



Power Solutions

MOTIVE POWER DIVISION

# FERRO FIVE® SERIES MOTIVE POWER CHARGERS

Installation and operating instructions for single  
phase and three-phase chargers

FERRO FIVE® FR, EFR, LIBERTY®, and REVOLUTION™  
SERIES chargers with RANGER II®, COMPUCHARGE®  
or SCOUT® controls



### WARNING!

Battery chargers present an electrical hazard to those who work with or service them. Although specific "CAUTIONS" and "WARNINGS" are included throughout the text of this manual, it is essential that extreme care be taken at all times to ensure a safe working environment.

### CAUTION

LIFT ALL FOUR  
CORNERS

### WARNING

A battery on charge gives off a mixture of oxygen and hydrogen gas, which is explosive. Ventilate the charger room to prevent gas accumulation. C&D chargers are convection cooled. To provide ample ventilation to carry off excess heat, keep chargers at least four inches from a wall and from other chargers and obstructions.

### CAUTION

Electrical connections can work loose during shipping. Check all connections for tightness before connecting the charger to the AC supply voltage.

### WARNING

Check all warning labels!

The charger should be connected to a fused safety disconnect switch or to a circuit breaker. Be sure the protective device and the incoming AC cables to the charger meet the local electrical codes and they match the current and voltage requirements of the charger or chargers. The charger nameplate shows AC volts, phase and current requirements at nominal line and rated output and recommended external fusing. In addition, check the tag on the charger for proper input voltage.

### CAUTION

DO NOT ATTEMPT TO  
RECONNECT VOLTAGE  
WITHOUT READING  
INSTRUCTIONS



THIS CHARGER  
CONNECTED FOR  
120V - 208V - 240V  
480V - 575V  
OTHER \_\_\_\_\_

JN-95

### CAUTION

### PHASE FUSE RATING

HIGH VOLTAGE	208 VOLTS	LOW VOLTAGE
3-4-5	3-4-5	3-4-5
6-7-8	6-7-8	6-7-8
10-12-15	10-12-15	10-12-15
20-25-30	20-25-30	20-25-30
35-40-45	35-40-45	35-40-45
50-60	50-60	50-60

### CAUTION

Make sure the charger positive terminal is connected to the charger connector terminal marked (+) and the negative terminal to the one marked (-).



### GROUND CONNECTION

### CAUTION

1. ALL THREE PHASES ON VOLTAGE CHANGEOVER TERMINALS MUST BE RECONNECTED WHEN CHANGING VOLTAGE.
2. AC FUSES MUST BE CHANGED WHEN CHANGING VOLTAGE. SEE LABEL IN CHARGER.

### DANGER

### SHOCK HAZARD

DO NOT TOUCH  
UNINSULATED BATTERY  
TERMINALS OR  
CONNECTORS

### WARNING

### ARC HAZARD

CONNECT OR DISCONNECT  
BATTERY PLUG ONLY  
WHEN CHARGE CYCLE IS  
COMPLETE

### DANGER

### HIGH VOLTAGE

DISCONNECT CHARGER  
FROM AC VOLTAGE SUPPLY  
AND BATTERY BEFORE  
SERVICING OR DISMANTLING

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# 1 RECEIVING AND INSTALLATION

## 1.1 Receiving

**CAUTION**  
LIFT ALL FOUR  
CORNERS

Inspect your C&D charger for any shipping and handling damage as soon as it arrives. Describe any damage on the receiving slip and immediately notify the shipper. Verify the model and serial numbers printed on the packing list against the nameplate (Figure 1.1). If they disagree, contact your C&D representative before proceeding with installation. Use caution when moving chargers. Do not drop or otherwise abuse them.

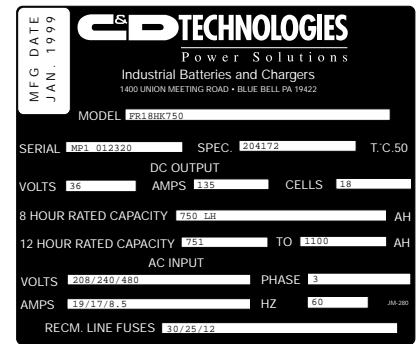
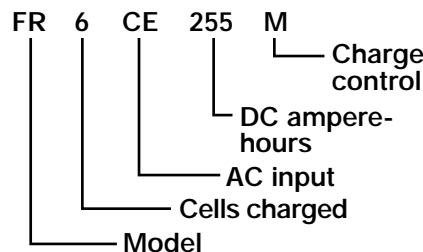


FIGURE 1.1-Nameplate

## 1.2 Identification

A five-element model number identifies each C&D charger. Each element describes a different charger performance characteristic. The model number of a FERRO FIVE charger describes its basic operating characteristics. A typical model number is:



**Model:** The first element in the numbering system identifies the model. In this example, an FR charger.

**Cells charged:** This entry indicates the number of lead-acid cells the system can charge. In this example, a six-cell lead-acid battery.

**AC input:** Letter codes listed in Table 1.1 describe the voltage, phase and frequency of the AC input current. In the example, the letters CE define a charger that requires a 240 or 480 VAC, single-phase, 60 Hz input. The number 5 placed between any

letters, C5E for example, denotes 50 Hz operation. Models with a CE or HK designation also include a tap for 208 VAC.

**DC Ah:** For EFR SERIES chargers, this is the largest size battery, discharged to 80 percent, that can be charged in eight hours. For FR series chargers, this is the largest size battery, discharged to 100 percent, that can be charged in eight hours. In this case, a 255 Ah battery.

