Motor Troubleshooting Guide

There is not a single listing of motor troubleshooting procedures to be followed in a given order. The procedures will also differ for new and existing installations, and motors that are being bench checked. As with anything dealing with electricity, personal safety is the prime concern.

Checking a motor in its application is the only practical method for most people to determine performance under load. If the motor is defective, the application provides many clues to help determine the cause. Did the motor fail due to a defect or old age, or was its failure hastened by the application or environment? The application is the only place an attempt may be made to check voltage.

On permanently installed equipment, the voltage may vary depending upon the total system load. It can also vary with the total load on the power company grid.

While some of the troubleshooting procedures that follow apply specifically to the two compartment A.O. Smith pump motor, the basics apply to other motors.

WARNING!
This is not a guide for the do-it-yourselfer. These tips and suggestions are offered for persons with proper qualifications and necessary test equipment.

See that this electrical list is followed:

- Assure proper voltage at motor terminals.
- Follow motor connection diagram on motor nameplate.
- Make sure motor is properly GROUNDED and complies with local and national electrical codes.
- See that the pump turns freely before starting motor.

FAILURE TO START
(MOTOR MAKES NO SOUND)

- Check voltage at motor line terminals. Voltage should correspond with motor nameplate rating (±10%).
- Check all electrical connections at the motor terminal board.
- If no voltage is present; check fuses, timers & switches.
- Protector tripped — wait until motor cools then restart — check protector for continuity.

$ The following chart shows recommended minimum wire sizes for pump motors. The calculations were based on motors with the highest starting currents. Larger wire sizes reduce the voltage drop at the motor in both the start and run modes. A lower voltage drop means the motor will run more efficiently (cooler) and have increased service life. In general, and up to a certain point, the efficiency gained from one size larger wire will have a payback of less than two years.

PUMP MOTOR RECOMMENDED MINIMUM WIRE SIZE*

Motor H.P.**	DISTANCE FROM SERVICE ENTRANCE/MAIN PANEL TO MOTOR							
	50 feet		100 feet		150 feet		200 feet	
	115V	230V	115V	230V	115V	230V	115V	230V
1/3	14	14	12	14	10	12	8	12
1/2	14	14	10	14	8	12	8	10
3/4	12	14	10	12	8	12	6	10
1	12	14	8	12	8	10	6	8
1-1/2	10	14	8	12	6	10	6	8
2	10	14	8	10	6	10	6	8
3		12		10		8		8

***Always follow all applicable codes.**
****Pump Motors with service factors greater than 1, and split phase designs. No more than 15 volts drop at start, in worst case.**

FAILURE TO START (MOTOR HUMS OR ATTEMPTS TO START)

- Check voltage at motor line terminals. If voltage is inadequate to start motor, check for loose connections, undersized wiring, overloaded circuit or other causes of voltage drop.
- Start switch contacts not closed when motor is not operating. Switch may require adjustment. Switch contacts dirty or pitted.
- Capacitor (where used) is "shorted" or "open".
- Check motor windings for "open" or "short".
- Check for continuity through protector.
- Turn the motor shaft by hand to get the "feel" of the motor. If the shaft feels tight or doesn't turn smoothly:
  - Check the bearings for smooth operation.
  - See if there is evidence of the rotor striking the stator.
  - Check for internal corrosion, cracked end frames, clogged fan or other obstruction within the motor.
  - Check pump for obstructions, binding impeller, or bent shaft.

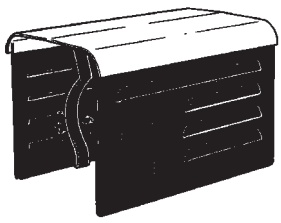
OVERHEATING

As in all motor applications, excess heat is very detrimental to motor operation and life. Heat over time breaks down motor insulation and leads to failure. The relationship of temperature to life is geometric. In other words, as the temperature goes up the winding life is shortened at an increasing rate.

A continuously running pump motor may be hot to the touch and this by itself does not mean the motor is overheating.

Excess heat has many possible causes:

- Low voltage. The voltage may be low at the source or there may be excessive voltage drop when the load is applied due to too small a wire size.



8200 MC-200
UNIVERSAL MOTOR COVER
(fits 1/3 HP to 2 HP motors)

- Overvoltage. This needs correction by the power company.
- High ambient temperature. Pool motors are normally designed to operate in higher ambients (50°C) than jet pump motor which usually have short duty cycles. Artificially high ambients may be created if the motor operates in a confined space and recirculates the air.
- Protect the motor from excess heat by shading from the sun with a motor cover such as the Blue Devil™ unit illustrated here. It is important that a motor cover provides fresh air circulation and does not allow air heated by the motor to recirculate.
- Reduced air flow. Foreign material such as grass clippings, leaves, lint and bugs and small lizards may plug air passages.
- If the motor has an internal cooling fan, is it intact and functioning properly?
- Application overload. In cases of flooded suction or positive pressure on the inlet to the pump, flow may be increased, overloading the motor.
- Misapplication. Specific motor and impeller combinations are sized to do a specific job. In most cases, the impeller loads the motor to the service factor horsepower. It is absolutely imperative that a replacement motor is able to develop the same or higher total horsepower (nameplate horsepower X service factor) as the motor being replaced.
- Compare the running amperage of the motor with MAXIMUM LOAD or SF amps. If amperage is higher than MAXIMUM LOAD or SF amps, with proper voltage applied, determine cause of overload.

