(12) UK Patent Application (19) GB (11) 2 107 638 A

(21) Application No **8230064**
(22) Date of filing **21 Oct 1982**
(30) Priority data
(31) **8131943**
(32) **22 Oct 1981**
(33) **United Kingdom (GB)**
(43) Application published **5 May 1983**
(51) **INT CL³ B29B 1/02**
(52) Domestic classification
B5A 1A2A 1R106X 1R163 1R314C3 1R429X 20T17 20T22 2B1 2B2 2C 2M T20P
U1S 1348 1452 B5A
(56) Documents cited
GB 1127877
GB 0729050
(58) Field of search
B5A

(71) Applicants
The Secretary of State for Defence,
Whitehall,
London SW1A 2HB
(72) Inventors
Ronald Percy Ayerst
Henry Charles Turner
(74) Agents
S. R. James,
Procurement Executive,
Ministry of Defence,
Patents 1A(4),
Room 2014,
Empress State Building,
Lillie Road,
London SW6 1TR

(54) **Cutting apparatus for extruded materials**

(57) This invention provides an apparatus for continuously cutting extruded materials, for example propellants, comprising a two-way cutting blade provided with a high speed reciprocating cutting action, and a control means for linking the reciprocating frequency with the speed of extrusion of the material. When cut by the apparatus, the extruded material undergoes very little cross-sectional distortion, and the cut grains produced very little in length.

A preferred embodiment of the apparatus has a blade (7) in the form of a plate with a double-edged knife (24) formed on the land portion (23) between two apertures (22) therein, which is moved by means of an electronically controlled piston and cylinder (10) operated by fluid pressure. Extruded material velocity is sensed by a rotatable wheel (4) which is connected to an electronic control unit linked to the piston and cylinder, thus providing automatic cutter control that is linked to material velocity.

Fig.1.

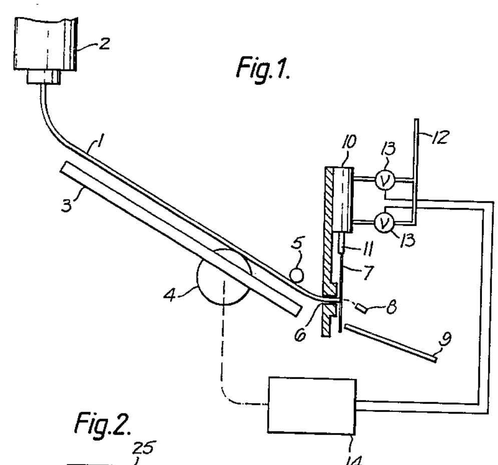
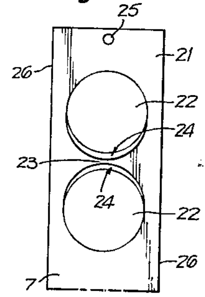


Fig.2.



2107638

1/1

Fig.1.

