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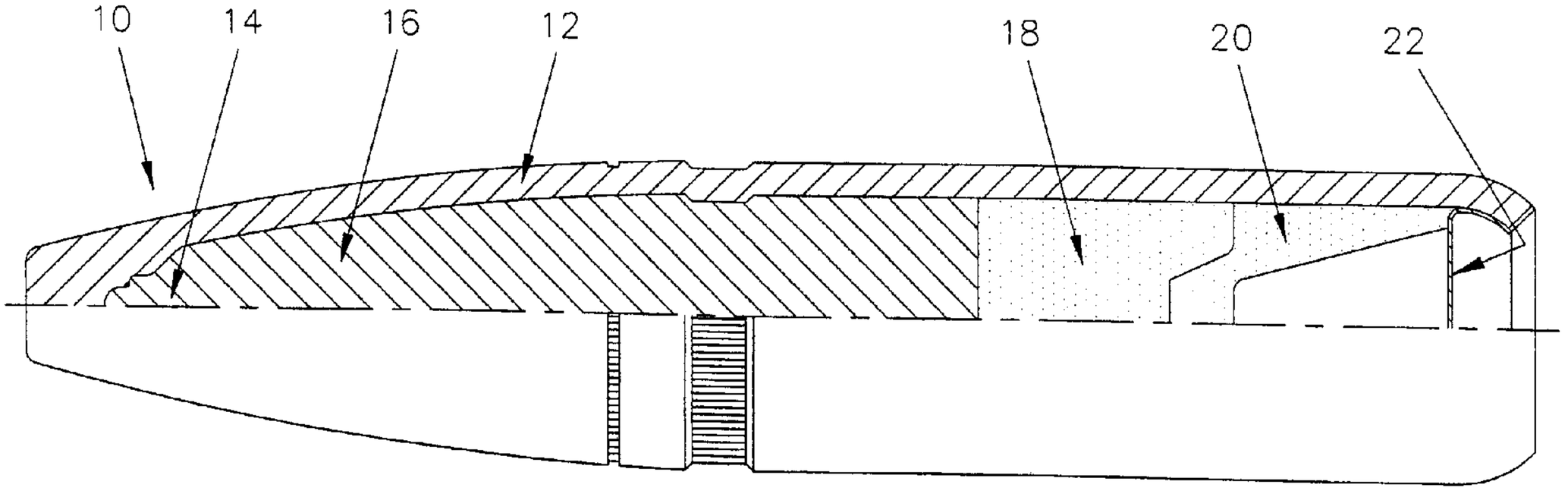
(54) **Titre : COMPOSITIONS DE TRACEUR NON TOXIQUES CONTENANT DU BORE ET PROJECTILES TRACEURS IR CONTENANT CES COMPOSITIONS POUR PRODUIRE UNE TRACE IR EN VISIBILITE FAIBLE**

(54) **Title: NON-TOXIC, BORON-CONTAINING, IR TRACER COMPOSITIONS AND IR TRACER PROJECTILES CONTAINING THE SAME FOR GENERATING A DIM VISIBILITY IR TRACE**



(57) **Abrégé/Abstract:**
A novel non-toxic IR tracer composition is provided herein which, when incorporated into an IR tracer projectile which is then fired, generates a dim visibility IR trace. Such IR tracer composition is a non-toxic, boron-containing, IR tracer composition comprising: from about 20 to about 30% by weight, or from about 45 to about 60% by weight, of potassium perchlorate; from about 5 to about 16% by weight of a metallic fuel which consists only of boron; from about 15 to about 25% by weight, or from about 40 to about 50% by weight, of a non-metallic fuel which consists of sodium salicylate; from about 5 to about 10% by weight of a retardant which consists either of iron carbonate, magnesium carbonate or calcium carbonate; and from about 5 to about 15% by weight of a first binder which consists of calcium resinate, wherein the total percentage of such ingredients add up to 100%. A novel IR tracer projectile containing such IR tracer composition for generating a dim visibility IR trace is also provided.

