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## ILLUMINANTS

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This invention relates to flare compositions, and particularly to improved magnesium illuminant compositions.

The value of illuminating or flare compositions is generally proportional to the candle power developed and the duration of the illumination. Thus, the candle power seconds generated by the combustion of such compositions is a reliable comparative measure of their value. The rapid oxidization of metallic magnesium is generally accompanied by an exceedingly brilliant light. Therefore, the most widely accepted illuminants are based on mixtures of metallic magnesium and an oxidizing agent to which a binder may be added. It is a well-known expedient to increase the luminosity of such compositions by reducing the particle size of the magnesium, but this is attended by a reduction in the burning time. Thus, little or no significant increase in the candle power seconds output of the compositions is obtained. Various other attempts have been made to increase the brilliance of such compositions but in each instance the increased luminosity was accompanied by a correspondingly increased burning rate and, in many instances, an actual decrease rather than an improvement in the candle power seconds output.

It is, therefore, an object of this invention to increase the luminosity of flare compositions. It is also an object of this invention to provide novel and improved magnesium illuminating compositions. A more specific object of this invention is to increase the candle power seconds output of magnesium-oxidizing agent compositions.

The present invention, by which these and other objects are attained, is predicated on the addition of small amounts of magnesium oxide (MgO) to magnesium-oxidizer illuminating compositions. The particular manner in which the magnesium oxide acts is not fully understood but it has been found that the addition of magnesium oxide within predetermined limits to illuminating compositions based on metallic magnesium and an inorganic oxidizing agent increases the candle power of the mixtures upon combustion without having a deleterious effect upon the burning time. Compositions containing between about 1% and about 5% magnesium oxide provide this increased luminosity while optimum results are obtained when such compositions contain approximately 2.8% magnesium oxide. Magnesium oxide in amounts less than about 1% by weight of the compositions has no noticeable effect on their burning characteristics; whereas when the magnesium oxide content is increased above about 5%, this compound acts as a diluent and actually detracts from the illuminating characteristics of the original composition.

The metallic magnesium is in finely divided form and to provide a mixture with suitable burning characteristics must be of a particle size sufficiently small to pass through a 25-mesh screen. The burning rate of the composition can be controlled at least to some extent by controlling the size of the metallic magnesium particles. Thus, the burning rate of the mixture is increased when mag-

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nesium having a smaller average particle size is utilized. Although magnesium particles being sufficiently small to pass through a 40-mesh screen may be satisfactory in some instances, when maximum luminosity is required it is preferred to use finely divided metallic magnesium that will pass through a 200-mesh screen. Generally, the metallic magnesium content of the compositions is maintained between about 40% and about 60%. Compositions containing less than about 40% metallic magnesium are quite difficult to ignite and upon combustion provide a flame having definitely inferior illuminating qualities. As the metallic magnesium content is increased, the ease of ignition, burning rate, and developed candle power also increase. However, when the amount of metallic magnesium in the compositions exceeds approximately 60%, the compositions have a very rapid burning rate and are susceptible to detonation. Thus, the metallic magnesium content of the compositions must be maintained between about 40% and 60%.

The compositions must also contain sufficient oxidizing agent to insure the complete oxidation of the metallic magnesium and the combustion of the plastic binder without forming excessive amounts of carbon. Thus, the oxidizer must be present in sufficient quantities to provide substantially oxygen balanced compositions. Because of safety, economy, and ease of handling, sodium nitrate has been found most suitable for use as an oxidizer in magnesium illuminant compositions and is the preferred oxidizing agent in accordance with the present invention. However, other inorganic oxidizing agents such as barium nitrate, potassium nitrate, ammonium perchlorate, potassium perchlorate, and the like can also be used in the formulations of the present invention.

The illuminants of this invention are made in cohesive form and are preferably compacted in cases. Polyvinyl acetate is the preferred binder, but any other flammable plastic materials which are combustible in this environment, which can be readily dissolved, and which will not produce substantial ash or black smoke on combustion, can be used. Suitable binders include polyester resins, epoxy resins, phenolic resins, and the like. The binder is normally present in the composition in ranges between about 4% and about 10% based on the weight of the entire mixture. Cohesive illuminants cannot be insured when smaller amounts of binder are used and larger amounts require inordinant proportions of the oxidizing agent to insure their complete combustion.

While the constituents making up the illuminants of the present invention can be mixed in any conventional manner, it is preferred to add the metallic magnesium to a solution of the binder to form a uniform slurry and then add a premixture of the oxidizing agent and the magnesium oxide to this slurry. When a uniform mixture is obtained, the composition is shaped into any desired configuration and then hardened by removal of the solvent. Although other sequences of incorporation of the ingredients can be employed, the preliminary mixing of the metallic magnesium particles in the solution of the binder provides the metallic magnesium with a protective coating before the addition of the other materials. Thus, the metallic magnesium is protected from atmospheric and oxidizing influences, and any danger of a premature reaction between the magnesium and the oxidizing agent is effectively inhibited.

