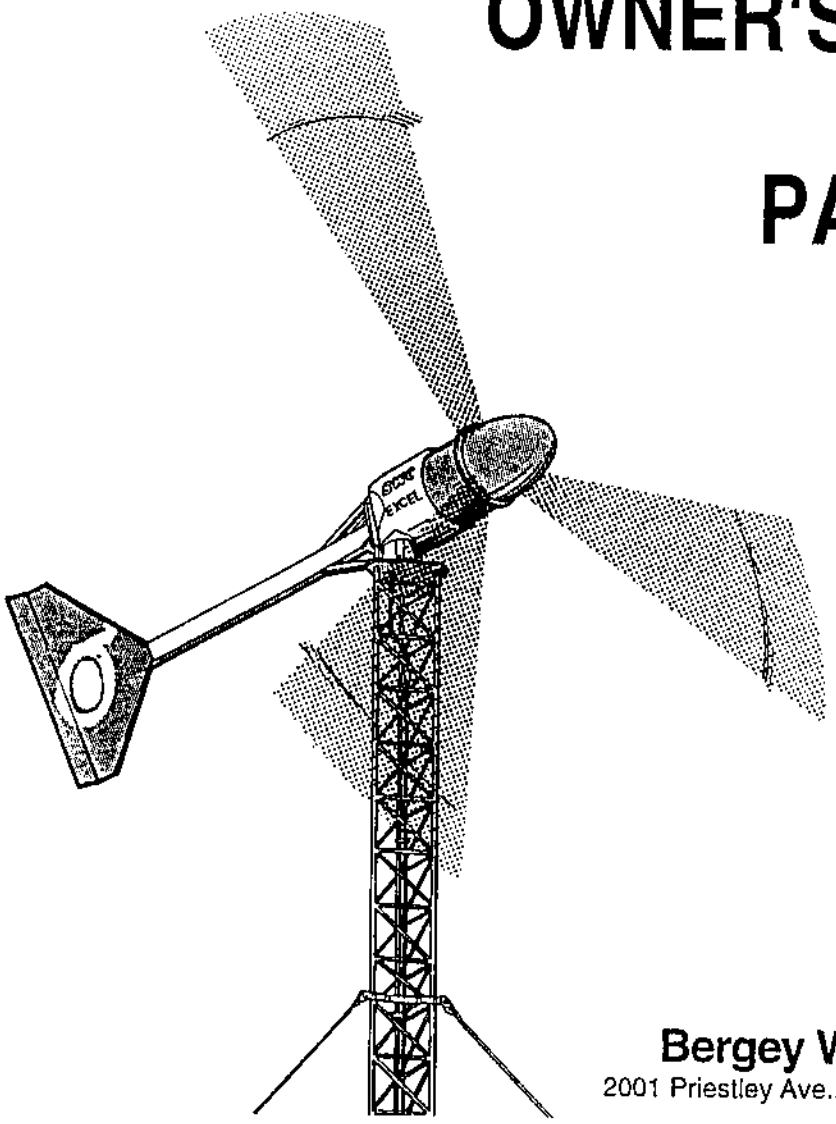
BWC EXCEL
WINDPOWER GENERATOR

OWNER'S MANUAL and PARTS LIST



Battery Charging System

BWC EXCEL-R
VCS-10

Bergey Windpower Co., Inc.
2001 Priestley Ave., Norman, Oklahoma 73069 USA
Telephone: (405) 364-4212
Fax: (405) 364-2078

BWC EXCEL-R SPECIFICATIONS

Performance

Start-up Wind Speed	3.1 m/s (7 mph)
Cut-in Wind Speed	3.5-4.5 m/s (8-10 mph)
Rated Wind Speed	12.4 m/s (28 mph)
Cut-out Wind Speed	none
Furling Wind Speed	15.7 m/s (35 mph)
Maximum Design Wind Speed	54 m/s (120 mph)
Rated Power	7 - 8.5 kW
Rotor Speed	0-350 RPM

Mechanical

Type	3 Blade Upwind
Rotor Diameter	7 m (23 ft)
Weight	463 kgs (1,020 lbs)
Blade Pitch Control	POWERFLEX®
Overspeed Protection	AUTOFURL™
Temperature Range	-40 to 60° C (-40 to 140° F)

Electrical

Output Form	48, 120, 220, or 240 VDC
Generator	Permanent Magnet Alternator
Output Control System	VCS-10 Charge Controller

INTRODUCTION

This manual contains important information concerning your BWC EXCEL wind turbine system and its operational characteristics. We strongly recommend that you read and familiarize yourself with its contents.

At several points in this manual items of special interest or significant impact are highlighted by one of the following symbols:

WARNING	Hazards or unsafe practices that could cause personal injury or death.
CAUTION	Hazards or unsafe practices which could cause product damage.
NOTE	Significant points of interest.

Serial Numbers

Each BWC EXCEL wind turbine has a serial number located on the tower adapter. The turbine serial number can also be found on t he outside of the shipping carton and on the warranty registration card. We recommend that the serial number be copied to this manual for possible future reference.

BWC EXCEL Serial No.: _____

The VCS-10 controller has a serial number label on the inside face of its door. We recommend that the VCS-10 serial number also be copied to this manual.

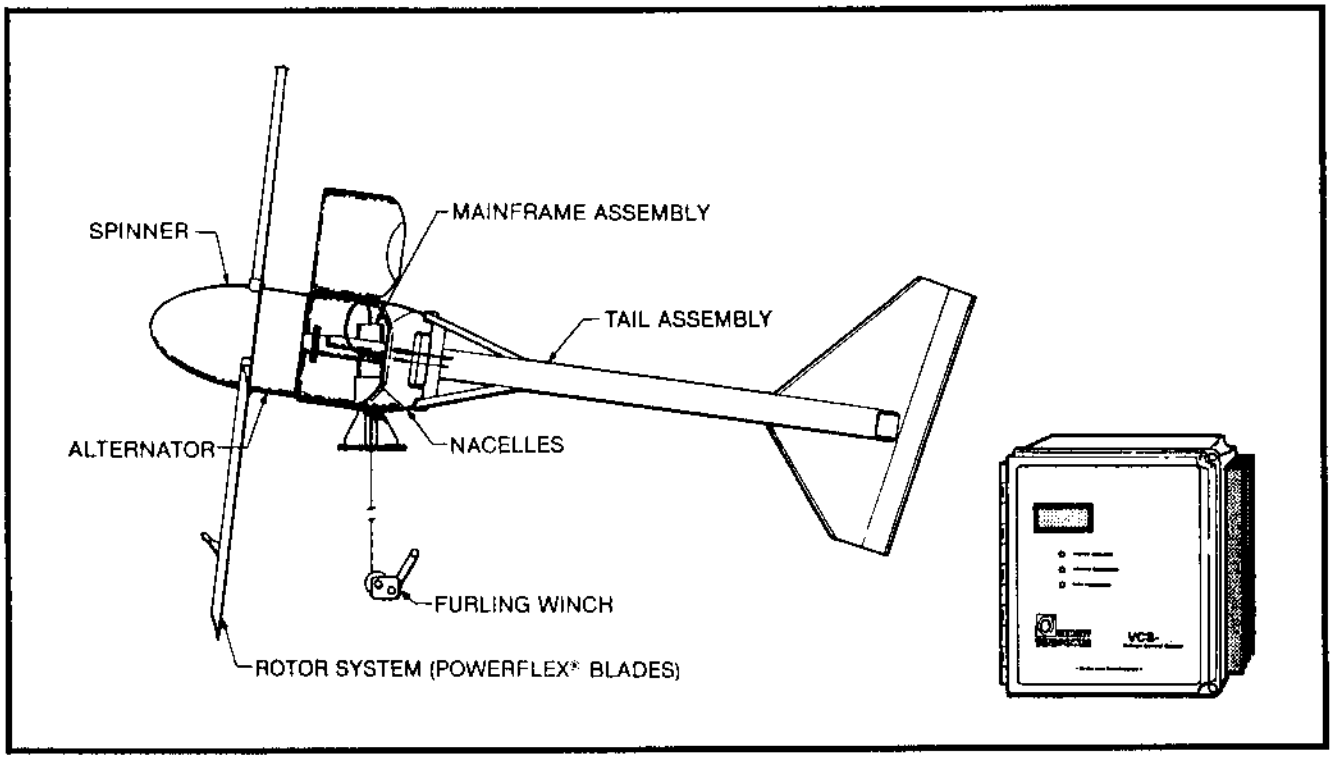
VCS-10 Serial No.: _____

Table of Contents

1. SYSTEM DESCRIPTION

The BWC EXCEL is an upwind horizontal-axis wind turbine designed to charge batteries in remote power systems. The complete unit consists of the following major components, as shown in the figure below:

