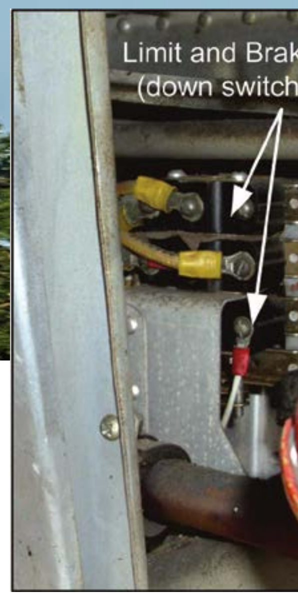


Beech Landing Gear Primer

Part 3: 14-Volt Motor and Dynamic Braking

by George Brown

The initial "BPPP: Beech Landing Gear Primer" in the January 2021 issue describes the landing gear mechanism in the ABS types and gives an overview of its electrical system. Part 2 in the June 2021 issue presents the components and operation of the 28-volt motor, relay, and dynamic braking within the landing gear system in Barons, Travel Airs, and 28-volt Bonanzas. In 14-volt Bonanzas beginning with D-201 and Debonairs, the operating principles for the motor and dynamic braking are identical to those in 28-volt ABS types. For your reading convenience, the Motor and Dynamic Braking Principles sidebar presents some information reprinted from Part 2.

As can be expected, the armature in a 14-volt landing gear motor turns approximately 3,000 RPM, less than half the RPM of the 28-volt motor. Actuation (opening) of either the up or down limit switch at the end of a gear-up or down operation shuts off electrical power to the motor with its spinning armature. As with the 28-volt motor, dynamic braking stops the motor armature from turning within

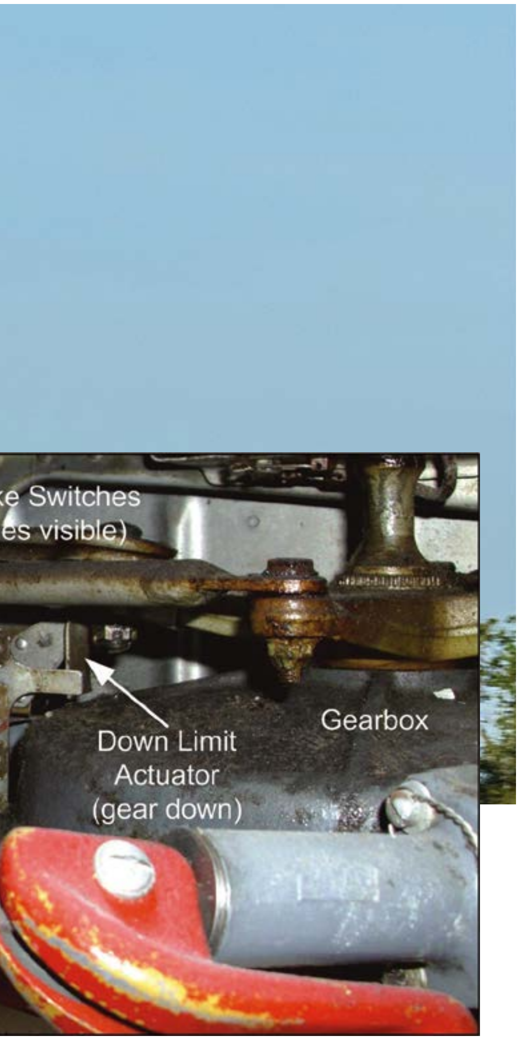


Figure 1

two revolutions, thus preventing the sector gear inside the gearbox from running hard against the internal stop.

Instead of the dynamic brake relay in the ABS twins and 28-volt Bonanzas, one of two normally open microswitches triggers dynamic braking of the 14-volt motor: one for gear-up operation and the other for gear down. Each switch is co-located with its corresponding up or down limit switch and is actuated by the main gear actuator spider (**Figure 1**). Although this figure shows the limit and brake switches in an M35, they are the same or similar in the other 14-volt Bonanzas and Debonairs. Actuation (closing) of either the up or down dynamic brake switch grounds one of the two field windings depending on gear direction, up or down, thereby turning the motor into a generator and stopping the armature almost immediately.

Motor and Dynamic Braking Principles

Landing Gear Motor

A 14-volt, 1/5- to 1/4-horsepower, intermittent-duty, split-field, series-wound, direct-current (DC) motor operates the landing gear. As shown in the motor schematic, 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. 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.

Although the 14-volt landing gear motors look the same and have the same armature and pinion gear as the 28-volt motors, they are not interchangeable because their brushes and field coils are different. As a result, a 28-volt motor cannot be used in an airplane with a 14-volt electrical system and vice versa.

