

HATCH LATCH MECHANISM FOR SPACELAB SCIENTIFIC AIRLOCK

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ABSTRACT

This paper describes the requirements, design trade-off, design and performance of the Spacelab scientific airlock hatch latching mechanisms.

At space side the hatch is closed and holded against internal airlock/module pressure by 12 tangential overcentre hooks driven by a drivering. At module side the hatch is holded by 4 hooks driven by rollers running on a cammed drivering. Both mechanisms behaved well in tests.

INTRODUCTION

The Spacelab Scientific Airlock (see fig. 1) will be mounted in the top of the Spacelab module as shown in figure 2. The main parts forming the airlock are:

- A 1 meter diameter and 1 meter long cylindrical shell with sealing and mounting flange
- A flat hatch on space side (Outer Hatch) with conical sealing flange, hinging as shown in fig. 2.
- A completely removable flat hatch on module side (Inner Hatch) with a flat sealing flange.
- A latticed table consisting of 3 parts moving an experiment upto 150 kg either into space or into the module. The airlock provides power and data lines to the experiment.
- Manually operated mechanical controls to move, latch, lock and interlock the various mechanisms
- Housekeeping, signals, heating, etc.

Most of above parts are rather specific for this airlock. Therefore only the more general latch mechanism for both the inner and outer hatch will be described here.

OUTER HATCH LATCHING MECHANISM

REQUIREMENTS

The main requirements which had to be fulfilled for the outer hatch latching mechanism are:

- Latching and holding of outer hatch against pressures up to 1.1. bar as limit and 2.2 bar as ultimate
- Allowable leakage over seal < 1 gram/day
- No drive failure allowed when 400 N is applied on the drive handle at any jam of the system
- Unlatching has to be performed with only 1 operation

DESIGN TRADE-OFF

To meet above requirements several design solutions have been studied. Mechanisms compressing an O-seal represent state of the art techniques, with hardly any need for qualification. However, due to the high forces needed to compress the seal, and maintain the seal compression against the airlock pressure, the mechanisms will be relatively heavy and high transmission ratios will be needed. This especially results in jamming behind the transmission becoming a considerable design case, furthermore, the feeling for a jam is negligible which might cause undesired damage. When different types of seals are used qualification of the seals is deemed to be necessary with a relatively high development risk. Sliding of the hatch over a compressed seal is impossible without a separate mechanism because of the long moment arms involved and undesirable because of increased wear.

Table 1 shows the different mechanisms studied and a summary of the main advantages and disadvantages. The tangential hook design was chosen for the outer hatch latch mechanism because of its straight forward and state of the art sealing technique,

but also its flexibility for thermal and mechanical distortions and the possibility for opening the outer hatch at relative high pressure differences.

DESCRIPTION OF CHOSEN DESIGN

The latch mechanism consists of 12 latches on overcentre cranks driven via pushrods by a drive ring at the bottom of the airlock flange as shown in fig. 3. The drivering is activated by a manually operated handle at module side driving a pinion running on a rack on the drivering. Wrong operations are prevented by interlocks. The hooks catch directly onto spherical bearings attached to the hatch. The seal flange is 60° conical to keep vertical seal compression forces and variations in gap size as low as possible. The outer hatch is guided by guidepins and leveled by spring-loaded seats just above seal contact to provide proper hatch alignment. To allow for misalignments up to 1 mm in lateral directions the hooks are supported in teflon lined spherical bearings, and stabilized by two springs pushing the hook towards the hatch grippoint. During latching the latch hooks rotate forward until they touch the ball bearings on the outer hatch and then they pull the hatch downward until nominally 2 mm overcentring in the cranks is reached. At pressurization overcentring can increase until the hooks reach their individual stops in the hook brackets. Therefore the drivering position is not very critical and ample clearances can be allowed. such preventing jamming cases. Overloading of the mechanism inherent to overcentring devices is prevented by the curved shape of the hooks.

