3.3 Full-Feathering and Constant-Speed Governing Systems

3.3.1 Principle

A constant-speed (RPM) system permits the pilot to select the propeller and engine speed for any situation and automatically maintain that RPM under varying conditions of aircraft attitude and engine power. Thereby permitting operation of propeller and engine at most efficient RPMs. RPM is controlled by varying the pitch of the propeller blades that is, the angle of the blades with relation to the plane of rotation. When the pilot increases power in flight, the blade angle is increased, the torque required to spin the propeller is increased and, for any given RPM setting, aircraft speed and torque on the engine will increase. For economy cruising, the pilot can throttle back to the desired manifold pressure for cruise conditions and decrease the pitch of the propeller, while maintaining the pilot-selected RPM.

A full-feathering propeller system is normally used only on twin-engine aircraft. If one of the engines fails in flight, the propeller on the idle engine can rotate or "windmill", causing increased drag. To prevent this, the propeller can be "feathered" (turned to a very high pitch), with the blades almost parallel to the airstream. This eliminates asymmetric drag forces caused by wind milling when an engine is shut down. A propeller that can be pitched to this position is called a full-feathering propeller.

Changing Pitch

Pitch is changed hydraulically in a single-acting system, using engine oil controlled by the propeller governor to change the pitch of the propeller blades. In constant speed systems, the pitch is increased with oil pressure. In full-feathering systems, the pitch is decreased with oil pressure. To prevent accidentally moving the propellers to the feathered position during powered flight, which would overload and damage an engine that is still running, the controls have detents at the low RPM (high pitch) end.

In a single-acting propeller system, oil pressure supplied by the governor, acting on the piston produces a force that is opposed by the natural centrifugal twisting moment of the blades in constant speed models or counterweights and large springs in full-feathering systems. To increase or decrease the pitch, high pressure oil is directed to the propeller, which moves the piston back. The motion of the piston is transmitted to the blades through actuating pins and links, moving the blades toward either high pitch for constant-speed systems or low pitch for full-feathering systems.

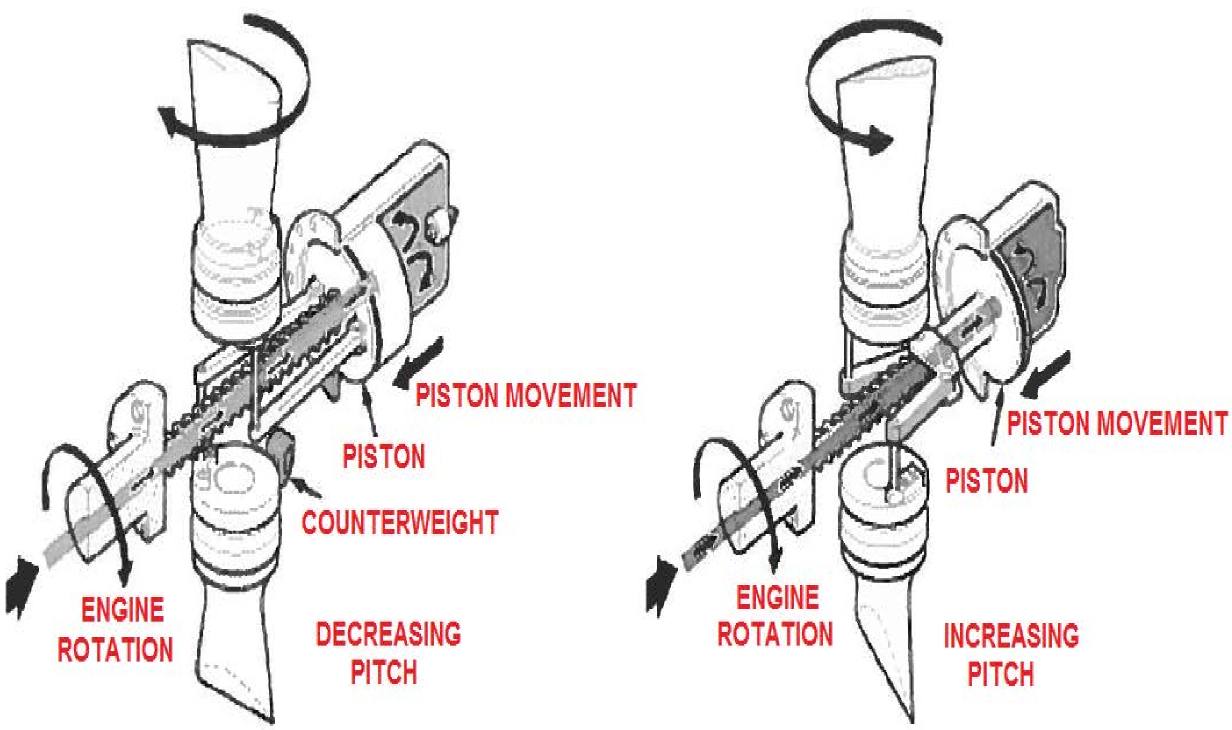

Figure 3.7: Supplying oil pressure - Counterweighted and non-counterweighted (Diagram courtesy of McCauley-Textron)