- Check motor windings and capacitor (where used) for “ground” or “short”.
- Check terminal board connections with the motor wiring diagram for proper applied voltage.
- Check the motor start switch and governor to be sure it is adjusted properly and is operational.

NOISY OPERATION

- Check motor coupling, brackets and other attached parts for adjustment or looseness.
- Motor bearings.
- Pump cavitation.

ELECTRICAL SHOCK

- Check motor windings, all motor wiring, and capacitor for ground.

PROTECT AGAINST MOISTURE

- The open drip proof type motors discussed here may be used outside, but their life expectancy is enhanced if they are protected from the elements. The enclosures should not restrict air flow or cause recirculation.
- Motors that are out of service, such as pool motors in the winter, should not be sealed in plastic bags which cause condensation directly in the motor.
- If the motor is not running it may be covered for short periods of time such as when the area around a swimming pool pump is being hosed down.

- Locate motor on a slight elevation so water will not run or puddle nearby.
- Avoid spilling or dripping liquid chemicals on or near the motor.
- Avoid splashing water on or near the motor.
- Repair leaky pipe joints, "O" rings, or pump seals promptly.
- Avoid locating motor in highest humidity area.

If the motor is flooded, the bearings may be ruined. Once they start making noise, failure is imminent.

If the seal leaks and is not replaced, the bearings may also be ruined. A new seal should be installed any time a motor is replaced. A slinger or flinger should also be used on the motor shaft to deflect water from the bearing location.

PROTECT AGAINST DIRT & CHEMICALS

- Avoid sweeping or stirring dust near the motor while it is running.
- Chemicals should not be stored near the motor. Chlorine can be especially damaging if in a liquid form being dispensed into a filter pit.

ELECTRICAL CHECKS

The next section explains the use of test equipment.

CONVENTIONAL MULTIMETER OR OHMMETER

An ohmmeter can be used to measure the resistance of the various motor windings as well as to test the insulation.

The ohmmeter will have numerous ranges from R x 1 where the meter reads directly in ohms to an Rx100K where the actual meter reading must be multiplied by 100,000 for the actual ohm value.

Before using an ohmmeter:

- Make sure all motor leads are disconnected from the power source.
- Make sure the meter is adjusted to zero before taking each reading.
- All troubleshooting checks specify the ohmmeter range to be used. If your meter does not have the exact range, use the next higher range.

DIGITAL OHMMETER/MULTIMETER

Direct reading digital ohmmeters are readily available in the field. To use this type:

- Make sure all motor leads are disconnected from the power source.
- Read instruction manual for the meter.
- You do not have to set the ohmmeter to a particular scale as the meter displays the ohm value up to the maximum capability of the meter.
- Install probes and take resistance readings in the normal manner.

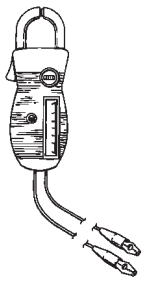
AMMETER AND VOLTMETER

Voltmeter Readings:

Install leads in bottom of Amprobe®. Select the desired voltage scale. Take readings by touching one probe to each of the lead line terminals.

Ammeter Readings:

- Arrange leads so the jaws of the Amprobe® will encircle one lead.
- Set meter on maximum amp scale and encircle jaws around one lead and take reading. It may be necessary to reset to a lower scale.



VOLTAGE CHECK

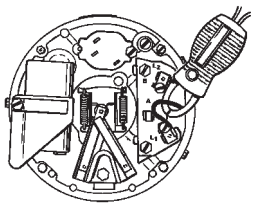
- Disconnect power source
- Remove canopy
- Determine motor voltage and set meter on proper scale
- Reconnect power
- Start motor

Touch one probe to L1 and the other to L2. Voltage reading to be within 10% of nameplate voltage, i.e. between 207 and 253 volts for a 230 volt motor.

If no voltage is recorded, check pressure switch, fuses, circuit breakers, timers, wiring, etc. for open connection or broken wires.

If voltage is outside the acceptable limits-check for adequate wire size. Look for loose terminals and connections, or pitted contacts, check pressure switch and pump disconnect switch.

Check voltage at service entrance. If not within ±10% contact power company.



AMPERAGE CHECK

- Turn off power at pump disconnect switch.
- Set ammeter scale based on max. load amps.
- Position one line lead (L1 or L2) so that jaws of amprobe can encircle one power lead.
- Make sure switch and governor are free of obstructions.
- Reconnect power.
- Start motor.
- Encircle one line lead with jaws of amprobe and take reading. This value should not exceed maximum load amps of motor.

Excessive amps means an overloaded condition or incorrect voltage applied. Problem could also be in motor.