1. Spinner
2. Powerflex Blades
3. Alternator
4. Mainframe
5. Yaw Bearing
6. Slip-ring and Brushes
7. Tail Assembly
8. Nacelle Assembly
9. Furling Winch
10. VCS-10 Controller



A. ROTOR SYSTEM

The rotor system consists of three Powerflex fiberglass blades. Acting like aircraft wings, the blades convert the energy of the wind into rotational forces that can drive a generator. Although the Powerflex blades are rigidly attached to the alternator they do change pitch during operation by passively twisting. The distinctive, and unique, pitch weight located three-fourths of the way out on each blades creates the passive blade pitching function. The blades start at a pitched-up position and flatten-out as the turbine speeds up. This lowers the start-up wind speed without sacrificing operating efficiency.

The blades for the BWC EXCEL are quite flexible. This contributes to their long life be reducing the stresses in the blades during both normal and severe conditions. Blade sets are carefully matched for balance at the factory to ensure smooth operation of the wind turbine. Each blade has a balance number inscribed on its root pad at the inboard end.

B. ALTERNATOR

The alternator converts the rotational energy of the rotor into electricity. The alternator utilizes permanent magnets and has an inverted configuration in that the outside housing rotates, while the internal windings are stationary. It was specifically designed for the BWC EXCEL and produces power at low speeds, eliminating the need for a speed-increasing gearbox. Since it uses permanent magnets, the alternator is generating voltage whenever the rotor is turning.

WARNING The output wiring of the BWC EXCEL presents shock hazard whenever the rotor is turning. Caution must be exercised at all times to avoid electrical shock.

C. MAINFRAME

The mainframe is the structural backbone of the wind turbine. It serves as the attachment point for the yaw bearing and the housing for the yaw-axis slip-ring brushes. The yaw-axis is the full 360 degree pivot that allows the turbine to freely align itself to the wind direction.

D. SLIP-RINGS AND BRUSHES

The slip-rings and brushes conduct the electricity generated in the alternator from the moving (as it orients with the direction) wind turbine to the fixed tower wiring. The slip-rings are enclosed in a metallic housing to help protect them from lightning.

E. TAIL ASSEMBLY AND AUTOFURL OPERATION

The tail assembly keeps the rotor aligned into the wind at wind speeds below approximately 15 meters/second (33 miles per hour). At about 15 m/s the Autofurl action turns the rotor away from the wind to limit the rotor speed in high winds. The tail appears to fold, but in reality the tail stays stationary as the rotor turns sideways to the wind. The rotor furls to a maximum angle of 70 degrees (limited by rubber tail stops), so that the unit continues to produce power in high winds. When the high winds subside the Autofurl system automatically restores the turbine into the normal straight position.

The flexibility of the BWC EXCEL's blades dictates that rotor be kept turning under all conditions. If the rotor is not turning, or it is turning very slowly, high winds can bend them backwards far enough to possibly strike the tower. If, on the other hand, they are turning at several hundred revolutions per minute they are stiffened significantly by centrifugal forces. For this reason, the BWC EXCEL is designed to always maintain rotor speed.

F. SPINNER AND NACELLE

The spinner (nose cone) and nacelles provide additional weather protection for the bearings and the slip-ring assembly.

G. VCS-10 VOLTAGE CONTROL SYSTEM

The VCS 10 controller rectifies the alternating current generated by the alternator and prevents the BWC EXCEL from overcharging the batteries. It also provides a digital display of battery voltage and has status lights that indicate its operating mode.

2. SYSTEM OPERATION

A. NORMAL OPERATION

The rotor of the BWC EXCEL should begin to rotate when the wind speed reaches approximately 3.6 m/s (8 mph). Battery charging should commence shortly after the rotor spins up to speed, but this may vary with battery state of charge. Once turning, the rotor may continue to turn in winds below 3.6 m/s (8 mph), but the system will probably not be charging the batteries.

NOTE All operational wind speeds given assume steady winds, sea-level conditions and moderate temperatures. Hot weather, high altitude, turbulance and gusting winds will reduce system performance.

The rotor speed will increase with increasing wind speed and the system will produce a higher output. This output increases rapidly because the energy available in the wind varies as the third power (cube) of the wind speed. For example, if the wind speed increased form 5 m/s to 10 m/s, a factor of two, the energy in the wind would increase from one unit to eight units, a factor eight (2 to the third power equals 8). One result of this relationship is that there is very little energy available in light winds. For the average site, winds in the range of 5.5 - 9m/s (12-20 mph) will provide most of the system's energy production.

Lower Peak Power: To obtain optimum output from a permanenet magnet alternator its output voltage must rise as its speed increases. In a battery charging application, however, the output voltage is constrained over a narrow range by the battery bank. Without sophisticated power electronics in the system the performance of the wind turbine can be optimized for low wind conditions or high wind conditions, but not both. The BWC EXCEL-R is optimized for low wind performance and, therefore, the peak output power is sacrificed. Depending upon the specific voltage and configuration, the BWC EXCEL-R can be expected to have a peak power output between 7 and 8.5 kW.

B. HIGH WINDS - AUTOFURL

During periods of high wind speeds the Autofurl system will automatically protect the wind turbine. When furled, the power output of the turbine will be significantly reduced and battery charging may cease or become intermittent. In winds between 15 m/s (33 mph) and 20 m/s (45 mph) it is normal for the turbine to repeatedly furl and then unfurl and then furl again. The intermittent charging and the high output surges, up to 12,000 watts, this may cause are normal.

C. UNLOADED OPERATION

As the battery voltage reaches its maximum the VCS-10 controller unloads the wind turbine to provide a lower current to the batteries and prevent overcharge. Under unloaded operation the rotor will spin faster and some increase in rotor sound may be noticed. The Autofurl system will function whether the turbine is loaded or unloaded.

During installation or maintenance it may be necessary to isolate the turbine from the VCS-10. This is normally accomplished by opening the turbine disconnect switch located at the base of the tower. In this situation it is perfectly acceptable to leave the turbine operating without load and unfurled. High wind speed protection will not be affected.

WARNING During unloaded operation the alternator can still generate high voltages, so the BWC EXCEL electrical system should be handled with the same caution used during normal operation.

D. MANUAL FURLING

The BWC EXCEL is designed for unattended operation over an extended period of time. Exceptional situations may occur, however, in which the wind turbine should be manually furled. These situations include:

1. **EXCESSIVE VIBRATION -** Uneven ice build-up, ice shedding, or blade damage may cause the wind turbine to experience excessive vibration. Always furl the turbine as soon as an increase in vibration is detected. Any new or excessive vibration in the turbine when ice is not present should be investigated immediately.

2. **HEAVY ICING - It is strongly recommended that the turbine be furled if ice accumulations exceed 1/4 inch.** Heavy icing slows the rotor down, reducing its stiffness, and may lead to

blade damage during concurrent high winds.

