By @AlphaOneSix:

I am actually one of my company's maintenance trainers, and I'm in charge of Mi-17 systems classes for the whole company, and I do flight training for crew chiefs as well, although that's not my primary job.

Flight Controls

The Mi-8 flight control system includes:

- Cyclic, Collective, and Directional controls for both pilot and co-pilot.
- Separate engine condition levers (ECLs) for the pilot.
- Engine shutdown levers for the pilot.
- Main rotor brake control for the pilot.
- Rotor RPM re-adjustment switch for both pilots.
- Electromagnetic brake and feel-spring assemblies for the cyclic and directional controls.
- Hydraulic actuators for lateral, longitudinal, collective pitch, and tail rotor controls.
- Tail rotor pitch limiting system.

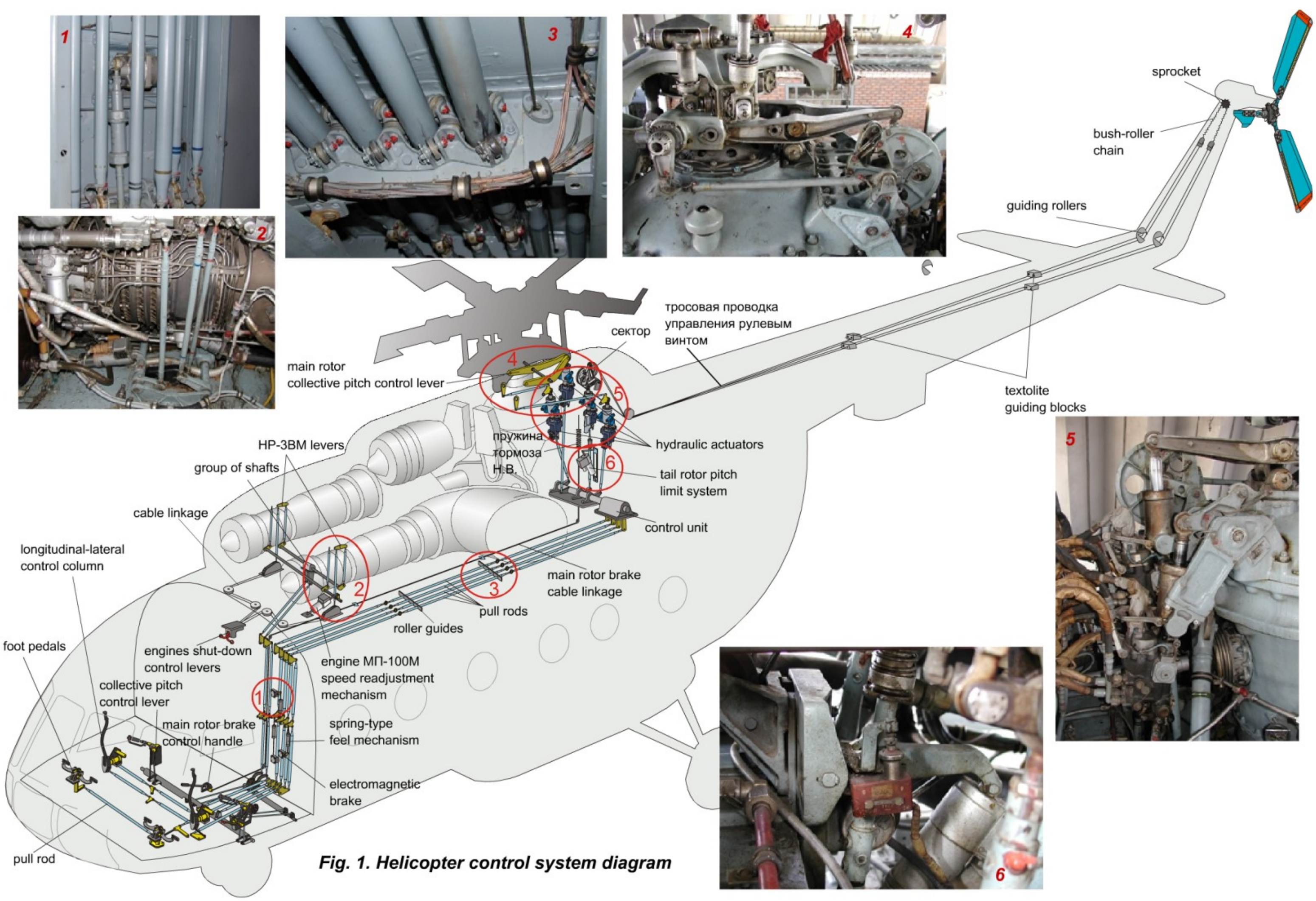


Fig. 1. Helicopter control system diagram

Hydraulic Actuators

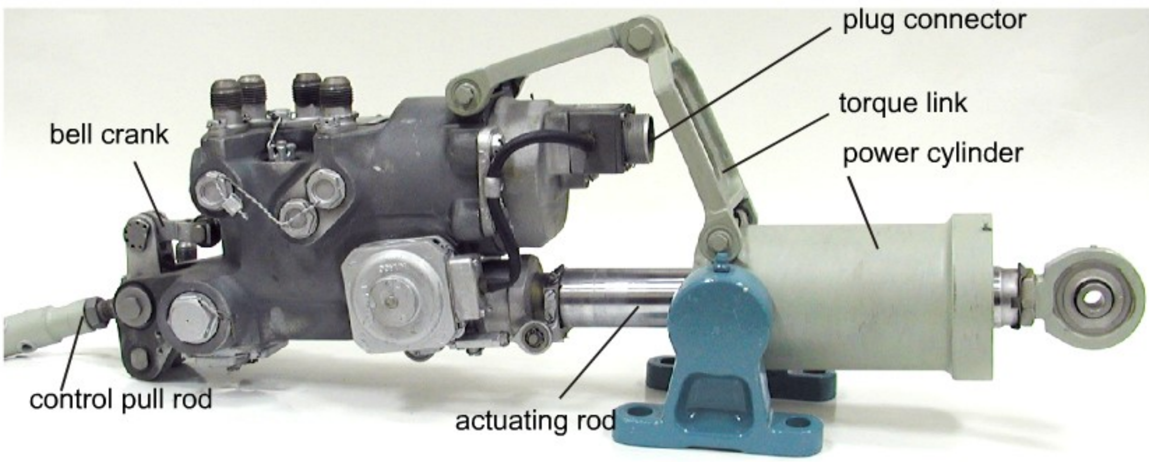
There are four hydraulic actuators mounted on the Mi-8.