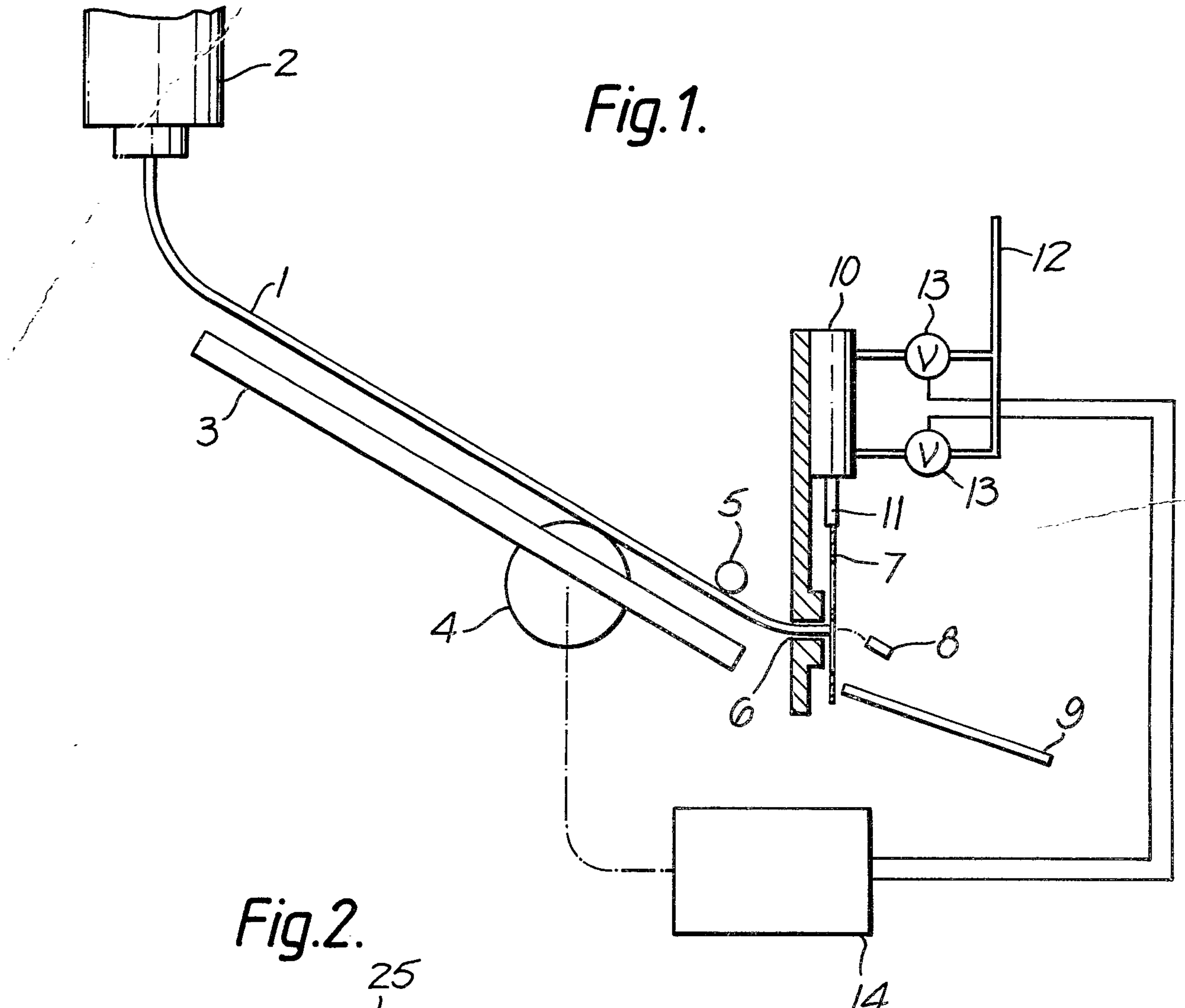
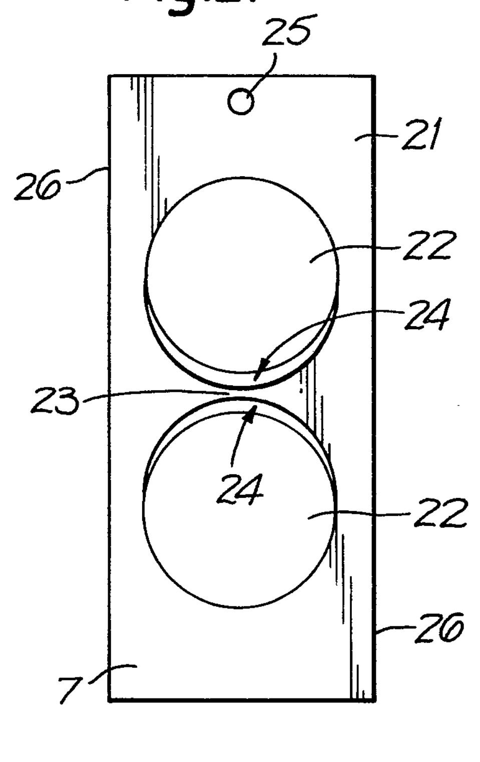


Fig.2.



SPECIFICATION

Cutting apparatus for extruded materials

This invenion relates to apparatus and a method for continuously cutting travelling materials, and in particular to cutters for cutting extruded threads of propellant compositions.

During the manufacture of the most widely used propellants, those based on nitrocellulose, used either alone in single-base propellants or mixed with nitroglycerine in double-base propellants, the propellant composition is usually prepared as a gelatinous mass which is then extruded through a die and cut into grains of suitable length for use. Such dies may have a single nozzle or several nozzles, and may be arranged to produce either a solid cord of extruded propellant or a cord provided with one or more axial channels.

It is desirable that the cutter used to produce the grains should be compact to enable it to be located close to the extrusion die. This is particularly desirable in a multiple-nozzle extrusion die, wherein many cords of extruded propellant are produced in close proximity, each extruded cord being guided to an individual cutter. A further advantage of a compact cutter is, of course, the low driving power demand.