TEST RESULTS

During tests the mechanism behaved well. The characteristic force curve at the handle is shown in fig. 4. The peak value depends on seal hardness and system adjustments; at nominal adjustment and a seal hardness of 75 shore a 100 N handle load was measured

The only disadvantage of the current system is the fact that jamming behind the transmission can hardly be felt on the handle with the risk of causing damage. Leakage was always found to be far within the 1 gram/day requirement, even with 1 hook failed. With 2 mating hooks failed an intermittent bleed-off at 600 millibars was found. Furthermore it was shown that the outer hatch can even be opened at 100 mBar

pressure difference without any chance for personnel injury, which reduces venting times tremendously. In practice opening will be allowed at about 30 mBar.

INNER HATCH LATCHING MECHANISMS

REQUIREMENTS

The main requirements which are applicable to the inner hatch latching mechanism are:

- Keeping the inner hatch in place and providing initial sealing against shell until module pressure seals the hatch firmly against seal and shell flange when the airlock is evacuated.
- Keeping inner hatch in place at repressurization, but allowing bleed-off when pressure difference airlock/module exceeds 30 mBar and preventing a pressure difference above 80 mBar at maximum supply (5 grams/sec).
- At release under zero G the latches shall free the hatch without the possibility that the hatch starts flying around.
- At release under 1G conditions the latches shall retain the 18 kg hatch
- Release shall be effected by a single operation

DESIGN TRADE-OFF

To obtain initial sealing at least 4 hooks are required to keep the hatch edge member within reasonable dimensions. A single release operation can only be obtained when the 4 hooks are interconnected by a drive ring. Because of the relative low loads required during latching a cam roller design was chosen because of its simplicity and resulting low mass.

DESIGN DESCRIPTION

Fig. 5 shows the current design for the latch mechanism. The hooks have a roller, fitting in the hatch rim and enabling mounting of the hatch in every rotational position. The rollers which are running, springloaded downwards, on a cam of the drivering, move the hooks up and down. The hooks are guided by the two side-walls of the brackets and two guiding pins in a slot on the hooks. During release the hooks move downwards on the cam until the guide pins touch the end of slot, which starts rotation of the hooks away from the hatch. However, under 1 g conditions the hatch mass keeps the hookroller in the rim until the hatch is slightly lifted. In space the hooks only rotate so far away that some force is needed to pull the hatch out of the hookrollers. The best method of replacing the hatch is to push the hatch through the rollers onto its seat. Under 1g conditions the hatch has to be hooked in into the rollers to avoid drop down. When latching, the hooks first move inwards and then upwards, giving enough pretension in the seal to obtain initial sealing.

The tubular drivering, running all the way around the cylinder and supported by rollers, is driven by a crank handle system. Its rotational accuracy is kept to a minimum by a flat upper surface of the cam. Overloading of the system is prevented by the curved shape of the hook.

TEST RESULTS

During tests the mechanism behaved well. However, on some points minor deviations were found:

- At airlock overpressure bleed off via the hatch sealing did not occur at the required 30 mBar but already at 20 mBar. It seemed possible to meet the 30 mBar requirement by change of adjustments, however, then the required handle forces became too high.
- When, under 1g conditions, release is performed too quickly, the hatch might drop down due to slight sticking effects of the hatch to the seal, which allow the hooks to swing out during the unlatching operation
- Sometimes the hookrollers remained at the edge of the rim of the hatch, which might cause high hookstresses when the airlock has some overpressure.

CONCLUSIONS

Both latching mechanisms described here were tested on detail models and recently on the first airlock model. Their functioning has proven to fulfill the requirements. In a few months time qualification of the mechanisms will be performed on the airlock qualification model.

REFERENCE

"Functional description of Scientific Airlock"
Spacelab Program Technical Report TN-FO-11-063-77 d.d.
19-09-77
Authors : Benes/ter Haar/Setz
Some copies will be available during the presentation.