ABSTRACT

A novel non-toxic IR tracer composition is provided herein which, when incorporated into an IR tracer projectile which is then fired, generates a dim visibility IR trace. Such IR tracer composition is a non-toxic, boron-containing, IR tracer composition comprising: from about 20 to about 30% by weight, or from about 45 to about 60% by weight, of potassium perchlorate; from about 5 to about 16% by weight of a metallic fuel which consists only of boron; from about 15 to about 25% by weight, or from about 40 to about 50% by weight, of a non-metallic fuel which consists of sodium salicylate; from about 5 to about 10% by weight of a retardant which consists either of iron carbonate, magnesium carbonate or calcium carbonate; and from about 5 to about 15% by weight of a first binder which consists of calcium resinate, wherein the total percentage of such ingredients add up to 100%. A novel IR tracer projectile containing such IR tracer composition for generating a dim visibility IR trace is also provided.

NON-TOXIC, BORON-CONTAINING, IR TRACER COMPOSITIONS AND IR TRACER PROJECTILES CONTAINING THE SAME FOR GENERATING A DIM VISIBILITY IR TRACE

FIELD OF THE INVENTION

[001] This invention relates to non-toxic, boron-containing, IR tracer compositions and to IR tracer projectiles containing such IR tracer compositions for generating a dim visibility IR trace.

BACKGROUND OF THE INVENTION

[002] Tracer projectiles provide a reliable means of determining whether projectiles impact on the desired target or whether adjustments in aim are necessary. One problem with the use of conventional tracer projectiles is that they emit visible light, which thereby makes the source of the tracer ammunition discernable to the enemy. Another problem with conventional tracer projectiles is that they contain metallic fuels, which tend to be toxic and pollute the environment. The art is replete with patents which are directed to compositions containing boron for various purposes, including, e.g., tracer compositions, incendiary compositions and pyrotechnic compositions. Among such prior art patents are the following:

[003] US Patent No 5,639,984, patented Jun 17, 1997, INFRARED TRACER COMPOSITIONS and assigned to Thiokol Corporation. Those patented compositions included strontium peroxide and barium peroxide in addition to boron. However, such infrared tracer compositions suffered the defect that barium was a toxic element.

[004] US Patent No 5,056,435, patented Oct 15, 1991, INFRARED ILLUMINANT AND PRESSING METHOD and assigned to Thiokol Corporation. Such patented compositions contained potassium nitrate as well as boron. Such patented compositions suffered the defect that flares including such composition also generated visible light.

[005] US Patent No 6,635,130, patented Oct 21, 2003, PYROTECHNIC COMPOSITION FOR PRODUCING IR-RADIATION, and assigned to Diehl Munitionssysteme GmbH & Co KG. Those patented compositions included

magnesium in addition to other metals, including boron. However, those compositions suffered the defects that the magnesium also generated visible light and that they did not produce a cool IR trace.

[006] US Patent Nos 6,485,586; 6,409 854; 6,402,864; and 4,915,756 all disclosed compositions which included titanium as well as boron. However, those compositions suffered the defects that the titanium also generated visible light and that they did not produce a cool IR trace.

[007] Examples of patented pyrotechnic compositions comprising boron which did not produce a cool IR trace include US Patent Nos 4,978,400; 4,406,228; and 3,695,951.

[008] Examples of patented pyrotechnic compositions comprising boron but also containing toxic materials include US Patent No 3,480,489; 4,204,895; and 3,475,237.

SUMMARY OF THE INVENTION

AIMS OF THE INVENTION

[009] It would thus be desirable to suppress visible emissions, whereby camouflage is optimized and an enemy cannot visually locate the source of the tracer projectile or the line of fire in order to direct a counter-attack toward that location.

[0010] Accordingly it is an object of a first aspect of the present invention to provide improved IR tracer compositions and projectiles in which visible emissions are suppressed, whereby camouflage is optimized and an enemy cannot visually locate the source of the tracer projectile or the line of fire in order to direct a counter-attack toward that location.

[0011] An object of a second aspect of the present invention is to provide improved IR tracer compositions and projectiles which generate a trace which is substantially-completely IR radiation.

