Boston Gear®

Ratiotrol®

DC Motor Speed Control

P-3036-BG ***Installation and Operation***

Doc. No. 86986

VEL-RG Series 1/6 – 1 HP
VEH-RG Series 1 – 5 HP

Boston Gear

An Altra Industrial Motion Company

Table of Contents

Introduction

This equipment manual contains installation, operation, and maintenance instructions for VEL/HRG Single-phase Adjustable Speed Regenerative DC Motor Controllers. A parts list and illustrations are also included.

General Description

Regenerative Controllers are high performance units which statically rectify single-phase AC line power to regulated DC for adjustable speed four quadrant armature control of DC motors. Applications include those requiring controllable bidirectional torque for overhauling loads, contactorless reversing or precise position control.
These controllers comply with applicable standards established by the National Electrical Code and NEMA for industrial motor and control equipment

Motors

VEL/H RG controls 1/6 through 3 HP have been factory-adjusted to run with permanent magnet motors supplied by Boston Gear. The VEHRG500CM, 5 HP control has been adjusted to operate with 18500A-B or 18500ATF-B motors

Operator's Control

The operator controls may be customer supplied or supplied by Boston Gear as a companion to the controller. Boston Gear's standard operator control stations contain industrial rated components in a NEMA Type 1 TENV enclosure, as listed in Table 1.

Table 1. Operator Control Stations

Catalog Number	Push-Buttons	Toggle Switch	Potentiom-eter (2)
66953RS	Run-Stop Emerg. Stop	-----	Motor Speed 100-0-100
66954RS	Run-Stop Emerg. Stop	Run-Jog	Motor Speed 100-0-100 Jog Speed 30-0-30
66955RS	Run-Stop Emerg. Stop	Fwd-Rev	Motor Speed 0-100

Model Types

Regenerative controllers are supplied in one of two basic model types, as follows:

1. Standard-Packaged functional controller supplied in a rugged die-cast aluminum NEMA Type 12 enclosure in ratings from 1/6 through 2 HP.
2. -CM-Basic chassis-mount controller, supplied in ratings from 1/6 through 5 HP, for those who want to build their own drive system by the addition of special logic or auxiliary control devices. This model is a complete self-contained functional controller which includes a power conversion and regulator module, AC line and DC loop protection, and a motor contactor. Various pre-engineered options are available.

Controller Identification

Each controller contains a data label. This label identifies the controller, user connection terminals and maximum wire size, controller ratings, operation notes, and applicable options.

Ratings

1. Horsepower Range . . . . . .1/6 – 5 HP
2. Power Source
   . . . . . 115 VAC, 1-phase, 50 or 60 Hz.
3. 115VAC Unit Output Voltages (1/6-1HP)
   Armature . . . . . .0-90 VDC
   Field . . . . . .100 VDC
4. 230VAC Unit Output Voltages (1-5HP)
   Armature . . . . . .0-180 VDC
   Field . . . . . .200 VDC
5. Service Factor 1.0
6. Duty . . . . . .Continuous
7. Overload Capacity
   (Armature Circuit) . . .150% for 1 minute
8. Reference Power Supply . . . . .±10 VDC

Table 2 Typical Application Data

Component			Rated Horsepower									
			1/6	1/4	1/3	1/2	3/4	1	1 1/2	2	3	5
1-Phase Ac Input (Full Load)	Line	115V Unit	3.9	5.0	6.0	8.7	12.4	15.8	---	---	---	---
	Amps	230V Unit	---	---	---	---	---	8.8	12.6	17.0	22.0	35.0
	KVA		.48	.58	.71	1.0	1.4	2.0	3.0	4.0	5.0	8.0
DC Output (Full Load)	Motor Armature	90V	2.0	2.8	3.5	5.4	8.1	10.5	---	---	---	---
	Amps	180V	---	---	---	---	---	5.5	8.2	11.6	15.1	24.0
	Motor Field	100V	2.0	2.0	2.0	2.0	2.0	2.0	---	---	---	---
	Amps (max)	200V	---	---	---	---	---	2.0	2.0	2.0	2.0	2.0
Full-Load Torque (lb. ft.) with 1750 RPM Base Speed Motors			0.5	0.75	1.0	1.5	2.2	3.0	4.5	6.0	9.0	15.0
Controller Weights		Std.	11.5 lbs (5.2 kg)									
		Ch. (1/6-2HP)	12.5 lbs (5.7 kg)									
		Ch. (3-5HP)	17.0 lbs (7.7 kg)									

Operating Conditions

1. Line Voltage Variation — ±10% of rated
2. Line Frequency Variation — ±2 Hertz of rated
3. Ambient Temperature*
   Standard Model Controller
   . . . . . .0 to 40ºC (32 to 104ºF)
   Chassis Model Controller*
   . . . . . .0 to 55°C (32 to 131°F)
4. Altitude (standard)
   . . . . .1000 meters (3300 feet) maximum

* Temperature within the enclosure in which the Chassis is mounted.

Performance Characteristics

1. Speed Range (controlled) – 0 to motor base speed
2. Efficiency (maximum speed)
   a. Controller SCR regulator - 99%
   b. Complete drive (controller with motor, typical) - 85%
3. Displacement Power Factor (at rated speed with rated load)- 87%
4. Acceleration (standard) – By current limit
5. Speed Regulation (*see Table 3*) – Regulation percentages are of motor base speed under steady-state conditions.
6. Ripple Frequency - 120 Hz w/60 Hz line
   - 100 Hz w/50 Hz line

Table 3 Speed Regulation Characteristics

Regulation Method	Variable				Speed Range
	Load Change	Line Voltage	Field Heating *(1)*	Temperature	
	95%	±10%	Cold/Normal	±10ºC	
Standard Voltage Feedback with IR Compensation	±1.5%	±1.5%	±7.0%	±0.5%	30:1
Optional Speed (Tach) Feedback	±0.2%	±0.2%	±0.2%	±0.2%	100:1

(1)Does Not Apply to Permanent Magnet Motors.

Standard Features

1. Power Conversion --– Dual full-wave converter consisting of two back-to-back bridges of four silicon controlled rectifiers (SCR's) each. Power bridges are integrated, encapsulated components.
2. Static Reversing--Solid-state reversal of motor armature.
3. Static Braking--Smooth regenerative braking under the following conditions:

Standard Features

a. Overhauling load-whenever the driven load attempts to exceed the speed reference signal
b. Speed reference change (signal reduction or change in polarity).
c. Stop function-motor brakes to minimum speed before motor contactor opens.

4. Feedback-Counter EMF voltage with adjustable IR compensation.
5. AC Line Protection-AC line fuse(s) provide instantaneous protection from peak loads and fault currents.
6. DC Loop Protection-Current limit fuse provides protection from inverting faults.
7. Voltage Transient Protection-Metal oxide suppressor (varistor) across the AC line, and RC networks across the power bridges, minimize effects of high voltage spikes from the AC power source.
8. Isolated Regulator-Internal DC circuits are isolated from the AC power circuitry for operator and equipment safety and simplified application. The control reference input common may be grounded or connected without additional isolation to other drive controllers or grounded output process controllers or grounded output process controllers. Isolation eliminates line voltage to ground potentials on the MOTOR SPEED potentiometer
9. Control Transformer-24-volt secondary isolates operator controls and magnetic control logic from the AC power source for operator protection.
10. Motor Contactor-Provides positive disconnection of motor armature from the controller output, and undervoltage protection. Contactor is sequenced with the regulator so that the controller is turned off before the contactor makes or breaks, thereby providing contact longevity.

Adjustments

The following potentiometers are located on the standard control circuit boards in the controller:

1. Current Limit (common forward and reverse circuits)--50 to 150% of full-load torque
2. Gain (motor stability, factory set)--Adjustable for individual motor characteristics
3. IR (load) Compensation – 0 to 100% of rated load
4. Maximum Speed (common forward and reverse circuits) 60 to 100% of motor base speed
5. Phase Shift (factory set)--Adjustable for individual motor characteristics
6. Error (factory set)--Line frequency calibration

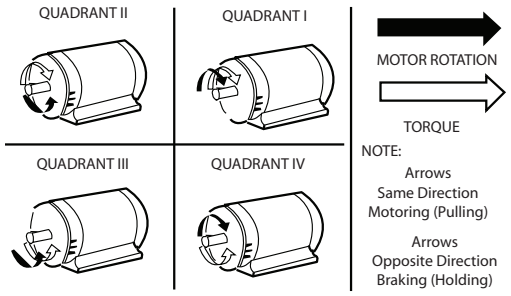
Options

Standardized pre-engineered optional equipment can be supplied with controllers at additional costs. *See Section VI* for option listing.

Principles of Operation

VEL/H RG Regenerative Controllers, also known as four quadrant controllers, not only control motor speed and direction of rotation, but also the direction or motor torque. See Figure 1.

Figure 1. Four-Quadrant Operation



Under braking conditions, controllers convert the mechanical energy of the motor and connected load into electrical energy, which is returned (regenerated) to the AC power source. With reference to Figure 1, page 5, when the drive (controller and motor) is operating in Quadrants I and III, motor rotation and torque are in the same direction, and the drive functions as a conventional nonregenerative unit. In Quadrants II IV, motor torque opposes the direction of motor rotation, which results in controlled braking. The drive can switch rapidly from motoring to braking modes while simultaneously controlling the direction of motor rotation.

