No. 854,778. PATENTED MAY 28, 1907.

E. THOMSON.

APPARATUS FOR MUFFLING THE EXHAUST OF GAS ENGINES.

APPLICATION FILED AUG. 20, 1904.

2 SHEETS—SHEET 1.

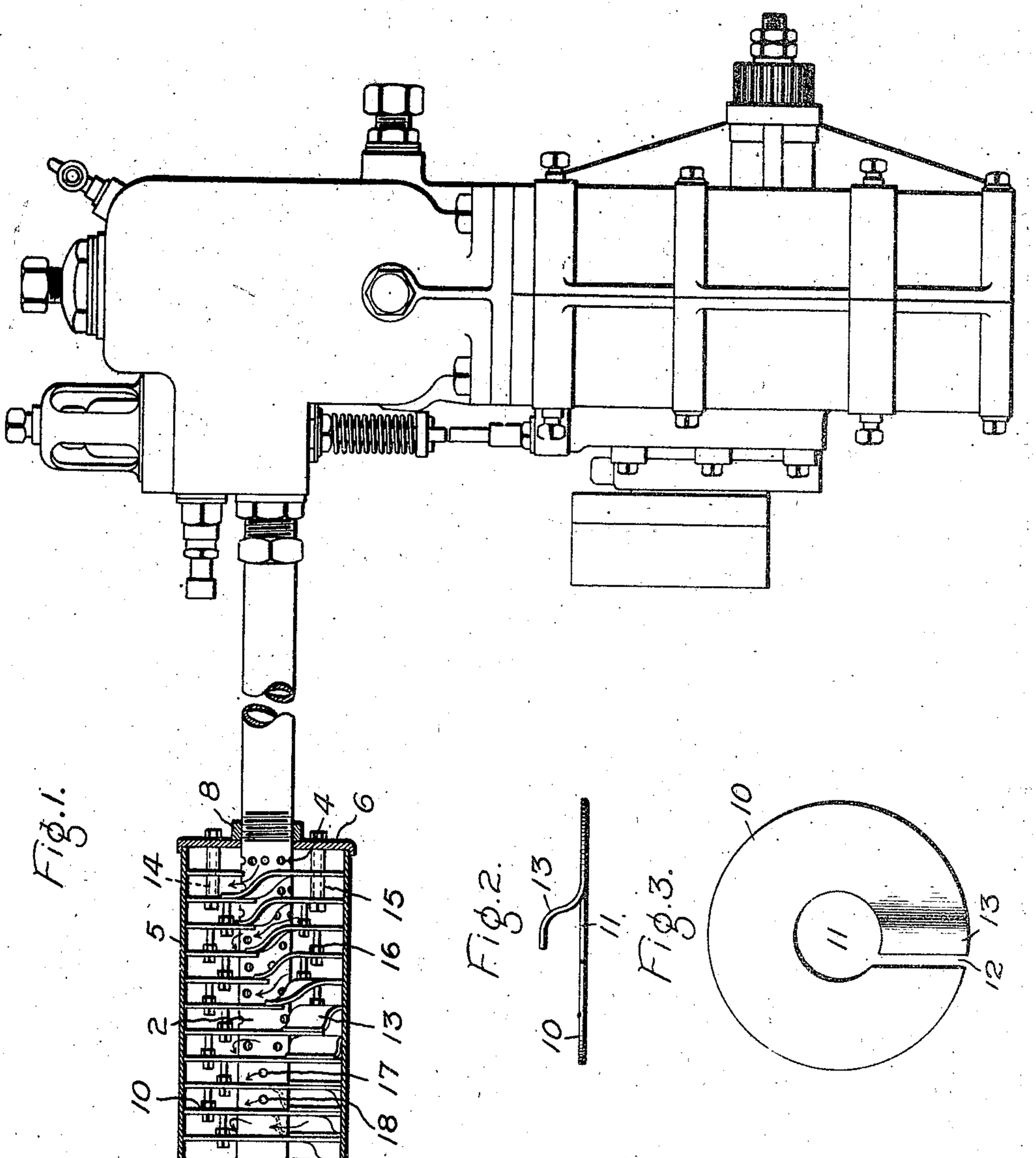

Fig. 1.

