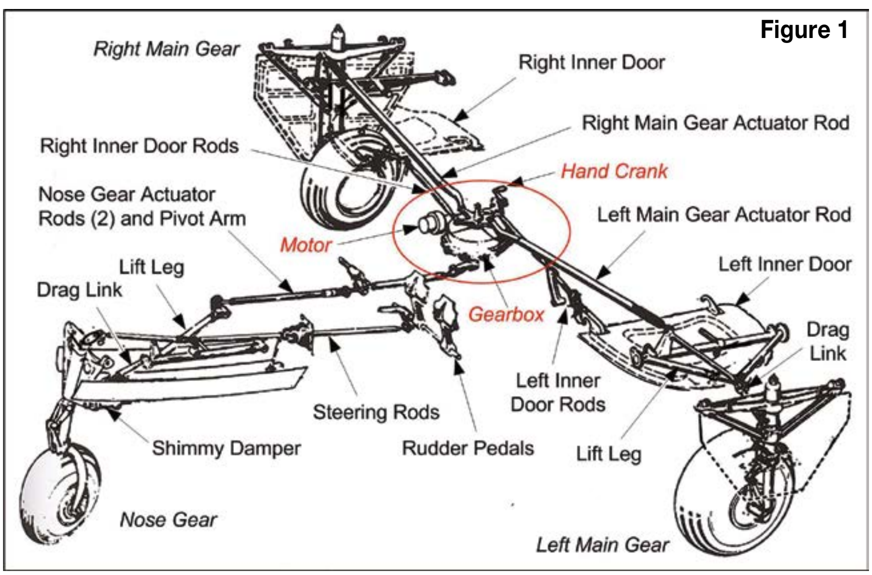
Beech Landing Gear Primer

by George Brown

From the Model A35 of 1949 through to today's G36 and G58, all Bonanzas and the derivative Debonairs, Travel Airs, and Barons have the same basic mechanical design of retractable tricycle landing gear. The only major design difference for a particular model was the original Model 35 of 1947-48 with its free castering nose wheel rather than the steerable nose wheel of the A35 and all later models.



To give you an understanding of the Beech gear system and how it operates, I'll present simplified drawings and examples of each of the major components. These examples may be slightly different from what you see on your aircraft, because over time these components have been revised for various reasons including increased airframe weights, faster gear operating airspeeds, and improved ride on the ground.

For information about the landing gear in your serial number of aircraft, refer to the system descriptions and also the normal and emergency operating procedures in your *Pilot's Operating Handbook* or *Owner's Manual*.

System Overview

Figure 1 shows the landing gear mechanism including the main gear inner doors. The heart of the mechanism is the gearbox driven by the electric motor. Operating the hand crank extends the gear manually in case of a motor or electrical

Figure 2

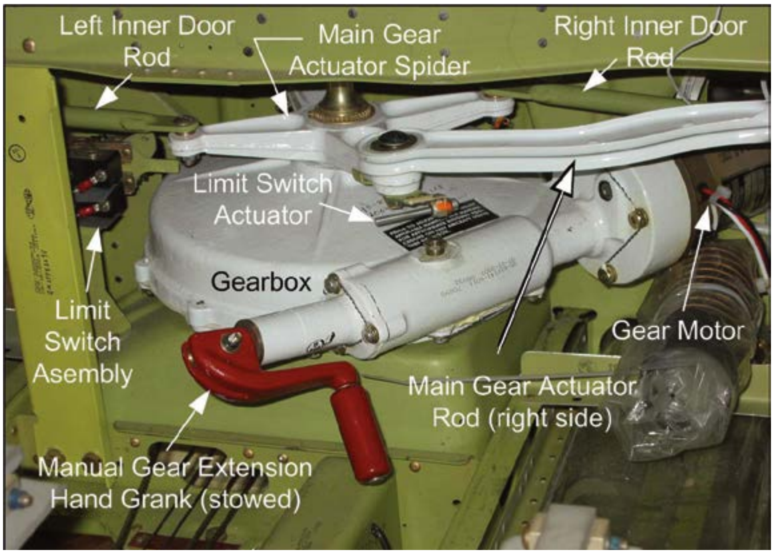
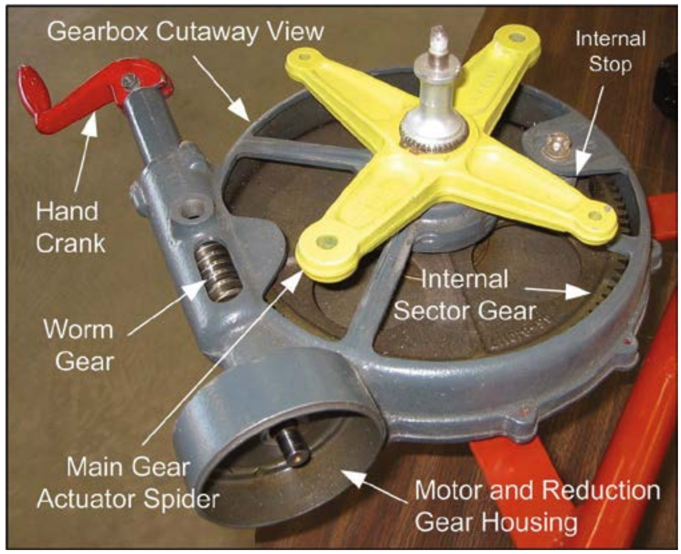


