



Beech Landing Gear Primer

Part 2: 24-Volt Motor and Relay

by George Brown

In “Beech Landing Gear Primer,” the BPPP feature in the January 2021 issue, we presented the mechanical Beech landing gear system with an overview of the system’s electrical power. As a brief review of gear motor operation within Barons, Travel Airs, and 24-volt Bonanzas, the gear motor armature turns at approximately 7,500 RPM to retract or extend the landing gear. At the end of either a gear-up or gear-down operation, the motor armature has to be stopped within two or five revolutions (depending on the gearbox) to keep the internal sector gear from stopping hard against the internal stop. (The gearbox internal stop is spring-cushioned with the sector gear normally stopping within the cushioning effect.)

To stop the motor, the limit switch (**Figure 1**) is opened by the appropriate limit switch actuator on the main gear actuator spider at the end of the gear-up or gear-down operation, thereby cutting electrical power to the motor and dynamic brake relay (**Figure 2**). This relay, mounted in the belly of the fuselage aft of the spar carry-through and below the copilot seat, is a large dual-coil unit (**Figure 3**). Inside the relay are two sets of internal coil-actuated heavy-duty contacts with one

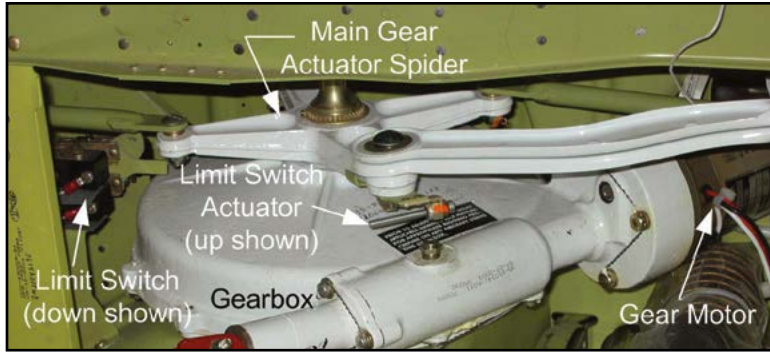


Figure 1

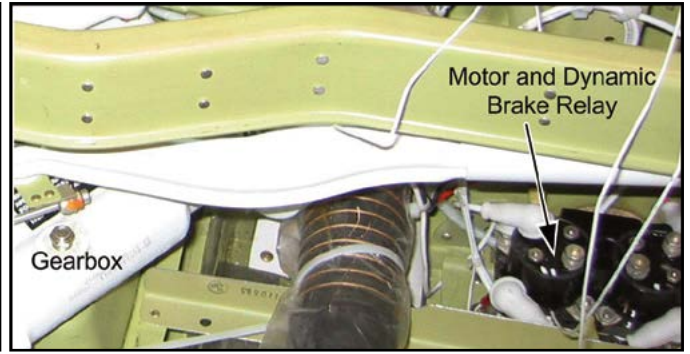


Figure 2

set for running the motor. The other set, along with a coil-actuated two-position shuttle switch (the latching relay), is for dynamic braking.

Landing Gear Motor

Before I get into the electrical operation of the landing gear motor and dynamic brake relay (called the landing gear relay or relay throughout this article), the gear is operated by a 1/5- to 1/4-horsepower, intermittent-duty, split-field, series-wound, direct-current (DC) motor (Figure 4).



Figure 3



Figure 4

(continued on page 42)



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The split-field motor has two field windings (also referred to as field coils) for turning the armature in one direction or the other for gear-up or gear-down operation (Figure 5). In a series-wound motor with its inherently high starting torque, the armature and field windings are connected in electrical series via the carbon brushes riding against the armature commutator.

Good mechanical and electrical connections of not only all external wire

terminals but also the internal brushes and armature commutator are critical for the required performance from the motor. The ABS technical team recommends overhaul every 2,000 hours of flight time or earlier on condition.

Dynamic Braking

In its basic form and without my getting into eye-rolling electromagnetic theory and math, basic dynamic braking turns a DC

electric motor into a DC generator by first disconnecting the motor from its power source and then immediately connecting the armature through a resistor to ground. This resistor is normally external to the motor, serves as the required load, and also dissipates the resultant heat. The lesser the resistance, the greater the electromagnetic drag on the armature and the rate of armature deceleration.