START SWITCH CHECK

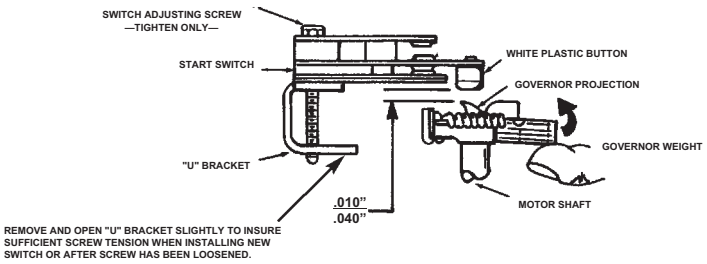
- Visual checks:
  - Disconnect power source.
  - Remove canopy.
- Make sure there are no obstructions preventing the proper operation of the rotating governor. Check wiring and make sure none of the leads are in the area of the governor where they can be cut or interfere with the governor. Check governor for proper operation and make sure flipper is free to move.
- Check switch contacts for severely burned or pitted contacts, sticking etc. Some blackening or pitting is normal after motor has been used. Replace switch if there is any doubt. Don't try to repair by bending the contact leaf.
- Unlike points in an automotive distributor, the switch contacts in motors are plated and should never be sanded which would remove the plating and cause early failure. They may be cleaned by wiping with a piece of cardboard or paper bag.
- Reconnect power.
- Start motor. Visually check the action of the switch and governor. Switch contacts must be closed when motor is at rest and should open when motor reaches about 2/3 of full load speed.

NOTE: Replace capacitor and switch at the same time. A defective switch usually stresses the start capacitor.

START SWITCH ADJUSTMENT

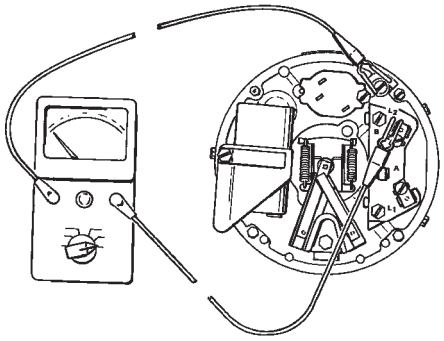
- Fasten switch snugly to end bell, through "U" bracket with the screw provided.
- A slight amount of switch movement is possible before the screw(s) is tightened. Check to see that the white switch button is centered over the governor projection.
- Reach in and move the governor weight (overcoming the spring tension) until it touches the stops on the governor.
  - The clearance between the projection and the white button should be .010" to .040" (.040 is about the thickness of paper clip wire).

- Most newer models use only one screw to secure and adjust the switch. When a new switch is installed, or an existing switch is being reinstalled, the "U" bracket should be opened slightly to insure sufficient tension against the screw. Tighten only when adjusting. If the screw is loosened, it should be removed and the "U" bracket should again be opened slightly.
- On models with two screws, turn the switch adjustment screw until the correct clearance is obtained. When finished, tighten the adjacent switch screw to secure the switch to the bracket.
- Under no circumstances should switch contact leafs be bent or deformed in an attempt to obtain proper contact clearance.



MOTOR COMPONENT CHECKS

Based on your observations perform the following checks to confirm that each component is functioning properly.



GROUND CHECK

Ground Check — Set ohmmeter to R x 1K.

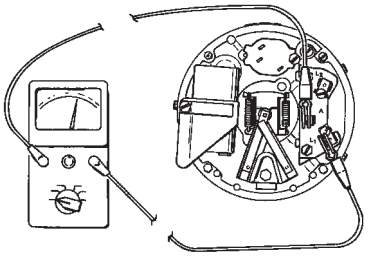
- Attach one probe to ground screw and touch other probe to all terminals on terminal board, switch, capacitor and protector. A reading of less than 10K could indicate a ground. New motors typically read over one megohm. Old motors with dust, dirt and moisture could show resistance to ground below 10K and still run satisfactorily. A cleaning may be in order. Readings may vary from day to day depending upon the humidity levels. Approximately 25K at 115 volts will trip a ground fault device. Keep in mind the ground fault device is seeing the total leakage of all loads on the circuit. GFI's normally trip on readings from 4 to 6 milliamps.
- If grounded, check all external leads for cuts, breaks, frayed wires, etc. Replace damaged leads and recheck for grounds and proper lead routings. Make sure replaced leads are not pinched between canopy and end bell. If ground is in stator, replacement of motor is recommended.

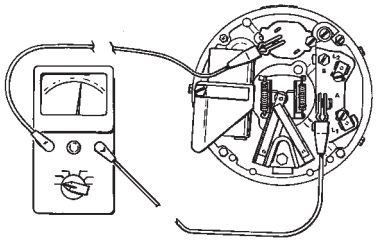
WINDING CONTINUITY

(For typical single phase, dual voltage only, capacitor start, single speed motor, connected for 230V. Set meter to R x 1).

For single voltage motors, check between L1 and L2.

Slip a heavy piece of paper between points, taking care not to bend tabs. Discharge capacitor by shorting across the terminals with the blade of an insulated screwdriver. Take the following ohm readings.

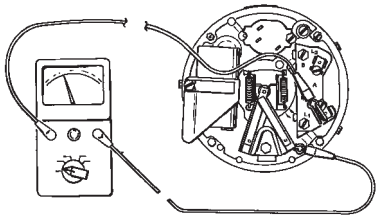




Resistance between L1 and A must be same as between A and yellow.

YELLOW TO RED

L_1 TO RED



Yellow to red (winding side of switch) must be same as L1 to same red terminal.

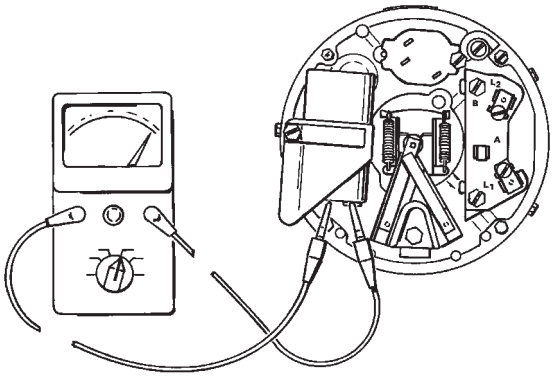
CAPACITOR

Capacitor — Set ohmmeter at R x 1K.

