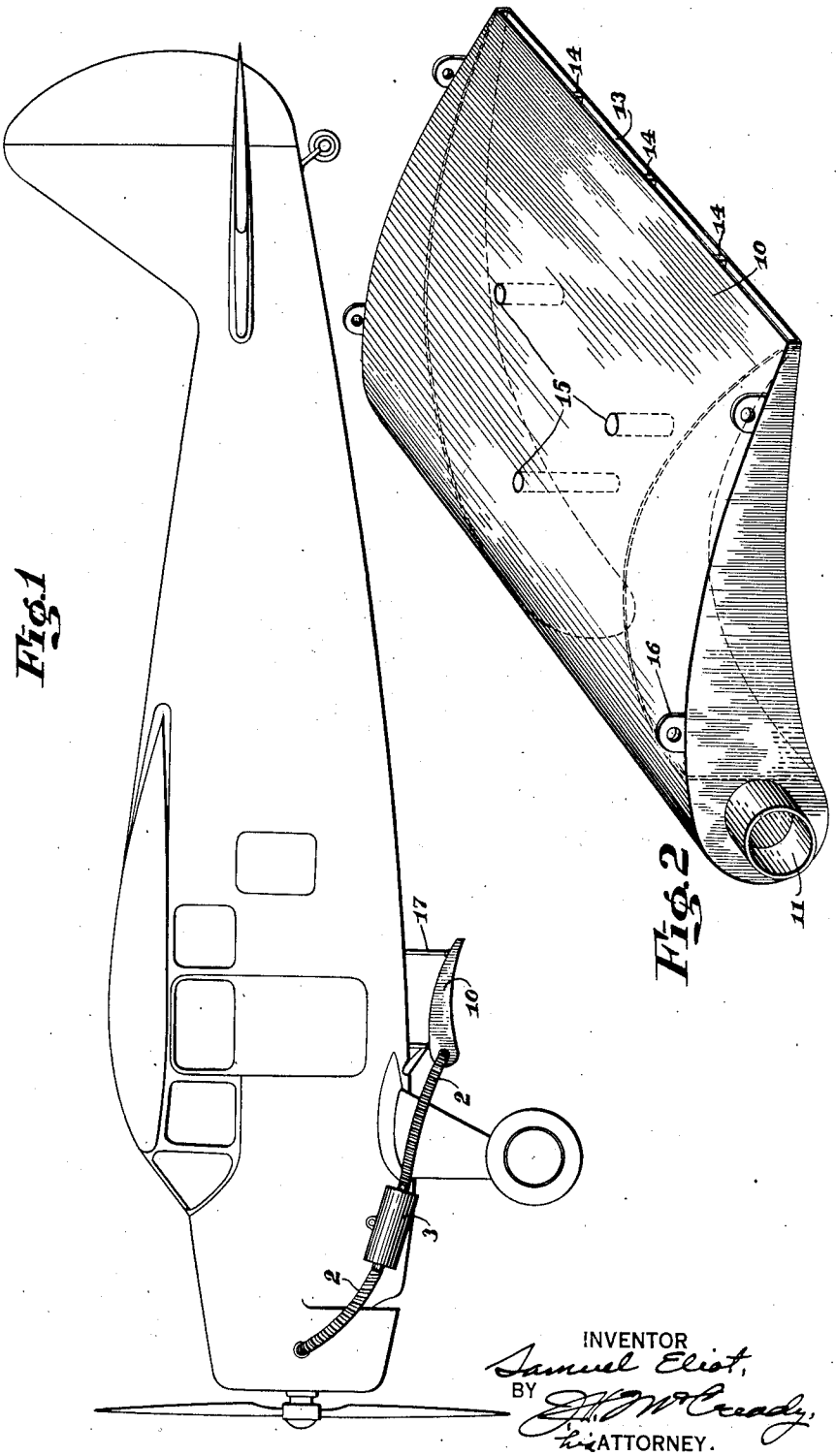
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MUFFLER FOR INTERNAL COMBUSTION ENGINES

