H. P. MAXIM.

EXHAUST SILENCER FOR ENGINES.

APPLICATION FILED NOV. 28, 1910.

1,115,853. Patented Nov. 3, 1914.

Fig. 1.

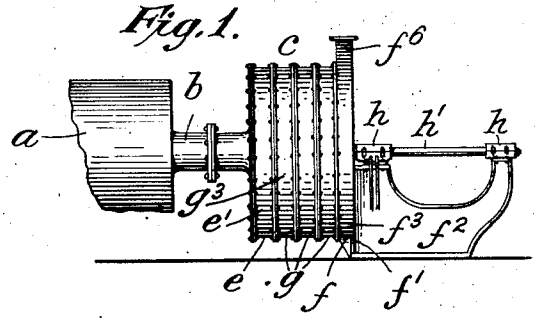


Fig. 2.

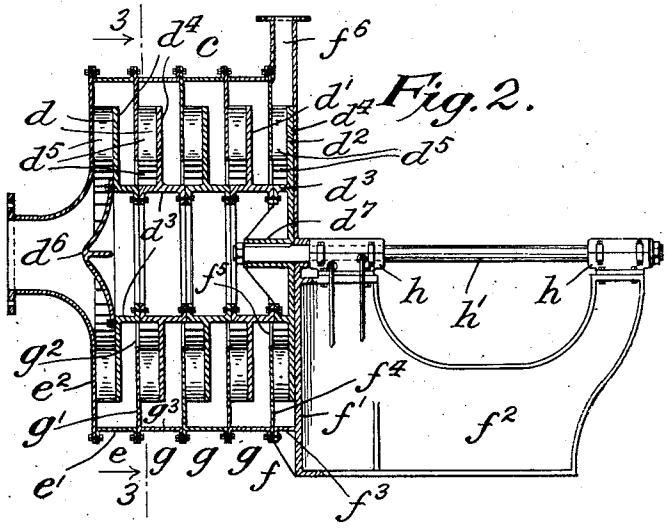
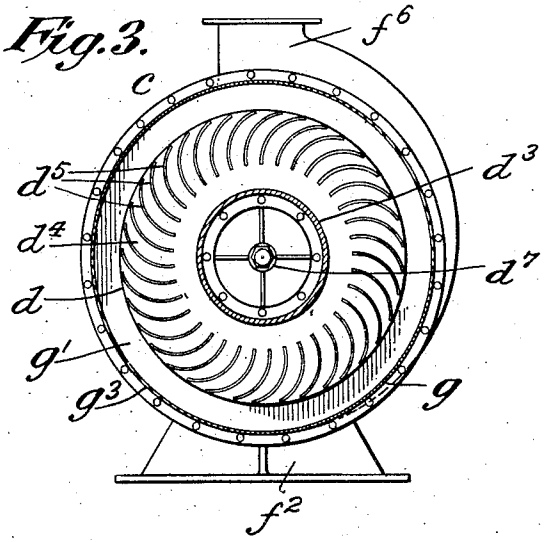


Fig. 3.



Attest:

Edgeworth Greene

W. M. Gross

Inventor:

by Hiram Percy Maxim

Redding, Greene & Austin

Atty

UNITED STATES PATENT OFFICE.

HIRAM PERCY MAXIM, OF HARTFORD, CONNECTICUT.

EXHAUST-SILENCER FOR ENGINES.

1,115,853. Specification of Letters Patent. **Patented Nov. 3, 1914.**

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To all whom it may concern:

Be it known that I, HIRAM PERCY MAXIM, a citizen of the United States, residing in Hartford, in the State of Connecticut, have invented certain new and useful Improvements in Exhaust-Silencers for Engines, of which the following is a specification, reference being had to the accompanying drawings, forming a part hereof.

