

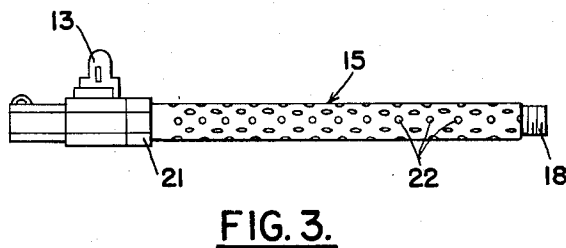
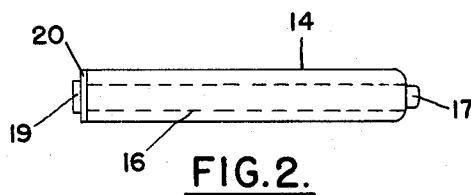
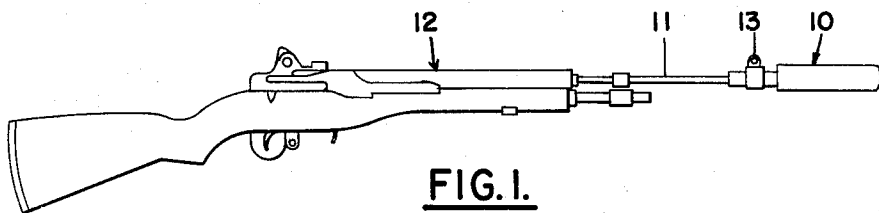
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SMOKE AND FLASH REDUCER

3,149,532

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2 Sheets-Sheet 1



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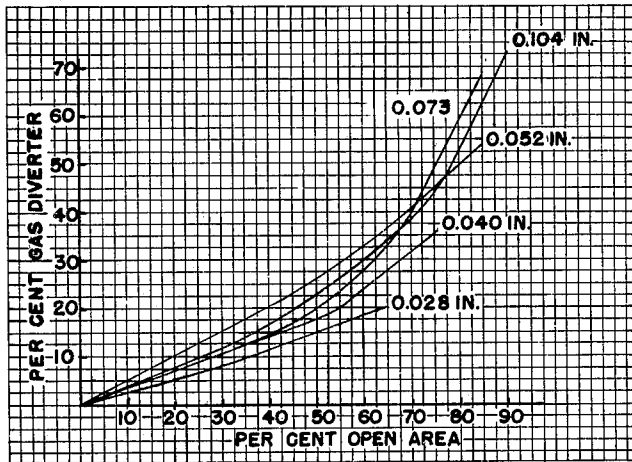


FIG. 5.

PERFORATION SCHEME OF THE MODEL IX SMOKE FILTER DIVERTER		
ROW NO.	HOLE DIAMETER (IN.)	NO. OF HOLES PER ROW
1	0.040	8
2		8
3		11
4		13
5	0.052	6
6		8
7		8
8		8
9		10
10		10
11	0.073	12
12		12
13		16
14		16
15		16
16		8
17		8
18		8
19	0.09375	8
20		10
21		10
22		8
23		8
24		10
25-39		12

FIG. 4.

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3,149,532

SMOKE AND FLASH REDUCER

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1 Claim. (Cl. 89—14)

This invention relates to the reduction of the smoke and flash incident to the discharge of high temperature and high pressure gases into the atmosphere. It has utility in connection with Ordnance, the operation of internal combustion engines and the like. It provides a method whereby there is produced a device capable of reducing such flash and smoke to an extent not heretofore realized. It embraces both an improved smoke and flash reducing device and a novel method of designing and manufacturing this improved device. The improved device greatly reduces weapon sound, blast, and recoil and increases the projectile muzzle velocity.

There has been a long continued effort to reduce the smoke and flash incident to the discharge of high temperature and high pressure gases into the atmosphere. To this end a great deal of emphasis has been placed on the research and development of small arms ammunition, and numerous types of smoke and flash reducing devices have been proposed. None of these devices have satisfactorily solved the problem.

The present invention solves this problem to a large extent by a unique method of controlling the flow of the high pressure and high temperature gases. This method is effected in accordance with calculations based on extensive experimental data and makes possible the design of a gas diverter which will deflect any desired amount of gas as a function of its length. As hereinafter explained, the smoke and flash reducer of the present invention includes, in addition to the gas diverter, a closed casing which surrounds the diverter and contains a filter of steel wool, steel shavings or the like, into which the gases are discharged through the perforated wall of the diverter.