Fig. 2.

Fig. 3.

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Fig. 4.

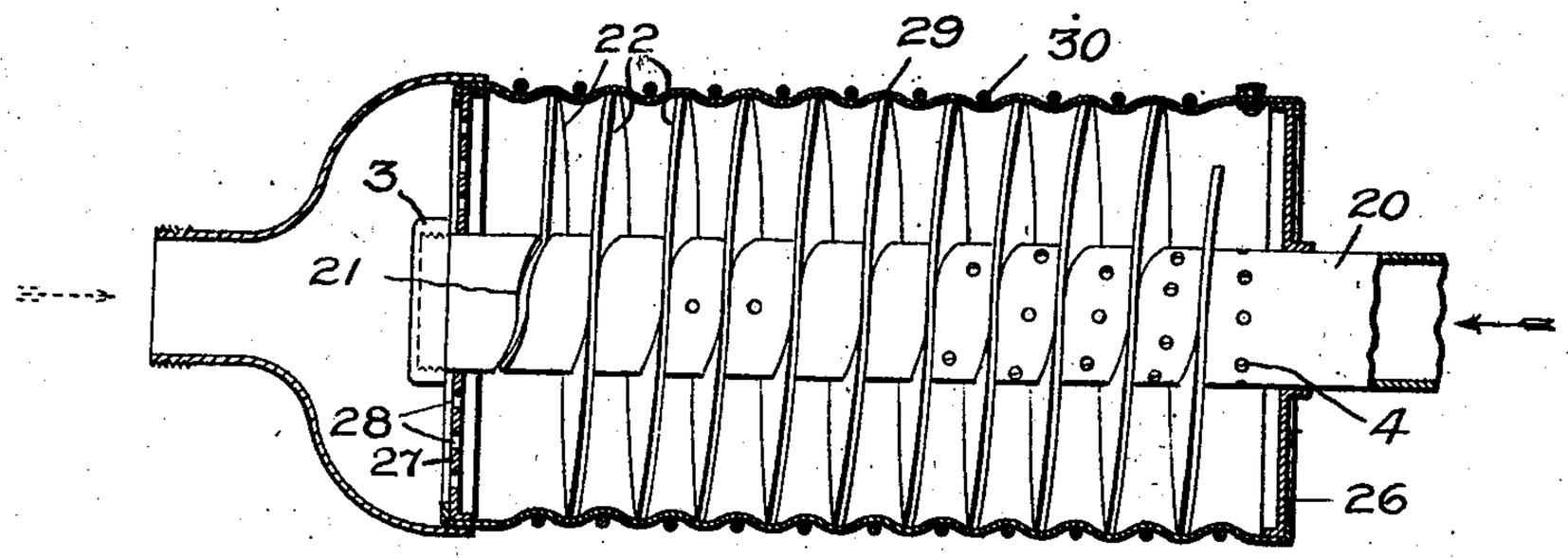


Fig. 5.

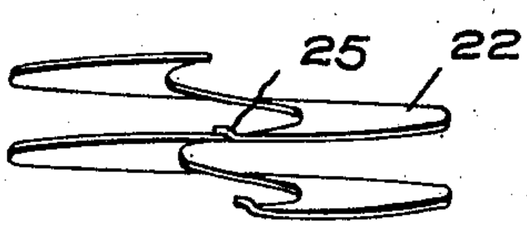


Fig. 7.

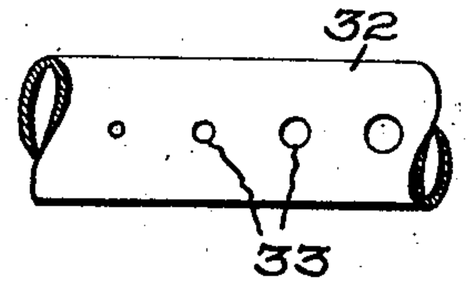


Fig. 6.