- Longitudinal and Lateral actuators, controlled by the cyclic.
- Collective pitch actuator, controlled by the collective.
- Directional actuator, controlled by the foot pedals.

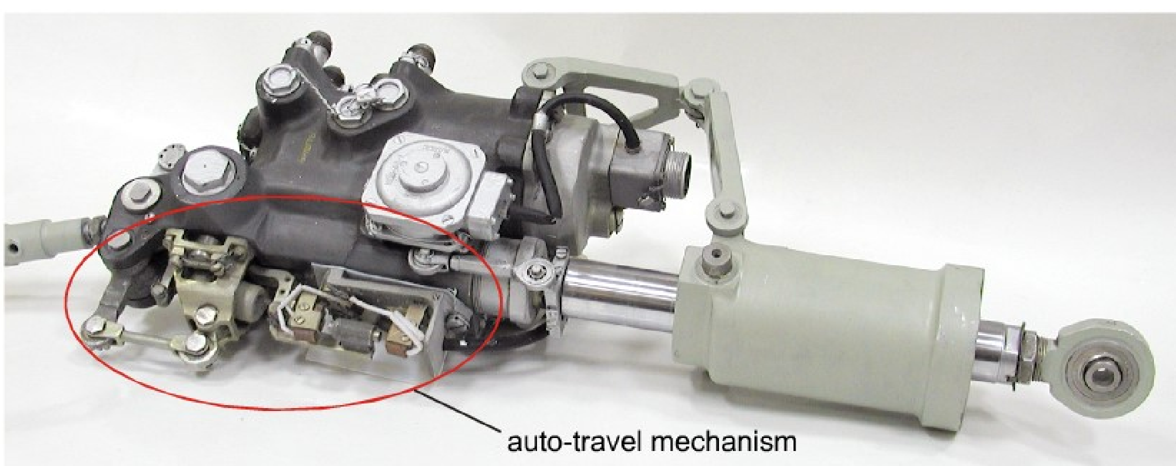
Each actuator has a control rod input from the pilot's controls, an electrical connector for receiving input signals from the AP-34B autopilot, and hydraulic connections for both the main and auxiliary hydraulic systems.

The Longitudinal, Lateral, and Collective actuators are of type KAU-30B. For safety reasons, the servo rod travel is limited to 20% from the autopilot.

The Directional actuator is of type RA-60B. The autopilot is allowed to move the servo rod through 100% of its travel range for this actuator.



Combination hydraulic actuator КАУ-30Б



Combination hydraulic actuator РА-60Б

Cyclic (Longitudinal/Lateral) Flight Controls:

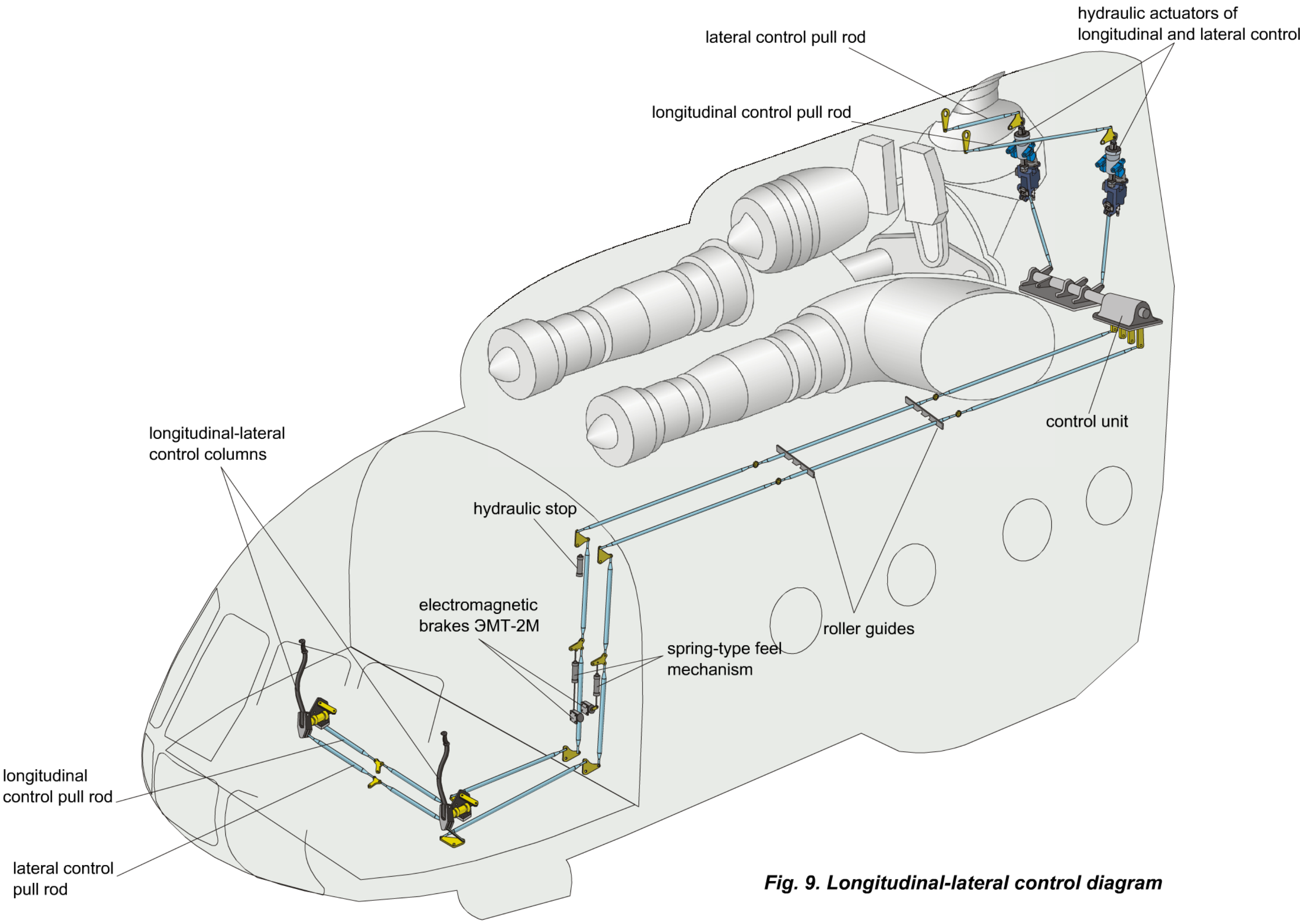


Fig. 9. Longitudinal-lateral control diagram

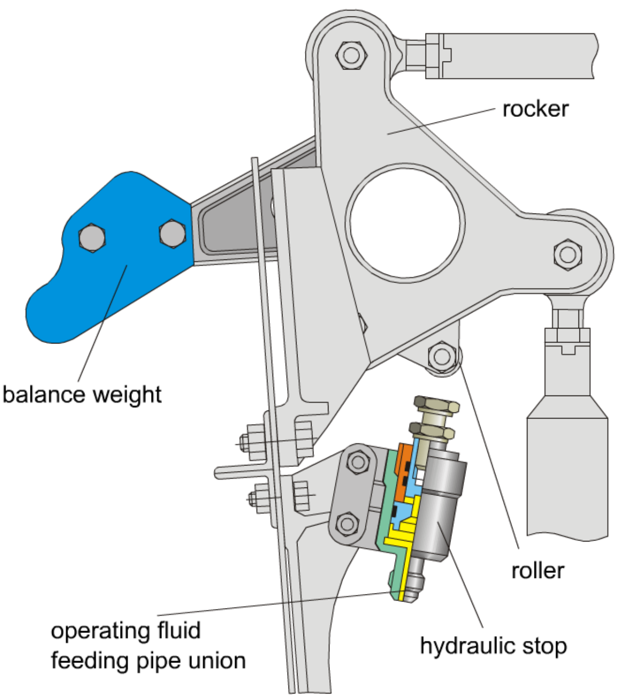
Longitudinal Stop

The longitudinal control shaft (for pitch, or fore-and-aft, movement) incorporates a longitudinal stop to prevent the pilot from applying to much aft cyclic while the helicopter is on the ground.

While operating on the ground (parked or taxiing), the hydraulic-powered stop is in an extended position, so that aft movement of the cyclic corresponding to 2° of swashplate tilt will cause the roller (attached to the flight control rods) comes into contact with the longitudinal stop.

Hitting the stop causes an increase in control forces required to move the cyclic to 12kg (26.2lb). In this way, the stop can be overridden by the pilot in an emergency, but the increase in required control force warns the pilot to stop puling aft on the cyclic.

Once the helicopter leaves the ground, the longitudinal stop retracts, and the swashplate can move through its entire range (5° aft) without difficulty.



Hydraulic stop in longitudinal control

EDIT: The electromagnetic valve that controls the longitudinal stop is the same type of electromagnetic valve used to turn the autopilot on and off, and also used for the hydraulic friction clutch for the collective.

When it receives power, it opens, allowing fluid to pass. So if it fails, or loses power, it is spring-loaded shut. I have never heard of a longitudinal stop getting stuck in the extended position, but I have seen them fail where they would not extend (requires the pilot to be very careful when taxiing).

Same goes for the weight on wheels switches...if the electricity to them fails, it's the same as if you are off the ground. So in just about every failure mode that's likely to occur, the stop will fail in the retracted position, not extended.