3. **UNUSUAL SOUND** - If the turbine begins making clinking, growling, or other unusual sound it should be furled and fully inspected as soon as possible.

4. **EXTREME WEATHER** - It is preferable to furl the turbine during severe wind storms such a thunderstorms (see following WARNING), gales, blizzards, and hurricanes (typhoons). This practice will extend the life of the wind turbine by reducing the severe loads experienced by the turbine during extreme weather.

5. **INSPECTION AND MAINTENANCE** - Whenever someone has to climb the tower the wind turbine must be manually furled, and the alternator dynamically braked (ie. electrically shorted), even if the wind speed is very low.

Manual furling of the BWC EXCEL is accomplished by operating the furling winch located at the base of the tower. The winch cable is connected to the tail boom such that as the cable is tightened the tail "folds" and the rotor is pulled away form the wind. Furling the wind turbine will not stop the rotor completely. Fully furled the rotor will still be partly facing into the wind and will normally turn at a reduced rate. The rotor can be brought to a complete stop by shorting the output leads of the furled turbine.

WARNING Do not attempt to furl the wind turbine or approach any part oft he tower when there is lightning in the area.

E. FURLING PROCEDURE

The furling winch is located at the base of the wind turbine tower. To furl the wind turbine, first make sure that the winch ratchet is engaged (a strong clicking sound should be heard as the handle is turned). The winch handle may then be turned until the tail comes to rest against its rubber stop. When the stop is reached the tail will stop rotating towards the blades and the force required to turn the handle will greatly increase. When fully furled the tail will have come around approximately 70 degrees: *it does not come around parallel to the blades.*

The turbine may not come out of the wind immediately because the rotor forces will sometimes resist the sideways force acting of the tail. This situation will correct itself after a few minutes.

CAUTION Do not over tension the furling cable. Tightening the cable beyond the amount required to furl the wind turbine will reduce its ability to track the

wind and may damage the furling system.

To return the turbine to the straight position, grasp the winch handle firmly and then release the ratchet mechanism. The cable can now be slowly unwound until the turbine has fully straightened out and the cable is slightly slack. It is a good idea to then reengage the ratchet.

WARNING Hold the winch handle *firmly* before the ratchet is released and until all tension is removed from the cable. The winch handle could whirl dangerously if it is released before the cable tension is reduced.

F. VCS-10 CONTROLLER

The wind turbine produces a three-phase AC (Alternating Current) that varies in voltage, and frequency as the wind speed varies. The VCS-10 rectifies this variable AC into the DC (Direct Current) required for battery charging. In place of diodes, however, the VCS-10 has silicon controlled rectifiers (SCR's) so the it can operate as a phase control regulator. The VCS-10 has a "constant voltage" charging scheme, which has been shown (in tests at Sandia National Labs) to maximize battery cycling life.

Under normal conditions all available power from the wind turbine is rectified and delivered to the DC source center. This provides power to the DC load(s) and any excess energy is stored in the batteries. When the batteries reach a predetermined voltage indicating that they are fully charged, however, the VCS-10 reduces the current delivered to the system. This prevents excessive out-gassing that could lower the battery electrolyte level and physically damage the battery cells. Following the onset of regulation, the VCS-10 provides a tapered charge that maintains the battery at its full state of charge, as determined by the battery bank voltage.

The VCS-10 is factory set to regulate at 2.3 volts per cell. In normal operation, before the onset of regulation, the VCS-10 will show a green **SYSTEM AVAILABLE** light on its front panel. When regulating, an amber colored indicator light, marked **NORMAL REGULATION** on the front panel will light up.

The VCS-10 has a high voltage shutdown that operates if the voltage reaches 2.65 volts/cell. The VCS-10 shuts down when this voltage is reached and will not reactivate itself until the battery voltage falls below 2.3 volts/cell. When in this mode the VCS-10 will show a red **HIGH REGULATION** light on its front panel.

In the event of a serious overvoltage, approximately 2.9 volts/cell, the VCS-10 has a crow-bar circuit that blows a 2 amp fuse located on its circuit board. This protects the VCS-10. Operation will not resume automatically as the fuse must be replaced before the VCS-10 can be made functional. Neither the indicator lights or the digital voltmeter will function when this fuse is blown. The VCS-10 and the balance of the complete power system must be checked before replacing this fuse.

The factory calibrated voltage settings for these operational modes are given in the following table.

Nominal System Voltage

	48 VDC	120 VDC	220 VDC	240 VDC
Normal Regulation	55.2	138	253	276
High Regulation	63.6	159	291	318
Crow-bar Shutdown	70	175	320	350

The factory settings are designed for lead-acid batteries under normal conditions. They may be changed by adjusting potentiometers located on the VCS-10 circuit board. If you wish to change or recalibrate these settings please contact the Service Department of Bergey Windpower for instructions. It is strongly recommended, however, that the factory settings not be changed without first checking the manufacturers recommendations for the batteries being used.

G. CELL EQUALIZATION

Over a number of charge/discharge cycles different cells within the battery bank can develop differing capacities that tend to lower the total capacity of the system. To correct this problem a procedure called cell equalization should be performed on the batteries every several months or whenever a 10% difference in the specific gravities of cell electrolyte is detected. In cell equalization the batteries are charged to a higher state of charge, which brings any weakened cells back up to their normal characteristics.

To activate the cell equalization function on the VCS-10, move the equalization switch located on the circuit board from "Normal" to "Equalize". In the "Equalize" mode the VCS-10 will charge the batteries up to the "High Regulation" voltage. If your battery suppplier recommends a different equalization voltage please contact the Service Dept. at Bergey Windpower for instructions on changing the voltage set-

points. To return the VCS-10 to normal regulation, move the equalization switch back to "Normal". The electrolyte level should always be checked following cell equalization.

CAUTION The recommendations of the battery manufacturer should always be consulted prior to performing any cell equalization procedure.

H. BATTERY VOLTAGE DISPLAY

Battery bank voltage is displayed on a front panel mounted LCD digital meter. The meter does not display the turbine output voltage.

I. OPTIONAL CURRENT DISPLAY

This option involves the installation of a current shunt and switch to the standard VCS-10. The output DC current of the wind turbine will be displayed when the front panel switch is set such that a small "A" is displayed on the LCD digital meter. Toggling the switch will return the LCD meter to displaying battery voltage.

3. INSTALLATION

Please use the following instructions in assembling and commissioning your system. If you need any additional information, please contact us.

A. BWC EXCEL WIND TURBINE and TOWER

Please refer to the BWC EXCEL Installation Manual, and any addendum for the specific tower design, for instructions on installing the wind turbine and tower.

B. FUSED DISCONNECT SWITCH

The electrical output of the wind turbine is a three-phase alternating current (AC). We strongly recommend the installation of a fused three-phase AC disconnect switch between the wind turbine and the VCS-10 controller, as shown if Drawing No. 92-125-001. This will help protect the alternator in the event of a wiring, controller, or load short circuit. A 60A weather-tight switch box with 25A fuses for the 48 VDC system, 45A fuses for the 120 VDC system, 25A fuses for the 220 VDC system, and 25A fuses for the 240 VDC system are recommended. The fused disconnect switch is normally installed at the base of the tower.

CAUTION Do not install a "short circuiting switch" that will provide dynamic braking of the alternator. These switches can be easily misused, leading to serious damage to the alternator. Such damage is not covered by the BWC warranty.