[0012] It is an object of a third aspect of the present invention to provide improved IR tracer compositions and projectiles which generate a trace which is substantially-completely IR radiation, and which has an appropriate burning rate so that it can be observed by the users at a longer distance down range.

[0013] It is an object of a fourth aspect of the present invention to provide improved IR tracer compositions and projectiles which generate a trace which is substantially-completely IR radiation, and which has a lower energetic output to minimize the risk of fire propagation in bushes and wooded areas where the projectile lands.

[0014] It is an object of a fifth aspect of the present invention to provide improved IR tracer compositions and projectiles which generate a trace which is substantially-completely IR radiation, and which has a controlled IR emission at any particular point to avoid very high intensity visible light emissions which could temporarily blind an observer using an infrared detection system.

[0015] It is an object of a sixth aspect of the present invention to provide improved IR tracer compositions which have a uniform granularity to facilitate the controlled production of the IR tracer projectiles which generate an IR trace which is substantially-completely IR radiation.

[0016] It is an object of a seventh aspect of the present invention to provide improved IR tracer compositions which do not significantly degrade with time under extreme environmental conditions when stored at about 5 to 20°C, and thus which provides IR tracer projectiles which generate an IR trace which is substantially-completely IR radiation.

[0017] It is an object of an eighth aspect of the present invention to provide improved IR tracer compositions which do not contain toxic heavy metals, e.g., barium nor any other toxic elements, and which are combined with a non-toxic igniter composition. Such compositions are environmentally-friendly.

[0018] It is an object of a ninth aspect of the present invention to provide improved IR tracer compositions which are formulated using a selected solvent for mixing the ingredients in order to facilitate the manufacturing process by providing the IR tracer composition with uniform granularity and improved flowability, so that the IR tracer charge weight compressed into IR tracer projectiles which generate an IR trace which is substantially-completely IR radiation could be better controlled.

STATEMENTS OF INVENTION

[0019] A broad aspect of the present invention provides a non-toxic, boron-containing, IR tracer composition comprising: potassium perchlorate, a non-metallic fuel which consists of sodium salicylate, a flame retardant which consists of either iron carbonate or magnesium carbonate, and at least one binder such as calcium resinate, in one or more of the following proportions by weight.

In one aspect of the present invention, there is provided A non-toxic, boron-containing, infrared tracer composition comprising: a) from about 20 to about 30% by weight, or from about 45 to about 60% by weight of potassium perchlorate; b) from about 5 to about 16% by weight of a metallic fuel which consists only of boron; c) from about 5 to about 20% by weight of a retardant which is selected from the group consisting of iron carbonate, magnesium carbonate and calcium carbonate; d) from about 15 to about 25% by weight, or from about 40 to about 50% by weight, of a non-metallic fuel which consists only of sodium salicylate; and d) from about 5 to about 15% by weight of a first binder which consists only of calcium resinate; wherein the total percentage of all said ingredients add up to 100%, with the proviso that when potassium perchlorate is present in the amount of from 20 to about 30% by weight, sodium salicylate is present in the amount of from about 40 to about 50% by weight; and when potassium perchlorate is present in the amount of from 45 to about 60% by weight, sodium salicylate is present in the amount of from about 15 to about 25% by weight.

[0020] Other embodiments and aspects of the invention comprise the following boron-containing, IR tracer compositions:

[0021] From about 20 to about 30% by weight or from about 45 to about 60% by weight of potassium perchlorate; from about 5 to about 16% by weight of boron; from about 5 to about 10% by weight of a retardant such as iron carbonate or magnesium carbonate; from about 20 to about 25% by weight or from about 40 to about 50% by weight of sodium salicylate; and an effective amount of binder; wherein the total percentage of the ingredients add up to 100%;

[0022] From about 20 to about 60% by weight of potassium perchlorate; from about 5 to about 12% by weight of boron; from about 5 to about 10% by weight of a retardant such as iron carbonate or magnesium carbonate; from about 20 to about 25% by weight or from about 40 to about 50% by weight of sodium salicylate; and an effective amount of binder; wherein the total percentage of the ingredients add up to 100%;

[0023] From about 20 to about 30% by weight of potassium perchlorate; from about 6 to about 16% by weight of boron; about 10% by weight of a retardant such as iron carbonate or magnesium carbonate; from about 40 to about 50% by weight of

sodium salicylate; and an effective amount of binder; wherein the total percentage of the ingredients add up to 100%; and

[0024] From about 22 to about 30% by weight of potassium perchlorate; from about 6 to about 16% by weight of boron; about 10% by weight of iron carbonate; from about 40 to about 50% by weight of sodium salicylate; and an effective amount of binder; wherein the total percentage of the ingredients add up to 100%.

