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(54) ROCKET MOTOR USING A DOUBLE-BASE PROPELLANT

(71) We, LES FORGES DE ZEEBRUGGE S.A., a body corporate organized and existing under the laws of Belgium, of 145, rue Bellenay, Herstal-lez-Liège, Belgium, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention concerns rocket motors contaning a power source that comprises a double-base propellant and a ballistic adjuvant which acts by external application as a ballastic modifier for said propellant.

Power sources comprising a double base propellant and a ballastic adjuvant are described and claimed in United Kingdom Specification 915700. In that specification the terms "double base propellant" and "ballistic modifier" are clearly defined and those terms and their definitions are accordingly adopted herein, as follows.

The expression "double base propellant" means a composition having one ingredient in which the slope of the curve of a logarithmic plot of its burning rate pressure relationship approaches zero in a favourable range of operating pressures while for the other substance the slope of a corresponding curve attains a negative value in a region of useful operating pressures. The expression "ballistic modifier" is intended to mean a material which enhances the ballistic performance of the jet actuated device, i.e. rocket motor in the present application, in which the propellant is used.

In accordance with the present invention, there is provided a rocket motor comprising a double-base propellant and a ballistic adjuvant which acts as a ballistic modifier for the double-base propellant by external application, i.e. without being incorporated in the propellant, by being disposed so as to act in the gaseous jet at high temperature inside the motor for stabilising the combustion and preventing the formation of postcombustion gleam and a detrimental evolution of fumes, the ballistic adjuvant comprising at least a plastics binding agent and an oxide of molybdenum, tin, chromium, tungsten, zirconium, cerium, lanthanum, cobalt, nickel, iron or magnesium.

The double-base propellant preferably comprises nitrocellulose and nitroglycerine or an equivalent thereto, e.g. diethylene glycol dinitrate or metriol trinitrate.

Preferably the ballistic adjuvant also comprises at least one of the following salts: potassium sulphate, potassium nitrate, potassium chloride, barium nitrate and potassium perchlorate.

The ballistic adjuvant may also comprise silicon dioxide or magnesium silicate.

Preferred ballistic adjuvant compositions comprising the following:

	% by weight
Potassium sulphate	67—76
Ethyl cellulose	10—15.5
Dibutyl phthalate	2—7
Butyl methacrylate	6.5—10.6
Polyglycol dimethacrylate	0.9—1.62
Benzoyl peroxide	0.09—0.16
Molybdic oxide	remaining portion

Ballistic adjuvants in accordance with the present invention may be used as ballistic modifiers for double-based propellants comprising nitrocellulose and nitroglycerine or an equivalent compound thereto, stabilising agents, plasticising agents, organic salts of copper or lead, and powdered aluminium. The nitroglycerine may be replaced by equivalent compounds, for instance dimethyleneglycol dinitrate, methyltrimethylol methane trinitrate, diethylene glycol dinitrate and metriol trinitrate. Suitable lead salts include lead salicylate, lead acetyl sali-

[*Price 5s. 0d. (25p)*]

cylate, lead 2,4-dihydroxybenzoate, lead 2-ethylhexoate, lead stearate and lead β-resorcylate. Suitable copper salts include monobasic cupric salicylate, cupric salicylate and cupric β-resorcylate.

Preferred double-base propellant compositions comprise, in addition to nitrocellulose and nitroglycerine or equivalent compounds thereto, additives comprising the following:

(a) a normal or monobasic copper salt, salicylic acid, β-resorcylic acid, 2,5-dihydroxybenzoic acid and 5-methylene disalicylic acid: this composition may further comprise a lead salt and, optionally, powdered aluminium;

(b) lead salicylate, lead acetyl salicylate, lead 2,4-dihydroxybenzoate and lead 2-ethylhexoate;

(c) lead salicylate or lead acetyl salicylate in an amount not more than 5% by weight: the composition containing lead salicylate may further comprise not more than 2% by weight of lead 2-ethylhexoate;

(d) propyl di - N - adipate, 2 - nitrodiphenylamine, monobasic cupric salcylate, monobasic lead β-resorcylate and candelilla wax;

(e) propyl di - N - adipate, 2 -nitrodiphenylamine, monobasic lead β-resorcylate, cupric β-resorcylate, candelilla wax and additional aliphatic or aromatic lead and/or copper salts.