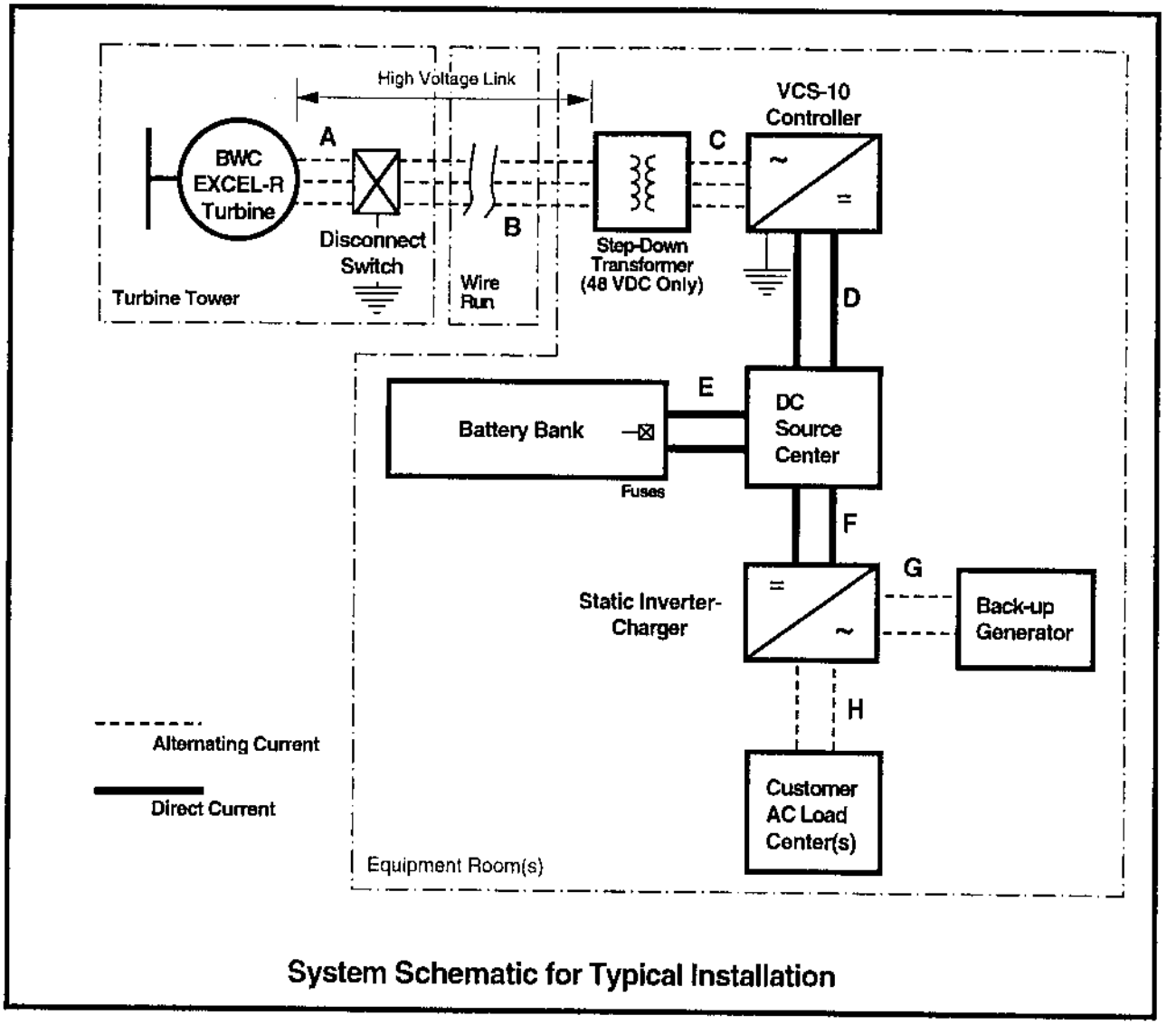
C. WIRE RUN AND WIRE SIZES

Please refer to the BWC EXCEL Installation Manual for recommended wire and conduit sizes for the tower-to-VCS wire run. For 220 VDC and 240 VDC systems, please follow the recommendations given for the 48 VDC system.

D. STEP-DOWN TRANSFORMER

On the 48 VDC unit a high-voltage link and a step-down transformer are used to

reduce the electrical losses in the wire run. This configuration is shown in the following electrical schematic drawing. The turbine produces a high voltage, low current output that reduces the wire size needed for the wire run. The three-phase transformer supplied with the unit is installed near the VCS-10 and serves to lower the wind turbine voltage to a level compatible (after rectification in the VCS-10) with a 48 VDC battery bank.



System Schematic for Typical Installation

E. VCS-10 CONTROLLER

The VCS-10 voltage control system should be installed indoors, near the batteries or the DC source center. The VCS-10 is designed to operate in a clean environment. It is capable of withstanding the same temperature extremes as lead-acid batteries and, if possible, should be installed in the same location as the batteries. The VCS-10 should not, however, be mounted directly above the batteries as the unit could be damaged by the corrosive vapors emitted by most batteries. The VCS-10 should not be installed outdoors as it is not weatherproof and could be damaged by rain.

The VCS-10 enclosure is fully isolated, so it can be installed as either a positive or negative grounded system. A typical system wiring schematic for the BWC EXCEL-R is shown in Drawing No. 92-125-001. In most systems the DC output of the VCS-10 will be connected to a DC Source Center, where all the DC sources, loads, and storage systems are combined. Wiring connections for the wind turbine AC input (3 wires), battery DC output (2 wires), and grounding should be made as indicated on the VCS-10 terminal block label. The three AC connections from the wind turbine can be connected to the VCS-10 terminals in any order; there is no required phase orientation. We recommend that the VCS-10 be grounded with its own grounding rod and that the wire run bond wire be connected to this ground.

WARNING Do not attempt to make the VCS-10 connections with energized leads. Always have the wind turbine fully disconnected and the battery disconnected before making the VCS-10 connections.

All wiring should conform to the National Electric Code or other governing local electrical code. The use of electrical conduit for wiring between components is highly recommended. All terminations should be coated with an anti-oxidation compound to prevent corrosion.

CAUTION All loads should be equipped with fuses or circuit breakers to avoid hazards from accidental short circuits.

CAUTION Do not connect the VCS-10 to a separate controller that could disconnect the VCS-10 from the battery bank. The VCS-10 should not be open-circuited when there is input from the wind turbine.

4. INSPECTIONS AND MAINTENANCE

The BWC EXCEL installation should be inspected 30 days and then again 180 days after installation. Following these two inspections the installation should be inspected every two years and after any particularly severe weather. Inspections should be done on days when the wind is below 7 m/s (16 mph).

Check List for Inspections

1. Inspect each of the anchor points. Ensure that all hardware is secure and the guy wires are properly tensioned. Check to ensure that no strands are broken.

2. Furl the wind turbine and check that the damper restricts the tail's unfurling to a period of at least three seconds when the winch cable is rapidly released.

3. Furl the turbine and short the alternator using the procedure given in the next subsection. Climb the tower. Always use proper safety belts and lanyards.

4. Inspect the blades for:
   A. Cracks around the hub or just past the long stiffener pad.
   B. Condition of the leading edge protection tape, particularly out board of the pitch weight.
   C. Erosion of the lead weight on the pitch weight.
   D. Tip damage.

5. Remove the spinner and hang it from the machine. Check the torque on the blade nuts; the recommended value is 150 ft-lbs. Check the front bearing for seal integrity and grease loss. Reattach the spinner and check that it is secure.

6. Open the hatch on the nacelle. Use a small rope to lash the hatch open.

7. Inspect the flanged connection between the mainframe and alternator. Check the torque on each of the bolts; the recommended value is 80 ft-lbs.

8. Check the rear alternator bearing for seal integrity and grease loss.

9. Inspect the mainframe for cracks.

10. Remove the slip-ring cover plate. Make the following inspections:
    A. Check brushes for ease or movement in the brush holder.
    B. Check slip rings for signs of arcing damage.
    C. Check that no grease from the yaw bearings has leaked on to the

slip-rings.