[0025] The present invention, in another aspect, also provides an IR tracer projectile comprising: a hollow cylindrical shell made of a suitable metallic material having a conical nose; a conventional heavy filler disposed in the hollow conical nose; the non-toxic, boron-containing IR tracer composition as described above in its generic and specific aspects, compressed immediately against the filler; a conventional ignition material compressed against the compressed tracer composition; and a metal disc capping the hollow shell.

GENERALIZED DESCRIPTION OF THE INVENTION

[0026] The present invention provides infrared-producing (hereafter "IR" producing) compositions which are capable of producing a consistent IR output when provided in tracer projectiles which are fired from either rifles or machine guns. The IR output includes near IR and far IR bands (0.76 to 3.0 μm). The intensity of the IR radiation depends on the specific wavelength of these bands.

[0027] Conventional IR radiation-emitting pyrotechnic compositions typically contain a finely-divided mixture of an oxidizer and a fuel (metallic, non-metallic or organic fuel). The oxidizer contains oxygen to sustain combustion and the metallic atoms are responsible for the characteristic color output. To sustain combustion of the mixture and to provide heat energy, a fuel is normally added.

[0028] Finely divided powdered fuel in conventional IR radiation emitting pyrotechnic mixtures is very reactive with an oxidizing agent. Above a certain temperature, namely, the ignition temperature, the oxidizer decomposes to release oxygen, which then reacts quickly with the fuel in an exothermic reaction. An oxidizer and a fuel alone, however, do not make practical pyrotechnics for the

purpose of providing IR emission. A flame retardant and a binding agent are also incorporated into such compositions.

[0029] The IR tracer compositions of aspects of the present invention possess unique requirements not generally addressed by the prior art conventional IR tracer compositions. While it is not desired to be limited to any particular theory, it is believed that a hypothesis concerning the formation of purely IR emission without the presence of visible light may be developed based on black body radiation theory. The requirement would then be for the tracer to maximize output at a wavelength in the 1 to 3 μm range.

[0030] The desired IR range is significantly below the flame temperature of present conventional tracer and flame formulations. This knowledge, coupled with the understanding that visible light output is normally the smallest proportion of energy radiation during combustion, leads to the conclusion that an effective IR tracer according to aspects of the present invention is based on a relatively cool burning IR tracer composition.

[0031] Various chemical compositions were investigated to maximize the IR intensity, to maximize the duration of the IR trace for each type of small caliber projectiles and to provide a relatively cool burning IR tracer composition. The IR tracer compositions to be described hereinafter burn cleanly with not too much heat generated and emit relatively-small, almost negligible, quantities of visible light in proportion to the IR radiation emitted.

[0032] The basic components of the compositions of the present invention are able to augment near IR emissions when fired. This is accomplished by the addition of IR producing oxidizer and fuel. Thus, the compositions of aspects of the present invention consist essentially of an oxidizer, an organic fuel, from about 5% to about 16% of a boron as the sole metallic fuel and a flame retardant.

[0033] The preferred oxidizer is potassium perchlorate, but, alternatively, potassium nitrate may also be used. Potassium perchlorate ($KClO_4$) is the preferred oxidizer because it liberates a large amount of oxygen (46% max) and is stable as a function of

time. Sodium perchlorate would not be suitable since sodium emits a visible yellow light. Lithium perchlorate would not be suitable since lithium emits a visible red light.

[0034] The preferred organic fuel when used is sodium salicylate ($C_7H_5NaO_3$). This organic fuel has a low melting point and generates a large amount of gases during the combustion, which facilitates the removal of solid residues and soot inside the tracer cavity of the projectile. Without obstruction, the trace can be seen at a longer distances down range. Neither lithium salicylate nor potassium salicylate would be suitable since they provide compositions which are too hygroscopic. Furthermore, these compounds are not conveniently commercially available.