**Charge control:** The last element in the numbering system identifies the control:

**E** indicates the optional RANGER II control.

**F** indicates RANGER II with LIBERTY option.

**G** indicates RANGER II with REVOLUTION option.

**M** indicates the optional COMPUCHARGE control.

**S** indicates the optional SCOUT control.

**T** is the standard electro-mechanical timer.

**JM** indicates a disconnect switch.

**R** indicates remote control.

Suffix letters may be combined.

A charger designated **MJM** contains both a COMPUCHARGE control and a disconnect switch.

AC INPUT POWER CODES							
Code	Input Power (VAC)	Phase	Cycles (Hz)	Code	Input Power (VAC)	Phase	Cycles (Hz)
A	120	1	60	S	380	1	50
B	208	1	60	C5E	208/240/480	1	50
C	240	1	60	M	575	1	60
E	480	1	60	Z	380	3	50
G	208	3	60	H5K	208/240/480	3	50
H	240	3	60	L	575	3	60
K	480	3	60				

TABLE 1.1

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## 1.2 Identification (continued)

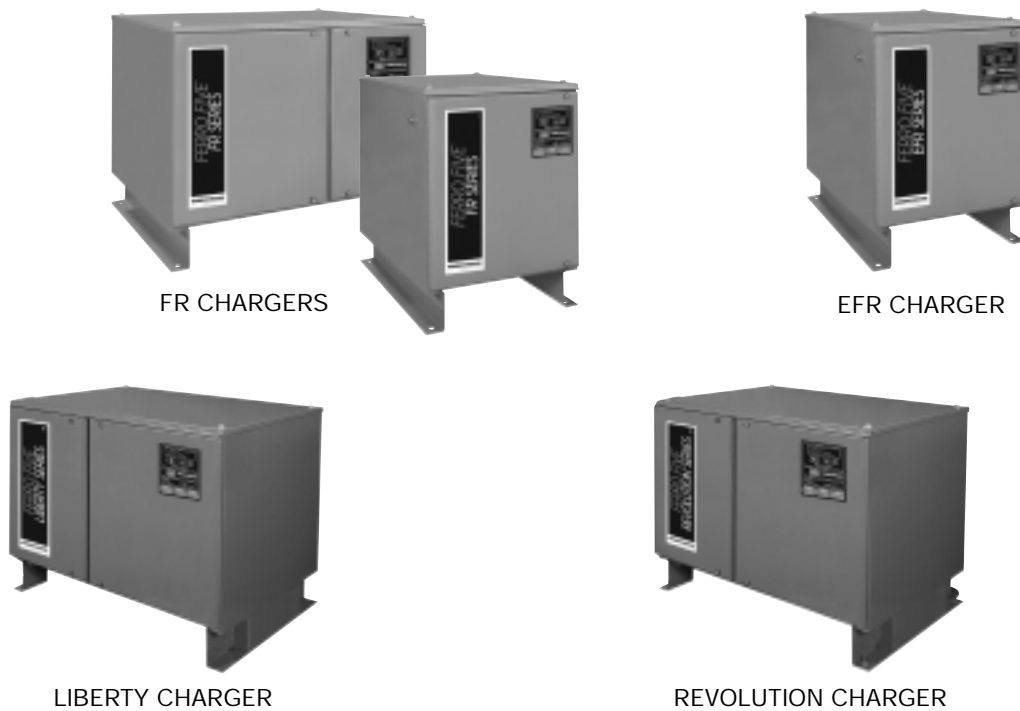


FIGURE 1.2-FERRO FIVE FR, EFR, LIBERTY and REVOLUTION SERIES chargers

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### 1.3 Storage

Keep the charger in its original shipping container until you are ready to proceed with installation. The unit can be safely

stored in any clean, dry area where temperatures remain between 40°F and 120°F (5°C and 49°C).

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### 1.4 Location

Battery charging produces heat and a potentially explosive mixture of odorless oxygen and hydrogen gases. Safe operation requires a clean, dry, well-ventilated area, where the temperature remains between 60°F and 100°F (16°C and 32°C).

C&D chargers are convection-cooled. Chargers require a MINIMUM of four inches of clearance between the floor, walls, chargers, and other obstructions for adequate air circulation.

EXPLOSIVE, COMBUSTIBLE OR FLAMMABLE MATERIALS SHOULD NOT BE PERMITTED IN THE CHARGING ROOM. NEVER MOUNT A CHARGER ON OR ABOVE COMBUSTIBLE MATERIALS.

To prevent the accumulation of explosive concentrations of hydrogen and oxygen, the charging area should have sufficient ventilation to prevent formation of one percent, by volume, of hydrogen. It is important to note hydrogen is generated at different

rates during various times in the charge cycle. Most of the gas forms during the last two to three hours of the charge, when the average cell potential exceeds 2.37 volts. Every pint of water dissociated during recharge releases 23 cubic feet of hydrogen gas to the atmosphere. To calculate hydrogen formation, determine the number of pints of water needed to correctly re-level cells after charging, then multiply the number by 23. Thus, a lead-acid motive power battery that requires 1.5 pints of water to relevel, will produce 34.5 cubic (1.5 x 23) feet of hydrogen.

An approximation technique may be used to estimate hydrogen production from C&D batteries charged by chargers equipped with COMPUCHARGE, SCOUT and automatic Start/Stop controls. It is estimated a total of 0.24 cubic feet of hydrogen gas will evolve from each cell per 100 ampere-hours of capacity.

