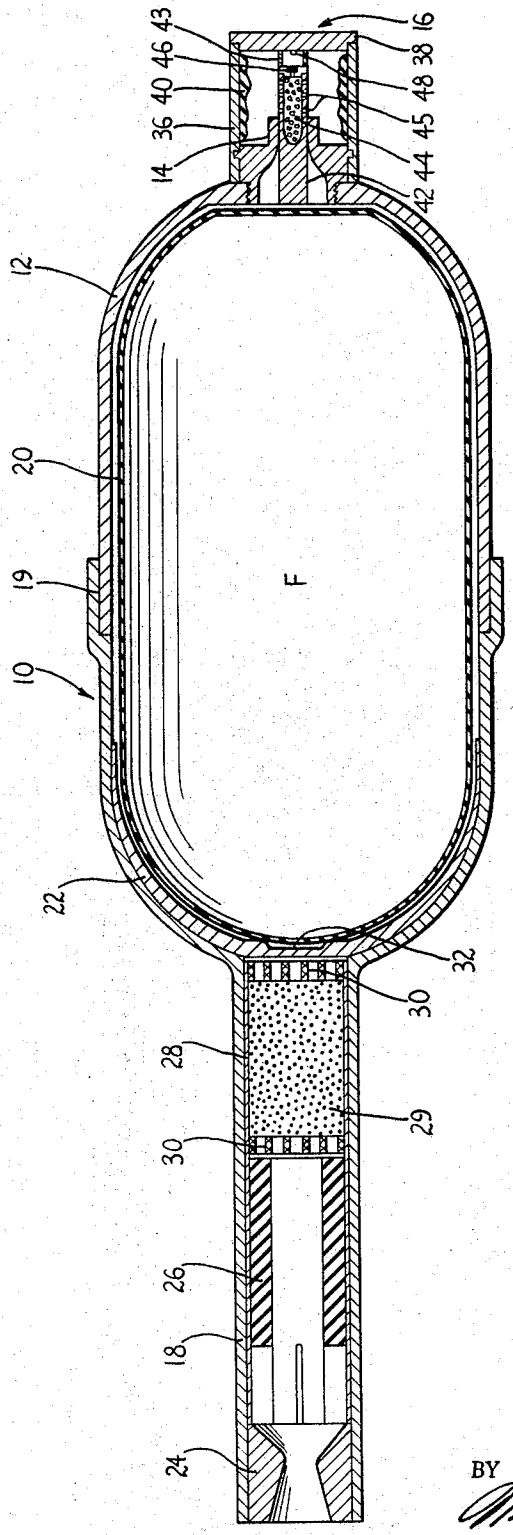
Aug. 15, 1967 E. C. KLAUBERT 3,335,780

FLAMETHROWER

Filed July 13, 1965



INVENTOR.
EARL C. KLAUBERT

BY William A. Wright Jr.

AGENT

United States Patent Office 3,335,780 Patented Aug. 15, 1967

3,335,780

FLAMETHROWER

Earl C. Klaubert, Lexington, Mass., assignor to Thiokol Chemical Corporation, Bristol, Pa., a corporation of Delaware

Filed July 13, 1965, Ser. No. 471,701
7 Claims. (Cl. 158—28)

ABSTRACT OF THE DISCLOSURE

A man portable device for projecting a flame is provided in which the "recoil" or reaction effect is nullified by means of a rocket blast which is equal to, opposite in direction to, and axially aligned with the direction of expulsion of the flame producing agent and wherein heat protection is provided between the agent and the combustion in the rocket.

This invention relates generally to flamethrowing apparatus and more particularly to a compact, lightweight portable flamethrower of improved range and in which compensation is provided for the fuel expulsion recoil.

Existing portable flamethrowers use thickened viscoelastic fuels which are expelled by gas pressure usually obtained from high pressure ambient temperature storage bottles. Maximum effective range of these devices is between 45 and 55 meters under ideal conditions and practical combat ranges often are much shorter. It is thus desirable to increase range substantially in order to increase weapon effectiveness and to decrease the operator's vulnerability.

The means of attaining greater range are well known. Basically, a larger expulsion nozzle diameter (than the .25–.31 inch of present portable models) is mandatory, with equivalent or higher expulsion velocity. The fuel flow rate increases roughly with the square of the nozzle diameter, and linearly with expulsion velocity; hence, the fuel tank volume for even short firing times (e.g., 5 seconds) increases very rapidly. The weight and bulk of the associated high pressure gas reservoirs therefore become equivalently larger, and further increases result from the demand for higher expulsion pressures. Thus the weight and size of the entire assembly promptly exceeds that which is practical for one man to carry under combat conditions. Furthermore, the expulsion recoil is nearly proportional to mass flow rate, and hence it almost immediately becomes uncontrollable for a man-held expulsion device, as range capability is increased.