A particularly preferred propellant composition is:

	% by weight
Nitrocellulose (12.6% N)	40—51
Nitroglycerine	38—50
Propyl di-N-adipate	0.1—0.6
2-Nitrodiphenylamine	1—3
Monobasic cupric salicylate	2—4.5
Monobasic lead β-resorcylate	1—3
Candelilla wax	0.08—0.3

in the presence of a ballistic adjuvant comprising, in the presence of a correlative proportion of a molybdenum oxide:

	% by weight
Potassium sulphate	67—76
Ethyl cellulose	10—15.5
Dibutyl phthalate	2—7
Butyl methacrylate	6.5—10.6
Polyglycol dimethyacrylate	0.9—1.62
Benzoyl peroxide	0.09—0.16

Preferably the ballistic adjuvant is disposed in a central longitudinally extending cavity provided in the double-base propellant. The ballistic adjuvant may be disposed at a certain dstance from or make contact with the double-base propellant. The ballistic adjuvant may comprise a portion disposed at a small distance from the double-base propellant or a portion in contact with the double-base propellant.

Examples of the construction of power sources for rocket motors comprising a double-base propellant and a ballistic adjuvant in accordance with the present invention will now be described with reference to the accompanying drawing in which:

Figure 1 is a cross-section or a rocket motor showing one form of a ballistic adjuvant;

Figure 2 is a cross-section of a similar motor as that of Figure 1, showing a second form of ballistic adjuvant;

Fgures 3 and 4 are partial longitudinal sections showing two dispositions of the ballistic adjuvant with respect to the double-base propellant;

Figures 5, 6 and 7 are longitudinal sections of a rocket motor showing the disposition of the ballistic adjuvant within a central cavity of the double-base propellant.

With reference to Figure 1, casing 1 of a rocket motor encloses a double-base propellant 2 provided with a central longitudinally extending cavity which is generally star-shaped in cross-section. A ballistic adjuvant 3 also generally star-shaped in cross-section is axially disposed in the central cavity, the arm of the ballistic adjuvant projecting into corresponding recesses of the central cavity. The ballistic adjuvant 3 is rigidly supported on radial members 4 and axial member 5. The thickness of the layer may be constant, or vary gradually or step-wise along the length of the casing 1, to allow for variation of the rate of combustion of the double-base propellant 2. The ballistic adjuvant 3 may comprise two or more layers.

With reference to Figure 2, a ballistic adjuvant 3a comprises a cylinder having radial apertures 10, the ballistic adjuvant 3a in this case being self-supporting.

With reference to Figure 3, in addition to the ballistic adjuvant 3b longitudinally disposed in the central cavity provided in the double base propellant 2, a ballistic adjuvant 3c in the form of a corrugated disc is provided adjacent to the end of the double base propellant 2. The ballistic adjuvant 3c may be in the form of a flat disc, comprise two or more layers, be perforated, or be shaped in order to present as large a surface area as possible. A spring 7 maintains the propellant charge 2 in the correct position through the ballistic adjuvant 3c which is in the form of a corrugated disc. A contact ring 11 is disposed between the propellant charge 2 and the ballistic adjuvant 3 in order to give good continuous contact. Supporting plate 8 for the axial member 5 is attached to a supporting gallows 9. A percussion cap is schematically shown at 10 and an envelope 12 is provided

to enclose and protect the propellant charge 2. This also facilitates the mounting of the charge.

