United States Patent [19]

Kelly et al.

[11] **3,908,509**

[45] **Sept. 30, 1975**

[54] **FUSE AND ITS METHOD OF MANUFACTURE**

[75] Inventors: **Cornelius James Noel Kelly; William Clinton Morrow,** both of Simsbury; **Alvaro Zappalorti,** Avon, all of Conn.

[73] Assignee: **E-B Industries, Inc.,** Simsbury, Conn.

[22] Filed: **Oct. 29, 1973**

[21] Appl. No.: **410,915**

[52] **U.S. Cl.** .... **86/1 R;** 86/20; 102/27 R; 264/3 R

[51] **Int. Cl.²** **C06B 21/00;** F42B 33/10

[58] **Field of Search** .... 149/72, 110; 86/20, 22, 86/1; 102/27; 264/3 R

[56] **References Cited**

UNITED STATES PATENTS

1,438,759	12/1922	Gray	149/72 X
2,102,024	12/1937	Pearsall	102/27 R
3,155,038	11/1964	Smith	102/27 R
3,260,201	7/1966	Kelly et al.	102/27 R
3,660,546	5/1972	Lovold	149/72
3,683,742	8/1972	Rohde	86/1 R

FOREIGN PATENTS OR APPLICATIONS

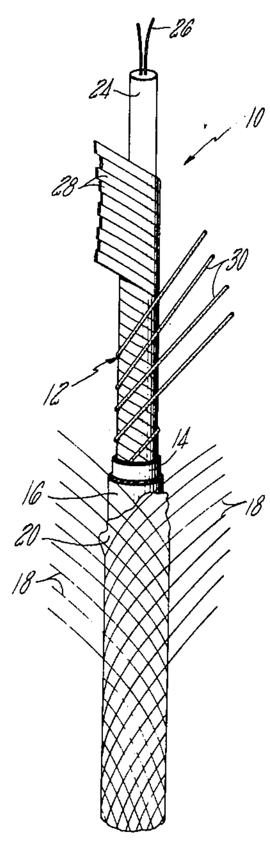
236,413	7/1925	United Kingdom	149/72
1,120,200	7/1968	United Kingdom	102/27 R

Primary Examiner—Verlin R. Pendegrass
Assistant Examiner—Harold Tudor
Attorney, Agent, or Firm—Prutzman, Hayes, Kalb & Chilton

[57] **ABSTRACT**

Improved safety is achieved in blasting fuse manufacture by utilizing unincorporated black powder confined within the core of the fuse by fibrillated polypropylene yarn. The unincorporated black powder is produced by premixing the sulfur and charcoal components and separately pregrinding the mixture and the alkali metal nitrate to a particle size of about 45 microns or less. The preground material is then blended immediately prior to its formation into the powder train of the fuse and is enclosed by a number of ribbon-like fibrillated polypropylene yarns which directly contact the powder core and by a number of additional superimposed protective layers. The resultant fuse exhibits uniform cross sectional size and a controlled uniform burning rate.