[0035] The preferred flame retardants are iron carbonate and magnesium carbonate although calcium carbonate would also be useful. The presence of iron carbonate, magnesium carbonate or calcium carbonate brings about a better control of the rate of burning and substantially reduces the flash and output of visible light at the point of firing. The carbonates of other transition metals are not suitable. For example, the carbonates of chromium and cobalt contaminate the atmosphere, the carbonate of nickel has carcinogenic properties and the carbonate of zirconium has excessive luminousity properties.

[0036] The sole metallic fuel in the composition of aspects of the present invention is boron. It contributes substantially to the exothermic reaction with the oxidizer and to a better combustion of the IR formulation and provides almost exclusively IR radiation and a cool burning IR trace. It provides IR tracer compositions having all the desired characteristics to be described in further detail hereinafter.

[0037] A binder maintains the other particulate forms of the constituents of the IR tracer composition together. The binder increases the structural integrity of the IR tracer material to prevent any break up of the IR trace in flight. It protects the IR tracer composition from moisture and increases the flowability of the composition. The preferred binder agent is calcium resinate which is added to the composition as a fuel retardant and acts as a waterproofing agent. Other binders, e.g. cellulose acetate butyrate (CAB) or the fluorocarbon elastomer known by the trade mark VITON A are suitable since they reduce soot formation.

BRIEF DESCRIPTION OF THE DRAWING

[0038] Embodiments of the present invention will be described, by way of example only, with reference also to the attached Figure, which is a one-half longitudinal cross-section of a tracer projectile according to one embodiment of the present invention.

EXAMPLES

PREPARATION OF COMPOSITIONS

[0039] The IR tracer compositions were prepared by first dry mixing the powdered ingredients to provide a dry intermediate composition. The binder was dissolved in a suitable aprotic solvent, namely, methyl ethyl ketone. The so-formed binder solution was then incorporated into the dry intermediate composition to provide a wet mixture. The wet mixture so provided was transferred to a suitable mixer in order to obtain a substantially-completely homogeneous mixture of all ingredients. The homogenous mixture so-formed was dried in an oven at about 20-40°C until it was sufficiently dry for sieving. The dry mixture was then sieved to break up agglomerated particles. The IR tracer compositions are thus provided as relatively small particles of random shape.

[0040] A series of IR tracer compositions was prepared according to the proportion of ingredients as set forth in the following Tables 1A and 1B.

TABLE 1A

INGREDIENT	PERCENTAGE IN TEST NO					
TEST NO	DT-63	DT-64	DT-65	DT-67	DT-71	DT-72
BORON	10	10	5	10	12	6
POTASSIUM PERCHLORATE	45	25	60	25	20	24
IRON CARBONATE	0	0	5	10	10	10
MAGNESIUM CARBONATE	10	10	0	0	0	0
SODIUM SALICYLATE	25	45	20	45	48	50
CALCIUM RESINATE	10	10	10	10	10	10

TABLE 1B

INGREDIENT	PERCENTAGE IN TEST NO			
TEST NO	DT-73	DT-74	DT-75	DT-76
BORON	6	12	16	11
POTASSIUM PERCHLORATE	30	28	24	22
IRON CARBONATE	10	10	10	10
MAGNESIUM CARBONATE	10	10	0	0
SODIUM SALICYLATE	44	40	40	47
CALCIUM RESINATE	10	10	10	10

PREPARATION OF TEST PROJECTILES

[0041] Each of the above IR tracer compositions was compressed into a projectile body of the desired caliber. For the tests which are to be described below, the caliber was 5.56/7.62 mm, i.e., for a rifle. Thus, as seen in the drawing, the tracer projectile 10 includes a hollow shell 12 of, preferably, a copper alloy (90% Cu/10% Zn), whose nose 14 is filled with a suitable conventional heavy filler 16. The IR tracer composition 18 is compressed immediately against the filler 16. A conventional ignition material 20 is compressed against the tracer composition 18. The tracer projectile 10 is capped by means of a closure disc 22, preferably of brass.

