

Feb. 18, 1969

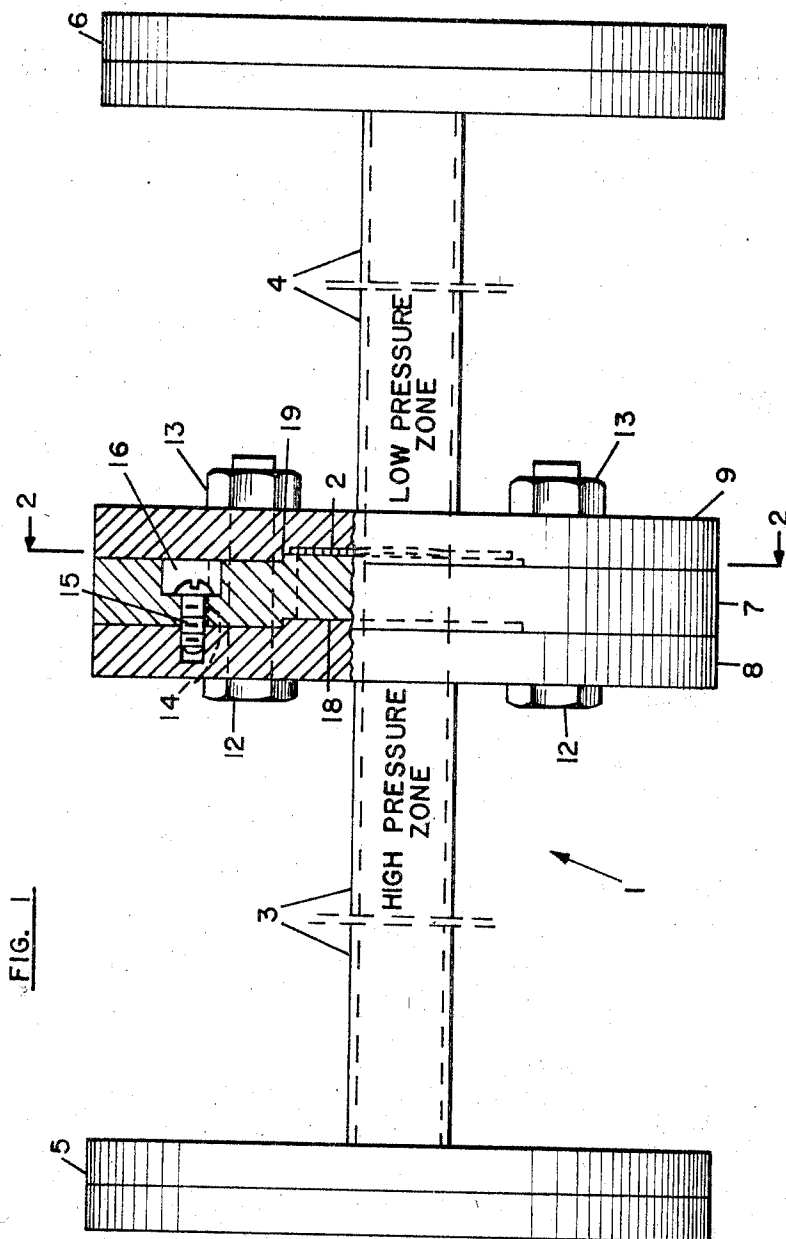
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3,428,022