11. Inspect damper. Some leakage around the front seal is okay.

12. Inspect the furling cable (particularly at the ball end/fork attachment to the tail boom) and furling cable conduit.

13. Check for cracks or loose hardware on the tail boom and fin.

14. Check the tail pivot pin and particularly its snap ring fasteners.

15. Close the nacelle and check that all of its fasteners are secure.

16. While descending the tower, inspect the following:
    A. Check that the tower wiring is properly secure.
    B. Check all fasteners.
    C. Look for any cracks in the tower structure.
    D. Check the condition of the guy wire attachment.
    E. Check the furling cable.

17. Check the furling winch and make sure that the furling cable is not twisted up. If the cable is twisted up, check the swivel.

18. Check the connection on all ground rods and hardware.

19. Use a VOM (Volt-Ohm Meter) to check the surge arrestors.

20. Remove the alternator shorting connection. Check the disconnect switch.

21. Switch the disconnect switch to "OFF" and unfurl the wind turbine. Listen to the sound of the machine as it speeds up. No mechanical sounds, such as a "clunking" or "banging," should be heard. Also watch for any new or significant vibration. The turbine operation should be very smooth.

22. Inspect the wire run, particularly all electrical connections.

23. Use a Meggar to check the three-phase wiring from the turbine to the controller (the procedure is the same as used for commissioning).

24. Use a VOM to check that the three legs of the AC output of the wind turbine are balanced.

25. Check condition of all wiring connections into and out of the VCS-10.

26. Check condition of the VCS-10 circuit board. Clean if necessary.

27. Dust off the heat-sink of the VCS-10.

At the second annual inspection, and at each alternate inspection thereafter, the right nacelle half should be opened and the slip-ring cover removed. This will allow the condition of the brushes and slip-rings, and internal fasteners to be checked.

WARNING Only qualified personnel with proper safety equipment should climb the tower. Never climb the tower when the rotor is turning.

5. Trouble-Shooting Problems

The following guide can help to pin-point the cause of operational problems with the BWC EXCEL wind turbine and the VCS-10 controller. For problems or symptoms not found in the following listing please contact the Service Department at Bergey Windpower Co. at Tel. No. 405-364-4212, Telefax No. 405-364-2078, OR E-mail: pieter@bergey.com

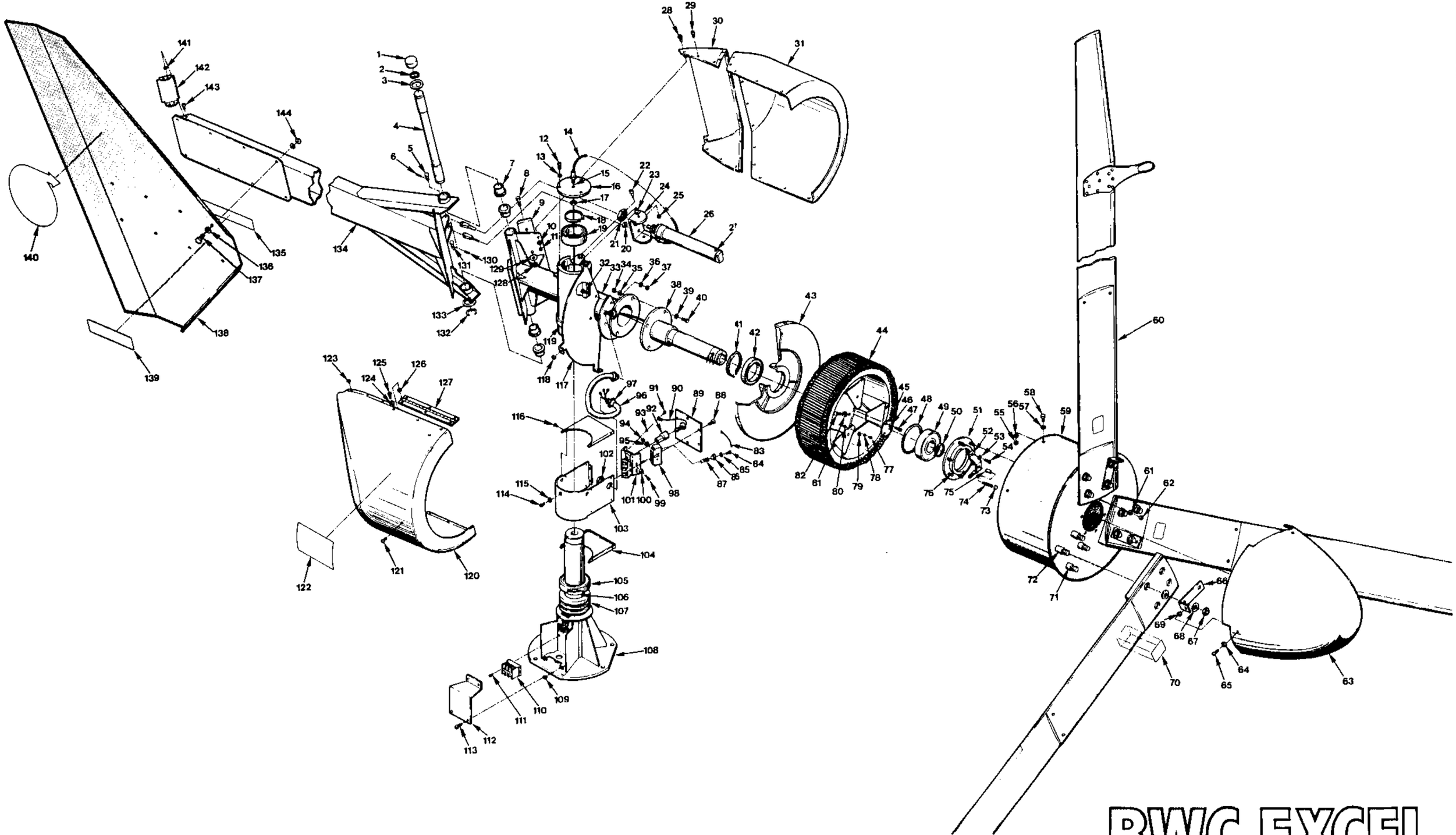
Problem	Cause(s)	Diagnosis	Remedy
Battery voltage gets too high.	VCS-10 regulating voltage set too high	Excessive battery out-gassing. Use VCS-10 voltage display to check battery voltage at regulation. Check against value given in this manual.	Contact BWC Service Department for voltage set-point adjustment procedure.
Batteries do not reach full state of charge.	VCS-10 regulating voltage set too low	Use hydrometer to check the specific gravity of the battery modules. Compare with battery manufacturers' recommendation.	Contact BWC Service Department for voltage set-point adjustment procedure.
	Loads are too large	Remove largest load. If battery bank reaches higher state of charge, then the system is overloaded	Consult with BWC for possible remedies.
Rotor turns, but the VCS-10 shows no green light.	Open disconnect switch	Check tower disconnect switch.	Close switch.
	VCS-10 failure	Check AC voltage going into VCS-10. If present in winds above 6.7 m/s (15 mph), a controller failure is indicated.	Contact BWC Service Department for further diagnoses and remedy.
Broken furling cable	Over-tightning of furling cable	Typically not able to diagnose	Refer to proper manual furling procedure in this manual.

