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INCENDIARY COMPOSITION

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The present invention relates to the formation of an incendiary by the addition of solid oxidizing agents to incendiary bomb mixtures including magnesium as one ingredient thereof, and to a method of creating incendiary conditions by causing an oxidation reaction to occur between ingredients of the incendiary.

In my copending application Serial No. 492,989, filed July 1, 1943, now Patent No. 2,509,710, I have set forth the production of magnesium metal from magnesium oxide by carbothermic reduction according to the process disclosed in Patent No. 1,884,993 (Hansgirg). Therein a mixture of magnesium oxide and carbon is converted into magnesium vapor and carbon monoxide by the heat of an electric arc furnace. This gaseous mixture is discharged from the region of the arc at a high enough temperature (above 1800° C.) that reversal of the reaction does not occur, and is then suddenly cooled and diluted by injecting large volumes of a shock chilling agent, which may be hydrogen, natural gas, hydrocarbon vapor or even a spray of liquid hydrocarbon.

In one particular practice of the process natural gas is employed. The magnesium vapor is condensed to magnesium metal in the form of extremely fine dust. Some of the vapor recombines with carbon monoxide with the result that the solid material precipitated in the condensing chamber comprises a substantial proportion from 30 to 65% of magnesium dust with the remaining 70 to 35% comprising carbon, magnesium oxide, and other impurities. A typical sample of a normal run shows 47% by weight of magnesium metal dust.

This condensate, i. e., the magnesium dust with admixed impurities, while it requires coalescing of the magnesium dust to produce compact metal, is, nevertheless, highly pyrophoric, and will combust spontaneously when exposed to the atmosphere. To diminish this tendency so that the material may be safely handled for sublimation into crystalline magnesium metal, it is now customary to wet the precipitate with a light hydrocarbon oil having a flash point above 100° F., with or without the addition of asphalt to produce a relatively stiff plastic mass which is termed herein as carbothermic magnesium paste. The asphalt is added when it is desired to make the mass somewhat cohesive, particularly where it is desired to tablet the material into compact pellets or briquettes. Where the shock chilling is produced by oil spray, the shock chilling oil wets the precipitate and inhibits ignition while forming carbothermic magnesium paste.

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Experiments proved that this carbothermic magnesium paste, i. e., magnesium dust and impurities wet with oil and with or without asphalt or other binder is not spontaneously reactive with dry air. However, water vapor or spray will ignite the carbothermic magnesium paste and this paste-water combination provides an inexpensive incendiary.

The average analysis of the magnesium dust is:

	Per cent
Magnesium	50
Carbon	10
Inert (principally MgO)	31

A small percentage of the magnesium (approximately 5%) exists as one or both of the carbides—MgC_2 and Mg_2C_3. There is generally a trace of sodium which is believed to be in elemental form and possibly minor traces of other carbides such as calcium, silicon and aluminum originating from the ash constituents from the metallurgical coke in the reduction furnace and/or from the minor ash constituent in the petroleum coke used for reduction. With the exception of occasional carry over of particles from the reduction furnace all of these materials have an ultimate particle size below the resolving power of optical microscopes. Electron microphotographs reveal agglomerates several microns in diameter and ultimate particles in the neighborhood of 0.1 micron.

The hydrocarbons which may be employed for wetting the magnesium dust may advantageously consist of 50% distillate and 50% asphalt which is a well-distilled residue, of high viscosity, of an asphalt-base oil. A typical analysis of a mixture of such hydrocarbons which has proved successful is as follows:

Distillate

Gravity °API at 60° F	23
Flash point Pensky-Marten closed cup °F	180
Viscosity Saybolt seconds Universal at 100° F	60

Asphalt

Gravity °API at 60° F	10.2
Flash point Pensky-Marten closed cup °F	430
Viscosity Saybolt seconds Furol at 210° F	145