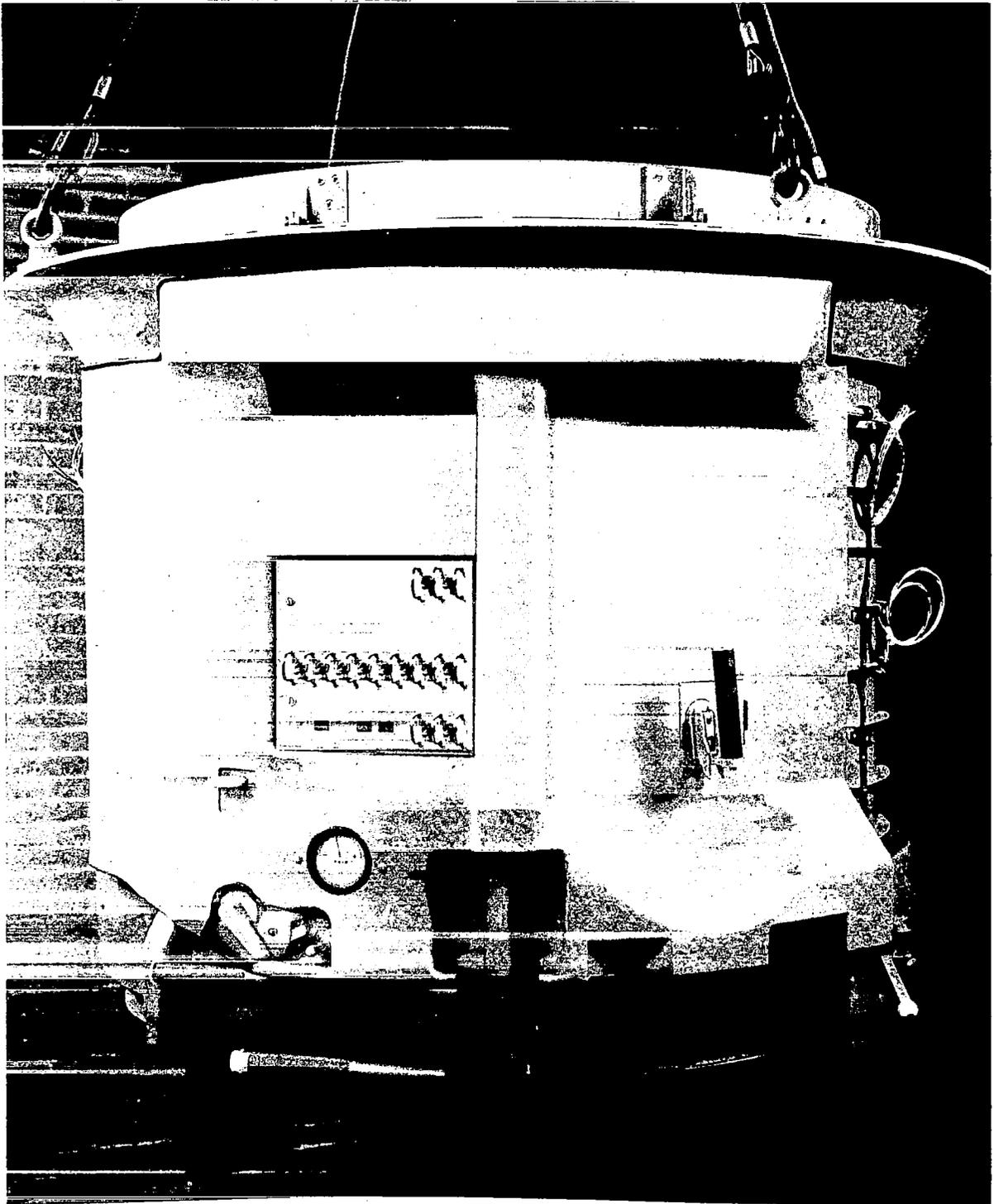


Fig. 1. Hard Mock-up model of Spacelab Scientific Airlock

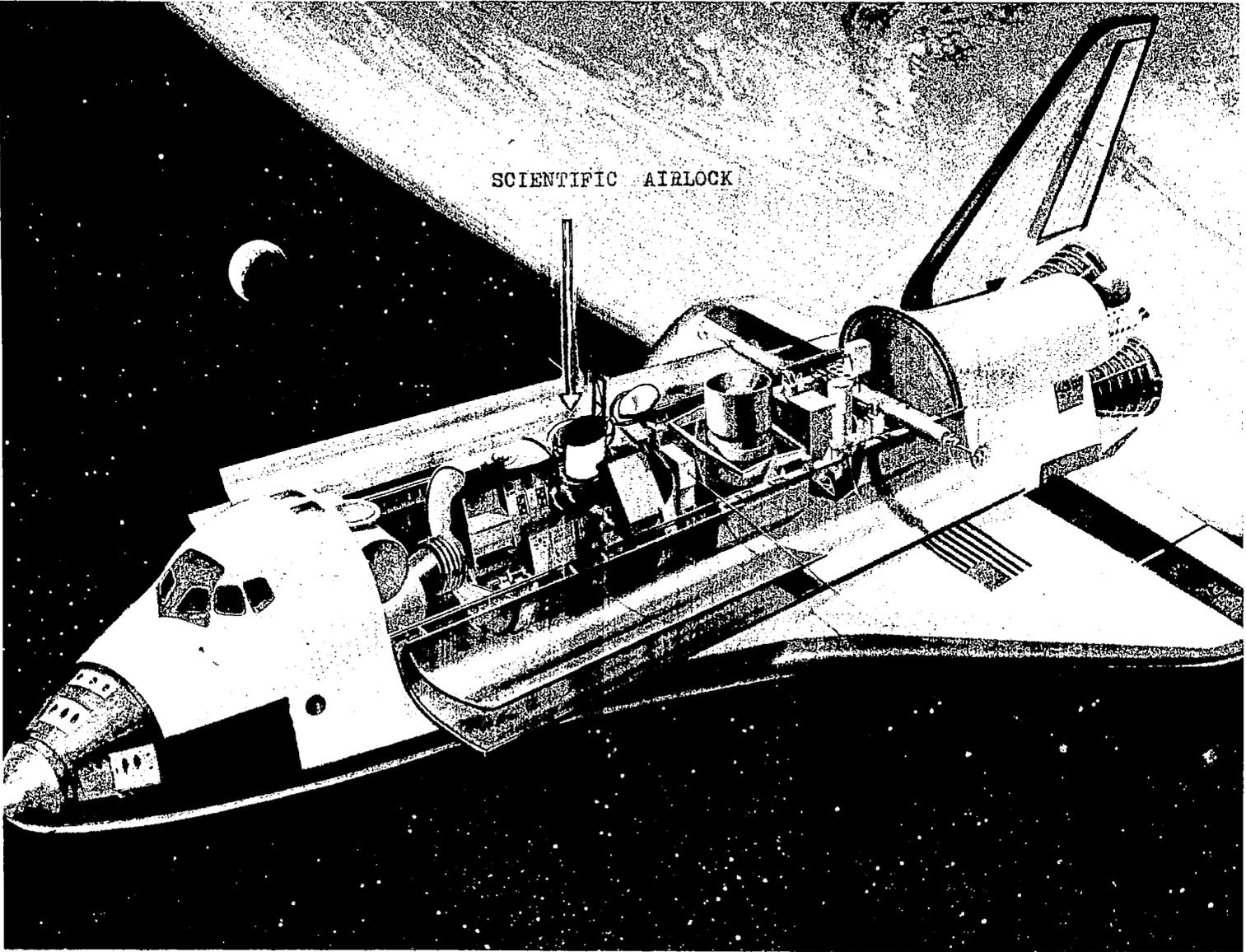


Fig. 2. Scientific Airlock mounted in Spacelab

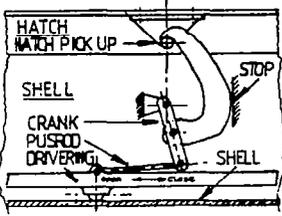
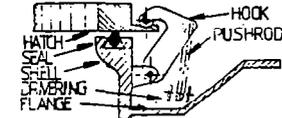
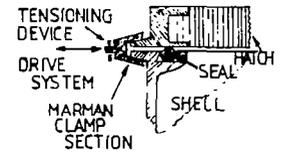
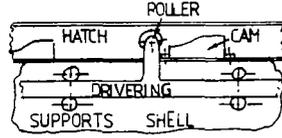
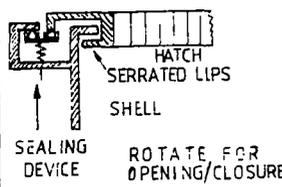
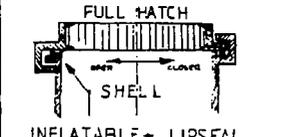
Type of mechanism	Characteristics
<p>M E C H A N I C A L</p> <p>1. <u>Tangential hooks</u></p>  <p>HATCH HATCH PICK-UP SHELL CRANK PUSHROD STOP SHELL</p>	<p>Main advantages:</p> <ul style="list-style-type: none"> - Short load path - Simple adjustability - Relative long travel allowing great mechanical and thermal distortions - Controlled unlatching at internal overpressure <p>Main disadvantages:</p> <ul style="list-style-type: none"> - Many parts causing high weight - Seal compression requires high strength - No feeling for jams
