

(54) Title of the Invention: **Lead-Free Ammunition Composition for Firearms**

(51) INT CL: **F42B 12/78** (2006.01) **C06B 23/00** (2006.01) **F42B 12/72** (2006.01) **F42B 12/74** (2006.01)
F42B 12/76 (2006.01)

(21) Application No:	2307422.2
(22) Date of Filing:	18.05.2023
(43) Date of A Publication	20.11.2024

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(58) Field of Search:
As for published application 2630119 A viz:
INT CL **C06B**, **F42B**
updated as appropriate

Additional Fields
Other: **SEARCH-PATENT**

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Lead-Free Ammunition Composition for Firearms

The present invention relates to a lead-free shot ammunition composition, particularly but not exclusively for shot, for firearms, that are more environmentally friendly and less damaging to wildlife than lead based ammunition.

- 5 Lead ammunition has long been the de-facto choice for hunting and recreational shooting activities. The ballistic properties of lead are chosen due to its high density and malleability, which can be difficult to replicate with other materials.

10 Lead is a highly toxic material, which has a damaging effect on the environment and can poison wildlife. Due to these issues and the resulting restriction proposals on lead ammunition, there is a strong need to develop alternative ammunition.

Steel ammunition is available on the market, but the lower density of steel compared to lead means more propellant is needed than lead bullets to achieve the same effect, which limits its usage. Additionally, steel is harder than lead, which means it does not deform on impact, lowering transmission of kinetic energy.

- 15 Ammunition made solely from bismuth is fragile and can break apart in the barrel when fired or on impact.

Bio-ammo, made from an alloy of bismuth and tin, has similar issues to bismuth ammunition when under pressure to achieve high velocity.

- 20 It is an object of the present invention is to provide an alternative to lead for the production of ammunition that does not suffer from the issues described with other alternative ammunition referenced above.

25 According to a first aspect of the invention, there is provided lead-free ammunition composition for use in the manufacture of ammunition rounds, the composition comprising: 20%-80% by weight of tin; 15%-80% by weight of nickel; and 0.99%-4.76 by weight of indium.

The use of indium as a binder is an expensive way of producing ammunition, but use in comparatively small percentages allows this to be mitigated with cheaper metals, and also allows for lead-like properties of other less toxic metals to be imparted to any final composition.

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Optionally, the composition comprises 30-40% by weight of nickel.

The inclusion of nickel in the composition allows the creation of lightweight composite materials of lower density. Additionally, the quantity of nickel can be varied to create a range of composite materials with varying hardness and deformability between that of bismuth and the composite material to which it was added.

Optionally, the composition comprises bismuth and nickel, and a combined percentage by weight of nickel and bismuth exceeds 15%, and the combined percentage by weight of nickel and bismuth is not greater than 80%..

The inclusion of multiple non-lead metal elements increases the range of composite materials that can be produced, thus providing a greater range of parameters for several relevant material properties, including density, melting point, hardness, plasticity and deformability.

Optionally, the composition comprises 40-80% by weight of tin.

Optionally, the composition comprises 60-70% by weight of tin.

According to a second aspect of the invention, there is provided ammunition for a firearm, the ammunition comprising a lead-free ammunition composition in accordance with the first aspect of the invention.

Optionally, the said ammunition comprises shot formed from the lead-free ammunition composition.

Optionally, the said ammunition is a bullet being formed from the lead-free ammunition composition.

Optionally, the said ammunition is cased ammunition, a casing of the cased ammunition being formed from the lead-free ammunition composition.

According to a third aspect of the invention, there is provided a method of making ammunition having lead-like shot properties, the method comprises the steps of: a] smelting a tin-nickel alloy, or tin and nickel, in the presence of indium, wherein there is 20%-80% by weight of tin, 15%-80% by weight of nickel, and 0.99%-4.76% by weight of indium, to form a lead-free ammunition composition; and b] forming the lead-free ammunition composition into ammunition.

Optionally, during the smelting step a], bismuth is present in the tin-nickel alloy, or bismuth is present.

The invention will now be more specifically described with reference to exemplary compositions.