This invention relates to the handling of the exhaust of engines in which the pressure differential between the cylinder and the atmosphere is so great that each exhaust puff or impulse produces an objectionable noise, particularly as in internal combustion engines of ordinary type, and has for its object to reduce the noise of the exhaust and also to assist the clearing out of the dead gases after each explosion, in internal combustion engines. Various devices for muffling the exhaust of internal combustion and other engines have been devised and are in use, but all of such devices, so far as is known, create more or less back pressure, which exists not only at the time of the exhaust impulse but between the impulses also, thereby preventing the proper clearing out of the dead gases. It has also been proposed, among such devices, to use turbines, driven by the exhaust itself, for the purpose of modifying the noise of explosion, but in every case, so far as is known, the desirability of augmenting the flow of the exhaust between the explosion impulses has been lost sight of altogether and it has been proposed to use only axial-flow turbines, which are incapable of operating to augment the exhaust between the impulses, so that such turbine mufflers heretofore produced, offer at all times more or less resistance and therefore create more or less back pressure. In accordance with the present invention, however, the same device which operates to silence the noise of explosion, operates also to augment the exhaust between the explosion impulses, the energy which is stored up in the silencing device by each impulse of explosion serving to operate the same device between the impulses to augment the exhaust. The particular form of device which is thus capable of performing this double function, not heretofore recognized as desirable or even possible, is a radial-flow turbine which is interposed in the exhaust and, being independent of and unconnected with the engine shaft and driven by the explosion impulses, continues to rotate between the impulses by the kinetic energy stored therein without regard to the speed of the engine and, through centrifugal action, maintains the forward movement of the exhaust gases in the same direction as that in which they move to rotate the turbine.

The invention will be more fully explained hereinafter with reference to the accompanying drawings in which it is illustrated as embodied in a convenient and practical form and in which—

Figure 1 is a view in elevation, showing a portion of an internal combustion engine of an ordinary type equipped with the invention. Fig. 2 is a detail view, partly in longitudinal section, showing an approved construction of the silencing devices. Fig. 3 is a view in transverse section on the plane indicated by the line 3—3 of Fig. 2.

In the drawings there is indicated at *a* so much of an internal combustion engine of ordinary form as is necessary to enable the invention to be understood. At any convenient point, but preferably in reasonably close proximity to the engine cylinder or cylinders, there is connected to the exhaust pipe *b*, a silencer *c* which comprises, essentially, one or more radial-flow turbine wheels *d*, unconnected with the engine shaft and mounted to rotate independently thereof. The structure shown in the drawings has been devised with special reference to economical manufacture, being made in sections which can be secured together readily in any desired number to suit the particular conditions of use. The silencing device shown is composed of an inlet section *e*, a discharge section *f*, and three identical intermediate sections *g*. The inlet section *e* consists of a flanged ring *e'* and a head or cap e^2 which is suitably formed to be joined to the exhaust pipe *b*. The discharge section *f* comprises a plate *f'* which may be a part of a casting f^2 which supports the bearings for the shaft of the turbine wheels as hereinafter described, the plate *f'* being formed with a flange f^3 to which may be secured the plate f^4 having a central opening f^5. The chamber which is thus formed between the plate *f'* and the plate f^4 is provided with a suitable outlet f^6. Each of the intermediate sections *g* comprises a plate

or wall g' which may be transverse with respect to the shaft and have a central opening g^2 and a flange g^3. All of these parts are so formed as to be capable of being secured together readily as indicated in the drawings.

The standard f^2, which supports the end plate f', is provided with suitable bearings h, h in which is mounted a shaft h' which carries the radial-flow turbine wheel or wheels d, d', d^2. The first wheel d and the last wheel d^2, if two or more wheels are required, are preferably specially formed, as shown, while the intermediate wheels d' are formed alike. The first wheel d comprises a flanged body or drum d^3, a web d^4 and blades d^5, which are generally radial in arrangement, although they are preferably curved somewhat as shown. A conical cap d^6, secured to the drum d^3, directs the incoming gases outward toward and between the blades d^5. The wheel d^2 is in general similarly formed, with a drum or body d^3 and blades d^5, the plate d^4 being in this case provided with a webbed hub d^7 by which this wheel and the others carried by it are mounted upon the shaft h'. Each of the intermediate wheels g' likewise comprises a drum or body d^3, a web or plate d^4 and blades d^5. The several wheels are so formed that they can be bolted together readily in any required number. As will be noted the plate or web d^4 of each wheel except the last preferably stands about midway in the chamber in which it is located, and its outside diameter is less than that of such chamber, so that the exhaust gases which have passed between the blades of each wheel may then pass over the periphery of the web or plate d^4 to the opening g^2 of the next dividing wall g' in proper relation to the blades d^5 of the next turbine wheel.

It has been stated above that the turbine wheels are practically identical, but it will be understood that in affixing the spirally curved blades to each wheel, the blades of each successive wheel preferably have a greater pitch than those of the preceding wheel so that each wheel shall have the same rotative effect notwithstanding the reduction in the velocity of the exhaust gases at succeeding wheels.