Figure 3



system failure. Gearbox operation retracts and extends the main and nose gear struts via actuator rods, lift legs, and drag links. Additional rods actuate the main gear inner doors, mechanically timed to operation of the main gear struts. Although at first glance the gear mechanism may appear complex, its overall design and operation is simple.

To retract or extend the landing gear, the main gear actuator spider rotates approximately 180 degrees clockwise as it pulls (retract cycle) or counterclockwise as it pushes (extend cycle) the actuating rods to the left and right main gear struts. The single actuator arm located underneath of gearbox also rotates 180 degrees pulling or pushing the actuating rods to the nose gear.

Gearbox and Motor

Figure 2 shows the gearbox that resides aft of the main spar carry-through structure near the cabin floor. The limit switch assembly shuts off the motor at the end of the landing gear retract or extend cycle. Not shown to the right of the gearbox is the relay for the motor and dynamic brake used in aircraft with 24-volt electrical systems.

Referring to **Figure 3**, inside the gearbox is the steel worm gear driven by either the motor and reduction gear at one end or the fold-away hand crank at the other. The worm rotates the half-round bronze internal sector gear and thereby the main gear actuator spider and nose gear actuator arm. An internal stop keeps the sector gear from being rotated too far and disengaging itself from the worm gear.

Because the gear ratio between the worm and sector gears is approximately 100:1, slightly over 50 turns of the hand crank in the counterclockwise direction rotates the sector gear 180 degrees to manually extend the gear. In spite of this rather low gear ratio, cranking the landing gear down manually takes a surprisingly high effort because turning the hand crank also spins the motor armature at the other end of the worm gear. Near the end of the cycle, cranking gets particularly difficult with the nose gear fully extending out into the slip stream in addition to compressing springs on the end of each actuating rod.

On gearboxes factory-installed in aircraft built before late 1981, about 1/8 to 1/4 turn of the hand crank will move

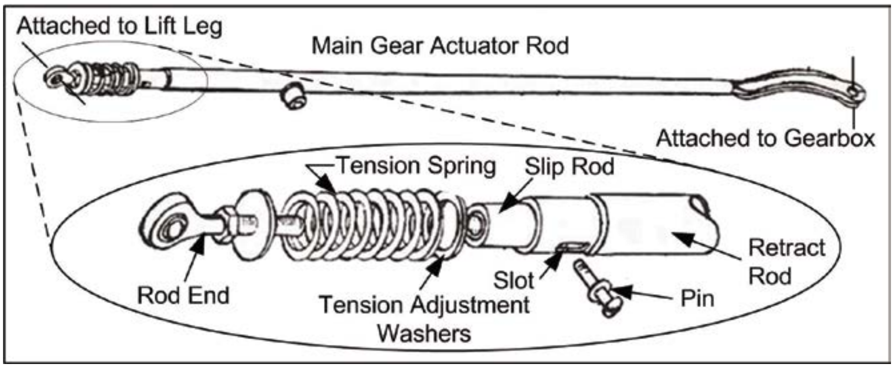


Figure 4

the sector gear against the stop after the motor stops. Factory-installed gearboxes were changed beginning late in the 1981 model year in Bonanzas and Barons. The new-style gearbox, which is still used in today's G36 and G58, takes 5/8 to 3 /4 turn of the hand crank.

Main and Nose Gear Actuator Rods

One of the two spring-loaded telescoping main gear actuating rods is shown in **Figure 4**. A pair of actuator rods with a pivot arm is between the gearbox and the nose gear lift leg. The forward nose gear rod employs a spring-loaded telescoping arrangement similar to the main gear rods.