Problem	Cause(s)	Diagnosis	Remedy
Large oil stain at rear of nacelle	Tail damper failure	Check damper effectiveness using procedure in Sect. 8 of the Installation Manual. If the damper fails the test the turbine should be furled during high (furling speed) winds until the damper is replaced.	Repair/Replace damper as necessary.
Turbine makes an unusual blade sound, such as a whistling, buzzing, or fluttering sound.	Damaged or missing blade leading edge tape	Check leading edge tape, particularly outboard of the pitch weight.	Refer to Repairs section of the Installation Manual.
	Blade tip damage	Check condition of blade tips.	Refer to Repairs section of the Installation Manual.
	Blade stiffner delamination	Visual inspection. Refer to Repairs section of the Installation Manual.	Refer to Repairs section of the Installation Manual.
Rotor is unbalanced, causing the turbine to move slightly back and forth as it spins.	Ice build up on blades	Visual inspection. Refer to Repairs section of the Installation Manual.	Refer to Repairs section of the Installation Manual.
	Blade damage	Visual inspection. Refer to Repair section of the Installation Manual.	Refer to Repairs section of the Installation Manual.
Turbine makes a banging or rattling sound once per revolution, particularly at low speeds.	Loose spinner	Check for loose spinner attachment hardware. If found, check for enlargement of the drilled bolt hole in the spinner.	Tighten or replace hardware as necessary. If spinner bolt hole is enlarged, use 5-minute epoxy to bond 1/2" washer into bolt hole.
	Failed alternator bearing	Check for excessive amount of grease around bearing seals or for damaged seal. Periodic noise indicates loss of one or more bearing balls.	Remove alternator (consult BWC for best procedure), replace bearings, re-install

Problem	Cause(s)	Diagnosis	Remedy
Turbine makes a continuous growling or rumbling noise, which may disappear at higher speeds.		Disconnect load. If noise disappears an electrical problem is indicated. If noise continues a mechanical problem is indicated.	
	Wiring fault	Check fuses. Check cables for continuity. Check for phase-phase fault. Check connections.	Repair or replace failed components as necessary.
	Controller/electronics fault	Check if turbine noise disappears if controller/ electronics are disconnected.	Refer to controller manual if available or contact the BWC Service Department.
	Load fault	Check for phase balance on load.	Consult BWC Service Department
	Failed alternator bearing	Check for excessive amount of grease around bearing seals or for damaged seal. Continuous bearing noise indicates loss of lubrication or spun race.	Remove alternator (consult BWC for best procedure), replace bearings, re-install.
Rotor turns only very slowly.	Ice build-up on blades	Check for ice.	Furl turbine, wait for ice to shed.
	Load short circuit	Open tower disconnect switch. If turbine spins freely, check load.	Consult BWC Service Department.
	Alternator short circuit	Disconnect alternator leads at the brush block inside the nacelle. If alternator will not spin freely, an alternator short is indicated.	Remove alternator (consult BWC for best procedure), rewind or replace stator, re-install.
Rotor does not turn at all	Mechanical failure inside alternator	Rotor does not turn in 6.7 m/s (15 mph) winds.	Consult factory. Blade damage can occur in

			strong winds due to excessive bending. In this case the blades should be removed as quickly as possible.

PARTS DRAWINGS and PARTS LISTS


BWC EXCEL

BWC EXCEL Wind Turbine Parts List

Drawing Part Number	BWC Part Number	Part Description	Number Required
1	HOC003	Tail Pivot Cap (Obsolete)	0
2	HRF001	Upper Tail Pivot Retaining Ring	1
3	HWF001	Upper Tail Pivot Washer	1
4	11102	Tail Pivot Pin	1
5	HM6001	Tail Damper Attachment Pin	1
6	HM0001	Damper Attachment Cotter Pin	1
7	BCF001	Tail Pivot Bushing	4
8	HB4003	Tail Bumper Bolt	4
9	11009	Tail Bumper	2
10	HW4001	Rear Nacelle Attachment Washer	4
11	HN4002	Rear Nacelle Attachment Nut	4
12	HS3006	Vertical Tube Cap Screw	3
13	HW3001	Vertical Tube Cap Washer	3
14	11109	Furling Cable Conduit	1
15	11110	Furling Cable	1
16	11084	Vertical Tube Cap	1
17	HN8001	Furling Cable Conduit Nut	1
18	HR0001	Tower Adapter Retaining Ring	1
19	BC0003	Upper Yaw Bearing	1
20	HN8001	Furling Cable Conduit Nut	1
21	HNF001	Damper Attachment Nut	1
22	HB8001	Pivot Bracket Bolt	2
23	BC8001	Pivot Bracket Bushing	2
24	11083	Pivot Bracket	1
25	HN6002	Pivot Bracket Nut	2
26	11082	Tail Damper	1
27	HO4001	Damper Filler Plug	1
28	HS4002	Rear Nacelle Attachment Screw	4
29	HS3001	Nacelle Sealing Screw (Obsolete)	0
30	11098	Left, Nacelle, Fixed Portion	1
31	11099	Left Nacelle, Hinged Portion	1
32	HB4004	Nacelle Bracket Bolt	3
33	11070	Mainframe	1
34	HN8001	Alternator Attachment Nut	4
35	HW8001	Alternator Attachment Washer	4
36	HW4001	Nacelle Bracket Washer	3
37	HN4002	Nacelle Bracket Nut	3
38	11013	Alternator Shaft	1

BWC EXCEL Wind Turbine Parts List

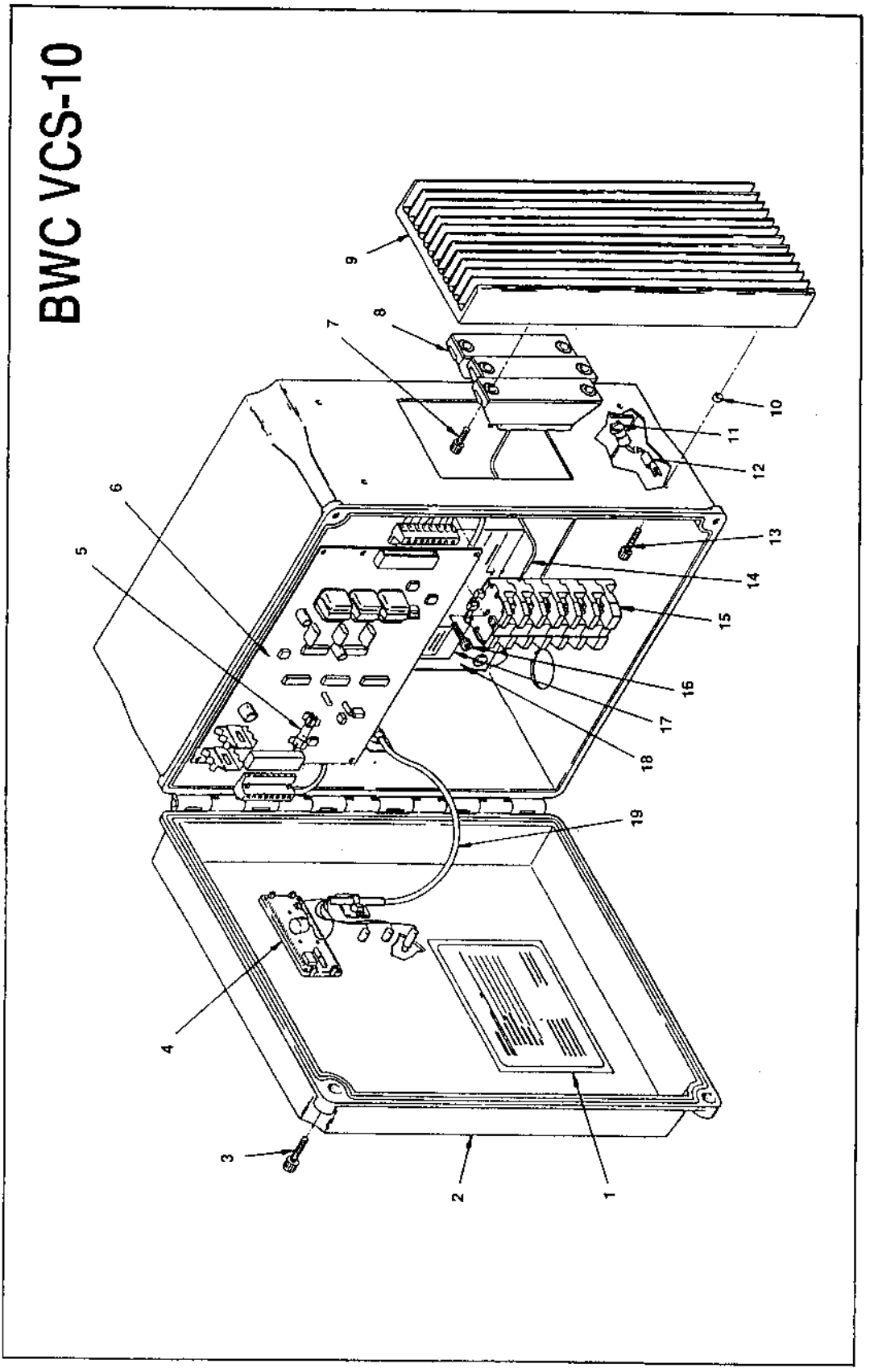
Drawing Part Number	BWC Part Number	Part Description	Number Required
39	HW8001	Alternator Attachment Washer	4
40	HB8002	Alternator Attachment Bolt	4
41	HR0002	Rear Bearing Retaining Ring	1
42	BC0003	Rear Alternator Bearing	1
43	11060	Rear Bearing Ring	1
44	11091	Stator Assembly	1
45	11048	Grounding Plate	1
46	HW3002	Grounding Plate Lock Washer	3
47	HS3002	Grounding Plate Screw	3
48	HR0003	Front Bearing Retaining Ring	1
49	BC0004	Front Alternator Bearing	1
50	HR0004	Alternator Shaft Retaining Ring	1
51	11059	Front Bearing Ring	1
52	11049	Grounding Brush Bracket	1
53	HW3002	Grounding Brush Bracket Lock Washer	2
54	HS3002	Grounding Brush Bracket Screw	2
55	HN4001	Magnet Can Attachment Nut	6
56	HW4001	Magnet Can Attachment Washer	6
57	HW4001	Magnet Can Attachment Washer	6
58	HB4005	Magnet Can Attachment Bolt	6
59	11092	Magnet Can	1
60	11066	Blade Assembly	3
61	HW7001	Front Bearing Casting Washer	6
62	HN7001	Front Bearing Casting Nut	6
63	11044	Spinner	1
64	HW4002	Spinner Attachment Washer	3
65	HS4001	Spinner Attachment Screw	3
66	11045	Spinner Support Bracket (Not as Shown)	3
67	HNB001	Blade Attachment Nut	12
68	HWC001	Blade Attachment Washer	12
69	HG4001	Spinner Attachment Grommet (Obsolete)	0
70	11094-2	"Powerflex" Decal (Obsolete)	0
71	11055-2	Blade Attachment, Short Stud	6
72	11055-1	Blade Attachment, Long Stud	6
73	EC8002	Grounding Brush Holder Cap	1
74	EC0002	Alternator Grounding Brush	1
75	EC8001	Alternator Grounding Brush Holder	1
76	HB7002	Front Bearing Casting Stud	6