To produce a mixture of crude dust and hydrocarbons, safe for shipment and suitable for compounding incendiary fuels, the shock chilled dust is conveyed in a closed atmosphere under natural gas to pug mill type extrusion presses where it is thoroughly mixed with the desired hydrocarbons

and extruded through a die plate into open drums. The limitations on this equipment are such that practical concentrations can be made between 55% and 70% solids, the balance hydrocarbons. For reasons of safety it is undesirable to include low flash hydrocarbons at this stage. Various mixtures of fuel oils, or asphalt cut-back with fuel oils, or kerosene in a considerable range, are practical from a production standpoint. This magnesium material when thoroughly wetted with hydrocarbons is not easily ignited nor will it flash or explode. However, if allowed to air dry or come in contact with water, acid, or perspiration, it will sooner or later ignite when such liquid has cut through the protective layer of hydrocarbon so as to react with the finely divided magnesium.

The construction of well known incendiaries, particularly those of the known "stick" form, involves the use of cast solid magnesium metal which is difficult to ignite except by thermite or a similar igniting charge. Incendiaries and flares of magnesium powder have therefore been made by first producing magnesium in solid metal form and then sub-dividing it. By my method the raw powder coming from the shock chilling step of the carbothermic process may be directly substituted for the far more expensive method at present utilized. Also, magnesium metal as employed in the carbothermic magnesium paste is of a state of subdivision far greater than that which it is practicable to produce by mechanical comminution.

According to my invention the magnesium powder even in the impure form as recovered from the vapor produced by carbothermic reduction, and with or without other materials, may be directly applied to incendiary use without going through the stage of first producing the coalesced or solid metal. A great advantage of using such a finely divided metal is that the desired ignition may be secured from mere contact with such simple media as air and water. Any substance which gives up oxygen freely enough to produce ignition, i. e., rapid combustion, may be used.

The finely divided magnesium produced in the carbothermic process has a particle size of substantially less than one micron, and as heretofore stated is capable of spontaneous combustion with the atmosphere unless wetted down with a material such as hydrocarbon oil. It is obvious that a particle size on the order of that mentioned cannot be achieved on a commercial scale by use of mechanical means. The fine particles, because of their pyrophoric qualities, would present a considerable fire hazard if mechanically produced, and the high cost and complicated equipment necessary to mechanically produce such particles in an inert atmosphere would be impractical. Thus additional advantages of this invention are that it utilizes an incendiary material of finely divided magnesium of a particle size never before attainable on a commercial scale, and yet such finely divided magnesium is capable of rapid and economic production, and can be safely handled.

The carbothermic magnesium paste may be used as is, as a paste, or it may consist of compacted or tableted pellets or briquettes. Magnesium and/or aluminum in the form of solid metal, including alloys thereof, either as a part or all of the container, or an admix in the form of borings, turnings, screenings or pieces of scrap metal, may be used in conjunction with the carbothermic magnesium paste and may partake of the incendiary reaction, after the same is initiated.

It is to be understood that after the carbothermic magnesium paste is once ignited, it will continue to burn by reaction with the oxygen and/or nitrogen of the air, and tends by the heat and flame produced to ignite adjacent combustibles. Water applied to extinguish it is of no use as it reacts readily with the magnesium, accelerating combustion. Such common extinguishers as carbon dioxide actually accelerate combustion.

Additional reagents which tend to sustain combustion of the magnesium powder, such as ferric oxide, barium oxide and other similar metal oxides, potassium chlorate, sodium nitrate, and other similar metallic salts containing combined oxygen, sulfur, gasoline or carbon, and mixtures thereof, may be added to the carbothermic magnesium paste, and after ignition is instituted as by the liquid oxidizing agent, the further combustion may be sustained or aided by such reagents. Where a liquid, such as water, is employed to produce ignition, the resulting gas, such as hydrogen, is combustible and tends to spread the fire. Similarly, liquids which by deoxidation by the finely divided magnesium produce combustible gases, tend also to spread the fire by producing a flame reaching into adjacent space for oxygen to support its combustion.