Directional (Tail Rotor/Yaw) Flight Controls

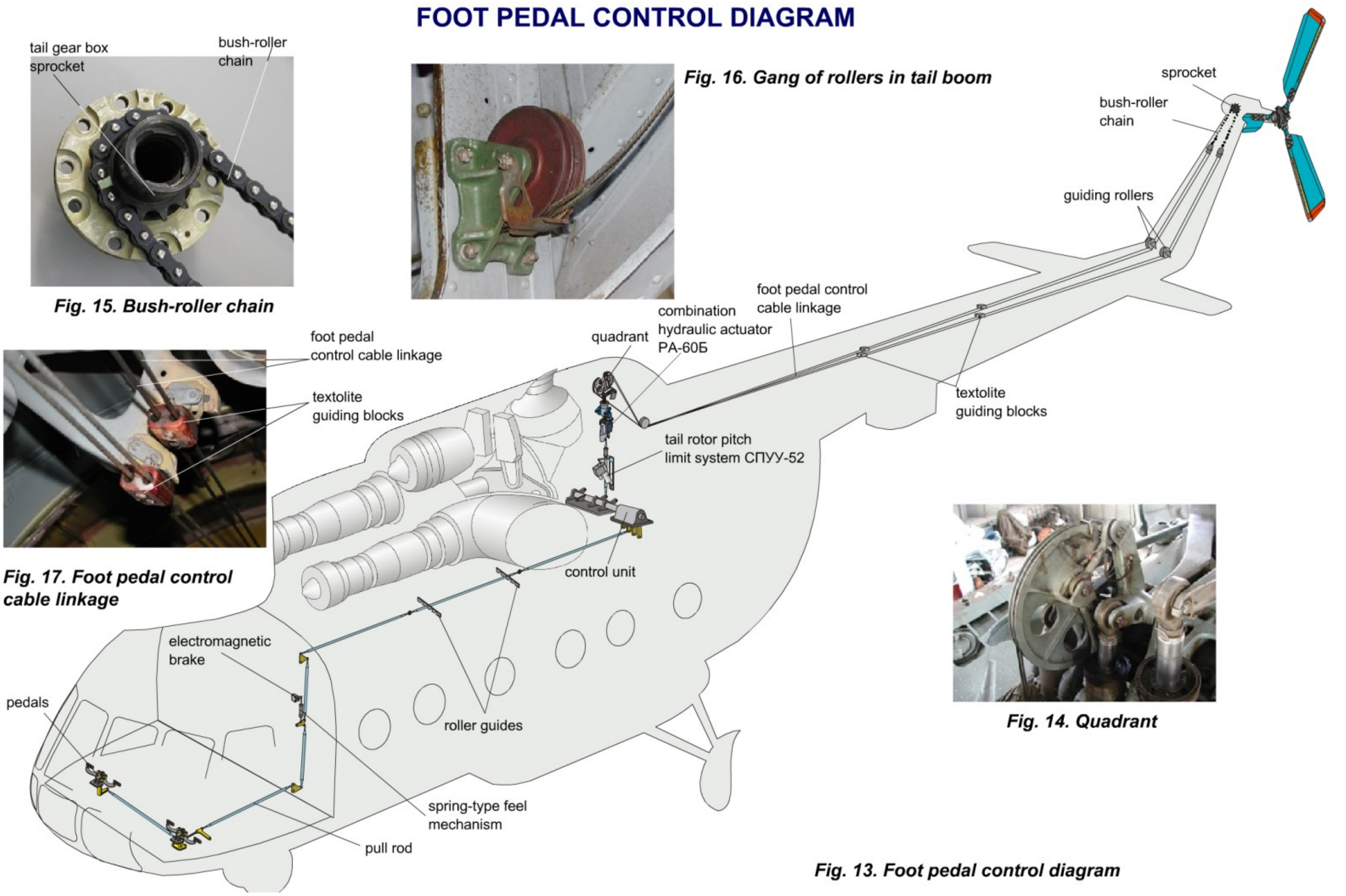


Fig. 13. Foot pedal control diagram

The pedals have microswitches in them. This basically tells the yaw channel of the autopilot when the pilot's feet are on the pedals. In this way, when the pilot's feet are OFF the pedals (not depressing microswitches), the autopilot will hold the helicopter's heading. When the pilot's feet are ON the pedals, the autopilot will not attempt to hold the aircraft's heading.

If the yaw servo (RA-60B) reaches the limit of its 20% authority, it will begin to move the control rod itself, and through the control rod, the foot pedals will move. So within the 20% authority built into the actuator, the pedals will not move due to autopilot input. Beyond this 20% authority, the auto-travel mechanism on the actuator will begin to move the foot pedals.

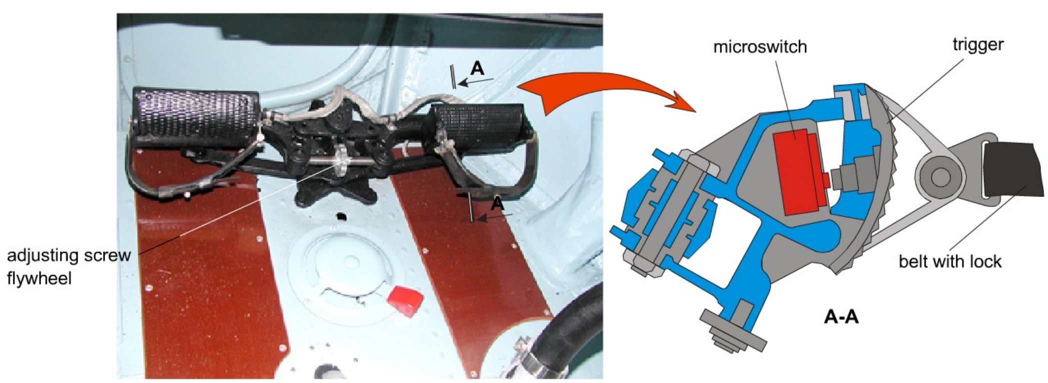


Fig. 18. Foot pedals

This allows the autopilot to have 100% control authority of the tail rotor when the pilot's feet are NOT on the pedals. Remember that when the pilot's feet are ON the pedals, the autopilot goes into "matching" or "synchronization" mode, where it actually has no input and the pilot provides all inputs (actually, the autopilot simply mirrors the pilot's inputs, resulting in the autopilot having no effect on the actuator position).

Tail Rotor Pitch Limit System SPUU-52

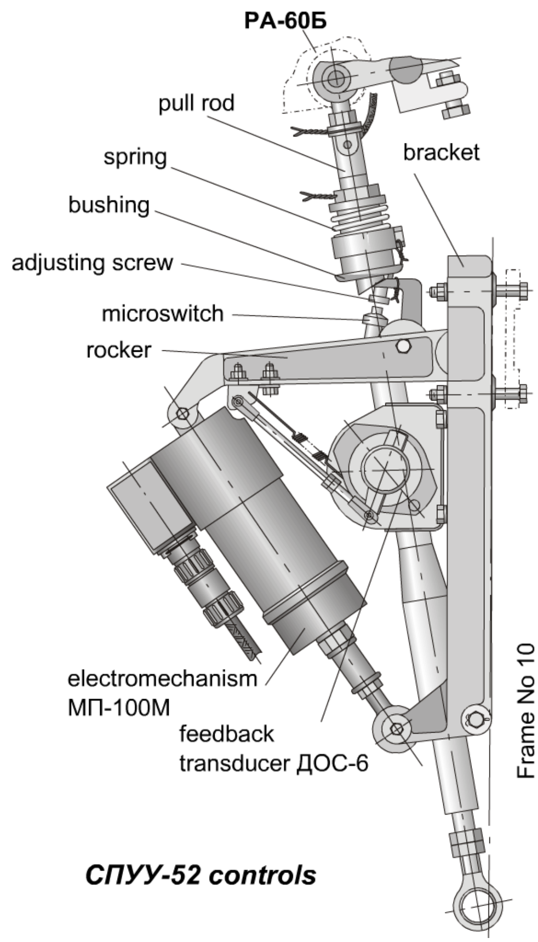
The tail rotor normally has a maximum pitch angle of 23°20’. At high air density (low altitude, cool day) this amount of pitch actually has a possibility of overloading the drive system. In order to prevent overloading the drive system, the tail rotor flight controls incorporate a pitch limiting system. This system decreases the amount of pitch available at higher air density. When fully limited, the tail rotor pitch is limited to 17°20’.

The system determines air density through the use of an air pressure sensor and a temperature sensor. A feedback transducer sends a signal to the control panel in the cockpit to indicate how far the electric actuator (MP-100M) is extended or retracted. The control panel in the cockpit is used to test the system, as well as visually determine the amount of extension of the actuator. At full extension of the actuator, tail rotor pitch is limited to 17°20’. At full retraction of the actuator, tail rotor pitch is not limited by this system, and can reach its full pitch of 23°20’. If the SPUU-52 system is receiving power, but is in the OFF position, the actuator fully retracts and the red lamp on the control panel lights up.

Control unit БУ-32
located on the central console

circuit breaker right panel

electric console left panel



СПУУ-52 controls

As you push on the right foot pedal, the control rod in the picture above moves downward (increasing pitch in the tail rotor blades). In high density air, the actuator (MP-100M) will be extended, and the rocker and stop will be higher than in the picture. The stop and the rocker are hinged together and held apart with a spring. This is why it sort of looks like Pac-Man or scissors or something.