In addition, for optimum ballistic performance of these propellant grains, the grains should be cut to substantially uniform lengths, should have cut ends which are substantially at right angles to the direction of extrusion, and with as little distortion of the cross-section of the grains or constriction of any axial channels as possible.

To obtain uniform cut lengths the operation of the blade of the cutter has to be related to the speed of extrusion of the propellant cord; to achieve ends which are substantially at right angles to the direction of extrusion and avoid distortion of the cross-section or constriction of axial channels, the velocity of the cutting blade should be as high as possible relative to the speed of extrusion. These are to a large extent mutually exclusive requirements in a cutter, as high blade velocities confer high momentum upon the blade, and a consequential difficulty in adjusting the operation of the cutter rapidly enough to relate its motion to moment-by-moment fluctuations in the speed of extrusion of the propellant. These requirements are not met adequately by either of the main types of mechanical cutter which are currently in use, ie cam-operated reciprocating guillotine type cutters or rotary cutters, which tend both to be bulky and to produce grains which are non-uniform in length.

It is one object of the present invention to provide an apparatus that overcomes at least some of the disadvantages of the prior art. Other objects and advantages offered by the present invention will become apparent from the following description thereof.

According to the present invention, there is provided an apparatus for continuously cutting an extruded cord of material which comprises

a cutting blade slidably mounted along a stationary cutting plane that is perpendicular to the direction of motion of the cord,

two cutting edges disposed in a back to back relationship on the blade, each cutting edge being adapted to cut the cord along the cutting plane,

and a blade actuating means that is adapted to displace the blade in such a manner that with respect to time the position of the blade is definable graphically by means of a square wave, and that, in use, actuates the blade in such a manner that the blade cuts the cord into grains of substantially uniform length.

The imposition of a square wave reciprocating motion upon the blade means that the blade accelerates and decelerates virtually instantaneously at the start and at the finish respectively of each cutting stroke. Thus the displacement of the blade through each cutting stroke need only be slightly greater than the thickness of the cord being cut. As a consequence, the present apparatus may be made to be more compact and to consume less power than prior art cutting devices. Furthermore, the imposition of square wave motion on the blade ensures that the velocity of the blade is kept high enough to prevent distortion of the cross section of the cord being cut. The velocity of the blade through the cord is preferably at least one hundred times that of the velocity of the cord through the cutting plane.

By employing a cutting blade having two cutting edges disposed in a back to back relationship, the blade of the present invention, when imparted with a square wave reciprocating motion with respect to the cord, is capable of cutting in both directions of its travel along the cutting plane. Thus two cutting strokes are made by the blade for every complete cycle of its reciprocating motion, enabling the blade to cut at twice the frequency that could be achieved by a single cutting edge.

The cutting blade is advantageously made as small and light as possible while being of sufficient mechanical strength to withstand, during cutting, the forces brought to bear on it by the blade actuating means. This ensures that the blade can achieve high cutting velocities and frequencies without having a high momentum. Increases in the mass of the blade not only tends to distort the square wave motion imposed on the cutting blade into sinusoidal motion, which hinders the production of grains having cut ends perpendicular to the direction of extrusion, but also increases the power required to actuate the blade. The blade should also be made easily replaceable, in order that in the inevitable event of it becoming blunted or broken during use, the blade may be changed quickly and cutting speedily resumed. These objectives are most conveniently achieved by making the blade out of thin sheet steel, from which light, cheap disposable cutters may be punched, and which is easily ground to a sharp edge.

The width of the blade between its cutting edges should be as small as is consistent with mechanical strength, so that the passage of the blade through the extruded cord of material disturbs the forward movement of the extruded cord for as short a time as possible. Blades comprising thin knives or cutting wires possess such a desirable cutting edge configuration, but a most preferred form of blade comprises a plate of thin metal which is provided with two apertures, large in comparison to the width of the extruded cord to be cut, said apertures being arranged in line along the direction of the cutting stroke of the blade in such positions that extrusion of material is not impeded by the blade at either extreme of reciprocation, the cutting edges being formed along the edges of the apertures such that each cutting edge is disposed in a back to back relationship to the other. This preferred form of blade combines mechanical strength, convenience of manufacture and handling, low cost of production and disposability. A preferred metal is steel, which can easily be ground to a sharp cutting edge.

