

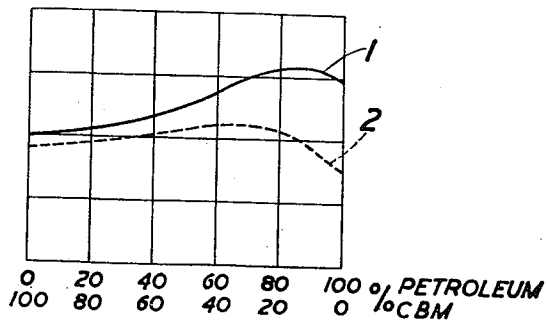
Jan. 19, 1960

W. G. GLENDINNING

2,921,897

FIRE SUPPRESSANTS

Filed July 23, 1956



INVENTOR
BY *John A. May*
ATTORNEY

1

2,921,897

FIRE SUPPRESSANTS

William G. Glendinning, St. James's, London, England, assignor of one-half to Grainer Manufacturing Company Limited, and one-half to Wilkinson Sword Limited, both of London, England, both British companies

Application July 23, 1956, Serial No. 599,646

5 Claims. (Cl. 252-8.1)

This invention relates to fire suppressants, and particularly relates to suppressants adapted for use in the suppression of explosions in aircraft.

According to the present invention there is provided a suppressant comprising a mixture of a liquid whose suppressant action is partly due to chemical inerting and partly due to cooling, with an inflammable liquid which is adapted to enrich an explosive mixture beyond its explosive range.

To understand the the action of the enriching liquid it must be appreciated that a fuel vapour/air mixture in which the vapour is less than about 1% by volume is too weak to be inflammable, whilst one in which the vapour is more than about 10% by volume is too rich to be inflammable. Thus, by distributing sufficient fuel in a vapour/air mixture, the mixture can be enriched beyond the limit at which it is still explosive and thereby rendered non-explosive. Moreover, even with a saturated explosive vapour, further enrichment can occur by vapourisation of fuel at the flame front.

The liquid acting partly by inerting and partly by cooling (hereinafter referred to for the sake of brevity as a "cooling suppressant") may for example by a halogenated hydrocarbon derivative, such as chloro-bromo-methane or di-bromo di-fluoro methane, whilst the enriching liquid may be an organic liquid, for example a petroleum ether fraction having a boiling point below 40° C. such as is sold commercially as "petroleum ether," which latter consists primarily of pentane.

For use in suppressing explosions in aircraft, for example in the aircraft fuel tanks, such a mixture has the advantage that by using a fairly high proportion of an enriching liquid to total amount of suppressant carried may be considerably less in weight than if the suppressant used were solely a cooling suppressant, due to the fact that the specific gravity of the latter may be from two to three-and-one-half times greater than that of an enriching liquid.

This can be seen readily from a comparison of the respective specific gravities of typical cooling suppressants and enriching liquids given in the following table which shows some of their characteristics.

Cooling Suppressants	Reid Vapour Pressure at 37.8° C.	Freezing Point at Normal Atmosphere Pressure, ° C.	Boiling Point at Normal Atmosphere Pressure, ° C.	Specific Gravity at 20° C.
Carbon tetrachloride.....	4	-22	77	1.6
Chloro-bromomethane.....	5	-86	67	1.9
Di-bromo di-fluoro methane.	18	-142	24.5	2.3
Methyl iodide.....	12	-66	42.5	2.3
Methyl bromide.....	45	-93	4	1.7
Di-bromo tetra-fluoro ethane.	11	-110.5	47.5	2.16
Enriching Liquids:				
Gasoline (AVGAS).....	7	-60	42.5	0.7
n-pentane.....	15	-131	36	0.62
iso-pentane.....	21	-160	28	0.62

2

The reasons for choosing a mixture will now be explained in greater detail. When used in the protection of aircraft a suppressant must be effective over a wide range of temperature, for example from minus 60° C. to plus 80° C. Now the effectiveness of a suppressant is directly related to its volatility and at the low end of this range the volatility of some conventional cooling suppressants, such as carbon tetrachloride, is so low that they are relatively ineffective. In fact as can be seen from the above table carbon tetrachloride freezes at about -22° C. On the other hand the table also demonstrates that other cooling suppressants such as methyl bromide, whilst sufficiently volatile at the low end of the temperature range have the great disadvantage that at the upper end of the temperature range they have such a high vapour pressure as to require an unduly strong container with consequent weight penalty. Although some cooling suppressants are effective over the whole range, for example chloro-bromo methane, di-bromo di-fluoro methane, di-bromo tetra-fluoro ethane and methyl iodide, these are heavy by comparison with enriching liquids which are also satisfactory over the temperature range and at the same time are relatively much lighter. Thus, the effect of combining a cooling suppressant with an enriching liquid is that whilst the enriching liquid will ensure satisfactory suppression at the low temperature end of the scale, even if the cooling suppressant is not entirely satisfactory at these temperatures, the cooling suppressant will provide enhanced suppression at other temperatures and also increase the range of distribution. In connection with this latter factor, it should be realized that if a high proportion of enriching fluid is used when the suppressant is distributed under high pressure, for example by ignition of an explosive charge in the manner described in the specification of Patent No. 2,787,330 the effective distribution range is less than that for one having a higher proportion of cooling suppressant due to a combination of factors resulting from the lower specific gravity of an enriching liquid, the droplet size which depends upon its physical properties, and the fact that at the fringes of the distribution pattern the concentration is lower so that the explosive mixture may not be enriched beyond its explosive limit.