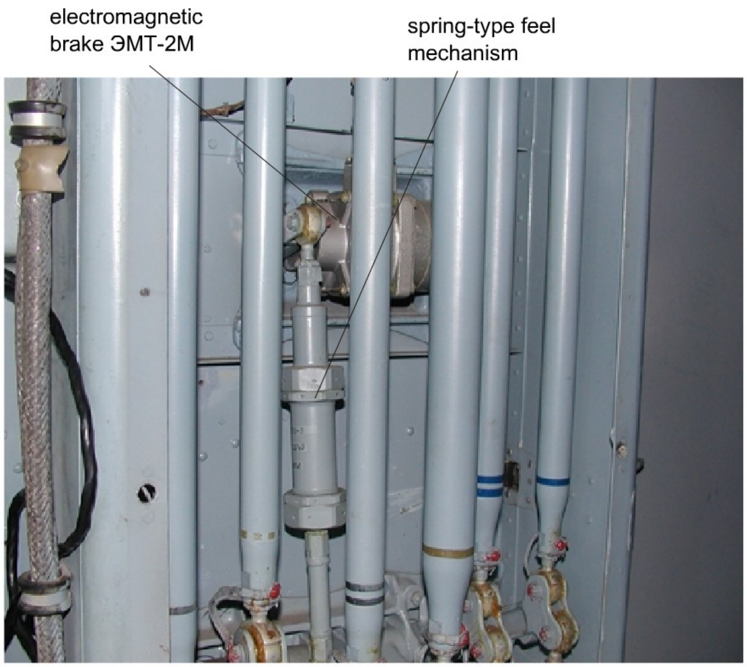
If you push too much right pedal, the bushing will come into contact with the stop. The stop is able to pivot slightly before it hits the rocker, at which point it can no longer move. Also, when the stop pivots onto the rocker, the microswitch is activated. The purpose of the microswitch is to temporarily disable the yaw channel of the autopilot, so the autopilot cannot continue to increase tail rotor pitch once the bushing hits the stop. (The autopilot yaw channel will begin to operate normally again once the stop moves away from the microswitch.)

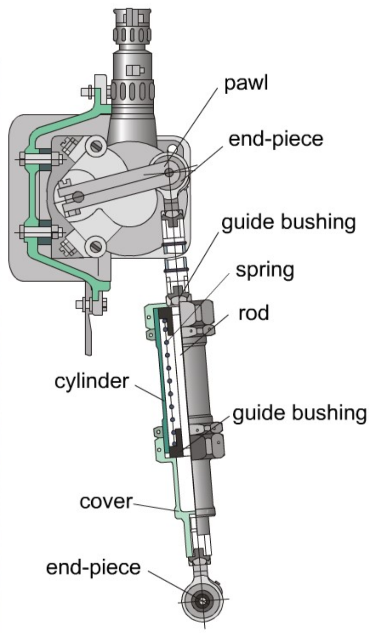
The bushing has a spring on it, so when the bushing, stop, and rocker are all in contact, this spring pressure alerts the pilot that he should stop applying right pedal input. The pilot can overcome some of the limit by pushing past the spring in an emergency, but not in normal flight...the pilot will stop pushing the pedal immediately upon feeling the spring resistance.

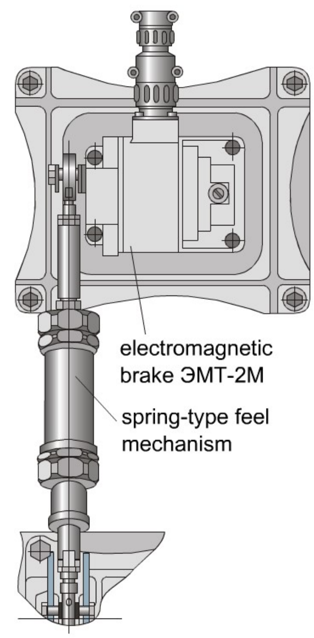
The feedback transducer is what tells the control panel where to move the actuator indicator (the white bar that moves left to right in the control panel window). When the actuator is fully retracted and no limiting is in effect, the white bar indicator will displace to the extreme left. As the actuator extends and pedal travel becomes more limited, the bar will move to the right.

Electromagnetic Brakes and Sprint-Type Feel Mechanisms

The lateral, longitudinal, and directional flight controls have mag brakes and feel springs to keep the cyclic and foot pedals in place. When the TRIMMER button is depressed on either cyclic control, all three mag brakes are energized and become free to move. In this way, control forces are removed and there is nor spring force to override to move the cyclic or pedals. When the TRIMMER button is released, the mag brakes are de-energized and no longer move. All cyclic and pedal control movements then must overcome the spring tension in the feel mechanisms.





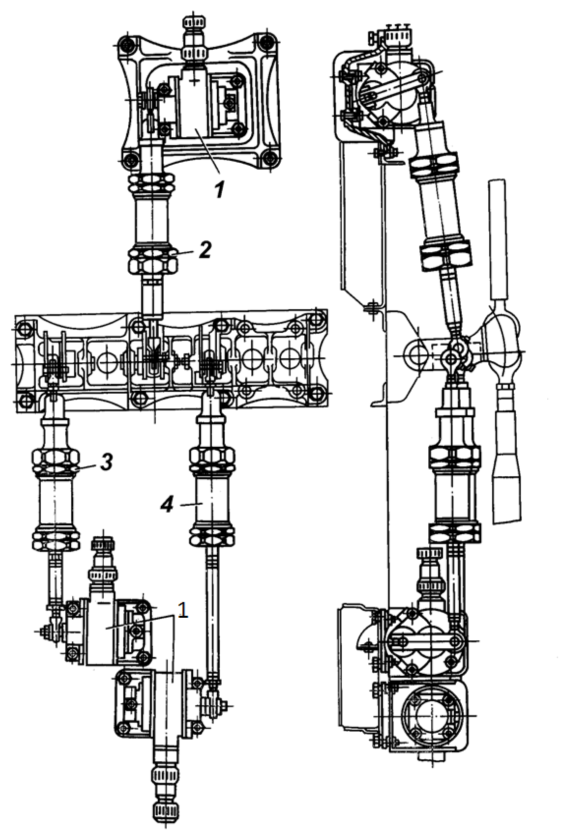


Each spring is set to a different maximum tension, but they all start at 9.1kgf (20lb). This initial tension must be overcome to begin moving the controls. As the controls move further and further without pressing the TRIMMER button, the tension increases in a linear fashion, up to the maximum, as listed below:

Foot pedals: 53 kgf (117lbf)

Lateral (left-right cyclic): 43kgf (95lbf)

Longitudinal (fore-aft cyclic): 55.4kgf (122lbf)



1. Electromagnetic brakes
2. Directional control spring-type feel mechanism
3. Lateral control spring-type feel mechanism
4. Longitudinal control spring-type feel mechanism

Collective Pitch and Engine Controls

The collective control, through control rods, connects to both the swashplate (to increase or decrease collective pitch of the main rotor) and to the engines (to increase power as the collective is raised, and reduce power when lowered).

