ANDROGYNOUS PERIPHERAL DOCKING SYSTEM (APDS)

Андрогинная периферийная система стыковки (АПСС)

THE SOYUZ-APOLLO ANDROGYNOUS PERIPHERAL DOCKING SYSTEM IS CONSIDERED HERE. PRESENTED ARE THE OPERATIONAL PERFORMANCE OF THE SYSTEM AND THE DOCKING SEQUENCE. THE DOCKING SPACECRAFT CREW PROCEDURES FOR THE ELIMINATION OF SYSTEM MALFUNCTIONS ARE DEFINED.

AN ANDROGYNOUS PERIPHERAL DOCKING SYSTEM, furtheron referred to as "the docking system", is intended for the Soyuz and Apollo docking and undocking after termination of their joint flight.

During docking, the system provides for attenuation, capture, alignment, spacecraft retraction, and interface sealing.

When undocking, it provides for separation and pushing apart of the spacecraft.

The system will ensure docking if the parameters at close approach do not exceed the following figures:

- range rate 0.05 - 0.3 m/sec;
- longitudinal axis displacement -300 mm;
- pitch, yaw and roll misalignment -7°;
- pitch, yaw and roll angular rates -1°/sec for the active spacecraft; 0.1°/sec for the passive spacecraft;
- lateral relative rate 0.1 m/sec.

The docking system consists of a docking assembly, an automatic unit, controls and displays.

The docking mechanism of the docking assembly includes:

- a ring with three guides;
- six rod interaction mechanisms mounted on the ring and body;

- three capture latch electric drives;

- three body-mount latch electric drives.

The guide ring is mounted on six moving rods and is controlled by means of a differential drive.

The body and structural ring make up the transfer tunnel which is closed from inside by a hatch.

The structural ring mounts:

- an interface sealing;

- a guide pin and a socket providing for the spacecraft final alignment;

- spring thrusters;

- an interface electric connector fixture;

- undocking, contact, and seal sensors;

- latch mechanisms with active and passive hooks.

The ring mounts ring alignment sensors.

For passive docking, the ring is retracted. For active docking, the ring is extended to the initial position for docking.

When the rings are aligned, the capture latches engage body-mount latches. It results in the ring capture.

After attenuation, the ring is retracted until the seals get in contact.

The rubber seal is pressure-sealed with the help of the pressurization drive.

The electric drive closes, by means of cables, the active hooks of the latch mechanism which engage passive hooks of the Apollo.

For undocking, the hooks of the capture latches or the body mount latches open. The spacecraft are pushed apart by spring thrusters. At the same time, the Soyuz micro engines are ignited for separation.

The docking assemblies of the Soyuz and Apollo spacecraft are similiar in design.

The Soyuz mounts ball screw actuators, as distinguished from the Apollo independent hydraulic attenuators, and electric drive with cable rigging for ring retraction.

The Soyuz docking assembly is also characterized by electric drives of body mount and capture latches and by the use of pyrotechnics applied to capture latches and hooks for back up undocking.

The automatic unit and controls provide for automatic and manual docking.

In automatic operation, the automatic unit logic device generates control signals to initiate subsequent operations if the previous operations have been carried out. The command/signal device and instrument board display information of the status of system mechanisms and the fulfilment of operations.

In the case of manual docking, the following commands can be carried out by the crew with

the help of the command/signal device:

- DOCKING SYSTEM POWER SUPPLY
- LATCH CLOSING
- RETRACTION
- HOOK CLOSING
- UNDOCKING
- SYSTEM BLOCKING OFF
- RING EXTENSION
- LATCH OPENING
- HOOK OPENING
- CLEARANCE FOR BACKUP UNDOCKING
- BACKUP OPENING OF PASSIVE HOOKS.

If necessary, some control commands can be issued to the spacecraft from the ground through the command/signal radio link.

The above-mentioned commands are accompanied by appropriate lights. The command/signal device has also the following lights:

- TRANSFER HATCH CLOSED
- PASSIVE READINESS

- ACTIVE READINESS
- RING ALIGNED
- CAPTURE
- INTERFACE ALIGNED
- INTERFACE SEALED.

All these lights serve to inform the crew members:

- of the system status at the given moment;
- of the beginning and progress of operation;
- of the result of operation.

When ready for passive docking, the guide ring is retracted, the active hooks of the structural latches are fully open, the body mount latches are closed (ready for docking), the PASSIVE READINESS light of the command/signal device is ON.

Now let's consider the operations sequence of the system.

When the DOCKING SYSTEM POWER SUPPLY command is given, the DOCKING SYSTEM POWER SUPPLY light of the command/signal device goes ON.

The active Apollo spacecraft approaches the Soyuz. When the spacecraft get in contact and the ring alignment sensors trip, the CAPTURE LIGHT goes on.

After attenuation, alignment of the spacecraft and retraction by the Apollo hook drive,

the seal sensors operate. The INTERFACE ALIGNED light of the command/signal device goes on. As the Apollo hooks close, the interface seal sensors switch on the INTERFACE SEALED light on the command/signal device. The power supply of the system is turned off and all the lights go off except for the PASSIVE READINESS light.

For undocking, the crew give the command: DOCKING SYSTEM POWER SUPPLY. The lights DOCKING SYSTEM POWER SUPPLY, INTERFACE SEALED, INTERFACE ALIGNED, CAPTURE will go on.

As the Apollo hooks open, the seal sensors are first released, the INTERFACE SEALED light goes off, then the seal contact sensors trip and the INTERFACE ALIGNED light goes off.

As the rings separate, the ring alignment sensors are released and the CAPTURE light goes off. The system power supply is turned off and the DOCKING SYSTEM POWER SUPPLY light goes off. The PASSIVE READINESS light is on.

Before the Soyuz and Apollo test docking the Soyuz brings its docking system to active readiness. The ring is extended to its initial position (six minutes), the RING EXTENSION light is ON. The capture latches are ready for docking. Active hooks are open. The ACTIVE READIESS light is ON.

The DOCKING SYSTEM POWER SUPPLY command switches on the lights DOCKING SYSTEM POWER SUPPLY and RING ALIGNED.

After contact of the Soyuz and Apollo the RING ALIGNED light goes OFF. The ring alignment

sensors trip. The CAPTURE light of the command/signal device is ON. Then the spacecraft are attenuated and aligned during not more than five monutes. The rod misalignment sensors again switch on the RING ALIGNED light. Eight seconds after the spacecraft alignment, the ring retraction begins. It continues not longer than six minutes. The beginning of the retraction is monitored by means of the RETRACTION and ACTIVE READINESS lights.

After the contact of the interface rubber seals, the interface sealing drive begins to operate. It is monitored with the help of the HOOKS CLOSING light and the INTERFACE ALIGNED light.

In 15 seconds, the drive of the docking mechanism is turned off. When the ring is fully retracted, the RETRACTION light goes off. It takes not more than five minutes for the active hooks to close. The signal of the hook closing sensors switches on the INTERFACE SEALED light and switches off all other lights. The light SYSTEM MODE OPERATION ACCOMPLISHED is ON.

After turning on the DOCKING SYSTEM POWER SUPPLY, the following lights will be ON:

- DOCKING SYSTEM POWER SUPPLY
- CAPTURE
- INTERFACE ALIGNED
- INTERFACE SEALED.

After the UNDOCKING command, the ring extends for 5 sec in order to unload the latches. The extension of the ring is monitored by means of the RING EXTENSION light which at first goes ON and then OFF.

The INTERFACE SEALED light goes OFF.

When the ring fully extends, the latches and hooks begin opening. This is monitored by means of the LATCH OPENING light which is ON for 5 sec.

The hook opening continues not longer than five minutes. After the release of the seal contact sensors, the INTERFACE ALIGNED light goes OFF; after the release of the capture sensors, the CAPTURE light is also OFF.

At the same time, the spring thrusters push the spacecraft apart and the micro engines operate for 8 sec to separate the Soyuz.

When the hooks fully open, the sensors switch on the light: SYSTEM MODE OPERATION ACCOMPLISHED, other lights go OFF. The system power supply is cut off.

So the undocking mode is accomplished.

