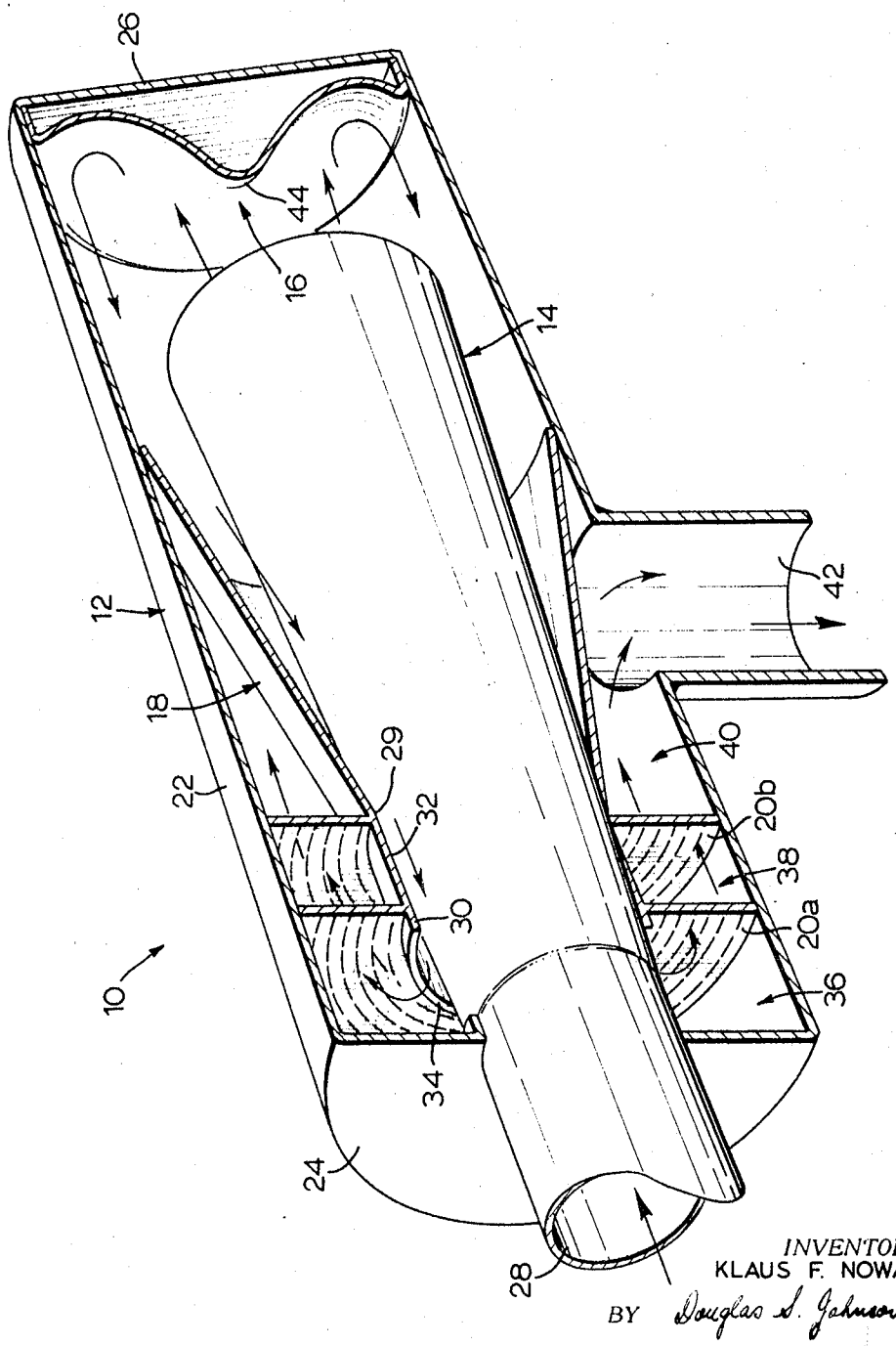
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EXHAUST SYSTEM FOR TWO-STROKE ENGINES

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INVENTOR.
KLAUS F. NOWAK
BY Douglas A. Johnson

Attorney

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EXHAUST SYSTEM FOR TWO-STROKE ENGINES

Klaus Frederick Nowak, 12 Weatherstone Crescent, Willowdale, Ontario, Canada

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ABSTRACT OF THE DISCLOSURE

An exhaust system for two-stroke engines, wherein a divergent cone and a convergent cone are fitted within a sleeve having ends, so that the converging cone overlies the diverging cone. Sound muffling baffles may be installed beyond and over the outlet end of the converging cone; and a reflector plate may be installed beyond the wide end of the diverging cone.