The effect of the various conflicting factors referred to above is shown in the accompanying drawing in which two curves have been plotted. Curve 1 is obtained by plotting the quotient of the radius of distribution divided by the specific gravity for mixtures consisting of various proportions by volume of chloro-bromo-methane and petroleum ether boiling point below 40° C. Curve 2 is obtained by plotting the quotient of the area of effective coverage divided by the specific gravity for the same mixtures. It will be understood that the units of the ordinate axis are arbitrary ones merely designed to indicate graphically the variations in the two quotients plotted as ordinates for various proportions of the mixture constituents. Distribution was effected by means of an explosive charge in the manner described in the aforesaid patent.

It will be seen that although the specific gravity falls with an increasing proportion of enriching liquid the curve does not rise in direct proportion to the ratio of specific gravities of the component liquids because the lighter mixture is not distributed over so great a radius for a given propulsive force. This is because of the reduced specific gravity and smaller drop size. Moreover, the high proportions of enriching liquid above about 80% the radius of distribution falls more rapidly than the specific gravity, which accounts for the turn of the curves.

The reason why curve 2 falls away more rapidly than curve 1 is that as the proportion of enriching liquid predominates the concentration of cooling suppressant is

not sufficient at the fringes of the distribution pattern to effect inerting nor is the concentration of enriching liquid sufficient to enrich the explosive vapour beyond its explosive limit. For this reason the effective radius of distribution becomes progressively smaller with an increasing proportion of enriching liquid as indicated by the fall in curve 2 for proportion of enriching liquid above about 70%.

It might be thought from a consideration of curve 2 that there is very little to be gained by using a mixture instead of using a pure cooling suppressant. However, when it comes to applying the teachings of curve 2 to the protection of typical aircraft fuel tanks a further factor must be taken into consideration. When using an explosive charge to effect distribution of the liquid the maximum power of the explosive charge which can be used is limited by the strength of the average fuel tank, as of course the charge must not be so powerful that it damages the tank. Thus, using the most powerful charge possible the radius of distribution of liquid will depend mainly upon the specific gravity of the liquid. Now for many typical aircraft fuel tanks, particularly in smaller aircraft, the cross-sectional dimensions of the tank are such that the maximum radius of distribution obtainable when using a pure cooling suppressant is not required. On the other hand, the smaller radius of action obtainable with a mixture having a high percentage of enriching liquid is sufficient to obtain complete coverage of the tank. Clearly then, it is advantageous to use a mixture having as high a proportion of enriching liquid as is compatible with giving effective distribution throughout the tank. In practice, it is found that the most satisfactory compromise of all the conflicting factors involved results from using a mixture of approximately 80% enriching liquid and 20% cooling suppressant. Thus, by using one specific construction of the kind of tubular suppressant container described in the aforesaid patent specification, it is possible to obtain an effective distribution radius of two feet when using an enriching liquid alone or three feet when using a cooling suppressant alone. The distribution range for a mixed suppressant will clearly lie somewhere between these two, dependent upon the proportions used in the mixture. However, for the 80/20 mixture referred to, the range is adequate and the effective distribution covers an appreciably greater volume than is covered by the use of enriching liquid alone, whilst the increase in weight over enriching liquid alone is only 30%.

It might be thought that for some fuel tanks optimum coverage for a given weight could be obtained when using a pure enriching liquid. However, there is still an advantage in the use of a mixture over the use of pure enriching liquid, albeit with some weight penalty, in that the mixture is less inflammable and is therefore safer to store. Moreover, there is less danger of re-ignition from a lingering source of ignition, particularly in conditions such as where an aircraft makes a rapid descent which causes air to be drawn into the tank in which an explosion has been suppressed and thus brings the mixture back to the explosive range. There is also less danger of a fire in the space surrounding the tank which may receive fuel as a result of leakage following upon damage to the tank.

By combining any enriching liquid with any cooling suppressant in proportions dictated by the above considerations it is possible to obtain an improved suppressant which is considerably lighter than the equivalent volume of a pure cooling suppressant, but has a greater effective range when distributed under high pressure than that of a pure enriching liquid.