RANGE RATE – **0.05-0.3** M/SEK M/СЕК

Скорость сближения

LONGITUDINAL AXIS DISPLACEMENT – **300** MM

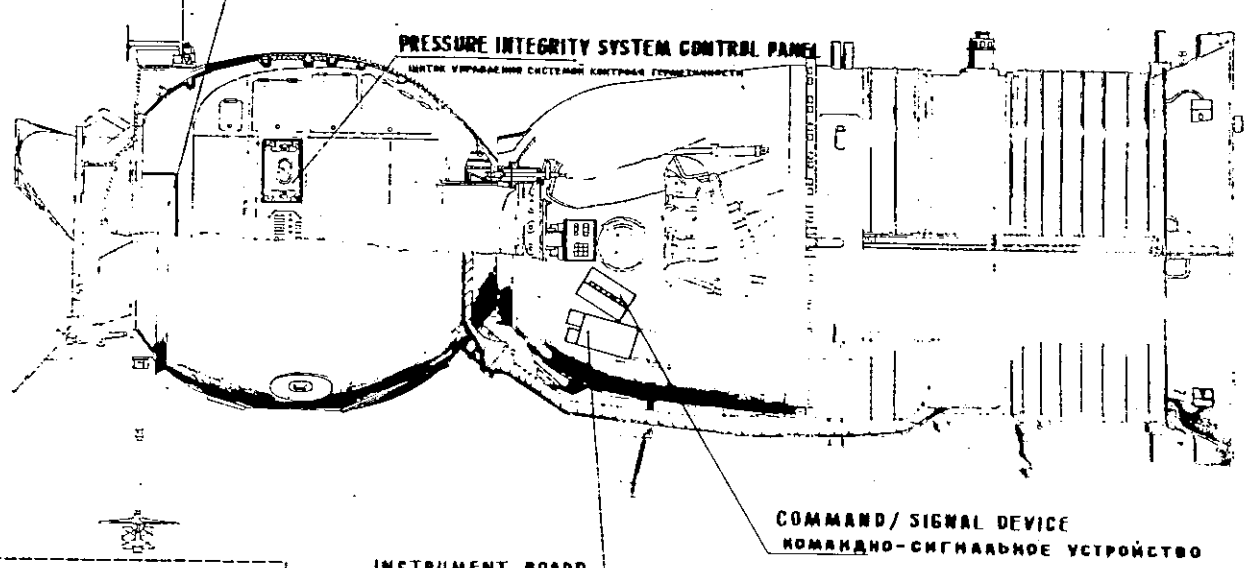
Смещение продольных осей

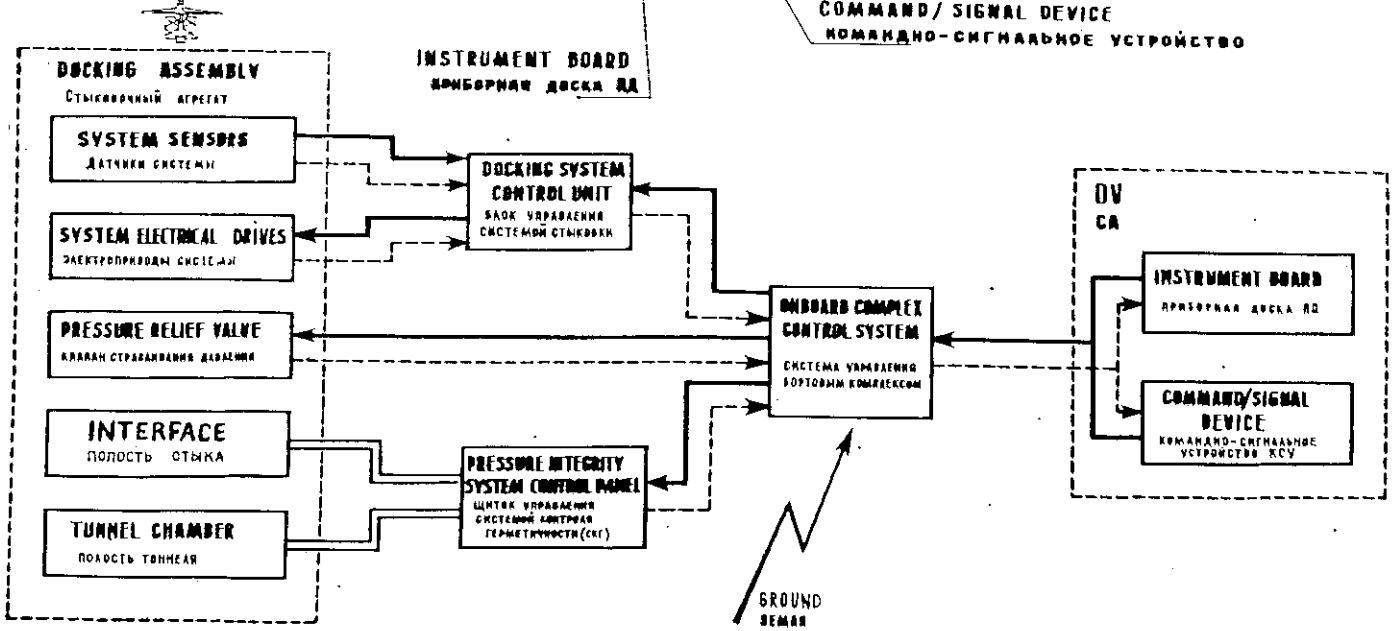
PITCH YAW AND ROLL MISALINEMENT – **7°**