While plain water is the simplest liquid oxidizing agent, there may be situations or conditions of use calling for the addition of antifreeze agents or of liquids which will withstand low temperatures without solidification. Thus, alcohols, such as methanol, aldehydes and organic acids may be employed. Also inorganic compounds such as chlorates, permanganates, particularly of the alkali metals, may be dissolved in the liquid or associated therewith. Wetting agents to accelerate the wetting of the incendiary material with the liquid may be used.

If it is desired to ignite the magnesium powder in a body of water, or under similar conditions, particularly where it is desired to ignite an oil slick on a body of water, it is advantageous to add an agent which will cause heat and/or gas generation, such as quicklime and/or carbides. The addition of carbides to the finely divided magnesium powder is particularly advantageous due to their gas generating properties, because the pressure generated causes the casing containing the incendiary material to burst more rapidly with consequent dispersion of the incendiary charge over the adjacent area in a very effective manner.

An additional feature of the invention is that the finely divided magnesium dust is colloidal in nature and can be readily incorporated to form a fortified hydrocarbon gel type incendiaries with good results in sharp contrast to mechanically comminuted magnesium which does not give good results. In the use of carbothermic magnesium paste with the gels or alone there is an additional advantage that the reaction between the colloidal magnesium particles and the oxidizing liquid takes place progressively throughout the mass to liberate great quantities of heat to destructively distill the hydrocarbons in admixture therewith and give off large quantities of inflammable gases with sufficient violence to induce air circulation and mixing to thereby burn the gases substantially to completion. It is to be noted that the use of heavy hydrocarbons is advantageous in that they have a higher heat of combustion on a volume basis than light hydro-

carbons, which is important in many instances, e. g. the storage capacity of an airplane. Another point of importance is that the generation of gases within the asphaltic mass of the incendiary yields a swelling ash which is useful.

The present invention is a continuation-in-part of my application Serial No. 492,989, filed July 1, 1943, now Patent No. 2,509,710.

The primary object of the invention is to form an incendiary including magnesium and solid oxidizing agents as active agents.

A further object is to provide an incendiary comprising the magnesium dust as hereinbefore described in combination with one or more solid oxidizing agents, preferably wetted with a hydrocarbon oil, an asphalt mixture or an oil-asphalt mixture, to reduce initial chemical activity, and a more easily ignitable substance to raise the temperature of the admixture to a point where oxidation and reduction reactions occur.

Another object is to provide an incendiary comprising carbothermic magnesium paste, one or more solid oxidizing agents, and an igniter to promote reaction.

Other and further objects and advantages of this invention will be apparent from the following description thereof and from the claims appended thereto.

In carrying out the invention, it is preferred to employ carbothermic magnesium paste-oxidizing agent-ignition promoter mixture. However, any magnesium-solid oxidizing agent mixture may be employed.

In an example of preparing a torch type bomb, a mixture is made as follows:

10 lbs. of starch are first wetted thoroughly with 1 lb. of distillate obtained from the coking of a crude petroleum. The wetted starch is then mixed with 9 lbs. of asphalt tar, 19 lbs. of said distilalte, 10 lbs. of magnesium shavings, 3 lbs. of gasoline and 48 lbs. of crude magnesium dust formed as in the carbothermic process hereinbefore described. This mixture is loaded into a magnesium bomb casing. A hole is formed down through the center of the mass. Into this hole is inserted a rope fuse and a slurry of sodium nitrate, and a mixture of magnesium dust with asphalt and distillate. The sodium nitrate is present in nitrate dust composition in a quantity amounting to approximately 50% by weight.

In the tail of the bomb is disposed a bottle containing 120 grams of black powder. A wooden plug closes the mouth of the bottle.

When one of these bombs was ignited flames shot out for 200 ft., then died down to about 60 feet. Flame continued for a total of 10 minutes, with the high velocity torch lasting about 7.5 minutes. Metal slag at about 100 feet from the bomb was ignited by the torch.

Another bomb prepared in the same manner gave a first flame of about 300 ft. in length which died down to about 75 ft., and started about fifty fires over a section 200 ft. by 75 ft. in area.