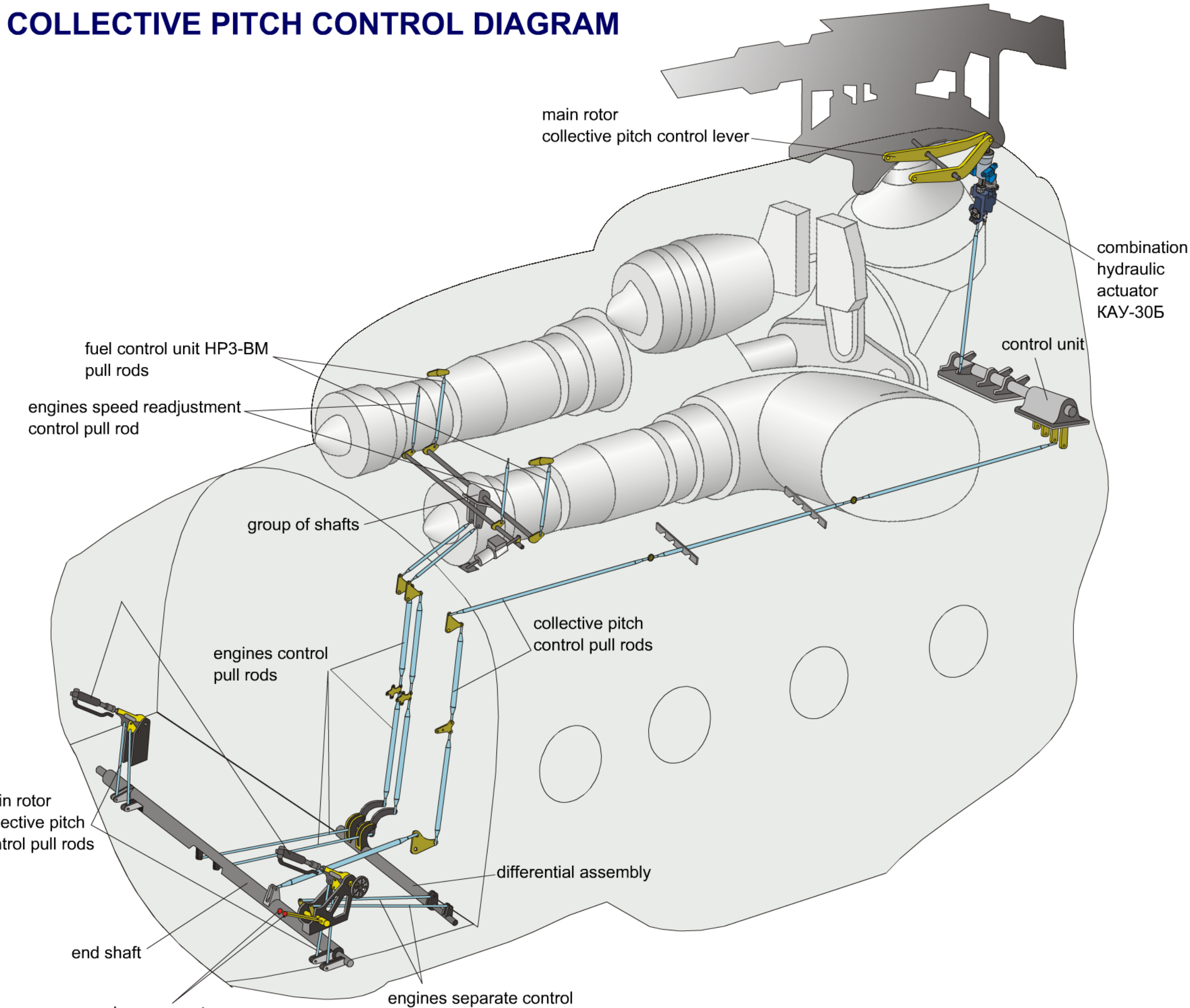
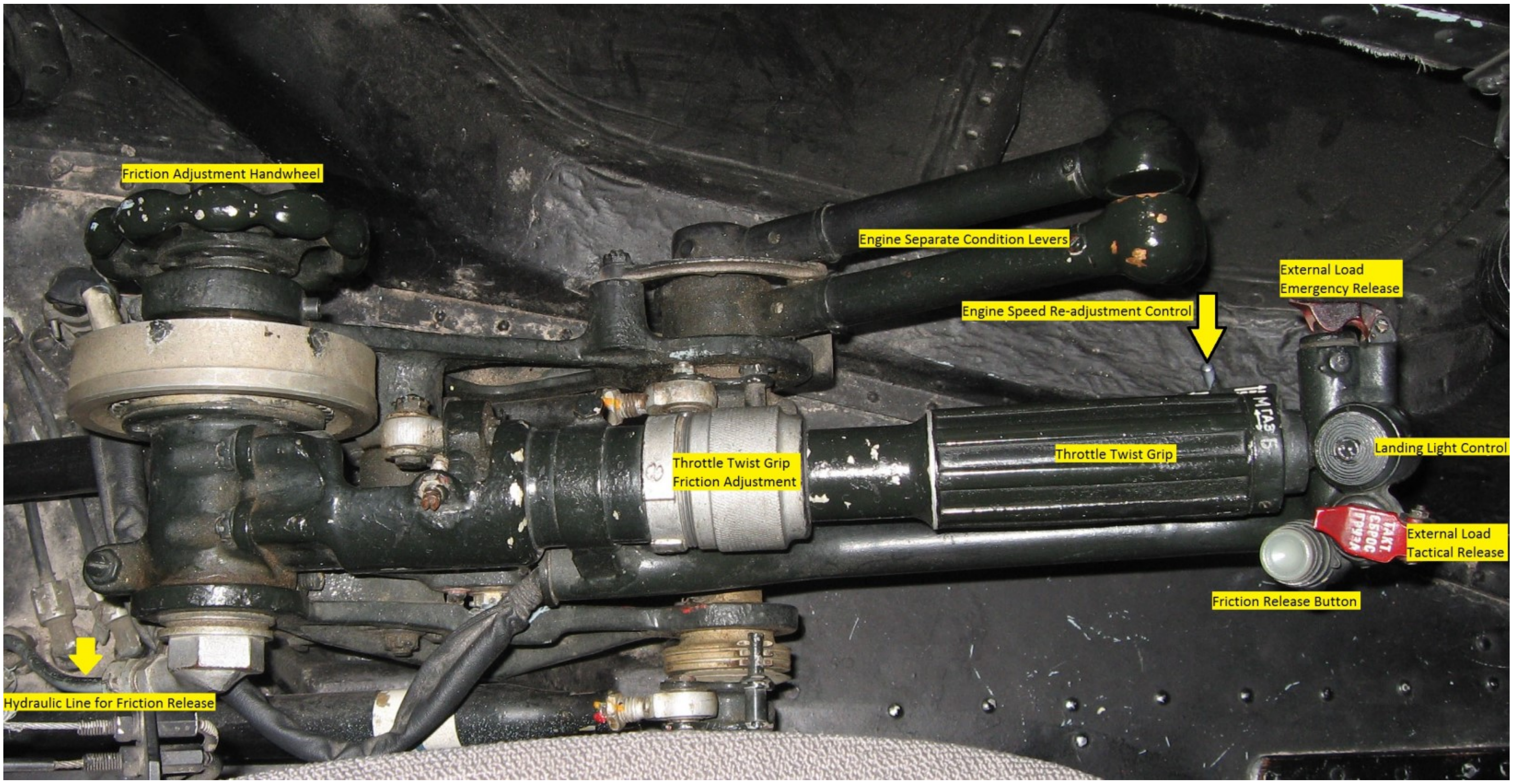


