ELECTRICALLY POWERED SEPARATION DEVICES

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ABSTRACT

Traditionally over the past 50 years, space mechanisms have been powered by pyrotechniques (Pyro). Pyro powered mechanisms provide the greatest power to weight ratio of all types of mechanisms. Hi Shear Technology Corporation, a major supplier of Pyro Powered Devices, has developed two new electrically powered separation devices, a separation nut, and a cable release device.

Advantages of Electrically Powered Separation Devices

Hi Shear's Electrically powered separation devices have advantages over pyro powered devices, some of which are:

1.) **Resettable**
Hi Shear's electrically powered separation devices are resettable for up 25 times (tested 50 times) with out disassembly or refurbishment.

2.) **No Pyro**
Hi Shears electrically powered separation devices have no pyro that provides the following advantages:

- No special explosive handling or storage.

- No stray voltage or bridgewire resistance tests required.

- May be installed at any time on the vehicle assembly line.

- No special access covers required for electrical tests.

- No pyro shock.

3.) **No Out-gassing**
Hi-Shear's design does not depend on elastromeric seals to prevent liquid or gaseous emissions.

4.) **Ultra-Low Shock**
Hi-Shear's electrically powered separation nut produces only 1.0 percent of the shock energy of a pyro separation nut. The release of bolt preload, which is the greatest contributor to shock, is slowly performed through a helix. Pyro shock has been eliminated since there is no pyro.

5.) **Easy Usable Power**
Hi-Shear's electrically, powered separation nut uses only 15 watts at 28 VDC of power and does not require special firing circuits (PIC, etc).

The Hi-Shear electrically powered separation devices provide reliable separation systems using mature release technology.

1. HI-SHEAR SEPARATION NUT BASICS

Hi-Shear has been designing and producing separation nuts since the 1964. All of these separation nuts use the same basic bolt release system. *Fig. 1* shows the functioning of the basic bolt release system.

Fig. 1a shows the bolt release system in the pre-actuation condition. Three or four threaded segments are held radially together by a load ring or collar. The segments are seated on a base keyseat that prevents the segments from rotating during bolt torquing. The seating plane between the segments and the base keyseat is at a slight angle to provide outward radial loading during bolt loading and post actuation. An extractor provides force to help extract the bolt and hold the segments in a release position after actuation. The bolt is torqued to a preload value that provides an outward radial load on the segments that are restricted by the load ring or collar.

Fig. 1b shows the bolt release system during actuation. The load ring or collar is moved up by gas pressure or spring. The threaded segments are no longer restricted by the load ring or collar, move out, releasing the bolt. The bolt is extracted by a combination of force from the extractor and the preload. With some applications, an

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external spring loaded extractor may be required for a positive complete extraction.

This basic bolt release system, used in all of Hi-Shear's separation nuts, provides a forty year pedigree to the new electrically powered devices.

2. SHOCK PRODUCED BY SEPARATION NUTS

The shock produced by Hi-Shear separation nuts is due to several different factors. Not all of these factors are present in all designs.

2.1 Pyro Shock

Pyro shock is produced by the rapid burning of the pyrotechnic in the initiator with its associated rapid pressure increase. In pyro actuated separation nuts, pyro shock provides approximately 10 percent of the shock output. In electrically powered separation nuts, there are no initiators and therefore, no pyro shock.

2.2 Bolt Strain Energy Release

This shock is produced by the rapid release of the preloaded bolt strain. In the standard pyro actuated separation nut, this shock accounts for approximately 60 percent of the shock output. This shock is greatly reduced in Hi-Shear's Ultra Low Shock Pyro and Electrically Powered separation nuts by the slow release of the strain energy.

2.3 Mechanical Impact

Mechanical impact shock is produced by the collision of parts in the nut during actuation. This shock accounts for approximately 30 percent of the shock output in standard pyro actuated separation nuts. The electrically powered nut's release is slow, therefore low impact collision of internal parts.

Fig. 2 shows the shock output of the electrically powered separation nut. The electrically powered separation nut shock energy output is only 1.0 percent of the standard pyro actuated nut.