Section II

Installation

Mounting Instructions

1. Surface mount the controller in a dry location with the mounting holes (or tabs) provided. The standard enclosure should not be used where a watertight, weatherproof, or explosion proof enclosure is required. See Figure 2 or 3 for mounting dimensions.

> **Caution**
> Never Mount The Controller Immediately Beside Or Above Heat-Generating Equipment, Or Directly Below Water And Steam Pipes.

2. Allow for free air circulation around the controller-four inches minimum clearance on all sides, for maximum cooling efficiency. If the controller is user-mounted in an enclosure, allow for adequate ventilation. Air passages into the bottom, with exit openings near the top, form an adequate configuration. If a small enclosure is used, a ventilation fan may be required.
3. Shock-mount the controller if it is subjected to external vibrations. Shock and excessive vibrations are detrimental to controller performance and life. Vibration can cause general deterioration of connections, and component damage.
4. Standard operator control stations can be wall-mounted using the two holes in the back of the enclosure. See Figure 4.
5. If the motor is to be foot-mounted, bolt the motor to a firm, flat foundation. If the foundation is not flat, use shims to prevent strain when tightening the bolts. If the motor is to be connected directly to a machine, be sure of correct alignment. Pulleys and couplings must slip freely onto the motor shaft.

> **Caution**
> Never hammer the pulleys, couplings, or motor shaft, nor overtighten drive belts or timing chains. Bearing damage could result.

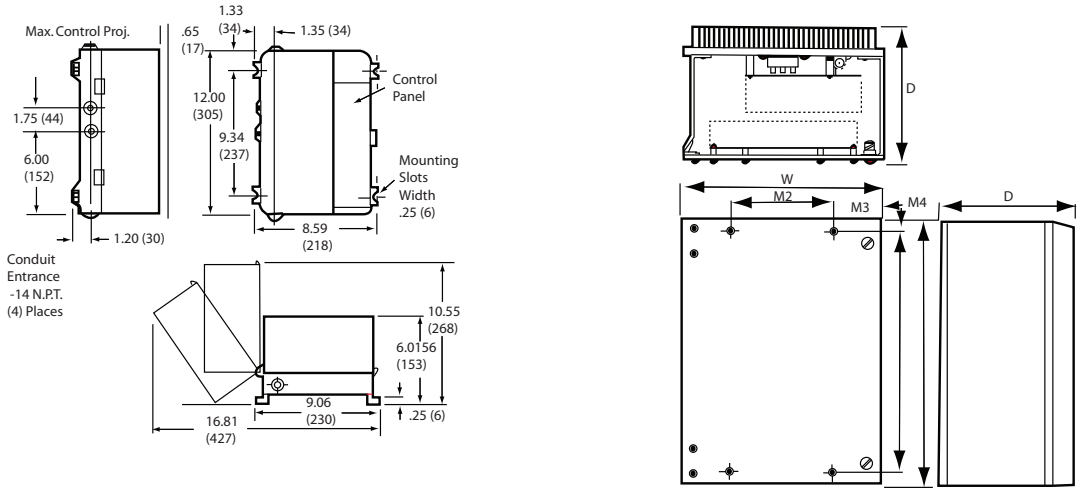


Figure 2. Enclosure Dimensions

Model	HP	Dimensions (Inches)							
		W	H	M1	D	M2	M4	M3	Holes
VEL/H RG16-200CM	1/6-2	9 7/8	13	12 1/4	6 9/16	5	3/8	2 7/16	3/16
VEH RG300/500CM	3-5	12 3/4	13	12	6 1/4	11 3/8	1/2	7/16	9/32

Figure 3. Chassis Dimensions

Wiring Instructions

1. Refer to the nameplate in the controller and be sure the input voltage and frequency to the controller complies with its rating.
2. The controller is protected from normal line transients and surges. However, to prevent problems from high-energy transients and large surges, observe the following:
   a. Place the controller on a feeder line separate from that supplying large inductive loads.
   b. If the input to the controller comes directly from a transformer, always switch power ON and OFF between the transformer secondary and the controller.

> **Caution**
> Never make or break power in the transformer primary. Transients could be generated which could damage the controller.

   c. If the controller must be fed from an AC feeder which also feeds highly inductive loads, supply additional suppression to limit transients or surges to 150% of peak line voltage.

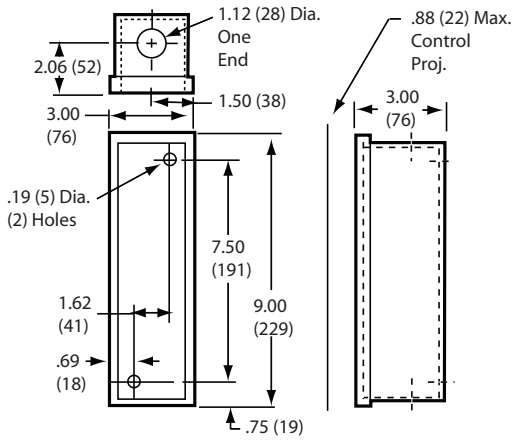


Figure 4. Operator Control Station Dimensions

> **Caution**
> Never Use The Power Factor Correction Capacitors On The Input Line To The Controller. These Capacitors May Damage The Solid-State Components

3. The wire size of the input power and motor wiring can be determined from Table 2 and the controller data label. Stranded wire is recommended for all external wiring.

> **Caution**
> 1. Oversize or solid wire, as well as large screwdrivers for electrical connections, can break terminal board barriers.
> 2. All wiring must comply with the national and local electrical codes

4. Use the 3/4-14 NPT tapped conduit holes in the enclosure of standard controllers to facilitate wiring.
5. All external wiring for low voltage signal sources; e.g., potentiometers, tachometer generators, transducers, should be run in separate conduit from all other wiring. Use twisted shielded cable. Maintain the separation of power and signal wiring within an enclosure by two inches minimum.

> **Caution**
> Pickup from unwanted signals can cause erratic operation and / or controller damage.

6. Since the DC circuits are isolated from the AC input power, the reference input common can be grounded, or connected without additional isolation to other drive controllers or grounded output process controllers.
7. Interconnection wiring is required between the controller, AC input power, operator controls, and applicable optional equipment.

AC Power Connections

> **Caution**
> Be sure metal chips from drilled conduit holes in a n enclosure do not enter the controller.
> Metal chips can cause short circuits and/or grounds which can damage the controller.

Connect the AC input power wires to controller Terminals L1 and L2. See Figure 11, 12 or 13, as applicable. If one of the power wires is a neutral wire (grounded potential), connect it to

Terminal L2 and connect the hot wire (H) to Terminal L1.
Connect the controller enclosure to an earth ground according to applicable electrical codes. A Ground Connection Screw (GND) is provided for this purpose in enclosed controllers. (See Figure 11)

Motor Connections

Check the motor data plate and be sure the HP, voltage, and current ratings are compatible with ratings listed on the controller data label. Connect the motor field and armature terminals (or leads) to controller Terminals F+, F-, A+ and A-, respectively.* (See Figures 11, 12, or 13)

> **Caution**
> Do not ground the motor wiring. Grounded wiring can cause controller damage.

NOTE* Terminals F+ and F- are not used with permanent-magnet motors

Connect the motor thermal switch, if used, in series with Terminal 1 (Terminal Board TB1) on the controller power board.

Operator Control Station Connections

Connect the operator control station as shown in Figure 5, 6 or 7 (as applicable)

Each standard operator control station contains two stop push-buttons-STOP and EMER STOP. A Stop function provides controlled regenerative braking, and an Emergency Stop function drops out the motor contactor immediately, applies dynamic braking and prevents a restart until the motor stops. If dynamic braking is impractical (due to load inertia) or is not desired, disconnect DB resistor(s). If one of the stop functions is not used, be sure to series connect the two stop buttons so that each button will stop the motor.

The MOTOR SPEED potentiometer must be 10,000 ohms with a 1/2 watt minimum rating.

Initial Startup

Before energizing the controller for the first time, be familiar with any installed options. See the option selection table in Section VI. The controller has been factory tested and adjusted with a motor under simulated operating conditions. Therefore, startup adjustments should not be needed. However, the following startup procedure should be performed for proper operation, system compatibility, and safety.

Startup Procedure

1. Be sure all interconnection wiring is correct, and all wiring terminations are tightened securely. Wiring errors and accidental grounds can cause controller and/or motor damage.
2. Check the factory sealed potentiometers on the control board and be sure they are at their factory settings. See Figure 11, 12 or 13 for potentiometer locations. If any potentiometer has been moved, return it to its factory setting.

NOTE: The MAX SPD (R52) and GAIN NO. 1 (R6) potentiometers are not sealed.