Each actuator rod is slightly longer than the distance between the attach points on the gearbox actuator and landing gear lift leg. When the landing gear is extended, the telescoping arrangement on one end of the rod compresses its spring as the gear strut reaches its maximum extension. The proper spring compression provides the required force at the strut's lift leg and drag link knee joint to lock the strut in the down position. Inserting washers behind the spring and the retract rod adjusts the compression force.

A common source of gear failure or collapse is a worn and/or corroded rod end that breaks. Beech recommends replacement of the rod ends, pins, and springs every 2,000 hours. ABS's Technical Advisors echo that recommendation.

Main and Nose Gear Struts

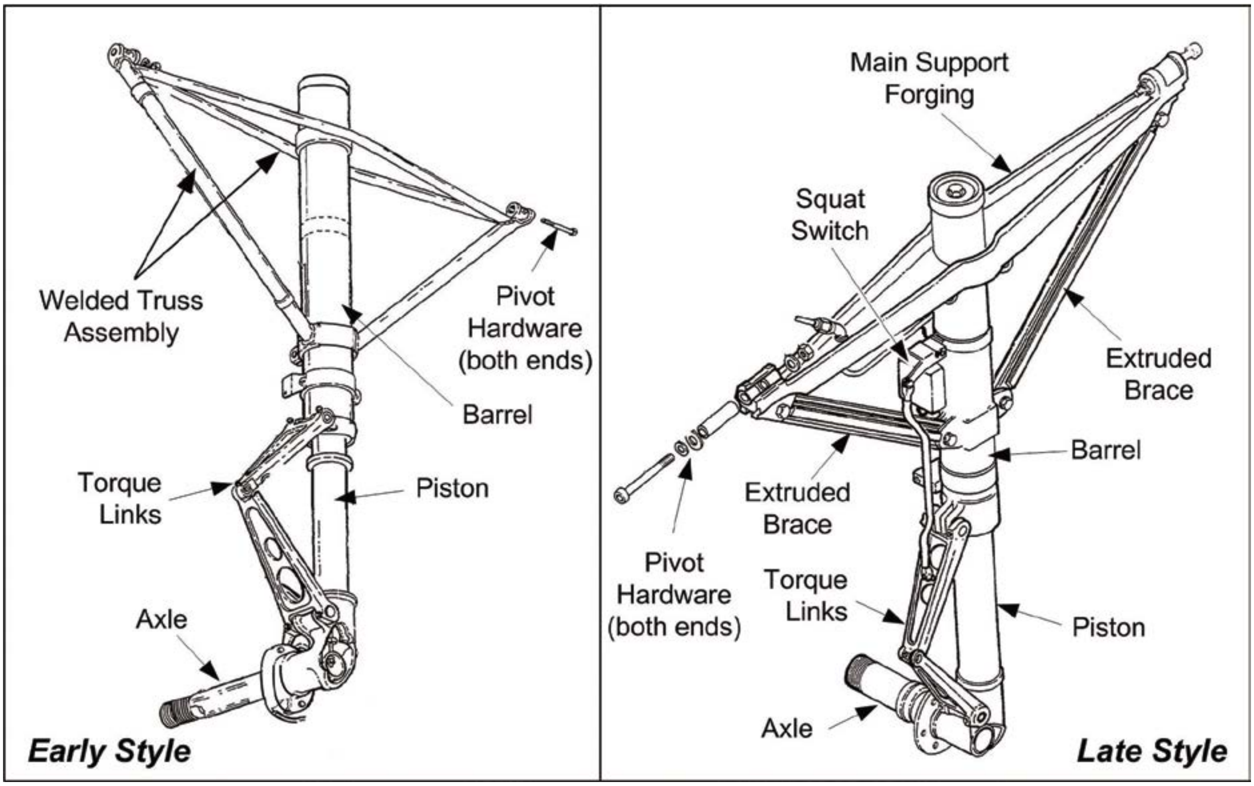
Beech landing gears employ pneumatic-oil oleo (shock) struts. These struts use a combination of nitrogen and hydraulic oil to absorb and dissipate the impacts of landings and also to dampen any resulting vertical oscillations. Basically, each gear strut is comprised of a piston telescoping inside a barrel. At the bottom of this piston is the axle for the wheel and on the main gear struts, mounts for the brakes. Torque links prevent the piston from rotating inside the barrel thus holding the piston, barrel, and wheel aligned.

