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B&C Starter Troubleshooting Guide

A high percentage of the starters returned to B&C for troubleshooting and/or repair perform correctly on the test bench upon arrival at B&C. This Troubleshooting Guide is intended to aid our customers in making accurate determinations of starting system faults. Hopefully this will avoid unnecessary loss of time and money returning good starters to B&C for repair.

Basic Starter Operation

All B&C starters have the same basic internal wiring and theory of operation. Refer to Figure 1 for an internal starter wiring diagram.

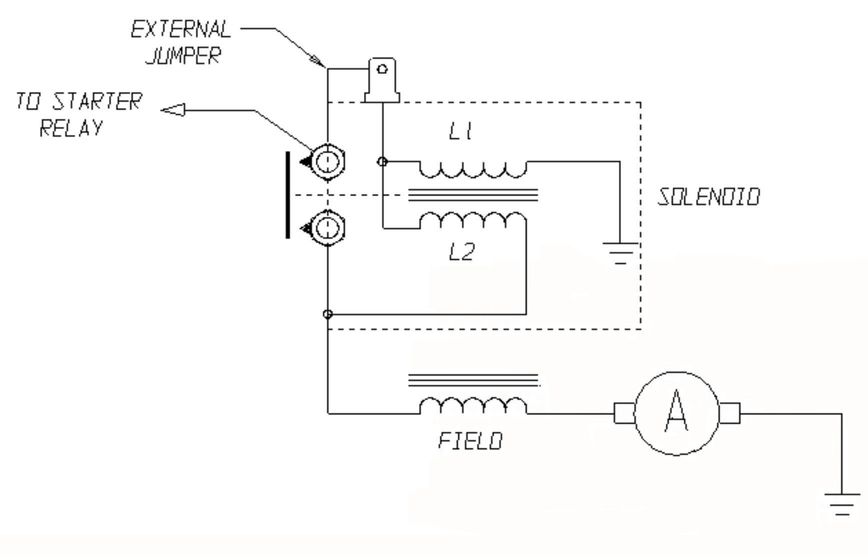

Figure 1

When power is applied to the starter solenoid post from the starter relay, it is also applied to both solenoid coils L1 and L2 through the external jumper. L1 is grounded inside the solenoid. L2 receives its ground through the starter motor. Both coils L1 and L2 act together to extend the starter pinion and then close the solenoid contacts. During this motion the current required to drive the two coils is approximately 30 Amps. When the contacts close, L2 is bypassed by the solenoid contacts, the motor is energized, and only L1 continues to hold the pinion engaged and the contacts closed. Note that if the contacts stick, subsequent attempts to start the engine will cause the starter motor to run and the pinion to remain retracted because L2 is still bypassed. This is sometimes experienced when starting from a bad battery or using poor jumper cables.

If this happens, a sharp rap on the outside of the solenoid will usually jar the contacts loose and restore normal operation. Be careful not to hit the bakelite switch on the rear of the solenoid or deform the metal rolled over to retain the switch on the solenoid. This may crack the switch and necessitate replacement of the solenoid.

Also notice that if the crimp joints or push on terminal of the external jumper are loose, it will be difficult for the jumper to handle the required 30 Amp in-rush current during the pinion extension time. If the starter pinion does not engage the ring gear and the starter motor does not run, this jumper is one possible culprit.

Starting System Troubleshooting

DANGER

In most of the following tests, the propeller will be turning. Be sure to clear the propeller area and keep the ignition switch(es) OFF before each test.