Filed June 28, 1939 2 Sheets-Sheet 1



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Fig. 3

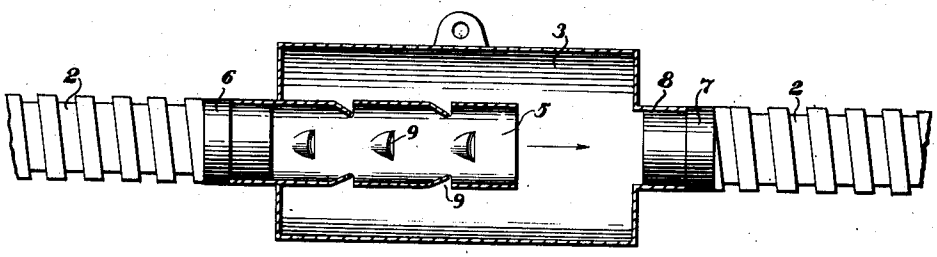


Fig. 4

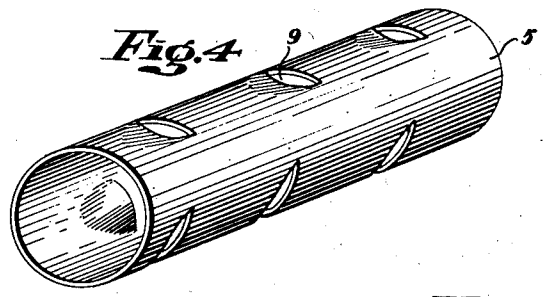
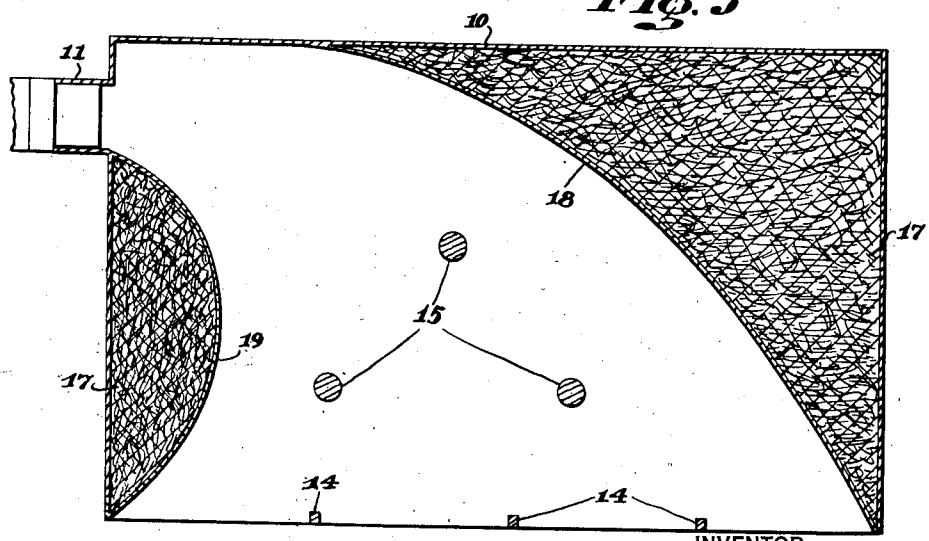


Fig. 5



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MUFFLER FOR INTERNAL COMBUSTION ENGINES

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10 Claims. (Cl. 181—51)

This invention relates to apparatus (commonly referred to as a muffler) for silencing the discharge of exhaust gases from an internal combustion engine.

While the desirability of silencing the exhaust of air plane engines has long been recognized, such engines have rarely been equipped with muffling apparatus because of the fact that it builds up a back pressure which, of course, reduces the efficiency of the engine.

It is the chief object of this invention to devise a muffler and a method of muffling which will reduce the noise of the exhaust of an airplane engine to within reasonable limits without building up any serious back pressure.

The nature of the invention will be readily understood from the following description when read in connection with the accompanying drawings, and the novel features will be particularly pointed out in the appended claims.