As shown in **Figure 5**, the main landing gear has two styles of main gear struts. The early struts on aircraft built before the 1962 model year employed a welded truss for support. Beginning with the 1962 model year, main gear strut supports were changed. These later struts are considerably stronger with the forged aluminum support and extruded braces. Main gear struts swing inward to retract, pivoting on bolts inserted through support bushings on the front and rear spars.

A landing gear safety (squat) switch prevents inadvertent retraction of the landing gear when the weight of the airplane is on the ground. Bonanzas with 12-volt electrical systems employ a squat switch on only the right-side main gear strut. Beginning with the 24-volt Bonanzas introduced in the 1978 model year, a squat switch is on both main gear struts wired in series so both switches have to be closed (aircraft weight off both struts) to retract the gear.

Barons built before the late 1974 model year and all Travel Airs also have a squat switch only on the right-side main gear

Figure 5



strut; however, Barons built afterwards have series wired squat switches, one on each main gear strut.

Figure 6 shows the style of nose gear on model-year 1961 and later Bonanzas as well as all Travel Airs and Barons. This cast magnesium strut does not have the lightening hole cast into web of earlier struts. Attached to both the brace and piston, the shimmy damper is a small cylinder and piston assembly filled with hydraulic fluid. At the top of the strut is the connection for the steering mechanism. During retraction, the nose gear swings aft, pivoting on bolts inserted through bushings on the gear tunnel side walls.

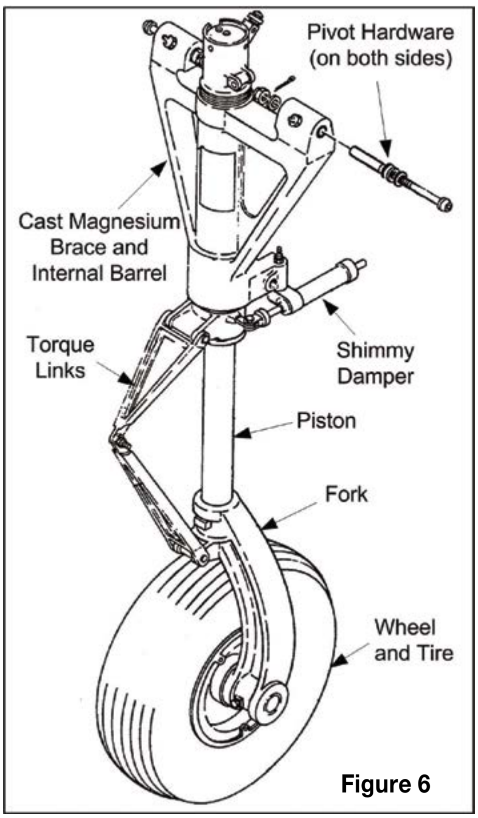


Figure 6

Landing Gear Cycle

The mechanical power train for retracting the gear begins with the motor driving the gear actuator spider's 180-degree clockwise, thus pulling on the actuating rods to each of the gear struts. (**Figure 7**). The numbers in the drawing represent the sequence of power from the gearbox to the nose and main gear struts while the arrows indicate the component's direction of motion. To extend the gear, the spider

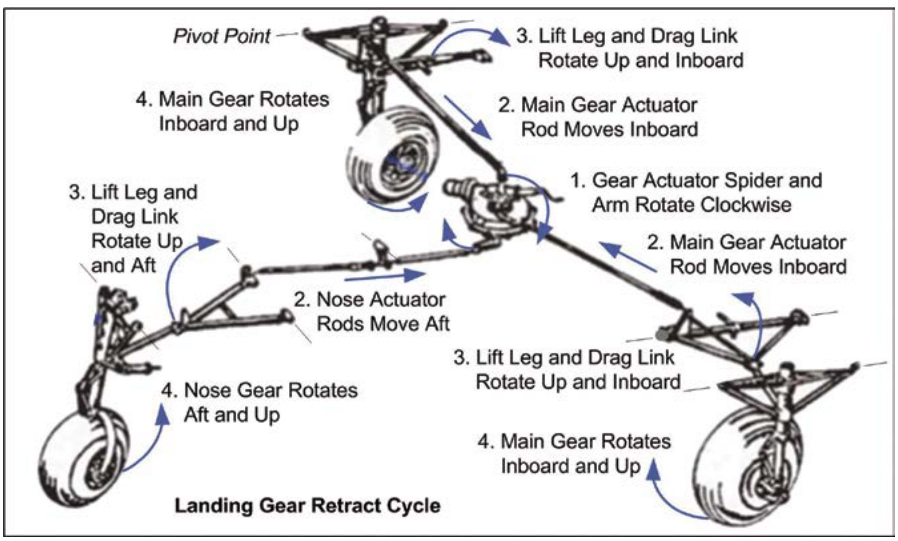


Figure 7

rotates 180 degrees counterclockwise with all the components moving in the opposite directions to those shown. **Figure 8** shows an example of the lift leg, drag link, and left main gear strut mid-way during retraction or extension.