5 **Example 1**

Composition	Parts			Total Parts	Percentage by weight		
	Tin	Indium	Bismuth		Tin	Indium	Bismuth
A	80	5	20	105	76.2%	4.76%	19.05%
B	70	5	30	105	66.7%	4.76%	28.57%
C	60	5	40	105	57.1%	4.76%	38.10%
D	50	5	50	105	47.6%	4.76%	47.62%
E	40	5	60	105	38.1%	4.76%	57.14%
F	30	5	70	105	28.6%	4.76%	66.67%
G	80	4	20	104	76.9%	3.85%	19.23%
H	70	4	30	104	67.3%	3.85%	28.85%
I	60	4	40	104	57.7%	3.85%	38.46%
J	50	4	50	104	48.1%	3.85%	48.08%
K	40	4	60	104	38.5%	3.85%	57.69%
L	30	4	70	104	28.8%	3.85%	67.31%
M	80	3	20	103	77.7%	2.91%	19.42%
N	70	3	30	103	68.0%	2.91%	29.13%
O	60	3	40	103	58.3%	2.91%	38.83%
P	50	3	50	103	48.5%	2.91%	48.54%
Q	40	3	60	103	38.8%	2.91%	58.25%
R	30	3	70	103	29.1%	2.91%	67.96%
S	80	2	20	102	78.4%	1.96%	19.61%
T	70	2	30	102	68.6%	1.96%	29.41%
U	60	2	40	102	58.8%	1.96%	39.22%
V	50	2	50	102	49.0%	1.96%	49.02%
W	40	2	60	102	39.2%	1.96%	58.82%
X	30	2	70	102	29.4%	1.96%	68.63%
Y	80	1	20	101	79.2%	0.99%	19.80%
Z	70	1	30	101	69.3%	0.99%	29.70%
AA	60	1	40	101	59.4%	0.99%	39.60%
BB	50	1	50	101	49.5%	0.99%	49.50%
CC	40	1	60	101	39.6%	0.99%	59.41%
DD	30	1	70	101	29.7%	0.99%	69.31%

Various compositions of tin, bismuth and indium are proposed. The compositions have been created by smelting of tin, indium and bismuth together, and then casting the

material into the desired shape. This could be the shape of shot, a bullet, or potentially even casing for ammunition where appropriate.

Compositions A, C, E, Y, AA, and CC have all been tested and shown to have lead-like shot properties.

- 5 For small-shot ammunition, the formation was performed via a lead-shot dripper, modified to accommodate the lower melting temperature of the lead-free ammunition composition. The melting point is approximately 30% lower than that of lead, and existing lead-shot drippers do require modification to be usable.

- 10 Crush and density testing was performed, and the composition found to be comparable to lead.

50 cartridges were loaded with wad and propellant, and chicken carcasses shot at 30m. Upon dissection, the performance of the shot was shown to be exactly the same as lead.

Shot pattern was also monitored at 20m with $\frac{1}{4}$ choke and $\frac{1}{2}$ choke, and also at 30m with full and $\frac{3}{4}$ choke. Performance was the same as for lead shot.

- 15 Advantageously, upon testing, there was no equivalent to the 'leading' effect found in the barrels of the firearms, which is attributed to the lower friction of the composition.

For bullets, eight different batches were tested for lower power ammunition types .22LR, .223, .308, and 9mm pistol. Formation of the bullets was achieved using wire, CNC, or hot die mould casting.

- 20 In the .22LR instance, which would normally use a solid lead bullet, the composition demonstrated a 1/2in minute of angle at 50m.

Penetration tests on 9mm pistol showed identical travel and mushrooming to a solid lead bullet.

- 25 The composition does leave residue in the barrel, similar to lead or copper bullets; however, it seems as though there does not appear to be similar effects with continued build up, as the composition for higher calibre ammunition appears to act as a lubricant. Higher and more uniform bullet velocities appear to be achievable.

- 30 Whilst testing has been limited thus far to small calibre ammunition, it is expected that the same properties outlined above make the ammunition composition feasible for high calibre ammunition.

The cost per gram of the lead-free ammunition composition is increased due to the inclusion of indium; however, it is broadly comparable to that of bio-ammo or pure bismuth ammunition.

Example 2

Composition	Parts			Total Parts	Percentage by weight		
	Tin	Indium	Nickel		Tin	Indium	Nickel
A	80	5	20	105	76.2%	4.76%	19.05%
B	70	5	30	105	66.7%	4.76%	28.57%
C	60	5	40	105	57.1%	4.76%	38.10%
D	50	5	50	105	47.6%	4.76%	47.62%
E	40	5	60	105	38.1%	4.76%	57.14%
F	30	5	70	105	28.6%	4.76%	66.67%
G	80	4	20	104	76.9%	3.85%	19.23%
H	70	4	30	104	67.3%	3.85%	28.85%
I	60	4	40	104	57.7%	3.85%	38.46%
J	50	4	50	104	48.1%	3.85%	48.08%
K	40	4	60	104	38.5%	3.85%	57.69%
L	30	4	70	104	28.8%	3.85%	67.31%
M	80	3	20	103	77.7%	2.91%	19.42%
N	70	3	30	103	68.0%	2.91%	29.13%
O	60	3	40	103	58.3%	2.91%	38.83%
P	50	3	50	103	48.5%	2.91%	48.54%
Q	40	3	60	103	38.8%	2.91%	58.25%
R	30	3	70	103	29.1%	2.91%	67.96%
S	80	2	20	102	78.4%	1.96%	19.61%
T	70	2	30	102	68.6%	1.96%	29.41%
U	60	2	40	102	58.8%	1.96%	39.22%
V	50	2	50	102	49.0%	1.96%	49.02%
W	40	2	60	102	39.2%	1.96%	58.82%
X	30	2	70	102	29.4%	1.96%	68.63%
Y	80	1	20	101	79.2%	0.99%	19.80%
Z	70	1	30	101	69.3%	0.99%	29.70%
AA	60	1	40	101	59.4%	0.99%	39.60%
BB	50	1	50	101	49.5%	0.99%	49.50%
CC	40	1	60	101	39.6%	0.99%	59.41%
DD	30	1	70	101	29.7%	0.99%	69.31%