In the drawings:

Figure 1 is a diagrammatic view illustrating an airplane having my improved muffler mounted thereon;

Fig. 2 is a perspective view illustrating the terminal or discharging element of the muffler;

Fig. 3 is a view in side elevation and partial cross-section of another element of the muffler;

Fig. 4 is a detail perspective view of the injector tube shown in Fig. 3; and

Fig. 5 is a cross-sectional plan view taken on a median plane through the unit shown in Fig. 2.

According to the method provided by this invention the exhaust gases are first conducted through a stage in which they are allowed to expand, to cool down somewhat, and in which, also, the impulses are smoothed out and the noise of the exhaust correspondingly reduced. This stage corresponds in a general way to the typical action of a muffler of the types heretofore used, although the invention involves a novel unit adapted to perform these functions. For convenience this unit may be referred to as an expansion chamber. If such a device were used alone some back pressure necessarily would be built up because of the fact that the entire flow through it is created by the internal pressure of the gases, that there necessarily is some frictional resistance to such flow, and also because these gases must be discharged against the pressure of the external atmosphere. According to this invention, however, the gases are conducted from this expansion and silencing stage through a discharging stage and the forward motion of the airplane is utilized to create a suction or vacuum which draws the gases out of the expansion chamber and thereby reduces very materially the back pressure which otherwise would be created therein. If the apparatus provided to operate in accordance with this method is properly designed, the silencing and cooling of the gases may be made highly effective, and at normal plane speeds the back pressure may be neutralized and replaced by a negative pressure.

Referring now to the drawings, a pipe leading from the exhaust manifold of an internal combustion engine driving the airplane shown in Fig. 1 is indicated at **2**. Interposed in this pipe is a muffler unit forming a novel feature of this invention and comprising a casing or expansion chamber **3**, Figs. 1 and 3, of a diameter considerably larger than that of the pipe. This chamber should have ample volume to permit a very substantial expansion of the gases. The casing may be secured by means of suitable brackets to any convenient point on the plane structure, but preferably in some location where its surfaces will be exposed to the outside atmosphere.

As best shown in Figs. 3 and 4, the muffler unit includes an intake tube **5** connected directly to one section of the exhaust pipe **2** and fixed securely in the wall of the casing. It projects for a considerable distance into the chamber and terminates at a point opposite, but spaced considerably from, the tubular outlet **8** from this casing. At various points along its length the material of the intake tube **5** is punched inwardly to provide openings **9** which are so shaped as to form louvers.

As the hot exhaust gases discharged by the engine flow through the tube **5** and into the chamber, they expand rapidly, filling the chamber, and then escape through the outlet **8** into the second section of the exhaust pipe. The flow of these gases past the louvered openings **9** creates an injector action which results in drawing expanded gases inwardly from the chamber and recirculating them through the tube or pipe **5**. As a result of such expansion and recirculation, the intermittent flow of gases is broken up, such flow is smoothed out and made more nearly continuous through the outlet of the chamber, and the noise of the exhaust is materially reduced. In addition, a pronounced cooling action also is effected because of the sweeping of the heat away from the casing by the passing current of air, and this fact contributes to the muffling or silencing of the exhaust.

From the expansion chamber the gases flow through the second section of exhaust pipe into