The blade actuating means preferably comprises at least one piston and cylinder operated by fluid pressure, each piston being adapted to connect with the cutting blade by means of a piston rod. By using fluid pressure and fluid control parameters appropriate to the dimensions of the present apparatus, the blade may be driven by such an actuating means with an almost explosive impulse providing virtually instantaneous blade acceleration. Blade deceleration can also be brought about virtually instantaneously by the piston striking one end of the cylinder at the completion of its driving stroke. The blade actuating means most preferably comprises a single double-acting piston and cylinder, as such a piston and cylinder arrangement may be made extremely compact and hence of low inertia, and is thus capable of achieving a suitable reciprocating frequency whilst having a low power requirement in comparison to prior art cutting devices. The piston may be driven pneumatically or hydraulically depending on the properties of the cord material to be cut. Pneumatic actuation has been found to be suitable for cutting thin cords of extruded materials at reciprocating frequencies up to about 50 Hz. Hydraulic actuation has been found to be suitable for heavy duty cutting, for example in the propellant field for cutting hard cordite. However the maximum reciprocating frequency achievable using hydraulic actuation is only about 10 Hz.

The blade actuating means is conveniently adapted to actuate the blade to cut substantially uniform lengths of the cord by a sensor for continuously sensing the velocity of the cord through the cutting plane and a means for automatically controlling the frequency of the cutting strokes of the blade such that the frequency varies in direct proportion to the velocity sensed by the sensor. Such automatic control of the blade actuating means ensures that, in use, the cutting blade cuts substantially uniform lengths of cord at a frequency which takes account of moment-by-moment fluctuations in the velocity of the cord, which fluctuations in velocity are characteristic of continuously extruded materials. The means for automatically controlling the frequency of the cutting strokes preferably comprises a processing unit adapted to receive signals from the sensor and to convert the signals into a series of pulses whose frequency is directly proportional to the velocity of the cord through the cutting plane, and a control means adapted to convert each pulse from the processing unit into a cutting stroke of the cutting blade via the blade actuating means.

The processing unit is preferably electronic, as electronic control of the blade actuating means facilitates a sensitive and rapid automatic response of the cutting blade to fluctuations in the velocity of the cord. Furthermore, the processing unit preferably includes a means for manually selecting the desired lengths of the grains of cord to be cut by the present apparatus. The continuous influence of the control means then ensures that the present apparatus will, in use, cut each grean substantially to the length selected regardless of moment-by-moment fluctuations in the velocity of the cord through the cutting plane.

Sensitive control of the blade actuating means is assisted by employing a control means which is preferably electromechanical, which requires that the processing means emits electrical pulses. For controlling at least one piston and cylinder operated by fluid pressure the control means preferably comprises two or more electromagnetic valves adapted to control the flow of fluid to and from the at least one cylinder in such a manner that the cutting blade is actuated to perform a single cutting stroke for each electrical pulse received by the valves. Such valves can be operated to open and close at very high speeds and can respond very quickly to each pulse received from the processing means. Electromagnetic valves, particularly when operated by an electronic processing means, can therefore provide a way of accurately controlling the preferred blade actuating means which is sensitive to variations in the velocity of the cord, and which enables the preferred blade actuating means to impose high frequency square wave motion on the cutting blade.

According to a further aspect of the present invention, the sensor comprises a freely rotatable wheel positioned adjacent the cutting plane so as to be rotated by tangential contact with the cord during extrusion, the rim of the wheel being made of a material which has a high coefficient of friction with respect to the cord, and a means for generating a constant number of electrical impulses per revolution of the wheel. One advantage of a sensor according to this aspect of the invention is that it may be electrically connected to a simple and reliable electronic processing means comprising an impulse counter which is arranged by means of an adjustable timing device to emit electrical pulses to the control means to actuate the blade actuating means. The timing device is adjusted manually to emit each pulse after a preselected number of impulses counted, and thus to preselect the length of the grains to be cut from the cord. A further advantage of such a rotatable sensor is that it can be adapted to measure cord velocity accurately without causing distortion of the shape of the cord.

In a preferred embodiment of this aspect of the present invention, the means for generating a constant number of electrical impulses per revolution of the wheel comprises one or more mirrors attached to the wheel, the mirrors being arranged so that light from each of the one or more mirrors is reflected, once per revolution, into a photoelectric cell. Other methods of generating electrical impulses in such a rotary sensor will be apparent to those skilled in the art. The higher the number of mirrors, the higher the number of impulses generated per revolution hence the greater will be the sensitivity of the rotary sensor to fluctuations in the velocity of the cord.