Slip a heavy piece of paper between points.

Discharge capacitor by touching the two terminals with the blade of an insulated handle screwdriver.

- Attach one probe to each terminal; ohmmeter needle should move rapidly to right then slowly drift to the left. (Low ohm reading to high ohm value).
- If a digital meter is used, readings should start low and rapidly increase to maximum value.
- Replace capacitor if bad.



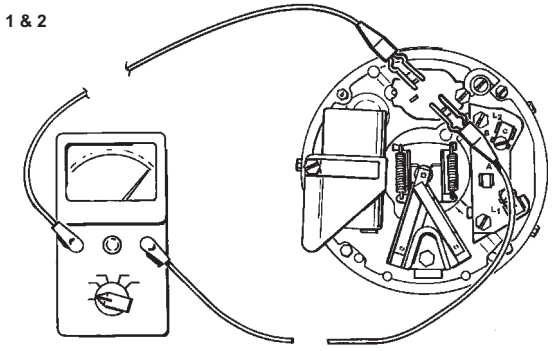
SWITCH

Remove paper and attach one lead to each switch terminal. Ohmmeter reading should be 0. Flip governor weight to running position. Reading should be infinity.

NOTE: Motor cycling on overload indicates some other problem, not just a defective overload.

PROTECTOR (THERMAL OVERLOAD)

Protector — Set ohmmeter to R x 1.
Resistance between protector terminals:
1 & 2 should be approximately 0 (Disc.).
2 & 3 should be approximately 0 (Heater).
Replace if either value exceeds 1 ohm.



PUMP DISASSEMBLY

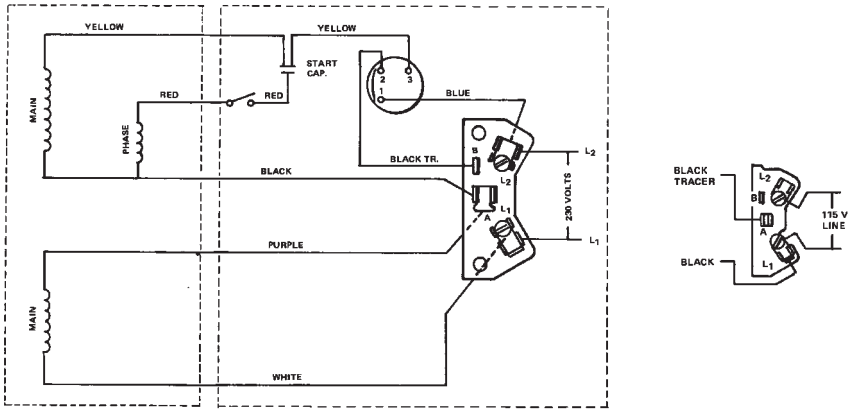
Wrench flats on shaft have been provided to facilitate impeller removal. Insert a 7/16" open end wrench under governor assembly and hold while unscrewing impeller. (NOTE: For easier access, the capacitor can be removed from its mounting bosses).

NOTE: If necessary to remove motor from pump, disassemble pump in accordance with pump manufacturer's recommendation.

* Motors produced since 2000, have an improved wrench access area behind the overload.