FIELD OF THE INVENTION

This application relates to an exhaust system for two-stroke engines. In particular, the application relates to an exhaust system for two-stroke engines which can increase the performance and output of a two-stroke engine both with respect to brake horsepower and torque at any given r.p.m., and as well provides a sound dampening or muffling effect.

BACKGROUND OF THE INVENTION

The use of two-stroke engines has greatly increased due to many factors. Included among them are the vastly increased market for engine driven vehicles adapted to be driven over snow and/or water; as well as a vastly increased market in small and medium sized motorcycles, scooters and powered bicycles. Additionally, many tools such as hammers and rodding machines for the construction industry, chain saws and the like have been developed which are self-powered. Also, many racing events wherein powered vehicles of one sort or another compete in classes—generally designated according to engine displacement and weight—are being organized. The effect of all of these factors has been a greater demand for two-stroke engines, particularly of the small and medium displacement ranges, and for higher output from such engines.

One way in which the output of a two-stroke engine may be increased is by mating the engine to a properly tuned exhaust system. By so doing, the exhaust system may then provide a supercharging effect and a more efficient scavenging to the two-stroke engine, and increased output is achieved. The present invention provides an exhaust system for two-stroke engines whereby the output of the engine may be increased, thereby increasing engine efficiency, and whereby the exhaust system provided is compact in size.

DISCUSSION OF THE PRIOR ART

Many studies have been made having to do with theoretical and empirical improvements in the efficiency of two-stroke engines. Particularly, attention has been paid to small two-stroke engines of the 50 to 600 cc. displacement range. Notable among such studies are two publications of the Society of Automotive Engineers Inc., namely Paper No. 660009, "The Present Day Efficiency and the Factors Governing the Performance of Small Two-Stroke Engines" by Claus Waker given at the Automotive Engineering Congress, Detroit, Mich., Jan. 10–14, 1966; and Paper No. 680469, "Investigation and Tuning of the Exhaust System of Small Two-Stroke Cycle Engines" by Wilhelm A. Huelsse given at the Mid-Year Meeting, Detroit, Mich., May 20–24, 1968.

From the aforenoted papers, it becomes evident that the efficiencies of two-stroke engines may be increased by using exhaust systems in which a divergent cone is in communication with the outlet of the engine, and which exhaust system may further include convergent cones, stepped orifices and/or other exhaust outlets. However, the length of an exhaust system such as those discussed in the S.A.E. papers mentioned above is quite substantial, depending on the engine r.p.m. at rated output. For example, exhaust systems as discussed in the S.A.E. papers are upwards of 750 millimeters or 30 inches for a very small engine of 50 cc. displacement and 7000+ r.p.m., up to nearly 2500 millimeters or over 110 inches for two-stroke engines of the 500+ cc. displacement range and 3000 r.p.m. Obviously, such long exhaust systems are adaptable, if at all, only to such devices as motorcycles.

A properly tuned exhaust system will develop pressure waves which travel back and forth in the exhaust system, and arrive at the open exhaust port of the engine at the proper time so as to provide scavenging and/or supercharging effects to the engine. The attempt is made, therefore, in any exhaust system for a two-stroke engine which is designed to increase the efficiency of the engine, to have a back-pressure wave arrive at the exhaust port as it is closing and during fuel injection so as to provide a super-charging effect; and to have a negative pressure or gauge vacuum presented at the exhaust port during cylinder scavenging. Because the precise dimensions of an exhaust system are dependent upon many factors of the engine, including displacement, compression ratio, crank case compression ratio type of scavenging system used, etc., the present invention is not related directly to the physical size of an exhaust system. Rather, the present invention relates to an exhaust system for two-stroke engines which, when properly dimensioned, increases the efficiency of any two-stroke engine; and examples are given of an exhaust system related to a specific engine whose performance characteristics are known and, whereby the efficiency of the engine is greatly increased.