BWC EXCEL Wind Turbine Parts List

Drawing Part Number	BWC Part Number	Part Description	Number Required
77	HS3004	Strain Relief Clamp Screw	1
78	HW3001	Strain Relief Clamp Washer	2
79	HO3001	Strain Relief Clamp	1
80	HN3001	Strain Relief Clamp Nut	1
81	HW6001	Stator Attachment Washer	6
82	HB6002	Stator Attachment Bolt	6
83	11138	Alternator Lead Jumper (Obsolete)	0
84	HS3007	Alternator Lead Attachment Screw	3
85	HW3002	Alternator Lead Lock Washer	3
86	EC7001	Power Brush Holder Cap	3
87	11111	Power Brush Assebly	3
88	HS2001	Slip-Ring End Cover Screw	6
89	11057	Slip-Ring End Cover	1
90	11089	Grounding Lead Assembly	1
91	HS3002	Brush Holder Bracket Screw	4
92	ECF001	Grounding Brush Holder	1
93	HW3001	Brush Holder Bracket Washer	4
94	HN3001	Brush Holder Attachment Nut	2
95	HW3001	Brush Holder Attachment Washer	2
96	HCB002	Alternator Lead Conduit	1
97	HCB001	Alternator Lead Conduit Connector	2
98	EC0003	Power Brush Holder	1
99	HS3007	Brush Holder Attachement Screw	2
100	HW3001	Brush Holder Attachment Washer	2
101	11053	Brush Holder Bracket	1
102	HNB002	Conduit Connector Nut	1
103	11054	Slip-Ring Wrap-Around Cover	1
104	11056	Slip-Ring Top/Bottom Cover	2
105	BC0005	Lower Yaw Bearing	1
106	11088	Grounding Ring	1
107	11033	Slip-Ring Assembly	1
108	11086	Tower Adapter	1
109	HG3001	Terminal Block Cover Grommet	4
110	EC0004	Terminal Block	1
111	HS3008	Terminal Block Attachment Screw	2
112	11087	Termianl Block Cover	1
113	HS3001	Terminal Block Cover Screw	4
114	HS3003	Wrap-Around Cover Screw	3