3. HI-SHEARS ELECTRICALLY POWERED SEPARATION NUT

The electrically powered separation nut is shown in *Fig. 3.* The reset tool is used only at the time of installation and is removed after the bolt is torqued to the preload value. The leads come from the release motor that requires 28 VDC at 15 watts to actuate the nut.

Fig. 4 shows the cross section of the nut in the fastened position without the bolt torqued. The installation tool is temporarily holding the spring loaded locking ring in place. *Fig.5* shows that when the bolt is torqued, the radial force on segments holds the locking ring in place and then the installation tool is removed.

Fig. 6, Fig. 7 and *Fig. 8* show the cam release assembly. In the locked position, the cam ring is forcing the rollers through the slots in the outer helical ramp into the pockets in the inner helical ramp. When the cam ring is allowed to rotate counter clockwise by the motor, the radial force on the rollers rotates the cam ring, releasing the rollers from the pockets in the inner helical ramp. This allows the inner helical ramp to screw down in the outer helical ramp, releasing the strain load on the bolt as shown in *Fig. 9.* With the bolt load released, the radial force on the segments is removed and the wave spring lifts the locking ring off of the segments. The segments are driven outward, releasing the bolt. A bolt extractor is required to reliably separate the bolt from the nut.

4. ELECTRICALLY POWERED CABLE RELEASE

The electrically powered cable release is shown in *Fig. 10* and *Fig. 11.* The cable release is acquired through a motor driven ball lock mechanism and a spring loaded cable retractor. Three lock balls and the motor driven cam ring hold the cable ferrule. To function, the motor rotates the cam ring allowing the balls to expand out, releasing the cable ferrule. The cable extractor pulls the cable and ferrule out of the release mechanism.