DIAPHRAGM RUPTURING DEVICE

Filed Sept. 30, 1966

Sheet 1 of 3



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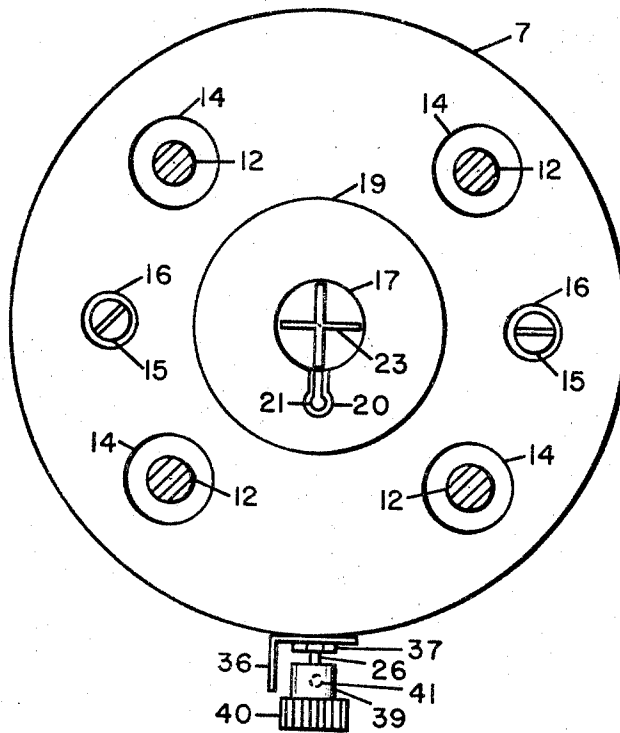


FIG. 2

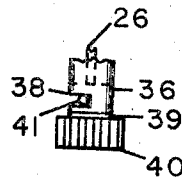


FIG. 3

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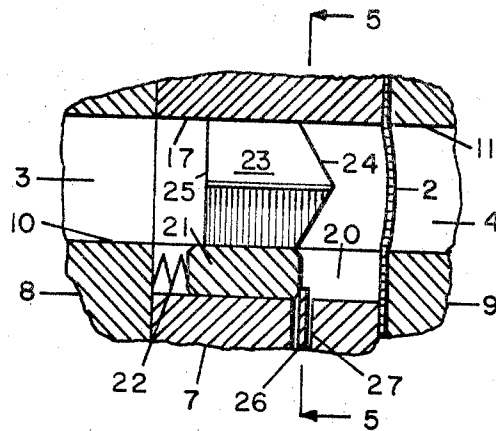


FIG. 4

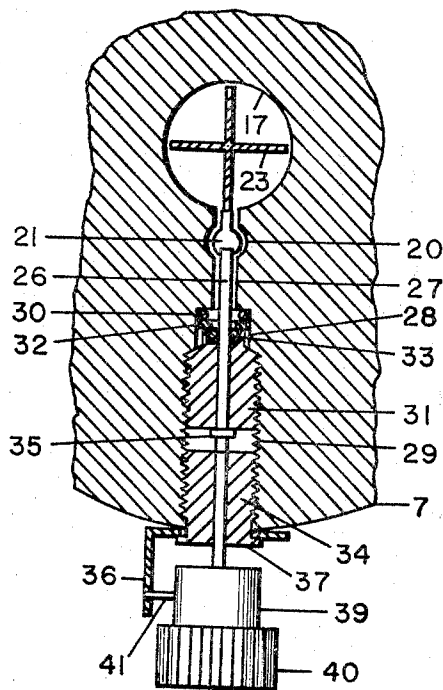


FIG. 5

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3,428,022

DIAPHRAGM RUPTURING DEVICE

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U.S. Cl. 116-137

Int. Cl. G10k 9/04

1 Claim

ABSTRACT OF THE DISCLOSURE

A manually-controlled device for rupturing a frangible diaphragm which separates two regions of different pressures, such as the two chambers of a stationary shock tube. A cutting blade is spring-biased to move toward the diaphragm, and is held away from the diaphragm by means of a locking pin which is manually releasable to allow the blade to move into contact with the diaphragm.

This invention relates to a diaphragm rupturing device, and more particularly to a device for rupturing a diaphragm separating the two chambers of a shock tube, the rupturing of such diaphragm serving to produce a shock wave in the tube.

Shock waves have utility for various purposes. For example, it has been found that the reaction conditions required for making acetylene from hydrocarbons can be met by subjecting the hydrocarbons to a shock wave. One way of producing such a shock wave is by the use of a shock tube. A diaphragm is placed in the tube defining two chambers therein, the ends of the tube being closed. Gas pressure is built up on one side of the diaphragm while the other side is evacuated and partly filled with a hydrocarbon make gas. When the pressure differential between the two chambers is sufficient, the diaphragm is ruptured mechanically. A supersonic shock wave is thereby set up as the high pressure gas expands into the low pressure gas. This wave travels along the tube at supersonic speed, setting up associated rarefaction and compression zones having associated low and high temperature areas, respectively, in the zones sufficient to cause cracking of the make gas to acetylene.