In the Beech implementation of the dynamic brake, after the DC power source is disconnected from the motor, the unused field winding is connected to ground; that is, the winding opposite of the one for the armature's current rotation. For example, if the armature is turning for gear down, the gear-up field winding is grounded. Here the grounded field winding functions as the load resistor with the collapsing electromagnetic field from the active field winding providing the momentarily available energy. With the very low resistance of the grounded field winding, the momentary surge of the fully available electromagnetic energy stops the armature almost instantly.

Unfortunately, all of the resultant heat is dissipated within the field winding and thereby the rest of the motor, so care must be taken to not overheat it during landing gear maintenance operations. For example, the *Baron 55/58 Maintenance Manual* limits landing gear cycles to no more than five within 10 minutes. See any restrictions in the maintenance manual for your aircraft.

Motor and Relay Operating Circuits

In the 24-volt Bonanzas and ABS twins, two separate electrical circuits operate the landing gear for retraction or extension (Figure 6). One circuit powers the motor directly through the motor circuit breaker and relay contacts. This circuit continually supplies 24 volts to the landing gear relay whenever the master switch is on and the circuit breaker is closed. Note that in Figures 6 through 10, active circuits and current flows are depicted in red.

WARNING: To operate the gear manually using the hand crank, do not engage it without first pulling (opening) the landing gear motor

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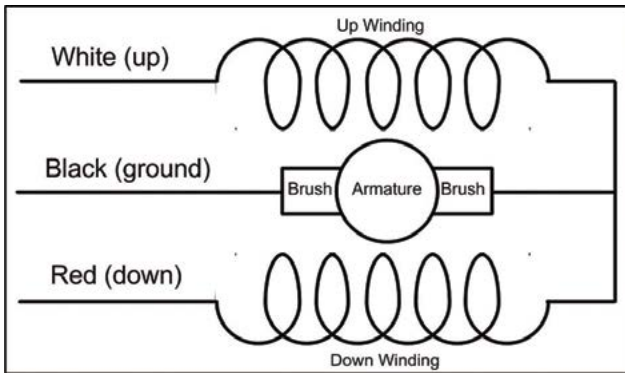


Figure 5

circuit breaker. With the motor circuit breaker pressed in (closed), any one of several mechanical conditions can cause the motor to run unexpectedly, rapidly spinning the engaged hand crank. Severe personal injury can result.

The other circuit controls relay operation through the relay circuit breaker, the pilot's gear switch on the instrument panel, squat switches, and limit switches. Generally, the position of the pilot's gear switch and the appropriate limit switch controls the electrical power to the relay for retracting or extending the landing gear.

Note that early 24-volt Bonanzas employ a pair of microswitches (one for gear up and the other for gear down) in conjunction with the limit switches to actuate dynamic braking. On later models, the landing gear relay replaced the microswitches.

On the relay, actuation of one coil or the other closes its associated set of run switches and opens its set of brake switches via an internal mechanical linkage for gear-up or gear-down operation. Conversely, when the coil is inactive, its run switches are open and brake switches are closed. Activating a coil also sets its two-position shuttle switch to "arm" the appropriate dynamic brake circuit by connecting the field winding to ground. The shuttle switch remains latched at the position set by the last actuated coil: up or down. Activating the other coil then sets the shuttle switch to its other position.

In one retract/extend cycle of the landing gear, its electrical system goes through four operating states: gear in transit up, gear up dynamic braking, gear in transit down, and gear down dynamic braking. The following sections describe the switch transfers and electrical current flows for each of these states.

Gear in Transit Up

The active circuit to and through the relay to raise the landing gear is depicted in **Figure 6**. When the weight of the airplane is off each of the two main gear struts (in flight or on jacks), the squat switch on each strut is closed. With 24 volts through the gear-up circuit consisting of the pilot's gear switch in the up position, squat switches closed, and up-limit switch closed, the up coil in the relay activates and (via a mechanical linkage) transfers the