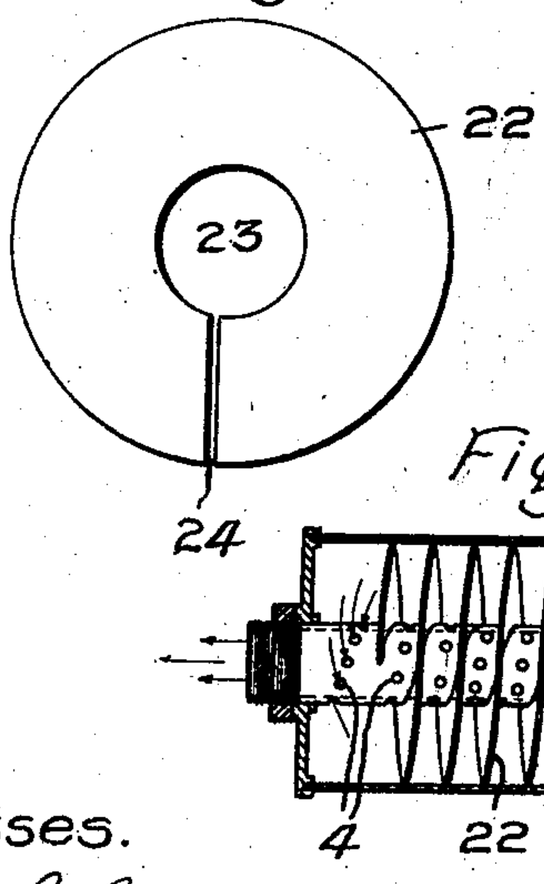


Fig. 8.

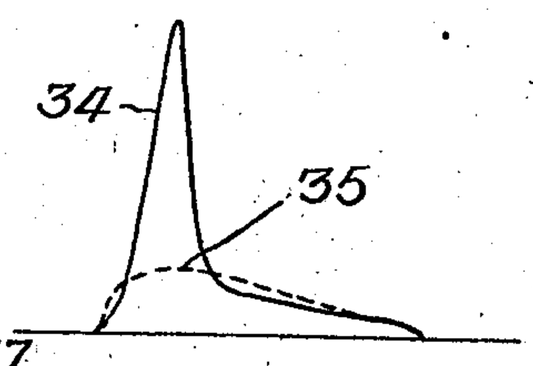
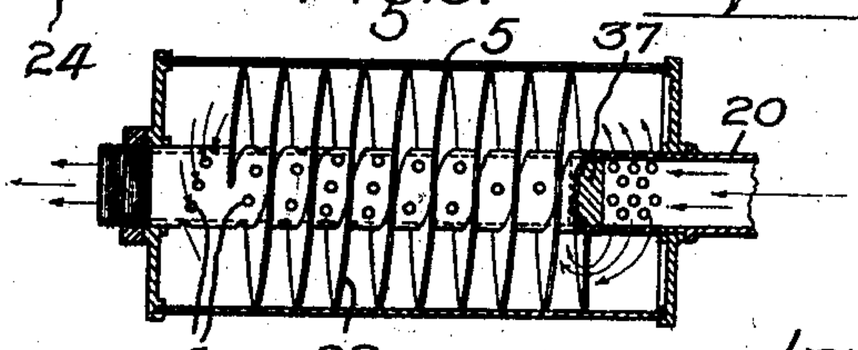


Fig. 9.



Witnesses.

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Inventor:
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UNITED STATES PATENT OFFICE.

ELIHU THOMSON, OF SWAMPSCOTT, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

APPARATUS FOR MUFFLING THE EXHAUST OF GAS-ENGINES.

No. 854,778. Specification of Letters Patent. Patented May 28, 1907.

Application filed August 20, 1904. Serial No. 221,472.

To all whom it may concern:

Be it known that I, ELIHU THOMSON, a citizen of the United States, residing at Swampscott, county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Apparatus for Muffling the Exhaust of Gas-Engines, of which the following is a specification.