With reference to Figure 4, in addition to the longitudinally disposed ballistic adjuvant 3d, an additional ballistic adjuvant 3e in the form of an annulus is disposed between the end of the ballistic adjuvant 2 and the nozzle 7 of the jet actuated device. The ballistic adjuvant 3e may be hollow or have a generally uniform or a contoured inner wall. To facilitate assembly, a ring 13 is placed between the body 1 and the rear assembly including the nozzles and vanes of the motor; annular element 14, only a part of which is shown, is the interconnection between the body and the rear assembly. A contact ring 15 is provided as the equivalent of the ring 11 in Figure 3. Part of the nozzle of the projectile, which is co-axial with it, is shown at 16. The rear end of the ballistic adjuvant 3c is denoted by 17.

In Figure 5 the ballistic adjuvant 3f disposed in the axial longitudinally extending cavity provided in a double base propellant 2 varies stepwise in thickness along the length of the casing of the jet actuated device, to allow for variation of the conditions of combustion of the double base propellant 2. In general, the manner in which the thickness of the ballistic adjuvant varies from the length of the casing of the jet-actuated device depends on the particular configuration and properties of the particular double base propellant.

Figure 6 shows a ballistic adjuvant 3g disposed in a central longitudinally extending cavity provided in the double base propellant 2. The thickness of the double base propellant varies continuously from one end of the casing of the device to the other.

In Figure 7 a ballistic adjuvant 3h disposed in a central longitudinally extending cavity provided in double base propellant 1 is helical in order to present large effective area. This embodiment includes an envelope 12 to protect the propellant charge 2 and also the spring 7, plate 8 and gallows 9 shown in Figure 3. A ring 18 is disposed between the propellant charge 2 and the spring 7.

WHAT WE CLAIM IS:—

1. A rocket motor comprising a double-base propellant and a ballistic adjuvant which acts as a ballistic modified for the double-base propellant by external application, i.e. without being incorporated in the propellant by being disposed so as to act in the gaseous jet at high temperature inside the motor for stabilizing the combustion and preventing the formation of postcombustion gleam and a detrimental evolution of fumes, the ballistic adjuvant comprising at least a plastics binding agent and an oxide of molybdenum, tin, chromium, tungsten, zirconium, cerium, lanthanum, cobalt, nickel, iron or magnesium.

2. A rocket motor according to claim 1, in which the ballistic adjuvant also comprises at least one of the following salts; potassium sulphate, potassium nitrate, potassium chloride, barium nitrate and potassium perchlorate.

3. A rocket motor according to claim 1 or 2, in which the ballistic adjuvant also comprises silicon dioxide.

4. A rocket motor according to claim 1 or 2, in which the ballistic adjuvant also comprises magnesium silicate.

5. A rocket motor according to claim 1, in which the ballistic adjuvant comprises from 67 to 76 weight percent of potassium sulphate, 10 to 15.5 weight percent of ethyl cellulose, 2 to 7 weight percent of dibutylphthalate, 6.5 to 10.6 weight percent of butyl methacrylate, 0.9 to 1.6 weight percent of polyglycol diacrylate, 0.09 to 0.16 weight percent of benzoylperoxide and a corellative amount of molybdic oxide.

6. A rocket motor according to any one of the preceding claims, in which the double base propellant comprises nitrocellulose and nitroglycerine or an equivalent compound thereto, a normal or monobasic copper salt, salicylic acid, β-resorcylic acid, 2,5-dihydroxybenzoic acid and 5-methylene disalicylic acid.

7. A rocket motor according to claim 6, in which the double-base propellant further comprises a lead salt.

8. A rocket motor according to claim 6 or claim 7, in which the double-base propellant comprises powdered aluminium.

9. A rocket motor according to any one of claims 1 to 5, in which the double-base propellant comprises nitrocellulose and nitroglycerine or an equivalent compound thereto, lead salicylate, lead acetyl salicylate, lead 2,4-dihydroxybenzoate and lead 2-ethylhexoate.

10. A rocket motor according to any one of claims 1 to 5, in which the double-base propellant comprises nitrocellulose and nitroglycerine or an equivalent compound thereto and not more than 5% by weight of lead salicylate.