Рассогласование по тангажу. рысканию и крену

DOCKING SYSTEM STRUCTURAL DIAGRAM

Структурная схема системы стыковки





RETRACTION RATE - **1-2** MM/SEC
MM/СЕК

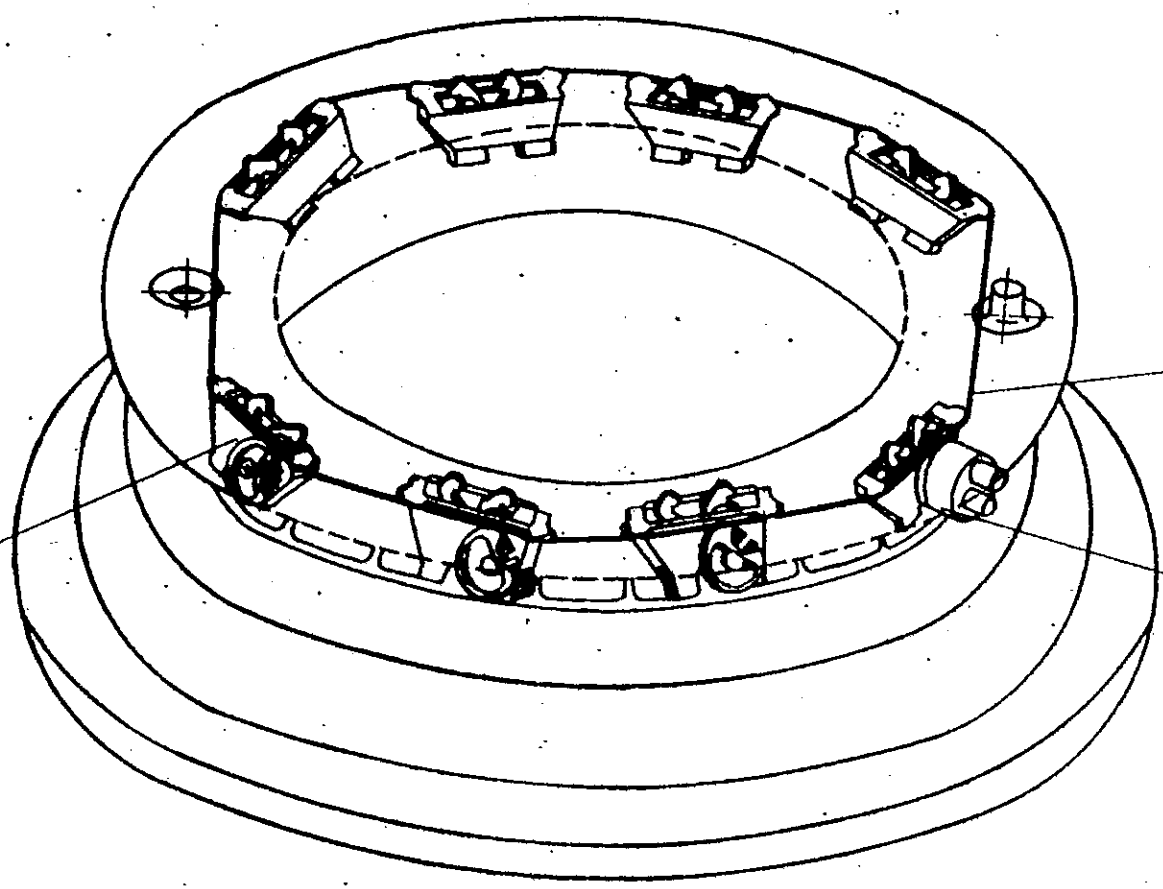
Скорость стягивания

RETRACTION TIME - ≤ **6** MIN
МИН

Время стягивания

RETRACTION FORCE - ≥ **1.5** T

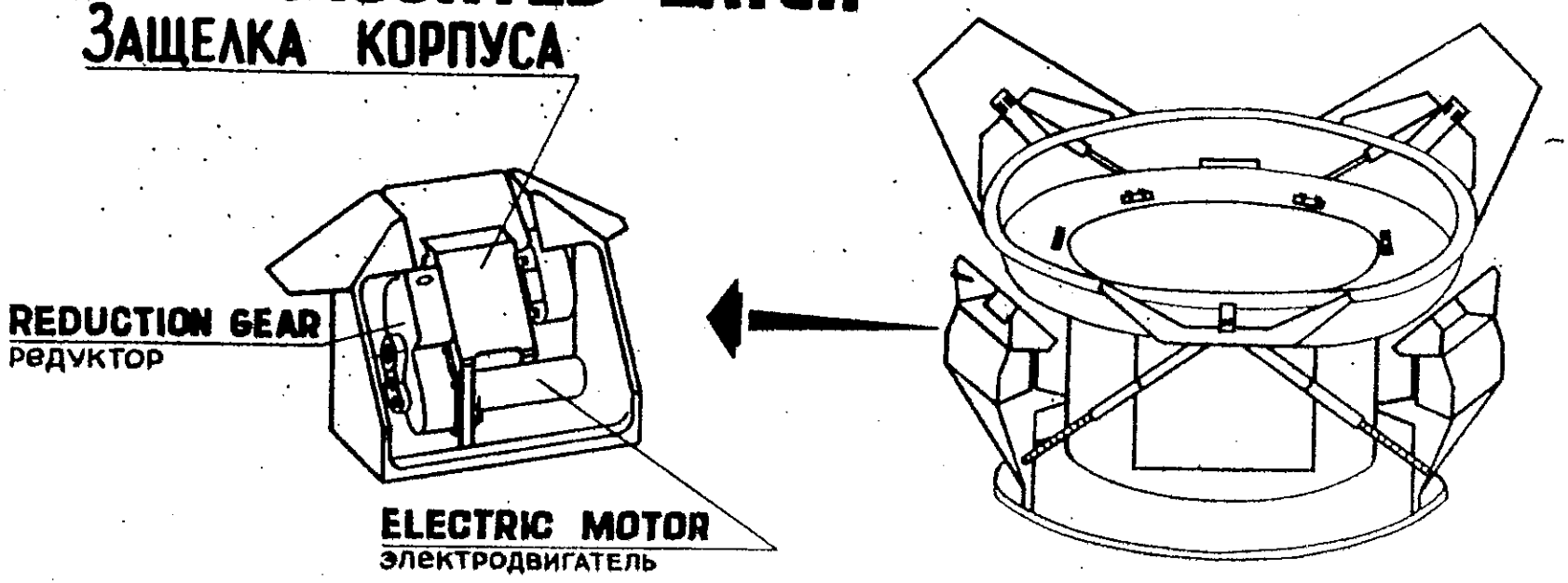
Усилие стягивания



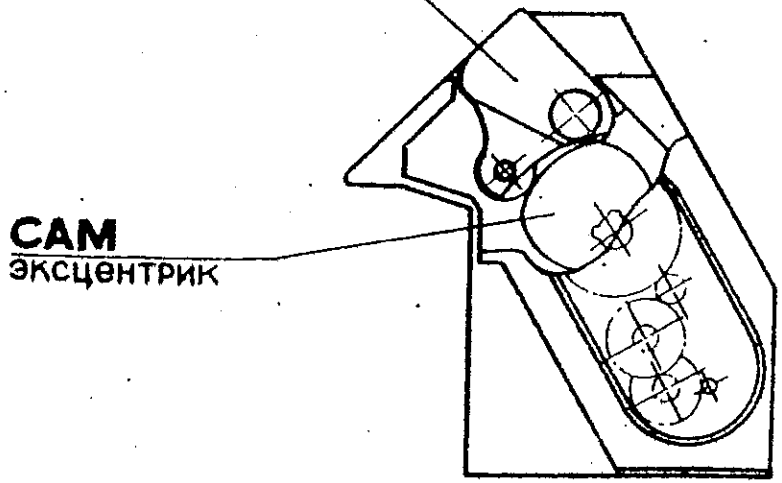
STRUCTURAL RING LATCH ACTIVATION MECHANISM