The conventional pyrotechnic "matches" which are used on present portable flamethrowers have been found to be unreliable in igniting the more heavily thickened, less volatile fuels required for long range operation. The use of hypergolic liquids for ignition has been proposed but would constitute a highly undesirable complication to this basically simple system. A series of propane/air flames along the rod trajectory also has been found to be ineffective in igniting the fuel rod. This last result is not surprising, because convective heat transfer from hot gases is hindered by a relatively low-conductivity gas film; and is further reduced by opposing mass transfer from the rod as the first bit of vapor begins to evolve.

The invention described herein provides a compact, readily ignited, lightweight portable flamethrower with a maximum range in excess of 100 meters, in which compensation is provided for substantially all of the expulsion recoil. Thus, its operation, hand-held by one man, is entirely feasible at fuel flow rates which would be completely uncontrollable without such recoil compensation.

As indicated above, flamethrowers are known in the art

but are characterized by one or more of a number of disadvantageous features. Among these are: (in addition to an excessive bulk and weight so as to require two men to carry it and thus form an inviting target) an expulsion recoil compensating means which is not coaxial with the expulsion nozzle so as to result in a force couple with an overturning moment too great for one man to cope with; an inadequate expelled fuel ignition means; a single combined pressurization and ignition charge; inadequate range; and in the case of multi-shot capability, a vulnerability to damage by a bullet, etc., so as to incapacitate the equipment for even a single shot. Also, conventional flamethrowers ignite the "match" prior to actual fuel expulsion by one to several seconds. This flare both discloses the flamethrower's position (thus inviting immediate and massive counterfire which may render the operator or weapon a casualty before flame attack is initiated) and warns potential victims of impending flame attack (which may permit them to take evasive or protective measures in addition to counterfire). The solid propellant fuel rod igniter is actuated only milliseconds prior to expulsion of the fuel rod, and by visual observation occurs simultaneously therewith. Thus the victim has essentially no warning of impending flame attack, other than the inevitable flight time of the burning rod.

Pyrophoric fuels which burn upon contact with the air or highly oxidizing agents which would burst into flame upon contact with a target may also be used with the present invention in which case no ignition means is needed. These are defined herein as flame-producing agents.

Accordingly, the main object of the present invention is to provide an improved flamethrower which obviates the above and other disadvantageous features of known structures.

An important object of the present invention is to provide an improved flamethrower which employs a single propellant to be ignited so that its combustion gases both pressurize the combustible or pyrophoric fuel or oxidizing agent, expel it through a forwardly directed nozzle, and discharge through a rearwardly directed exhaust nozzle to balance the expulsion recoil forces.

Another important object of the main invention is to provide a means for cooling the pressurizing gases before admitting them to the fuel or agent containing flamethrower tank.

A further important object of the present invention is to provide a heat shield between the propellant pressurizing gases and the fuel or agent in the flamethrower tank.

A still further important object of the present invention is to provide means to balance the thrust and recoil effects of the propellant pressurizing gases after the fuel or agent has been fully expelled from the tank of the flamethrower.

Another important object of the present invention is to provide an improved portable, one-use flamethrower of high reliability which has an all-attitude expulsion capability of the contained, prepackaged fuel or agent and which is susceptible of ready and economic manufacture and is simple to use.

Other objects and advantages of the invention will become apparent during the course of the following description.

In the drawings I have shown one embodiment of the invention. In this showing:

The single figure is a central longitudinal sectional view of the invention.

Referring to the drawings, numeral **10** designates the portable flamethrower comprising one embodiment of the invention as a whole which comprises a fuel tank **12** terminating at its forward end in a fuel expulsion nozzle

14, fuel igniting means adjacent thereto and also indicated as a whole by numeral **16**, and a small rocket **18** which is axially aligned with the nozzle **14** and attached to and communicating with the opposite end of the tank **12**.

The fuel tank **12** is formed of any suitable, lightweight, high-strength material and since it is planned as an expendable unit, may be an economic, laminated paper/phenolic product formed in two halves and joined as at **19**.

The thickened visco-elastic fuel F which may be gelled gasoline is contained in the tank in a bladder **20** of polyethylene (or other plastic, rubber, or thin flexible material) both to prevent evaporation and/or contamination during storage and also to provide positive expulsion at any attitude of the flamethrower.