When the opposing forces are equal, oil flow to the propeller stops and the piston also stops. The piston will remain in this position, maintaining the pitch of the blades until oil flow to or from the propeller is again established by the governor.

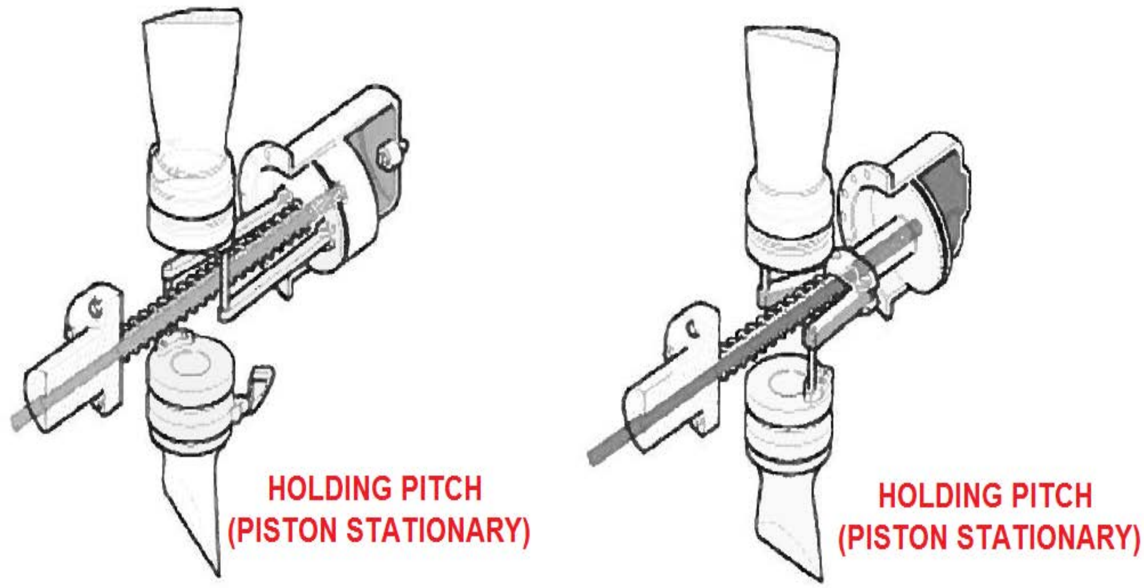

Figure 3.8: Holding oil pressure - Counterweighted and non-counterweighted (Diagram courtesy of McCauley-Textron)

From this position, pitch is decreased for constant-speed systems or increased for full feathering systems by allowing oil to flow out of the propeller and return to the engine sump. When the governor initiates this procedure, hydraulic pressure is decreased and the piston moves forward, changing the pitch of the blades until oil flow to or from the propeller is again established by the governor.