ПРИВОД ГЕРМЕТИЗАЦИИ СТЫКА

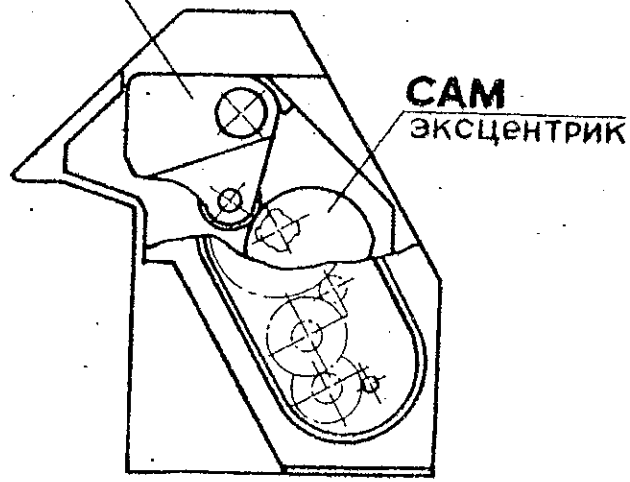
BODY MOUNTED LATCH
ЗАЩЕЛКА КОРПУСА



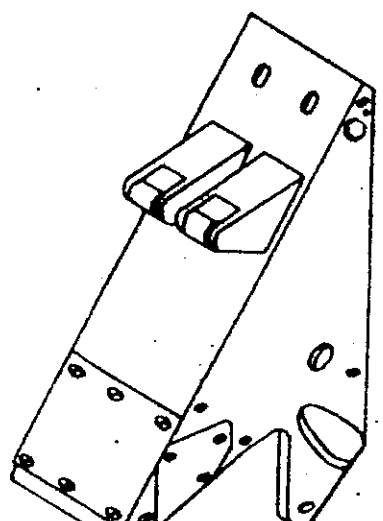
LOCKED ЗАКРЫТА

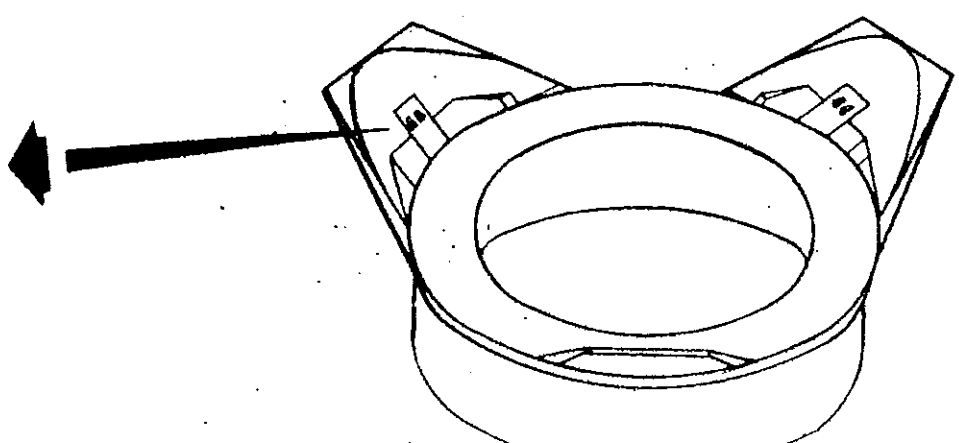


UNLOCKED ОТКРЫТА



CAPTURE LATCH
ЗАЩЕЛКА КОЛЬЦА





ЗАКРЫТА
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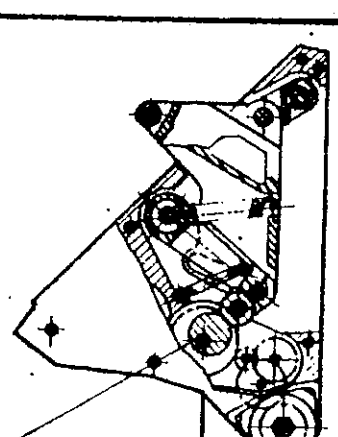
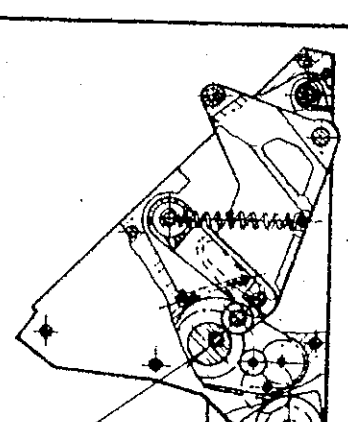
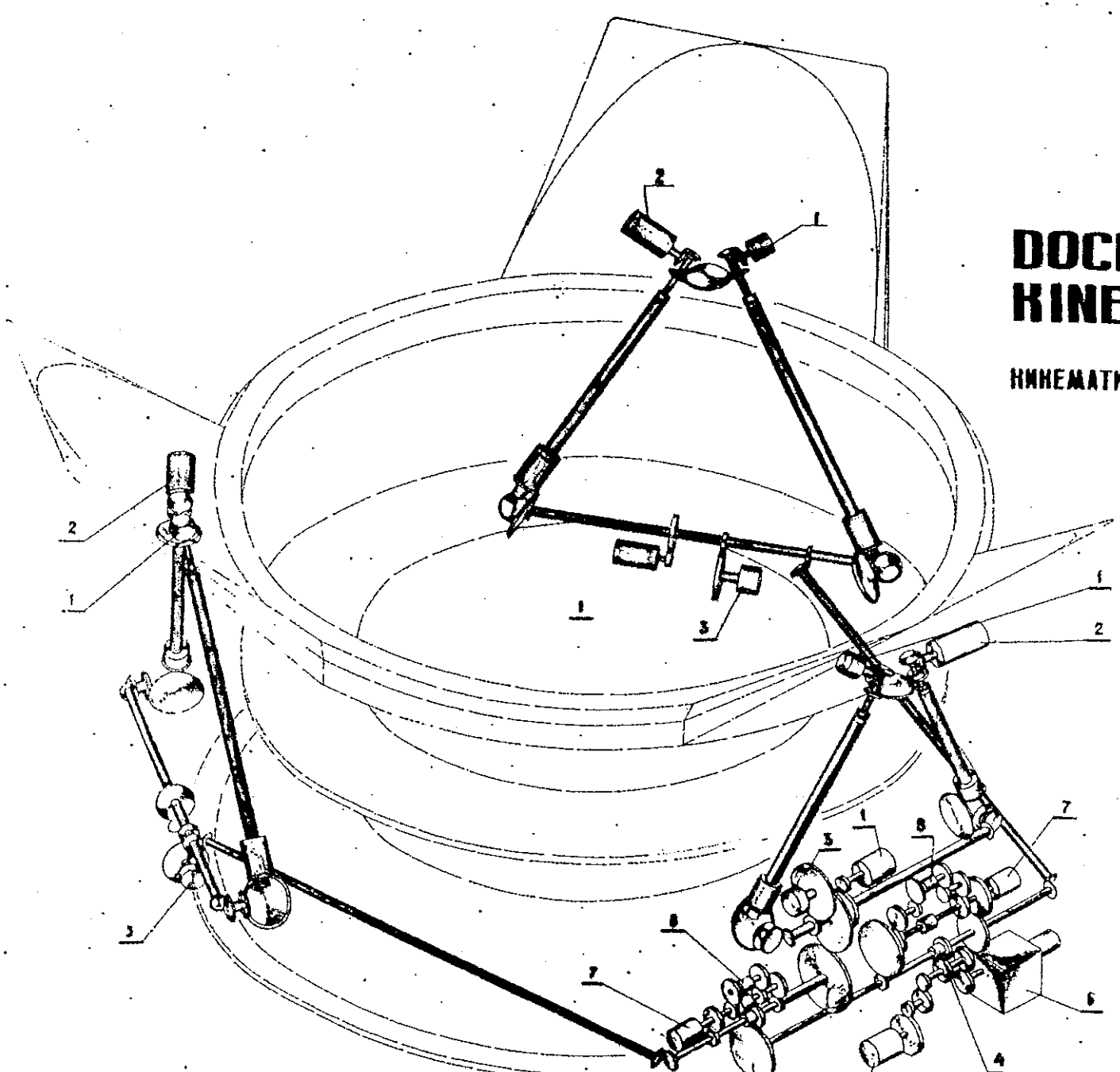