Figure 8

Main Gear Inner Doors

Among the unique features of the ABS types are the inner gear doors fully enclosing the retracted main gear struts and wheels. **Figure 9** shows the mechanism that operates the left inner door in the retract cycle; the mechanism for the right-side door is the same.

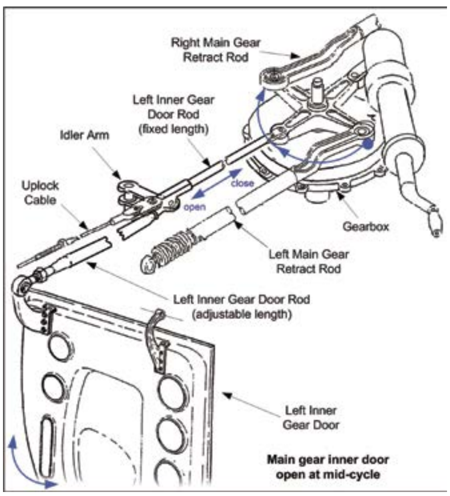


Figure 9

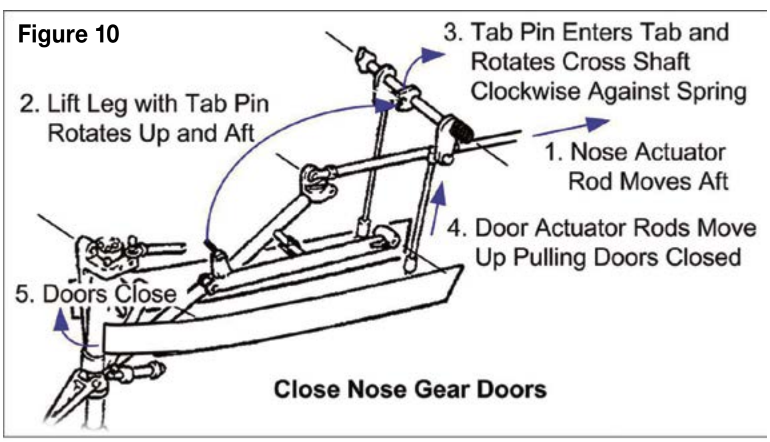
Operated by the main gear actuator spider via a pair of push rods, each inner door is fully open with the main gear strut half-way retracted or extended and closed with the gear up or down. The only difference between a gear retract or extend cycle is the direction the actuator spider rotates. A threaded rod end for each door provides the adjustment for proper tension when the door is closed.

Opening and closing of the doors also operates the main gear uplock via the cable shown in the figure. A clevis on the cable adjusts the tension of the uplock cable. I'll discuss the main gear uplock in a later section.

Nose Gear Doors

Figure 10 shows the mechanism that operates the nose gear doors during gear retraction. A torsion spring wrapped around the cross shaft opens the doors. The mechanism shown pulls the doors closed against the spring torsion as the nose gear nears being fully up and opens them as the gear starts down. A threaded clevis at each end of each of the two door actuating rods provides for adjustment of its respective door when closed.

Figure 10



Main Gear Up and Down Locks

All of the ABS types have an uplock for each main gear that is the same or similar to the mechanism shown in **Figure 11**. Beginning with the late 1974 model year, Barons also have a positive downlock in addition to the uplock (**Figure 12**). The boot (usually canvas) protects the uplock (and downlock) mechanism from ice inhibiting their operation.

The uplock holds the main gear fully retracted. The uplock cable (operated by the main gear inner door mechanism as the door closes during gear retraction) pulls the uplock into position next to a roller on the lift leg knee joint, thereby locking the gear. As the inner door opens for extending the gear, the uplock cable relaxes and the spring pulls the uplock arm away from the lift leg roller allowing the gear to extend.