It will now be understood that in the operation of the silencer the exhaust gases, passing between the blades or vanes of the turbine wheels, cause such wheels to rotate and as the wheels are comparatively heavy they acquire considerable momentum so that their rotation is continued at a high speed between exhaust impulses without regard to the speed of the engine. The energy of the exhaust gases, at each impulse, is absorbed to a considerable degree in rotating the wheels so that such gases eventually issue from the muffler with greatly reduced pressure and velocity, thereby eliminating largely the noise of explosion. Furthermore, the centrifugal action of the rapidly rotating wheels upon the gases not only causes the gases to be discharged at the peripheries of the wheels but, between the impulses, it tends to create a partial vacuum between the engine and the silencer and therefore augments or accelerates the exhaustion of the dead gases from the cylinder after the passage of the high pressure impulse.

It will be understood that the invention is not limited to the precise form and details of construction shown in the drawings, but that the same may be changed to suit different conditions of use.

I claim as my invention:

1. An exhaust silencer adapted for use with gas engines and so forth comprising a cylindrical shell built up of units each comprising a flange and a substantially transverse partition plate provided with a central opening and forming a series of chambers within said shell, a built-up radial flow turbine coöperating with said casing and comprising a series of units each comprising a central drum, an attached radial web and spiral turbine blades coöperating with one of the partition plates in each of said chambers and leaving free the circumferential portion of said chamber in communication through the central opening in the opposite partition plate with the succeeding chamber, a connection to admit exhaust gases to one end of said casing adjacent the central portion thereof and a conical cap in the path of said gases to spread and direct them through the blades of the first turbine of said series.

2. An exhaust silencer adapted for use with gas engines and so forth comprising a cylindrical shell built up of units each comprising a flange and a substantially transverse partition plate provided with a central opening, and forming a series of chambers within said shell, a built-up radial flow turbine coöperating with said casing and comprising a series of units each comprising an attached radial web and spiral turbine blades coöperating with one of the partition plates in each of said chambers and leaving free the circumferential portion of said chamber in communication through the central opening in the opposite partition plate with the succeeding chamber, a connection to admit exhaust gases to one end of said casing.

3. An exhaust silencer adapted for use with gas engines and so forth comprising a shell built up of units each comprising a flange and a substantially transverse partition plate provided with a central opening, and forming a series of chambers within said shell, a built-up radial flow turbine cooperating with said casing and comprising

a series of units each comprising an attached radial web and spiral turbine blades leaving free the circumferential portion of said chamber in communication through the central opening in the opposite partition plate with the succeeding chamber.

4. An exhaust silencer adapted for use with gas engines and so forth comprising a shell built up of units each comprising a flange and a partition plate provided with a central opening, and forming a series of chambers within said shell, a turbine coöperating with said casing and comprising a series of units each comprising an attached radial web and turbine blades leaving free the circumferential portion of said chamber in communication through the central opening in the opposite partition plate with the succeeding chamber.

5. An exhaust silencer adapted for use with gas engines and so forth comprising a cylindrical shell comprising flanges and substantially transverse partition plates each provided with a central opening and forming a series of chambers within said shell, a radial flow turbine coöperating with said casing and comprising a central drum, attached radial webs and spiral turbine blades coöperating with one of the partition plates in each of said chambers and leaving free the circumferential portion of said chamber in communication through the central opening in the opposite plate with the succeeding chamber, a connection to admit exhaust gases to one end of said casing adjacent the central portion thereof and a conical cap in the path of said gases to spread and direct them through the blades of the first turbine of said series.

6. An exhaust silencer adapted for use with gas engines and so forth comprising a cylindrical shell comprising flanges and substantially transverse partition plates each provided with a central opening and forming a series of chambers within said shell, a radial flow turbine coöperating with said casing and comprising attached radial webs and spiral turbine blades coöperating with one of the partition plates in each of said chambers and leaving free the circumferential portion of said chamber in communication through the central opening in the opposite partition plate with the succeeding chamber, a connection to admit exhaust gases to one end of said casing.

7. An exhaust silencer adapted for use with gas engines and so forth comprising a shell comprising flanges and substantially transverse partition plates each provided with a central opening and forming a series of chambers within said shell, a radial flow turbine coöperating with said casing and comprising spiral turbine blades and leaving free the circumferential portion of said chamber in communication through the central opening in the opposite partition plate with the succeeding chamber.

8. An exhaust silencer adapted for use with gas engines and so forth comprising a shell comprising partition plates each provided with a central opening and forming a series of chambers within said shell, a turbine coöperating with said casing to be substantially coaxial with said openings and comprising turbine blades and leaving free a portion of some of said chambers in communication through the central opening in the opposite partition plate with the succeeding chamber.