ОТКРЫТА
UNLOCKED



DOCKING SYSTEM KINEMATIC DIAGRAM

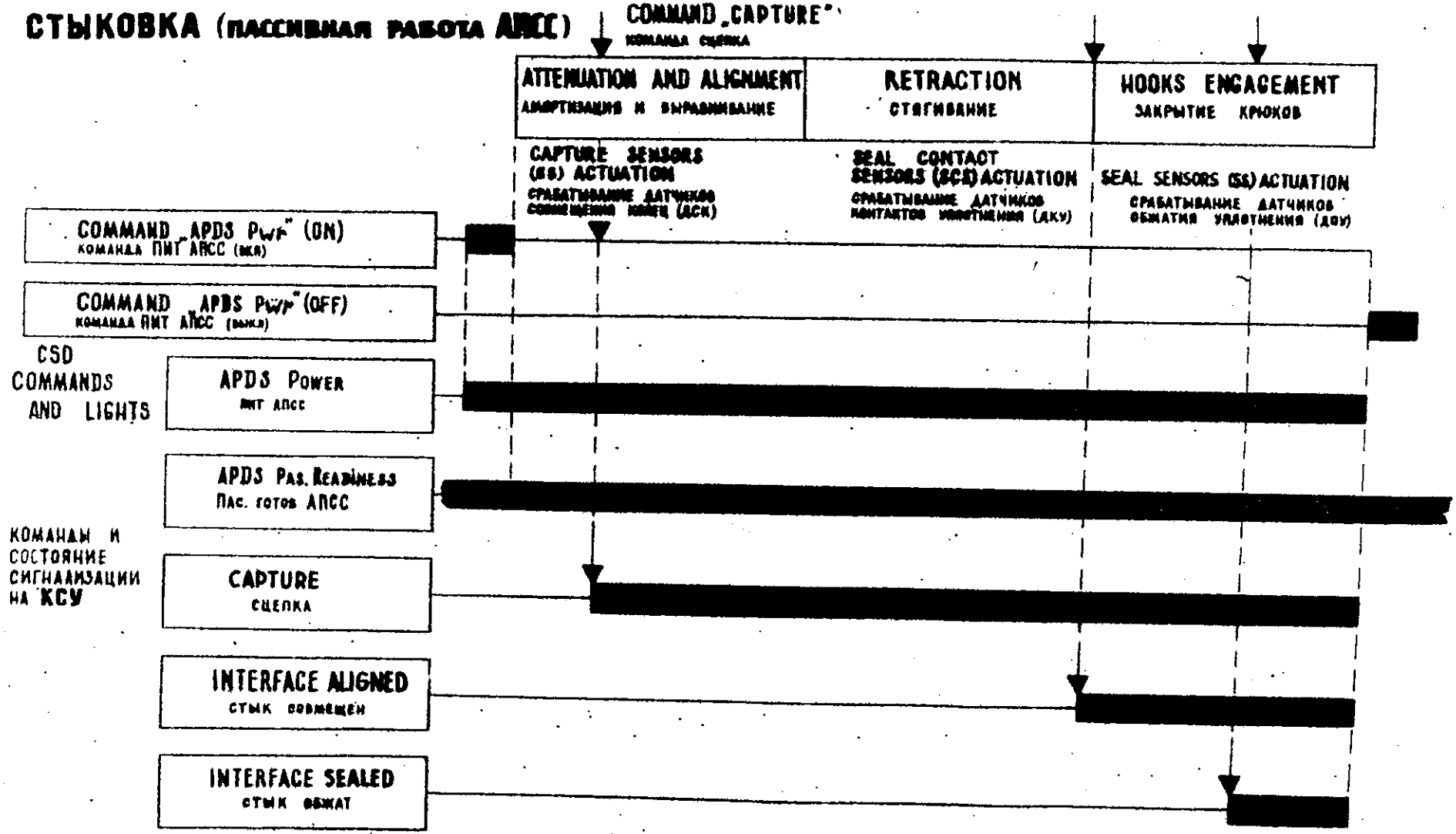
КИНЕМАТИЧЕСКАЯ СХЕМА СИСТЕМЫ СТЫКОВКИ



1. ELECTROMAGNETIC BRAKE
   ЭЛЕКТРОМАГНИТКЫЙ ТОРМОЗ
2. SPRING MECHANISM
   ПРУЖИННЫЙ МЕХАНИЗМ
3. POTENTIOMETER
   ПОТЕНЦИОМЕТР
4. DIFFERENTIAL
   ДИФФЕРЕНЦИАЛ
5. CONTACT GROUP
   КОНТАКТНАЯ ГРУППА
6. MECHANISM DRIVE
   ПРИВОД МЕХАНИЗМА
7. ELECTROMAGNETIC FIXING DEVICE
   ФИКСАТОР ЭЛЕКТРОМАГНИТНЫЙ
8. MISALIGNMENT SENSOR
   ДАТЧИК РАССОГЛАСОВАНИЯ

DOCKING APDS PASSIVE OPERATION

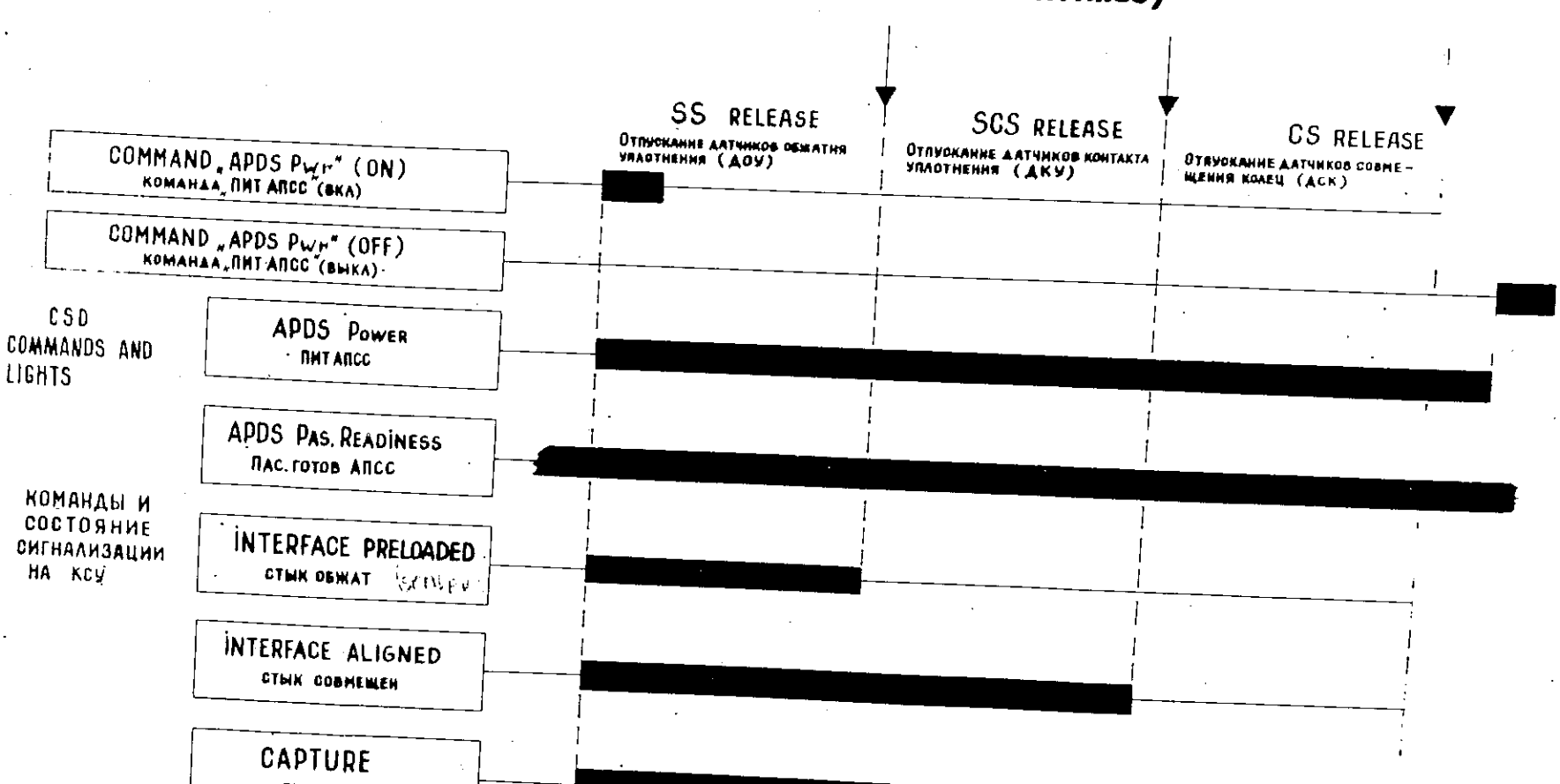
СТЫКОВКА (ПАССИВНАЯ РАБОТА АПСС)