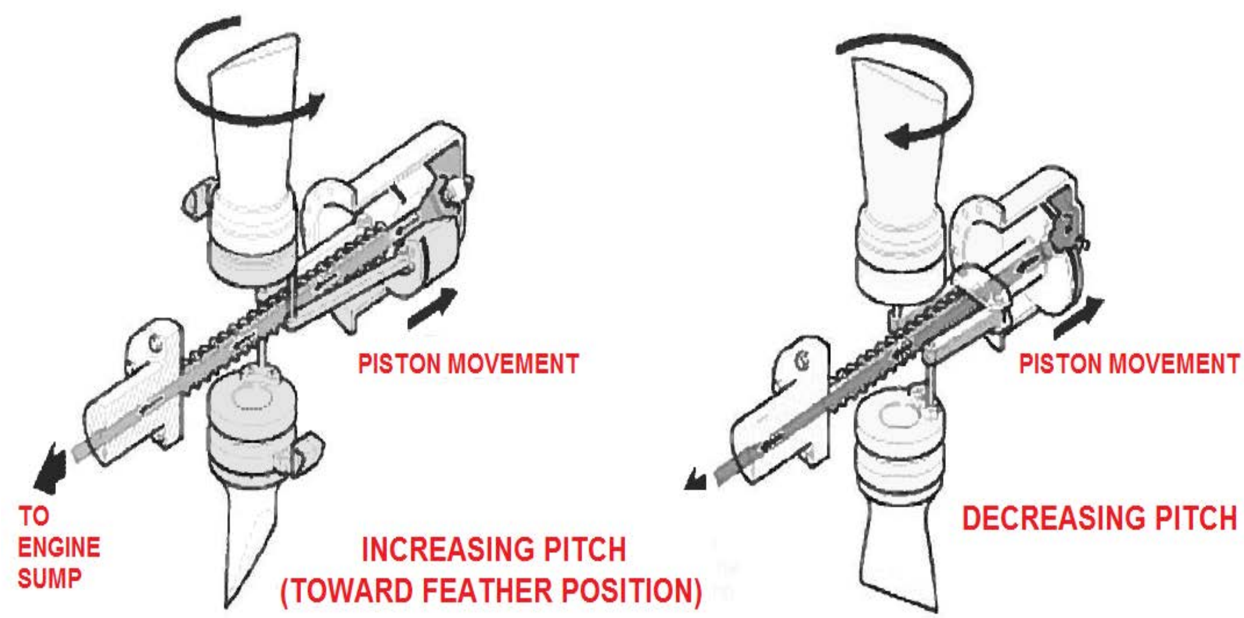

Figure 3.9: Releasing Oil Pressure - Counter-weighted and non-counterweighted (Diagram courtesy of McCauley-Textron)

3.3.2 The Governor

Besides the propeller, the other major component of the system is the governor. Each governor mounts on and is geared to the engine, which drives the governor gear pump and the flyweight assembly. The gear pump boosts engine oil pressure to provide quick and positive response by the propeller. The rotational speed of the flyweight assembly varies directly with engine speed and controls the position of the pilot valve. Depending on its position, the pilot valve will direct oil flow to the propeller, allow oil flow back from the propeller, or assume a neutral position with no oil flow. These oil flow conditions correspond to increasing pitch, decreasing pitch or constant pitch of the propeller blades.