It is well known that the exhaust from gas or explosion engines produces a disagreeable noise which partakes of the nature of an explosion. To overcome this objection various kinds of mufflers have been provided which reduce the sound to a certain extent. As a general proposition it may be stated that the more these mufflers reduce the sound, especially when of small interior volume, the greater will be the back pressure created thereby. In other words, all such mufflers cause considerable loss in efficiency, which loss increases as the sound decreases. I have discovered however that the sound of the exhaust can be decreased to a point where it is unobjectionable, and this without the loss of any substantial amount of energy, by breaking up each sound wave into parts and delaying one or more parts behind the other or others, so that their deliveries to the point of final discharge will lag in time one with respect to the other or others. In other words, my invention depends upon the acoustic principle of interference between impulses, and the sound wave for each exhaust discharge, instead of having a high and well defined sharp peak, is flattened and the discharge takes place with a low hissing sound.

In practicing my invention a chambered receptacle is provided having a number of graded discharge orifices, through which the exhaust gases pass on their way to the point of final discharge. These orifices are so arranged that practically speaking they all receive their portion of the exhaust products at the same time, and between them and the point of final exhaust are one or more conduits or passages. The conduit or conduits are so arranged that it or they receive the exhaust from a number of different orifices, the latter however being so arranged that the gas escaping from some of them has a longer path to travel than the gas escaping from the remaining orifice or orifices. In other words, one increment of gas or vapor due to a given impulse has to travel a certain distance in order to escape, while another increment has to travel twice as far, and a third has to travel three times as far and so on. An elongated slot, tapering in width, might replace the series of orifices. The orifices are preferably so arranged that either their area decreases toward the point of discharge or, the area remaining the same, the number decreases. In either case there would be a gradual decrease in the effective area of discharge.

With the construction described tests show that there is virtually no back pressure, the sound is reduced to a point where it is unobjectionable, and the muffler as a whole is smaller than those customarily employed for the same size and type of engine.

In the accompanying drawings, which illustrate an apparatus for practicing the invention, Figure 1 is a view showing a gas engine connected to a muffler of improved construction, the latter being shown in longitudinal section; Figs. 2 and 3 are detail views showing the construction of the disks used to form the exhaust-conveying passages; Fig. 4 shows a slight modification in the construction of the muffler; Figs. 5 and 6 show the disks employed in forming the gas-conveying passage; Fig. 7 illustrates a construction wherein the orifices admitting gas to the elongated gas passage successively decrease in area instead of being of the same size and decreasing in number, as in Figs. 1 and 4; Fig. 8 is a diagram showing the effect of my improved muffler, and Fig. 9 is a further modification.

1 represents the engine, which may be of any suitable character and operated by gasolene, kerosene or other similar form of energy. The exhaust from the engine is discharged into a chambered receptacle 2 which in the present illustration takes the form of a tube that is open on the end adjacent to the engine and closed by suitable means, such as a cap 3, at the opposite end. This receptacle is provided with a plurality of discharge orifices 4, which orifices are graded from one end of the receptacle to the other; that is to say, the orifices are the most numerous near

the inlet end of the tube 2 and progressively decrease in number toward the cap 3. Instead of decreasing the number of orifices, the same number may be employed, but the size of the orifices should be decreased from the inlet toward the closed end of the tube 2. By reason of this construction a greater amount of gas or other vapor will be discharged at the inlet end of the chambered receptacle than at the closed end. Surrounding the chambered receptacle is a cylinder 5 which engages the heads 6 and 7 that are mounted on the tube 2. These heads are secured in place by suitable means such as the nut 8 and cap 3. The head 6 is made solid, while the head 7 is perforated, as at 9, to permit the products of combustion or other vapor to escape. The interior of the cylinder 5 is divided up by partitions 10 arranged to form an elongated passage. The right-hand end of the passage or end adjacent to the engine is closed, while the outer end is in free communication with the orifices 9 that communicate with the atmosphere.