UNDOCKING

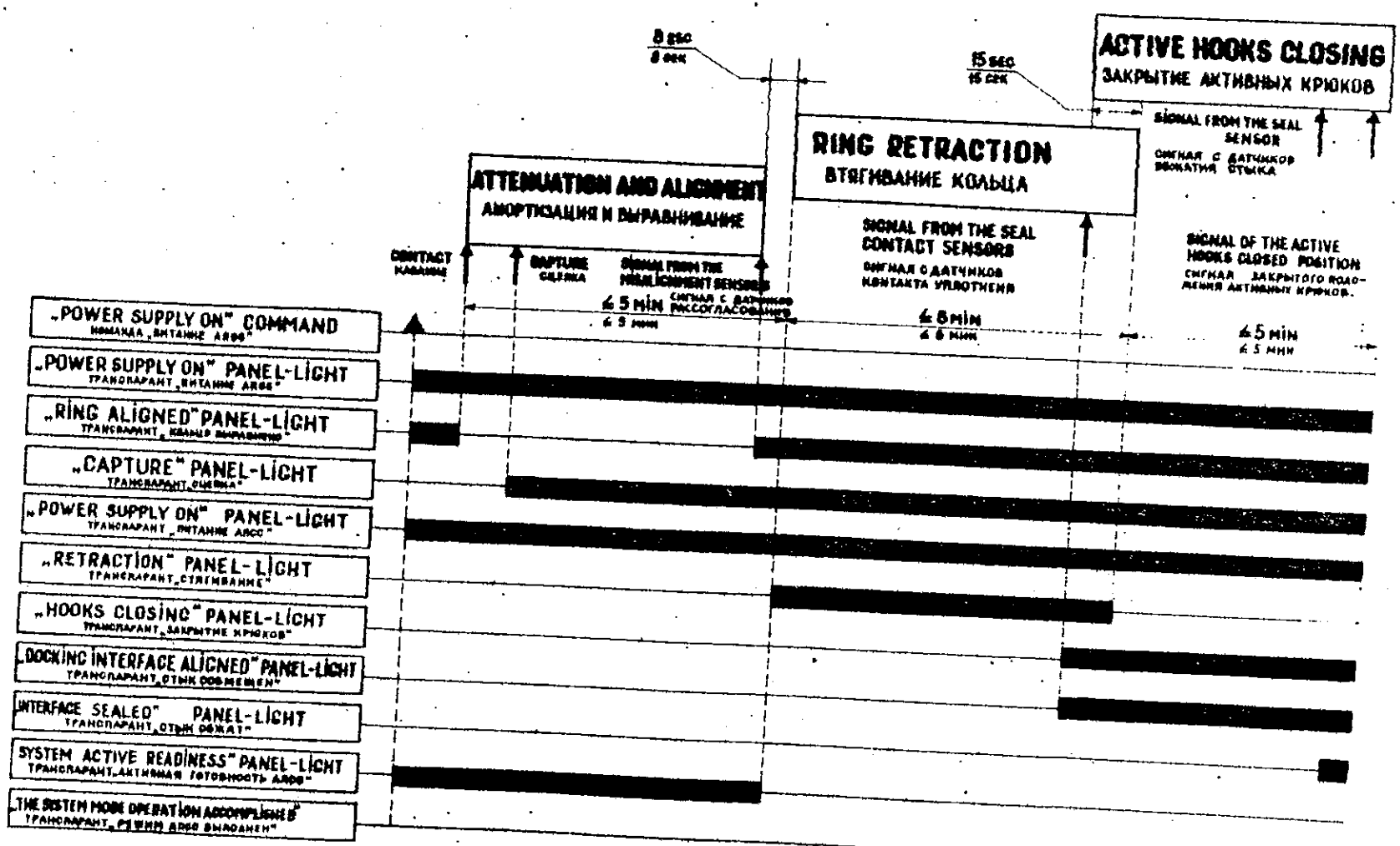
APDS PASSIVE OPERATION

РАССТЫКОВКА (ПАССИВНАЯ РАБОТА АПСС)



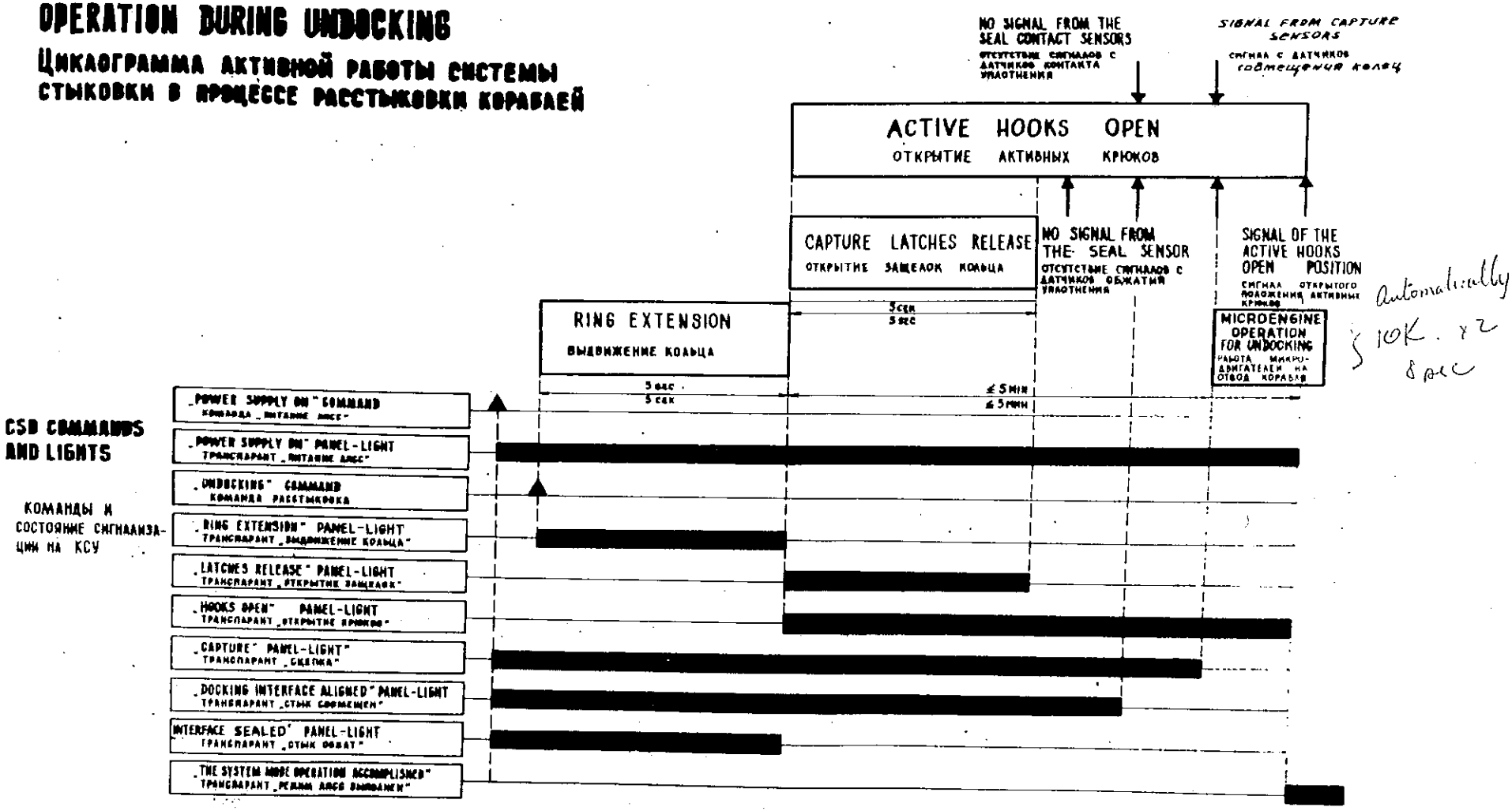
PROCEDURE OF THE SYSTEM ACTIVE OPERATION DURING DOCKING

Циклограмма активной работы системы в процессе стыковки кораблей.



PROCEDURE OF THE ACTIVE SYSTEM OPERATION DURING UNDOCKING

Циклограмма активной работы системы стыковки в процессе расстыковки кораблей



Automatically
≥ 10K. x 2
8 sec

CONTINGENCY AND EMERGENCY SITUATIONS IN CASE OF „SOYUZ" DOCKING SYSTEM MALFUNCTIONS

НЕШТАТНЫЕ И АВАРИЙНЫЕ СИТУАЦИИ В СЛУЧАЕ ВОЗНИКНОВЕНИЯ НЕИСПРАВНОСТЕЙ СИСТЕМЫ СТЫКОВКИ КОРАБЛЯ „СОЮЗ"

TROUBLE Вид отказа	REMEDY Мероприятия по ликвидации отказов	NOTE Примечание

1. GUIDE RING WON'T EXTEND

Кольцо с направляющими не выдвигается

1. MAKE ANOTHER ATTEMPT TO EXTEND GUIDE RING.
Повторная попытка выдвинуть кольцо.

IS GUIDE RING EXTENDED?
Выдвинуто ли кольцо?

NO

YES

2. CONTINUE ACTIVE OPERATION OF SOYUZ DOCKING SYSTEM
Продолжается активная работа системы стыковки „Союза"

INFORM APOLLO CREW AND CHECK READINESS FOR PASSIVE DOCKING

Уведомить экипаж „Аполлона" и проверить пассивную готовность.