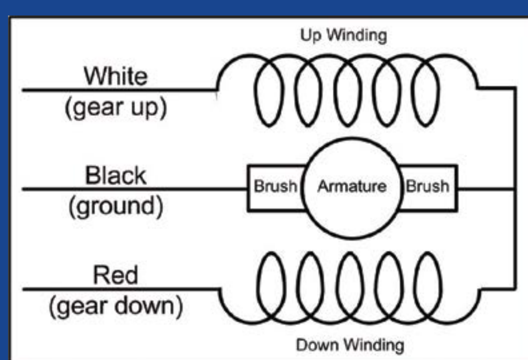
Good mechanical and electrical connections of not only all external wire terminals but also the internal brushes and armature commutator are critical for the required performance from the motor. The ABS Technical Team recommends following the factory overhaul recommendation at every 2,000 hours of flight time or earlier on condition. ABS's concurrence with the Beech recommendation is based on experience with failures of the gear motor that become more frequent with over 2,000 hours of airframe flight time.

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 spinning 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. Although early Beech shop manuals do not mention limits to the number of landing gear operating cycles, some of the later Beech maintenance manuals recommend limiting them to no more than five cycles within 10 minutes.



Split-Field Motor Schematic

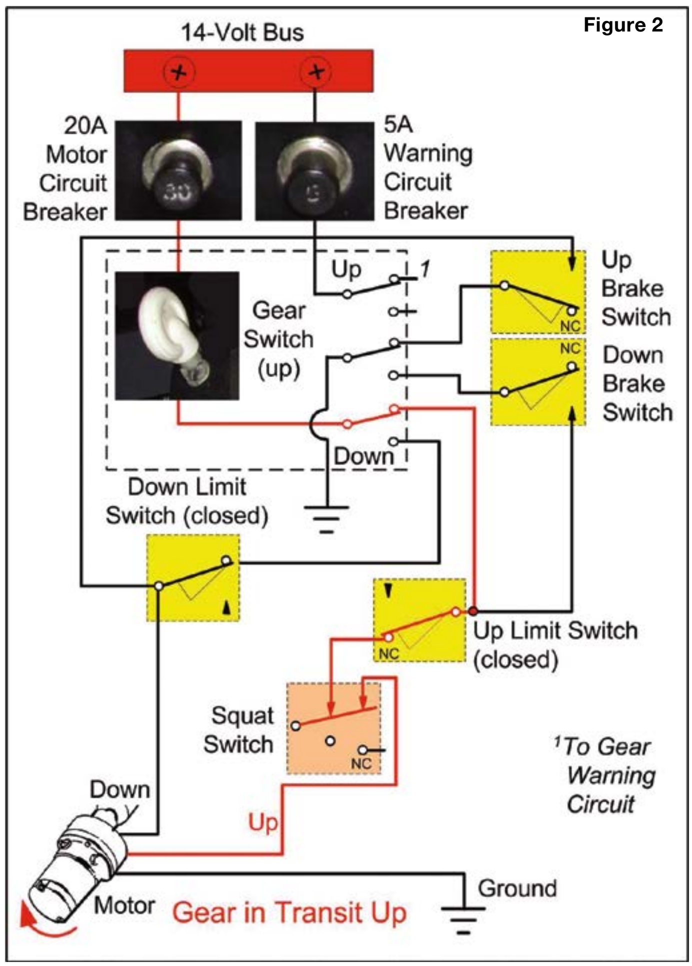
Motor Operating Circuits

Across the line of 14-volt Bonanzas and Debonairs beginning with the first Model 35 of 1947, a number of landing gear motor drive circuit designs were employed. The initial Bonanzas built in 1947 (D-1 through D-200) had no dynamic braking of the gear motor; however, the next 1,300 (D-201 through D-1500) built in 1947 and 1948 had factory-installed dynamic braking using a rudimentary relay actuated by the up and down limit switches.

From 1949 (beginning with D-1501) to the introduction of 28-volt electrical systems during the 1977 model year, a number of variations existed between the several designs of landing gear motor drive and dynamic brake circuits. **Figures 2** through **5** are wiring diagrams generally representing most of these circuits. As shown in these diagrams, two separate electrical circuits run the landing gear motor: one to retract the gear and the other to extend it. The pilot's gear switch on the instrument panel activates the particular circuit, with the current flow from the 20-amp circuit breaker through the switches and wires depicted in the respective diagram. In these diagrams, the active 14-volt motor drive circuit is represented by red lines.

WARNING: To operate the gear manually using the hand crank, do not engage it without first pulling (opening) the landing gear motor circuit breaker. With the motor circuit breaker pressed in (closed), any one of several

Figure 2



mechanical conditions can cause the motor to run unexpectedly, rapidly spinning the engaged hand crank. Severe personal injury can result.