BWC EXCEL Wind Turbine Parts List

Drawing Part Number	BWC Part Number	Part Description	Number Required
115	HW3001	Wrap-Around Cover Washer	3
116	HS2001	Top/Bottom Cover Screw	4
117	11105	Nacelle Support Bracket	1
118	HG3001	Nacelle Attachment Grommet	3
119	11139	Slip-Ring Cover Gasket (Obsolete)	0
120	11097	Right Nacelle Half	1
121	HS3001	Nacelle Attachment Screw	3
122	11123	"BWC EXCEL" Decal	2
123	HG3002	Nacelle Sealing Grommet (Obsolete)	0
124	HW3001	Hinge Attachment Washer	6
125	HS3001	Hinge Attachment Screw	6
126	HG3001	Hinge Attachment Grommet	6
127	11122	Nacelle Hinge	1
128	HN4002	Tail Bumper Nut	4
129	HW4001	Tail Bumper Washer	4
130	HM0002	Cable Attachment Cotter Pin	1
131	HM5001	Furling Cable Attachment Pin	1
132	HRF001	Lower Tail Pivot Retaining Ring	1
133	HWF001	Lower Tail Pivot Washer	1
134	11037	Tail Boom	1
135	10094-1	"Autofurl" Decal	1
136	HW6001	Tail Fin Attachment Washer	16
137	HB6003	Tail Fin Attachment Bolt	8
138	11014	Tail Fin	1
139	11124	"Bergey" Decal	1
140	11125	BWC Logo Decal	2
141	HG4002	Closure Plate Grommet (Obsolete)	0
142	11115	Tail Boom Closure Plate (Obsolete)	0
143	HS4001	Closure Plate Screw (Obsolete)	0
144	HN6002	Tail Fin Attachment Nut	8
145	HB4008	Spinner Bracket Bolt	6
146	HW4003	Spinner Bracket Lock Washer	6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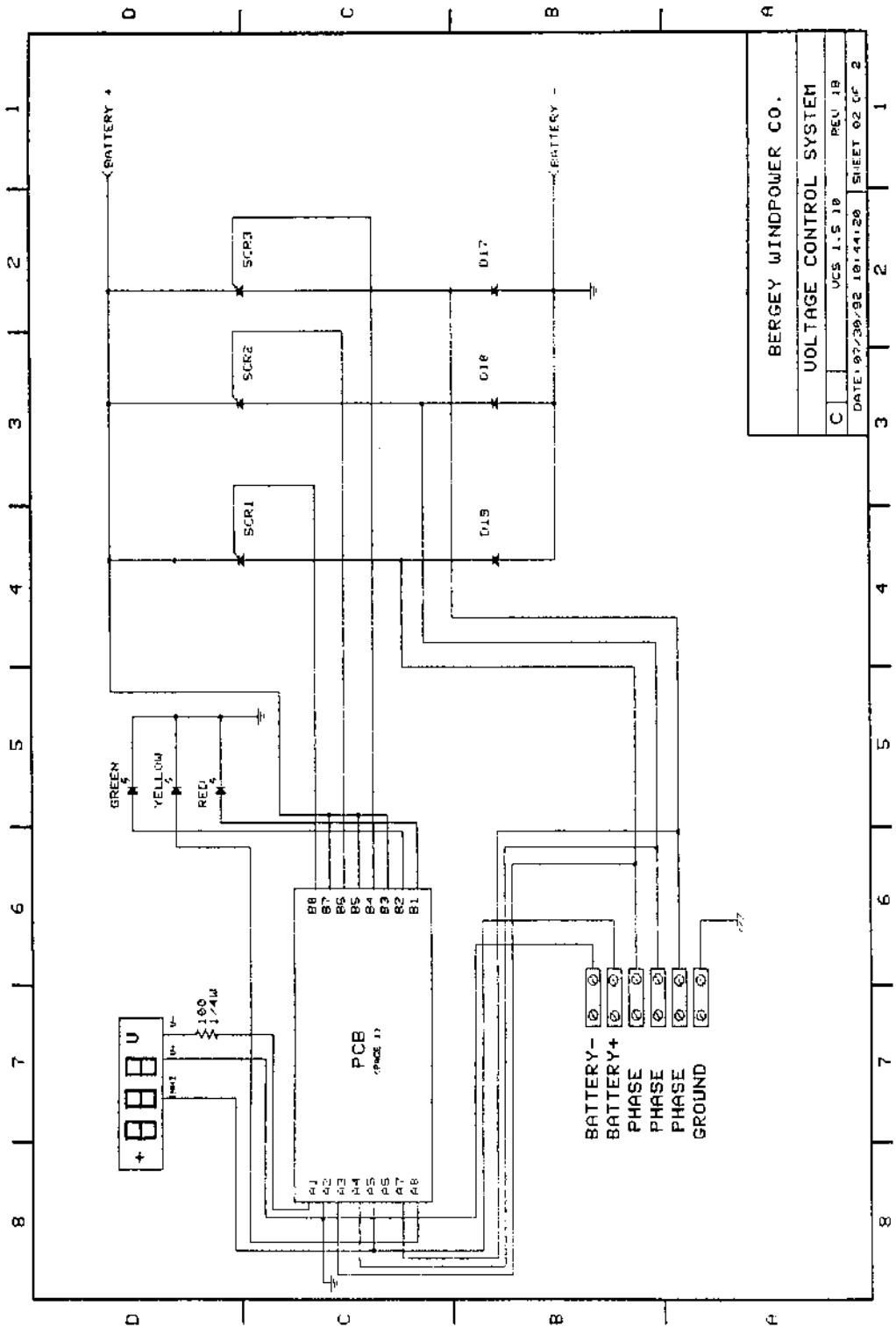
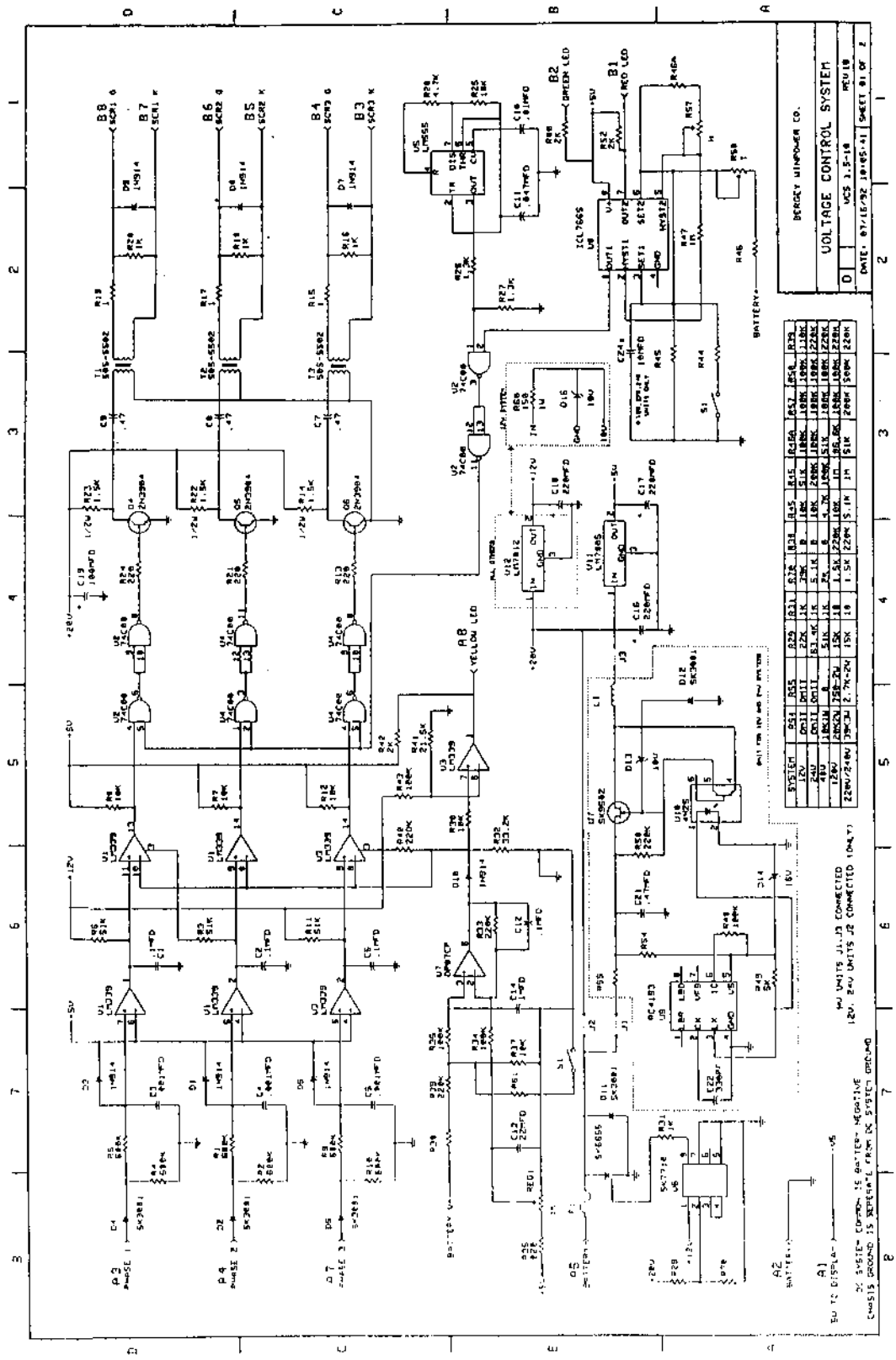
BWC VCS-10 Controller Parts List

Drawing Part Number	BWC Part Number	Part Description	Number Required
1	EC1002	Nameplate Decal	1
2	EC1003	Enclosure	1
3	EC1004	Door Screw	2
4	EC1005	Digital Display	1
5	EC1006	Circuit Board Fuse (1A)	1
6	EC1007	Circuit Board*	1
7	EC1008	Power Module Screw	6
8	EC1009	Power Module*	3
9	EC1010	Heat Sink*	1
10	EC1011	Heat Sink Spacer	4
11	EC1012	Panel Screw	4
12	EC1013	Grounding Lead	2
13	EC1014	Heat Sink Screw	4
14	EC1015	Power Lead*	9
15	EC1016	Terminal Block	1
16	EC1017	Terminal Block Screw	2
17	EC1018	Terminations Decal	1
18	EC1019	Panel	1
19	EC1020	Wiring Harness*	1

* - Specify Voltage



Electrical Schematic of VCS Controller



Electrical Schematic of the VCS Circuit Board