The Propeller Governors and the PC12

By John Morris

This article was created after attending the 13th Annual Pilatus Owners and Pilots Association (my 9th in-a-row!). I just want to take a moment to commend the POPA board, and Laura Mason, for again putting on a great convention. Given the current economic upheaval I was pleasantly surprised at the attendance and enjoyed the selection of discussions made available to the attendees and of course, the accommodations and amenities. But I will digress to the reason for this article.

While attending this year's POPA convention I had a chance to talk with some Air Force pilot's who operate the PC12 (designated the U-28A). I had heard through the grapevine that their version of the PC12 is operated a little harder than the way that, hopefully, none of us drive the civilian version. I was informed that they had encountered, during their "normal" operations, a propeller overspeed that resulted in the shutdown of the engine. Upon inspection of the engine/propeller governor it was determined that the governor CSU drive shaft had failed due to excessive wear, possibly due to corrosion (gee, couldn't be from were they operate? Duh!). To my memory this is the first confirmed time that I have ever heard of an actual propeller overspeed (turboprop), let alone one requiring the shut down of the engine [see POH-Section 3-Emergency Procedures, 3.6.6 or 3.6.7 Propeller-Overspeed (MSN 101-888) or 3.6.2 Engine – NP for /NG aircraft].

This brought to mind the numerous discussions that I have had over my years of flying/instructing regarding PT6A propeller governing and the associated protections related to the propeller RPM of turboprop engines. So I will now review the operation principles surrounding the propeller governors as they relate to the PT6A-67B/P engines and the associated emergency procedures and then look at why the U-28A had to shut down its engine.

As stated from the Pilot's Operating Handbook (POH), Section 7, Airplane and Systems (condensed): The propeller is powered by the engine through the reduction gearbox. Propeller pitch is adjusted by engine oil pressure regulated through the Propeller Governor/Constant Speed Unit (CSU). Oil pressure from the engine oil system is boosted to a higher pressure by a pump in the CSU.

Should the CSU governing system fail, the overspeed governor will operate to limit the propeller speed (Np) to 106% (1802 rpm).

In case that neither the CSU nor the overspeed governor limits the propeller speed, the Nf governor will limit the engine power (Np=109%) 1853 rpm.

The basic idea of the propeller governor is the that engine oil pressure is boosted from a nominal 90-120 psi to a maximum 480 psi by the CSU (governor) pump [See diagram]. That increased oil pressure is used to control propeller blade pitch (through the propeller hub assembly) to a normal operating rpm of 1700 via a pilot valve plunger that is moved up/down by rotating flyweights and a speeder control spring. When the pilot valve plunger is positioned in the center-neutral position, then oil can neither enter nor exit the propeller hub, thus establishing a constant (propeller) speed. The flyweights work against the speeder control spring, which in most propeller-driven aircraft is adjustable by the propeller control to set a desired rpm based on aircraft performance needs, but in the case of the PT6A-67B/P, is pre-set for a 1700 rpm constant speed. The speeder control spring applies an opposing force against the pilot valve plunger, which is being (lifted) driven by the flyweights. When the flyweights equalize to the speeder spring pressure then the pilot valve plunger is in the center-neutral position. The idea is that when the propeller rpm increases beyond 1700 the flyweights will lift the pilot valve from the neutral position, due to greater force that the speeder control spring, causing oil (pressure) to return to the engine oil system from the propeller hub assembly, thereby reducing the increasing pitch/rpm back towards 1700 and if the propeller rpm drops below 1700 the flyweights will not be able to hold the pilot valve plunger against the speeder control spring pressure causing the pilot valve plunger to drop and oil (pressure) from the CSU pump to enter the propeller hub, increasing the pitch, thus increasing the rpm towards 1700. **The flyweights are driven by a shaft connected through the CSU pump to a bevel gear in the reduction gear box (RGB), which is connected to the propeller.**

The overspeed governor works similarly except that a splined gear in the RGB separately drives it and its speeder control spring is set for approximately 1802 rpm before releasing oil back to the engine oil system. [In other PT6A applications this is sometimes referred to as the Hydraulic Topping Governor (HTG)]

And not to be overlooked, also in the CSU governor is the Airbleed Lever. This lever is connected to the Py Airbleed orifice. If the pilot valve plunger is lifted sufficiently, due to excessive flyweight speed overcoming the speeder control spring, then this lever will be pushed up, causing the associated orifice lever to uncover a previously closed port to the Py line. The Py Airbleed line is tied to the P3 Air Bleed line, which is used to regulate the Engine Fuel Control Unit (FCU). If the Py orifice is opened it will release (P3) air to atmosphere causing the FCU to reduce fuel flow to the engine thus causing a reduction of power. This power reduction will then cause the propeller pitch/rpm to also reduce. Also, if you look at the diagram note the Reset Arm under the orifice lever. The Reset Arm, connected in series to the Beta Valve via the PCL control linkage, adjusts the position at which the Airbleed and Orifice Levers will operate when engaging Beta/Reverse to protect the propeller from overspeed by scheduling the FCU to reduce power if the revised position is exceeded while operating in this mode. This is what is referred to as the Nf governor [In other PT6A applications this function is sometimes referred to as the Fuel Topping Governor].

Emergency Procedures are fairly straight-forward for the PC12 when it comes to Propeller Overspeed: REDUCE POWER / REDUCE AIRSPEED. Monitor. If continuing overspeed: Land ASAP and retain glide capability in case of engine shutdown.