3. Turn the MOTOR SPEED potentiometer to zero on its dial.
4. If used, place the RUN/JOG switch in RUN position.
5. Couple the motor to the machine (load).
6. Turn on the AC power.
7. Depress the RUN button, and slowly turn the MOTOR SPEED potentiometer until the motor rotates. If motor rotation is opposite to that desired, stop the motor with the STOP button, turn off the AC input power, and interchange the motor armature leads at the motor connection box
8. Turn the MOTOR SPEED potentiometer to 100 on its dial. The motor should run at top speed. Top speed is rated (base) speed. If top speed cannot be reached, check motor armature voltage. If armature voltage is below rated, proceed as follows:

Controller Rating	Minimum Line Voltage
115 VAC	103 VAC
230 VAC	207 VAC

   a. Check for insufficient line voltage on controller Terminals L1 and L2. Minimum requirements are as follows:
   b. If the motor has a shunt field, check the voltage on Terminals F+ and F-. If rated line voltage is 115 VAC, the shunt Field

voltage should be 100 VDC, ±10 VDC. If rated line voltage is 230 VAC, the shunt filed voltage should be 200 VDC, ±20 VDC

c. Depress a RUN button, and turn the MOTOR SPEED potentiometer to 100 on its dial.

d. Turn the MAX SPD potentiometer (R52)

> **Caution**
> Do not exceed rated armature voltage. Excessive armature voltage may cause the controller fuses to blow when motor speed is decreased rapidly from top speed or when a Stop function is initiated.

until rated armature voltage is recorded. See Figure 11, 12 or 13 for the location of R52.

e. If desired, maximum speed can be decreased to 60% of motor base speed.

f. If the adjustment of Potentiometer R52 does not increase top speed, see Indication #7 in the troubleshooting table (Table 5). Also see Step 2 of this Startup Procedure.

9. If the MOTOR SPEED potentiometer has a "zero-center" for bidirectional operation, turn it fully counterclockwise to 100. The motor should run in the reverse direction at rated speed Forward and reverse maximum speeds should be identical.

10. If motor speed is unstable, proceed as follows:

a. Run the motor at half speed and slowly turn the GAIN NO. 1 potentiometer (R6) clockwise until motor speed stabilizes. See Figure 11, 12 or 13 for the location of R6. If instability increases, turn potentiometer R6 counterclockwise until motor speed stabilizes.

b. If the adjustment of potentiometer R6 does not stabilize motor speed, adjust R6 for minimum instability, then turn the IR COMP potentiometer (R63) counterclockwise until motor speed stabilizes. See Figure 11, 12 or 13 for the location of R63. If motor speed does not stabilize, see Indication #9 in the troubleshooting table (Table 5). Also see "Adjustment Instructions" in Section IV.

11. If the rate or acceleration of braking response is too slow, if top speed cannot be reached after performing Step 8, or if there is a probability of armature current being limited, proceed as follows:

a. Turn off the AC power and connect a zero center DC ammeter in series with the motor armature. Suggested ammeters are as follows:

HP Rating	Ammeter Scale
1/6-2	30-0-30
3-5	50-0-50

b. Apply AC power, set the MOTOR SPEED potentiometer at 50%, and depress the RUN button. During acceleration, the ammeter should read 150% or rated armature current. Depress the STOP button, and the ammeter should again record 150% armature current.

c. If 150% of rated armature current is not recorded, refer to Stop 9 of "Adjustment Instruction" in Section IV.

12. Turn the MOTOR SPEED potentiometer to 0 and depress the STOP button.

13. Close and latch the enclosure door.

Section III

Operation

General

VEL/H-RG Controllers provide the following operation functions: Run, Stop, Emergency Stop, Speed Control, and Reversing. The actual operator controls and location of same will vary according to the model controller and the options selected.

Power ON/OFF

Controllers are energized when AC power is applied to the controller. Normally, this occurs when the user supplied input line disconnect switch or circuit breaker is turn on.

Run

To start the motor, depress the RUN button, and the motor will accelerate to the setting of the MOTOR SPEED potentiometer.

Speed Control

Motor speed is directly proportional to the setting of the MOTOR SPEED potentiometer. This potentiometer may be adjusted while the motor runs or may be preset at any position before the motor is started.

Reverse

When a zero-center MOTOR SPEED potentiometer is used, turning it one direction rotates the motor in a particular rotating direction at a speed directly proportional to the potentiometer setting. Turning the potentiometer in the opposite direction, rotates the motor in the opposite direction at a speed directly proportional to the potentiometer setting. When the potentiometer is in center position, motor speed is zero.

Stop

Depress the STOP button or the EMER STOP button to stop the motor.

When the STOP button is depressed, the controller provides controlled regenerative braking

When the EMER STOP button is depressed, power is removed immediately from the motor armature, and the motor dynamically brakes to a stop. An Antiplug Relay (APR) prevents the motor from being restarted until it stops. Relay APR picks up immediately after the motor starts and drops out immediately before the motor stops. APR contacts, connected in the run/stop logic, prevent an operation function until a safe minimum speed is attained.

NOTE: If the dynamic braking is disconnected, depressing the EMER STOP button will cause the motor to stop at a rate proportional to the deceleration (coast) rate of the driven load.

Dynamic braking provides exponential rate braking of the motor armature, which occurs when the circuit opens between the controller and the motor armature, and a Resistor (DB) connects across the armature.

When an Emergency Stop (dynamic braking) function is initiated, the motor functions as a DC generator and feeds the kinetic energy of its armature and connected load through Resistor DB where it is dissipated as heat. This opposes motor rotation, thereby stopping the motor.

Resistor DB is rated to provide initial braking torque as shown in Table 4.

Caution
High inertia loads and / or armature voltage higher than rated may extend braking time beyond the wattage rating of the resistor.

Table 4. Dynamic Braking Characteristics

Component	Unit	Rated Horsepower									
		1/6	1/4	1/3	1/2	3/4	1	1 1/2	2	3	5
Braking Torque %	115V	300	215	170	110	75	60	---	---	---	---
	230V	---	---	---	---	---	220	145	105	170	100
Stops Per Minute	115V	9	6	5	5	4	4	---	---	---	---
	230V	---	---	---	---	---	4	3	3	4	4

Jog

Controller are capable of jogging, but Option 9 must be selected for the function.
If jogging is installed, place the RUN/JOG toggle switch in JOG position and jog the motor with the RUN button. Jog is momentary, causing motor rotation only while the RUN button is depressed. Release the RUN button to stop the motor. Jog speed is controlled by a separate JOG SPEED potentiometer, adjustable from 0 to 30% of motor base speed.

Inoperable Motor

If the motor stops and/or won't start, check the controller for a blown fuse. See Figure 11, 12 or 13 for fuse locations. The fuses provide instantaneous protection for the solid-state components from fault currents and peak loads. Therefore, if a fuse blows replace it with an exact replacement.

Caution
Do not substitute fuses.
Substitute fuses can cause controller and/or motor damage.

If the replacement fuse blows, turn off the AC power and refer to the troubleshooting table in Section IV of this manual.

Section IV

Maintenance

WARNING

1. CONTROLLERS CONTAIN HIGH VOLTAGE WHICH CAN CAUSE ELECTRIC SHOCK RESULTING IN PERSONAL INJURY OR LOSS OF LIFE.
2. NEVER CLEAN, REPAIR OR ADJUST THE CONTROLLER WITH THE AC POWER ON.

General

Controllers require very little maintenance, other than occasional visual inspection and, if necessary, external cleaning. They must be kept dry and reasonably free from dust, dirt, and debris. No parts require periodic replacement.
Maintain the motor according to maintenance instructions supplied by the motor manufacturer.

Visual Inspections

1. Be sure all wires are fastened securely.
2. Check components for damage due to overheating or breakage. All damaged and/or faulty components must be replaced satisfactory operation.

Adjustment Instructions

Controllers are factory adjusted with a motor under simulated operating conditions. Therefore, except for initial startup adjustments (see Section II), readjustments should not normally be needed. However, if circuit boards are replaced, or to make the controller compatible with another type motor, the following adjustments can be made. All adjustments must be made in strict conformance to the following instructions. Refer to Figure 11, 12 or 13 when performing the adjustment instructions.

Equipment Required

1. Ungrounded oscilloscope or an oscilloscope isolated from the AC supply.
2. A zero center DC ammeter (1/6-2 HP 30-0-30 scale; 3-5 HP, 50-0-50 scale).
3. Digital voltmeter or a multimeter with minimum input impedances of 20,000 ohms/volt DC and 5,000 ohms/volt AC.
4. Tachometer (useful, but not required).

Power on Adjustments

1. Turn on the AC power.
2. Connect the oscilloscope probe to Pin #1 of Integrated Circuit U9 (or Test Point TP5, if provided), located on the control board. Be careful not to short circuit the pins on U9.
3. Adjust the POS ERROR (FWD RAMP) potentiometer (R81) until the negative peaks of the waveform on the oscilloscope are at zero volts, as shown below.

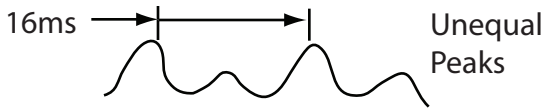
NOTE: If negative peaks are less than zero volts, unstable operation and/or fuse blowing will occur.

4. Connect the oscilloscope probe to Pin #7 of U9 (or Test Point TP6, if provided).
5. Adjust the NEG ERROR (REV RAMP) potentiometer (R89) for the results described in Step 3.
6. Uncouple the motor from the load (machine).
7. Set the MOTOR SPEED potentiometer at zero.
8. Depress the RUN button and slowly turn the MOTOR SPEED potentiometer to 50% in either direction. Check for stable motor speed. If motor speed is unstable, see Indication #9 in the troubleshooting table (Table 5).
9. With the MOTOR SPEED potentiometer set at 50%, alternately depress the STOP and RUN buttons while observing the ammeter. During acceleration and braking, armature current should reach 150% of rated. If necessary, adjust the CUR LIMIT potentiometer (R16) to attain 150% rated armature current immediately after a RUN or STOP button is depressed.