SUMMARY OF THE INVENTION

The present invention, therefore, provides an exhaust system for two-stroke engines wherein there is provided a divergent cone which communicates with the exhaust port of the engine, and a converging cone which overlies the diverging cone to some extent and whose greatest diameter is therefore somewhat larger than the greatest diameter of the diverging cone. Additionally, the present invention may provide a reflector plate near the wide end of the diverging cone, and sound muffing baffles which are in communication with the converging cone so as to provide a sound reducing effect to the exhaust of the two-stroke engine.

BRIEF DESCRIPTION OF THE DRAWING

A more complete description of the exhaust system for two-stroke engines according to this invention follows in association with the single figure of drawings which illustrates, in partial and perspective cross-section, an exhaust system made according to this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The exhaust system shown generally at **10** basically comprises an outer shell **12** within which there is assembled a diverging cone **14**, a reflector **16**, converging cone **18** and baffles **20***a* and **20***b*. In general, the assembly is made of such material as steel, and is welded. However, the exact assembly details of the exhaust system are irrelevant to the present discussion.

The outer shell **12** comprises a cylindrical sleeve **22** to which end plates **24** and **26** are attached. Except as noted hereafter, the envelope enclosed by sleeve **22** and end plates **24** and **26** is substantially gas tight.

An exhaust pipe **28** which communicates with the exhaust port of the two-stroke engine passes through the end plate **24** and into the interior of the shell **12**. The divergent cone **14** is attached to, and extends from, exhaust pipe **28** within shell **12**. It will be noted that the length of the divergent cone **12** is such that it does not extend to within very close proximity of the end **26** of the shell **12**, but stops some distance short thereof.

Also situated within shell **12** is converging cone **18**. The largest diameter of cone **18** is such that the cone sits against the sleeve **22** at its large end; and the large end of cone **18** is closer to the end **24** of shell **12** than is the large end of cone **14**. At the rear or small end of converging cone **18** there is a portion **30** thereof of substantially constant diameter, which diameter is somewhat larger than the diameter of the diverging cone **14** taken at the same distance from end **24** of shell **12** as the start of the substantially constant diameter portion of diverging cone **14**. The start of the substantially constant diameter portion of converging cone **18** is indicated in the drawing at **29**. Because of the diameter of the rear portion **30** of cone **18** is greater than any diameter of cone **14** measured along cone **14** beneath where portion **30** overlies the same, a somewhat annular passage **32** of increasing passage width is provided between the inner surface of cone **18** and the outer surface of cone **14**.

It is also noted that the end **34** of cone **18** is spaced axially along the interior of shell **12** from the end **24**. Also, it will be noted that the baffles **20***a* and **20***b*, which are slotted so as to allow gas flow therethrough, extend radially outwards from the rear portion **30** of cone **18** to contact the inner surface of the sleeve **22**.

It is now seen that there are several enclosed volumes within the shell **12** of the exhaust system **10** of this invention. The enclosed volumes of particular significance to this discussion are: the interior of exhaust pipe **28** and diverging cone **14**; the volume beyond the end of diverging cone **14** to reflector plate **16**; the interior of converging cone **18** exterior of diverging cone **14**; the passageway **32** between rear section **30** of converging cone **18** and the exterior surface of diverging cone **14**; the volume **36** between end plate **24** and first baffle **20***a* exterior of diverging cone **14**; volume **38** exterior of rear section **30** of converging cone **14** and between baffles **20***a* and **20***b*; and volume **40** which lies forward of baffle **20***b* exterior of converging cone **18**. The enclosed volumes **36**, **38** and **40** are all bounded at their peripheries when considered with respect to the longitudinal axis of shell **12** by the interior surface of the sleeve **22**.

Also communicating with the enclosed volume **40** is an outlet pipe **42** which conducts the exhaust gases away from the exhaust system of this invention to the atmosphere.

The exhaust gas flow within the exhaust system for two-stroke engines according to this invention is indicated by the flow arrows shown on the drawing. As can be seen, the exhaust gases enter the exhaust pipe **28** from the two-stroke engine and flow through the diverging cone **14**. On exiting from the diverging cone **14**, the exhaust gas impinge upon the reflector plate **16** and the flow of the exhaust gases is reversed as indicated in the drawing. The gases then flow into the converging cone **18** and through the passageway **32** into the enclosed volume **36**. Within the enclosed volume **36** the direction of the flow of gases is again reversed, and the gases flow through the baffle **20***a*, through the enclosed volume **38**, through the baffle **20***b* and into the enclosed volume **40** whence they are removed to the atmosphere through outlet pipe **42**.