The invention will be better understood from the following description when considered in connection with the accompanying drawings and its scope is indicated by the appended claim.

Referring to the drawings:

FIG. 1 depicts the improved smoke and flash reducer as applied to a "Caliber .30T44E4 Rifle."

FIG. 2 is an exterior view of the casing which surrounds the gas diverter and encloses the filter,

FIG. 3 illustrates the gas diverter which is fixed to the barrel of the gun, extends through the casing, and may carry the front sight of the gun,

FIG. 4 details a suitable perforation scheme for the diverter, and

FIG. 5 shows the effect of port diameter on the amount of gas diverted.

FIG. 1 shows the improved smoke and flash reducer 10 as attached to the barrel 11 of a rifle 12. In the illustrated embodiment of the invention, the front sight 13 of the rifle is mounted on the reducer. This, however, is not an essential feature of the invention.

The smoke and flash reducing device 10 includes a casing 14 (FIG. 2) and a gas diverter 15 (FIG. 3).

The casing 14 forms a filter chamber which contains an annular body of steel wool 16 or the equivalent. This casing is fabricated from thin wall, steel tubing. The front of the tube is necked down and welded to a threaded spud 17 which secures the filter chamber to the threaded diverter muzzle 18. The rear end of the casing 14 is closed

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with a concave ring 19 which has its outer periphery welded to the casing tube. At its inner periphery, the ring 19 has a flange 20 which fits into a circumferential groove on the front surface of a shoulder 21 on the diverter 15.

The total weight of the device, including 7 oz. of filter packing is 16 and one-half oz. Its outside diameter is 1.64 in. It extends the rifle barrel by 5.57 in. which is only 2.52 inches more than the standard 5-bar flash suppressor.

Operation of the above-described device involves a technique known as impingement filtration. This is accomplished by passing the gas at high velocity into a metallic porous matrix. The porous filter medium is contained in a closed casing which surrounds the diverter. The gas does not flow radially from the filter chamber but reverses direction and flows out the diverter bore at the end of the ballistic cycle. At the present time, a coarse steel wool is used as the filter but better materials are available. Smoke reductions of 79 percent have been achieved, which is equivalent to complete filtration of about 94 percent of the total gas diverted.

The impingement filtration technique has several advantages over systems using glass fiber filter elements. The impingement type filter devices give equal or better smoke reduction with identical diverters, are less costly and do not produce white fog.

A diverter may be defined as a cylindrical extension of the gun barrel, or other gas discharge pipe, with openings in the wall to allow the escape of gas in the radial direction. The area of the openings in the wall which allow the escape of diverted gas in the radial direction is termed the port area. To obtain the most effective use of the filters, it is necessary to distribute the diverted gas evenly along the diverter length. This is accomplished by a special technique of perforating the diverter wall. A method of locating the perforations to distribute the diverted gas evenly along the diverter length was developed from an experimental relation between the percent open area and the amount of smoke diverted from the bullet path. The percent open area is defined as follows:

$$\text{Percent open area} = \frac{\text{Total port area}}{\text{Total port area} + \text{cross sectional area of the bore}} \times 100$$

In other words, the percent open area is simply a ratio of the port area to the total area available for the gas to exit through. There is a quantitative relationship between the percent open area and the amount of gas diverted. An accurate determination of this relationship may be obtained experimentally. One method of determining the amount of gas diverted consists of optically measuring the smoke carried in the gas stream. This experimental procedure has been outlined in detail in the Historical and Technical Summary Report, "Reduction of Smoke and Flash in Small Arms Ammunition," Midwest Research Institute, October 31, 1954.

The calculation method of determining the pattern of the holes 22 is based on the relationship of open area to amount of gas diverted. This relationship is dependent upon the size of the ports. Several of these relationships have been determined with cal. .30 weapons and shown in FIG. 5. Theoretically, the amount of gas diverted is primarily a function of the state of the propellant gas in the weapon chamber. Therefore, the information shown in FIG. 5 is not limited by weapon size. For example, a diverter designed for a 40 mm. gun, based on the data in FIG. 5, has given satisfactory results.

The mathematical procedure for calculating diverter design for a desired flow distribution consists of the following steps:

- (1) Establish the bore diameter.

(2) Divide the diverter into arbitrary increments of length.

(3) Number the increments, starting at the rear where the gas enters, consecutively to the forward end where the gas exits.