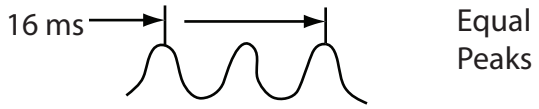
NOTE: If the controller contains bidirectional linear acceleration or “soft” acceleration/deceleration, the rate of acceleration must be set at minimum to attain the correct results when performing Step 9.

10. Turn the MOTOR SPEED potentiometer toward zero until the motor is running approximately 50 RPM.

11. Connect the oscilloscope probe to Test Point TP2 on the control board.
12. Turn the CUR STBLY potentiometer (R28) clockwise until the waveform frequency is 60 Hertz. Then turn Potentiometer R28 counterclockwise until the waveform frequency is 120 Hertz.
13. Stop the motor and recouple it to the load (machine).
14. Depress the RUN button and run the motor at half speed in the rotating direction so that Terminal 2 on the input board is positive, with respect to Terminal 4. This is normally the forward rotating direction.
15. Connect the oscilloscope probe to Test Point TP1 on the control board.
16. a. Slowly turn the GAIN NO. 2 Potentiometer (R11) clockwise until the peaks of the waveform become unequal in voltage (height) as shown below.



b. Slowly turn GAIN NO. 2 Potentiometer (R11) counterclockwise until the waveform peaks are equal, as shown below.



17. With the motor running at half speed, turn the GAIN NO. 1 Potentiometer (R6) counterclockwise until the waveform becomes unstable. Then turn potentiometer R6 clockwise until the waveform stabilizes.
18. Connect the oscilloscope probe to Test Point TP3 on the control board.
19. Slowly turn the IR COMP potentiometer (R63) counterclockwise until the oscilloscope displays minimum AC ripple. If motor speed is unstable, turn potentiometer R63 counterclockwise until motor speed stabilizes.
20. Adjust the 0 SHIFT Potentiometer (R47) for minimum AC ripple at Test Point TP3. If motor is unstable, turn IR COMP Potentiometer R63 counterclockwise until motor speed stabilizes.
21. Set maximum speed as described in Steps 8d through 8g under “Initial Startup” in Section II.
22. Stop the motor, turn off the AC power and disconnect all test equipment.

Troubleshooting

Most electrical failures are caused by incorrect connections, overload, or the accumulation of dirt, dust or moisture. Dirt and dust deposits limit the transfer of heat from the solid-state components. Moisture, usually caused by either “wash-down” or condensation, can cause insulation failures and short circuits. Be sure the controller is clean and dry before doing troubleshooting.

WARNING

BE SURE THE AC POWER IS TURNED OFF BEFORE WORKING ON THE CONTROLLER.

If repeated fuse blowing and/or power bridge failures occur, turn off the AC power and protect the Power Bridge (BR1) by connecting a 4 ohm, 300 watt resistor in series with the Current Transformer (CT1) primary, as follows:

HP Rating	Installation Instructions
1/6-2	Remove the wire from Tab E1 on the power board, and connect the resistor between the wire and Tab E1.
3-5	Remove the wire from Terminal 10 at Terminal Board TB-2 on the power board and connect the resistor between the wire and Terminal 10.

Then, check the AC input power for transients (high level spikes) or rapid power fluctuations. Remove the resistor after the cause of failure has been corrected.

If a circuit board fails, check all inputs to the board for proper values before replacing the board. Install a resistor, as described above, before applying power to a new circuit board. If the controller operates correctly, turn off the AC power and remove the resistor.

Use standard troubleshooting procedures; e.g., continuity checks, to detect faults in relay and switching logic and operator controls.

Table 5. Troubleshooting

Indication	Possible Cause	Corrective Action
1. AC Line Fuse (F1, F3) blows when power is applied to controller	Wiring faulty or incorrect	Check all external wiring terminating in the controller.
	Circuit, component, or wiring grounded	Remove unwanted ground.
	Power Bridge (BR1, BR2) shorted	Replace shorted power bridge
	Power board failure	Replace power board.
	Control board failure	Replace control board.
	Shunt field shorted or grounded	Repair or replace motor.
2. AC Line Fuse (F1, F3) blows when motor starts to turn	Power Bridge (BR1, BR2) shorted	Replace shorted power bridge.
	Motor shorted or grounded	Repair or replace motor.
	Control board failure causing SCR's to turn on fully	Replace control board
3. AC Line Fuse (F1, F3) blows while motor is running	Low line voltage	Check for rated line voltage, ±10%, controller AC line terminals.
	Overload	Check shunt field current. Insufficient shunt field current causes excessive armature current. If field current is OK, check for mechanical overload. I If the unloaded motor shaft does not rotate freely, replace motor bearings. Also check for shorted armature.
	Loose or corroded connection. Wiring faulty, incorrect or grounded	Check fuse terminals and all terminals, connections and wiring between the line, controller and motor.
	Top speed set too high	See Steps 8d through 8g under "Initial Startup" in Section II.
	Motor shorted or grounded	Repair or replace motor.
	SCR breaking down (intermittently shorting) in Power Bridge (BR1, BR2)	Replace faulty power bridge.
	Control board failure causing SCR false firing or misfiring	Replace control board.
4. Armature Fuse (F2) blown	Overload	Check shunt field current. Insufficient shunt field current causes excessive armature current. If field current is O OK, check for mechanical overload. If the unloaded motor shaft does not rotate freely, replace motor bearings.
	Wiring faulty, incorrect, or grounded between the controller and motor.	Check wiring and connections
	Armature shorted or grounded	Repair or replace motor.
5. Fuses not blown, but motor won't run	AC line open	Be sure external disconnect switch or circuit breaker is turned on and ra rated AC power is applied to controller.
	Operator controls or relay logic inoperable	Repair accordingly.
	MOTOR SPEED potentiometer failure	Replace potentiometer.
	Motor Failure	Repair or replace motor.
	Control, input or power board failure	Replace faulty board.
6. Motor rotates when speed reference is zero	High line voltage	Check for rated line voltage, ±10%, on controller AC line terminals.
	Power Bridge (BR1, BR2) shorted	Replace shorted power bridge.
	Control or input board failure	Replace faulty board.

Table 5. Troubleshooting

Indication	Possible Cause	Corrective Action
7. Motor does not attain top speed	Low line voltage	Check for rated line voltage, ±10%, on controller AC line terminals.
	Overload	Check shunt filed current. Insufficient shunt field current causes excessive armature current. If filed current is OK, check for mechanical overload. If Unloaded motor shaft does not rotate freely, replace motor bearings. Also check for shorted armature.
	MOTOR SPEED potentiometer failure	Replace potentiometer.
	MAX SPEED potentiometer (R52) misadjusted	See Steps 8d through 8g under "Initial Startup" in Section II.
	Control or input board failure	Replace faulty board.
	Power Bridge (BR1, BR2) failure	Replace faulty power bridge.
8. Motor runs at fast speed only	Power Bridge (BR1, BR2) failure	Replace faulty power bridge.
	Control board failure	Replace faulty board.
	Feedback circuit open	Check for open Resistor (R5-R8) and feedback board.
9. Unstable speed	AC line voltage oscillating	Observe line voltage with voltmeter or oscilloscope. If oscillations occur, contact electrical or local utility company.
	Oscillating load connected to the motor	Correct condition accordingly.
	Motor failure	Check motor brushes and replace if needed. Repair or replace motor.
	SCR's misfiring or false firing	Replace Power Bridge (BR1, BR2) and/or control board.
10. High, unstable speed, low torque	Armature and field connections interchanged	Check controller-to-motor wiring.
	Power Bridge (BR1, BR2) failure	Replace faulty power bridge.
11. Top speed only 1/2 (approximately) of motor base speed and motor noisy (possible half-waving)	Power Bridge (BR1, BR2) breaking down	Replace faulty power bridge
	Faulty control board	Replace control board.
12. Motor surges when starting	Power Bridge (BR1, BR2) breaking down (shorting intermittently)	Replace faulty power bridge.
	Faulty control board	Replace control board.
13. Line and armature current excessive	Overload	Check shunt field current. Insufficient shunt field current causes excessive armature current. If field current is OK, check for mechanical overload. If unloaded motor shaft does not rotate freely, replace motor bearings. Also check for shorted armature.
14. Shunt field current insufficient	Open shunt field winding or wiring to the shunt field	Check motor shunt field and associated circuitry for loose connection or broken wire.
	Field bridge failure	Replace field bridge (Diodes D1, D2, D3, D4) or power board.
15. Shunt field current excessive	Field bridge failure	Replace field bridge (Diodes D1, D2, D3, D4) or power board.
	Shunt field windings shorted	Check shunt field current and/or measure shunt field resistance and compare with motor data plate. Repair or replace motor.

Table 5. Troubleshooting

Indication	Possible Cause	Corrective Action
16. Motor thermal switch open (if so equipped)	Ventilation insufficient	Free the motor intake and exhaust screens from dirt, dust and debris.
	Motor armature drawing excessive current	Check shunt field current. Insufficient shunt field current causes excessive armature current. If field current is OK, check for a mechanical overload.
	Motor overheating from friction	Check for misalignment. Realign motor.
	Shorted motor windings faulty bearings	Repair motor.