The shape of the reflector plate **16** is illustrated as having a centrally located peak **44** facing along the axis of the exhaust system **10** into the wide end of diverging cone **14**. The reflector plate is also shown as being upturned at its periphery adjacent the interior of the sleeve **22**, with an annular depression between the peak and the upturned periphery. Obviously, such a shape for the reflector plate **16** provides a more complete reversal of the exhaust gas flow out of diverging cone **14** into the converging cone **18**, and also more readily assures that the exhaust gas flow will change from a somewhat axial flow as it leaves diverging cone **14** to an annular flow as it enters the converging cone **18**. However, it is not absolutely necessary that the reflector plate **16** has the shape as shown, or indeed that the reflector plate be installed within the exhaust system **10**. The reversal of the gas flow and the change from axial to annular flow may be effected by the gas impinging upon the end plate **26**. However, as will appear more evident hereinafter, a reflector plate **16** having a shape somewhat as illustrated assures a more efficient operation of the exhaust system **10** over a wider r.p.m. range for any given two-stroke engine.

It is evident that any tuned exhaust system for a two-stroke engine must be related physically as to its size to the engine with which the exhaust system is operating. Thus, an exhaust system which may be tuned for a 50 cc. engine having a maximum output at 7400 r.p.m. may be entirely unsuitable for a 350 cc. engine having a maximum output at 5000 r.p.m. However, the precise dimension of the exhaust system according to this invention as it may be prepared for any two-stroke engine may be readily ascertained by one skilled in the art, provided that the engine characteristics are known; particularly engine displacement, engine r.p.m. for peak output, compression ratio, crank case ratio, the type of scavenging and the timing cycle of the engine. That is to say, knowing the above characteristics of the two-stroke engine to which the exhaust system is to be mated, the dimensions of the exhaust system can be determined so as to set up a standing wave within the exhaust system in such a way that the back-pressure and the gauge vacuum arrive at the exhaust port of the engine at the appropriate times during the engine cycle.

However, it has been found that for a most efficient exhaust system for a two-stroke engine according to this invention, and for compactness of the assembled exhaust system, the angle of divergence of the diverging cone **14** should be between 5° and 8°, and the angle of divergence of the converging cone **18** should be between 15° and 40°.

As it has been stated above, the precise design of the baffles **20***a* and **20***b* is irrelevant, and is dependent upon the amount of sound muffling required and as well on the engine characteristics of the engine to which the exhaust system is mated.

It should also be noted that the rear portion **30** of the converging cone **18** may be of somewhat decreasing diameter, so that the width of passageway **32** between the outside of diverging cone **14** and the inside of the rear portion **30** remains constant.

It will be seen that—apart from the standing wave which may be set up in the exhaust system at any constant engine r.p.m.—because there is mass flow of exhaust gases through the system there is an expansion of the gases as they leave diverging cone **14**; a compression of the gases as they flow through the converging cone **18** and the gas passageway **32**; an expansion of the gases in the enclosed volume **36**; and a recompression of the gases as they flow into the enclosed volume **40**. In this manner, the direction of flow of the exhaust gases from the engine is assured without unnecessary back-pressures occurring to impede the flow, particularly through the passageway **32**. Also, the precise configuration of reflector plate **16** and end plates **24** and **26** are not critical, although as mentioned, the reflector plate **16** when as illustrated assumes a more complete flow reversal.

By way of example, there follows a brief discussion of tests which were performed with an exhaust system made according to this invention mated to an engine as dis-

cussed below. The engine which was used during the tests was one which was specifically intended for installation in snow-mobiles. The engine had a displacement of 320 cubic centimetres and had a name plate rating of 17 horsepower at 5500 r.p.m. Three tests were performed, the first being with the exhaust system and muffler as supplied by the manufacturer with the engine, the second with an open pipe 15 inches long, and the third with an exhaust system according to this invention.