In the preparation of the incendiary, starch and similar oxidizing agents should be oiled and/or dried prior to admixture with magnesium dust or paste, as it has been found that chemical activity develops immediately unless these precautions are taken.

If the starch, or the like, is coated with a protective hydrocarbon oil it is not necessary to dry the starch. This oil coating is probably burned off by the first ignition and then the oxidation-reduction reaction proceeds between the starch and carbothermic magnesium paste. The starch

may be prepared by admixing it with the asphalt-distillate protective agent with stirring and heating to not over about 280° F., for several hours, depending upon the size of the batch.

Any suitable solid oxidizing agent may be employed as one active ingredient of my incendiary.

The following oxidizing agents have been used in preparing incendiaries.

1. Nitrates, specifically $NaNO_3$, KNO_3
2. Sulfates, specifically $BaSO_4$
3. Oxides, specifically ZNO, Fe_2O_3, FeO, Fe_3O_4, Venetian red, chrome green or other pigments containing metal oxides, red lead, basic lead carbonate, PbO_2, MnO_2
4. Chlorates, $KClO_3$, $NaClO_3$
5. Organic, specifically sugar, such as glucose, cellulose (burlap bags), starch, shredded cellulose fiber material.
6. Hygroscopic agents which will take up moisture from the air when the bomb bursts and thus facilitate oxidation of the charge—$CaCl_2$.
7. $KMnO_4$

The above oxidizing agents are effective in varying degrees. The more effective agents are the organic, particularly finely ground cornstarch or white flour, nitrates, $KMnO_4$, chlorates and oxides such as iron oxides. The less effective were sulfates and oxides such as manganese oxide. Any solid oxidizing agent is helpful to some extent in promoting reaction of the magnesium.

These oxidizing agents are useful as additives in the incendiary or explosive incendiary bomb, in an oil-slick igniter, with or without gas generating additives. In some cases, where rate and direction of fall are important, the specific gravity of the filling can be varied by varying the type of oxidizing agent. Thus, to increase the specific gravity a heavier oxidizing agent such as basic lead carbonate may be added as the whole or a part of the solid oxidizing ingredient. Up to 10% of the weight of the charge may suitably be oxidizing agent.

The oxidizing agents added are insufficient to oxidize all of the incendiary load and the rest of the oxidation is accomplished by the air.

The best of the solid oxidizing agents are starch and sodium nitrate, either used separately or in combination. Other alkali nitrates are also very effective.

Some of the advantages of starch as an oxidizing agent in any of the mixes are (1) after giving up its oxygen to the magnesium, a combustible hydrocarbon remains, (2) it is more stable to detonation, (3) it gives an excellent flame in which there is gradual transition from the long hydrocarbon flame to the white magnesium flame. These advantages may be due in part to the property of starch of dextrinizing. It is well known that the starch molecule breaks down through a series of intermediate products to its final elements and some of these materials are very cohesive.

The combination of sodium nitrate and basic lead carbonate provides a very effective oxidizing agent for the incendiary as it gives a soft, sticky, non-resilient mix with the carbothermic magnesium paste. When the incendiary containing the sodium nitrate-basic lead carbonate mixture is burned there is developed a long flame which burns quietly at a temperature of around 1600° F.

It is preferred that the various solid oxidizing agents be treated with a protective liquid, such as liquid hydrocarbon, e. g. of the lubri-

cating oil type, before admixture with the carbothermic magnesium paste.

It is contemplated that the incendiaries of the invention may be employed either in bombs, containers or otherwise as is more fully set forth hereinafter. For example, when utilizing a cellulose oxidizing agent, there can be employed a roll of burlap comprising alternate layers of carbothermic magnesium paste and burlap, both preferably oiled. The roll is placed in a bomb casing.