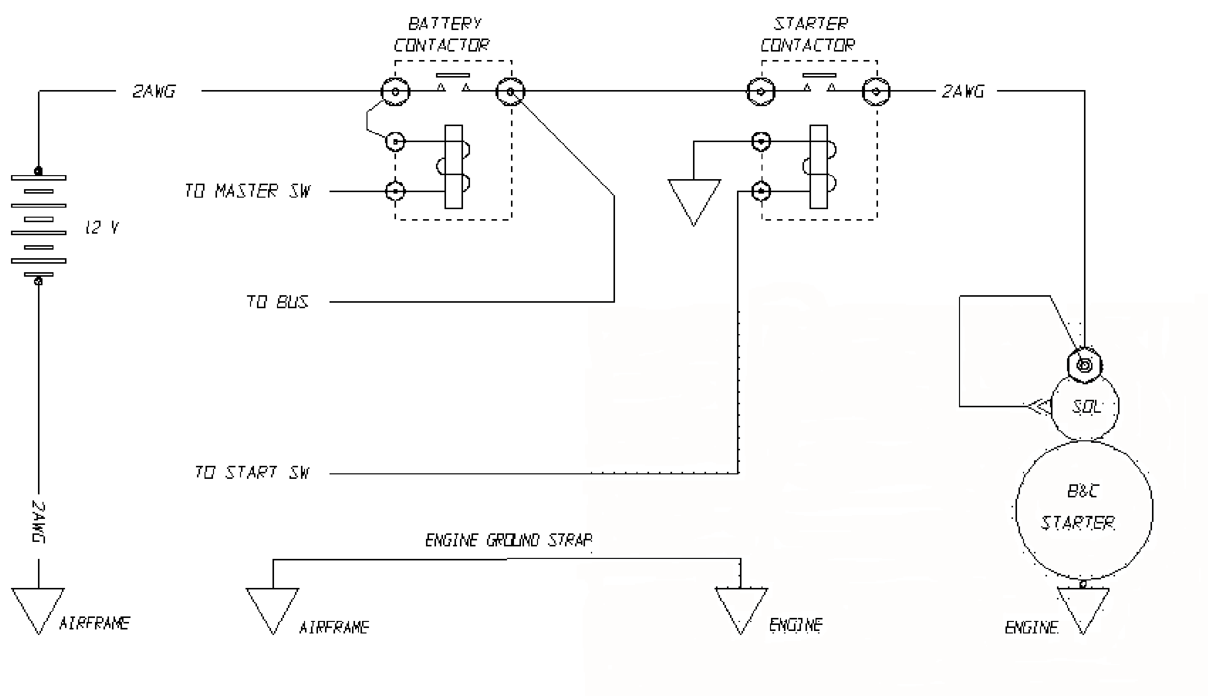

Figure 2

Refer to Figure 2 for typical starting system wiring. It is important that the starting system elements have low enough resistance to be able to supply a minimum of 8.5 to 9 Volts to the starter terminals during cranking. Place a voltmeter directly between the starter input post and the starter case to measure this voltage during cranking. If the voltage is at or above the specified voltage, and the starter does not crank the engine, the problem is most likely in the starter. If the voltage falls below the specified value, the problem is most likely not the starter, but rather the battery, other elements of the starting circuit, or a combination of the two.

The Battery

The battery is the power source for engine starting. A good, fully charged, Lead-Acid battery will have an open-circuit terminal voltage of approximately 12.6 to 12.7 Volts (this may be higher if the battery has been charged within the last few hours). As starting current is drawn from the battery, internal battery resistance will cause the battery terminal voltage to decrease in proportion to the current being drawn. Battery condition may be tested by measuring this terminal voltage during an engine crank. If the Battery terminal voltage drops to 9 Volts or less during cranking, there is not enough voltage left to overcome starting circuit losses and still provide 9 Volts at the starter. This indicates a bad or undersized battery.

The Starting Circuit

If the starting circuit were perfect, the starter terminals would receive the same voltage as the battery terminal voltage. In a practical circuit, each component has a small amount of resistance that causes a corresponding voltage drop at high cranking current. Taking voltage measurements between any two points in the starting circuit while cranking will give the voltage loss in that part of the circuit. This includes the voltage drops in the negative side of the starter circuit which is typically through the engine ground strap, the battery ground strap and the airframe. These voltage measurements may be taken across smaller and smaller portions of the starting circuit until the voltage drop for each component is known. The total of the voltage drops will equal the battery terminal voltage during the crank. Example:

Component	Test Points	Voltage Drop
Cable 1	Batt (+) post to Master Relay input post	0.09
Batt Contactor	Batt Contactor input post to Batt Contactor output post	0.15
Cable 2	Batt Contactor output post to Starter Contactor input post	0.1
Starter Contactor	Starter Contactor input post to Starter Contactor output post	0.17
Cable 3	Starter Contactor output post to Starter input post	0.16
Gnd Strap 1	Engine case to Airframe ground bolt	0.1
Airframe	Engine airframe GND bolt to Battery Airframe GND bolt	0.1
Gnd Strap 2	Battery (-) post to Airframe ground bolt	0.12
Starter	Starter input post to Starter motor case	9.11
Total	Battery terminal voltage while cranking	10.1

The above voltages are typical values. As the engine cycles through compression strokes the current (and the voltage drops) will be varying with starter load. Try to record values near the maximum of the voltage excursions.

A good rule-of-thumb is to expect 10 Volts or more at the battery terminals during a crank and less than 1 Volt total voltage drop in the starting circuit (a 1 Volt or less total voltage drop in the starting circuit may not be attainable on installations with long cable runs between the battery and the starter). This will result in at least 9 Volts at the starter terminals during the crank. Look for a starting circuit element that contributes a particularly large percentage of the total drop or one that is large in comparison to other similar elements in the system. For instance, if two similar length cable's resistance are different by a factor of 2 or more, be suspicious of the cable with higher resistance. If the battery is particularly good, more system loss can be tolerated. If the battery is poor, the rest of the system is going to have to be in top condition. Keep in mind, also, that there can be multiple offenders. For example, many older airplanes were assembled with Aluminum battery and starter cables. Over time these cables have been shown to deteriorate, particularly at the terminal crimps. In this case there may be multiple cables that need to be replaced to get the overall starting circuit resistance down to an acceptable value.

The Starter

As already mentioned, if the starter input post voltage is 9 Volts or more and the starter will not engage or will not crank the engine the problem can be the starter. Starter coils can be shorted due to over-heat or the armature may drag the field poles due to bad bearings or mechanical damage. If this is the case, the starter will demand excess current and run slowly even if it is not under load. A simple test for this condition would be to short the two 5/16" diameter threaded studs on the starter with a screwdriver or heavy jumper and attempt to crank the engine. If the two posts are shorted, the starter pinion will not extend but the starter motor will run. If the starter runs slowly, makes a "growling sound, or pulls high current the starter is in need of repair. If the starter spins up quickly, draws nominal current, and coasts normally to a stop, the starter is most likely not the problem.

If the starter will not engage and the starter motor does not run, check to make sure that the external jumper on the starter is in good condition. The jumper wire ends should not move inside the terminal crimps. The push-on terminal should push on tightly and neither the male blade or female wire terminal should be corroded. Also, check to see if battery voltage is present on the male blade terminal when attempting a crank. If this voltage is correct, the solenoid may be bad or may need to be removed, cleaned, and lightly lubricated with Aeroshell No. 7.

If the starter engages and runs but turns the engine poorly, consider the possibility of slipping starter over-run clutch. Clutches seldom go bad unless the starter has high in-service hours or there have been engine kick-back events. Engine kick-backs Brinell the clutch races and rollers and cause the clutch to slip in certain locations. If the clutch is slipping, the starter may sound like it is running but the propeller may move slowly or not at all.

Addendum for Robinson Helicopters

B&C starters have been used on Robinson Helicopters from the factory for many years. On these installations, RHC elected to omit the typical starter contactor as shown in Figure 2, remove the starter external jumper, and supply the 30 Amps in-rush starter solenoid control voltage through an interlocked starter relay. Therefore, the troubleshooting tips on the external jumper given above do not apply except for the voltage measurement on the male terminal blade during an engine cranking sequence. If the starter will not engage and begin turning, check to make sure that the voltage on this blade (not the female terminal) is near 12 Volts. If so, the solenoid may be bad or need the lubrication described above. If the voltage on the male blade is less than 9 Volts, suspect the starter control circuit in the airframe. Use the same voltage-drop method described above to find the offending voltage drop in the airframe starting relay circuit.

If the starter engages but cranks poorly, the same voltage drop test as described under “The Starting Circuit” above may be used in the high-current starter circuit in the helicopter. There will be no starter contactor but the theory applies to all of the remaining components in the starting circuit.