If the cable breaks, the uplock will not function. Although the gear will retract, failure of the uplock in turbulence or during an aggressive pitch-up will allow the gear to sag partially out of its well with the attached gear door opening into the slipstream. At high airspeeds, partially opening the gear door could cause a sudden and significant pressure increase inside the wheel well and *possible subsequent structural damage.*

Figure 11

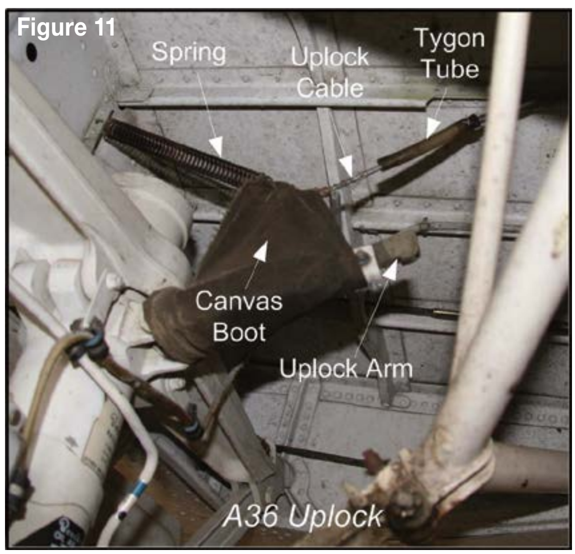
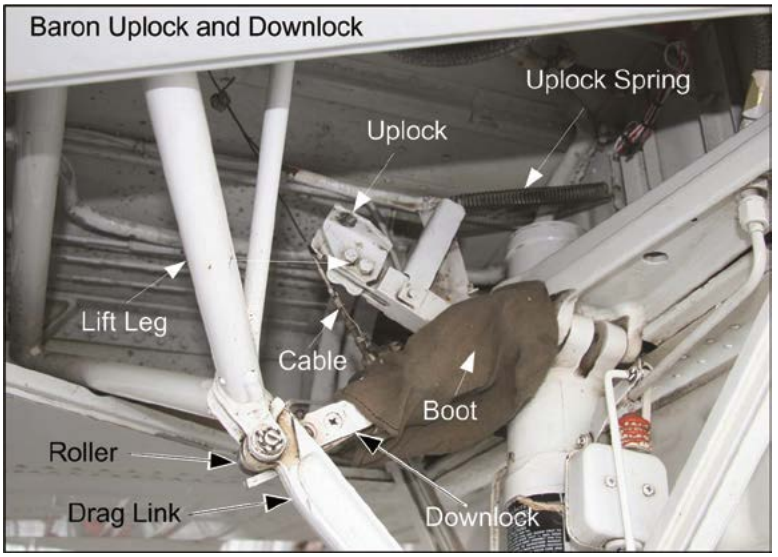


Figure 12



Should the spring break, the uplock will most likely not move away from the lift leg knee roller; *the gear then cannot be extended electrically of manually.*

Both the cable and the spring should be inspected for damage or deterioration at each preflight. A frayed cable or corroded spring need to be replaced. *If the cable or spring is broken or missing, do not fly the airplane until repairs are made.*