The following are a very few examples only of the many possible compositions of mixtures of cooling suppressant and enriching liquids which may be used as fire

and/or explosion suppressants in accordance with the invention, based on the above considerations:

Example I

	Percentage by volume
5 Chloro-bromo-methane -----	20
Petroleum ether fraction having boiling point below 40° C. -----	80
	100

Example II

10 Di-bromo di-fluoro methane -----	12
Petroleum ether fraction having boiling point below 40° C. -----	88
	100

Example III

20 Chloro-bromo-methane -----	25
Iso-pentane -----	75
	100

Example IV

25 Di-bromo tetra-fluoro ethane -----	5
Gasoline -----	95
	100

Example V

30 Methyl bromide -----	95
Iso-pentane -----	5
	100

Example VI

40 Methyl bromide -----	12
Chloro-bromo-methane -----	8
Iso-pentane -----	80
	100

Example VII

45 Chloro-bromo-methane -----	92
N-pentane -----	8
	100

Example VIII

50 Di-bromo di-fluoro methane -----	50
Iso-pentane -----	50
	100

Example IX

60 Di-bromo tetra-fluoro ethane -----	80
Gasoline -----	20
	100

Example X

65 Chloro-bromo methane -----	11
N-pentane -----	89
	100

Example XI

70 Di-bromo di-fluoro methane -----	25
Iso-pentane -----	75
	100

Example XII

Chloro-bromo-methane	18
N-pentane	19
Iso-pentane	63
	100

Because in a mixture the cooling suppressant need not necessarily be effective throughout the whole temperature range, any cooling suppressant in addition to those specifically referred to above and which is effective over part of the required temperature range may be used. However, as pointed out in the case of methyl bromide, a cooling suppressant having a low boiling point may involve a rather greater weight penalty in respect of the container. For this reason I give preference to cooling suppressants having a boiling point of between 20 and 80° C., although it is quite satisfactory to use other cooling suppressants.

Similarly, to ensure adequate volatility I prefer to use enriching liquids having a boiling point below 40° C., although this is by no means essential.

It will be apparent that the proportions of the optimum mixture will vary from fuel tank to fuel tank dependent upon the size of the tank. In practice, therefore, the proportions finally selected must be a compromise for the sake of standardisation. For this reason the invention is not limited to any range of proportions; even quite a small proportion of enriching liquid say five percent will almost always lead to a weight saving, whilst even quite a small proportion of cooling suppressant say five percent will reduce the fire risk in storage, in fuel tank bays and reduce the danger of re-ignition. Thus, it will be seen that the proportion of enriching liquid used in a mixture of enriching liquid and cooling suppressant may be varied from as little as five to as much as ninety-five percent by volume of the mixture. Conversely, the proportion of cooling suppressant used in a mixture of enriching liquid and cooling suppressant may be varied from as little as five to as much as ninety-five percent by volume of the mixture. Throughout this whole range such as mixture will possess one or more of the advantages referred to above over the use of either a pure enriching liquid or a pure cooling suppressant.

What I claim is:

1. An explosion suppressant consisting of a mixture of two liquids, the first liquid being a bromine derivative of

hydrocarbon which represents between 5% and 95% by volume of the mixture, the balance of the mixture being pentane, said bromine derivative of hydrocarbon having a boiling point at normal atmospheric pressure which lies within the range of 20° C. to 80° C.

2. An explosion suppressant according to claim 1 in which said bromine derivative of hydrocarbon is selected from the group consisting of chloro-bromo methane, di-bromo di-fluoro methane, methyl bromide and di-bromo tetra-fluoro ethane.

3. A liquid explosion suppressant consisting of a bromine derivative of hydrocarbon having a boiling point at normal atmospheric pressure which lies within the range of 20° C. to 80° C., admixed with a petroleum ether fraction having a boiling point at normal atmospheric pressure below 40° C., said petroleum fraction constituting 80% by volume of the mixture and the balance being constituted by the bromine derivative of hydrocarbon.

4. An explosion suppressant consisting of a mixture of pentane with a halogenated hydrocarbon, said halogenated hydrocarbon being selected from the group consisting of chloro-bromo-methane, di-bromo di-fluoro methane, methyl bromide and di-bromo tetra-fluoro ethane, said halogenated hydrocarbon constituting between 20% and 80% by volume of the mixture and the balance of the mixture being pentane.

5. An explosion suppressant according to claim 4 in which said pentane is selected from the group consisting of n-pentane and iso-pentane.

References Cited in the file of this patent

UNITED STATES PATENTS

1,316,191	Sadtler	Sept. 16, 1919
1,926,396	Midgley et al.	Sept. 12, 1936
2,353,098	Whiteley et al.	July 4, 1944
2,524,590	Boe	Oct. 3, 1950

OTHER REFERENCES

"Preparation of Insecticidal Aerosols by the Use of Liquefied Gases," article by Goodhue and Sullivan, April 1942, U.S. Bureau Entomology and Plant Quarantine Quarterly (ET-190), Dept. of Agriculture Publication, 3 pages relied upon.

Industrial and Engineering Chem., July 1949, pages 1523-1527.

Industrial Solvents, Mellan, 2nd Ed., Reinhold (1950), pages 195, 201 and 208.