It should be readily apparent that the CSU pump / flyweights are the key to this system. So what is turning the flyweights? Answer: the RGB. What is turning the RGB? Answer: The Power Turbine section of the engine (fuel) *or* the Propeller (airspeed). So either source can drive the RGB, which drives the CSU (oil) pump / flyweights. I will concentrate on the Propeller (airspeed) drive since the Engine power side (fuel) should be well known.

With sufficient airspeed (airborne) turning the [un-feathered] propeller the RGB will operate the CSU pump / flyweights to control the propeller pitch, without engine power input. In the case of the U-28A it can be supposed that the reason the propeller went to an excessive overspeed condition was due to high airspeed and an apparent failure of the primary and overspeed governors to control the propeller pitch.

Why high airspeed as the probable culprit? The CSU and Overspeed governor flyweights lost the ability to lift their respective plunger valves [shaft failure], but sufficient oil pressure from the CSU pump (propeller airspeed driven by the RGB) remained to keep the propeller at a high pitch. Also, the Nf section (fuel) of the CSU would be a non-function since reducing power had most likely already occurred. If you review the Propeller-Overspeed Emergency checklist you will see that when all else fails-REDUCE AIRSPEED. Or, as the case was with the U-28A, the engine had to be shutdown, probably due to excess vibration from the propeller overspeed (also in the checklist).

Conclusion is that the PT6A-67B/P is very well protected against the possibility of propeller overspeed but take nothing for granted. Always respect this fine machine and its components and stay proficient.

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John Morris
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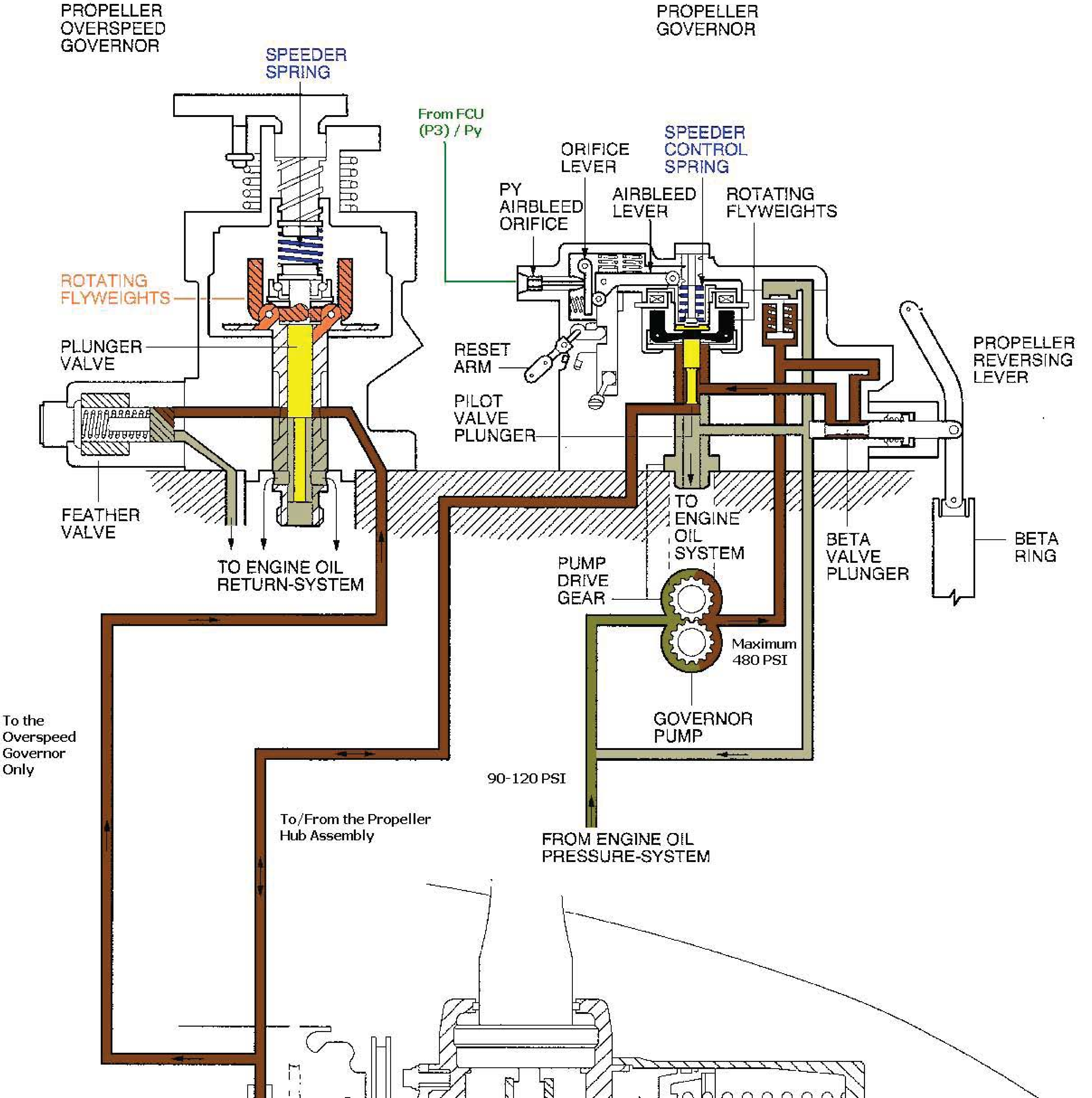

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