10 Claims, 2 Drawing Figures



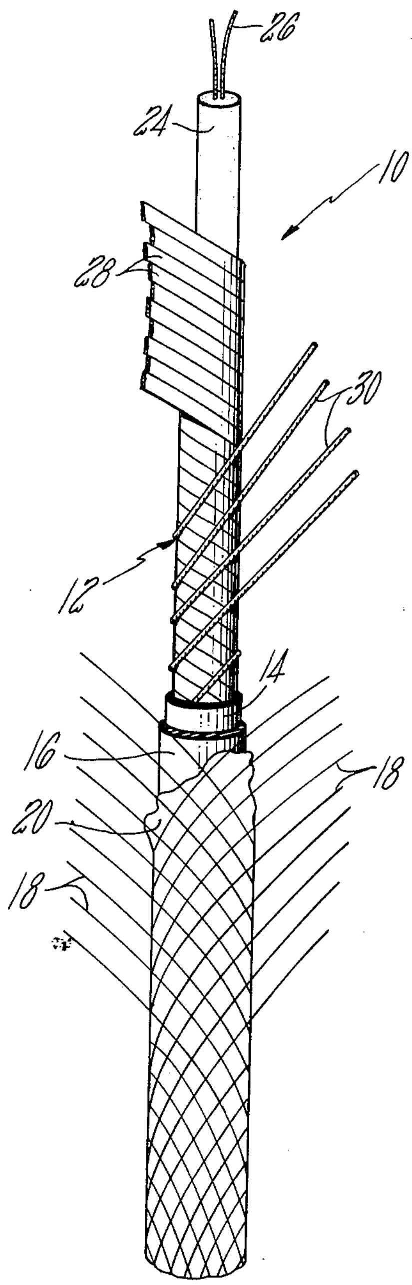


FIG. 1

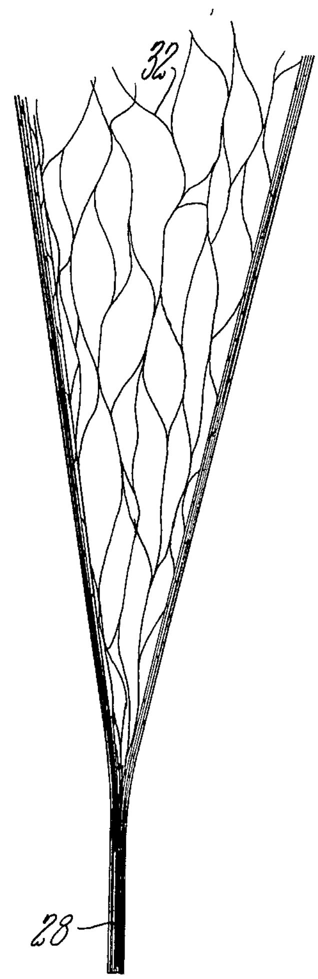


FIG. 2

FUSE AND ITS METHOD OF MANUFACTURE

BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates to fuses for initiating explosives and the like. More particularly it is concerned with a new and improved black powder fuse and with its method of manufacture.

Heretofore combustible fuse and particularly blasting fuse known as "safety fuse" has been constructed from a raw core enclosed within a moisture resistant covering. The raw core is comprised of a powder train of black powder surrounded by a wrapping of jute or similar yarns. This construction is more fully described in the Pearsall U.S. Pat. No. 2,102,024. In more recent years some of these blasting fuses have utilized a plastic moisture resistant jacket as described in the Kelly et al. U.S. Pat. No. 3,260,201.

In both of the foregoing types of blasting fuse a conventional granular black powder train or core has been utilized. This black power consists of coarse coal-like particles having bright, shiny surfaces that have been polished by treatment with small amounts of graphite. The powder is composed of an intimate mixture of an alkali metal nitrate, sulfur and charcoal. Conventionally, these three components are mixed and pulverized to incorporate the nitriate and the sulfur within the pores of the charcoal. This "incorporated" mixture is a granular material having a particle size wherein 55% to 70% is retained on a 50 mesh screen and only 2% of the granules pass through a 100 mesh screen. Unfortunately this powder presents numerous safety hazards during its manufacture and despite precautions has resulted in accidental explosive detonation accompanied by substantial loss.

Accordingly, it is an object of the present invention to provide a new and improved process for manufacturing safety fuse which avoids many of the safety hazards evidenced heretofore. Included in this object is the provision for a new and improved unincorporated black powder adapted to being produced immediately prior to its use within the fuse.

Another object of the present invention is to provide a process using unincorporated black powder that obviates abrasive grinding of the combined powder constituents and simply blends prepulverized components at the fusemaking location. Included in this object is the provision for blending the nitrate with a charcoal-sulfur premix under substantially less abrasive blending conditions and at a time immediately prior to its use so that the requirement for storage is substantially minimized.