It has been found that optimum rotation of the wheel by passage of a cord of extruded propellant material of conventional diameter is achieved when the cord is directed over said wheel at an angle of between 30° and 60° to the horizontal. At higher angles the cord does not bear with sufficient force upon the surface at the wheel to overcome the tendency to slip, and at lower angles thin cords tend to buckle. With other, denser, extruded materials, or with thicker propellant cords, lower angles may be suitable.

Using conventional propellant extruding equipment, for example, cutting apparatus according to the invention including a drive unit coupled to the speed of extrusion has been found suitable for producing grains of propellant of 1 to 15 mm diameter, of length 3 to 20 mm, with a variation in grain length of no more than 5%.

The invention will now be described by way of example only with reference to the accompanying drawings in which,

Fig 1 shows an overall schematic view of a propellant extruder and a cutting apparatus

Fig 2 shows a cutting blade as used in the cutting apparatus shown in Fig 1.

With reference to Fig 1, a cord of propellant 1 is extruded from an extruder 2 which may have one or more extrusion nozzles. The cord 1 is directed onto a guide rail 3, above which it is frictionlessly supported by means of jets of air directed through holes therein. The rail 3 is arranged so as to be at an angle of between 30° and 60° to the horizontal The cord 1 is guided so as to be in tangential contact with a rotary sensor 4, which is capable of being rotated by the passage of said cord, then under a guide roller 5, through a guide nozzle 6, so as to be cut by the reciprocating double-edge cutting blade 7 located immediately adjacent to the nozzle 6, and moving in a stationary cutting plane at right angles to the direction of motion of the extruded cord 1 at the point of cutting. The grains produced, 8, are collected via a chute 9.

The blade 7 is reciprocably moved in low friction guide rails (not shown) by means of a double-acting piston and cylinder 10 through a connecting rod 11. The piston and cylinder 10 is actuated by means of a compressed gas, especially air or nitrogen, supplied through the line 12, the access and the exhaust of the gas to and from the cylinder being controlled by double-acting electromagnetic valves 13. The design of the piston and cylinder 10, the valves 13, and the pressure of the gas is such that the blade 7 is moved by an effectively instantaneous impulse, so as to impose substantially square wave motion upon the blade 7. The displacement of the blade 7 is the minimum possible to achieve severance of the grains from the cord.

The operation ofthe blade 7 by the piston and cylinder 10 is controlled by electronic activation of the valves 13 by means of the sensor 4 and an electronic processing means 14. The rotary sensor 4 comprises a substantially freely rotating wheel, the outer perimeter of which is coated with a resinous adhesive, to ensure a high coefficient of friction with the propellant cord 1. Around the inner perimeter of the wheel are situated a number of mirrors (not shown) capable of reflecting light from a lamp (not shown) into a photoelectric cell (not shown) when the mirrors, lamp and photoelectric cell come into a suitable configuration during rotation, so as to generate a constant number of electrical impulses per revolution.

The output from the sensor 4 is transmitted to the electronic processing means 14. This contains an impulse counter (not shown), and an adjustable clock circuit (not shown) arranged to transmit electrical signals to the electromagnetic valves 13 so as to activate them at preselected counts of impulses. By altering these preselected counts, the length of the grains 8 may be varied.

The blade 7, which is shown in greater detail in Fig 2, comprises a rectangular plate 21 made of steel, with the minimum thickness consistent with mechanical strength. The plate 21 is provided with two circular apertures 22, which are arranged in line along the direction of the reciprocatory motion of the blade, and which are of greater diameter than the diameter of the extruded cord 1 to be cut. The edges of the apertures 22 which are in a substantially back-to-back relationship across the land portion 23 between said apertures 22 are ground to form sharp cutting edges 24. The land portion 23 is of the minimum width consistent with mechanical strength. A fitting 25 is formed at one end of the plate 21, in line with the centres of the apertures 22, to allow connection of the blade to the connecting rod 11. This fitting 25 may be of any convenient design, for example a hole co-operating with a pin or grub screw (not shown) on the connecting rod 11.

In use the blade is mounted with its long edges 26 resting in the low friction guide rails (not shown), and is attached to the connecting rod 11. The plate 21 is positioned adjacent to the guide nozzle 6, so that said nozzle 6 faces one of the apertures 22 at one extremity of the reciprocatory motion of the blade 7, and faces the other aperture 22 at the other extremity of reciprocatory motion. The extruded cord 1 passing through the guide nozzle 6 is thereby cut on both forward and backwards strokes of the reciprocatory motion of the blade.