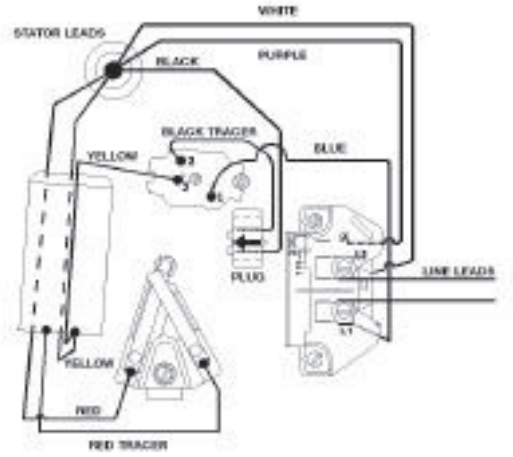
SINGLE SPEED MOTOR — TYPICAL SCHEMATIC DIAGRAMS

Capacitor Start
Induction Run — Single Speed

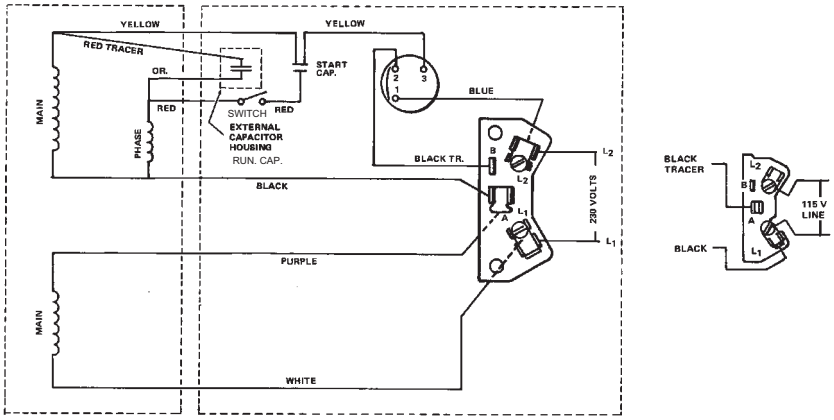


EXT. & WIRE ROUTING

Dual Voltage — Single Speed — Capacitor Start
With Voltage Change Plug

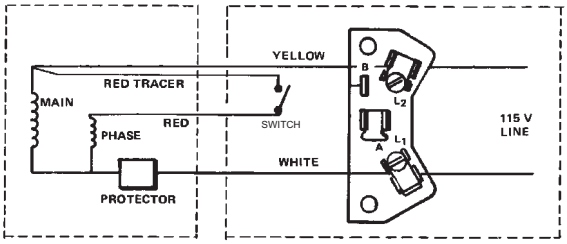


Capacitor Start
Capacitor Run — Single Speed



SINGLE SPEED MOTOR — TYPICAL SCHEMATIC DIAGRAMS

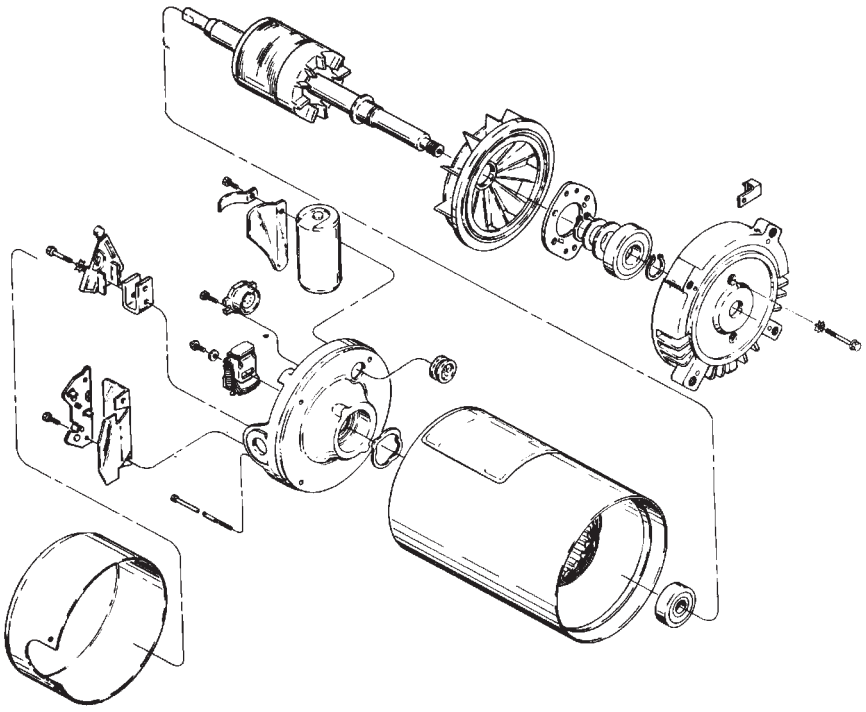
Capacitor Start* or Split Phase
Single Voltage on Winding Protector



*Capacitor not shown in schematic.

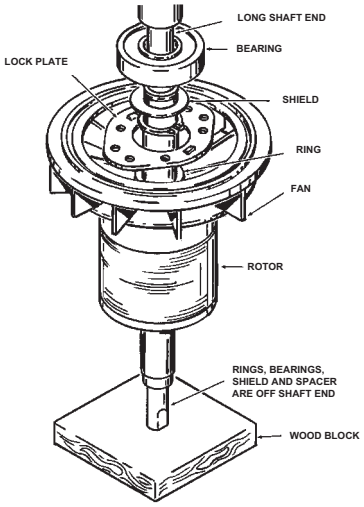
MOTOR ASSEMBLY

All of the motors covered by this manual are similar in design and construction, with variations in baffles, type of protector, type of flange, and bearing construction. When disassembling, make sure you note the exact location of all components so they can be reassembled in the proper order. This is especially true of the bearing assembly where the number and types of small parts (rings, washers, etc.) varies substantially from model to model.

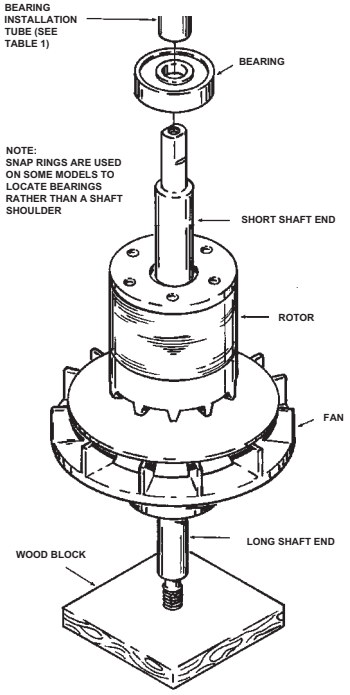


HOW TO REPLACE BEARINGS

1. Remove the bearing(s) from the motor shaft following these steps as necessary:
   - Use an external ring pliers to remove snap rings which are used to secure bearings.
   - Use a bearing puller to remove defective bearing(s). Don't reuse a bearing which has been removed from the shaft.
   - Remove miscellaneous small parts (washers, etc.) from shaft after bearings are removed. Be sure to replace in proper order.



