OPERATING/MAINTENANCE TIPS FOR THE BEECH ELECTRIC PROPELLER

During the first nine years of the Beech 35's history it was fitted with an electrically operated, controllable pitch (later to become a constant speed) propeller manufactured to Beech specifications. The first propeller blades were made from laminated birch covered with a plastic coating as protection against moisture penetration and to increase surface hardness. These blades were limited to 2450 rpm which in the "E" engine of the time would produce 196 horsepower (HP).

As the need for durability of the blades and higher rpm (HP) became necessary, heat treated aluminum blades were installed on the C35 which allowed 2600 rpm. These aluminum blades came in lengths to produce 88" diameter for the E 185/205 engine and the E-225 as installed in the E and F35, and 84" for the E-225 engine, as installed in the F and G35. The shorter length became necessary to avoid excessive tip speed at the E-225 engine's 2650 rpm takeoff speed. This rpm/diameter results in tip speed of 0.87 Mach which is the accepted upper limit of propeller efficiency, at least for blades of that airfoil design. The earlier wooden blades were structurally and, to a lesser degree, vibration/flex limited.

These propellers have had a long history of satisfactory service if properly maintained; however, as with many of our older Bonanzas, they have not received good maintenance attention, and that coupled with unnecessary wear and tear via poor operational techniques have degraded their aerodynamic performance and mechanical integrity to an unacceptable level.

Although my "G" model airplane now has the Hartzell propeller installed (see *ABS Magazine* pages 1499-1500); I did have about 275 hours of operation with the Beech prop and gathered some interesting operational and maintenance information.

If the "Operator's Handbook" procedure for ground check of the propeller is used, the motor/gearbox and all linkage of the pitch change mechanism is unnecessarily subjected to severe shock loading and wear. CAUTION: Any handling of the propeller should be done with mixture at fuel cutoff position and magneto-switch to "off or bat" only position. A check to be sure that the mags are in fact grounded should be made at each engine shutdown to assure the proper functioning of the cockpit mag switch in all positions. Always use caution handling the propeller. The best thing to do is remove all the top spark plugs. This not only makes the engine unable to run but also aids in any work that requires turning the engine through, such as magneto work, etc.

In order to see just what is taking place during the act of returning the prop to the fine pitch stop (high RPM) for takeoff by "holding the propeller toggle to increase rpm until no further rpm increase is observed" (per the manual), do this test. With the airplane parked, engine not running, and cowl open, observe the propeller pitch change mechanism while an assistant runs the prop toward "decrease rpm" for several seconds. There should be no growling or grinding noises, only the whining sound normally associated with a motor/gearbox. Stop the motor when about 2 inches of travel of the large ring gear has occurred. This is approximately the position of the gear during the run-up check. Now, run the prop toward "increase rpm" and observe the very severe shock the mechanism receives after engaging the spring stop at the end of the ring gear travel. This jumping in and out of the ring gear by the gear box pinion gear is exactly what takes place for some period of time depending on how long you hold the switch to assure the prop has returned to full high rpm for takeoff. The shock and abuse produced by the spring stop is considerable and unnecessary.

A far better method is to place the propeller toggle switch to "auto" and let the governor run the prop to the microswitch cutout point which is just short of the spring stop. The original Beech governor will do this without the engine running; however, if the more modern and much more reliable Airborne Electronics solid state governor has been installed, the engine must be running – this unit requires magneto output to activate the required circuitry.

During the time I operated the Beech propeller, I installed a set of three light-emitting diodes adjacent to the tachometer. The top and bottom lights were red in color, the center light green. The bottom light was connected in parallel with the govern output to the "decrease rpm" relay and the upper light to the "increase rpm" relay. The center or green light was connected to one pole of the pitch control motor. (There is 12/14 volts at both motor poles with the motor running either direction.) Therefore with these annunciator lights it could be

determined (1) if the pitch change motor was running – green light on; (2) what the governor was calling for – higher or lower rpm – with the upper or lower red lights.

By observing these lights over approximately 200 hours operating time, the following conclusions were reached. (Both the Beech and later the much better Airborne governor were used.)

1. Nearly continuous operation of the pitch change mechanism occurs while operating in the "auto" mode, the Airborne unit being slightly better than the Beech governor which it replaced. This condition is aggravated by turbulence, power changes or airspeed changes. With the Beech unit, a sticky drive flex cable, or in the Airborne unit a problem with the associated magneto, will also cause additional governor speed search.

2. Due to previous wear on the pitch change mechanism, primarily the three screw threads and lugs on the pitch change bearing outer race, even with all factors constant in either auto or manual mode, there would be enough rpm change (10-20 rpm) for the governor to call for higher or lower rpm. This slop in the mechanism had developed over 3400 hours usage and is not adjustable. The only way to tighten up these clearances is with new parts of which there are few or none available. Although the prop by theory should drift toward fine pitch (higher rpm) by aerodynamic forces, it may in fact drift either direction with a drift toward fine pitch being the more likely. This aerodynamic drift is counteracted by the attached weights on the prop blades in an effort to get the whole assembly to be neutral in tendency to drift either direction. The balancing of the Beech prop is quite a complicated procedure and if not done correctly will stall the pitch change motor in one direction or the other since the motor can not overcome the torque produced by the blade/weight assembly with an improperly located weight.

3. The best method, from a wear and tear standpoint, to return the prop to fine pitch for takeoff or landing is by means of the "auto" function by observing the upper red light on and green light out which indicated the governor wanted more RPM but the motor was not running due to being shut off via the fine pitch microswitch. At this point the cockpit switch would be set to manual for takeoff or landing. Unless over 100 MPH indicated airspeed and full throttle is used, the engines should not exceed red-line rpm during a go-around.