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## 1.4 Location (continued)

For example, an 18-cell battery rated at 720 ampere-hours:

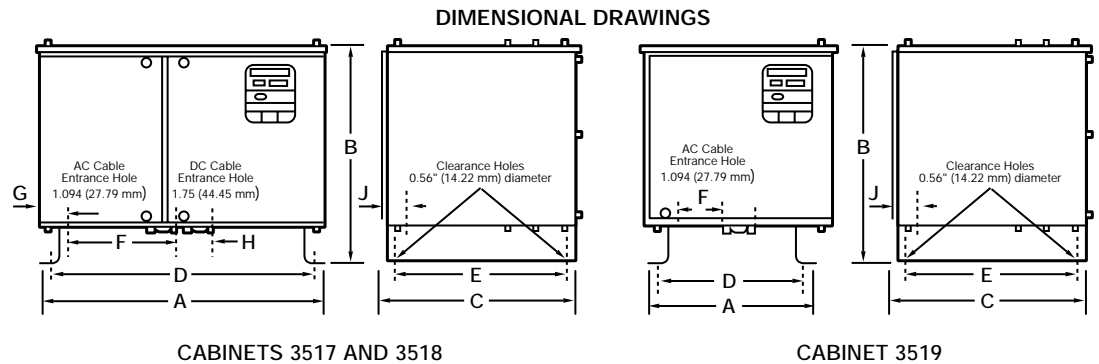
$$\text{Cells} \times \text{Capacity} \times \frac{0.24}{100} = \text{Cubic feet of hydrogen/charge cycle}$$

$$18 \times 720 \times \frac{0.24}{100} = 31.1 \text{ Cubic feet of hydrogen/charge cycle}$$

## 1.5 Mechanical installation

Chargers can be bolted to noncombustible floors or steel benches. For maximum space saving, up to three units can be stacked. Consult

Figure 1.3 for charger cabinet dimensions. Wall mounting requires the optional brackets described in Section 6.6.



CABINET NO.	A		B		C		D		E		F		G		H		J	
	inches	mm	inches	mm	inches	mm	inches	mm	inches	mm	inches	mm	inches	mm	inches	mm	inches	mm
3517	32.22	818	24.00	610	21.81	554	30	762	19	483	11.00	279	2.81	71.4	4.38	111	1.50	38.1
3519	18.22	463	24.00	610	21.81	554	16	406	19	483	4.00	102	2.81	71.4	4.38	111	1.50	38.1
3518	43.22	1098	32.00	813	28.81	752	41	1041	26	660	16.50	419	2.81	71.4	4.38	111	1.50	38.1

FIGURE 1.3-Cabinet dimensions

## 1.6 Electrical connection

Each charger requires a fused safety disconnect switch or a circuit breaker. Use a line protection device rated for the recommended line fuse value shown on the charger nameplate (Figure 1.1).

Electrical installations must be performed by a qualified electrician and satisfy all local, national and federal electrical codes. It is vital to the reliable operation of the charger that it be provided a good earth ground.

### CAUTION

Electrical connections can work loose during shipping. Check all connections for tightness before connecting the charger to the AC supply voltage.

## 1.7 Input voltage changeover

The voltage circled on the AC voltage rating label (Figure 1.4) must match the available line voltage. If the voltages are different, it will be necessary to change AC line fuses, AC phase fuses and the connection terminal on both the ferroresonant power and control transformers. Consult the voltage changeover instruction label inside the cabinet door. **BE SURE THE CHARGER IS DISCONNECTED FROM**

### ITS AC POWER SUPPLY BEFORE ATTEMPTING THIS MODIFICATION.

**NOTE:** AC voltage changeover must be made at the terminals of both the ferroresonant power transformer and the control transformer.

Input voltage changeover CANNOT BE PERFORMED on chargers manufactured for 575 VAC only operation.



### 1.7 Input voltage changeover (continued)

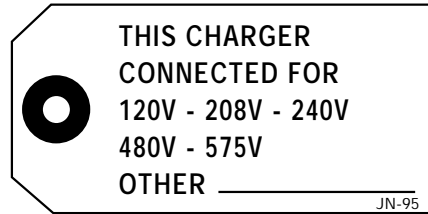
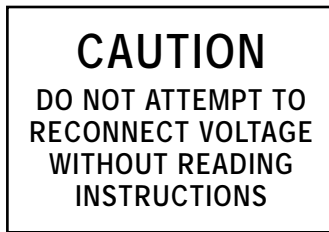


FIGURE 1.4-AC voltage rating label  
(voltage circled)

CAUTION AC FUSE RATING		
HIGH VOLTAGE	208 VOLTS	LOW VOLTAGE
3-4-5	3-4-5	3-4-5
6-7-8	6-7-8	6-7-8
10-(12)-15	10-12-15	10-12-15
20-25-30	20-(25)-30	20-25-(30)
35-40-45	35-40-45	35-40-45
50-60	50-60	50-60

FIGURE 1.5-AC fuse rating chart as it would be marked for an FR18HK750. Circles indicate the proper fuses for each voltage.

### 1.8 AC input voltage cables

Customers or electrical contractors must furnish the AC connection. Cables should be sized for the recommended line fuse values shown on the charger nameplate. Allowable variations from nominal AC line voltages appear in Table 1.2.

#### ALLOWABLE AC INPUT RANGES

Nominal charger voltage	AC voltage ranges
120	106 - 127
208	184 - 220
240	212 - 254
480	424 - 508
575	508 - 600*

\*Certain kinds of control and protective equipment have a maximum voltage limit of 600V. The manufacturer or power supplier, or both, should be consulted to assure proper application.