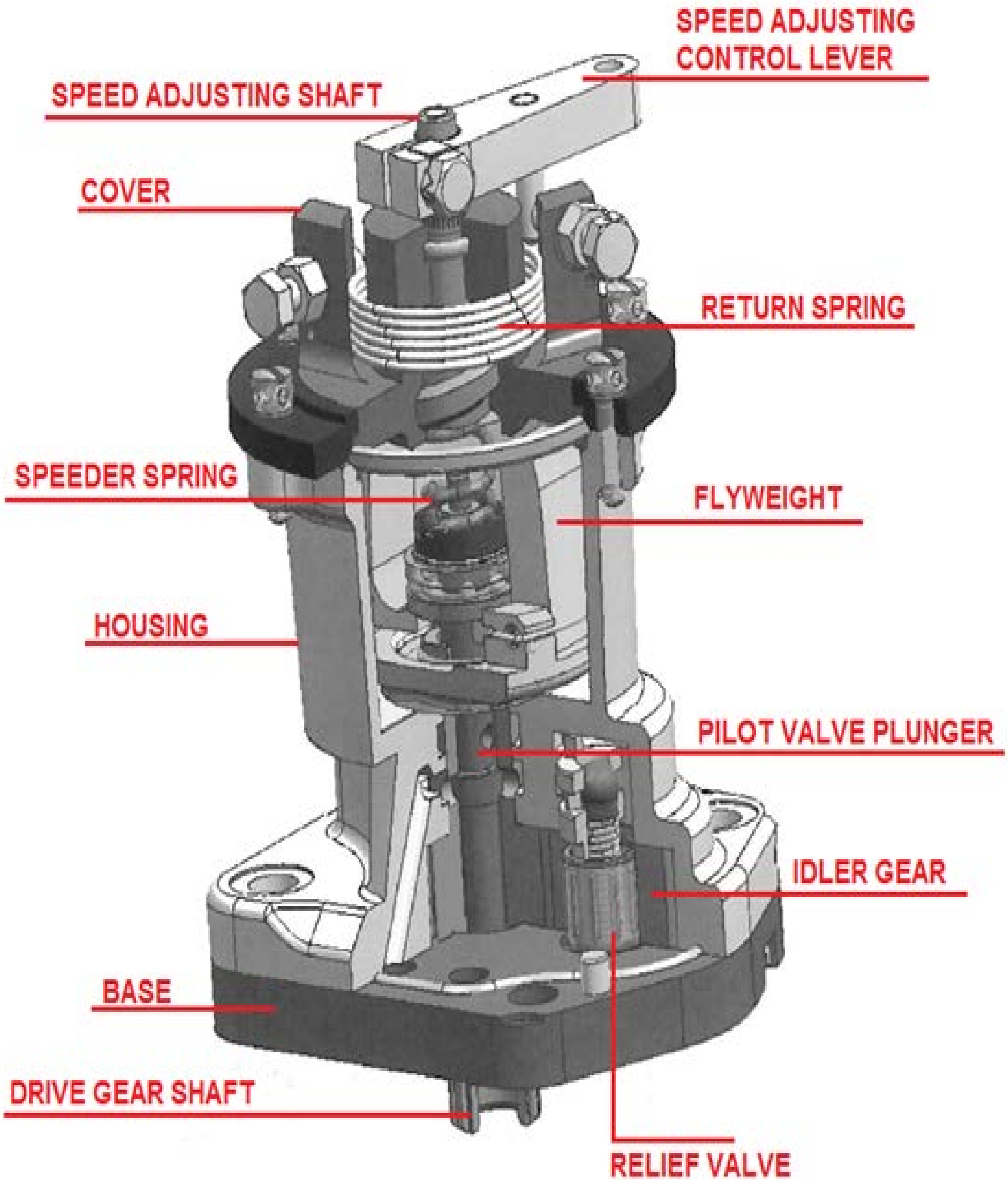

Figure 3.10: Sectioned view of a propeller governor

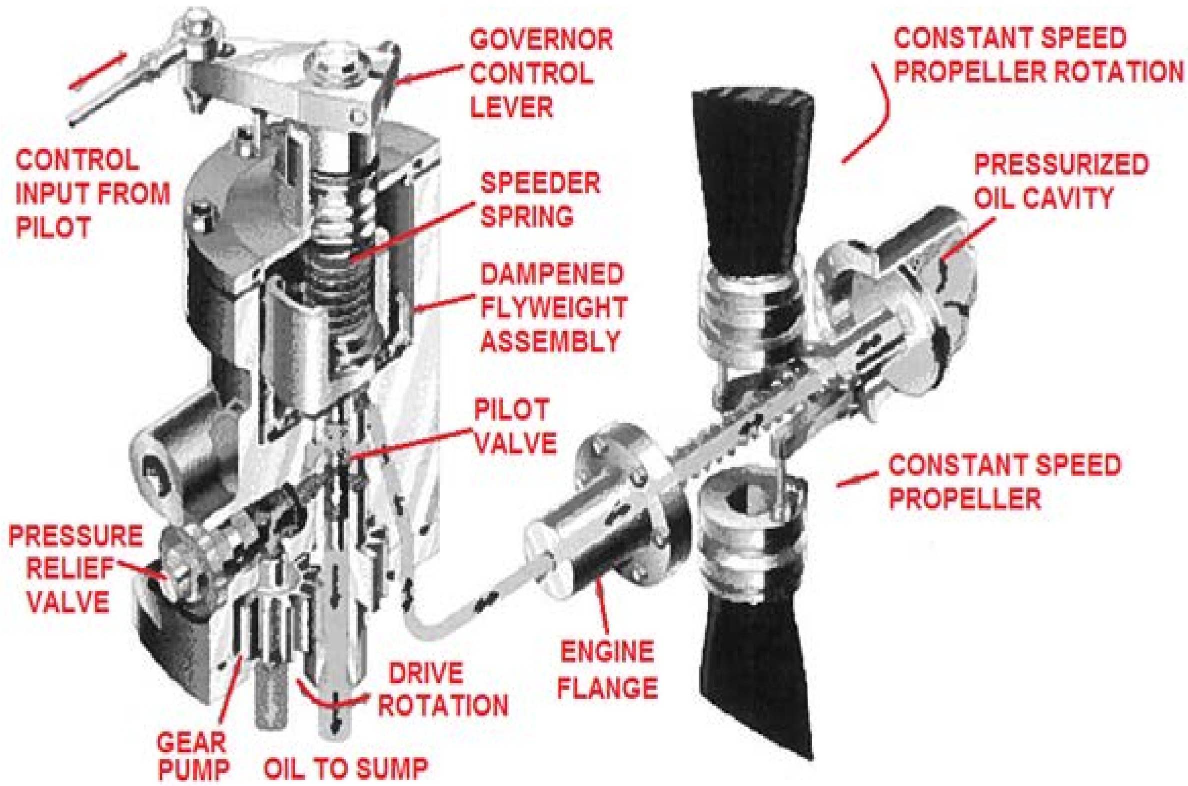

Figure 3.11: PCD/Governor system layout (Diagram courtesy of McCauley-Textron)

The propeller governor maintains *a* constant engine speed by controlling propeller pitch. Engine speed is selected by a cockpit control connected to the governor speed control shaft.