In Figs. 2 and 3 are shown the disks for forming the spiral passage round the tube 2. Each disk is provided with a central opening 11 which corresponds in size to the external diameter of the tube 2. The disk is cut, as at 12, to form the lip 13, which lip is offset a distance equal to that between the disks when assembled as in Fig. 1. The disks are slipped over the tube and are bolted one to the other and to the head 6 by bolts 14, suitable spacing devices such as tubes 15 or nuts 16 being employed to preserve the proper relationship of the parts. When the disks are assembled as in Fig. 1, a spiral passage is formed beginning at the right-hand end of the muffler, which is in communication with all of the orifices 4. Since all of the orifices receive gas or other vapor in multiple and at substantially the same time, it follows that the increment of gas or other vapor issuing from the orifices 17 has a greater distance to travel than a similar increment issuing from the orifice 18. In the present illustration the difference in distance traveled is equal to the length of a path once round the tube 2. It also follows that the distance traveled by increments of gas or other vapor issuing from orifices nearer the inlet end of the tube will have a correspondingly greater distance to travel.

The particular muffler illustrated has been used in connection with an explosion engine of the four-cycle type designed to use either gasolene or kerosene, and to deliver between eight and ten horse power. The number and arrangement of the orifices can be changed to suit the requirements. In the muffler under consideration the first turn of the spiral passage was provided with about ten holes, each from $\frac{3}{16}$ to a quarter inch in diameter, and the number of holes successively decreased toward the left-hand end. For convenience in constructing the apparatus, holes of the same size may be employed for each turn, but I have found it rather more satisfactory to have the orifices on the right-hand end somewhat larger in diameter than those on the left-hand end.

In order to lighten the construction as much as possible and at the same time to give it the requisite strength, it is desirable to employ a construction such as illustrated in Figs. 4 to 6 inclusive. 20 represents a piece of tube or pipe which is provided with a coarse screw-thread 21 to receive the disks 22. The latter are each provided with a central opening 23 to receive the tube. They are also split, as at 24, to permit of the disk being bent to form a spiral like a screw-thread as shown in Fig. 5, the edge of one disk being provided with an offset 25 to receive the edge of the adjacent disk. Mounted on the tube are heads 26 and 27, the former being solid while the latter is provided with perforations 28. The total cross-sectional area of these perforations should preferably exceed the total cross-sectional area of the orifices in the tube 20. Surrounding the disks is a sheet-metal cylinder 29 that is retained in place by a binding band 30 made of wire. It is to be noted that the wire slightly depresses the metal between the spirally arranged disks, which holds the edges of the latter in place and prevents them from rattling. The wire should be made of steel or equivalent material and be put on under tension, and the ends suitably fastened.

The discharge end of the muffler may be provided with a neck or nozzle 31 as shown in Fig. 1, in order to direct the outgoing body of gas or vapor, but this is not essential.

It will be seen from this construction that the length of the path of gas escaping from the orifices 4 differs greatly between the right-hand and the left-hand end of the muffler, the said paths successively decreasing in length from right to left. The rate of travel of the gas impulse at ordinary atmospheric pressures and at about the density of air, is about 1000 feet per second. With a denser gas the rate is slower. The gas escaping from the numerous holes at the right-hand end has to travel practically ten times around the inner tube 20. Another portion of the gas has to travel nine times around the tube, and another portion eight, and so on. The gas escaping from the last hole on the discharge end of the tube may pass directly through one of the orifices 28, or it may pass a fraction of a turn or even more than a turn round the tube.

In Fig. 7 is shown a section of a tube 32 wherein the gas-discharging orifices 33 successively decrease from right to left.

In Fig. 8 is shown diagrammatically the effect which is brought about by the use of my improved muffler. It is to be understood that this figure does not however represent the exact relationship which exists. 34 represents an impulse from a gas engine when the muffler is not employed, and 35 represents the relationship between the parts of the same impulse when lagged behind one another due to the effect of the muffler. In other words, 34 represents a sound wave having a well defined and sharp peak, while 35 represents a sound wave which lasts longer, but is much smoother and of lower pitch.