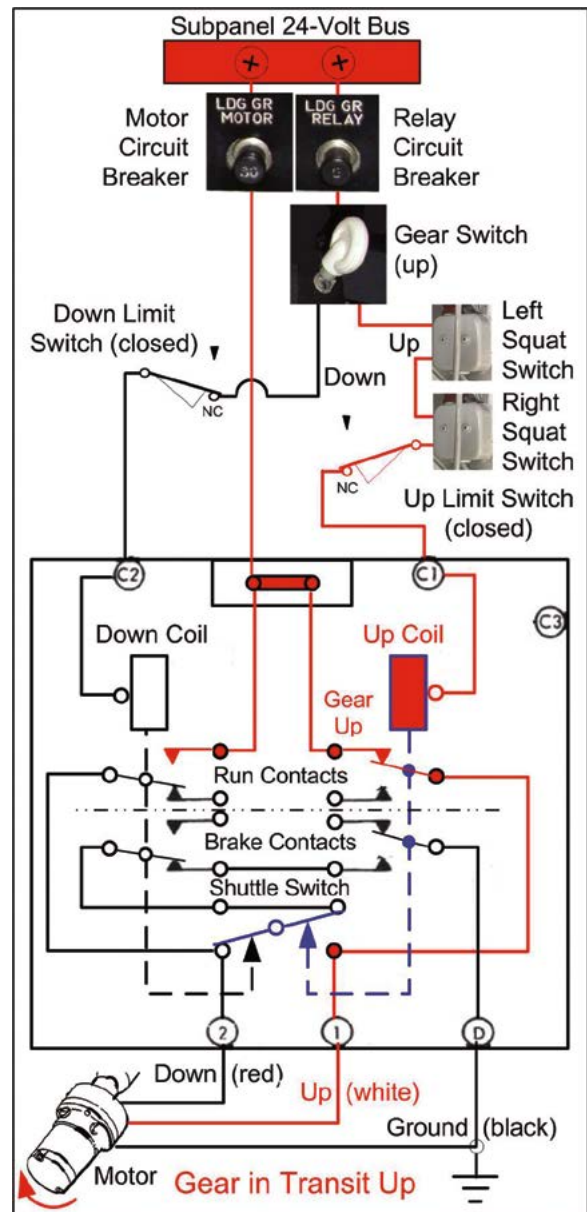


Figure 6

gear-up contact to closed. Closing the gear-up contact applies 24 volts from the gear motor supply circuit to the motor, thereby running the motor clockwise to raise the landing gear.

The up coil also mechanically opens the brake contact and rotates the shuttle switch to arm the dynamic brake. Opening the brake contact disables the dynamic brake circuit during the time the gear is in transit up with the up-limit switch closed and the up coil activated.

Gear Up; Dynamic Brake

At the end of the gear-up operation, the limit switch actuator on the main gear actuator spider actuates (opens) the up-limit switch thereby de-activating the gear-up circuit to the landing gear relay. Inside the relay, the up coil is