The governor consists of a gear-type oil pressure boost pump and a spring-loaded governor, which are driven through gearing from the engine crankshaft. Several valves control oil flow through the governor.

The boost pump receives oil from the engine pressure oil system and boosts the pressure to the value necessary for satisfactory propeller operation. The spring-loaded governor operates a pilot valve, which moves up and down in the drive shaft of the boost pump and controls the delivery of this oil to the propeller by opening or closing ports in the drive shaft.

The governor mechanism consists of two L-shaped flyweights, the inner ends of which lift under a ball-race attached to the pilot valve. These flyweights act against a conical spring whose pressure is controlled from the cockpit through a linkage, control shaft, pinion and rack.

When oil from the governor is not required by the propeller, it is bypassed through a relief valve. A feathering valve in the base of the governor admits oil from the feathering pump to the propeller. The feathering valve is spring-loaded and normally supplies oil to the propeller from the governor boost pump.

3.3.3 Governor Operation

Governor flyweights and the attached pilot valve tend to adjust themselves to the ON SPEED (neutral) condition. The RPM at which the ON SPEED condition is reached depends on governor spring force, which is controlled from the cockpit. Since the governor is driven through gearing from the crankshaft, governor RPM is proportional to engine RPM.

When the governor is in the ON SPEED condition centrifugal force generated by the flyweights is balanced by governor spring force and the pilot valve exactly covers ports in the boost pump drive shaft so that no oil can get in or out of the propeller; consequently the pitch does not change.