TABLE 1.2

### 1.9 Grounding

The AC system and the charger enclosure connect to ground from the tagged stud, located in the lower left front of the enclosure. It is imperative

to dependable performance of the charger that it be provided a reliable earth ground.

### 1.10 DC cables and cable connectors

C&D ships each charger with a standard, eight-foot long DC output cable that terminates with an appropriate cable connector. As an option, other lengths are available. If it is necessary to install longer cables, they must be properly sized to prevent overheating and ensure compliance with electrical codes. DC CABLE LENGTHS FROM 15 TO 25 FEET SHOULD BE ONE CABLE SIZE LARGER THAN THE STANDARD CABLE. CABLE LENGTHS FROM 25 TO 35 FEET SHOULD BE TWO CABLE SIZES LARGER. DC CABLE LENGTHS

SHOULD NOT EXCEED 35 FEET. When specifying replacement cable connectors, it is important to remember C&D single-phase chargers produce higher peak currents than similarly rated C&D three-phase systems. The maximum DC current flowing from a single-phase charger is typically 1.3 times the panel ammeter reading.

C&D recommends higher capacity SB-350 connectors be specified as retrofit equipment for all single-phase chargers rated at over 135 amperes.

#### CAUTION

Be sure the charger positive terminal is connected to the charger connector terminal marked (+) and the negative terminal to the one marked (-).

#### CAUTION

Due to the high currents involved it is imperative that connectors be properly maintained. See your C&D representative for more information.

## 1.11 Maintenance

Battery chargers work most efficiently and deliver better service life with good heat dissipation. Periodic cleaning with dry, low-pressure air will remove accumulated dust to assure good heat transfer to the surrounding air. At least

twice a year, check input and output circuit connections to make sure they are tight. Otherwise, there are no maintenance adjustments to the FERRO FIVE SERIES chargers.

# 2 RANGER II CONTROL

## 2.1 Description

### WARNING

Battery chargers present an electrical hazard to those who work with or service them. Read and understand all warnings and cautions in this manual as well as those affixed to the charger. Exercise extreme care to assure a safe working environment.

The RANGER II control uses a "plain-English," menu-driven display program. When the charger is idle, the display shows the number of cells, the current date and the time.

Features of the RANGER II control include:

- **Bright, two-line vacuum fluorescent display**—visible in ambient light
- **"Plain English," menu-driven display**—for fast set-up, preview and change of equalize, delayed start and other charge parameters

- **Delayed start**—turn-on time delay is selectable from five seconds to 12 hours in one second intervals and time of day start
- **Real-time 24-hour clock**—with automatic adjustment for daylight savings time. Fully Year 2000 compliant
- **Automatic or manual equalize**—automatic equalize selectable from one to 50 cycles or day of the week; manual equalize selectable from front panel
- **Automatic three-day refresh cycle**—if battery is connected for more than 72 hours, a brief boost charge is provided to maintain battery in fully charged condition
- **Automatic charge termination**—when voltages stabilize indicating full charge or if battery overheats
- **User programmable cool down step**
- **Adaptable to low maintenance and sealed modes**
- **A variety of cell and shunt sizes**—selectable for six through 36-cell batteries and four shunt sizes
- **Output for optional automatic watering device**
- **Advanced features with SMARTBATTERY II:**
  - Equalize by battery cycles
  - Watering by cycles

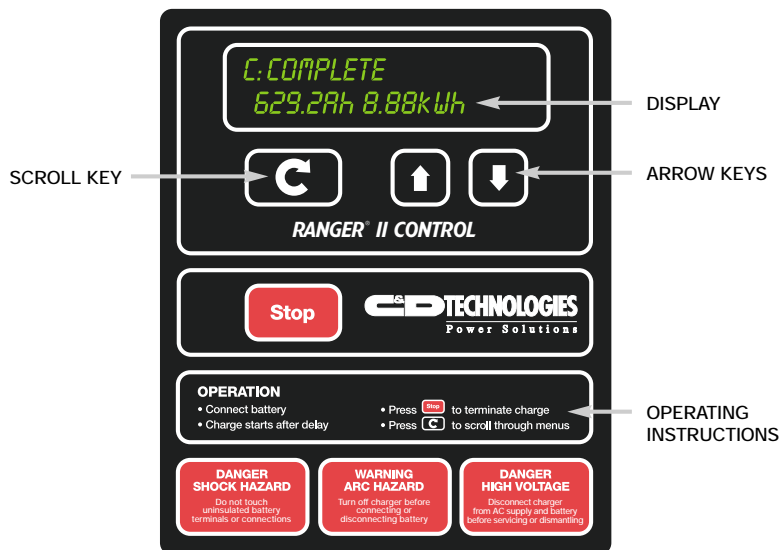


FIGURE 2.1-RANGER II control


Manual equalize and charger reports can be accessed by pressing the Scroll key. Refer to Sections 2.3.3 and 2.3.5 for specific information.

## 2.2 Basic Settings

Basic control settings such as number of cells, shunt size, delay before starting, etc. are set from the front panel using a "hidden" menu with restricted access. Before operating your charger, check to be sure these initial settings have not been changed.

Should you need to change any of these settings, you may access them through the RANGER II control panel. The battery must be disconnected in order to enter the parameters menu.

**To access this menu, press both Arrow keys at the same time when the seconds portion of the time display indicates :01 changing to :02.**

The Scroll key  is used to move

from selection to selection, and the Arrow keys are used to enter information. Begin by using the Arrow key to select "parameters," then press the Scroll key to view the first parameter. To return to the idle display, press the Stop key. All parameters are automatically saved and overwrite existing parameters.