Fig. 23. Collective pitch control diagram

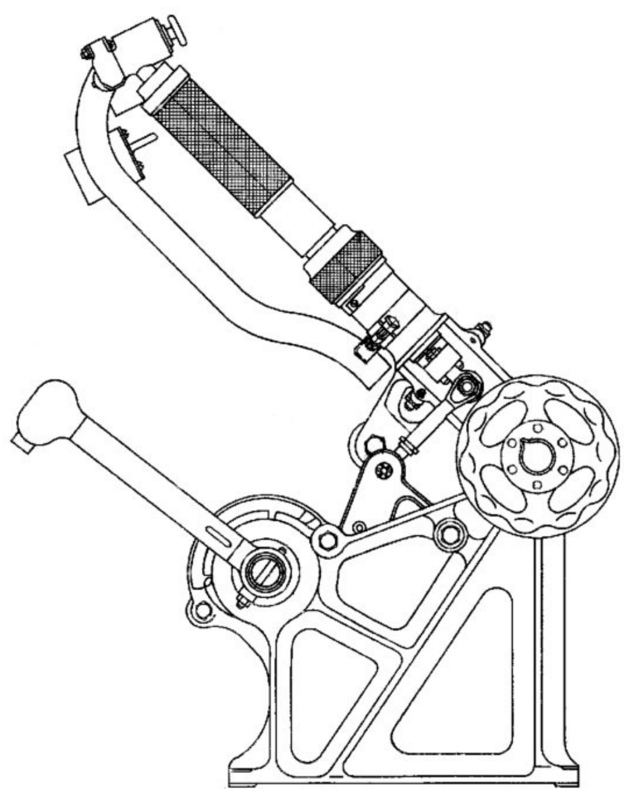
When the collective control lever is moved up and down, the power setting for both engines is increased at the same time and by the same amount. For testing and emergency purposes, there are also two independent engine condition levers provided to allow changing the power settings of each engine individually. The engine condition levers are mounted on the pilot's (left seat) collective assembly only. The co-pilot (right seat) does not have access to the engine condition levers.

The collective friction assembly, likewise, only exists on the pilot's collective, although both pilots have a friction release button in order to remove the collective friction force. The amount of friction (without pressing the friction release button) can be adjusted using the handwheel on the left side of the collective friction assembly. Adjusting the handwheel loosens or tightens spring force against a friction plate within the assembly, thereby reaming or adding friction force. Pressing the friction release button on either collective control cause hydraulic pressure to push against the friction plate to remove this friction force.



Pressing the collective friction release also disengages the autopilot altitude channel, if it was engaged. If desired, the autopilot altitude channel can be re-engaged after the friction release button is released by pressing the altitude channel button on the autopilot control panel.

The collective control also includes a throttle twist-grip. When the throttle is fully opened (twisted to the right, or clockwise looking from behind) the engines are set to automatically maintain the proper main rotor speed. This setting is analogous to the AUTO setting for the throttles in the Ka-50. Turning the twist grip to the left disables automatic rotor speed control and gradually reduces engine power to the idle setting when the twist grip is fully closed (turned to the left).



The engine separate condition levers can be moved through a range, and includes three detent positions. During normal operations, the separate engine condition levers are left in their middle position, and engine power changes are introduced using the twist grip throttle and movements of the collective up and down. During emergencies or for testing, each engine condition lever can be moved up or down separately from its central position, with the lower position corresponding to idle power. When moved to the full up position, the engine will produce full power.

Engine Speed Re-Adjustment Control

In order to maintain the main rotor RPM within the desired range, both pilots' collective controls include an engine speed re-adjustment control. The switch on the control is spring loaded to its central position. Pressing the switch forward increases main rotor RPM, while pressing the switch to the rear decreases main rotor RPM. This switch adjusts the fuel controls for both engines simultaneously.