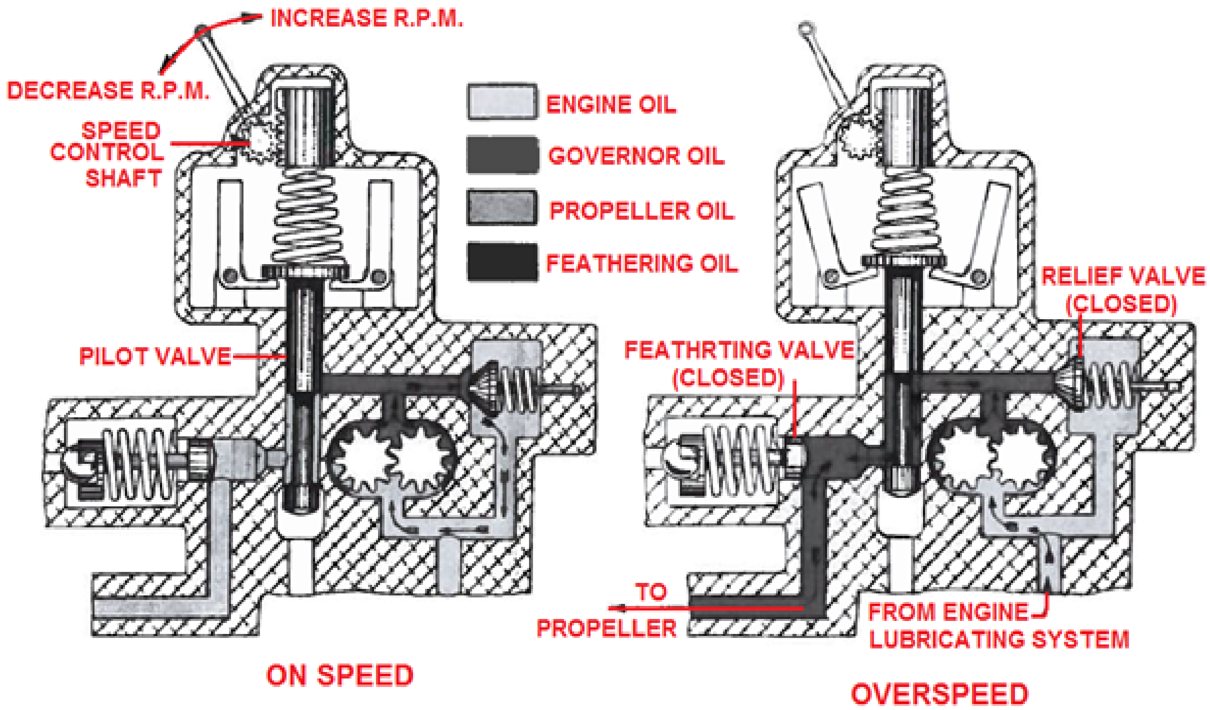

Figure 3.12: Governor operation - On Speed and Overspeed

If engine speed starts to increase the governor will react to the OVERSPEED condition. Flyweight force exceeds governor spring force, lifting the pilot valve and allowing high-pressure oil to enter the propeller. This increases the propeller pitch and brings the engine RPM back to the selected value. As engine and governor RPM decrease the governor returns to the ON SPEED condition.

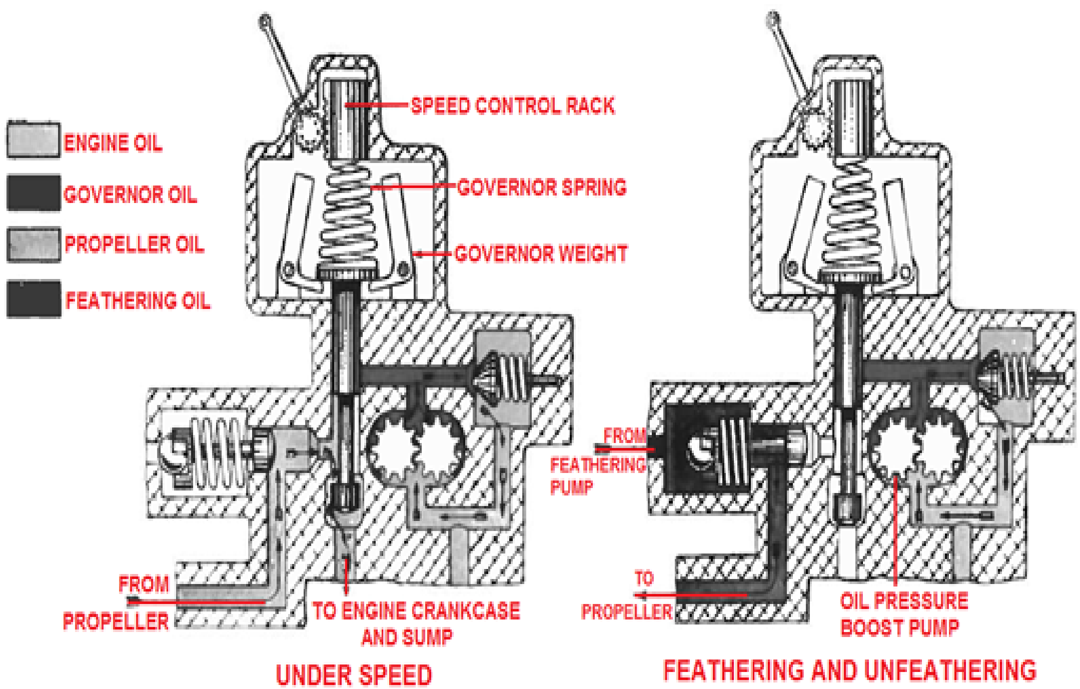

Figure 3.13: Governor operation - Under Speed, Feathering and Unfeathering

If engine speed starts to decrease the governor will react to the UNDERSPEED condition. Governor spring force exceeds flyweight force, dropping the pilot valve and allowing high-pressure oil to exit the propeller. This decreases the propeller pitch and brings the engine RPM back to the selected value. As engine and governor RPM decrease the governor returns to the ON SPEED condition.

When the cockpit feathering button is pressed the feathering pump is actuated and supplies high-pressure oil to the base of the propeller governor. The feathering oil acts on the spring-loaded feathering valve, which routes feathering oil to the propeller in place of governor oil.

3.3.4 Cockpit Control

The cockpit control lever is connected to the governor control lever which in turn is attached to a threaded shaft. As the lever is moved, the threaded shaft turns and moves up or down to increase or decrease compression on the speeder spring. For example, when the cockpit control is moved forward, the governor control shaft is screwed down, increasing compression on the spring. This increases the speed necessary for the flyweights to move the pilot valve and produces a higher RPM setting. The cockpit control lever allows the aircraft pilot to shift the range of governor operation from high RPM to low RPM or any area in between.