It has also been found that the wrappings used heretofore in conventional safety fuse construction cannot be efficaciously employed when the powder core is composed of fine particles of unincorporated black powder. Due to the extremely small size of the unincorporated powder, i.e., 100% through 325 mesh, it has been found that the jute wrapping used heretofore is completely ineffective in retaining the powder within the desired core configuration. It has also been found that when a solid longitudinal tape is used to confine such powder in a manner similar to that described in U.S. Pat. No. 3,320,847, substantial variations occurred in the burning rate of the resultant product so as to make it unreliable on a commercial scale.

Accordingly, it is another object of the present invention to provide a new and improved fuse construction particularly well adapted for confining extremely fine unincorporated black powder within the core while at the same time providing uniform size and cross section and a uniform and regular burning rate.

A further object of the present invention is to provide a new and improved fuse construction of the type described that is of substantially lighter weight at identical core loads and provides the requisite coverage and confinement of the fine powder core. Included in this object is the provision for a powder confining yarn of the split-film or "fibrillated" type that combines the advantageous features of a multi-film yarn with the necessary confining characteristics of a tape.

A still further object of the present invention is to provide a fuse construction of the type described that not only facilitates the use of powder cores of very fine particle siae but also provides the necessary uniformity in size and performance coupled with enconomies in the manufacturing operation and in the materials used within the fuse construction.

Other objects will be in part obvious and in part pointed out in more detail hereinafter.

These and related objects are accomplished in accordance with the present invention by providing a process for manufacturing safety fuse comprising the steps of providing an intimate mixture of sulfur and charcoal having an average particle size of less than 45 microns, providing an alkali metal nitrate having an average particle size less than 45 microns, blending the intimate admixture of sulfur and charcoal with the nitrate without grinding, feeding the powder blend to form a powder column and confining the column within a wrapping of fibrillated synthetic yarn is intimate confining relationship with the powder core. The fibrillated yarn exhibits a relatively flat ribbon-like configuration and is comprised of a multitude of flexible individual filaments integrally interconnected in a net-like configuration with the filaments extending predominantly along the longitudinal dimension of the yarn.

A better understanding of the invention will be obtained from the following detailed description and the accompanying drawing which set forth certain illustrative embodiments indicative of the various ways in which the principles of the invention are employed.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing:

FIG. **1** is a fragmented elevational view of a fuse incorporating the features of the present invention, the fuse being partially broken away to illustrate the different layers of the confining and protective material covering the powder train of the fuse; and

FIG. **2** is a plan view of the powder confining fibrillated yarn used in the fuse of FIG. **1** with a portion of the yarn being spread apart to better illustrate the filamentary network thereof.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to the drawing in greater detail, a fuse **10** incorporating the features of the present invention is shown as comprised of a raw core **12** and a serirs of protective outer coatings circumscribably sheathing the raw core to provide protection from the surrounding environment. In the particular embodiment illustrated, the protective sheathing consists of a first coating **14** of asphalt or the like which covers and impregnates the outer periphery of the raw core **12.** The asphalt layer **14** is, in turn, encased within a plastic coating **16,** such as polyethylene tube, layer or the like, that is covered by countering strands or ends of yarn **18** spirally wound in opposite directions. Finally, the strands **18** are covered by a thin film **20** of water-proof material such as wax or the like.

The raw core **12** is shown as consisting of a central black powder core or train **24** embedding one or more center threads **26** and encased within a plurality of spirally wound fibrillated synthetic yarns **28.** The raw core is also shown as including a number of spaced cotton threads **30** spirally wound around the fibrillated yarns **28** in a countering fashion.

