United States Patent [19]

Lista et al.

[11] **3,890,877**

[45] **June 24, 1975**

[54] **STAPLE ORIENTING APPARATUS**

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[73] Assignee: **Aerojet-General Corporation**, El Monte, Calif.

[22] Filed: **Oct. 6, 1969**

[21] Appl. No.: **866,088**

Related U.S. Application Data

[63] Continuation of Ser. No. 521,757, Jan. 18, 1966.

[52] **U.S. Cl.** ..... **86/1**; 102/101; 264/3 R

[51] **Int. Cl.** **C06b 21/00**

[58] **Field of Search** ..... 86/20, 1; 102/101, 99; 264/3 R

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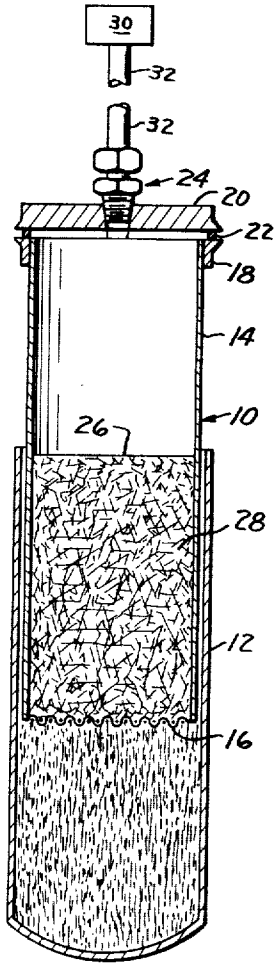
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[57] **ABSTRACT**

Apparatus for casting uncured solid propellant having metal staples disbursed therein, which apparatus is a container having a discharge opening covered by a fine mesh screen or a plate with multiple openings. A means is operably associated with the container for forcing the staple containing propellant through the screen whereby the staples within the propellant are oriented in the direction of propellant flow and the propellant is deposited in the casting with the staples in a planar orientation.