3. RETRACT GUIDE RING INTO PASSIVE POSITION FOR Apollo TO PERFORM ACTIVE DOCKING
Втягивается кольцо с направляющими в пассивное положение для стыковки с активной системой „Аполлона"

TROUBLE Вид отказа	REMEDY Мероприятия по ликвидации отказов	NOTE Примечание
2. SPACECRAFT WON'T CAPTURE нет сцепки кораблей	1. SEPARATE SPACECRAFT. KEEP STATION. OPEN AND THEN CLOSE GUIDE RING CAPTURE LATCHES; TRY TO DOCK AGAIN Разведение кораблей. Зависание. Открытие и повторное закрытие защелок кольца, попытка повторной стыковки. ARE LATCHES CAPTURED? есть ли сцепка?	INFORM APOLLO CREW OF CAPTURE сообщается экипажу „Аполлона" о наличии захвата
	NO → 2. CONTINUE ACTIVE OPERATION OF SOYUZ DOCKING SYSTEM продолжается активная работа системы стыковки „Союза"	YES
	3. RETRACT GUIDE RING INTO PASSIVE POSITION FOR APOLLO TO PERFORM ACTIVE DOCKING втягивается кольцо в пассивное положение для активной работы системы стыковки „Аполлона"	INFORM APOLLO CREW AND CHECK SYSTEM READINESS FOR PASSIVE DOCKING уведомить экипаж „Аполлона" и проверить пассивную готовность

TROUBLE Вид отказа	REMEDY Мероприятия по ликвидации отказов	NOTE Примечание
3. AFTER CAPTURE, GUIDE RING WONT ALIGN ПОСЛЕ СЦЕПКИ КОЛЬЦО НЕ ВЫРАВНИВАЕТСЯ	1. EXTEND GUIDE RING AS FAR AS IT WILL GO FOR FORCED ALIGNMENT КОЛЬЦО ВЫДВИГАЕТСЯ В КРАЙНЕЕ ПЕРЕДНЕЕ ПОЛОЖЕНИЕ ДЛЯ ПРИНУДИТЕЛЬНОГО ВЫРАВНИВАНИЯ IS THE GUIDE RING ALIGNED ? ВЫРОВНЯЛОСЬ ЛИ КОЛЬЦО ? NO YES 2. CONTINUE ACTIVE OPERATION OF SOYUZ DOCKING SYSTEM ПРОДОЛЖАЕТСЯ СТЫКОВКА АКТИВНОЙ СИСТЕМОЙ „СОЮЗА" 3. OPEN CAPTURE LATCHES AND RETRACT GUIDE RING INTO PASSIVE POSITION FOR APOLLO TO PERFORM ACTIVE DOCKING ПРОВОДИТСЯ РАСКРЫТИЕ ЗАЩЕЛОК КОЛЬЦА И ВТЯГИВАНИЕ КОЛЬЦА В ПАССИВНОЕ ПОЛОЖЕНИЕ ДЛЯ СТЫКОВКИ АКТИВНОЙ СИСТЕМОЙ „АПОЛЛОНА"	INFORM APOLLO CREW ABOUT FORCED ALIGNMENT OF GUIDE RING СООБЩИТЬ ЭКИПАЖУ „АПОЛЛОНА" О ПРОВЕДЕНИИ ПРИНУДИТЕЛЬНОГО ВЫРАВНИВАНИЯ КОЛЬЦА INFORM APOLLO CREW AND CHECK READINESS OF SYSTEM FOR PASSIVE DOCKING УВЕДОМИТЬ ЭКИПАЖ „АПОЛЛОНА" И ПРОВЕРИТЬ ПАССИВНУЮ ГОТОВНОСТЬ

TROUBLE
Вид отказа

REMEDY
Мероприятия по ликвидации отказов

NOTE
Примечание

4.

AFTER ATTENUATION AND ALIGNMENT GUIDE RING WON'T RETRACT

После амортизации и выравнивания кольцо с направляющими не втягивается

1. EXTEND GUIDE RING AND TRY AGAIN TO RETRACT IT

кольцо выдвигается и производится попытка втягивания кольца

IS GUIDE RING RETRACTED?

втянулось ли кольцо?

YES

2. CONTINUE ACTIVE OPERATION OF SOYUZ DOCKING SYSTEM

продолжается стыковка активной системой „Союза"

NO

3. OPEN CAPTURE LATCHES AND TRY AGAIN TO RETRACT GUIDE RING INTO PASSIVE POSITION

открытие защелок кольца и попытка произвести втягивание кольца в пассивное положение

REQUEST APOLLO CREW FOR CLEARANCE TO OPEN CAPTURE LATCHES

запрашивается согласие экипажа „Аполлона" на открытие защелок кольца

IS GUIDE RING RETRACTED?

втянулось ли кольцо?

NO

5. NO DOCKING

стыковка не может быть выполнена

INFORM APOLLO CREW AND MISSION CONTROL CENTER

сообщение экипажу „Аполлона" и наземному центру управления

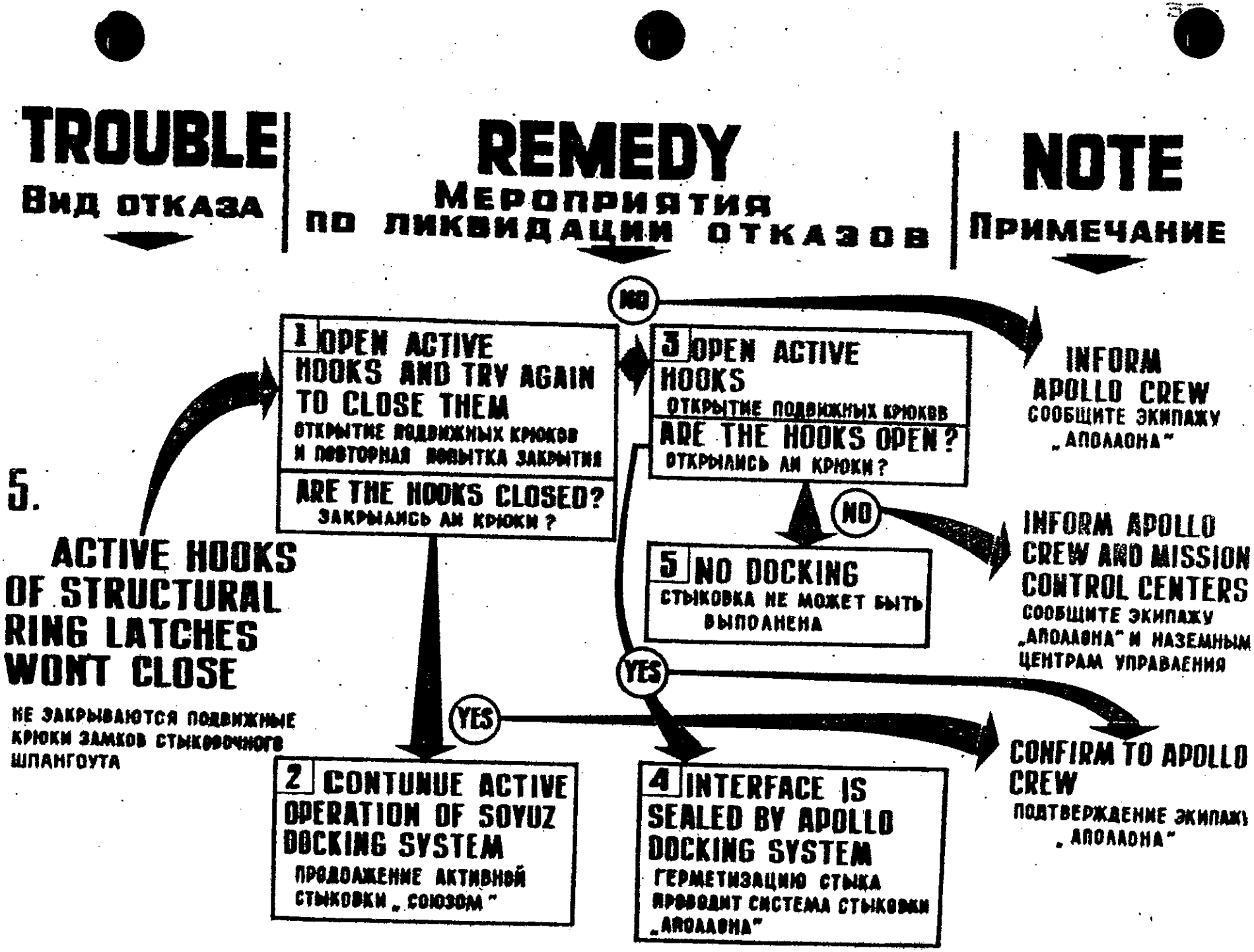
YES

4. CONTINUE ACTIVE OPERATION OF APOLLO DOCKING SYSTEM

активная работа системы стыковки „Аполлона"