An important feature of the invention resides in the provision of a heat shield **22** at the rear of the tank adjacent its connection and communication with the rocket **18**. The heat shield **22** protects the bladder **20** from possible cutting by the direct impingement of the hot pressurizing gases which are cooled, as will be explained, from the 4000–5000° F. propellant combustion temperature to 600–1200° F. Because of the short operating time and very small pressure differential across the heat shield, it may be formed of a thermoplastic such as polyethylene or polypropylene.

The rocket **18** terminates rearwardly in an exhaust nozzle **24** and is powered by a solid propellant **26** although it will be apparent that mono and bi-propellant liquid fuels could be employed if desired. Because of the short burning time and the solids-free exhaust gas, an economical nozzle can be produced from ordinary injection-molded fiber/phenolic compositions. This insert can be bonded into the aft end of the motor and shear stress on this bonded joint will be very small.

As shown in the drawings, the rocket exhausts to the rear (in the direction opposite to that of the fuel or agent expulsion) to provide a thrust which substantially compensates for the recoil caused by fuel or agent expulsion. A relatively small portion of the gases generated by the burning rocket propellant **26** are tapped off at its forward end and pass to the tank **12** to pressurize the fuel or agent F therein and to cause the expulsion thereof.

Another feature of the invention resides in the provision of a coolant-diluent bed **28** which is interposed between the rocket **18** and the fuel tank **12** to cool the portion of the solid propellant gases used to pressurize the tank. The bed **28** contains a material **29** that vaporizes and/or decomposes endothermically, mixes with the hot gases and is heated thereby, and thus reduces the temperature of the gas mixture. The solid rocket propellant contemplated (BF–122 Mod. 1) is a highly oxidized polysulfide/ammonium perchlorate (18/82 weight ratio) formulation with a flame temperature at 500 p.s.i.a. of ca. 4600° F. Obviously the portion of gas used to pressurize the gelled gasoline tank will have to be cooled very substantially. Ammonium chloride, NH_4Cl, has been found to be a very effective solid for hot gas dilution and cooling. It is economical, and stable at normal temperatures, but decomposes at ca. 660° F. to yield NH_3 and HCl. Corrosivity of these gases is of no consequence in this short-duration, one-use application. Theoretical calculations show that temperatures below 600° F. can be obtained with this system, and a temperature of 600° F. was selected. The weight of NH_4Cl required is approximately 1.2 times the weight of propellant gas to be cooled, and a 100% excess is recommended to ensure adequaate cooling. The NH_4Cl, in crystalline or pelleted form, will be inserted into the rocket ahead of the propellant **26**, and will be confined between perforated paper/phenolic plates and metal screens **30**. The propellant gas will flow through this coolant bed **28** and directly into the gelled gasoline container **12**.

It will be appreciated that during operation when all of the flamethrower fuel or agent F has been ejected through the nozzle **14** from the tank **12** by the pressurizing gases, the fuel expulsion recoil (which has been substantially balanced by the thrust of the rocket **18**) will cease. It is therefore essential that the counter-recoil thrust of the rocket be neutralized simultaneously with the end of expulsion as otherwise the large volume of pressure gas behind the heat shield **22** and the bladder **20** would vent through the rocket nozzle **24** and generate a large, relatively-long-duration forward thrust which would propel the flamethrower from the operator's hands and possibly seriously injure him or adjacent personnel.

Another important feature of the invention is the provision of a weakened center section or blow-out panel **32** in the heat shield **22** to prevent such unbalanced forward thrust upon the exhausting of the fuel. It will be apparent that as long as a significant amount of fuel F remains in the tank **12** within the bladder **20**, the fuel pressure behind the fuel expulsion nozzle **14** will be essentially equal to the gas pressure from the propellant **26** acting on the heat shield **22** (and the bladder **20**) so that the pressure differential across the heat shield will be small and the blow-out panel will be intact.

When nearly all the fuel has been expelled, the heat shield **22** will tend to bridge across the inner part of the curved forward tank end, fuel pressure will drop, and the pressure differential across the heat shield will increase. When this differential reaches a level substantially above that existing during expulsion, but still small with respect to gas pressure (perhaps 20–40 p.s.i.), the blow-out panel **32** will fail and allow the propellant pressure gases to rupture the rear end of the bladder and vent forwardly through the fuel expulsion nozzle **14** as well as rearwardly through the rocket nozzle **24**.

Obviously, proper design of flow restrictions in the forward direction with respect to similar restrictions in the rearward direction can provide for substantially complete balancing of the gas discharge forces in opposing directions.