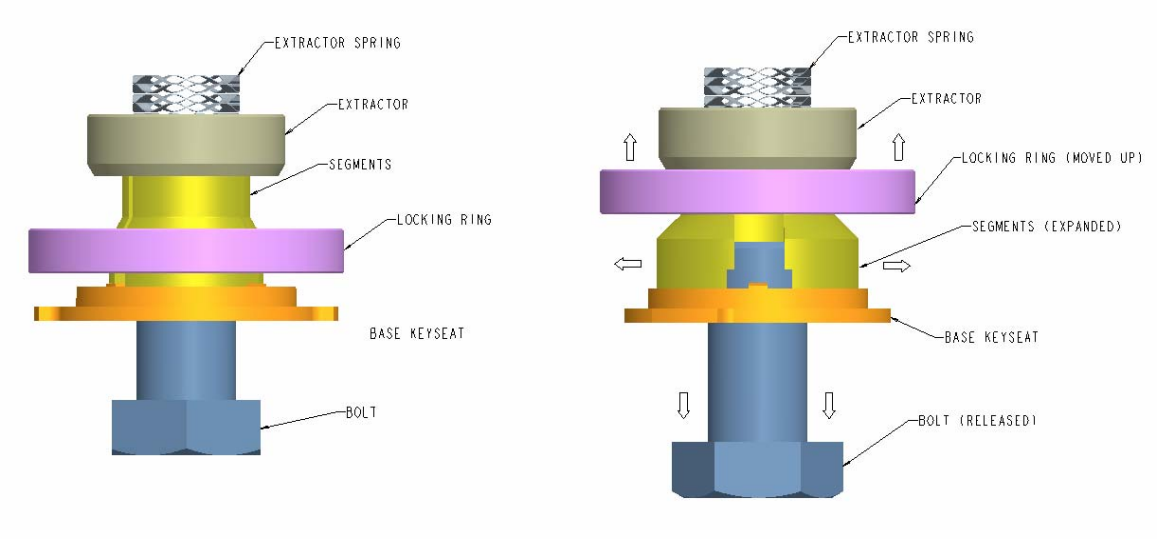


Figure 1a. Before Actuation *Figure 1b. After Actuation*

Figure 1. Hi-Shear's basic bolt release system

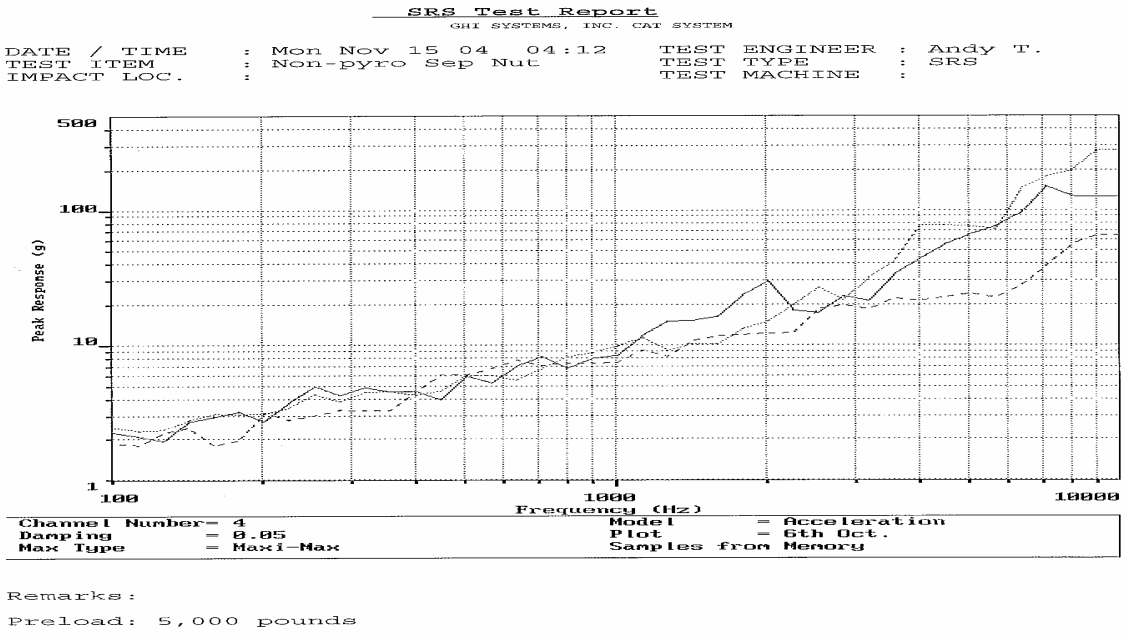