Referring now specifically to the powder core **24** of the fuse and particularly to the combustible composition making up that core, this composition is substantially identical from a chemical standpoint to the conventional black powder used heretofore. In other words, it consists of a mixture of charcoal, sulfur and an alkali metal nitrate such as sodium or potassium nitrate. As is well known, the amounts of the respective components of the black powder may vary. However, the alkali metal nitrate comprises a major portion of the composition and generally consists of from about 55% to about 75% by weight of the black powder. The remainder of the composition consists of sulfur and charcoal with the sulfur to charcoal ratio varying within the range of from about 1:4 to about 4:1. As is well known, the higher charcoal levels are generally employed in those formulations where increased burning rate is desired. In accordance with the present invention, it is generally preferred that the nitrate constitute about two parts by weight of the black powder composition and that the sulfur and charcoal constitute one part by weight. The amount of sulfur preferably is equal to or exceeds the amount of charcoal such that the ratio of sulfur to charcoal is within the range of about 1:1 to 4:1 and preferably 3:2 to 3:1 for those fuses which operate at a burning rate of about 120 seconds per yard.

As mentioned hereinbefore, in accordance with the preferred embodiment of the fuse manufacturing operation the sulfur and charcoal are intimately mixed and pulverized for a sufficient period of time to reduce their particle size to about 45 microns and less. This intimate grinding operation effectively smears the sulfur on the charcoal and results in absorption of the sulfur within the pores of the charcoal. As a result, 96%–100% of the intermixed material passes through a 325 mesh screen and exhibits the requisite particle size of less than 45 microns. In this connection, it has been found that the use of sulfur supplied by Stauffer Chemical Company under the trade designation "Tube Blend Item 30-10" can be used with consistently good results. This material has a typical sulfur analysis of 99.9% and a screen analysis of 98% through a 325 mesh screen. Similarly, a charcoal found to give excellent results is the extremely fine charcoal powder described as "Air Float", for example, the charcoal designated "A 200" by Susquehanna Company or the air float charcoal sold by Roseville Charcoal Company. Although the exact size of the charcoal particles is not known, generally 100% of the charcoal as received will pass through a 100 mesh screen. It is believed that this starting material exhibits an average particle size comparable to the suflur which it is mixed.

The charcoal and sulfur are mixed and milled in a dry condition for a sufficient period of time to work the sulfur into the cellular openings of the charcoal and provide the requisite fine particle size and intimate admixture of these two components of the black powder. As will be appreciated, this intimate ground mixture is a stable, relatively safe composition that can be premixed, preground and stored well prior to blending with the alkali metal nitrate, In this way, it is possible to avoid many of the safety hazards previously associated with the black powder manufacturing technique wherein all three components of the powder were admixed, usually in a wet or moist condition, were subsequently dried and then milled to produce the shiny granular and coarse coal-like particles of "incorporated" black powder.

The alkali metal nitrate used in the unincorporated powder of the present invention is preferably of a fine particle size wherein approximately 100% of the material passes through a 325 mesh screen although some coarser nitrates that are pulverized prior to blending also may be used. This particle size can be readily obtained by pregrinding the nitrate and good results have been obtained using as a starting material the double refined USP powder potassium nitrate sold by Battelle and Renwick that has a particle size of 100% through a 200 mesh screen. This material is pulverized as received to provide an average particle size of about 20–40 microns.

The finely powdered nitrate and the intimately mixed charcoal and sulfur are then blended immediately prior to use in the fuse manufacture. The blending is carried out in such a manner as to provide homogeneous mixing of the components without grinding or excessive abrasive action. In this connection, it has been found that a simple tumbling action will produce the desired blending. However, since the potassium nitrate has a tendency to form coalesced lumps, best results are achieved by simply blending the material in the presence of a plurality of hard rubber balls or similar means to assure a particulate end product. When such a blending action is performed, the desired very fine powder blend is readily achieved.