In order to illustrate the present invention and its advantages, magnesium illuminants containing magnesium oxide were formulated and compared with substantially identical compositions not containing magnesium oxide. In each instance, the magnesium oxide and sodium nitrate were thoroughly mixed in a ball mill for about a half hour to provide a substantially homogeneous premixture. Meanwhile, a solution of polyvinyl acetate was prepared

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by dissolving the polyvinyl acetate in two parts of methylene chloride for each part of the binder. When the polyvinyl acetate was completely dissolved, the metallic magnesium was added to the solution and uniformly dispersed therethrough by means of a sigma blade mixer. After a substantially uniform dispersion of the magnesium was attained, the magnesium oxide-sodium nitrate premixture was added. Mixing was then continued for about 30 minutes until a substantially uniform mixture was obtained. The resultant composition which was virtually solvent-free was then formed into pellets about one inch in diameter and having substantially the same length and weighing about 25 grams. The residual methylene chloride was removed from the pellets by evaporation. The pellets thus obtained were ignited to determine their luminosity and burning rates.

The results of these tests are set forth in the following table in which luminosity is expressed in candlepower, burning time in seconds, and total output in candlepower seconds as cp.s. In these formulations and throughout the specification and claims, all components are expressed in parts by weight.

Mix	Composition				Composition Output		
	Mg	NaNO <sub>3</sub>	PVac	MgO	Luminosity	Burning Time	Cp.s. × 10 <sup>6</sup>
1.....	50.0	42.7	4.5	2.8	760,000	2.24	1.70
2.....	50.0	42.7	7.3	-----	300,000	3.60	1.08
3.....	44.0	37.5	4.5	14.0	131,000	4.90	0.64
4.....	50.0	42.7	7.3	-----	100,000	9.30	0.93
5.....	50.0	42.7	4.5	2.8	420,000	8.00	3.4

The metallic magnesium in the first three mixes was sufficiently fine to pass through a 200 mesh screen while the magnesium used in mixes 4 and 5 had a considerably larger average particle size but was sufficiently small to pass through a 40-mesh screen. By comparing the luminosity and candlepower seconds of mixes 2 and 4, it will be noted that although the luminosity of mix No. 2 is three times as great as that of mix No. 4 due to the utilization of a smaller particle size metallic magnesium that the candlepower second output of these two mixtures is substantially the same.

Mix No. 1 constitutes a preferred embodiment of the present invention. Basically this mixture has the same composition as mix No. 2 but differs therefrom in that magnesium oxide was added thereto at the expense of the polyvinyl acetate binder. By the inclusion of magnesium oxide into the composition, the candlepower was increased from 300,000 to 760,000 while the burning time was only relatively slightly decreased from 3.60 seconds to 2.24 seconds. This results in an increase in candlepower seconds from 1.08 to 1.70 × 10<sup>6</sup>; i.e., an increase of almost 60%.

Mix No. 5 represents another preferred embodiment of the invention utilizing -40 mesh magnesium rather than the -200 mesh magnesium of mix No. 1. Here again, the preferred embodiment represents a modification of the basic formulation of mix No. 4 by the addition of magnesium oxide thereto at the expense of the polyvinyl acetate. The addition of the magnesium oxide in

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this instance resulted in a four-fold increase of candlepower and a slight reduction in the burning time from 9.3 seconds to 8 seconds. Also, the candle power second output of mix No. 5 is more than two and a half times greater than that of mix No. 4 not containing magnesium oxide.

Mix No. 3, containing 14% magnesium oxide, is not within the scope of this invention. This example was included to show that excessive amounts of magnesium oxide have a deleterious effect upon magnesium illuminants. This is readily illustrated by this example in which the luminosity was decreased from 300,000 to about 131,000 cp. and the candle power seconds output was reduced from 1.08 to 0.64 × 10<sup>6</sup>.

While the above embodiments, particular formulations were given and these formulations contained sodium nitrate and polyvinyl acetate, it will be readily appreciated that various modifications can be made in these formulations and also that other inorganic oxidizing agents and binders can be utilized without departing from the scope of the present invention.

From the foregoing description, those skilled in the art should readily understand that the invention accomplishes its objects and provides a substantially improved magnesium illuminant. While one complete disclosure of the invention has been set forth in detail and modifications indicated, it is not to be understood that the invention is limited to such details of the disclosure but that such modifications and variations thereof as do not depart from the spirit of the invention are contemplated by and within the scope of the appended claims.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. An improved, substantially oxygen balanced illuminant consisting essentially of between about 40% and about 60% magnesium, between about 1% and about 5% magnesium oxide, from between about 4 percent and about 10 percent polyvinyl acetate and the balance sodium nitrate.

2. An improved substantially oxygen balanced illuminant consisting essentially of about 50% magnesium, about 2.8% magnesium oxide, about 42.7% sodium nitrate and about 4.5% polyvinyl acetate.

3. An improved oxygen balanced illuminant consisting essentially of between about 40% and about 60% magnesium, between about 1% and about 5% magnesium oxide, between about 4% and about 10% of a flammable plastic binder selected from the group consisting of polyvinyl acetate, polyester resins, epoxy resins and phenolic resins, and the balance an inorganic oxidizing agent selected from the group consisting of barium nitrate, sodium nitrate, potassium nitrate, ammonium perchlorate and potassium perchlorate.

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