<p>L Y C</p> <p>2. <u>Radial hooks</u></p>  <p>HATCH SEAL SHELL FLANGE HOOK PUSHROD</p>	<p>As 1.</p> <p>Additional disadvantages:</p> <ul style="list-style-type: none"> - Critical lateral hatch positioning - Difficult shape hatch rim - Roller cold welding - Critical for mechanical and thermal distortions of hatch
<p>O M P R E S S E D</p> <p>3. <u>Marman clamp principle</u></p>  <p>TENSIONING DEVICE DRIVE SYSTEM MARMAN CLAMP SECTION SEAL HATCH SHELL</p>	<p>Main advantages:</p> <ul style="list-style-type: none"> - Slight weight reduction possible w.r.t. 1 - Direct load path - Simple design <p>Disadvantages:</p> <ul style="list-style-type: none"> - Well known operational problems - Many possible coldwelding areas - Reliability clamp release - Complex drive - Opening at higher ΔP questionable
<p>S E A L S</p> <p>4. <u>Cam-roller system</u></p>  <p>HATCH ROLLER CAM DRIVERING SUPPORTS SHELL</p>	<p>As 1.</p> <p>Additional disadvantages:</p> <ul style="list-style-type: none"> - System cannot apply high compression loads so alternative sealing technique required - Very sensitive for debris - Required accuracy and similarity of cams - Loose of function at jam of 1 roller - Coldwelding problems
<p>P R E S S U R E S E A L S</p> <p>5. <u>Pressure cooker principle</u></p>  <p>HATCH SERRATED LIPS SHELL SEALING DEVICE ROTATE FOR OPENING/CLOSURE</p>	<p>Main advantages:</p> <ul style="list-style-type: none"> - Relative high weight reduction possible w.r.t. 1 to 4 - Simple design - Direct structural load support <p>Main disadvantages:</p> <ul style="list-style-type: none"> - Drive power required to slide over seal → soft seal design - Alignment sealing - Redundancy sealing - Qualification sealing technique - No unlatching possible at overpressures
<p>S E A L S</p> <p>6. <u>"Sliding" lip</u></p>  <p>FULL HATCH SHELL INFLATABLE → LIPSEAL</p>	<p>As 5.</p> <p>Additionally:</p> <ul style="list-style-type: none"> - Sealing design (inflatable seal + lipseal) requires additional pressure system - Sealing design needs development and qualification