Figure 2. Bolt Release Shock Output

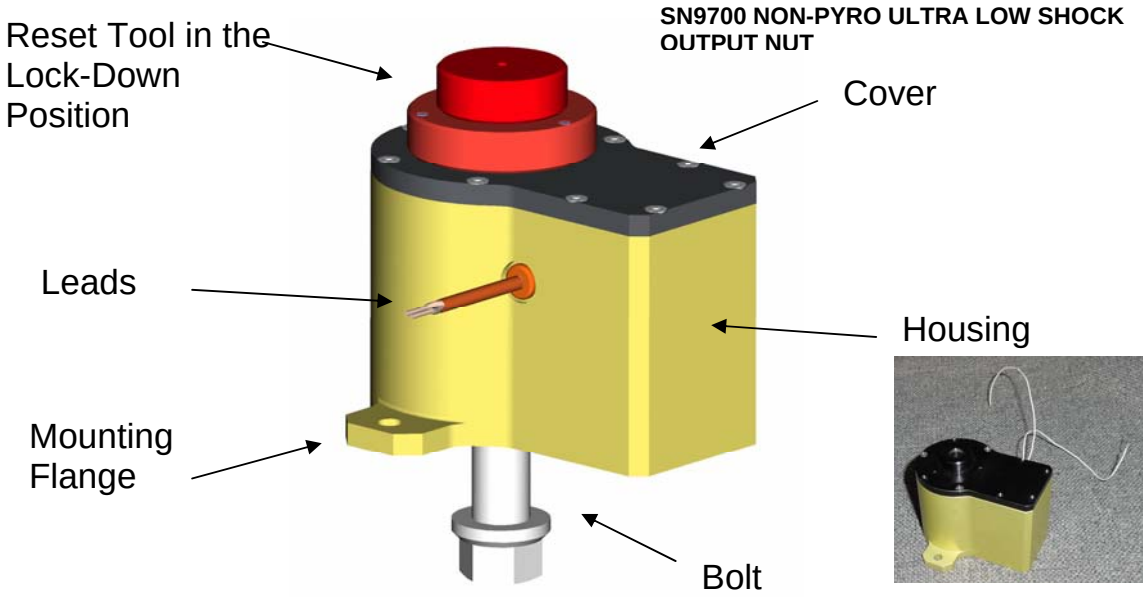


Figure 3. SN9700 Series Electrical Powered Separation Nut

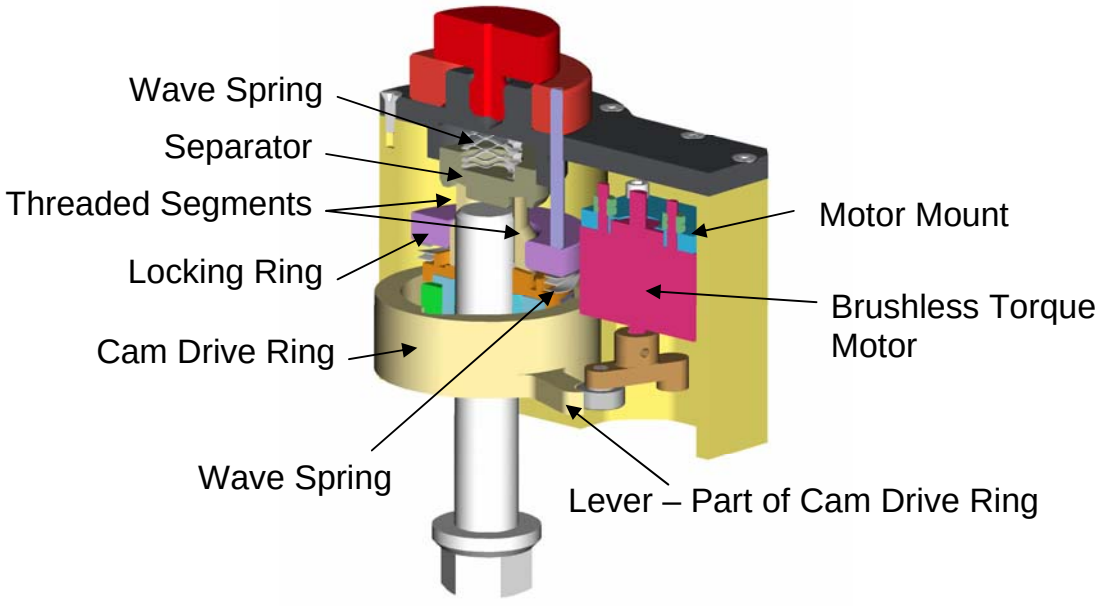
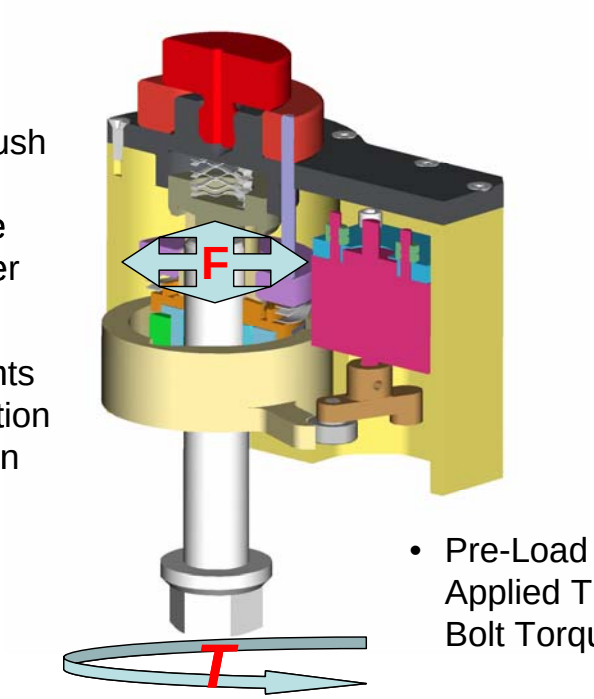