Fig. 25. Switch ОБОРОТЫ БОЛЬШЕ- МЕНЬШЕ (Speed Increase-Decrease)

The INCR-DECR switch is just to set what RPM you want the engines to be set to. For example, the nominal RPM for the rotor during fight is 95%. You check this on the ground by pulling in 3 degrees of pitch with the collective. If the rotor RPM is not at 95%, you use the INCR-DECR switch (engine speed re-adjustment control) to set the rotor at 95%. Then you are done and you don’t touch it anymore after that. In most cases, you never have to touch that switch at all, except during testing.

Periodically, the engine speed re-adjustment mechanism is tested. During this test (with the aircraft running) the adjustment range is tested. The manual specifies that the bottom value for the test is 91% rotor RPM, plus or minus 2% (hence 89-93%). At the top end, the value is 97%, with a plus 2% or minus 1% variation (hence 96-99%).

Before flight, the rotor is brought to 3 degrees of pitch with the collective, and the rotor RPM is verified to be at 95%. If it's not, this switch is used to make it 95%. I have never seen any information in a Mi-8 manual that says its okay for the pilot to choose another rotor RPM setting, and I can't really see any value in it, either.

Engine Shutdown Levers

The engine shutdown levers (not to be confused with the engine fuel shutoff valves), are located on the cockpit ceiling above the pilot's seat.

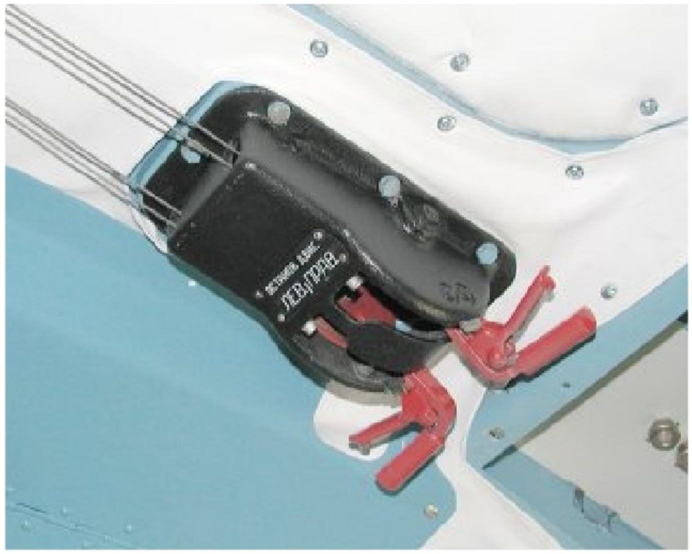


Fig. 27. Engines shut-down control levers

When in the aft position, fuel from the engine fuel control is shut off from the engine fuel manifolds. When in the forward position, fuel is permitted to flow into the engine fuel manifolds and into the combustion chambers.

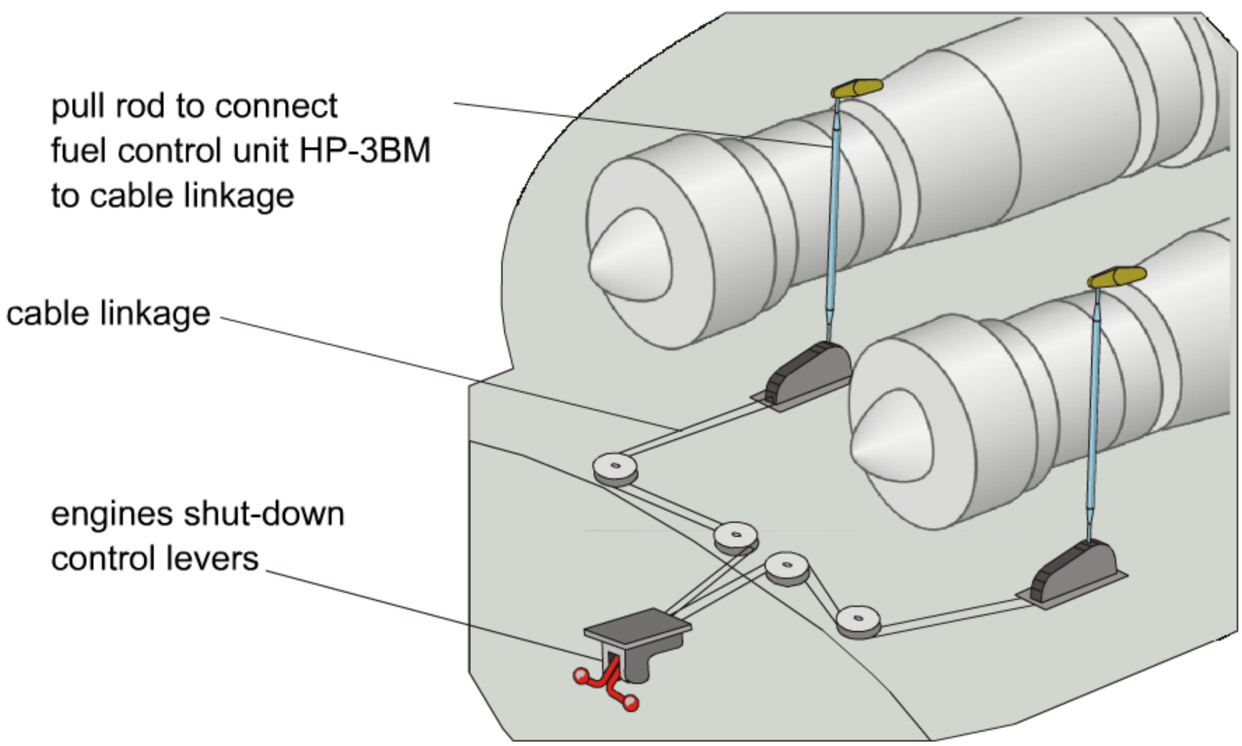


Fig. 26. Engines shut-down control diagram

Differences between pilot and copilot collective controls

It should be noted that the copilot (right seat) collective control lacks several of the controls available to the pilot (left seat).

The following lists the available controls to the pilot. The list items in bold are ONLY located on the pilot's collective control assembly. Items not in bold are available on both collective assemblies:

- Collective Control Lever
- Throttle Twist Grip
- **Throttle Twist Grip Friction Adjustment**
- **Collective Friction Adjustment Handwheel**
- Collective Friction Release Button
- **External Cargo Emergency Release Button**
- **External Cargo Tactical Release Button**
- **Individual Engine Condition Levers**
- Engine Speed Re-adjustment Switch
- Landing Light Control (there are two landing lights, one for each pilot)