Advantageously the burning rate of the unincorporated black powder can be adjusted by varying the charcoal to sulfur ratio of the composition. One method of accomplishing this adjustment is to formulate a "fast" composition and a "slow" composition and selectively combine the fast and slow compositions to achieve the desired burning rate. For example, a fast burning composition consisting essentially of 67% potassium nitrate, 21% sulfur and 12% charcoal can be mixed with a slow composition consisting essentially of 67% potassium nitrate, 25% sulfur and 8% charcoal to accurately control the burning rate of the fuse made therefrom. This adjustment is advantageously obtained by measuring the burning rate of the fast and slow compositions individually and then selectively combining the compositions, such as by using one part of fast and two parts of slow, to achieve an extremely accurate and highly controlled unincorporated black powder for use in the desired fuse construction. As will be appreciated, other combinations of compositions can rreadily be employed so as to achieve this result.

As mentioned hereinbefore, the powder train is formed in a manner similar to that described in U.S. Pat. No. 3,320,847 wherein the powder is fed through a funnel or other hopper with the aid of one or more center threads. The fine particle form of the powder will tend to cavitate at the center of the funnel and therefore vibration of the feed system is preferred. In place of the tape and firs winding of yarn, a plurality of fibrillated or split-film yarns are spirally wrapped about the powder train to fully confine and enclose the powder. In the preferred embodiments of the invention these split-film yarns advantageously exhibit a relatively flat ribbon-like cross section and are composed of a plurality of interconnected filaments arranged within a regular or random net-like array, as illustrated in FIG. **2.** The split-film yarns are preferably zero twist, multi-filament members formed from oriented films of synthetic material that have been fibrillated by a suitable technique so as to produce either a regular or random filamentary network. Although a number of different technique may be employed to produce the fibrillated or split-film yarns, the technique preferably employed utilizes a large number of steel pinms mounted on rolls which revolve in the direction of the oriented or stretched film. The pins engage the stretched film as it passes the rolls, rupturing the film and forming the individual interconnected filaments of limited length within the network. Unlike most yarns the filaments are essentially rectangular in cross section and provide the greatest covering and confining capability with the least bulk while retaining the flexible fiber character and breathability of the yarn. It may exhibit a regular or random network with respect to the lattice and denier of the filments and need not be twisted prior to use. As shown in FIG. **2,** the yarn **28** may exhibit a random network having individual filaments **32** of varying length and exhibiting interconnected fibrils which may be connected to the network at only one end thereof to give a "hairy" or "bushy" appearance to the yarn. Yarns of such construction will have a tendency to laterally yield so as to provide a mesh work of filaments that cushion and confine the finely powdered core of the fuse.

The fibrillated split-film yarns are preferably made from synthetic polymeric material well suited to film formation. In this connection, polyolefins such as polypropylene, high density polyethylene, polyesters, polyamides such as nylon and polyacrylates including copolymers thereof may be used; however the polyolefins are preferred and have found most extensive use in the invention. These materials also advantageously exhibit a desirable hydrophobic character. The preferred material is polypropylene that is stretched or oriented along the longitudinal dimension of the film prior to fibrillation. Accordingly, during the fibrilling process, the individual random filaments of fibrils may show substantialy variation in length and denier, as shown in FIG. **2** and extend predominantly along the longitudinal dimension of the ribbon-like yarn.

The preferred zero twist fibrillated polypropylene yarn generally exhibits a thickness of about 1–2 mils and preferably about 1.2–1.6 mils. This thickness can be controlled by the thickness of the starting film. It has a denier of about 1800–2600 grams/9000 meters and preferably 2200–2500 grams/9000 meters that is controlled by a number of factors including film thickness and draw down ratio and the fibrillation is controlled by the arc of contact with the film, relative speeds, etc. As will be appreciated the lower denier material is used with coarser powder cores while the higher denier is used with the very fine powder. The yarn has a preferred tenacity greater than 3.0 grams per denier and an elongation of less than 20%. These yarns are particularly well suited to the manufacture of fuse since they are able to provide appropriate coverage for the fine power core while at the same time eliminating the need for both a powder-confining tape and the relatively bulky jute yarn utilized heretofore. The flexibility of the individual fibers within each yarn enhances its ability to confine the extremely fine powder and result in a firm, compact self-containing construction. Additionally the weight of the fibrillated yarn is about one third less than the weight of jute used heretofore.