11. A rocket motor according to any one of claims 1 to 5, in which the double-base propellant comprises nitrocellulose and nitroglycerine or an equivalent compound thereto and not more than 5% of lead acetyl salicylate.

12. A rocket motor according to claim 10, in which the double-base propellant comprises no more than 2% by weight of lead 2-ethylhexoate.

13. A rocket motor according to any one of claims 1 to 4, in which the double-base propellant comprises nitrocellulose and nitroglycerine or an equivalent compound thereto, organic salts of copper or lead, powdered alu-

to enclose and protect the propellant charge 2. This also facilitates the mounting of the charge.

With reference to Figure 4, in addition to the longitudinally disposed ballistic adjuvant 3d, an additional ballistic adjuvant 3e in the form of an annulus is disposed between the end of the ballistic adjuvant 2 and the nozzle 7 of the jet actuated device. The ballistic adjuvant 3e may be hollow or have a generally uniform or a contoured inner wall. To facilitate assembly, a ring 13 is placed between the body 1 and the rear assembly including the nozzles and vanes of the motor; annular element 14, only a part of which is shown, is the interconnection between the body and the rear assembly. A contact ring 15 is provided as the equivalent of the ring 11 in Figure 3. Part of the nozzle of the projectile, which is co-axial with it, is shown at 16. The rear end of the ballistic adjuvant 3c is denoted by 17.

In Figure 5 the ballistic adjuvant 3f disposed in the axial longitudinally extending cavity provided in a double base propellant 2 varies stepwise in thickness along the length of the casing of the jet actuated device, to allow for variation of the conditions of combustion of the double base propellant 2. In general, the manner in which the thickness of the ballistic adjuvant varies from the length of the casing of the jet-actuated device depends on the particular configuration and properties of the particular double base propellant.

Figure 6 shows a ballistic adjuvant 3g disposed in a central longitudinally extending cavity provided in the double base propellant 2. The thickness of the double base propellant varies continuously from one end of the casing of the device to the other.

In Figure 7 a ballistic adjuvant 3h disposed in a central longitudinally extending cavity provided in double base propellant 1 is helical in order to present large effective area. This embodiment includes an envelope 12 to protect the propellant charge 2 and also the spring 7, plate 8 and gallows 9 shown in Figure 3. A ring 18 is disposed between the propellant charge 2 and the spring 7.

WHAT WE CLAIM IS:—

1. A rocket motor comprising a double-base propellant and a ballistic adjuvant which acts as a ballistic modified for the double-base propellant by external application, i.e. without being incorporated in the propellant by being disposed so as to act in the gaseous jet at high temperature inside the motor for stabilizing the combustion and preventing the formation of postcombustion gleam and a detrimental evolution of fumes, the ballistic adjuvant comprising at least a plastics binding agent and an oxide of molybdenum, tin, chromium, tungsten, zirconium, cerium, lanthanum, cobalt, nickel, iron or magnesium.

2. A rocket motor according to claim 1, in which the ballistic adjuvant also comprises at least one of the following salts; potassium sulphate, potassium nitrate, potassium chloride, barium nitrate and potassium perchlorate.

3. A rocket motor according to claim 1 or 2, in which the ballistic adjuvant also comprises silicon dioxide.

4. A rocket motor according to claim 1 or 2, in which the ballistic adjuvant also comprises magnesium silicate.

5. A rocket motor according to claim 1, in which the ballistic adjuvant comprises from 67 to 76 weight percent of potassium sulphate, 10 to 15.5 weight percent of ethyl cellulose, 2 to 7 weight percent of dibutylphthalate, 6.5 to 10.6 weight percent of butyl methacrylate, 0.9 to 1.6 weight percent of polyglycol diacrylate, 0.09 to 0.16 weight percent of benzoylperoxide and a corellative amount of molybdic oxide.