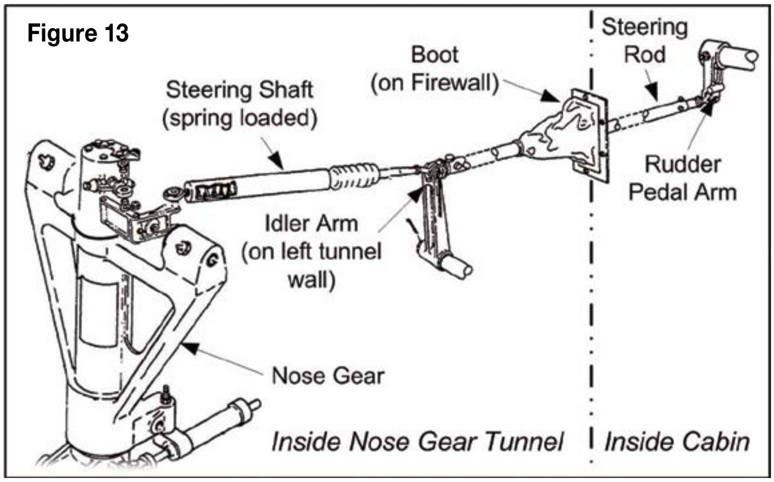
Nose Gear Steering

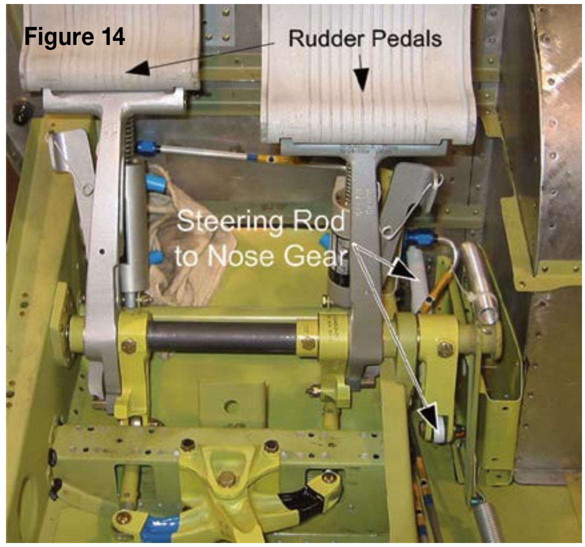
Referring to **Figure 13**, the rudder pedals connect to the nose gear via a spring-loaded set of push-pull rods and an idler arm. The steering shaft with an internal spring is threaded for minor adjustment of the nose wheel tracking.

Inside the cabin, the rudder pedals connect to the nose gear steering rod (**Figure 14**). Turning right pushes the steering rods; turning left pulls the rods. When the nose gear retracts, a roller at the top of the strut enters a channel on the airframe, centering the nose wheel as it enters the wheel well. The steering shaft's internal spring takes up movement of the steering mechanism during flight.

Electrical Overview

On early Bonanzas and Debonairs with 12-volt electrical systems, a complete landing gear retract or extend cycle takes 9 to 11 seconds. On Travel Airs, Barons, and later Bonanzas with 24-volt electrical systems, the gear cycle takes 3 to 5 seconds. **Figure 14** (12-volt) and **Figure 15** (24-volt) are simplified diagrams of the landing gear electrical system. For specific details about the landing gear wiring in your aircraft, refer to the Beech maintenance manual





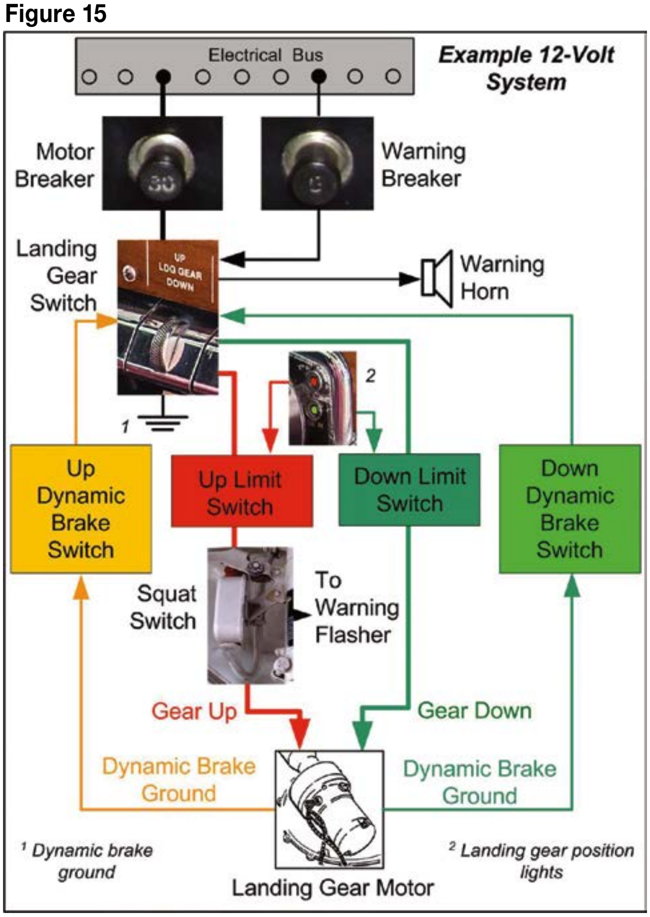
or wiring diagram manual for the aircraft's serial number.

On Bonanzas built before the 1970 model year, B55, E55, and 58 Barons built before the 1974 model year, and all Travel Airs, the landing gear up (red) and down (green) indicator lights are wired through the up and down limit switches at the gearbox. These lights only indicate the position of the gearbox spider, not the landing gear struts. Additionally, a mechanical pointer at the base of the control console shows the position of the nose gear actuator rods, but again not the strut. Model year 1970 and later Bonanzas, 1974 and later B55, E55, and 58 Barons have a strut position switch in each wheel wired to a green light that, when on, indicates the respective landing gear leg is down: nose, left main, and right main. In this later system, a red light indicates gear-in-transit and no lights indicate the gear is retracted.