Note that the RPM setting is made by varying the amount of compression in the speeder spring. Positioning of the speeder spring rack is the only action controlled manually. All others are controlled automatically within the governor.

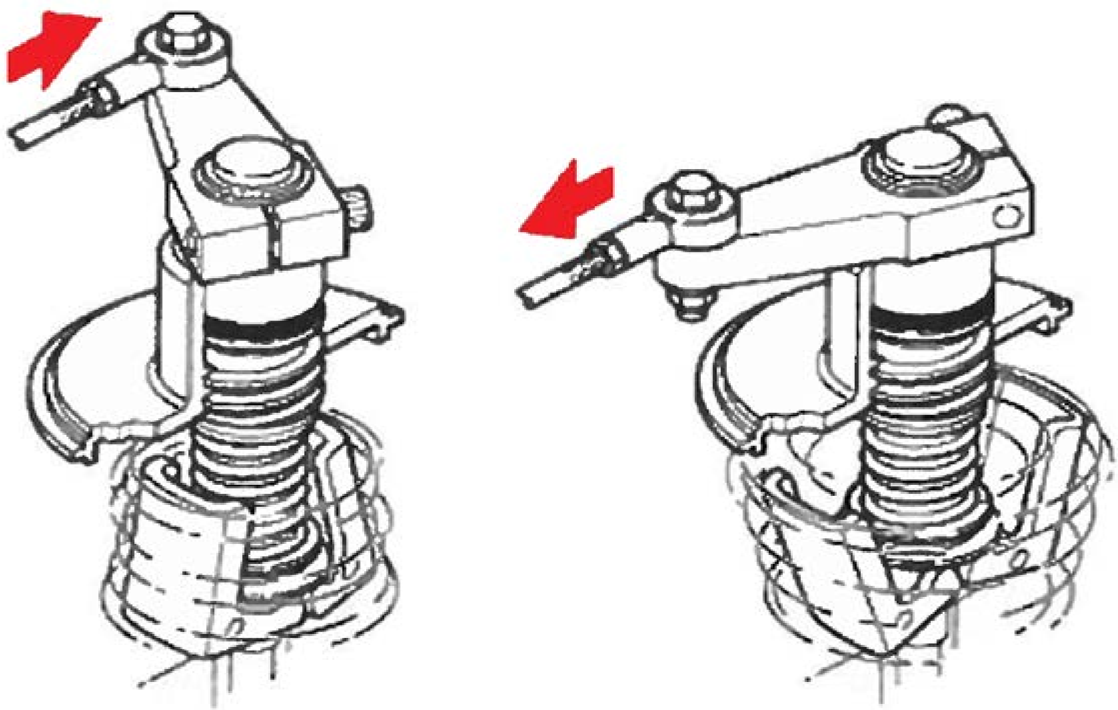

Figure 3.14: Governor operation - Cockpit control
(Diagram courtesy of McCauley-Textron)

This system results in constant speed by producing what is known as an 'on speed' condition, which exists when the RPM is constant. Movement of the cockpit controls have set the speeder springs at the desired RPM. The flyweights have positioned the pilot valves to direct oil to or from the propellers.

This, in turn, has positioned the propeller blades at a pitch that absorbs the engine power or RPM selected. When the moment of RPM balance occurs, the force of the flyweights equals the speeder spring load. This positions the pilot valves in the constant RPM position with no oil flowing to or from the propellers.