Prior devices, operable from the outside of the tube, for mechanically rupturing the diaphragm (which is sometimes made of cellophane) have generally been unsatisfactory. The device must be leak-tight, which requirement in the past has not generally been satisfied; the sealing is difficult since the seals must be capable of sealing against both subatmospheric and superatmospheric pressures. Furthermore, the device must be capable of breaking or rupturing the diaphragm at reproducible pressures; prior devices have generally been unsatisfactory in this respect, also.

An object of this invention is to provide a novel diaphragm rupturing device or cutter.

Another object is to provide a diaphragm rupturing device which satisfactorily meets the reproducibility and sealing requirements previously mentioned.

The objects of this invention are accomplished, briefly, in the following manner: A cutting blade is located within the shock tube and is mounted to travel, longitudinally of the tube, in a channel which communicates with the interior of the tube. A releasable locking means prevents movement of the blade toward the diaphragm to be cut, this locking means being sealed through the wall of the tube and being operable from the outside of the tube for unlocking the blade so that it will then travel toward the diaphragm and cut the same. The rupturing device is entirely within the vacuum or pressure system of the tube, except for the releasable locking means which comprises only a small pin.

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A detailed description of the invention follows, taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is an elevation, partly broken away, of a shock tube assembly utilizing the diaphragm rupturing device of the invention, but rotated 90° from the position the assembly would normally occupy;

FIG. 2 is a face view of the cutter device subassembly taken generally on the plane 2—2 of FIG. 1, but rotated 90° from FIG. 1 to the normal position;

FIG. 3 is a partial view, looking at the side of FIG. 2 and illustrating a detail;

FIG. 4 is a partial vertical axial section (on an enlarged scale) of the FIG. 1 assembly; and

FIG. 5 is a partial sectional view through the cutter device subassembly, taken on the line 5—5 of FIG. 4.

Referring first to FIG. 1, a shock tube, denoted generally by numeral 1, is separated by means of a diaphragm 2 into a high pressure zone (compression chamber) 3 and a low pressure zone (expansion chamber) 4. A flanged coupling 5 (shown schematically) at one end of the tube 1 provides an arrangement whereby driver gas used to generate the shock wave may be introduced into the high pressure zone 3 (via a suitable line and valve, not shown) until the desired contained pressure is obtained. A flanged coupling 6 (shown schematically) at the other end of tube 1 provides an arrangement whereby the low pressure zone 4 may be evacuated (via a suitable line and valve connected to a vacuum pump, not shown). Also, the coupling 6 may be utilized for a flow of hydrocarbon (driven) gas or mixture into the zone 4 (via a suitable line and valve, not shown) until the desired pressure is obtained in the low pressure zone. Usually, the pressure in compression chamber 3 is considerably greater than that in the expansion chamber 4.

The diaphragm 2 is ruptured or broken mechanically by the cutting device which is the subject of this invention and which will be described hereinafter in detail. On rupturing of this diaphragm, the gas in the zone 3 starts expanding into the zone 4. A centered rarefaction wave travels from the diaphragm location back into the zone 3 at sonic speed toward the opposite end of this zone, where it is reflected. The gas expanding through this rarefaction wave is cooled adiabatically and is accelerated to supersonic speed. The cooled gas expanding into the expansion chamber 4 adiabatically compresses the gas originally in this chamber, heats it, and imparts to it a velocity equal to its own. When this compression wave generated in the low pressure gas is traveling at a supersonic speed relative to that gas, a shock wave is formed. As the shock wave travels through the expansion chamber 4, it heats up the hydrocarbon molecules. Additional high temperatures are attained at the "outlet" end of the expansion zone. At this point the shock wave is reflected, causing a recompression of the end gases. These gases are then cooled by the reflected rarefaction wave, as well as by the on-rushing expanding gases. The product gases are then removed through another line and valve (not shown) associated with the coupling 6.