**NOTE:** An internal, nonrechargeable lithium battery permits the RANGER II control to retain programmed operating parameters in memory even when the charger is disconnected from an AC line. This battery has an expected service life of more than 10 years, and, when required, should be replaced by C&D. In the event of battery malfunction, contact your local C&D representative.

### 2.2.1 Real-time or fixed increment starting

**PP: Delay mode [ ▲▼ ]**

**IMPORTANT:** When using real-time starting or fixed increment delay starting, be sure to allow for at least eight hours of charging before the battery is used again.

Delayed starting lets you delay the time when the charge begins in order to take advantage of lower, off-peak utility rates, or to spread out peak demand loads.

**PP: Delay [ ▲▼ ]**

**NOTE:** When using real-time start, if you connect a battery within four hours

after the preset start time has passed, the battery will still be charged after a short delay. This allows for unusual situations, such as extended-shift where the battery would not be available until after the preset time.

Real-time or fixed delay starts can be selected from the programmable parameters menu.

Use the Arrow keys to select either "Start at real time" or "Fixed delay mode." If you have selected "Start at real time," press the Scroll key, and use the Arrow keys to enter the start time in HH:MM. If you have selected "Start after delay," press the Scroll key, and use the Arrow keys to enter the delay in HH:MM:SS.

### 2.2.2 Automatic equalizing

The RANGER II control can be set to automatically equalize the battery for every one to 50 cycles or to equalize all batteries charged on a particular day of the week.

Automatic equalize can be set through the programmable parameters (see Section 2.2). Use the Scroll key until the display reads.

**PP: Equiz mode [ ▲▼ ]**

Press the Arrow keys to select either the number of cycles, the day of the week, never, or always. Depending on your selection the following screens will appear:

**PP: Equiz cycl [ ▲▼ ]**

or

**PP: Equiz mode [ ▲▼ ]**

If you have selected never or always, the next menu will be:

**PP: Water Mode [ ▲▼ ]**

To return to the idle display, press the Stop key or the Scroll key to continue entering parameters. When equalization is scheduled, "C:(E)" is displayed.

### 2.2.2 Automatic equalizing (continued)

If you have selected number of cycles or day of the week, press the Scroll key and use the Arrow keys to enter the appropriate information. Equalizing cycles can be programmed for two to 50 cycles.

**NOTE:** When a RANGER II charger programmed to equalize by cycles is connected to a SMARTBATTERY II it will equalize by battery cycles. Otherwise, it will equalize by charger cycles.

### 2.2.3 Automatic watering

Provisions for automatic watering have been made within the RANGER II control. **NOTE:** If a charge mode other than conventional has been selected, these do not apply and the menus will not appear. It can be set to always, never, and if a communications board has been added for SMARTBATTERY II, every 5 cycles or every 10 cycles. To select automatic watering, scroll through the programmable parameters until the display shows:

**PP: Water mode [ ▲▼ ]**

Use the Arrow keys to select watering options.

**NOTE:** If the automatic watering parameter is set to every 5 cycles or every 10 cycles and a battery without SMARTBATTERY II is connected,

the RANGER II will always water the battery. Once watering has been activated, it is important that it remain activated long enough to ensure all cells have been fully watered. In order to limit possible over-flow due to damage or malfunction, the RANGER II only maintains water flow for a limited duration. This time is factory set at one minute, but can be adjusted.

To adjust automatic watering time, press the Scroll key until the display reads:

**PP: Set WTR tm [ ▲▼ ]**

Use the Arrow keys to set the length of the watering cycle. The watering cycle can last from 15 seconds to three minutes.

### 2.2.4 Setting cool time

**PP: Set cool time**

After the charge is completed, the charger will pause for a preset period of time to allow the battery to cool. Select a time from one minute to eight hours.

### 2.2.5 Monitoring water flow

To monitor the flow of water during a watering cycle, use the Arrow keys to select "enable."

**PP: Flow check [ ▲▼ ]**

When the flow check is enabled, the water flow is checked soon after the

watering triac is turned on. If no flow is detected, the triac is turned off and a fault appears "(- Flo)". The flow is also checked at the end of the watering cycle, and if flow is still detected, the fault will appear "(+ Flo)". All flow faults appear after the postcharge display. The fault is cleared by disconnecting the battery.

### 2.2.6 Main power override

**PP: ctl MAIN [ ▲▼ ]**

Under certain conditions, such as troubleshooting or recovery of an overdischarged battery, it is useful to be able to override the logic of the main control board and force the charger to

turn on. Press the Arrow key to activate this feature. When activated, this feature energizes the main contactor and only checks for a connected battery. The contactor will be energized for a maximum of three minutes to preclude damage to a charger or battery caused by excessive charging with defective or mismatched equipment.

### 2.2.7 Water control override

**PP: CTL WATER [ ▲▼ ]**

The water control override feature allows the watering output to be forced on for an indefinite period for troubleshooting.

It should not be left in the ON position for an extended period of time. Use the Arrow keys to turn it on and off.

### 2.2.7 Water control override (continued)

If charge mode is set for other than conventional, the CTL water display will be replaced by the following:

**PP: CTL STAGE 2 [▲▼]**

Use the Arrow keys to turn the second stage ON or OFF for troubleshooting purposes. Watering mode functions, including flow check, are not available in non-conventional modes.

### 2.2.8 Setting the number of cells

**PP: Set CELLS [▲▼]**

The number of cells for the charger and the RANGER II control are designed to match. After entering the programming menu, as explained above, scroll through the selections until the above

display appears. Use the Arrow keys to set the number of cells to match the charger nameplate rating. You may enter from six to 36 cells in one cell increments.