(4) Choose the amount of gas to be diverted in each increment.

(5) Choose the size of holes or ports to be used in each increment.

(6) Enter the cumulative amount of gas diverted at each increment into a relationship such as that shown in FIG. 5 and obtain the open area from the proper curve.

(7) Calculate the total port area at each increment using Equation 1, line 41, column 2.

(8) Obtain the port area in each increment by subtracting the total port area at the preceding increment from the total port area at the increment being determined. This can be done only for values of total port area based on the same hole size. If the hole size is changed an adjustment must be made as discussed below.

(9) Divide the port area in each increment by the area of the hole or port size used in that increment to determine the number of holes in each increment.

The bore diameter referred to in step 1 must be established independently. It is usually determined experimentally to eliminate any ballistic interference. The length increments may take the physical form of a circumferential row of holes. Step 4 is the specification of the desired flow distribution which is the objective. The flow may be distributed in an infinite number of different ways. If uniform distribution of diverted gas is desired, however, the amount of gas to be diverted per increment will be constant. There is one limitation to the flow distribution. After a certain quantity of gas is diverted, usually over 75 percent, the port area requirements may become too large to be physically placed on the diverter wall surface.

Step 7 can be simplified by rearranging Equation 1 into the following form:

$$A_T = \frac{PA_b}{1-P}$$

Where

A_T =total port area

A_b =bore area

P =open area (fractional)

Step 8 is simply an operation based on the fact that the whole is equal to the sum of its parts or:

$$A_T = A_1 + A_2 + A_3 + \dots + A_n$$

Where $A_1, A_2 \dots$ =port area of increments 1, 2, etc.

Step 8 is usually started at the first increment and progresses through successive increments. Total port area of succeeding increments can be subtracted only if they are derived from the same hole size. If a hole size change is made, then an equivalent open area must be determined for the preceding increment. The equivalent open area is that which would divert the same quantity of gas if the previous increments contained the same hole size. Determination of the equivalent open area is an adjust-

ment of step 6 and is obtained in a similar way, i.e., from a relationship such as that shown in FIG. 5.

To illustrate the above-described adjustment for a change in hole size, consider a diverter which diverts 15 percent gas in the 10th increment and contains 0.028 in. diameter holes to that point. Reference to FIG. 5 shows the open area to be 50 percent. The 11th increment is to contain 0.040 in. diameter holes which requires an adjustment of the 10th increment open area. The equivalent open area for the 10th increment is read from FIG. 5 as 40.8 percent. This value is used to calculate the open area in increment No. 11 using 0.040 in. diameter holes.

The stepwise procedure given above is fundamental and several simplifying modifications are possible. For instance, steps 6 and 7 can be combined by using a plot of total port area versus the amount of gas diverted. Another modification involves the substitution of the diverter length for the coordinate of amount of gas diverted. This latter, however, is only useful for uniform or even flow diverters.

The perforations 22 of the gas diverter 15 are arranged in a pattern which was determined by the above method and is detailed in the table of FIG. 4. In this table, the first column lists number of the row beginning at the row closest to the muzzle of the gun, the second column lists the diameter of the holes in the various rows, and the third column the number of holes per row.

Even flow diverters, such as that illustrated by FIG. 3, may be designed to divert various quantities of gas per increment of their length. Therefore, terminology is necessary to differentiate between them. Even flow diverters are designated by number, the number being the slope of the line relating percent gas diverted to percent diverter length. For example, the diverter discussed above is a 1.18 even flow diverter.

From the foregoing considerations, it follows that the flow distribution of gun muzzle gas can be controlled by diverters designed according to the process described above. Stated another way, the present invention makes it possible to predict the flow distribution of a gas diverter from the design parameters so that the filter material is more effectively utilized.

We claim:

A smoke and flash reducer for attachment to the barrel of a rifle or like discharge conduit for high-pressure high-temperature gases comprising, an outer closed cylindrical casing and an inner tubular gas diverter in concentric spaced relation with an annular body of porous gas filter medium within the casing and space surrounding the diverter, and said diverter being adapted to provide a coaxial extension of said barrel or conduit with a larger bore for projectile or like discharge clearance, and said diverter being provided with wall openings substantially in annular rows and of increasing effective area from the entrance to the exit end thereof, thereby to provide substantially uniform gas distribution along the length of the diverter.

References Cited in the file of this patent

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