With respect to the particular exhaust system used, its overall length was 13 inches, its overall diameter 4 inches and the large end of the diverging cone **14** was 3 inches from the end **26** while the large end of the converging cone **18** was 5 inches from the end **26** of the shell **12**. The first baffle **20***a* was placed 2 inches from the end **24** and the baffle **20***b* was spaced 1 inch from baffle **20***a*. The diameter of the constant diameter rear portion **30** of diverging cone **18** was 2 inches while the diameter of the diverging cone **14** immediately beneath baffle **20***b* was 1⅞ inches. The diameter of the exhaust pipe **28** was 1½ inches, and the diameter of the open end of diverging cone **14** was 2½ inches. A reflector plate of the sort illustrated in the figure was used.

The following table shows some dynamometer readings taken at various r.p.m. of the engine, and indicates both output torque in foot pounds and brake horsepower:

TABLE

	With open pipe		With tuned exhaust system	
Engine, r.p.m.	BHP	Torque (ft. lbs.)	BHP	Torque (ft. lbs.)
3,500	10.2	15.8	10.0	15.5
4,000	12.3	16.6	12.4	16.7
4,500	14.2	16.9	14.7	17.7
5,000	15.7	16.9	17.0	18.3
5,500	16.8	16.5	19.1	18.6
6,000	15.4	13.8	19.3	17.3

It should be noted that the table indicates figures only for the 15 inch long open pipe and the tuned exhaust system according to this invention. All of the test results taken with the normal muffler supplied by the engine manufacturer were lower than the test results taken with the open pipe.

It is seen from the table, that except at the relatively low engine r.p.m. of 3500, the tuned exhaust system made according to this invention significantly increased the output of the engine. As noted, the rated output of the engine was 17 horsepower at 5500 r.p.m. and it is noted that with the open pipe at 5500 r.p.m. the brake horsepower was 16.8 whereas with the tuned exhaust system according to this invention the brake horsepower was 19.1. Additionally, it will be noted that at r.p.m. higher than rated, the brake horsepower and torque of the engine both fell off significantly when the open pipe was used whereas the torque fell off a lesser amount with the tuned exhaust system while the brake horsepower actually increased. Also, it will be noted that the torque output of the engine peaked at the rated r.p.m. when the exhaust system according to this invention was used, whereas it peaked at somewhat lower r.p.m. with the open pipe.

Other tests have indicated that, when no reflector plate is installed in the exhaust system, the maximum BHP and torque output available from the engine were slightly less; and that the torque output tended to peak at r.p.m. slightly less than rated r.p.m.

There has been described an exhaust system for two-stroke engines which can increase the output of the engine while, at the same time, being of compact size representing both an economy in weight, material cost and manufacturing cost, and which also provides a noise muffling effect. The principle of the operation of the exhaust system according to this invention has been discussed, and a specific example has been given for purposes of illustration.

I claim:

1. An exhaust system for a two-stroke engine comprising:

a cylindrical shell having first and second ends;

a first cone axially situated within said shell having its narrow end near the first end of said shell and its wide end spaced apart from the second end of said shell, the narrow end of said diverging cone being adapted for communication with the exhaust port of a two-stroke engine;

a second cone axially situated within said shell so that it overlies said first cone, and having its wide end in contact with the inside surface of said cylindrical shell and spaced further apart from the second end of said shell than the spacing of the wide end of said first cone;

the narrow end of said second cone being spaced apart from the first end of said shell and radially spaced apart from the outside surface of said first cone so as to provide a gas passageway therebetween;

an extension of said second cone overlying said first cone and having an angle of divergence less than the angle of divergence of said second cone so as to provide a gas passageway between the inside surface thereof and the outside surface of said first cone and being spaced apart from said first end of said shell;

and an outlet pipe communicating with the interior of said shell closer to said first end thereof than the contact between the wide end of said second cone and the inside surface of said shell.

2. The exhaust system of claim **1** further comprising at least one sound muffling baffle placed radially outwardly from the outside surface of said extension of said second cone.

3. The exhaust system of claim **2** further comprising a reflector plate spaced from the wide end of said first cone; said reflector plate having a centrally located peak facing along the axis of said first cone, and being upturned in the same direction as said peak at the periphery of said plate.

4. The exhaust system of claims **1**, **2** or **3** wherein the angle of divergence of said first cone is from 5° to 8°; the angle of divergence of said second cone is from 15° to 40°; and the angle of divergence of said extension of said second cone is 0°.

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CARLTON R. CROYLE, Primary Examiner

DOUGLAS HART, Assistant Examiner

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