side chambers can be made variable so that precise tuning is obtained by adjustment. An increase of the volume of a side chamber produces similar effects as an extension of the exhaust conduit.

Referring to the drawings:

Fig. 1 shows an exhaust controller of my invention in vertical section and connected to the exhaust of a two-cycle internal combustion engine with crank-case transfer;

Fig. 2 is a fractional cross-section on line 2—2 of Fig. 1;

Fig. 3 represents a somewhat modified embodiment of my invention in vertical section and adapted to be connected to an engine exhaust;

Fig. 4 gives a fractional cross-section on line 4—4 of Fig. 3;

Fig. 5 shows a second modification connected in the exhaust between the engine and a muffler;

Fig. 6 illustrates a third modification disposed in the same manner as in Fig. 5; and

Fig. 7 is a cross section along line 7—7 of Fig. 6.

Referring now to the figures more particularly, Fig. 1 shows a controller comprising a cylindrical shell 1 with end walls 3 and 4 and with an intermediate wall 2 midway between the end walls forming two cylindrical chambers 9 and 10 in the shell, as shown in cross-section in Fig. 2. A tubular conduit 5 passing eccentrically through the header and partition walls and separately communicating with the chambers 9 and 10 by means of the apertures 7 and 8 has flanged end portions 6 of which one is attached to the exhaust port *e* of the engine cylinder *a* with piston *b* and inlet port *f*, while the other fits to the exhaust pipe *d*. Thus conduit 5 forms an intermediate section in the exhaust system.

The gas volume in the chambers can be changed through displacing it by a larger or smaller quantity of liquid, preferably water, as indicated by the surface level lines L.

A number of accessory elements provide for the filling, draining, and adjusting of the water in the chambers. Water is admitted through pipe and valve 11 and is then distributed at will to the chambers 9 and 10 by means of pipes and valves 12 and 13 respectively. Drainage takes place through pipe and valve 14, and adjustment is facilitated by gauges 15 and 16 respectively.

The same acoustic system is realized according to Figs. 3 and 4 through somewhat different structural means comprising two separately spaced cylindrical chambers 35 and 36 with neck portions 37 and 38 respectively, which form an acoustic coupling between the chambers and the externally arranged exhaust gas conduit 5. In all other accessory details, this construction will readily be recognized as being identical with the previously described construction. This structure is more suitable in cases where little area but sufficient vertical space is available.

In certain cases, for instance on boats, it will be preferable to use adjusting means for the gas volumes in the chambers that do not change in form, under the influence of accelerations. It is evident that in such cases different expedients would be available as a substitute for the water,—for instance, materials that are substantially or perfectly solid at normal temperatures. Usually I perfer chambers closed by a displaceable piston as depicted in Fig. 5. *a* is the engine cylinder, *b* the piston, *p* a spark plug, *r* the piston rod, *c* the crank shaft, *w* the fly wheel, and *f* and *e* are the inlet and exhaust ports respectively. The cast iron controller inserted between the exhaust port *e* and the exhaust pipe *d* comprises a cylindrical shell 17 with movable piston 18 therein. By means of the hand wheel 20 and the threaded piston stem 19 the piston can be adjusted in its position, thus forming, together with the walls of the cylindrical shell, a variable and adjustable enclosed gas volume 21 which, by means of the neck 22, communicates with the gas conduit 23. The exhaust pipe *d* is connected to a muffler *m* terminating in an extension pipe *t*.

The modification shown in Fig. 6 will now readily be understood. The conduit 24 is provided with two separate side chambers 25 and 26. The tuning effect of these side chambers can be varied by changing the active area of the apertures 29 and 30 respectively by means of movable covers 27 and 28, controlled by the hand wheels 31 and 32 as indicated by different positions, one closed and one partly open, in the figure. By making the communicating apertures between the conduit 24 and the side chambers 25 and 26 variable, it is possible to accomplish tuning within certain ranges, without the use of a variable sidebranch volume.

The figures depict controllers with two side chambers; however, no restriction as to the number of chambers is intended thereby. If sufficient, also a single chamber may be employed.

The advantages of the apparatus described may briefly be pointed out in regard to various applications.

A ready-for-operation installation comprising the engine, exhaust piping, and adjustable controller with directions for proper tuning in conjunction with the engine and pipes can be produced and marketed. If this same installation should be connected to an exhaust pipe extension, such as a pit with a stack, a somewhat different tuning may be necessary, especially if the volume of the pit is small and cannot acoustically be regarded

as equivalent to the open-air terminal of the exhaust pipe. In most cases, the new tuning will be accomplished by changing the gas volume in the controller, and only in exceptional cases may it be necessary to add another controller chamber. It ought to be understood that the controller represents an almost pure reactive load while an increment of the pipe length also adds a friction load to the system which will unfavorably influence the exhaust conditions as compared with the addition of another controller chamber.

In a great many cases, the dimensions of the exhaust and stack piping system are more or less determined by available space and considerations with respect to neighborhood. Under such circumstances the compact controller offers a means of meeting most different and adverse conditions that heretofore presented sometimes unsurmountable difficulties to the engineer who tried to reconcile efficiency of engine operation with other exigencies.

It has been found that certain kinds of two-cycle engines work most effectively at a system frequency of about forty cycles per second. From the foregoing explanations, it will now be apparent that a pipe too long will be just as objectionable as one too short for meeting such a requirement, whereas the controller will permit of proper tuning to 40 cycles independent of the extension of the exhaust pipe and its continuation in a pit and stack.

In certain small high-speed two-cycle gasoline engines, such as outboard motors for high-speed marine craft, the application of a controller may be very useful. The output of such engines, generally run at top speed, is seriously affected by ordinary mufflers, and, for this reason, they are frequently operated without any silencing device at all, a certainly very objectionable expedient. The higher power output of the engine due to the tuning of the controller will more or less balance the power loss in a muffler or silencer construction, so that a combination of the two devices offers itself as the natural solution of this problem. This combination has frequently the further advantage that the muffler provides a desirable terminal load that assists tuning.

What I claim is:

1. A tuned passage for controlling terminal pressure conditions in a gas flow system subject to pressure pulsations, comprising a gas conduit, a water containing chamber having the space above the water acoustically coupled to said conduit as a side branch, and means for varying the water level in said chamber to change the effective acoustic size of said side branch chamber.

2. A tuned passage for controlling terminal pressure conditions in a gas flow system subject to pressure pulsations, comprising a gas conduit, a plurality of water containing chambers having their spaces above the water acoustically coupled to said conduit at spaced points as side branches, and means for varying the water level in said chamber to change the effective acoustic size of each of said side branch chambers independently.

In testimony whereof I have affixed my signature.

ROLAND B. BOURNE.