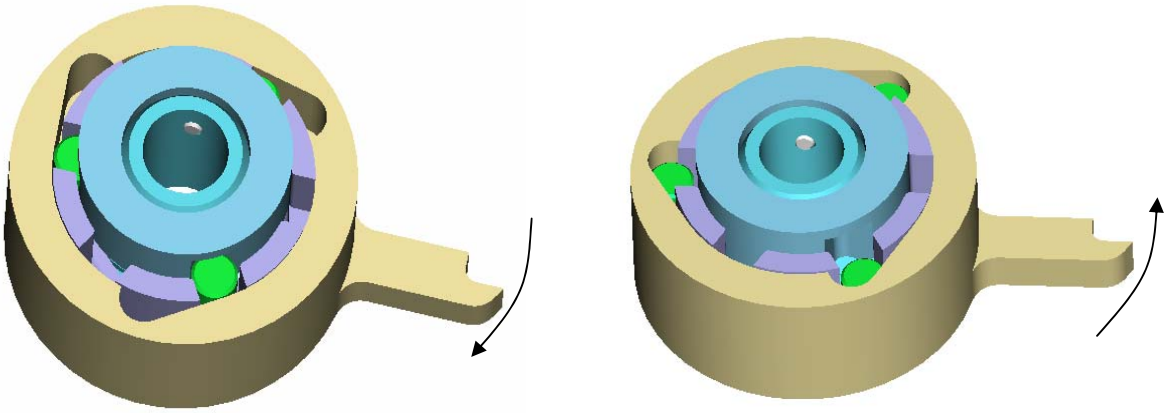
Figure 4. SN9700 Series Cross Sectional View "Fastened Position"

- Normal Forces Push the Segments Outward, onto the Locking Ring Inner Surface
- Ring and Segments are held into position by Surface Friction Forces