The foregoing comprises a somewhat generalized description of the operation of a shock tube; the construction and operation of the diaphragm rupturing device of this invention (which is utilized to rupture the diaphragm 2 at the desired instant) will now be described.

The cutter device subassembly of the invention is carried by and mounted in a cylindrical block 7 which may be sandwiched between two mounting flanges 8 and 9 carried respectively by the compression chamber 3 and by the expansion chamber 4. It may be noted that mounting flange 8 is secured and sealed to that end of compression chamber 3 opposite to flanged coupling 5, and also that mounting flange 9 is secured and sealed to that end of expansion chamber 4 opposite to flanged coupling

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6; if the cylindrical block 7 were not utilized, the flanges 8 and 9 would be directly coupled together in face-to-face relation to provide the shock tube. The flange 8 has a central axial bore 10 therein (see FIG. 4) which is of the same diameter as the bore of chamber 3, is aligned with this bore, and which forms a part of such chamber; similarly, the flange 9 has a central axial bore 11 therein which is of the same diameter as the bore of chamber 4, is aligned with such bore, and which forms a part of such latter chamber.

Flanges 8 and 9 are fastened together, with mounting block 7 sandwiched therebetween, by means of a plurality of bolts 12 (see FIG. 2) on which are threaded nuts 13; the bolts 12 pass through clearance holes in flanges 8 and 9 and through large-diameter clearance holes 14 in block 7. Block 7 is fastened securely to flange 8 by means of a pair of diametrically-opposite machine screws 15 which pass through clearance holes in block 7 and thread into tapped bottomed holes in the right-hand face of flange 8. Thus, when nuts 13 are unscrewed to separate flange 9 from block 7 (e.g., when the diaphragm 2 needs to be replaced), block 7 will remain secured to flange 8. Counterbores 16 are provided in that face of block 7 which is adjacent flange 9, these counterbores being concentric with the clearance holes in block 7 utilized for screws 15.

Block 7 has a central axial bore 17 therein which is of the same diameter as bores 10 and 11, is aligned with these latter bores, and which forms a part of chamber 3. When block 7 is sandwiched between flanges 8 and 9, the left-hand circular face of block 7 contacts the right-hand face of flange 8, and the right-hand circular face of block 7 contacts the left-hand face of flange 9. The left-hand face of block 7 has therein a central recess (the diameter of which is greater than the diameter of bore 17) which is designed to receive (when items 7 and 8 are assembled together) an upstanding central boss 18 formed on the right-hand face of flange 8. The right-hand face of block 7 has formed thereon an upstanding central boss 19 (the diameter of which is equal to the diameter of boss 18) which (when items 7 and 9 are assembled together) fits into a central recess provided in the left-hand face of flange 9. When block 7 is omitted for some reason, it may be seen that the boss 18 on flange 8 will fit into the central recess of flange 9.

The circular diaphragm 2 (which is to be ruptured in order to develop the shock wave) is clamped between the right-hand face (boss 19) of block 7 and the left-hand face of flange 9. For sealing purposes, an O-ring (not shown), mounted in a groove provided in the right-hand face of block 7, may be utilized between block 7 and diaphragm 2. This O-ring has a diameter greater than that of bore 17 but less than that of boss 19, so that the O-ring groove is located in the face of boss 19. The diameter of the diaphragm 2 (which is sometimes made of cellophane, but is frequently made of other materials, e.g., Mylar) may be slightly less than that of boss 19, as illustrated in FIG. 1. Diaphragm 2, of course, extends across bore 17 and when imperforate seals off and separates chamber 3 from chamber 4.

A track or channel 20, having a shape in cross-section resembling an inverted keyhole, is cut into the block 7, the top side of this channel opening into the bottom side of bore 17. Channel 20 extends parallel to the axis of bore 17 (and thus parallel to the axis of the shock tube) and extends throughout the entire axial length of block 7; channel 20 is of course on the high pressure side of diaphragm 2 since, as previously stated, bore 17 forms a part of the high pressure zone 3. An elongated blade supporting member 21, having a cross-sectional shape matching that of channel 20, is mounted for free sliding movement in channel 20 in a direction lengthwise of the channel and parallel to the axis of bore 17 and of the shock tube, the upper substantially planar face of member 21 being approximately tangent to bore 17 at the lowest point

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thereof. One end of a compression spring 22 bears against the right-hand face of flange 8 and the other end of this spring bears against the left-hand end of member 21; thus, spring 22 biases member 21 to move toward the right (in FIG. 4), within channel 20.