Although only one cord of extruded propellant 1 is shown in the drawings, it will be appreciated that by mounting several of the present apparatus in parallel, a number of cords of propellant may be extruded and cut to length simultaneously.

Although the apparatus of the invention has been described above in connection with the production of propellant grains, it will be appreciated by those skilled in the art that it could equally be used in the production of food products, plastics materials, and other materials which are extruded then cut.

CLAIMS

1. An apparatus for continuously cutting an extruded cord of material comprising

a cutting blade slideably mounted along a stationary cutting plane that is perpendicular to the direction of motion of the cord,

two cutting edges disposed in a back to back relationship on the blade, each cutting edge being adapted to cut the cord along the cutting plane,

and a blade actuating means that is adapted to displace the blade in such a manner that with respect to time the position of the blade is definable graphically by means of a square wave, and that, in use, actuates the blade in such a manner that the blade cuts the cord into grains of substantially uniform length.

2. Apparatus according to claim 1 wherein the cutting blade comprises a plate of thin metal which is provided with two apertures, large in comparison to the width of the cord to be cut, said apertures being arranged in line along the direction of either cutting stroke of the blade in such positions that extrusion of the cord is not impeded at either extremity of square wave motion of the blade, the cutting edges being formed along the edges of the apertures such that each cutting edge is disposed in a back to back relationship to the other.

3. Apparatus according to either claim 1 or claim 2 wherein the cutting blade comprises thin sheet steel.

4. Apparatus according to any previous claim wherein the blade actuating means comprises

at least one piston and cylinder operated by fluid pressure, each piston being adapted to connect with the cutting blade by means of a piston rod.

5. Apparatus according to claim 4 wherein the blade actuating means comprises a single double acting piston and cylinder.

6. Apparatus according to any previous clam wherein the blade actuating means further comprises a sensor for continuously sensing the velocity of the cord through the cutting plane, and a means for automatically controlling the frequency of the cutting blade such that the frequency varies in direct proportion to the velocity sensed by the sensor.

7. Apparatus according to claim 6 wherein the means for automatically controlling the frequency of the cutting strokes of the blade comprises a processing unit adapted to receive signals from the sensor and to convert the signals into a series of pulses whose frequency is directly proportional to the velocity of the cord through the cutting plane, and a control means adapted to convert each pulse into a cutting stroke of the cutting blade via the blade actuating means.

8. Apparatus according to claim 7 wherein the processing unit is electronic.

9. Apparatus according to either claim 7 or claim 8 wherein the processing unit includes a means for manually selecting the length of the grains into which, in use, the cord is cut.

10. Apparatus according to any of claims 7 to 9 inclusive wherein the series of pulses from the processing means are electrical, and the control means is electromechanical.

11. Apparatus according to claim 10 whenever dependent on claim 4 wherein the control means comprises two or more electromagnetic valves adapted to control the flow of fluid to and from the at least one cylinder in such a manner that the cutting blade is actuated to perform a single cutting stroke for each pulse received by the valves from the processing means.

12. Apparatus according to any of claims 6 to 11 wherein the sensor comprises a freely rotatable wheel positioned adjacent the cutting plane so as to be rotated by tangential contact with the cord during extrusion, the rim of the wheel being made of a material which has a high coefficient of friction with respect to the cord, and a means for generating a constant number of electrical impulses per revolution of the wheel.

13. Apparatus according to claim 12 whenever dependent on claim 9 wherein the processing means comprises an impulse counter which is arranged by means of an adjustable timing device to emit an electrical pulses to the control means, after each preselected number of impulses counted, to actuate the blade actuating means.

14. Apparatus according to either claim 12 or claim 13 wherein the means for generating a constant number of electrical impulses per revolution of the wheel comprises one or more mirrors attached to the wheel, the mirrors being arranged so that light from each of the one or more mirrors is reflected once per revolution into a photoelectric cell.

15. Apparatus according to any of claims 12, 13 and 14 wherein the cord is directed over the wheel at an angle of between 30° and 60° to the horizontal.

16. Apparatus according to any previous claim substantially as hereinbefore described with reference to the drawings.

17. Grains whenever cut from a cord of extruded material using the apparatus according to any previous claim.

18. Grains according to claim 17 wherein the extruded material comprises a propellant.

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1983.
Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.