Table 6. Parts List

Drawing Designation	Description	Boston Part Number		
		115 VAC	230 VAC	
		1/6-1 HP	1-2 HP	3-5 HP
APR	Relay, Antiplug	60263	60263	60263
BR1, BR2	Power Bridge	66940	66940	66942
-----	Control Board	66936	66936	66936
-----	Latch	63817	63817	63817
F1	Fuse, Line	66946	66946	66949
F2	Fuse, Armature	66946	66946	66949
F3	Fuse, Line	66952	66947	66951
-----	Feedback Board	66945	66945	66945
-----	Input Board	66943	66943	66943
-----	Power Board	66937*	66937*	66938*
RV1	Varistor	60878	60878	60878
DB	Resistor, Dyn. Brake	66920	66920	66924

NOTE: *Specify horsepower when ordering.

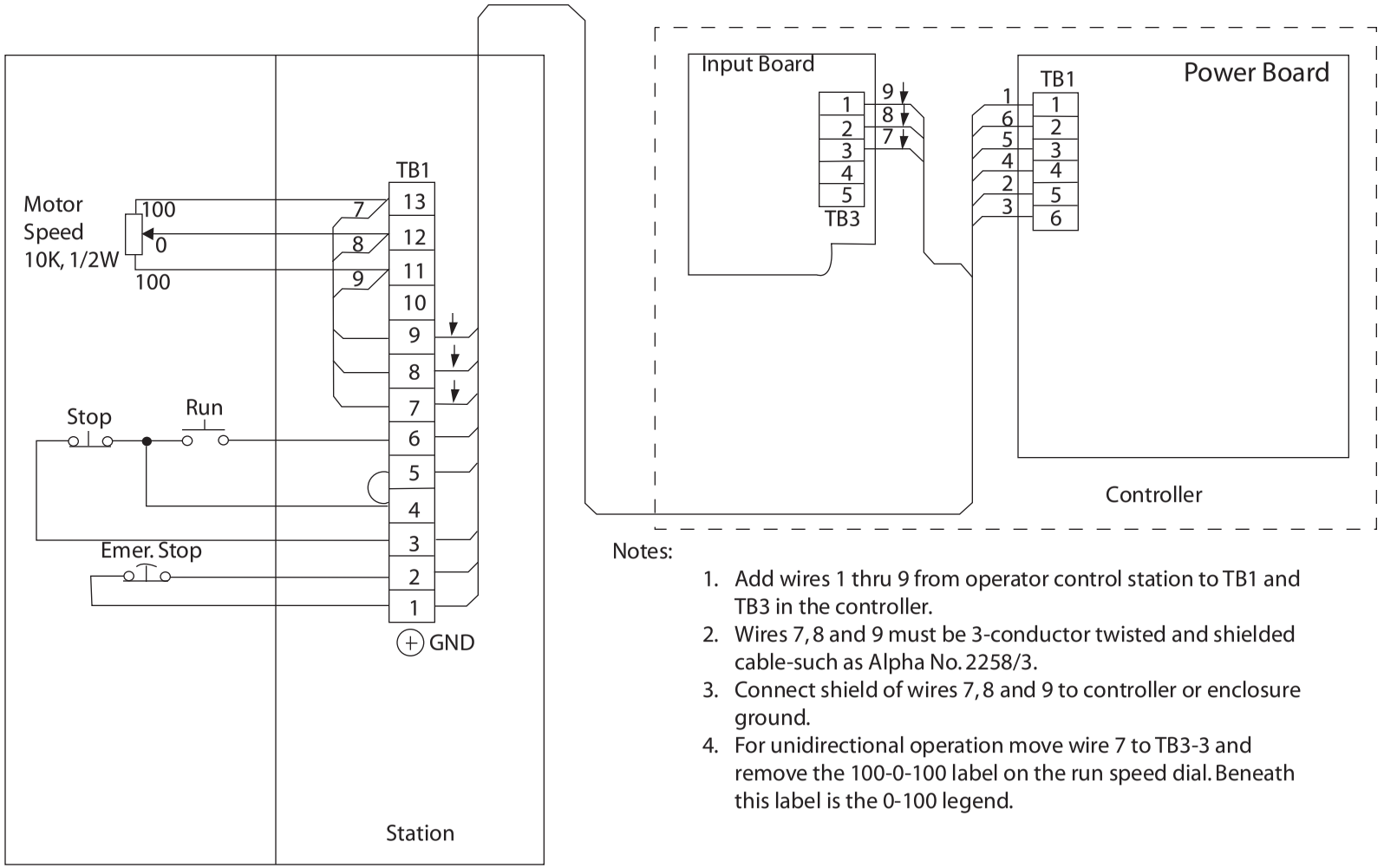
Section VI

Option Combinations

Table 7. Option Combinations

All VEL/H RG Controllers are supplied, as standard, with Dynamic Braking. Other options are listed below. Only one option from Group “C” can be utilized in a single control.

Group	No.	Description	Remarks
A	4	Dynamic Braking	Standard
	--	Unidirectional Operation	Standard, by reconnection of of remote station to input board
	--	Direction by Selector Switch	Specify Remote Station Item No. 66955
	21	10-Turn Speed Pot	Specify Kit No. 66929, for installation in remote station-*unidirectional only*
B	9	Jog by Selector Switch, Adjustable	Specify Remote Station Item No. 66954
C	17	Adj. Bidirectional Linear Accel.	Specify Item No. 66925
	17S	“Soft” Accel/Decel	Specify Item No. 66926
	22	DC Tach. Follower	Specify Item No. 66930
	25	DC Signal (ma) Follower	Specify Item No. 66935
D	24	DC Tach. Feedback	Specify Item No. 66932



Notes:

1. Add wires 1 thru 9 from operator control station to TB1 and TB3 in the controller.
2. Wires 7, 8 and 9 must be 3-conductor twisted and shielded cable-such as Alpha No. 2258/3.
3. Connect shield of wires 7, 8 and 9 to controller or enclosure ground.
4. For unidirectional operation move wire 7 to TB3-3 and remove the 100-0-100 label on the run speed dial. Beneath this label is the 0-100 legend.

Figure 5. Connection Diagram, Run/Stop, Remote Control Station, Part #66953

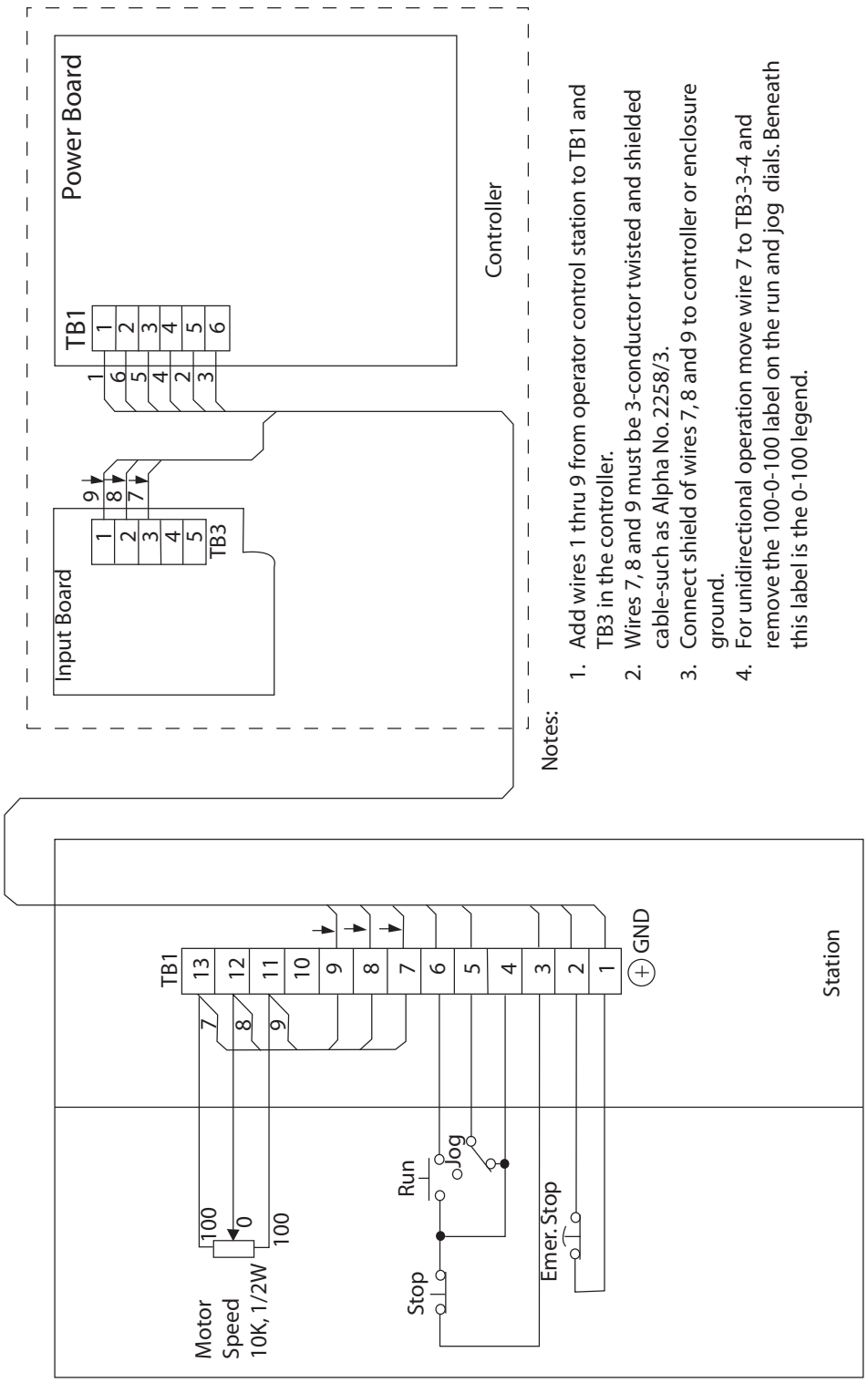


Figure 6. Connection Diagram, Run/Stop/Jog Selection with . Remote Control Station, Part #66954