9. An exhaust silencer adapted for use with gas engines and so forth comprising a shell comprising substantially transverse partition plates each provided with a central opening and forming a series of chambers within said shell, a radial flow turbine coöperating with said casing and comprising spiral turbine blades and leaving free the circumferential portion of each of said chambers in communication through the central opening in the opposite partition plate with the succeeding chamber, said blades having an increasingly greater pitch in the successive chambers through which the exhaust passes.

10. An exhaust silencer adapted for use with gas engines and so forth comprising a cylindrical shell provided with substantially transverse partition plates provided with central openings to form a series of chambers in said shell, a rotating drum mounted within said shell and having webs extending within each of said chambers and leaving free the circumferential portions of said chambers to direct the exhaust material outward through each chamber around the web and then radially inward on the other side of said web and through the central opening to the succeeding chamber and a series of spiral curved vanes on each of said webs forming narrow spiral channels through which the exhaust passes in its radial passages, said vanes having an increasingly greater pitch in the successive chambers through which the exhaust passes.

11. An exhaust silencer adapted for use with gas engines and so forth comprising a shell provided with partition plates provided with central openings to form a series of chambers in said shell, a drum mounted within said shell and having webs extending within each of said chambers and leaving free the circumferential portions of said chambers to direct the exhaust material outward through each chamber around the web and then radially inward on the other side of said web and through the central opening to the succeeding chamber and a series of spiral curved vanes on each of said webs forming narrow spiral channels through which the exhaust passes in its

radial passages, said vanes having an increasingly greater pitch in the successive chambers through which the exhaust passes.

12. An exhaust silencer adapted for use with gas engines and so forth comprising a shell provided with partition plates provided with central openings to form a series of chambers in said shell, a drum mounted within said shell and having webs extending within each of said chambers and leaving free portions of said chambers to direct the exhaust material outward through each chamber around the web and then radially inward on the other side of said web and through the central opening to the succeeding chamber and a series of spiral curved vanes on each of said webs forming narrow spiral channels through which the exhaust passes in its radial passages.

13. An exhaust silencer adapted for use with gas engines and so forth comprising a shell provided with partition plates provided with central openings to form a series of chambers in said shell, webs extending within each of said chambers and leaving free portions of said chambers to direct the exhaust material outward through each chamber around the web and then radially inward on the other side of said web and through the central opening to the succeeding chamber and a series of spiral curved vanes forming narrow spiral channels through which the exhaust passes in its radial passages.

14. An exhaust silencer adapted for use with gas engines and so forth comprising a shell provided with partition plates to form a series of chambers in said shell, webs extending into said chambers to direct the exhaust material outward through said chambers around the webs and then radially inward through central openings provided in said partition plates into the succeeding chambers and curved vanes in said chambers forming narrow channels through which the exhaust is guided in passing successively through a series of said chambers.

15. An exhaust silencer adapted for use with gas engines and so forth comprising a shell provided with partitions to form a series of chambers in said shell, and curved vanes in said chambers forming narrow channels through which the exhaust is guided in passing successively through a series of said chambers, the outer portions of said chambers being left free to allow circulation of the exhaust around the same.

16. An exhaust silencer adapted for use with gas engines and so forth comprising a shell provided with partitions to form a longitudinal series of communicating chambers in said shell, webs and curved vanes forming narrow gas channels extending into said chambers and leaving free the circumferential portions thereof in which to allow circulation of exhaust material, to thereby direct the exhaust material outward through each of said chambers around the web and then inward through central openings provided in said partitions into the succeeding chambers, and effect its passage through said channels in passing successively through a series of said chambers.

17. An exhaust silencer adapted for use with gas engines and so forth comprising a shell provided with partitions to form a series of communicating chambers in said shell, webs and vanes forming narrow gas channels extending into said chambers and leaving free the circumferential portions thereof in which to allow circulation of exhaust material, to thereby direct the exhaust material outward through each of said chambers and then inward through openings provided in said partitions into the succeeding chambers and effect its passage through said channels in passing successively through a series of said chambers.

18. An exhaust silencer adapted for use with gas engines and so forth comprising a shell provided with partitions to form a series of communicating chambers in said shell, webs and vanes forming channels extending into said chambers and leaving free the circumferential portions thereof in which to allow circulation of exhaust material around the inside of said shell, to direct the exhaust material through each of said chambers around said webs and partitions in passing successively through a series of said chambers.

This specification signed and witnessed this 21st day of November, A. D., 1910.

HIRAM PERCY MAXIM.

Signed in the presence of—
R. R. SEYMOUR,
S. R. OSBORN.