5 Claims, 5 Drawing Figures



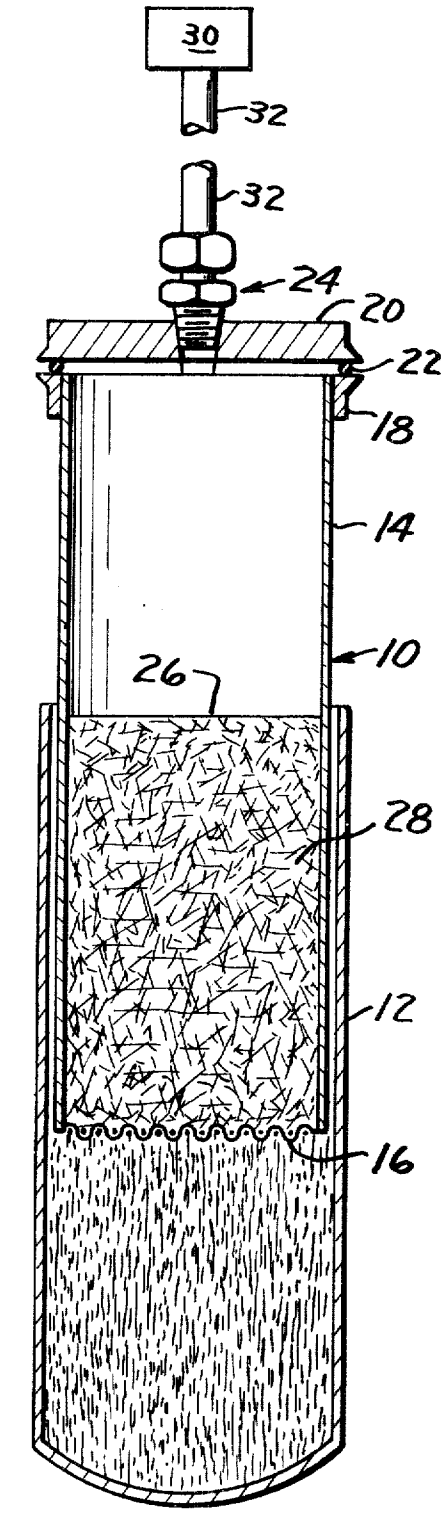


FIG. 1

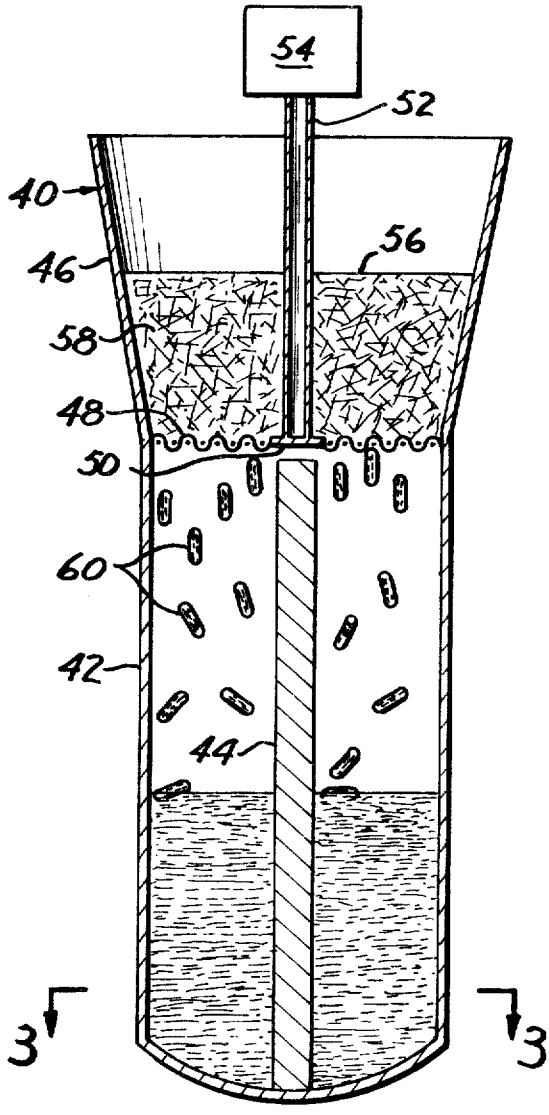


FIG. 2

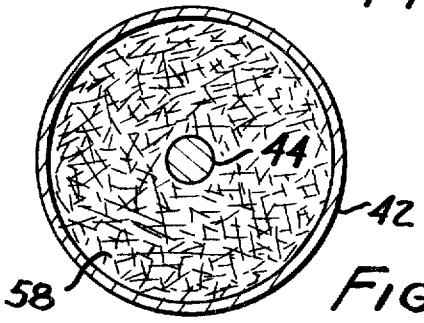


FIG. 3

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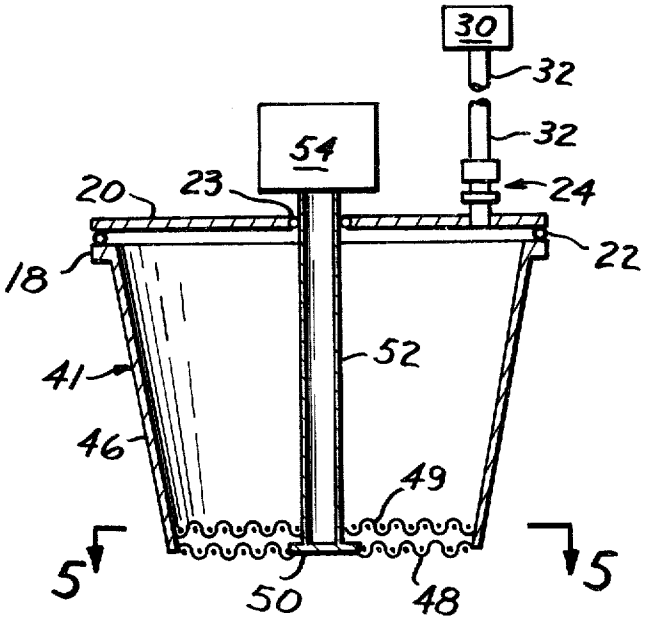


FIG. 4

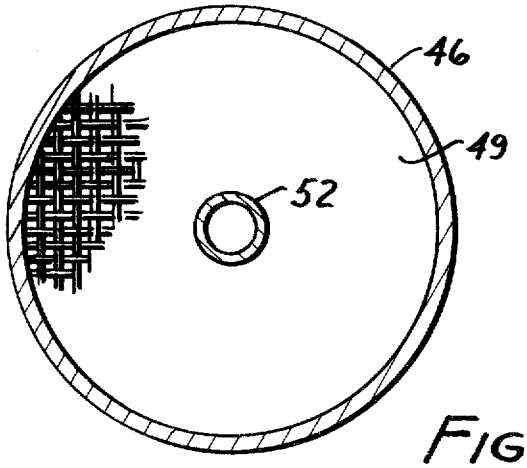


FIG. 5

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STAPLE ORIENTING APPARATUS

This is a continuing application of our copending application Ser. No. 521,757 filed Jan. 18, 1966, entitled "Staple Orienting Method and Apparatus."