TEST PROCEDURES

[0042] For these series of tests, each of which the IR tracer compositions was inserted into 5.56mm tracer projectiles and fired. When the IR tracer projectile was fired, the IR tracer composition inside the projectile body was ignited by hot gases emitted by a propellant and an IR trace was produced.

[0043] Several important criteria for the IR trace, namely its stability, its intensity, whether any visible light was detected and if a spark occurred at the firing point, were evaluated as follows:

[0044] Three observers were stationed, one each, at the point of firing, at 250m down range and at 400m down range. These observers noted each of the above criteria.

[0045] The visibility with night vision goggles was determined by the same observers at the same three positions.

[0046] The distinctness of the trace was noted at a barrier located 1000m down range. NATO criteria is distinctness of the IR trace at 600m down range.

[0047] The visibility with the naked eye of the tracer projectile was determined at the firing position along the trajectory path and perpendicular to the trajectory path at 200m down range and at 400m down range from the firing position.

[0048] The calorific output of the tracer projectile was measured with a calorimeter.

[0049] The results are summarized as follows:

[0050] The IR trace was found to be visible from the firing position and could not be seen with the naked eye by an observer placed at an angle with respect to the trajectory of the IR tracer projectile.

[0051] The calorific output of the IR tracer composition measured with a calorimeter was about 500 cal/g, which is about one third less than the calorific output generated by conventional tracer compositions, (500 cal/g compared to 1200 cal/g for conventional tracer compositions). The IR trace can, thus, be designated as a cool IR trace.

[0052] The IR intensity of the IR emission as measured with a spectrophotometer equipped with IR filters at a wavelength of 760 nanometers was found to be about 1 to 4 watts/steradian and at a wavelength of 3,000 nanometers was found to be about 1.7

to 2.1 watts/steradian. The IR tracer compositions of aspects of the present invention was found to have an IR luminosity as measured with a spectrophotometer at a wavelength of 760 nanometers of about 1 to 2 watts/steradian and an IR luminosity as measured with a spectrophotometer at a wavelength 3000 nanometers of about 1 to 4 watts/steradian.

[0053] For 5.56mm tracer projectiles, the IR tracer can be seen up to 1000m compared to up to about 600m for 5.56mm conventional tracer projectile.

[0054] The IR projectiles of an aspect of the present invention containing the IR tracer compositions of aspects of the present invention have been found to increase the length of trace along the firing line by up to about 120%.

[0055] It has been found that the IR tracer compositions of aspects of the present invention produce relatively low burn rate materials so that the IR trace can be seen from the firing point to a longer distance down range. The burn rate is adjustable for 5.56mm and 7.62mm ammunition to meet or exceed NATO and specific user requirements. The IR tracer compositions of aspects of the present invention are also applicable to short/limited range training ammunition (5.56mm, 7.62mm). Thus, particular burn rates can be adjusted, the ratio of IR radiation to visible light can be optimized (i.e., substantially no visible light), and the general physical and chemical properties can be carefully selected.

[0056] The IR tracer compositions of aspects of the present invention do not degrade with time, when properly stored at a temperature varying between 5°C and 20°C, with a relative humidity which ranged between 50% and 70%. For example, the calorific heat of an IR tracer projectile containing IR tracer compositions of aspects of the present invention at the beginning of the storage period was about 500 cal/g and remained constant over a minimum storage period of 6 months.

[0057] The IR tracer compositions of aspects of the present invention do not contain any toxic elements.

[0058] The IR tracer compositions of aspects of the present invention may easily be industrialized.

[0059] Not all boron-containing compositions satisfy the utility requirements which are met by the IR tracer compositions of aspects of the present invention. Thus, compositions having the ingredients/proportions set forth in the following Tables 2A and 2B below have been found not to be useful when subjected to the above tests.