### 2.2.9 Selecting the shunt size

**PP: Set SHUNT [▲▼]**

The RANGER II control is matched to its shunt size at the C&D factory. There should be no need to change the shunt size unless a replacement control board is installed.

Should you need to change the shunt size, refer to the parts lists on pages 34, 35, 36. Use the Arrow keys to set the shunt at 100 mV to 100, 200, 300, or 500 amperes.

Press the Scroll key to set the shunt size.

### 2.2.10 Setting the rated output current

**PP: Rated AMPS [▲▼]**

Set the rated current of the charger as it is indicated on the charger nameplate.

Use the Arrow keys to enter rated current from 0 to 500 amperes in five ampere increments.

Press the Scroll key to set rated output current.

### 2.2.11 Setting the charge mode

**PP: Charge Mode [▲▼]**

Select the proper setting according to the type of battery being charged. This setting must be consistent with the charger circuitry. Any FR can function in conventional mode but only a FERRO FIVE LIBERTY SERIES charger can function in LM mode and only a FERRO FIVE REVOLUTION SERIES charger can function in VR mode. The ready screen will indicate the mode in use.

If the charger is set for conventional mode:

**READY (STD): ## cells**

If the charger is set for Flooded Low Maintenance mode:

**READY (LM): ## cells**

If the charger is set for REVOLUTION mode:

**READY (VR): ## cells**

### 2.2.12 Setting the date

**PP: Set DATE [▲▼]**

The current date is set by pressing the Arrow keys until the current date

is displayed. The display is in MM/DD/YY format.

Press the Scroll key to set the current date.

### 2.2.13 Setting the correct time

#### PP: Set TIME [ ▲▼ ]

The RANGER II charger has a 24-hour clock, which allows charger operation to begin at a preset time or at a fixed delay from time of connection. It also allows the charger to report the actual time, date and when the charge was begun and completed. The 24-hour clock is

set when it leaves the factory; however it may need to be adjusted if you live in a different time zone than the factory. The correct time must be set before placing the charger in operation. Set the current time HH:MM:SS by pressing the Arrow keys until the current time is shown.

Press the Scroll key to set the correct time.

### 2.2.14 Setting the day of the week

#### PP: Set DAY [ ▲▼ ]

By keeping track of weekdays, RANGER II can perform equalizing charges on the day most convenient for the user. For example, you can program

the RANGER II so all Friday charges include an equalizing charge. Refer to Section 2.2.6. Using the Arrow keys, set the current day of the week.

Press the Scroll key to set the day of the week.

### 2.2.15 Activating daylight savings time

#### PP: Set DST [ ▲▼ ]

If the charger will be operated in an area using Daylight Savings Time, the automatic daylight savings time feature can be activated to automatically adjust the clock to daylight savings time and back to standard time on the proper days.

To activate this feature, press an Arrow key until "Auto daylight time" appears on the display. If you do not need daylight savings time, press an Arrow key until "Always STD time" appears on the display.

To activate daylight savings time, press the Scroll key.

### 2.2.16 Activating and setting the address

#### PP: Set NET [ ▲▼ ]

If RMS system is in use, set the address for this charger ON. On the RANGER NET™, if no RMS system is in use set to net inactive.

### 2.2.17 Setting the baud rate

#### PP: Set Baud [ ▲▼ ]

If the network is activated, set the baud rate for RANGER NET. See RMS Manual for appropriate baud rate.

## 2.3 Operations

### 2.3.1 Manual starting

1. CONNECT THE CHARGER TO THE AC SUPPLY LINE. The digital display will show the number of cells for which the charger has been set as well as the charge mode selected (see 2.2.11) and the time of day.

2. CONNECT THE BATTERY. The charge cycle will begin within five seconds, if no other delay time has been selected. The RANGER II control display will show the time remaining until the start of charge. If the battery is fully charged, the charger will move from charging to post-charge, or if manual equalize is selected, to equalize. When the charge begins, the display will show the elapsed time charging, voltage and current in amperes. When the

battery is 80 percent charged, an "(80%)" will appear after the elapsed time display.

If manual or automatic equalize is selected, an "(E)" will appear in the upper left hand corner. When voltage and current have stabilized "(EXT)" will appear after the elapsed time display. When equalization has begun, an "(EQU)" will appear on the display after the elapsed time.

When the charge is complete, the RANGER II will show the ampere-hours and kilowatt-hours returned to the battery.

### 2.3.1 Manual starting (continued)

In the event of a charging problem or error, an error message will be displayed. Refer to Section 7, Troubleshooting, for more information on error messages.

**NOTE:** This error message will clear if the battery is disconnected. This information and other charge parameters are also available during the charge and can be accessed by pressing the Scroll key twice.

### 2.3.2 Stopping the charge manually

To interrupt the charge before it is complete, press the Stop button.

#### CAUTION

Always be sure charger is turned off—either manually or automatically—before disconnecting the battery from the charger. Otherwise, hazardous arcing will occur.

### 2.3.3 Manual equalizing

In the course of the normal charge/discharge cycle, a motive power battery develops inequalities of voltage and specific gravity among its cells. Equalizing batteries at regular intervals will restore cell equality, assuring rated performance.

Manual equalizing is activated by pressing the Scroll key at anytime before or during a charge. The normal equalization program is

overridden, and so this feature can be used to equalize a fully charged battery.

**MNU: Manual EQU [ ↑↓ ]**

To activate manual equalize, press an Arrow key. To deactivate manual equalize, press an Arrow key again. After 60 seconds, the display will return to the idle charger display.