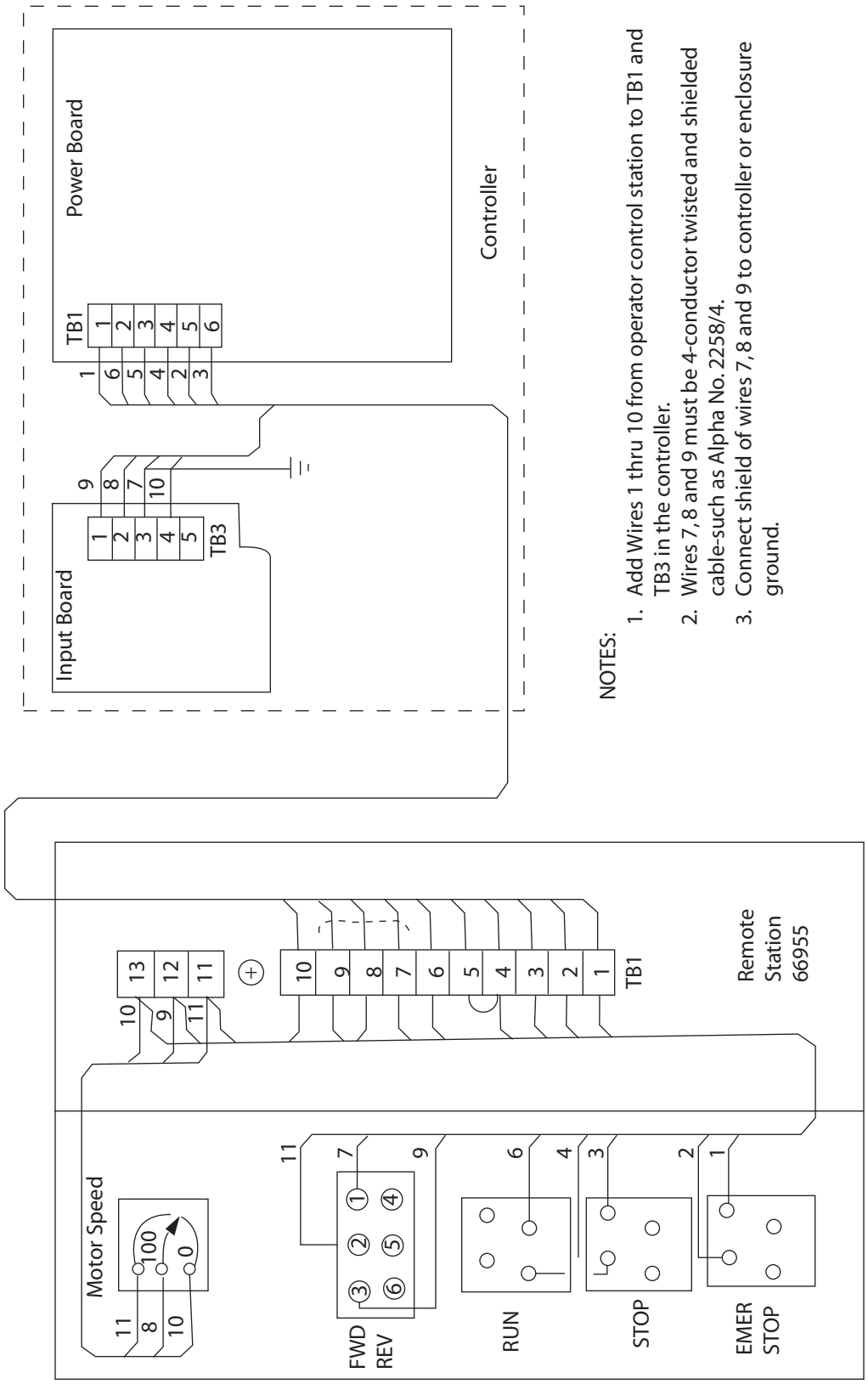


Figure 7. Connection Diagram, Run/Stop/Forward-Reverse Selection, Remote Control Station Part # 66955