A cutting blade 23, in the form of a cross T shaped to a point at its right-hand end, is positioned within bore 17, the lower edge of the vertical component of the T being rigidly connected to the upper substantially planar face of member 21 (see FIGS. 4 and 5), so that the blade 23 moves with member 21. The axis of member 21 is parallel to the axis of blade 23, and the blade lies entirely within bore 17. The leading edge 24 of blade 23, and also the trailing edge 25 of this blade, are sharpened to reduce turbulence (in this connection, it will be realized that the blade 23 is positioned in the path of the gas flow through the shock tube). The channel 20, as previously mentioned, extends through the entire axial length of block 7; channel 20 has a length sufficient to accommodate therein the spring 22 and the member 21 (to which blade 23 is attached), plus a short travel distance from the right-hand end of member 21 to the left-hand face of flange 9 (which immediately adjoins diaphragm 2).

In FIG. 2 the rupturing device is illustrated in its released position i.e., with member 21 all the way to the front in channel 20.

For use, the spring 22 is fully compressed by pushing back the member 21 with the cutting blade attached thereto. A releasable locking means, which will now be described, is utilized to lock the blade in this position, thus preventing the movement of the blade 23 toward diaphragm 2 until it is desired to trigger the device. (It may be seen that the pointed end of blade 23 faces the diaphragm 2, as illustrated in FIG. 4.)

A triggering pin 26, whose axis is perpendicular to the axis of bore 17 (and of the shock tube) and to the axis of channel 20, extends into the bottom of channel 20 a distance just sufficient to engage the front or right-hand end of member 21 (when the latter has been pushed back in channel 20 as far as possible) and thus to hold this member back, i.e., to the left in FIG. 4, or away from the diaphragm 2. Pin 26 is sealed through the cylindrical wall of block 7 in a leak-tight manner (as will be described), and is operable from without this block, from a position below the block. The triggering pin is not illustrated in FIG. 1 since, as previously stated, in this figure the assembly has been rotated through 90° about the shock tube axis, and thus the pin would be hidden on the far side of the tube in this figure.

Triggering pin 26 passes through a hole 27 which extends in a radial direction from the outside of block 7 into the bottom of channel 20. Below channel 20, hole 27 is enlarged in diameter as at 28, and the radially-outer (lowermost) end of the larger-diameter hole is internally threaded at 29. An O-ring 30 seats against the shoulder formed at the upper end of the larger-diameter hole 28, to provide a seal for threads 29. This O-ring is held in position by means of a gland member 31 which screws into threads 29; gland member 31 carries at its upper end an integral annular pressure ring which pushes against the lower face of a spacer 32 whose upper face engages the lower side of O-ring 30. Gland member 31 also has at its upper end a recess in which an O-ring 33 is positioned. O-ring 33 provides a seal around pin 26. O-ring 30 and 33 are made of a silicone rubber, and pin 26 is lubricated with a special grease made for high vacuum work; thus, the pin is sealed in a leak-tight manner into channel 20, from outside the block 7.

Radially outwardly of gland 31, pin 26 passes freely through an outer bushing 34 which screws into threads 29. A surrounding collar 35 is firmly secured (as by welding) to pin 26, to serve as a stop member. When the triggering pin 26 is pulled radially outwardly (i.e., downwardly) to release the supporting member 21 (and the cutting blade 23) from its locked position, thereby to

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rupture the diaphragm 2, the collar 35 eventually comes into engagement with the upper end of the fixed bushing 34, thereby preventing further movement downwardly of the triggering pin. In this way, the downward travel of pin 26 is limited by stop member 35, to prevent accidental removal of the pin when rupturing the diaphragm. The collar 35 is adapted to come into engagement with the lower end of gland 31 (it is illustrated in this position in FIG. 5) to limit the upward (or inward) movement of the pin 26.