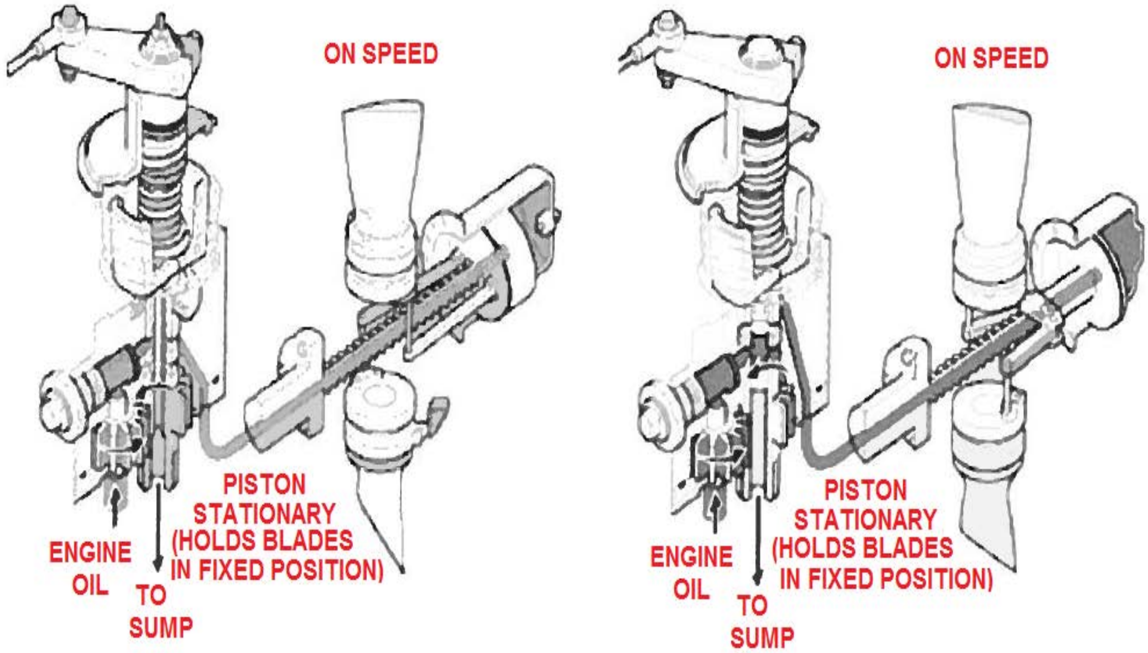

Figure 3.15: Governor/PCU operation - On Speed (counterweighted and non-counterweighted propellers) (Diagram courtesy of McCauley-Textron)

At constant-speed, an over speed condition results and airspeed increases when the aero plane begins a descent or engine power is increased. Since the pitch of the propeller blades is too low to absorb engine power, the engine RPM begins to increase. At the instant this happens, however, the flyweights move out and raise the pilot valves, causing oil to flow from the propellers in a full-feathering system (Figure 3.16 A) and to the propeller in a constant-speed system (Figure 3.16 B), increasing the pitch of the blades in both cases. Engine speed then slows to the original RPM setting.

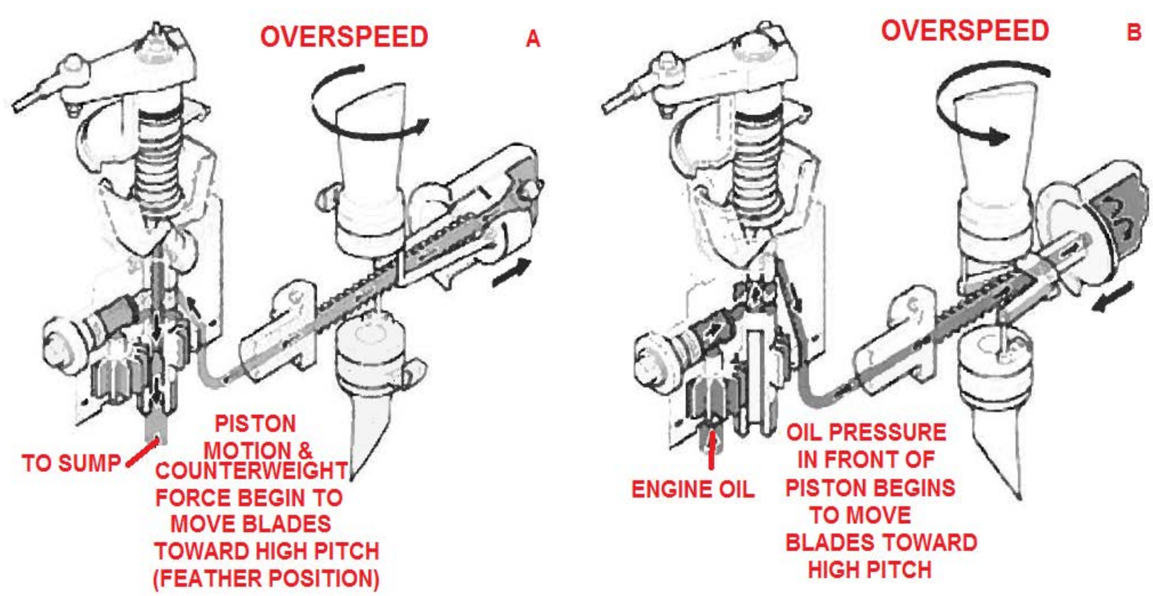

Figure 3.16: Governor/PCU operation – Overspeed (counterweighted and non-counterweighted propellers) (Diagram courtesy of McCauley-Textron)