Should the 20-amp motor circuit breaker open on its own, do not reset it to retry the landing gear operation under power. An electrical short has likely occurred in this high-current circuit. Repeated resetting of the breaker can cause a cabin fire. Extend the gear using the hand crank as described in the Pilot's Operating Handbook.

Additionally, separate circuits for gear-up or gear-down operation provide the dynamic braking with the active grounding brake circuit depicted in the diagrams by blue lines. Dedicated contacts within the pilot's gear switch essentially "arm" the respective up or down dynamic brake circuit to stop rotation of the motor armature at the end of gear travel.

The landing gear electrical system in a single gear-up/gear-down cycle operates sequentially 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 electrical switching and current flow in each of these states.

Gear in transit up (Figure 2)

This diagram shows the 14-volt gear-up circuit originating at the bus bar and 20-amp circuit breaker with current flow through the gear switch in the up position, closed up limit switch, and closed squat switch. The 14-volt power is applied to the motor's up field winding, thus turning its armature clockwise to raise the landing gear.

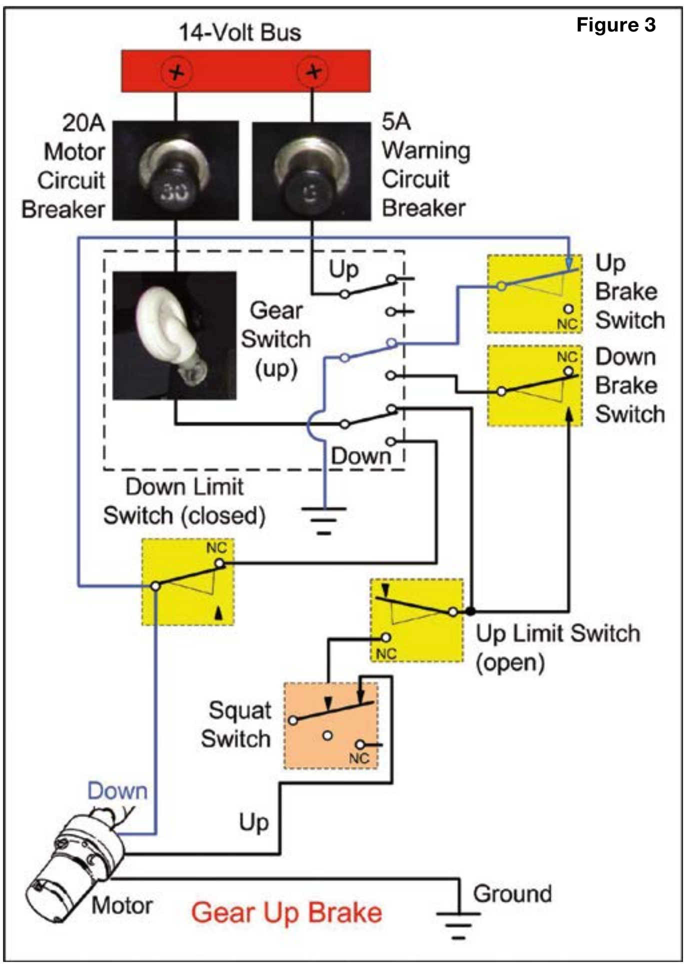
Note that early Bonanzas and Debonairs have only one squat switch, which is on the right main landing gear strut. When the weight of the airplane is off this strut (in flight or on jacks), the squat switch is closed enabling gear retraction. Later 14-volt Bonanzas have two squat switches; one on each main gear strut. These dual switches are wired in series so both have to be closed before the landing gear can be retracted.