To prevent premature triggering of the device (by movement of the triggering pin downwardly), a slotted locking bracket 36 is utilized. One leg of this L-shaped bracket is secured to the outer cylindrical wall of block 7 by means of threaded bushing 34, whose head 37 clamps bracket 36 against block 7. The downwardly-extending leg of bracket 36 has therein, near the lower end thereof, a horizontally-extending slot 38 (see FIG. 3) which opens into one side of the bracket. A knob, having a smooth-sided cylindrical upper portion 39 and a lower knurled cylindrical portion 40, is secured to the lower end of triggering pin 26. A horizontally-extending short pin 41 is rigidly attached to upper knob portion 39 and extends laterally outwardly from the cylindrical outer wall thereof. Pin 41 is adapted to enter the slot 38 in bracket 36, when knob 40 is rotated about a vertical axis. Once pin 41 is in this slot, the triggering pin 26 cannot be moved either upwardly or downwardly until knob 40 is first rotated to disengage pin 41 from slot 38. Thus, inadvertent movement of the triggering pin, either upwardly or downwardly, is obviated.

Since (as previously stated) FIG. 2 illustrates the device in its released position, in this figure the pin 41 is shown out of engagement with bracket 36.

To operate the diaphragm rupturing device (diaphragm cutter) of this invention (assuming that flange 9 has been separated from block 7), the compression spring 22 is first inserted in the cylindrical portion of channel 20 from the front or right-hand side of block 7. Next, the cutting blade-supporting member combination 23, 21 is inserted into channel 20 and pressed against spring 22, forcing the blade just far enough back to permit the triggering pin 26 to come up through the bottom of channel 20 and lock the blade back. Then, the diaphragm 2 is inserted between the block 7 and flange 9 and the flanges are tightened, using nuts 13. Following this, the desired experimental conditions, such as pressures and temperatures of driver and driven gases are set. Finally, the triggering pin 26 is pulled rapidly downwardly (by means of knob 40) to withdraw it from the channel 20, out of the path of member 21. This releases the spring-loaded cutting blade 23 so that it snaps forwardly or to the right in FIG. 4 (as guided by member 21 sliding in track 20), breaking or rupturing the diaphragm 2 as the result of the cutting blade coming into contact with the diaphragm.

If desired, the diaphragm rupturing device of this invention may be operated electrically, by mechanically connecting the triggering pin 26 to the plunger of a solenoid.

It should be apparent, from the foregoing description, that the structure of the diaphragm rupturing device of this invention is entirely positioned within the vacuum-

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pressure system, except for the small triggering pin 26, which latter may be easily sealed through the surrounding wall. Thus, sealing difficulties are substantially eliminated.

It has been stated previously that the diaphragm rupturing device is on the high pressure side of the diaphragm; thus, of course, it must be capable of sealing against superatmospheric pressures. However, it must be capable of sealing against subatmospheric pressures, also; the reason for this latter requirement will now be explained. In order to get reproducible results, the driver gas composition must be known. The only way to accomplish this is to first evacuate the driver (high pressure) side of the diaphragm, before adding the driver gas; this evacuation assures one that the only gas in the driver section is the gas which is thereafter intentionally added. During the evacuation, the seal must be maintained.

The invention claimed is:

1. In combination, a tubular member constituting a shock tube having therein a longitudinal bore of substantially uniform diameter, a rupturable partition mounted transversely across said bore to separate said bore into first and second chambers, a longitudinal channel formed within the wall of said member outside the diameter of said bore, said channel forming a common opening with said bore and contiguous with said partition; a cutting blade in said bore, a supporting member for said blade mounted for sliding movement in said channel, the active portion of said blade being directed towards said partition, said blade being adapted to move into contact with said partition, biasing means in said channel operatively associated with said supporting member biasing said supporting member to move said blade into rupturable contact with said partition, a transverse opening in said member communicating with said channel, a retractable pin positioned in said opening and extending into said channel to partially obstruct said channel thereby to prevent movement of said blade towards said partition and means associated with said pin and manually operable from outside said member for withdrawing said pin from said channel thereby to permit said blade to move into and rupture said partition.

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