An important feature of the present invention resides in the fuel igniting means **16** which is essential to the attainment of maximum range when a combustible fuel is used. As is known, the range attained by a burning "rod" of fuel is approximately twice that attained by the same rod if unignited, and ready ignition thereof has heretofore been a bothersome problem.

The fuel igniting means **16** comprises a housing **36**, a weather cap **38** therefor, a solid fuel rod igniting propellant **40**, a propellant ignition plunger **42** therefor, an ignition booster charge **44** within the plunger, a percussion primer **46** mounted in the outer end of the plunger, and a firing pin **48** fixed to the cap **38** in alignment with the plunger **42** and its support **43**.

The arrangement disclosed provides a preferred means of transferring heat to the fuel rod (to vaporize a small amount of fuel which then ignites and provides a self-sustaining flame), which will not be affected by a low conductivity convective film, and which will impact the surface of the fuel rod with large numbers of small, very hot, solid particles. These particles will penetrate the gas film and come into direct physical contact with the fuel to which they transfer their heat either by conduction or radiation or both. In addition, thermal radiation from a cloud of these hot particles surrounding but not impacting the fuel rod, will also transfer energy directly to the rod independent of the convective film. As previously stated, the ignition means is used only when a combustible fuel is used and not when a pyrophoric or highly oxidizing agent is used, in which case it is omitted from the location in and surrounding the agent expulsion nozzle and only the weather cap **38** and housing are used.

More specifically, the propellant **40** is intended to be a heavily-aluminized solid rocket propellant which generates large weight percentages of very hot (over 5000° F.) fine solid particles, and intense thermal radiation. In addition, this propellant has been shown to be insensitive to

impact (even of bullets), heat, and temperature cycling, and yet capable of rapid ignition from a proper source and of reliable combustion at atmospheric pressure.

In order to take advantage of the foregoing properties, a tubular grain of the aluminized solid propellant **40** is shown mounted in the housing **36** around and in front of the fuel expulsion nozzle **14** as shown in the drawings. This propellant is ignited only milliseconds prior to the expulsion of the fuel F (appearing visually to be simultaneous) and promptly generates a small cloud of very hot gas and particles around the trajectory of the fuel rod and flows concurrently with the rod for a short distance, and burns throughout the expulsion of the fuel. Other metals than aluminum could be used such as boron, magnesium, zirconium and their hydrides, alloys and/or derivatives thereof.

The hollow ignition plunger **42** is shown mounted in the expulsion nozzle **14** where it bars efflux of the fuel F and is supported against fuel pressure by the support **43** which is tubular or of other shape and formed of a rigid, brittle plastic such as polystyrene to methylmethacrylate, and itself supported on the weather cap **38**.

In operation, the rocket **18** is fired by any suitable means (not shown) and the combustion gases commence to pressurize the fuel F. As the pressure rises, the plastic plunger support **43** fails at a predetermined level and allows the plunger **42** to impact sharply against the weather cap **38**. The firing pin **48** fires the percussion primer **46** mounted in the end of the plunger **42**, flashes into the ignition booster charge **44** and ignites said booster charge which flashes through vent holes **45** in the plunger to ignite the solid propellant fuel rod igniter **40**. Until the igniter **40** generates significant pressure, the weather cap **38** restrains the plunger **42** which prevents the expulsion of the flamethrower fuel at low pressure (which would result in a portion of the fuel falling short of steady-state range).

When pressure in the rod igniter **40** reaches a preset level (which is determined by the manner of securing the weather cap **38** to the housing **36**), the pressure ejects the weather cap which is followed by the plunger **42**, and then by the flamethrower fuel F. Proper adjustment of the several variables involved will result in ejection of the plunger at substantially the time that fuel pressure reaches a steady-state operating level. Thus, essentially the entire quantity of fuel will be expelled at very nearly constant pressure which will enhance the uniformity of range and hence maximize the concentration of the burning fuel upon the intended target.

It will be appreciated that the rocket/coolant bed assembly can be made demountable from the fuel tank by the provision of a suitable joint (not shown). This would reduce the length of the flamethrower as packaged for shipping by almost half of the assembled length and greatly facilitate its air transport to combat zones by helicopter, etc. During shipping the ignition assembly **16** could also be removed in which case the forward and rear opening of the tank **10** would be closed by shipping plugs to protect the bladder and the heat shield against puncture, and to also support the bladder against rupture by hydrostatic pressure resulting from dropping, etc.