### 2.3.4 Operation after loss of AC power (warm start)

If the charger has been started manually, it will return to its previous operating mode as soon as power is restored and continue charging the battery until the charge cycle is completed. If the charger is set for real-time start and the power is discontinued and then restored before the selected start time, charger operation is unaffected.

If the charger is set for real-time start and the power loss occurs 1) after start or 2) before start and extends into the preselected charge period, the charger

will resume operation as soon as power is restored and continue the charging sequence until the charge cycle is completed. An exception to this would be if the power outage lasted into the next day (beyond 24:00, midnight), in which case the charger would not restart until the preset hour that day. To reduce the possibility of tripping a breaker in multiple charger installations, the RANGER II control distributes charger starts randomly. The minimum delay time is 15 seconds and the maximum delay time is 3 minutes and 30 seconds.

### 2.3.5 Charge data retrieval

When a charge is completed, the RANGER II control can display the ampere-hours and kilowatt-hours required for the charge, followed by the word "complete." Pressing the Scroll key will enable the user to access information about starting time and date, open circuit battery voltage, starting and ending battery voltage, starting and ending battery current, ampere-hours and kilowatt-hours of charge, length of charge, ending time and date, and the number of non-equalized cycles. If the battery being charged has a SMARTBATTERY II installed and the charger is equipped for SMARTBATTERY II communications,

additional removed data will be available: ampere-hours moved on discharge and on charge temperatures. Press the Scroll key until the display reads:

**MNU: Charge rpt [ ↑↓ ]**

This data can be retrieved and shown on the display during or after the charge cycle.

In the event of an error during the charge cycle, a "plain English" error message is displayed. Refer to Section 7, Troubleshooting.

## 2.4 Special features with SMARTBATTERY II

A RANGER II charger connected with a SMARTBATTERY II module will operate in the same manner as described in Sections 2.1 through 2.4, except for the enhancements noted below.

While the charger is charging a battery with SMARTBATTERY II connected, the RANGER II control checks the SMARTBATTERY II module to see that the last charge was full and the battery is discharged. It then calculates and displays the percent charged. If the SMARTBATTERY II indicates the battery is already fully charged, the charge cycle is terminated within two minutes.

The display will indicate the percent charge. The charger may enter a cooling cycle if the SMARTBATTERY II module indicates temperatures within a certain range; if it does so it is indicated on the display as C:Cooling xx°F, with the hours, minutes and seconds. When the battery temperature is less than 105°F, the RANGER II resumes the charge cycle and will enter the equalize mode, if necessary.

After equalization or watering, the RANGER II checks the SMARTBATTERY II again for temperature. It may enter the cooling stage again, indicating it on the display.

Because the SMARTBATTERY II keeps track of battery cycles, you can equalize and water the battery by battery cycles, not charger cycles. If equalization is selected, the display will show "C:E." During equalization, the percent charge is displayed. You may specify equalizing parameters as indicated in Section 2.2.2 on Page 6.

When a SMARTBATTERY II module is connected to a RANGER II charger, the watering options are always, never, every five battery cycles or every 10 battery cycles.

**NOTE:** A SMARTBATTERY II capable, RANGER II control programmed for watering by battery cycles will always perform the watering cycle if connected to a battery without SMARTBATTERY II. Changing watering parameters is also described in Section 2.2.7 on Page 8.

### 2.4.1 Installing a SMARTBATTERY II communications board

The RANGER II control is designed to interface with a SMARTBATTERY II, enabling you to get data such as depth of discharge information, start and end of charge temperatures, minimum volts per cell, low volts per cell and more.

In order for a RANGER II control to interface with SMARTBATTERY II, the

charger must have a communications board installed.

The communications board is installed by inserting it into the RANGER II board at expansion slot A. Firmly seat the communications board onto the RANGER II board. (Be sure to disconnect both AC power and the battery during this procedure.)

### 2.4.2 Retrieving data from SMARTBATTERY II modules

When entering the programmable parameters, a choice is given between the programmable parameters and the SMARTBATTERY II menu.

The SMARTBATTERY II terminal menu is used to retrieve information from

the SMARTBATTERY II attached to a RANGER II control. If the RANGER II cannot communicate with the SMARTBATTERY II, COMerr is displayed on the interface. If COMerr is displayed, contact your local C&D representative.



#### 2.4.2 Retrieving data from SMARTBATTERY II modules (continued)

The following information is displayed; the Scroll key is used to move through the menu items.

Menu display	Description
BT: Present T [C] 87°F	The current temperature of the battery.
BT: Dischrg data [C] 2.37V 329AH 14.21	Shows minimum volts per cell, ampere-hours removed and time in discharge. When this information is retrieved, the equivalent information in the charge summary report is replaced with this new data.
BT: Discharges [C] 1000 cycles	The number of discharge cycles from the SMARTBATTERY II. When this information is retrieved, the equivalent information in the charge summary report is replaced with this new data.
BT: Low VPC [C] 25 cycles 2.5%	The number of low volts per cell cycles and the percent of the total.
BT: Lo DOD cycls [C] < 250, 30-70% 700	The number of low depth of discharge cycles for 30% (indicated by "<") and 30 to 70% categories.
BT: Hi DOD cycls [C] 70-90% 45, > 5	The number of high depth of discharge cycles for 70-90% and > 90% (indicated by ">").
BT: SOC T cycls [C] < 250, 500, > 250	The number of cycles in each of three start of charge temperature categories: < 60°F (indicated by "<"), 60°F-100°F, and > 100°F (indicated by ">").
BT: EOC T cycls [C] < 250, 500, > 250	The number of cycles in each of the three end of charge temperature categories: < 60°F (indicated by "<"), 60°F-100°F, and > 100°F (indicated by ">").
BT: Power cycls [C] 2	The number of times the power to the SMARTBATTERY II has been cycled.
BT: Status [C] SW Version 1.00	The version of the SMARTBATTERY II software.