Since the incorporated powder described hereinbefore exhibits an extremely fine particle size, it tends to also exhibit certain fluid characteristics which enhance its use in manufacturing fuses via a dry spinning technique. In this porcess the unincorporated black powder is fed to a vibrating hopper of a spinning machine and is fed therefrom using the combined effect of a center thread pull and the vibrating motion of the hopper. The feed rate and size of the powder train is controlled so as to produce a fuse having a core load of approximately **20** grains per foot and the powder core is immediately wrapped in multiple strands of fibrillated yarn, the strands being positioned in side-by-side relationship as shown in FIG. **1.** The confined powder train spirally wound polypropylene yarn continuously moves toward the second spinning plate where five ends of another yarn such as cotton yarn or the like are counterwound thereon in spaced parallel relationship to complete the production of the raw core **12** of the fuse. This raw core advantageously exhibits a cross sectional dimension which is uniform throughout its length. In the preferred embodiment it has a diameter of about 0.147 inch so that the application of subsequent coverings will result in a fuse diameter of standard size. The resultant fuse can then be wound on reels for storage and shipment.

The invention now will be further described with reference to the following specific examples which are provided in order that the present invention may be more readily understood. These examples are given by way of illustration only and are not intended to be a limit on the practice of the invention.

EXAMPLE ONE

Unincorporated black powder suited for use in a safety fuse was prepared by initially mixing 10 parts by weight of "Air Float" Susquehanna "A 200" charcoal and 23 parts by weight of "Tube Sulfur Item 30-10" followed by milling of the mixture for a period of 1 hour. The resultant milled material was then screened to assure 100% passage through a 325 mesh screen (Standard U.S. Sieve). About 67 parts by weight of double refined USP grade potassium nitrate powder was separately ground to an average particle size of less than 40 microns. The pulverized potassium nitrate and the mixture of charcoal and sulfur were then added to a wooden barrel blender provided with **20** hard rubber balls in amounts sufficient to resuslt in two pounds of black powder. The material was blended in the rotary blender for a period of 1 hour.

Using this aforementioned unincorporated black powder, a safety fuse was fabricated at a core load of about 20 grains per foot. A powder core was formed using a vibrating hopper and a pair of cotton center threads. Ten strands of zero twist fibrillated polypropylene yarn having a denier of 2400 grams per 9000 meters and a thickness of 1.46 mils were spirally wound in side-by-side relationship in direct contact with the powder core and five ends of 10/2 cotton yarn were counterwound thereon. The resultant raw core was then sheathed in a coating of asphalt and polyethylene and covered by countering threads prior to subsequent impregnation with wax.

The resultant fuse exhibited a substantially uniform cross sectional dimension throughout its length and burned at a uniform average burning rate of about 119 seconds per yard.

EXAMPLE TWO

The procedure of Example One was followed except that the average particle size of the resultant unincorporated black powder composition was varied from about 44 microns to 20 microns. The fuses made therefrom exhibited a burning rate that increased from 128 seconds per yard to 85 seconds per yard as the particle size of the powder core decreased.

EXAMPLE THREE

The procedure of Example One was repeated except that six parts by weight of charcoal and 27 parts by weight of sulfur were utilized in the manufacture of the unincorporated black powder. As the particle size of the material varied from 30 to 20 microns, the burn rate of the composition remained substantially unchanged at 190 seconds per yard.

Using a blend consisting of two parts of the aforementioned composition and one part of the composition from Example One, an average particle size of about 30 microns was obtained and resulted in a composition having about 67% potassium nitrate, 7.5% charcoal and 25.5% sulfur. A fuse made from this blend using the procedure of Example One exhibited an average burn rate of about 128 seconds per yard, thus indicating that the burn rate of the fuse could be controlled by preparing a fast and slow mix and blending these mixes in suitable proportions so as to manipulate and more precisely control the burn rate of specific fuse product.