This invention relates to a novel apparatus for increasing the performance of solid rocket propellant which includes the orientation of metallic staples disbursed throughout the propellant.

It is well known that the addition of metal staples, such as wires, filaments, strips, and the like, will increase the burning rate of solid propellant rocket motors. These staples which have a substantially higher thermal difusivity or conductivity and the solid propellant material serve as miniature heat conductors. The increased burning rate results from the fact that the metal staples effect rapid heat transfer from the high temperature combustion gases in the flame zone to the unburned propellant in the grain. In this manner the flame propagates rapidly along the metal staples. As a result, the burning surface travels along the metal staple (heat conductor) at a much faster rate than the normal propellant burning rate. In addition, the burning surface recesses to form a cone with the metal staple at its apex and thereby becoming much larger than normal. This greatly increases the effective burning rate of the propellant grain along with the rate of gas evolution.

In a solid rocket motor the maximum increase in burning rate obtained from the metal staples can only be achieved if the staples are oriented perpendicular (normal) to the burning surface of the propellant. Methods of dispersing metal staples within the solid propellant matrix, however, inevitably resulted in a random orientation of the staples. While the random orientation achieved measurable increases in burning rates, it did not produce optimum results and oftentimes results in uneven burning. This is true for both end burning and internal burning grains.

It is therefore an object of this invention to provide an improved method for increasing the performance of solid propellant rocket motors.

Another object of this invention is to provide an improved method of orienting metallic staples disbursed within a solid propellant rocket motor.

A further object of this invention is to provide an improved bayonet for casting solid propellant having metal staples disbursed therein.

These and other objects of this invention will be apparent from the detailed description which follows when taken together with the appended drawings wherein:

FIG. 1 is a cross-sectional view of an end-burning solid propellant rocket motor casing and bayonet of the present invention during the casting process;

FIG. 2 is a cross-sectional view of an internal burning solid propellant rocket motor, casing and bayonet of the present invention during the casting process;

FIG. 3 is a cross-sectional view of the casing of FIG. 2 taken along line 3—3 of FIG. 2;

FIG. 4 is a cross-sectional view of a casting bayonet similar to that shown in FIG. 1 except that it is modified to show a second screen and to show a pressurizing means similar to that utilized for the casting bayonet shown in FIG. 1; and

FIG. 5 is a cross-sectional view of the bayonet of FIG. 4 taken along the line 5—5 of FIG. 4.

The metallic staples which are employed as burning rate additives in solid propellants are comprised of any metal or metal alloy of high heat conductivity and high melting point, such as copper, aluminum, iron, stainless steel, hafnium, brass, zirconium, silver, and many others. These staples, which may be of any cross-section, such as circular, rectangular, square, or many-sided, can vary in length up to and in some cases exceeding 500 mils. In the usual case, however, all of the staples in a given matrix will be of the same length and have a maximum side-to-side dimension of approximately 20 mils.

The solid rocket propellant composition is mixed in the normal manner and the staples added at some point in the process prior to the casting of the propellant. The dispersion of the staples in the propellant during the mixture thereof will result in a random or uneven orientation of the staples in the mixture. An example of a staple-containing propellant is taught in copending application Ser. No. 338,527 by Ralph W. Lawrence, filed Jan. 17, 1964, now U.S. Pat. No. 3,793,097 and assigned to the same Assignee as the present invention.

Referring now to FIG. 1 there is shown a propellant casting tube or bayonet **10** inserted within an end-burning rocket motor casing **12.** Bayonet **10** comprises a long, cylindrical tube **14,** having a wire cloth or screen **16** at the bottom thereof. The top of the tube **14** is fitted with a flange **18.** A cover plate **20** over the top of the tube **14** effects a pressure seal with the tube flange **18** when used with an O-ring **22.** A tri-clover fitting can also be used to effect this pressure seal. A fitting **24** (such as a Hanson fitting) threaded into the cover plate **20** provides access for a pressurized fluid to the top of the tube **14.** A connecting line **32** joins the fitting **24** with a source **30** of gas, such as nitrogen under pressure.