INFORM APOLLO CREW ABOUT SYSTEM READINESS FOR PASSIVE DOCKING AND ASK APOLLO CREW TO INITIATE ACTIVE DOCKING

сообщают экипажу „Аполлона" о пассивной готовности и предлагают экипажу „Аполлона" провести активную стыковку


TROUBLE
Вид отказа
REMEDY
Мероприятия по ликвидации отказов
NOTE
Примечание
5.
ACTIVE HOOKS OF STRUCTURAL RING LATCHES WONT CLOSE
НЕ ЗАКРЫВАЮТСЯ ПОДВИЖНЫЕ КРЮКИ ЗАМКОВ СТЫКОВОЧНОГО ШПАНГОУТА
1 OPEN ACTIVE HOOKS AND TRY AGAIN TO CLOSE THEM
ОТКРЫТИЕ ПОДВИЖНЫХ КРЮКОВ И ПОВТОРНАЯ ПОПЫТКА ЗАКРЫТИЯ
ARE THE HOOKS CLOSED?
ЗАКРЫЛИСЬ ЛИ КРЮКИ ?
NO
3 OPEN ACTIVE HOOKS
ОТКРЫТИЕ ПОДВИЖНЫХ КРЮКОВ
ARE THE HOOKS OPEN?
ОТКРЫЛИСЬ ЛИ КРЮКИ ?
NO
INFORM APOLLO CREW
СООБЩИТЕ ЭКИПАЖУ „АПОЛЛОНА"
5 NO DOCKING
СТЫКОВКА НЕ МОЖЕТ БЫТЬ ВЫПОЛНЕНА
INFORM APOLLO CREW AND MISSION CONTROL CENTERS
СООБЩИТЕ ЭКИПАЖУ „АПОЛЛОНА" И НАЗЕМНЫМ ЦЕНТРАМ УПРАВЛЕНИЯ
YES
YES
2 CONTUNUE ACTIVE OPERATION OF SOYUZ DOCKING SYSTEM
ПРОДОЛЖЕНИЕ АКТИВНОЙ СТЫКОВКИ „СОЮЗОМ"
4 INTERFACE IS SEALED BY APOLLO DOCKING SYSTEM
ГЕРМЕТИЗАЦИЮ СТЫКА ПРОВОДИТ СИСТЕМА СТЫКОВКИ „АПОЛЛОНА"
CONFIRM TO APOLLO CREW
ПОДТВЕРЖДЕНИЕ ЭКИПАЖУ „АПОЛЛОНА"

TROUBLE Вид отказа	REMEDY Мероприятия по ликвидации отказов	NOTE Примечание
6. ACTIVE HOOKS OF STRUCTURAL RING LATCHES WON'T OPEN Не открываются подвижные крюки замков стыковочного шлангоута	1. SWITCH ON AND THEN OFF HOOKS MOTOR. TRY TO OPEN HOOKS AGAIN. Включение и выключение привода замков. Повторная попытка открыть замки. ARE THE HOOKS OPEN ? Открылись ли замки? NO YES 2. UNDOCKING IS OVER Расстыковка завершена 3. OPEN APOLLO PASSIVE HOOKS Открытие неподвижных крюков „Аполлона" ARE THE HOOKS OPEN ? Открылись ли крюки? NO YES 4. USE PYROTECHNICS TO OPEN SOYUZ ACTIVE HOOKS Использование пиротехники для открытия подвижных крюков „Союза"	INFORM APOLLO CREW AND ASK THEM TO OPEN APOLLO PASSIVE HOOKS Сообщение экипажу „Аполлона" и предложение произвести открытие неподвижных крюков „Аполлона"

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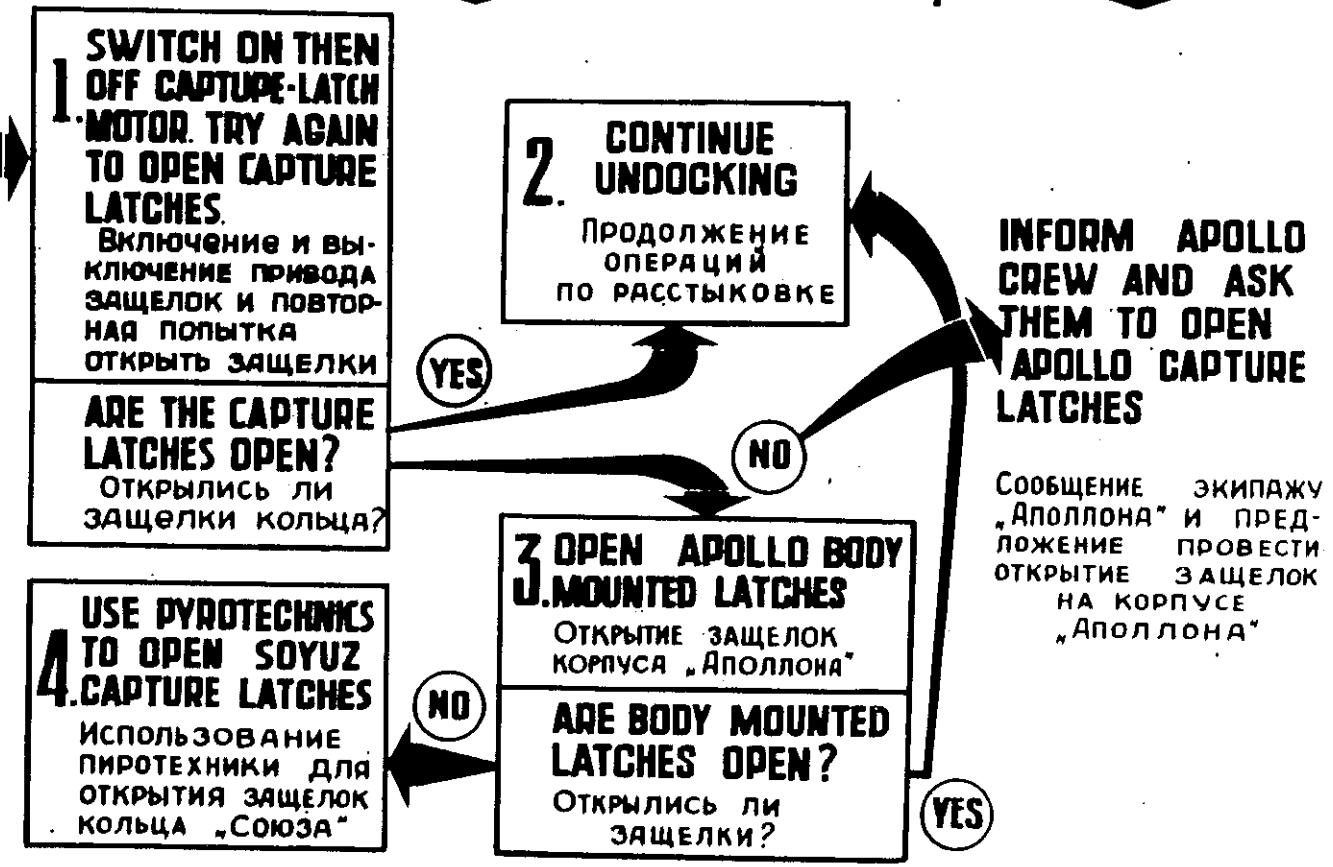
7. CAPTURE LATCHES WON'T OPEN

Не открываются защелки кольца



TROUBLE Вид отказа	REMEDY Мероприятия по ликвидации отказов		NOTE Примечание
8. EMERGENCY SITUATION Аварийная ситуация	1. USE PYROTECHNICS OF CAPTURE LATCHES AND/OR LATCH HOOKS FOR EMERGENCY UNDOCKING Аварийная расстыковка с помощью пиротехнических средств по защелкам кольца и (или) крюкам	MICRO THRUSTERS ARE FIRED FOR 8 SEC TO MOVE SOYUZ AWAY При этом на 8 сек включаются реактивные микродвигатели на отвод корабля „Союз"	AGREE BETWEEN CREWS AND, IF TIME AVAILABLE, WITH MISSION CONTROL CENTER По согласованию между экипажами и, если позволяет время, с наземными пунктами управления

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