Table 1 Design trade-off Outer Hatch latching mechanism

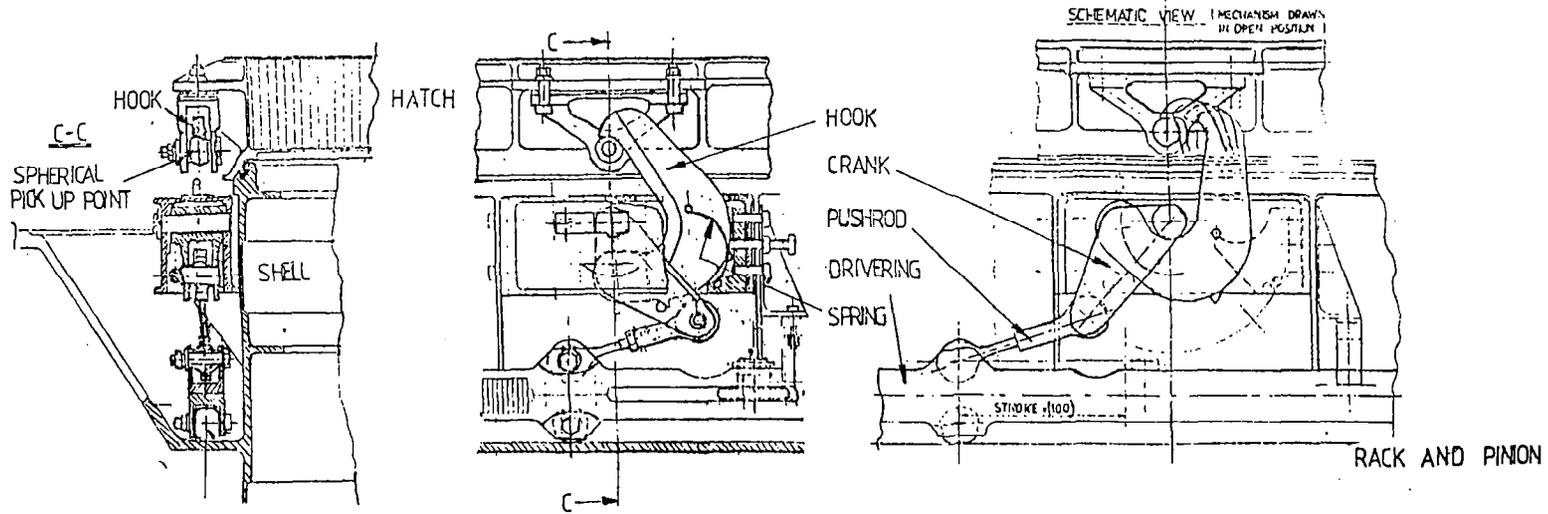


FIGURE 3 Outer hatch latch mechanism

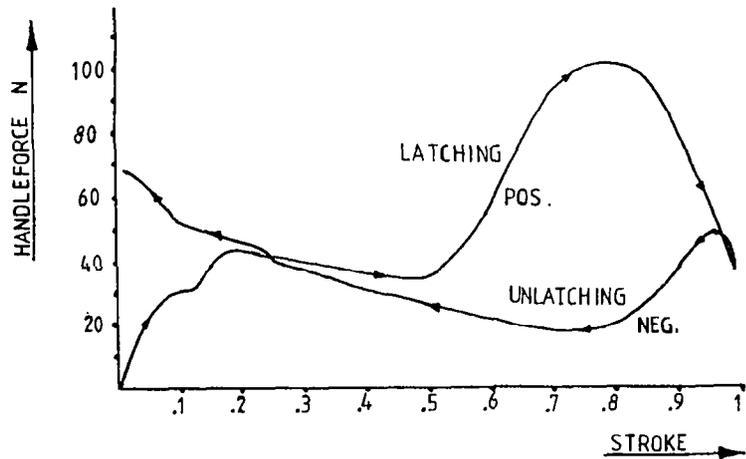
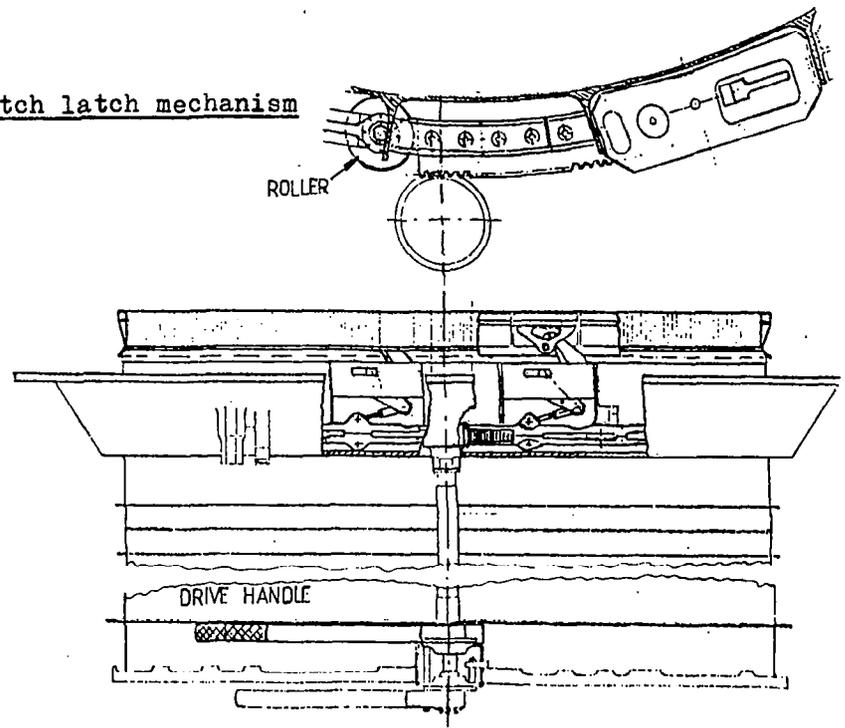