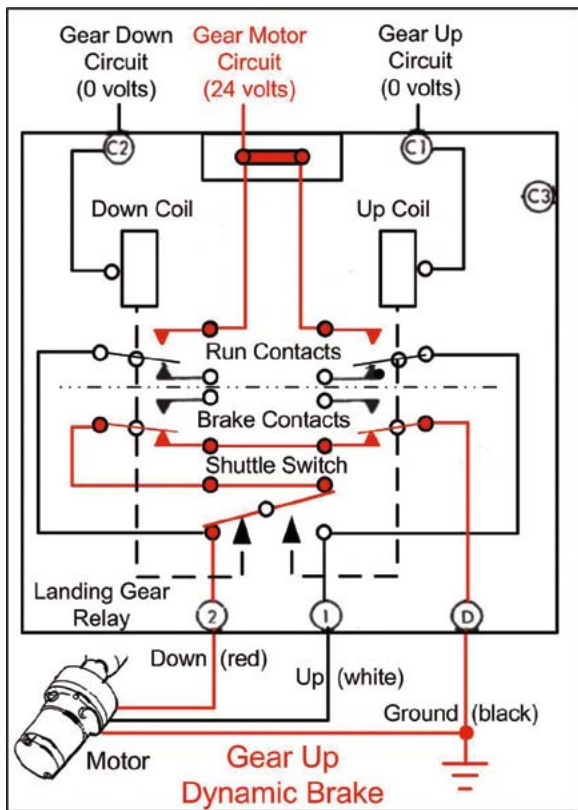


Figure 7

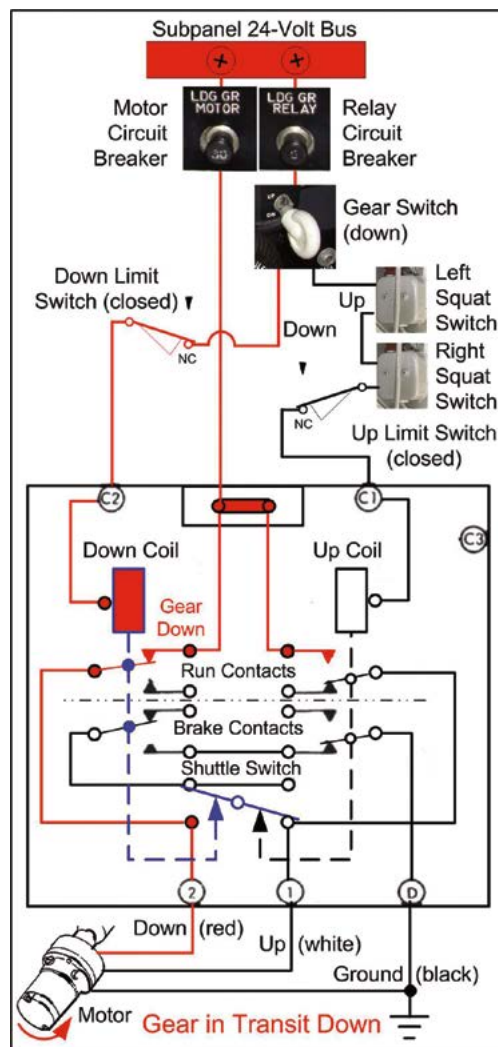


Figure 8

de-energized thus opening the run contacts and closing the brake contacts (**Figure 7**). Opening the run contacts shuts off power to the motor. With the shuttle switch armed, closing the brake contacts connects the down field windings to ground for dynamic braking of the armature. Dynamic braking is completed within a few milliseconds with the gear motor stopped and no further electrical current flow within the landing gear relay.

Gear in Transit Down

The relay's gear-down circuit and operation (**Figure 8**) is similar to the one for gear up with the 24 volts from the pilot's gear-down switch and closed down-limit switch actuating the down coil. The gear down run contacts close, delivering 24 volts to the gear motor causing it to run counterclockwise, thus lowering the landing gear. At the same time, the brake contacts open and the shuttle switch is rotated to arm the dynamic brake circuit.

Gear Down; Dynamic Brake

As with gear-up dynamic braking, the mechanical action of the main gear actuator spider and its limit switch actuator opens the down-limit switch thereby removing 24-volt power from the

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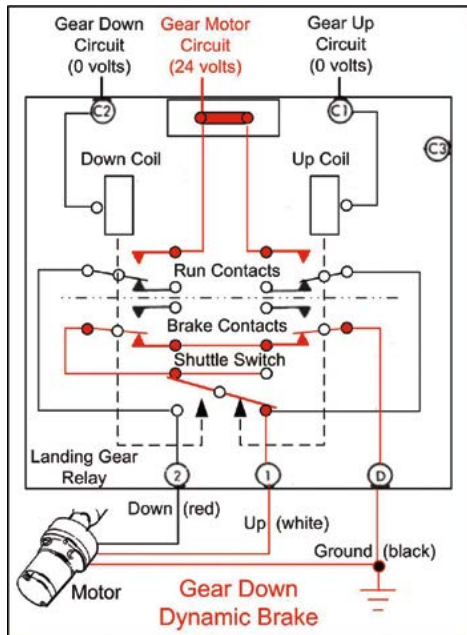


Figure 9

relay's down coil (Figure 9). With the coil de-energized, the run contacts open shutting off power to the motor and the brake contacts close to connect the motor's up windings to ground—dynamic braking again quickly stops the motor armature.

With the landing gear extended during flight, the squat switches are closed as is the up-limit switch thus enabling the gear to be retracted again, such as for a go-around or as part of a training exercise. If the airplane is on the ground, the squat switches are open with no power available to the landing gear relay and motor, electrically inhibiting an inadvertent retraction of the landing gear.

Epilogue

The landing gear electrical system in the 24-volt Bonanzas and ABS twins is not as complex as it initially seems. Understanding the system and its operation can help one take the right action to resolve, or at least mitigate, a problem if a gear failure occurs in flight. Additionally, being able to explain what and when in the gear cycle a problem or failure occurred can help your maintenance technician identify the root cause of the problem and make the appropriate repairs.



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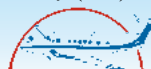
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