2. Install the new bearing(s) using the motor illustration and typical bearing installation view as an assembly guide. Follow these steps as necessary.
   - Refer to the table for the size tube needed to install new bearing(s). It is important to press only on the bearing inner race. The bearing will be damaged if the outer race surface is used for pressing.
   - Fan end: Place the short end of the shaft on the wood block. Place the bearing (and other parts as used) over the long end of the shaft. Tap the bearing into place using the proper size tube and a mallet, or use a press. Attach any parts (as used) to the long shaft end.



- Opposite end: Place the long end of the shaft on the wood block. Place the bearing (and other parts as used, such as snap rings and washers) over the short end of the shaft. Tap the bearing into place using the proper size tube and a mallet, or use a press. Attach any other parts (as used) to the short shaft end.

Compare the rotor and shaft parts assembly shown on the previous pages with the order of assembly found on the motor during teardown. The miscellaneous parts (washers, snap rings, etc.) vary from motor to motor, so when disassembling use care to identify these parts and their order so they can be reassembled in the proper sequence.

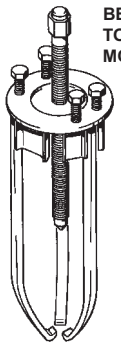
BEARING INFORMATION TABLE

Bearing Size	Bearing Dimensions			A.O. Smith Bearing Part No.[1]	Bearing Installation Tube Dimensions (In Inches)[2]		
	Diameter (Inches)		Width		Outer Diameter of Tube	Wall Thickness	Minimum Length
	Inside	Outside	(Inches)				
202-16	.6299	1.3780	.4331	610358-1	7/8	.095	3
203	.6693	1.5750	.470	604005-4			
204	.7874	1.8504	.5512	600269-2	1	.095	3
304	.7874	2.0472	.5906	603628-2			
205	.9843	2.0472	.5706	612096-1	1-1/4	.125	3

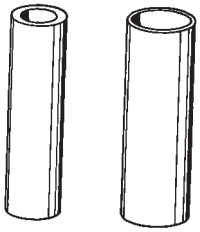
1. Only use bearings obtained from A.O.Smith and ordered by the proper A.O.Smith part number. Do not substitute other bearings, or reuse bearings which have been pulled from shafts. Bearings obtained from A.O.Smith are built with balls having a specific fit, checked for sound level and filled with high grade grease for the temperature and service conditions.

2. Replacement instructions show how the bearing installation tube is used to install new bearings.

RECOMMENDED TOOLS

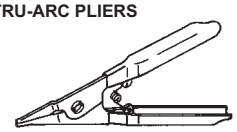


BEARING PULLER SNAP-ON TOOLS MODEL NO. CG-250 OR EQUAL



BEARING INSTALLATION TOOLS

TRU-ARC PLIERS



EXTERNALRING PLIER SNAP-ON TOOLS MODELNO. PRS 22 OR EQUAL

CAUTION: When routing leads under the canopy be sure that:

A. No leads are in the area of the rotating governor.
B. When the canopy is installed make sure leads will not be pinched between the canopy and the end frame.

NOTE: In either case the fault could cause a ground, resulting in a very dangerous condition should power be applied without proper grounding.

MOTOR REASSEMBLY

Reassemble the motor in reverse of the disassembly procedure.

- Observe all reassembly precautions and adjust the motor start switch.
- Recheck wiring.
- Check rotor and shaft and make sure it turns freely by hand.
- Check motor for grounds before applying power.

2-SPEED MOTORS

Two-speed motors are regulated by various types of controls which range from a simple "high-low" toggle switch to elaborate and exotic automatic systems. Thus troubleshooting two-speed systems requires an extensive knowledge of both motors and controls.

Two-speed motors are built with and without high-low switches. The conversion of a "with" switch motor to "remote" switch operation requires more than just removing the switch. Schematic diagrams are included in this section for conversion purposes.

Capacitor start — Motors of this design have a model number beginning with C (i.e., C48 or C56) and usually start on the high speed (2-pole) winding.

Split phase — a split phase motor (S48) always starts on high speed. There is no start capacitor, therefore, the red tracer lead from the start winding connects directly to terminal #2 on the switch.

Capacitor start and run — motors of this design have a model number beginning with K (i.e., K48 or K56) and will have a run capacitor mounted on the exterior of the motor.

Thermal protector — 2-speed motors always have the thermal protector located on the motor windings.

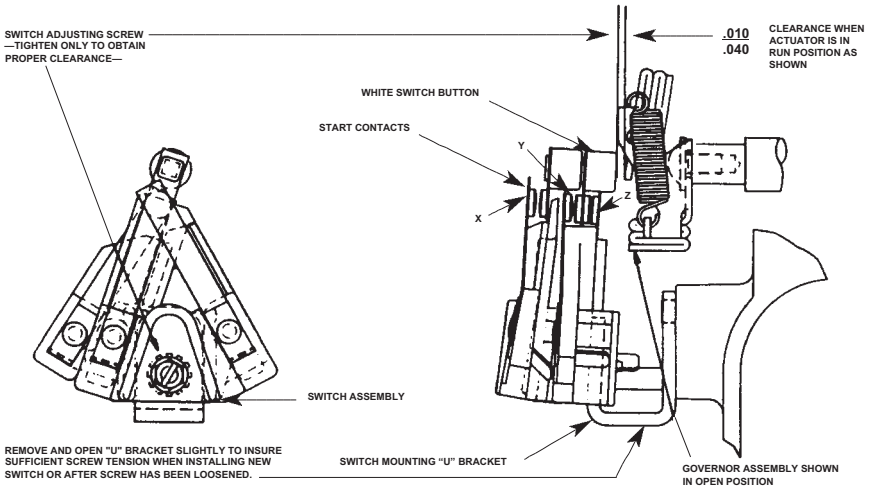
START SWITCH REPLACEMENT AND ADJUSTMENT — 2-SPEED MOTORS

Proper starting switch adjustment on two-speed motors is essential for satisfactory operation and contact life.