- Pre-Load is Applied Through Bolt Torque

Figure 5. Torque Application to Generate Fastener Locking Mechanism



Rollers in Locked Position

Rollers in Unlocked Position

Figure 6. Cam Assembly Release Mechanism

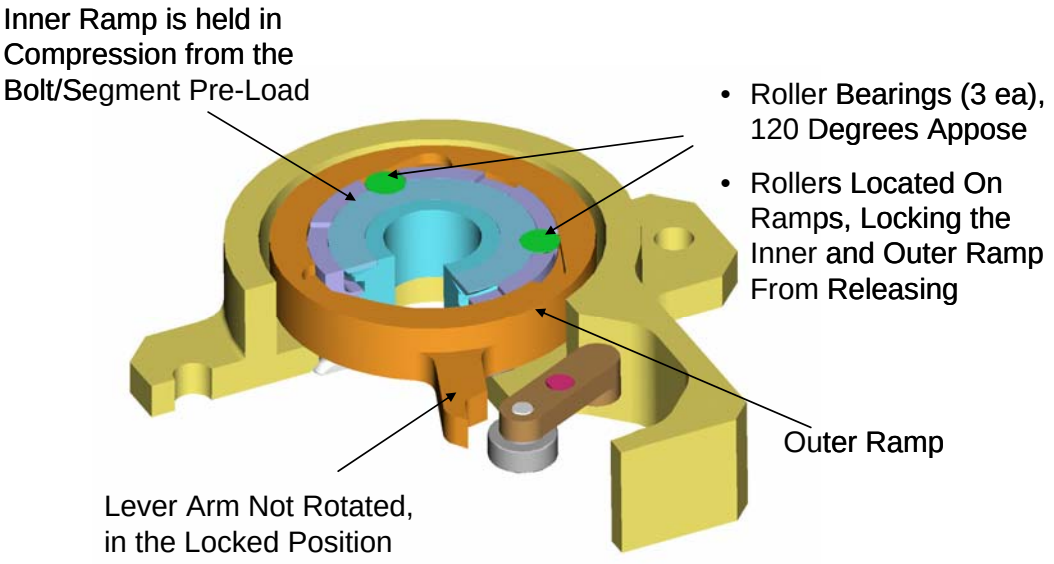


Figure 7. Cam Assembly in the Locked Position

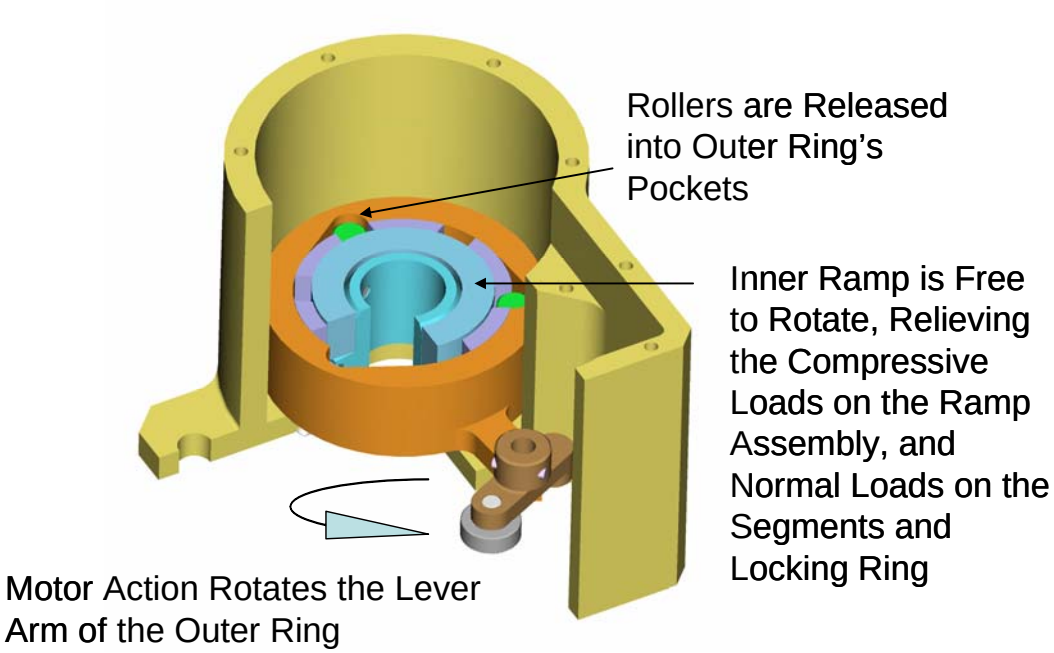