With the worm to sector gear ratio of 100:1 and reduction gear ratio of 10:1 between the motor armature and the worm gear, the overall gear ratio between the motor armature and sector gear is approximately 1000:1. Given this gear ratio, the armature makes about 500 revolutions to rotate the sector gear 180 degrees to either raise or lower the landing gear.

In airplanes with 12-volt electrical systems, the landing gear motor turns approximately 3,000 RPM; motors in 24-volt systems turn at approximately 7,500 RPM. At either speed, the motor

Figure 15



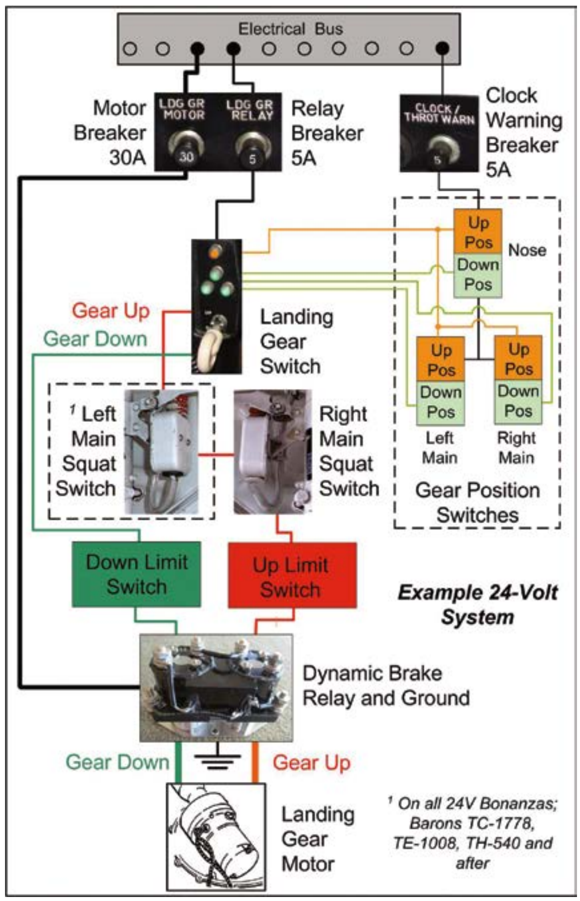


Figure 16

armature has to be stopped within two to five revolutions (depending on the gearbox) to keep the sector gear from hitting the internal stop. When the limit switch for up or down cycle actuates, it shuts off electrical power to the motor. Actuation of either the up or down dynamic brake switch (12-volt system) or the motor relay (24-volt system) grounds the motor's field winding thereby turning the motor into a generator and stopping the armature immediately. With the change to 24-volt electrical systems and the possibility of excessive arcing on the switch points because of the higher current, the latching-type of motor and dynamic brake relay with its heavy contact points replaced the individual dynamic brake switches.

Although the 12-volt and 24-volt motors appear to be identical, they are not interchangeable; that is, a 24-volt motor cannot be used in a 12-volt airplane and vice versa. Internally, the armatures are the same but the field windings and brushes are different.

Any slowing of the gear cycle speed frequently indicates the gear motor needs immediate attention by a qualified shop. A common cause of landing gear motor slowing or even failure is worn brushes and commutator. Beech recommends brush replacement every 500 hours with motor overhaul every 2,000 hours.

Owner Maintenance

For owners who like to do their own preventive maintenance under the regulations in 14 CFR 43, five of the first six maintenance tasks listed in Appendix A paragraph (c) and shown below are approved preventive maintenance on the landing gear.

> (c) ***Preventive maintenance.*** Preventive maintenance is limited to the following work, provided it does not involve complex assembly operations:

1. Removal, installation, and repair of landing gear tires.
2. (Not applicable for the ABS types)
3. Servicing landing gear shock struts by adding oil, air, or both.
4. Servicing landing gear wheel bearings, such as cleaning and greasing.
5. Replacing defective safety wiring or cotter keys.
6. Lubrication not requiring disassembly other than removal of nonstructural items such as cover plates, cowlings, and fairings.

Each of the above preventive maintenance tasks is usually described in the maintenance or shop manual for your serial number aircraft with parts shown in the appropriate illustrated parts breakdown.

For reliable operation of the landing gear in all of the ABS types, the system must be periodically checked and rigged by a licensed mechanic who is knowledgeable on the Beech system. For information about rigging the landing gear for you or your mechanic, download the *Landing Gear Inspection Checklist and Repair Guide* from *www.bonanza.org/maintenance/inspection-guides/*, which is free to ABS members.