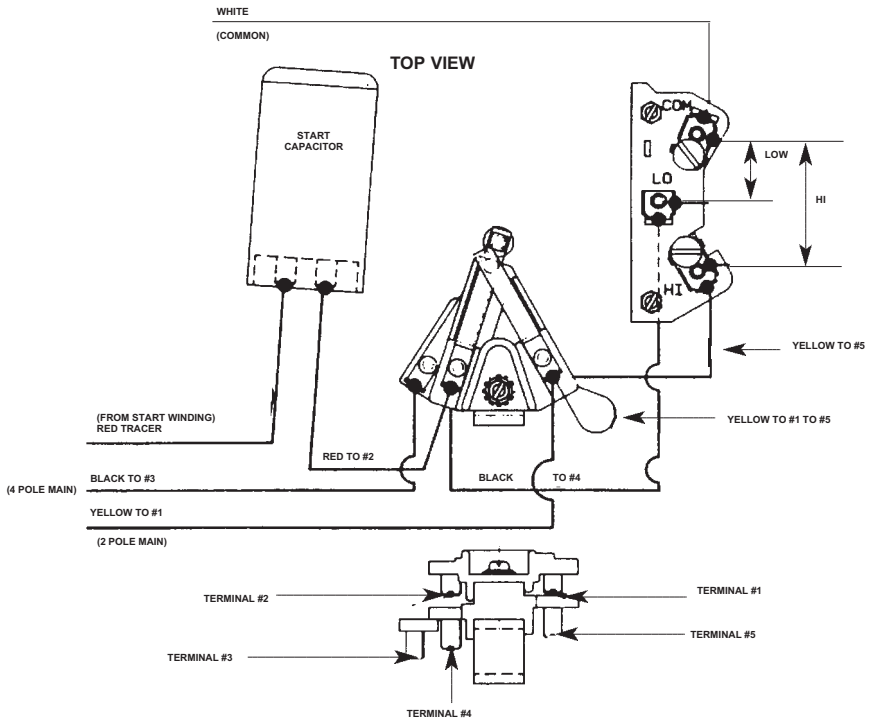
- Disconnect all power to the motor before attempting any repair. Repair work should only be performed by a qualified electric motor technician.
- Fasten switch snugly to end bell, through "U" bracket with the switch mounting screw provided.
- A slight amount of switch movement is possible before the screw(s) is tightened. Check to see that the white switch button is centered over the governor projection.
- Lift the governor weight (overcoming spring tension) until it touches the stops on the governor. Clearance between the governor projection and white button should be .010" to .040".
- Most newer models use only one screw to secure and adjust the switch. When a new switch is installed, or an existing switch is being reinstalled, the "U" bracket should be opened slightly to insure sufficient tension against the screw. Tighten only when adjusting. If the screw is loosened, it should be removed and the "U" bracket should again be opened slightly.
- Under no circumstances should switch contact leafs be bent or deformed in an attempt to obtain proper contact clearance.
- Once the governor weight is released, and the governor projection pushes on the switch button, contact Z should move away from the motor by approximately .030". This movement assures that the points will have sufficient contact no matter what position the rotor/shaft and governor projection are in at rest.

In run position contacts X & Y must be open and contact Z closed. At rest, contacts X & Y must be closed and contact Z open.

SWITCH ADJUSTMENT

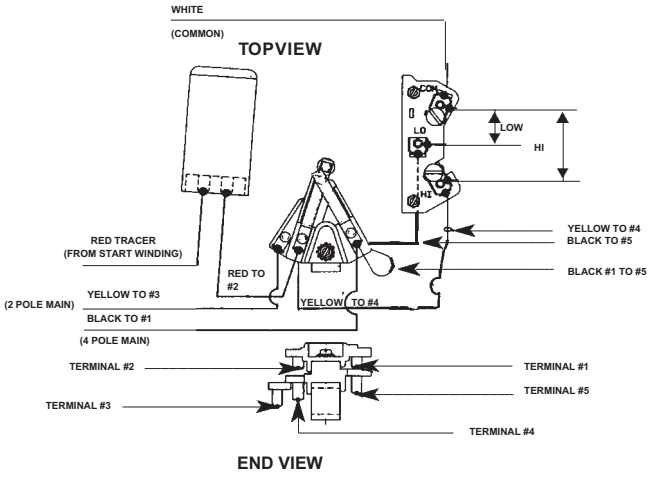


SWITCH CONNECTIONS — HIGH SPEED START

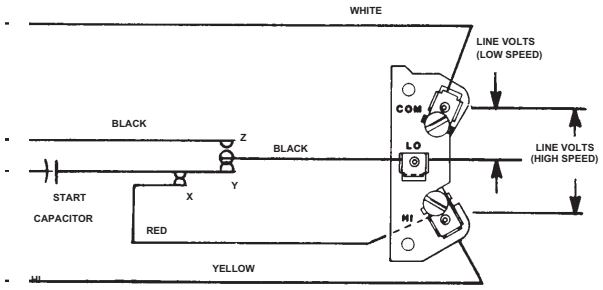


SWITCH CONNECTIONS — LOW SPEED START

Low speed start — this design motor always starts on the low speed (4-pole) windings. When the control calls for high speed run, the start switch automatically switches the motor to high.