EXAMPLE FOUR

Fast and slow compositions were also made in accordance with the procedure of Example One, tested and blended to produce a fuse giving excellent results. In this example the charcoal was material supplied by Roseville Charcoal Company and designated as air float charcoal. The compositions were as follows:

Material	Percent	
	Fast	Slow
Potassium nitrate	67	67
Charcoal	17	13
Sulfur	16	20

EXAMPLE FIVE

Samples of fuse were made using the unincorporated black powder blend of Example Three and were tested for burning uniformity in lengths of 3 feet, 6 feet, 9 feet and 12 feet. The fuses exhibited an average burning rate of 120.5 seconds per yard and coefficients of variation ranging from 0.4% to 1.3%. This coefficient of variation compares favorably with the values obtained from safety fuse of the same construction but containing incorporated black powder. Such fuse exhibits coefficients of variation within the range of .84% to 1.22%.

When the same blend of unincorporated powder was used as the power train in a raw core having a longitudinal polyethylene tape wrapped in ten ends of 12 pounds jute and five ends of 10/2 cotton yarn, it was found that the burn uniformity was extremely poor with coefficients of variation ranging from 0.8% to 7.7%, thus illustrating the substantial improvement achieved by utilizing the fibrillated polypropylene yarn rather than the solid polyethylene tape envelope.

In all of the foregoing examples, it was found that the fibrillated polypropylene yarn usage was about two pounds per thousand feet as opposed to the usual three pounds per thousand feet for jute yarn.

As will be appreciated by persons skilled in the art, various modifications, adaptations and variations of the foregoing specific disclosure can be made without departing from the teachings of the present invention.

We claim:

1. A process for producing safety fuse comprising the steps of providing an intimate mixture of sulfur and charcoal having an average particle size of less than 45 microns, providing alkali metal nitrate particles having an average particle size of less than 45 microns, blending the intimate admixture of sulfur and charcoal with the nitrate particles without subjecting the blend to substantial grinding forces to provide a powder blend exhibiting fluid characteristics, flowably forming the powder blend into a continuous powder column and confining the column within a split-film yarn wrapping exhibiting a relatively flat ribbon like configuration, said wrapping being in intimate confining relationship with the powder column and being comprised of a multitude of flexible individual filaments integrally interconnected in a net-like array.

2. The process of claim 1 wherein the split-film yarn wrapping is comprised of a fibrillated synthetic plastic tape.

3. The process of claim 1 wherein the split-film yarn wrapping is a polyolefin material and the individual filaments within the yarn extend predominantly along the longitudinal dimension of the yarn.

4. The process of claim 1 wherein the yarn wrapping is a fibrillated zero twist polypropylene yarn having a thickness of about 1–2 mils.

5. The process of claim 1 wherein the sulfur to charcoal ratio within the mixture falls within the range of from about 4:1 to about 1:4.

6. The process of claim 1 wherein the blend includes about two parts by weight of nitrate particles and one part by weight of the admixture of sulfur and charcoal.

7. The process of claim 1 wherein the admixture and the nitrate are separately pulverized prior to blending to result in the average particle size of less than 45 microns.

8. The process of claim 1 wherein the continuous powder column is formed by flowably feeding the powder blend under agitation with the aid of a center thread.

9. The process of claim 1 wherein the alkali metal nitrate is selected from the group consisting of potassium nitrate and sodium nitrate.

10. The process of claim 1 wherein the alkali metal nitrate is potassium nitrate and the powder blend consists essentially of two parts by weight potassium nitrate and one part by weight of the admixture of sulfur and charcoal, the ratio of sulfur to charcoal being within the range of about 1:1 to 3:1.

* * * * *