the device shown at 10 in Figs. 1, 2 and 5, which may aptly be termed an "exhaust discharger." As above stated, this device is designed to utilize the passing flow of air created by the motion of the airplane, to produce a partial vacuum or suction effect which serves to speed up the discharge of gases from the expansion chamber 3. For this purpose the casing 10 is given an appropriate stream-lined form, resembling rather closely a section of an airplane wing as shown in Figs. 1 and 2. For the same reason it should be located on the plane in some position where the action created on it will be similar to that on one of the wings of the plane: For convenience a casing of this general shape, referring both to length and cross-sectional form, will be designated as an "aerofoil" form. By a casing of "aerofoil" form I mean one having a cross-sectional form from front to rear essentially like that of an airplane wing of the usual type. That is, it has a rounded forward edge and is curved smoothly as it extends backwardly to a relatively thin edge at the rear. This shape of the casing is maintained throughout at least the greater part of its lateral dimension and that dimension is very considerable so that the casing has a large discharging capacity for its dimensions, a long narrow outlet, and creates a substantial degree of vacuum in the surrounding atmosphere at and immediately outside of said outlet. As shown in the drawings, the upper and lower surfaces of this device are curved in much the same manner as a wing, the lower curve preferably being somewhat more concaved than that usual in airplane wings, and the forward edge being smoothly rounded, the whole presenting a typical stream line shape. The exhaust pipe 2 is led into the casing at the inlet nipple 11 located at one side and in the larger end thereof. The casing is tapered rearwardly and is provided at its trailing end with a narrow aperture 13 through which the exhaust gases are discharged, this aperture opening into the atmosphere at a point where a substantial degree of vacuum is maintained by the action of the air currents in flowing past the casing. The casing may conveniently be made of sheet metal, the upper and lower walls being held apart by suitable spacing studs 14 at the trailing edge and by additional studs 15 at intermediate points. Also, intermediate curved plates 18 and 19, Fig. 5, are welded, or otherwise secured, to the top and bottom plates to reduce the resistance to flow of gases through the discharger. The space between these curved plates and the outer plates of the casing preferably is filled with some sound deadening material, such as mineral wool. Without these spacing and sound deadening elements there is a tendency for the plates to set up a drumming sound which, however, is readily eliminated in the manner just described.

A muffler structure such as that above set forth in which the exhaust gases are passed through the two stages referred to has proved very satisfactory. Neither stage alone accomplishes the desired result, but they cooperate with each other to reduce the noise of the exhaust very substantially while reducing or eliminating back pressure. In a simple form of discharger, such as that above described, a very substantial degree of vacuum can be created at airplane speeds. In fact, by suitable designs it may be made sufficient to maintain a negative pressure in the expansion chamber 3, although this is not always necessary to the satisfactory operation of the muffler structure. The point on the discharger surface at which the maximum degree of vacuum or suction will be created will, of course, vary with the design of the discharger as well as with the speed of the vehicle. The particular design shown will produce ample suction at the trailing edge and consequently at the point of discharge of the gases into the atmosphere. In some cases it may be found desirable to locate the discharger in the slip stream of the propeller.

A further and surprising advantage of this construction, as so far used, has been that it eliminates "torching," that is, the discharge of flame from the end of the exhaust pipe. Whether this will be found to be true in a very wide use of the invention is as yet too early to state.

Tests have shown that this invention does effect an increase in engine speeds, other conditions being equal, and that under similar conditions the engine runs cooler.

As above indicated, the invention is particularly valuable as applied to internal combustion engines used in airplanes, but it is also of advantage with engines driving or used on motor vehicles or conveyances of any type in which sufficient speed is developed to make the discharger operate in the manner above described. Accordingly, all such conveyances will, for convenience, be included hereinafter in the term "vehicles." It will also be evident that the particular arrangement of the expansion chamber and discharger, the number of these units used on a given vehicle, and the coupling of them to each other and to the engine or engines, necessarily will be varied in accordance with the requirements of individual installations. Accordingly, while I have herein shown and described a typical construction and arrangement, the invention may be embodied in other forms without departing from the spirit or scope thereof.

Having thus described my invention, what I desire to claim as new is:

1. A muffler structure for the exhaust gases of an internal combustion engine mounted on an airplane or other motor vehicle comprising an expansion chamber for said gases, and a suction-induced discharging means of "aerofoil" form for receiving the gases from said chamber and discharging them into the atmosphere in a region where suction is created by the motion of the vehicle on which it is mounted.

2. A muffler structure for the exhaust gases of an internal combustion engine mounted on an airplane or other motor vehicle comprising an expansion chamber for said gases, and means of "aerofoil" form connected with said chamber for receiving the gases discharged therefrom and discharging them into the atmosphere, said means of "aerofoil" form being constructed and arranged to utilize air currents external thereto and created by the motion of the vehicle on which it is mounted to produce a suction at the point of such discharge into the atmosphere.