Various compositions of tin, nickel and indium are proposed. The compositions have been created by smelting of tin, indium and nickel together, and then casting the material into the desired shape. This could be the shape of shot, a bullet, including jacketed bullets, or

potentially even casing for ammunition where appropriate. Where jacketed bullets are provided, a first indium-including composition could be used which is comparably heavy, with a second indium-including composition being used as the jacket, and which is lighter due to the alloy composition. This would allow mushrooming of the tip of the jacket, with the jacket expanding and the travel of the inner bullet being given higher kinetic thrust on impact.

Compositions N, O, T and U have all been tested and shown to have lead-like shot properties.

The cost per gram of the lead-free ammunition composition is increased due to the inclusion of indium; however, it is broadly comparable to that of bio-ammo and other non-lead alternatives.

Whilst this example highlights how tin and nickel can be used together, it is more likely that a combination of tin, nickel, and bismuth could be bound together using indium. It is expected that as the size of the shot or bullet increases, that the percentage of nickel increases.

Preferred compositions are expected to have between 40-80%, and more preferably 60-70% of tin. The percentage of indium is expected to be less than 10%, and more preferably less than 5%. The indium percentage is likely to increase as the size of the ammunition increases, to improve the binding effect.

The non-lead metals other than tin, here bismuth and nickel, are preferred to have a total weight in the range of 40-60%. Small shot might use exclusively bismuth, and small bullets only a small percentage of nickel, with bismuth making up around 30-40% of the total composition weight. For large shot, there may be close to equal percentages of bismuth and nickel, whereas for large bullets, there may be predominantly nickel, around 30-40% of the total composition, with maybe perhaps 10% bismuth.

Furthermore, it may be possible to alloy bismuth and nickel together using indium, without the use of tin, or indeed, generally using non-lead metals alloyed together using indium, in the context of making ammunition.

It is therefore possible to provide a lead-free ammunition composition for use in the manufacture of ammunition rounds which uses indium as a binding agent for non-lead metals. Whilst this is an expensive component, it can be used in small quantities to minimise cost whilst still retaining beneficial properties in the final composition.

The words 'comprises/comprising' and the words 'having/including' when used herein with reference to the present invention are used to specify the presence of stated features, integers, steps, or components, but do not preclude the presence or addition of one or more other features, integers, steps, components, or groups thereof.

- 5 It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable sub-combination.
- 10 The embodiments described above are provided by way of examples only, and various other modifications will be apparent to persons skilled in the field without departing from the scope of the invention as defined herein.

Claims

1. A lead-free ammunition composition for use in the manufacture of ammunition rounds, the composition comprising:
 - 20%-80% by weight of tin;
 - 15%-80% by weight of nickel; and
 - 0.99%-4.76% by weight of indium.
2. A lead-free ammunition composition as claimed in claim 2, wherein the composition comprises 30-40% by weight of nickel.
3. A lead-free ammunition composition as claimed in claim 2 or claim 3, wherein the composition comprises bismuth and nickel, and a combined percentage by weight of nickel and bismuth exceeds 15%, and the combined percentage by weight of nickel and bismuth is not greater than 80%.
4. A lead-free ammunition composition as claimed in any one of claims 1 to 3, wherein the composition comprises 40-80% by weight of tin.
5. A lead-free ammunition composition as claimed in claim 4, wherein the composition comprises 60-70% by weight of tin.
6. Ammunition for a firearm, the ammunition comprising a lead-free ammunition composition as claimed in any one of claims 1 to 5.
7. Ammunition according to claim 6, wherein the said ammunition comprises shot formed from the lead-free ammunition composition.
8. Ammunition according to claim 6, wherein the said ammunition is a bullet being formed from the lead-free ammunition composition.
9. Ammunition according to claim 6, wherein the said ammunition is cased ammunition, a casing of the cased ammunition being formed from the lead-free ammunition composition.

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10. A method of making ammunition having lead-like shot properties, the method comprises the steps of:

5 a] smelting a tin-nickel alloy, or tin and nickel, in the presence of indium, wherein there is 20%-80% by weight of tin, 15%-80% by weight of nickel, and 0.99%-4.76% by weight of indium, to form a lead-free ammunition composition; and

b] forming the lead-free ammunition composition into ammunition.

11. A method as claimed in claim 10, wherein, during the smelting step a], bismuth is present in the tin-nickel alloy, or bismuth is present.