The main concept of the invention embraces the feature of forming an incendiary comprising magnesium and solid oxidizing agent. The magnesium may be present in any one of many forms, but it is preferred to have the carbothermic magnesium paste as one ingredient of the incendiary. It is also preferred for some uses to employ a magnesium-oxidizing agent-ignition accelerator mixture. The ignition accelerator may be any easily ignitable substance which can function to bring the temperature of the incendiary up to the point that an oxidation-reduction reaction proceeds between the magnesium compound and the oxidizing agent in the presence of air as an additional oxidizing agent when it is available. Gasoline, kerosene, or any members of the petroleum series having a relatively low flash point may be employed as ignition promoters. Such substances as gun powder, and the like, may be employed. Any other suitable ignition or reaction promoter may be used in the practice of the invention.

The oxidizing agent may be present in the incendiary in varying percentages by weight depending upon results desired. Ordinarily, the oxidizing agent is present in about 5–15% by weight, although higher and lower percentages may be used in the incendiary.

A further concept of this invention relates to a method of creating incendiary conditions including the feature of bringing about an oxidation-reduction reaction between a solid oxidizing agent and other ingredients of an incendiary including a magnesium compound.

It is to be understood that the term "incendiary" as used herein is not intended to be limited to incendiaries as applied to bombs or the like, but instead is intended to include any application wherein such material is useful, such as fireworks, flares, signals, etc.

The incendiary of the invention is ideal in many applications because it vastly increases the chances of self-sustaining combustion.

I claim:

1. An incendiary comprising, magnesium dust formed in the thermal reduction of magnesia by carbon and coated with hydrocarbon to reduce its activity in air, and about 5% to 15% by weight of solid oxidizing agent.

2. An incendiary comprising, magnesium dust formed in the thermal reduction of magnesia by carbon and coated with a hydrocarbon to reduce its activity in air, about 5% to 15% by weight of solid oxidizing agent, and an ignition accelerator.

3. An incendiary comprising magnesium dust formed in the thermal reduction of magnesia by carbon and coated with a hydrocarbon compound to reduce its activity in air, and a solid oxidizing agent coated with a hydrocarbon compound, said oxidizing agent being present in the incendiary in the amount of about 5% to 15% by weight.

4. An incendiary comprising, magnesium dust formed in the thermal reduction of magnesia by carbon and coated with a hydrocarbon compound to reduce its activity in air, and an organic solid oxidizing agent coated with a hydrocarbon compound, said oxidizing agent being present in the incendiary in the amount of about 5% to 15% by weight.

5. An incendiary comprising, magnesium dust formed in the thermal reduction of magnesia by carbon and coated with a hydrocarbon compound to reduce its activity in air, a solid oxidizing agent coated with a hydrocarbon compound, and an ignition accelerator, said oxidizing agent being present in the incendiary in the amount of about 5% to 15% by weight.

6. An incendiary composition comprising, magnesium dust formed in the thermal reduction of magnesia by carbon and coated with a hydrocarbon compound to reduce its activity in air, and starch and sodium nitrate, the combined weights of said starch and sodium nitrate amounting to about 5% to 15% by weight of the composition.

7. An incendiary comprising, magnesium dust formed in the thermal reduction of magnesia by carbon and coated with a hydrocarbon compound to reduce its activity in air, and starch coated with a hydrocarbon compound, said starch being present in the incendiary in the amount of about 5% to 15% by weight.

8. An incendiary comprising, magnesium dust formed in the thermal reduction of magnesia by carbon and coated with a hydrocarbon compound to reduce its activity in air, and sodium nitrate coated with a hydrocarbon compound, said nitrate being present in the incendiary in the amount of about 5% to 15% by weight.

9. An incendiary comprising an amount not exceeding 15% by weight of solid oxidizing agent, and magnesium dust obtained by the thermal reduction of magnesia with carbon and the shock-chilling of the magnesium-containing vapors produced thereby, said magnesium dust being protectively coated with an asphalt-containing hydrocarbon.

10. An incendiary composition comprising not exceeding about 10% by weight of solid oxidizing agent, and magnesium dust obtained by the thermal reduction of magnesia with carbon and the shock-chilling of the magnesium-containing vapors produced thereby, said magnesium dust being protectively coated with an asphalt-containing hydrocarbon.

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