6. A rocket motor according to any one of the preceding claims, in which the double base propellant comprises nitrocellulose and nitroglycerine or an equivalent compound thereto, a normal or monobasic copper salt, salicylic acid, β-resorcylic acid, 2,5-dihydroxybenzoic acid and 5-methylene disalicylic acid.

7. A rocket motor according to claim 6, in which the double-base propellant further comprises a lead salt.

8. A rocket motor according to claim 6 or claim 7, in which the double-base propellant comprises powdered aluminium.

9. A rocket motor according to any one of claims 1 to 5, in which the double-base propellant comprises nitrocellulose and nitroglycerine or an equivalent compound thereto, lead salicylate, lead acetyl salicylate, lead 2,4-dihydroxybenzoate and lead 2-ethylhexoate.

10. A rocket motor according to any one of claims 1 to 5, in which the double-base propellant comprises nitrocellulose and nitroglycerine or an equivalent compound thereto and not more than 5% by weight of lead salicylate.

11. A rocket motor according to any one of claims 1 to 5, in which the double-base propellant comprises nitrocellulose and nitroglycerine or an equivalent compound thereto and not more than 5% of lead acetyl salicylate.

12. A rocket motor according to claim 10, in which the double-base propellant comprises no more than 2% by weight of lead 2-ethylhexoate.

13. A rocket motor according to any one of claims 1 to 4, in which the double-base propellant comprises nitrocellulose and nitroglycerine or an equivalent compound thereto, organic salts of copper or lead, powdered alu-

minium, stabilising agents and plasticizing agents.

14. A rocket motor according to any one of claims 1 to 5, in which the double-base propellant comprises nitrocellulose and nitroglycerine or an equivalent compound thereto, together with propyl di - N - adipate, 2-nitrodiphenylamine, monobasic cupric salicylate, monobasic lead β-resorcylate and candellila wax.

15. A rocket motor according to any one of claims 1 to 5, in which the double-base propellant comprises nitrocellulose and nitroglycerine or an equivalent compound thereto, together with propyl di - N - adipate, 2-nitrodiphenylamine, monobasic lead β-resorcylate, cupric β-resorcylate, candelilla wax and additional aliphatic or aromatic salts of lead and/or copper.

16. A rocket motor according to any one of claims 5 to 15, in which the equivalent compound to nitroglycerine is dimethylene glycol dinitrate, methyltrimethylol methane trinitrate, diethylene glycol dinitrate or metriol trinitrate.

17. A rocket motor according to claim 1, in which the double-base propellant comprises 40 to 51 weight percent of nitrocellulose (12.6 percent of nitrogen), 38 to 50 weight per cent of nitroglycerine, 0.1 to 0.6 weight percent of propyl di - N - adipate, 1 to 3 weight percent of 2-nitrodiphenylamine, 2 to 4.5 percent of monobasic cupric salicylate, 1 to 3 weight percent of monobasic lead resorcylate and 0.08 to 0.3 weight percent of candelilla wax.

18. A rocket motor according to any one of the preceding claims, in which the ballistic adjuvant comprises an element disposed in an axial passage provided in the double-base propellant and in contact with the double-base propellant.

19. A rocket motor according to any one of claims 1 to 17, in which the ballistic adjuvant comprises an element disposed in an axial passage provided in the double-base propellant at a small distance from the double-base propellant, and another element in contact with the double-base propellant.

20. A rocket motor according to claim 19, in which the element of the ballistic adjuvant disposed in the axial passage provided in the double-base propellant gradually varies in thickness along its length.

21. A rocket motor according to claim 19, in which the thickness of the ballistic adjuvant disposed in the axial passage provided in the double-base propellant varies stepwise along its length.

22. A rocket motor according to any one of the preceding claims, in which the ballistic adjuvant comprises layers.

23. A rocket motor according to any one of the preceding claims, in which an element of the ballistic adjuvant is disposed adjacent to the part of the double-base propellant adjacent to an outlet of the motor.

24. A rocket motor substantially as hereinbefore described with reference to the accompanying drawing.

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