Figure 8. Cam Assembly in the Released Position

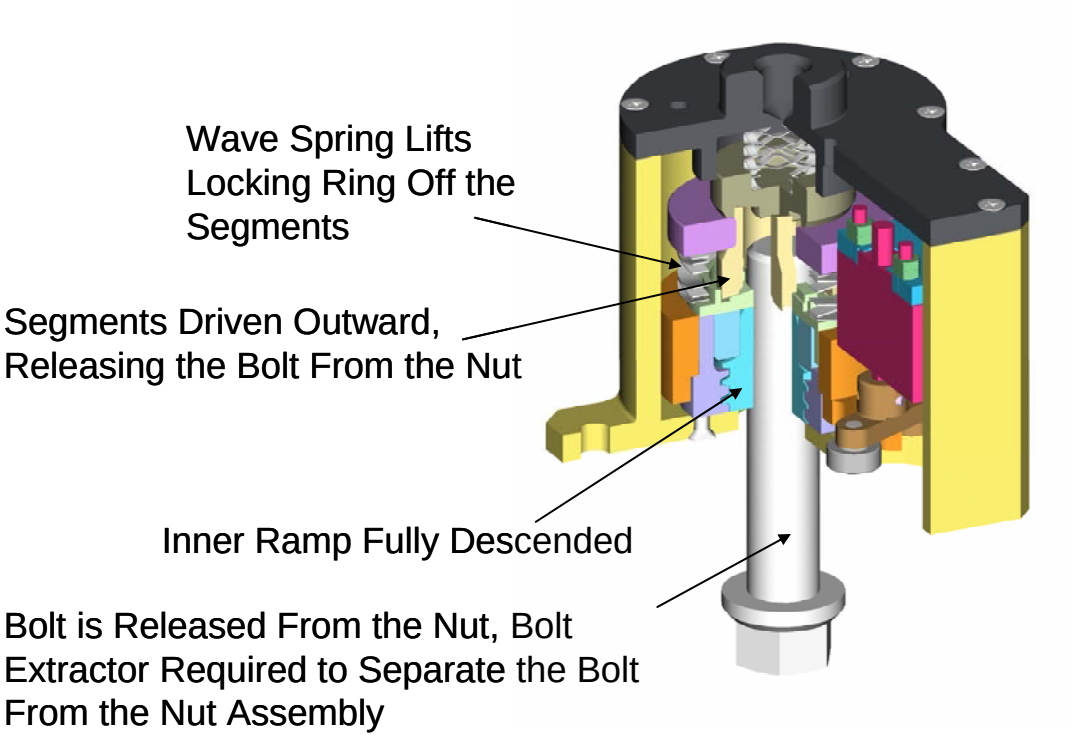


Figure 9. Cross Section SN9700 in the Actuated Position

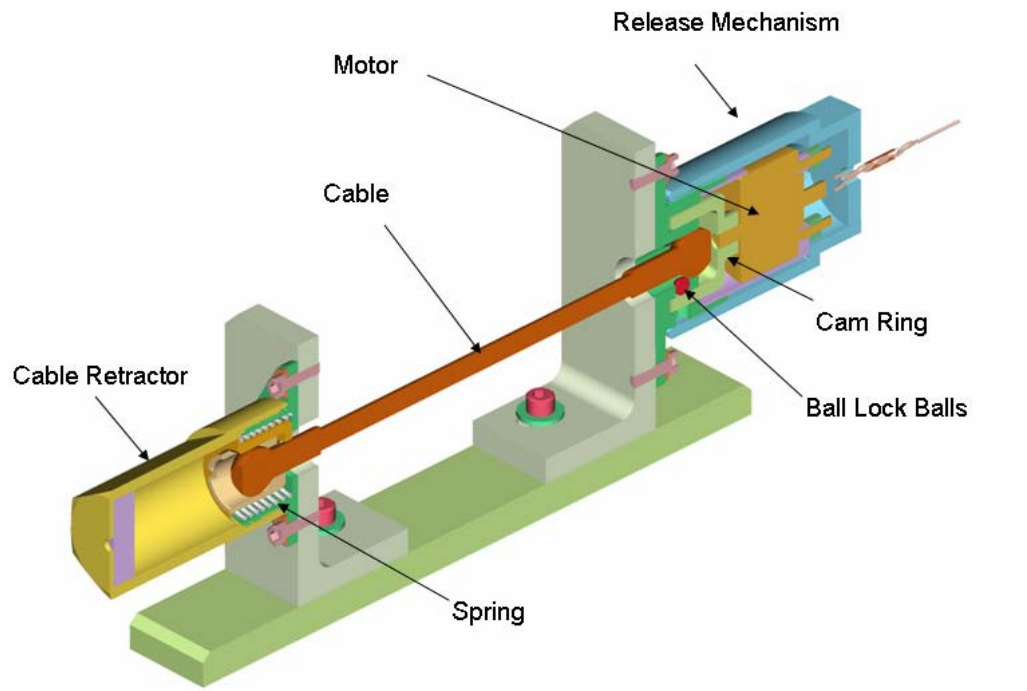


Figure 10. Electrically Powered Cable Release Cross Section

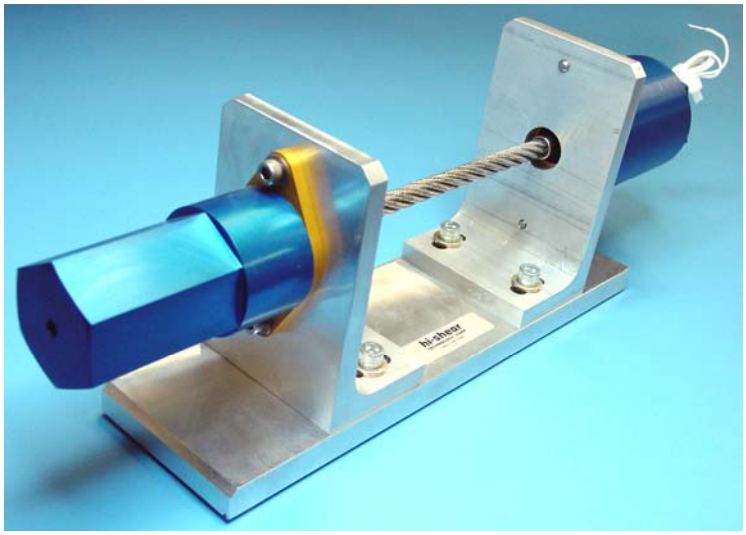


Figure 11. Electrically Powered Cable Release