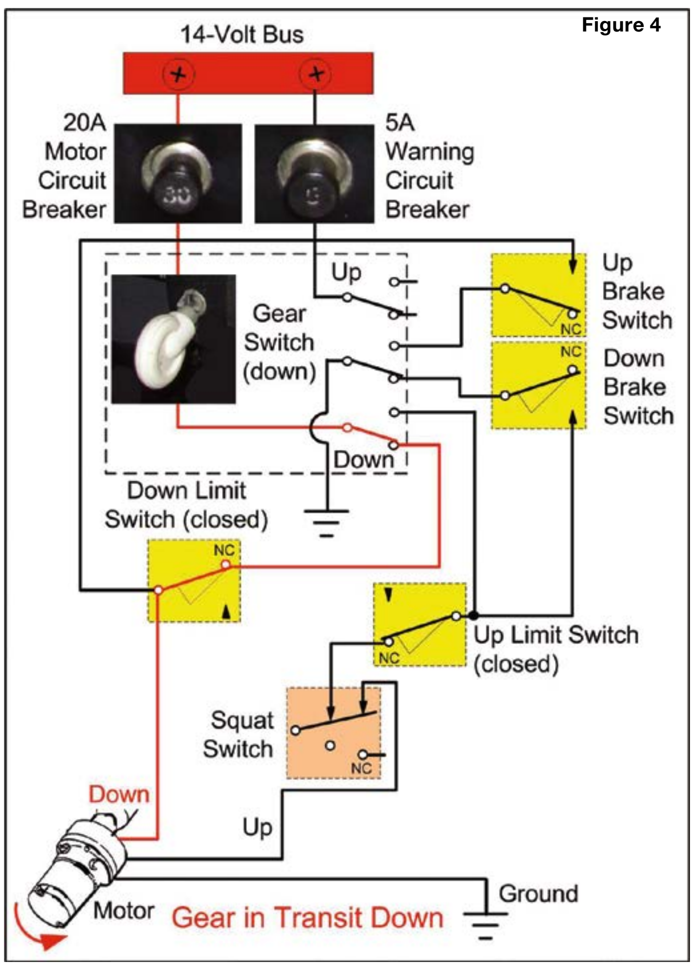
Gear up; dynamic brake (Figure 3)

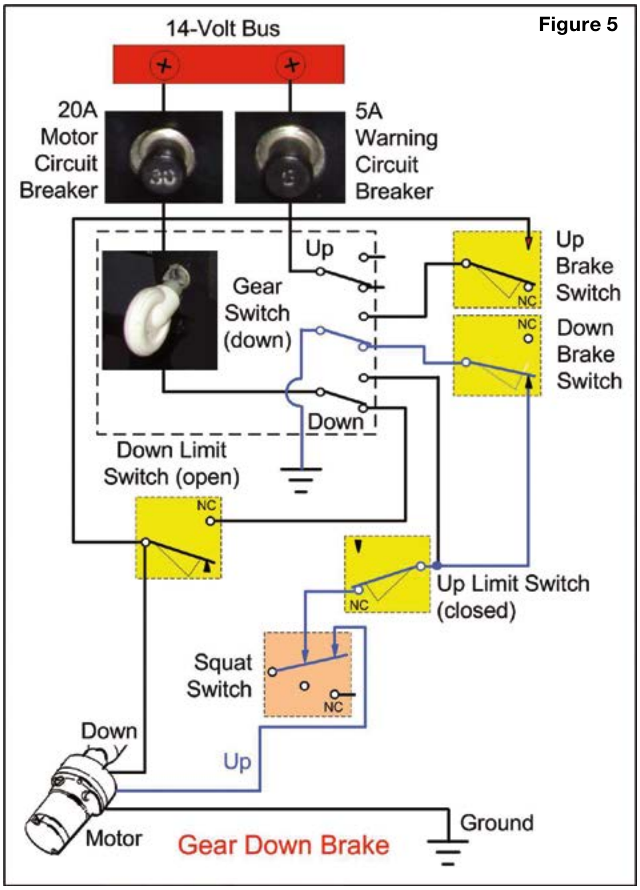
With the gear fully retracted, the actuator tab on the main gear actuator spider triggers (opens) the up-limit switch, shutting off power to the gear motor. The same tab on the spider also closes the up brake switch for dynamic braking of the armature. Closing the brake switch connects the gear motor's down field winding to airframe ground via the common terminal of the down limit switch, closed up brake switch, and closed brake contacts in the gear switch. Dynamic braking is completed within a few milliseconds with the gear motor stopped and no electrical current flow within the landing gear motor or brake circuits.

Gear in transit down (Figure 4)

Moving the gear switch to down closes its down contacts. This action delivers 14 volts through the normally closed down limit







switch to the gear motor's down field winding. Here the armature rotates counterclockwise to extend the landing gear.

Gear down; dynamic brake (Figure 5)

In a similar actuation to gear-up dynamic braking, the position of the main gear actuator spider and its limit switch actuator opens the down-limit switch and closes the down brake switch. Opening the down limit switch shuts off the 14-volt power to the motor's down field winding. Closing the down brake switch grounds the motor's up field windings through the closed squat switch, normally closed up-limit switch, down brake switch, and the down brake contacts in the gear switch. Again the motor armature stops within two revolutions.

With the landing gear extended during flight (or when on jacks), the squat switch is closed as is the up-limit switch, thus enabling the gear to be retracted again, such as for a missed approach or as part of a training (or maintenance) exercise.

Epilogue

Should a gear failure occur in flight, understanding the system and its operation can help you take the right action to resolve or at least mitigate the problem. Additionally, accurately describing what you observed during the failure event can help your A&P mechanic identify the root cause and make the necessary repair.