By actual test I have demonstrated that there is practically no back pressure when this muffler is employed. This is demonstrated by coupling the engine to a dynamo load and employing a volt and ampere meter to make readings. With a constant load I have found that throwing the muffler on and off does not make a difference of more than one-half to one per cent. At a distance of some thirty feet from the engine the sound of the exhaust is hardly noticeable, the noises produced by the cams, etc. being the prominent sounds.

It will be evident that the same principles of action are fulfilled if, instead of letting the gas flow in the direction shown and described in Fig. 4, it moves in the direction shown by the dotted arrow; in fact I find that the arrangement works well whichever the direction of flow.

A slight modification is shown in Fig. 9 in which there is a pipe 20 extending through the casing which is divided by a septum or partition 37, in advance of which are numerous holes, so that the gas entering such pipe instead of passing directly therethrough is turned aside into the outer space, and traverses the elongated or spiral passage. The exit portion of the pipe 20 has a similar series of openings from the turns of the spiral passage, which is described in connection with other figures, the area of the number of openings increasing toward the outlet, preferably. It will thus be seen that the arrangement, Fig. 9, is virtually the same as Fig. 4, except that the construction is somewhat simplified and the gas finally escapes through the pipe 20 at a point beyond the partition 37.

In accordance with the provisions of the patent statutes I have described the principle of operation of my invention together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative, and that the invention can be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. A device discharging gas or vapor in the form of impulses, in combination with a muffler therefor comprising a chambered receptacle, an elongated passage, and orifices communicating with the receptacle and passage, the cross-sectional area of the orifices being greatest at the inlet end of the receptacle.

2. A device discharging gas or vapor in the form of impulses, in combination with a muffler comprising a chambered receptacle, a plurality of orifices arranged to simultaneously discharge gas or vapor from the chamber, and means causing a greater retardation of the passage of gas or vapor between certain of the orifices and the point of final discharge than between others.

3. A device discharging gas or vapor in the form of impulses, in combination with a muffler comprising a chambered receptacle which is closed at one end, a plurality of orifices for discharging the contents of the receptacle, and an elongated passage communicating with all of the orifices and so arranged that the path of the escaping gas or vapor from one of the orifices is longer than from the other or others.

4. In a muffler, the combination of a receptacle having a plurality of discharge orifices which decrease in cross-sectional area as they recede from the inlet to the receptacle, and means for causing the body of gas or vapor discharged by the orifices nearest the inlet to travel a greater distance than those more remote.

5. In a muffler, the combination of a receptacle, which is open at one end and closed at the other, a plurality of discharge orifices contained in the receptacle which gradually decrease in total area from the inlet toward the closed end, a helically arranged passage communicating with the orifices and so arranged that the gas or vapor from some of the orifices travels farther than from others.

6. In a muffler, the combination of a tube which is open at one end and closed at the other, a plurality of discharge orifices for said tube which decrease in effective cross-sectional area toward the closed end, and a means for carrying off the gas or vapor from the tube, the said orifices and means acting to split up the sound waves and to lag one portion with respect to another.

7. In a muffler, the combination of an elongated passage, with a plurality of orifices discharging into it in multiple, the said orifices being graded so that the amount of gas or vapor passing through them gradually decreases toward the point of discharge of the passage.

8. In a muffler, the combination of a chambered receptacle arranged to receive the ex-

haust impulses from an engine, means for breaking up the continuity of each impulse, and other means coöperating with the first to cause the several parts of the impulse to issue successively.

9. In a muffler, the combination of a tube having an admission and a closed end, orifices arranged in the tube, which discharge gas or vapor from the tube and are arranged in multiple, and a spiral passage which surrounds the tube and receives gas or vapor from the orifices, the tube and orifices being arranged to cause a part or parts of the impulse to issue before another part or parts.

In witness whereof, I hereunto set my hand this 17th day of August 1904.

ELIHU THOMSON.

Witnesses:
JOHN A. MCMANUS, JR.,
DUGALD MCK. MCKILLOP.