TABLE 2A

INGREDIENT	PERCENTAGE IN TEST NO				
TEST NO	DT-09	DT-10	DT-11	DT-12	DT-25
BORON	10	10	10	10	19
POTASSIUM NITRATE	25	25	25	25	0
MAGNESIUM CARBONATE	10	10	10	10	10
POLYISOBUTYLENE	5	5	5	5	3
ZINC PEROXIDE	50	0	0	0	0
CESIUM NITRATE	0	0	0	50	0
STRONTIUM OXIDE	0	0	50	0	0
POTASSIUM PERCHLORATE	0	0	0	0	28

TABLE 2B

INGREDIENT	PERCENTAGE IN TEST NO				
TEST NO	DT-26	DT-27	DT-28	DT-29	DT-30
BORON	19	10	4	4	11
POTASSIUM PERCHLORATE	38	47	45	34	38
MAGNESIUM CARBONATE	10	0	0	0	0
POLYISOBUTYLENE	3	3	3	3	3
ZINC PEROXIDE	30	30	38	49	38
STRONTIUM OXIDE	0	0	50	0	0

SUMMARY

[0060] In summary, the present invention provides IR tracer compositions for small caliber ammunition. The IR tracer compositions of aspects of the present invention are non-toxic and when provided in an IR tracer projectile and fired, produced an IR

trace having a lower calorific output than conventional compositions. The IR trace is not visible by the naked eye, i.e., it is a dim trace. The rate of burning is selectively controllable so that the IR tracer can be seen at longer distance from the firing position than the IR trace provided by conventional IR tracer compositions.

CLAIMS

1) A non-toxic, boron-containing, infrared tracer composition comprising:
    a) from about 20 to about 30% by weight, or from about 45 to about 60% by weight of potassium perchlorate;
    b) from about 5 to about 16% by weight of a metallic fuel which consists only of boron;
    c) from about 5 to about 20% by weight of a retardant which is selected from the group consisting of iron carbonate, magnesium carbonate and calcium carbonate;
    d) from about 15 to about 25% by weight, or from about 40 to about 50% by weight, of a non-metallic fuel which consists only of sodium salicylate; and
    e) from about 5 to about 15% by weight of a first binder which consists only of calcium resinate;

wherein the total percentage of all said ingredients add up to 100%, with the proviso that when potassium perchlorate is present in the amount of from 20 to about 30% by weight, sodium salicylate is present in the amount of from about 40 to about 50% by weight; and when potassium perchlorate is present in the amount of from 45 to about 60% by weight, sodium salicylate is present in the amount of from about 15 to about 25% by weight.

2) The composition of claim 1 further comprising up to about 7.5% by weight of a synthetic resin binder which is selected from the group consisting of a copolymer of hexafluoropropylene and vinylidene fluoride, and cellulose acetate butyrate.

3) The composition as claimed in claim 1 or 2, comprising:
    from about 5 to about 12% by weight of boron; and
    from about 20 to about 30% by weight of potassium perchlorate.

4) The composition as claimed in claim 1 or 2, comprising:
    about 10% by weight of boron;
    about 45% by weight of potassium perchlorate;
    about 10% by weight of magnesium carbonate; and

about 25% by weight of sodium salicylate.

5) The composition as claimed in claim 3, comprising:

about 10% by weight of boron;

about 25% by weight of potassium perchlorate;

about 10% by weight of magnesium carbonate; and

about 45% by weight of sodium salicylate.

6) The composition as claimed in claim 1 or 2, comprising:

about 5% by weight of boron;

about 60% by weight of potassium perchlorate; and

about 20% by weight of sodium salicylate.

7) The composition as claimed in claim 3, comprising:

about 10% by weight of boron;

about 25% by weight of potassium perchlorate;

about 10% by weight of iron carbonate; and

about 45% by weight of sodium salicylate.

8) The composition as claimed in claim 3, comprising:

about 12% by weight of boron;

about 20% by weight of potassium perchlorate;

about 10% by weight of iron carbonate; and

about 48% by weight of sodium salicylate.

9) The composition as claimed in claim 3, comprising:

about 6% by weight of boron;

about 24% by weight of potassium perchlorate;

about 10% by weight of iron carbonate; and

about 50% by weight of sodium salicylate.