FIGURE 4 Operational force curve



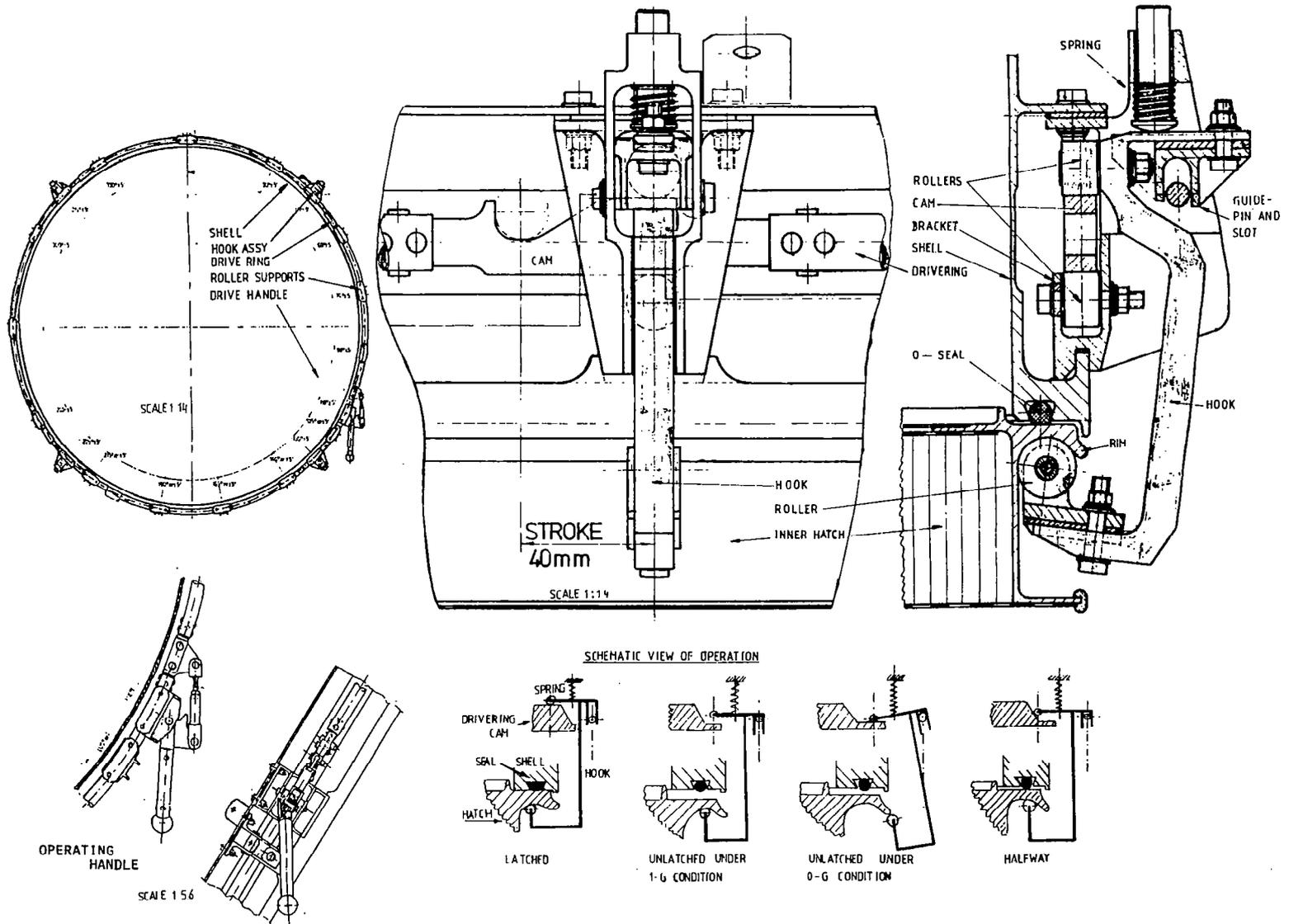


Fig. 5 Inner hatch latching mechanism