It will now be apparent that the improved flamethrower comprising the present invention is self-pressurized and requires no accessory compressors as are required to charge existing flamethrowers, provides a maximum payload ratio (weight of fuel/total weight), is amenable to compact packaging, and effectively solves the ignition and recoil problems which heretofore characterized such apparatus.

The term flame-producing agent is defined as including combustible fuel, pyrophoric fuel or a highly oxidizing agent.

It is to be understood that the form of the invention herewith shown and described is to be taken as a preferred example of the same and that various changes in the shape, size, and arrangement of parts may be resorted to without departure from the spirit of the invention or the scope of the subjoined claims.

I claim:

1. A portable flamethrower comprising, in combination, a tank for flame producing agent terminating forwardly in an expulsion nozzle; a rocket motor axially aligned with said nozzle and terminating rearwardly in an exhaust nozzle connected to and communicating with the other end of said tank and including a propellant the combustion gases of which pressurize the flame producing agent and furnish forward expulsion recoil balancing thrust, and gas cooling means interposed between said tank and said rocket motor, said cooling means comprising a bed of solid crystalline material effective to dilute and cool the rocket propellant combustion gases.

2. The combination recited in claim **1** wherein a heat shield is interposed between the flame producing agent and said cooling means.

3. A portable flamethrower comprising, in combination, a tank for flame producing agent terminating forwardly in an expulsion nozzle; a rocket motor axially aligned with said nozzle terminating rearwardly in an exhaust nozzle connected to and communicating with the other end of said tank and including a propellant the combustion gases of which pressurize the flame producing agent and furnish forward expulsion recoil balancing thrust, and a heat shield interposed between the flame producing agent and the propellant combustion gases, said heat shield including a blow-out panel operable upon flame producing agent ejection completion to break and afford forward ejection of gases through said expulsion nozzle to balance the thrust of the gases through said exhaust nozzle.

4. A portable flamethrower comprising, in combination, a tank for a combustible fuel flame producing agent terminating forwardly in an expulsion nozzle; means axially aligned with said nozzle and connected to and communicating with the other end of said tank and operative to pressurize the flame producing agent, expel it through said nozzle, and to balance the rearward recoil forces of said expulsion; and ignition means to ignite said fuel; said ignition means comprising a solid ignition propellant which when ignited, generates small very hot particles, surrounding said expulsion nozzle; a firing pin aligned with said nozzle; a plunger including an ignition booster charge closing said expulsion nozzle and movable upon pressurization of the fuel against said pin to ignite said charge and said ignition propellant to subject the fluid being expelled to the ignition action of the small, very hot particles.

5. The combination recited in claim **4** wherein said ignition propellant is metallized to effect the formation of said hot particles when ignited.

6. A portable flame thrower comprising, in combination, a rocket motor including a propellant terminating rearwardly in an exhaust nozzle and terminating forwardly in a fuel containing tank terminating forwardly in a fuel expulsion nozzle, said rocket propellant being ignitable to form combustion gases to pressurize the fuel and simultaneously ignite and expel it from said expulsion nozzle and to exhaust gases from said rocket nozzle to balance the recoil forces of the fuel expulsion; and a heat shield interposed between said rocket motor combustion gases and the fuel contained in said fuel containing tank, said heat shield including a blow-out panel operable upon fuel expulsion completion to break and afford forward ejection of combustion gases through said expulsion nozzle to balance the thrust of gases through said exhaust nozzle.

7. A portable flamethrower comprising, in combination, a rocket motor including a propellant terminating rearwardly in an exhaust nozzle and terminating forwardly in a fuel containing tank terminating forwardly in a fuel expulsion nozzle, said rocket propellant being ignitable to form combustion gases to pressurize the fuel and simul-

taneously ignit and expel it from said expulsion nozzle and to exhaust gases from said rocket nozzle to balance the recoil forces of the fuel expulsion; combustion gas cooling means interposed between said motor and said fuel containing tank; and a heat shield interposed between said cooling means and the fuel contained in said fuel containing tank, said heat shield including a blow-out panel operable upon fuel expulsion completion to break and afford forward ejection of combustion gases through said expulsion nozzle to balance the thrust of the gases through said exhaust nozzle.

References Cited

UNITED STATES PATENTS

1,797,654	3/1931	Grund.	
2,479,570	8/1949	Hayner et al.	158—28
2,952,309	9/1960	Fay	158—28
3,016,086	1/1962	Smith	158—28
3,097,564	7/1963	Stevenson	89—1.705
3,106,238	10/1963	Bruce	158—28

JAMES W. WESTHAVER, *Primary Examiner.*