The tube **14** of a structural material, such as stainless steel, is filled under vacuum with a solid propellant **26** having disbursed within it randomly oriented metal staples **28.** The screen **16** retains the propellant within the tube when there is no external pressure applied to the propellant **26.** The size of the openings in the screen **16** will depend primarily upon the dimensions of the staples and would normally be between 2½ and 4 mesh. Additionally, more than one screen may be utilized at the bottom of the tube **14** e.g., a 2½-mesh screen over a 4-mesh screen.

The bayonet **10,** once it has been filled with propellant, is inserted screen-end down into the motor casing **12** so that the screen **16** of the bayonet is only a short distance from the bottom of the casing **12.** The outside diameter of the bayonet tube **14** should be only slightly smaller than the inside diameter of the casing **12.** By applying pressure to the top of the propellant **26** by such means as a compressed or pressurized gas admitted through the fitting **24** the propellant is forced through the screen **16** at the bottom of the tube **14** and into the rocket motor casing **12.** Alternately, a mechanical or hydraulic displacement technique can be used to force the propellant through the screen **16.**

The screen **16** through which the propellant containing the randomly oriented metal staples **28** is forced, orients the metal staples in a direction perpendicular to the plane of the screen. The openings of the screen **16** are too small to permit the metal staples to proceed through in any other orientation.

As the propellent **26** with the metal staples **28** now oriented along axis of the motor casing fills the motor casing **12** the bayonet **10** is raised to permit the propellant to substantially fill the casing **12.** The screen **16** of the bayonet **10** may be kept a short distance from the propellant already deposited or cast into the motor or may be in contact with the deposited propellant such that the propellant offers a slight resistance to the flow which helps to align the staples. The propellant will, in effect, flow from the bayonet into the casing as a viscous fluid under pressure. In this manner the propellant cast into the motor casing retains the staple orientation resultant from passing through the screen. This cast propellant can now be cured in the conventional manner as if there were no staples disbursed therein.

With the metal staples oriented along the axis of the motor casing, the staples will be normal to the burning surface of an end-burning propellant grain. Thus, there will be provided the maximum increase available in the burning rate from the use of the added metal staples.

Should for any reason it be desirable to provide the staples thus oriented in an internal burning motor a central void could be provided in the bayonet **10** to enable the bayonet to be inserted into the casing **12** within a core in place. Such a staple orientation would normally, however, be undesirable for an internal burning motor.

Referring now to FIG. **2,** there is shown a bayonet **40** positioned over an internal burning solid propellant rocket motor casing **42.** A core **44** is positioned in the central portion of the casing **42.**

The bayonet **40** comprises a tube **46** which is shown as a truncated conical section with the base of the conical section upward. A fine mesh cloth, perforated plate, or wire screen **48** extends across the lower end of the tube **46** which is positioned over the upper end of the casing **42.** A diaphragm **50** is positioned in the screen **48** directly over the core **44** of the casing **42.** The diaphragm **50** may be connected to a vibrator **54** external to the bayonet **40** by means of a hollow rod **52.** The bayonet **40** would be filled with a solid propellant **56** in which metal staples **58** are randomly dispersed.

FIG. **4** is an alternate arrangement of the bayonet **40** shown in FIG. **2.** In FIG. **4** the bayonet **41** is comprised of a tube **46** which is a truncated conical section with the base of the conical section upward. A fine mesh cloth or perforated plate or wire screen **48** extends across the lower end of the tube **46** and has a second fine mesh cloth, perforated plate, or wire screen **49** extending across the lower portion of the tube **46** immediately above the first screen **48.** The second or upper screen **49** may be a 2½-mesh screen over the lower screen **48,** which may be a 4-mesh screen. A diaphragm **50** is positioned in the screen **48** in the approximate center thereof. The top of the tube **46** is fitted with a flange **18.** A cover plate **20** over the top of the tube **46** effects a pressure seal with a tube flange **18** when used with an O-ring **22.** A fitting **24** threaded into the cover plate **20** provides access for a pressurized fluid to the top of the tube **46.** A connecting line **32** joins the fitting **24** with a source **30** of gas such as nitrogen under pressure. The diaphragm **50** may be connected to a vibrator **54** external of the bayonet **41** by means of a hollow rod **52** extending through the cap **20** which is provided with a pressure seal by the use of an O-ring **23.** The bayonet **41** would be filled with a solid propellant having metal staples randomly dispersed therein.