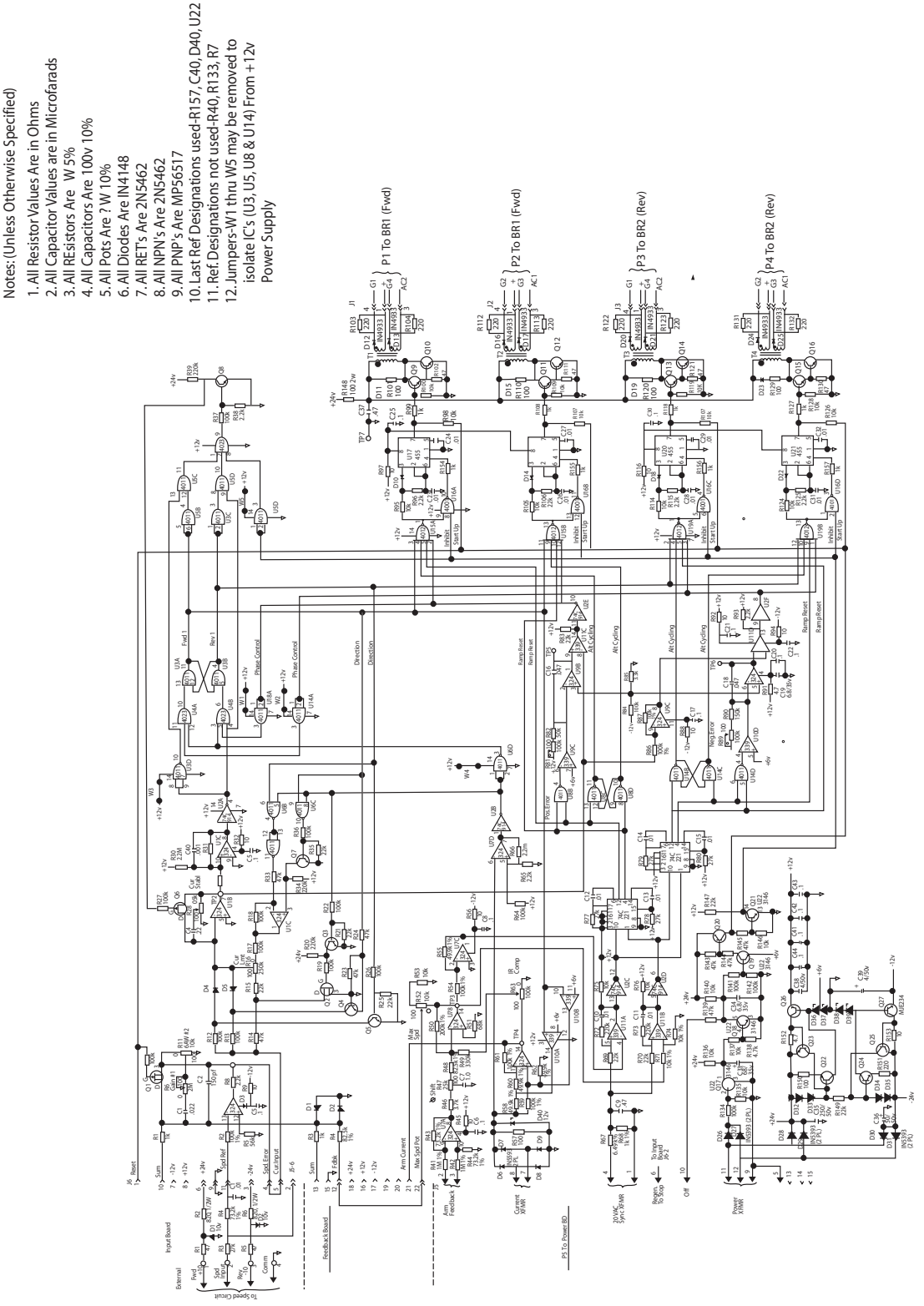


Figure 8. Schematic Control Board VEL/H RG, Part #66936

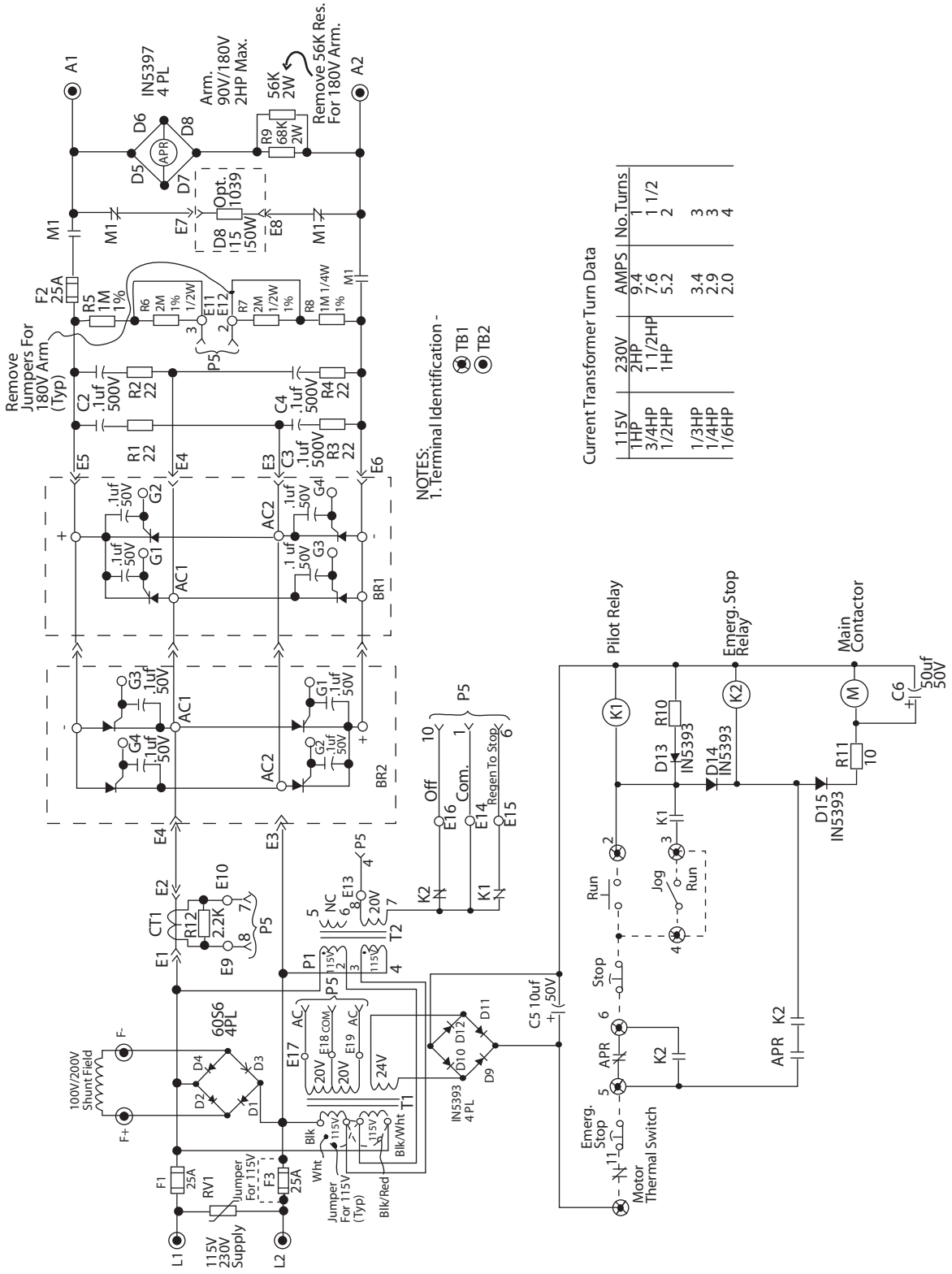
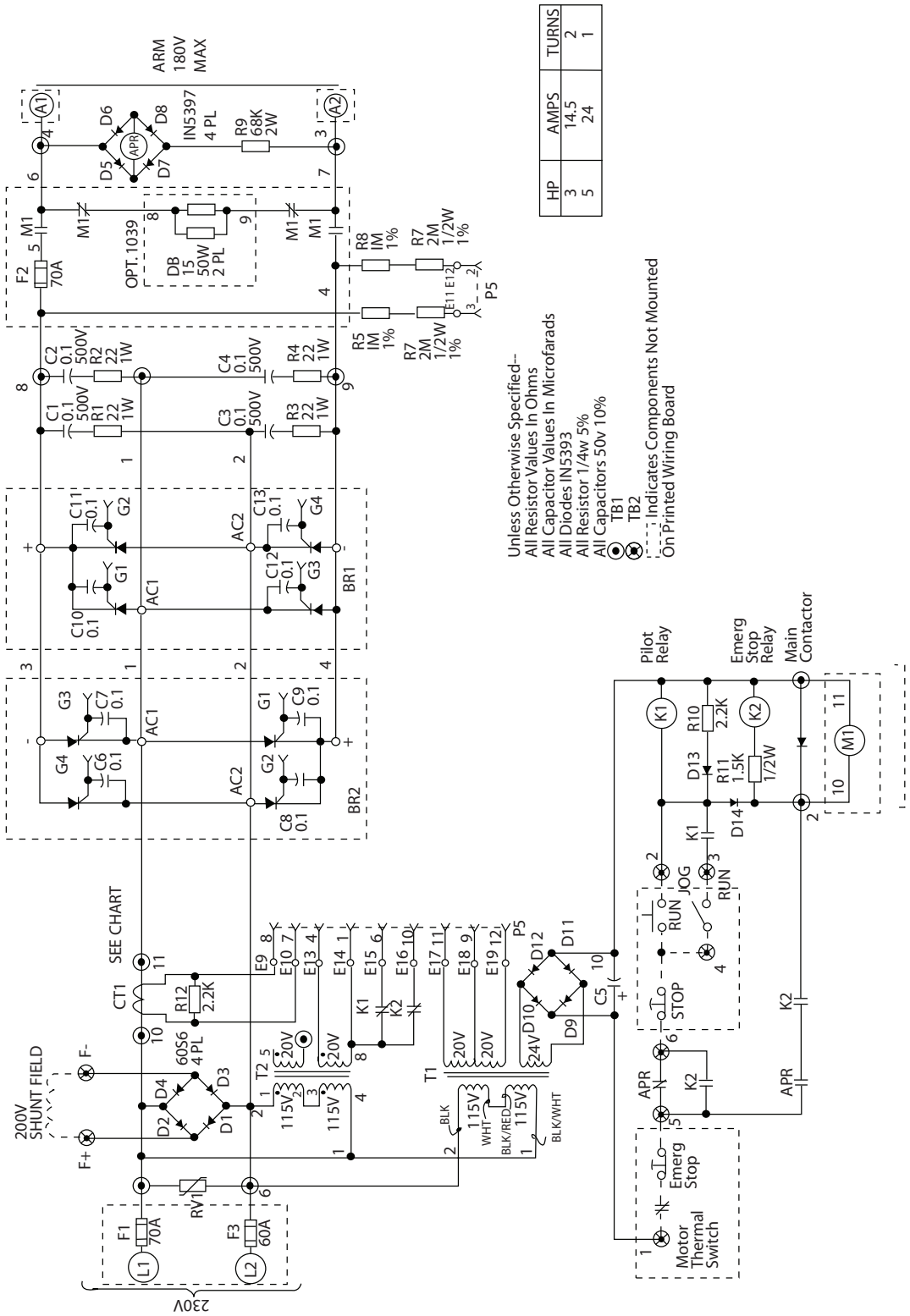


Figure 9. Schematic, Power Board, 1/6-2 HP
Part #66937



HP	AMPS	TURNS
3	14.5	2
5	24	1

Unless Otherwise Specified–
All Resistor Values In Ohms
All Capacitor Values In Microfarads
All Diodes IN5393
All Resistor 1/4w 5%
All Capacitors 50v 10%
TB1
TB2
- - - Indicates Components Not Mounted On Printed Wiring Board