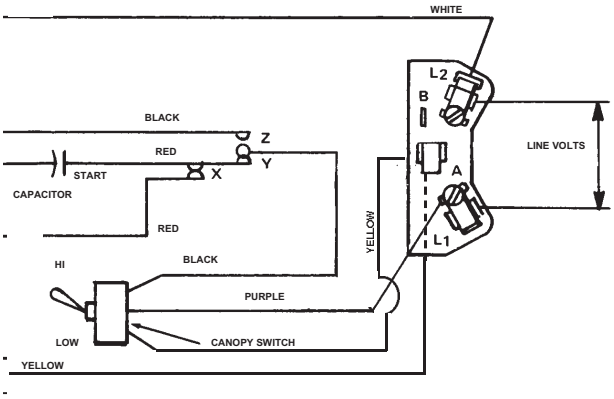
2-SPEED MOTORS — HIGH SPEED START
SCHEMATIC DIAGRAM
2-Speed for Remote Switch Operation



START - X & Y CLOSED Z
OPEN
RUN - X & Y OPEN Z CLOSED

2-SPEED MOTORS — HIGH SPEED START SCHEMATIC DIAGRAMS AND RECONNECTION INSTRUCTIONS FOR REMOTE OPERATION

2-Speed with Hi - Low Switch
Mounted on Motor Canopy



YELLOW MUST BE CONNECTED TO BOTTOM TERMINAL WITH SWITCH IN POSITION SHOWN

START - X & Y CLOSED Z OPEN
RUN - X & Y OPEN Z CLOSED

NOTE: Several different connections have been used in production. If the wiring on the motor you are reconnecting does not match these diagrams contact A.O. Smith and we will FAX or mail a connection for that model.

RECONNECTION FOR REMOTE SWITCH OPERATION

REMOVE BOTH YELLOW LEADS FROM 'A' TERMINALAND CONNECT TO TERMINALL1.

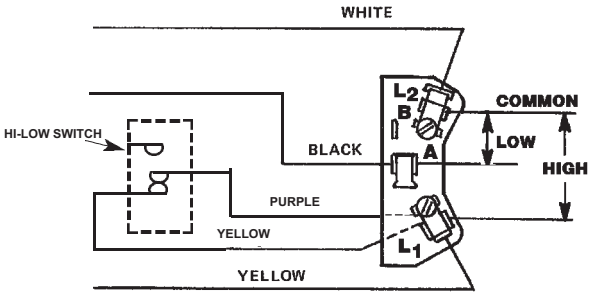
REMOVE BLACK LEAD FROM HI-LOW SWITCH AND CONNECT IT TO TERMINALA.

LEAVE SWITCH IN CANOPYAND LEAVE PURPLE LEAD CONNECTED TO SWITCH.

CONNECT POWER SUPPLY LINES TO TERMINALBOARD

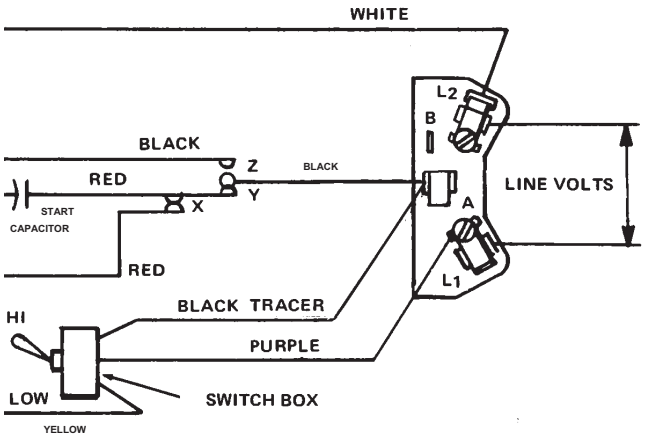
L2-L1	HIGH SPEED
L2-A	LOW SPEED

BEFORE REPLACING MOTOR CANOPY, BE SURE ALLLEADS ARE PROPERLY PLACED TO PREVENT DAMAGE FROM GOVERNOR AND/OR CANOPY.



2-SPEED MOTORS — HIGH SPEED START SCHEMATIC DIAGRAMS AND RECONNECTION INSTRUCTIONS FOR REMOTE OPERATION

2-Speed with Hi - Low Switch
Mounted in External Box



NOTE: Several different connections have been used in production. If the wiring on the motor you are reconnecting does not match these diagrams contact A.O. Smith and we will FAX or mail a connection for that model.

RECONNECTION FOR REMOTE SWITCH OPERATION

DISCONNECT PURPLE AND YELLOW LEADS FROM HI-LOW SWITCH AND CONNECT TOGETHER.

DISCONNECT BLACK TRACER LEAD FROM HI-LOW SWITCH PERMANENTLY. TAPE UPEXPOSED END.

CONNECT POWER SUPPLY LINES TO TERMINALBOARD

L2-L1	HIGH SPEED
L2-A	LOW SPEED