The same results can be obtained without the lights by seeing any rpm less than governor setting: That is, if in "auto" and the "cruise detent" (2300 rpm +/-) and an rpm of less than 2300 is observed, the prop is on the fine pitch cutoff microswitch. This will occur for sure by 100 IAS and 15" MP which would or should be proper downwind speed and power setting.

There is an interesting scenario which could result if the "auto" function is used for takeoff with either governor. If an internal governor malfunction were to take place which allowed the governor to call for full low rpm, the resulting engine speed would be 1500 +/- rpm. Unless the pilot had the presence of mind to realize exactly what was taking place, he might think an engine failure had occurred when in fact the prop had unnecessarily run away. This very thing appears to have happened several times.

My procedure is "manual" for takeoff with governor speed selector knob preset to 2300 rpm. After gear retraction, set mode selector switch to "auto". Engine speed should not exceed 2650 rpm if airspeed does not exceed 100 IAS, all of which is about right for a normal departure. The action of the pitch change mechanism is slow enough so accompanying throttle adjustments to limit MP/rpm against over boost can be made after selecting "auto". After accelerating to climb speed (140 IAS or higher) and rpm stabilizes at 2300, set the mode switch to manual and make small RPM adjustments by "blipping" the toggle switch as needed. This saves countless and for that matter useless adjustments of the prop which would take place if "auto" is used. The same manual procedure for cruise, letdown and after returning the prop to fine pitch as described above should be used for landing.

The main idea being to save the finite operating cycles and useful life of the pitch change mechanism. If it breaks, wears out or otherwise quits, you will probably have to repair with parts which also are worn out or nearly so, not to mention the expense of it all.

The propeller must be removed each 250 hours in order to repack the pitch change bearing with grease. DO NOT allow the bearing to run beyond this time without lubrication. There may be a few new bearings

somewhere (safe deposit boxes or vaults, etc.) but the normal replacement is an already partially worn out, used bearing. I have measured about ten used bearings and have not found one of them to be within the allowable wear on the thread engagement lugs, although the bearing itself seemed to be in serviceable condition. Failure to maintain this lubrication schedule is asking for big problems right up to and including loss of the airplane due to a forced landing. When doing the bearing lube, the motor gearbox grease should also be checked for quantity and quality together with motor brush condition. Make sure to replace brushes with the correct brush part number for these serve as a brake for pitch control motor coastdown during manual operation of the prop and holding the prop at desired pitch when the motor is not running. Dynamic braking is available during auto function of a system that has a governor installed just as the airplanes manufactured before the optional governor was made available had in manual mode. In other words, if the pitch change relay box is controlling the motor operation dynamic braking occurs during motor stoppage. I believe Airborne Electronics has a supply of these brushes.

Most propeller shops will want to disassemble the blades from the hub while greasing the pitch change bearing with the intent of refinishing the blades. If the airplane has been operated from un-improved runways or other conditions have caused blade damage requiring refinishing, then yes, it should be done; however, it is not required until the 500 hour inspection that the blades be removed from the hub and then only to repack the blade bearings with grease. This should add about 1 ½ hours work to the lube of the pitch change bearing only. The overhaul manual is contradictory regarding the need for blade bearing lubrication at the 250 hour point. If the airplane is stored indoors and not subjected to water infiltration by washing, rain, etc., the blade grease should be satisfactory for 500 hours.

Each time this refinishing is done, a considerable amount of material is removed from the face (flatside) of the blade. This does three things: 1. reduces the aerodynamic efficiency of the blade; 2. increases the cost of prop shop visit; 3. brings the blade closer to "being retired from service."

To be sure, if your shop thinks blade overhaul is necessary, and it really is, it should be done. Don't do it for cosmetic reasons though. As with all parts for these props, fat blades are very hard to come by.

In case anyone reading this would like to measure their blades while the propeller is on the airplane (in order to know whether or not replacements might be necessary at next overhaul for an early start on finding replacements), if they will send me a $20.00 bill and mailing instructions, I will send complete blade drawings with dimensions and detailed instructions on how to measure the blades.

As these propellers accumulate more and more time in service, it becomes more necessary to do everything possible to extend their life. If the propeller becomes unusable due to wear and tear (some or even most of which can be avoided by thoroughly knowing how the propeller system works and how to use it to best advantage), and the Hartzell retrofit propeller becomes the only option (see *ABS Magazine* pages 1499-1500), it is too late to begin educating one's self about its care and use and seeing to the implementation of that knowledge.

Another area which is important, especially in props with mismatched blades, is balance. Although perfect aerodynamic balance is nearly impossible to achieve in old blades, mass balance can be achieved to very close tolerances by means of dynamic balancing. This type of procedure not only relieves stress on the prop, but will also greatly reduce future maintenance on all engine and airframe components, especially those forward of the firewall. The cost is reasonable enough considering the benefits.

If you happen to own one of the "oldie but goodie" Bonanzas with a Beech prop in good condition installed, do everything you can to preserve this highly efficient, easy to own and operate piece of aircraft history.

MORE BEECH PROP STUFF

The Beech prop has a few requirements to achieve a long, trouble free service. Operate the prop in "automatic" as little as possible.

The electrical wiring for the Beech propeller was changed at S/N D-1821. Prior to D-1821, the manual prop control switch controlled relays which were wired in series through the limit microswitches located at the propeller. These first 1,820 prop relay units also incorporated a dynamic brake shuttle switch similar to the landing gear relay used on D-201 through D-1500. After D-1820, the limit microswitches were only in the circuit in "auto." This means that any time the manual function is used, the prop pitch change motor will run if the switch is held to increase or decrease. When the gearbox pinion gear reaches the end of the ring gear, a