Figure 10. Schematic Power Board, 3 & 5 HP
Part #66938

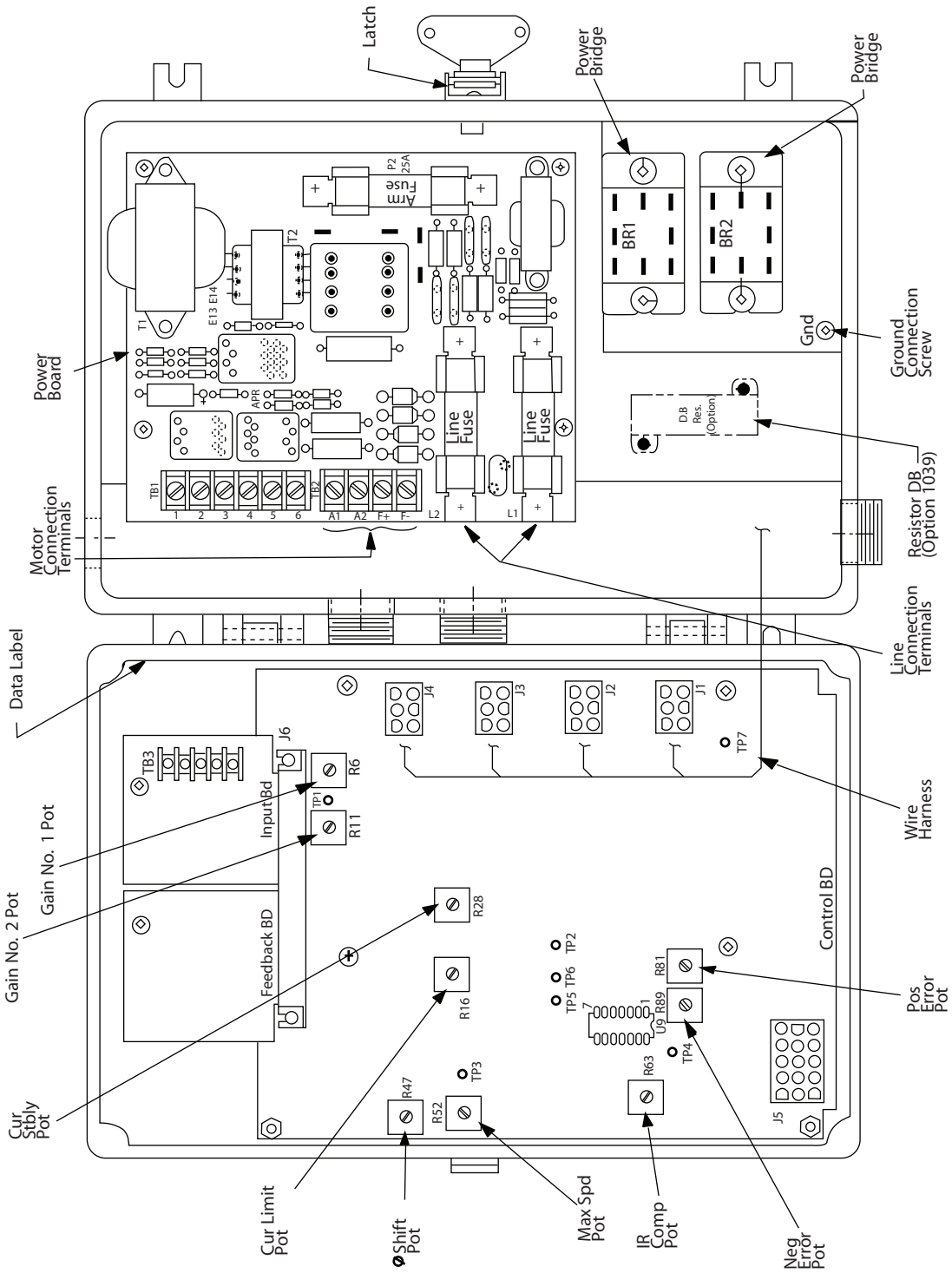


Figure 11. Intemal View, Standard Controller, 1/8-2 HP

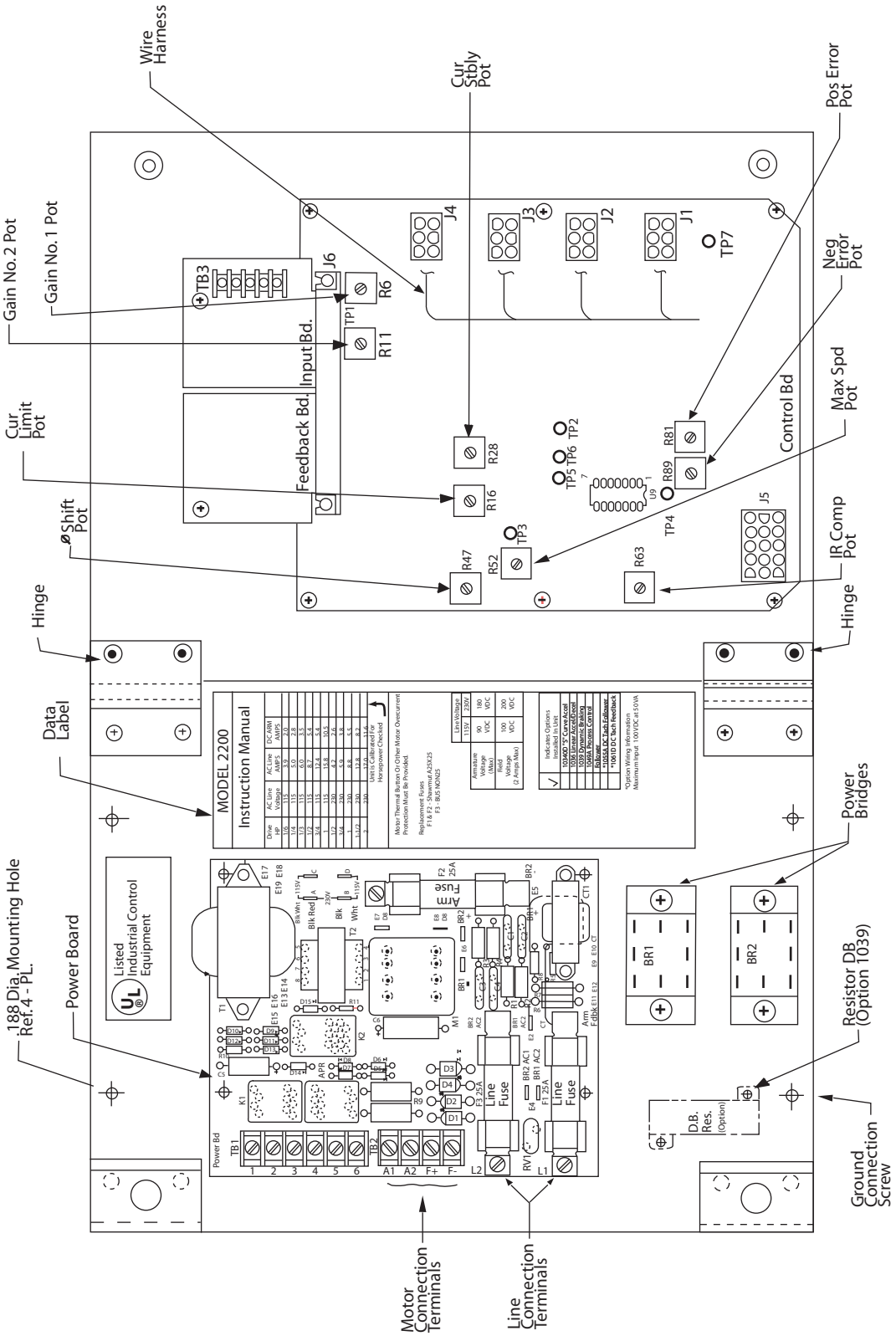


Figure 12. Internal View, 1/6-2 HP Chassis, Controller

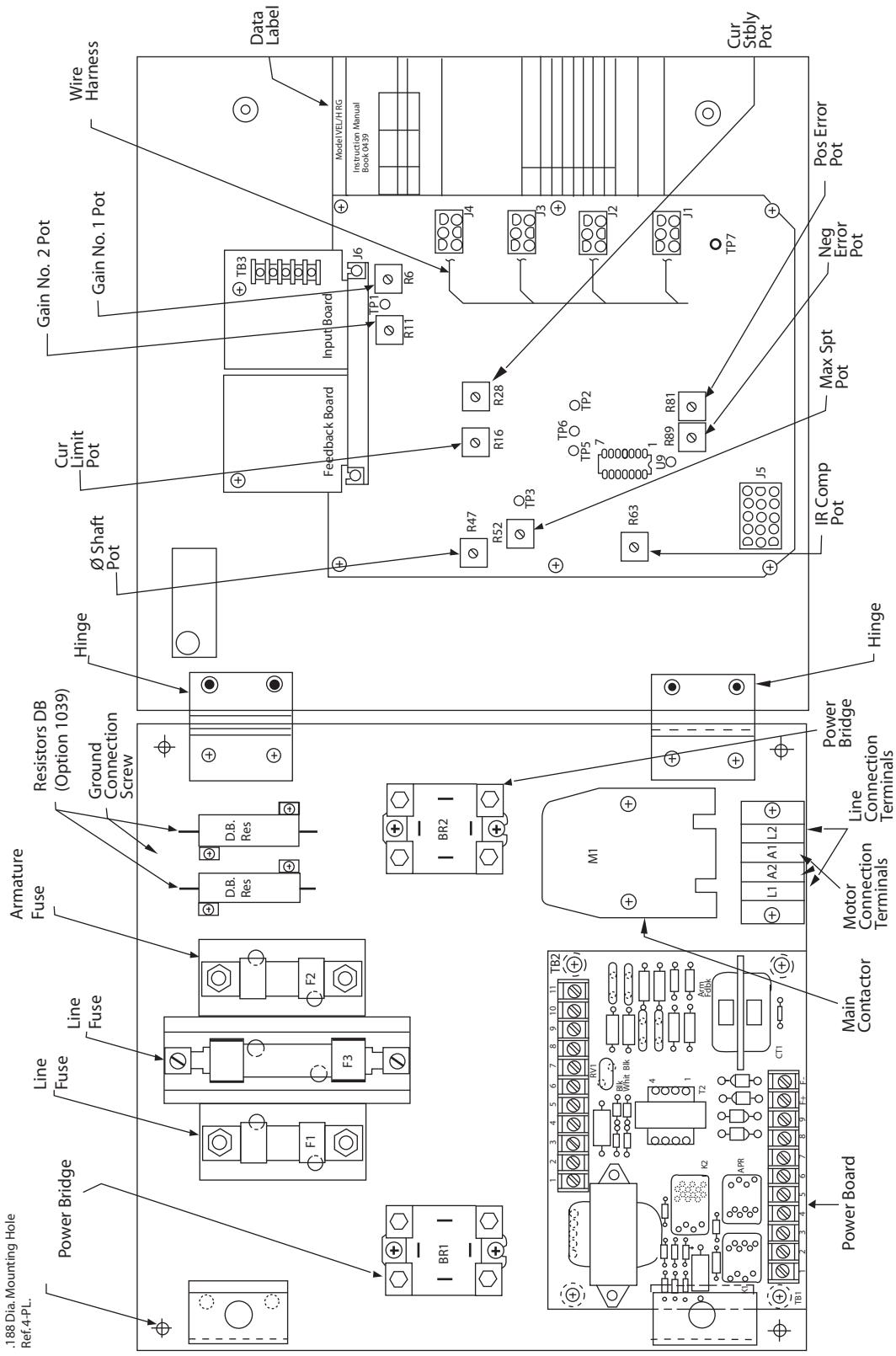


Figure 13. Internal, 3 & 5 HP Chassis, Controller

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