3. A muffler structure for the exhaust gases of an internal combustion engine mounted on a motor vehicle, comprising a muffler unit in which the gases are allowed to expand and cool, said unit including means for reducing the pulsations in the gases and smoothing out their flow, means operatively connecting said unit with said engine, and a discharge unit separate from but connected with the first mentioned unit to receive the gases therefrom, the latter unit including a relatively thin casing of "aerofoil" form and provided with a rounded forward edge, whereby the motion of said casing through the atmosphere with the

engine will create a vacuum zone at the external surface thereof, said discharge unit also having a long narrow outlet for said gases through which they are discharged into the atmosphere in said vacuum zone.

4. That improvement in methods of discharging exhaust gases from an internal combustion engine mounted on an airplane or other motor driven vehicle, which consists in passing said gases through a stage in which they are allowed to expand under control and the pulsations in their flow are reduced, cooling the gases in said stage, then conducting them into and through a second stage, separate from the first stage and in which the gases are discharged in a wide flat band into the surrounding atmosphere, and utilizing the motion of the plane or other vehicle to create a substantial degree of negative pressure in the free atmosphere in the entire region at which said gases are so discharged.

5. That improvement in methods of discharging exhausts gases from an internal combustion engine mounted on an airplane or other motor driven vehicle, which consists in passing said gases through a stage in which they are allowed to expand under control and the pulsations in their flow are reduced, cooling the gases in said stage, then conducting them into and through a second stage, separate from the first stage, and in which the gases are discharged in a wide flat band into the surrounding atmosphere, and utilizing the motion of the plane or other vehicle to create a negative pressure both in said second stage and in the entire region at which said gases are so discharged into the atmosphere.

6. A muffler structure for the exhaust gases of an internal combustion engine mounted on an airplane or other motor driven vehicle, said structure comprising a casing of aerofoil form adapted to be connected to the exhaust pipe of an engine and having an elongated exhaust slot opening through the wall of said casing in approximately the region at which maximum suction is created at the outer surface of the casing by the motion of said casing through the atmosphere.

7. A muffler structure for the exhaust gases of an internal combustion engine mounted on an airplane or other motor driven vehicle, said structure comprising a casing of "aerofoil" form provided with an elongated rounded forward edge and upper and lower surfaces extending rearwardly therefrom and converging to a relatively thin rearward edge, said casing being adapted to be connected to an engine exhaust pipe and having an elongated slot extending along the rearward edge thereof for the discharge of the gases into the surrounding atmosphere.

8. A muffler structure for the exhaust gases of an internal combustion engine mounted on an airplane or other motor driven vehicle, said structure comprising a casing of aerofoil form provided with a slot at the rearward portion thereof extending transversely to the direction of motion of the casing for the discharge therethrough of said gases into the atmosphere.

9. A muffler structure for the exhaust gases of an internal combustion engine mounted on an airplane or other motor driven vehicle, said structure comprising a casing of "aerofoil" form having an elongated and rounded forward edge with the walls of said casing approaching each other as they extend rearwardly, said casing having a slot therein flanked by wide smooth outside surfaces along which the flow of free air creates a negative pressure at and outside of said slot, and means for conducting exhaust gases into said casing where they will be discharged through said slot.

10. In an airplane or other high-speed motor vehicle driven by an internal combustion engine, a muffler structure connected with said engine and comprising a chamber in which the exhaust gases from said engine are allowed to expand and cool, and a discharge unit through which the gases from said chamber are conducted, said unit including a casing of aerofoil form, relatively wide in a direction at right angles to the direction of motion of the vehicle, so that a partial vacuum is created by the flow of air over the surfaces of said unit when the vehicle is in motion, said unit having a slot extending along the trailing edge of said casing and disposed transversely to the direction of motion of the vehicle, said slot forming the discharge outlet for said gases into the surrounding atmosphere.

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