With the bayonet **40** as shown in FIG. **2** positioned over the casing **42** the propellant **56** containing the staples **58** will, either due to gravity or as a result of an externally applied pressure, pass through the screen **48.** The openings of the screen **48** are such as to produce a large number of elongated propellant droplets **60,** with each droplet having the metal staples oriented along its axis of elongation. A means for encouraging the formation of droplets rather than string-like extrusions would be employed, which means may include controlling the rate of casting so that the propellant will break off in the form of droplets or employing a rotatable or pivotal screen, not shown, which screen may be suspended immediately below the screen **48.** In the alternate embodiment shown in FIGS. **4** and **5** the propellant is forced through the screen **49** to initiate staple orientation prior to being forced through the screen **48.** In either embodiment of FIG. **2** or FIG. **4** the openings in the screen **48** are sufficiently small that as propellant is forced therethrough the weight of the propellant will be sufficient to cause the propellant to break and form droplets **60** as shown in FIG. **2.** The droplets **60** will then fall to the bottom of the casing **42.** The staples within the propellant which is in the bottom of the casing **42** will have planar orientation, as shown in FIG. **2,** however, within the plane the staples **58** may have random orientation, as shown in FIG. **3.**

It has been experimentally demonstrated that although the droplets **60** tumble in random directions as they fall to the bottom of the casing **42** they will come to rest in the bottom of the casing with their axis of elongation in a plane perpendicular to the axis of the casing **42.** Thus, regardless of the angle at which the droplets hit the partially filled propellant in the bottom of the casing, they flop over on their side before coming to rest. In this manner, the staples are oriented in a plane normal to the axis of the casing. The diaphragm **50** prevents droplets **60** from falling directly upon the core **44.**

This planar randomization of the staples permits even burning of the propellant. Conventional casting of the propellant around the core **44** has been known to partially orient the staples which resulted in uneven burning characteristics for the propellant. The planar randomization will not, however, produce the maximum burning rate achievable with the metal staples, which requires that the staples be oriented normal to the burning surface. In the case of an internal burning motor, this requires a radial orientation of the staples.

To achieve this radial orientation, the screen **48** can be vibrated up and down by means of a vibrator with the greatest amplitude at the center of the screen **48** at the point where the rod **52** is attached to the diaphragm **50** of screen **48.** The vibration will give the individual droplets of propellant falling from the screen **48** as a radial moment, either toward or away from the center of the screen **48.** This radial momentum will result in the droplets **60** achieving a radial orientation in the casing **42** and thereby orient the staples normal to the propellant burning surface, which will produce a maximum burning rate from the staples.

While preferred forms and embodiments of the invention have been shown and described, it will be apparent to those skilled in the art that modification can be made without departing from the principles and spirit of the invention, the scope of which is defined in the appended claims.

What is claimed is:

1. An apparatus for casting uncured solid propellant having elongated metal staples randomly dispersed therein comprising:

a tube for containing the uncured solid propellant; and

a fine mesh screen fixedly attached to the bottom end of said tube, said screen having openings therein whereby when the solid propellant passes through said screen, the metal staples of said propellant are oriented in the direction of propellant flow.

2. The apparatus for casting uncured solid propellant having elongated metal staples randomly dispersed therein as described in claim 1, and in addition:

a means for applying pressure to the top of the propellant in said tube to force said propellant through said screen.

3. The apparatus for casting uncured solid propellant having elongated metal staples randomly dispersed therein as described in claim 1, and in addition:

a means for vibrating said screen to impart a radial moment to the propellant leaving said screen.

4. The apparatus for casting uncured solid propellant having elongated metal staples randomly dispersed therein as described in claim 1, and in addition:

a second fine mesh screen fixedly attached to said tube adjacent the bottom thereof and above the other screen, said second screen having openings therein whereby said second screen initiates staple orientation in the direction of propellant flow.

5. The apparatus for casting uncured solid propellant having elongated metal staples randomly dispersed therein as described in claim 1, and in addition:

means operably associated with said screen for encouraging said propellant to form into droplets.

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