10) The composition as claimed in claim 1 or 2, comprising:

from about 6% to about 12% by weight of boron;

from about 20% to about 30% by weight of potassium perchlorate; and

from about 40% to about 50% by weight of sodium salicylate.

11) The composition as claimed in claim 1 or 2, comprising:

from about 6% to about 16% by weight of boron; and

from about 22% to about 30% by weight of potassium perchlorate.

12) The composition as claimed in claim 11, comprising:

about 6% by weight of boron;

about 30% by weight of potassium perchlorate; and

about 44% by weight of sodium salicylate.

13) The composition as claimed in claim 11, comprising:

about 12% by weight of boron;

about 28% by weight of potassium perchlorate; and

about 40% by weight of sodium salicylate.

14) The composition as claimed in claim 11, comprising:

about 16% by weight of boron;

about 24% by weight of potassium perchlorate;

about 10% by weight of iron carbonate; and

about 40% by weight of sodium salicylate.

15) The composition as claimed in claim 11, comprising:

about 11% by weight of boron;

about 22% by weight of potassium perchlorate;

about 10% by weight of iron carbonate; and

about 47% by weight of sodium salicylate.

16) The composition as claimed in claim 1 or 2, comprising about 10% by weight of calcium resinate.

17) An IR tracer projectile comprising:

a) a hollow cylindrical shell made of a suitable metallic material and having a conical nose;

b) a heavy filler disposed in said hollow conical nose;

c) the non-toxic, boron-containing IR tracer composition as claimed in any one of claims 1 to 16, compressed immediately against said filler;

d) a ignition material compressed against said compressed IR tracer composition; and

e) a metal disc capping said hollow shell.

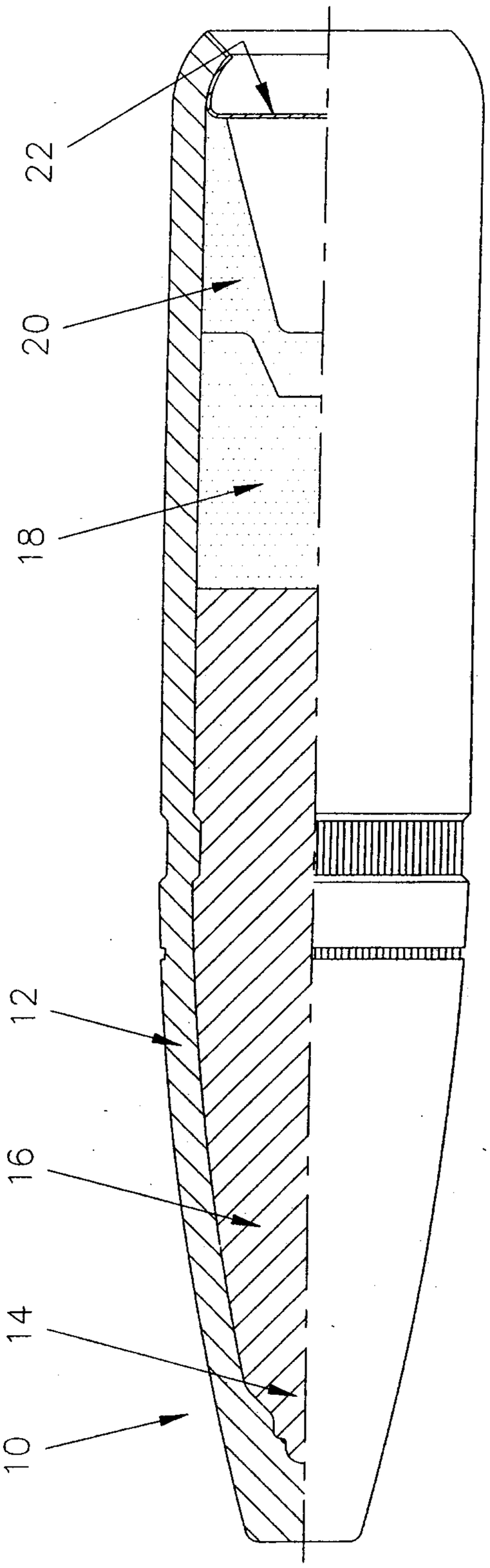


FIGURE 1