#### 2.5 Communications port

RANGER II controls are designed to be able to interface with a computerized management system. The unique RANGER NET fiber optic communications bus establishes a link with the RMS-2000, enabling a user to have complete charging information on a fleet of FERRO FIVE SERIES chargers with RANGER II controls.

The network address should be set to inactive unless there is an RMS. This will hide the baud rate menu. For information on setup and using an RMS, see the RMS operating manual. For more information on the RMS-1000 or RMS-2000, ask your local C&D representative for a brochure.

## 3 COMPUCHARGE CONTROL

### 3.1 Description

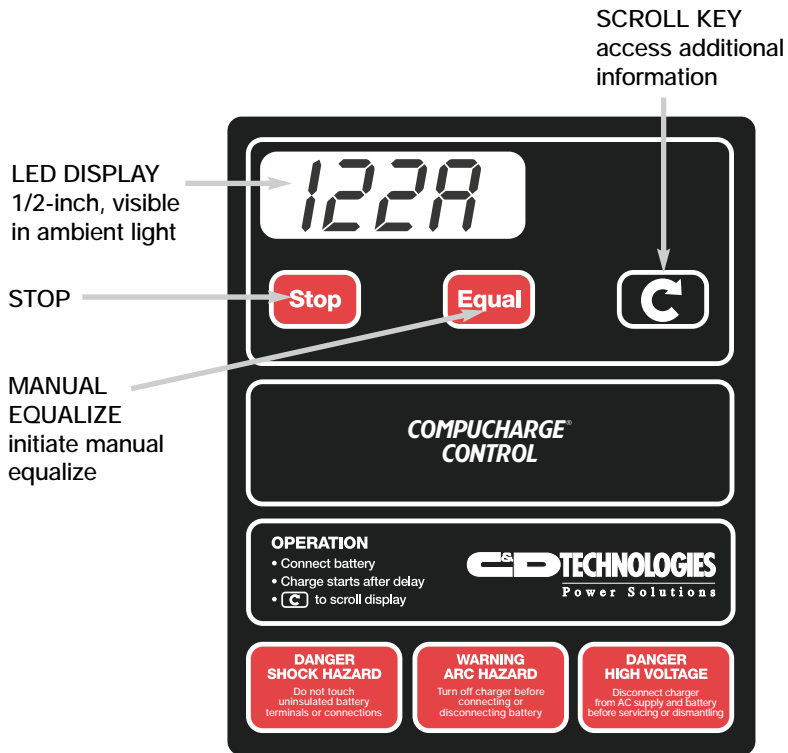


FIGURE 3.1-COMPUCHARGE control

### 3.2 Operation

The operating panel of the COMPUCHARGE control is a sealed membrane with a five character, 1/2 inch LED display, a Stop key, an Equal key and a Scroll key.

When the charger is idle, the COMPUCHARGE display will show the number of cells for which the charger is set.

Charging begins when the battery is connected. COMPUCHARGE checks to be sure the charger is connected to a battery with the proper voltage. If the match is correct, the display will show a countdown until the charge starts. If a mismatch is detected, an error code— "bU E"—will appear. (Refer to Section 7, Troubleshooting, for more information.)

If equalize is scheduled, either automatically or by pressing the Equal key, a dot will appear on the display after the last character on the right. If automatic equalize is selected, this dot will flash; if manual equalize is selected, it will not flash. After the user-selected start up delay, the charge cycle begins. (For safety reasons, the minimum delay

COMPUCHARGE continually monitors the changes in voltage and current over time to determine the proper length of charge. This efficient method prevents undercharging and overcharging, keeping energy costs down and maximizing battery life.

Other COMPUCHARGE features are:

- **Zero current shut off**—within five seconds of detecting battery disconnect
- **Battery voltage sensing**—the charger will only start if connected to a battery with proper voltage
- **Battery refresh**—every three days
- **Turn on time delay**—five seconds to seven hours, 45 minutes, in 15 minute increments
- **LED display**—easy to read in ambient light
- **Automatic equalize**—never, every seven days, 1, 2, 3, 4, 5, 6 or 7 cycles

is five seconds, which is set at the factory.) The current from the charge cycle is shown on the display during the charge.

COMPUCHARGE monitors the change in voltage and current to determine the exact time of charge. When the charge is greater than 80% complete, the last letter on the display will flash.

Pressing the Scroll key at any time during the charge cycle will reveal voltage of the battery ("99.9U"). Pressing the Scroll key twice reveals ampere-hours returned ("999r"). The display will return to normal if left unattended or if the Scroll key is pressed a third time.

Charging continues until cell electrolyte is completely mixed and the battery is charged to the rated capacity. If the battery remains connected to the charger for more than three days, COMPUCHARGE will automatically activate a refresh charge.

Sometimes, cells nearing the end of their operating life and mistreated batteries are unable to accept a complete charge without overheating.

### 3.2 Operation (continued)

If COMPUCHARGE detects a voltage rise that has not stabilized after 12 hours, the charge cycle is stopped and an error message appears on the display.

When AC power is interrupted during a charge, charging will restart after a randomly timed start up delay, not exceeding two minutes.

#### WARNING

If it is necessary to disconnect the battery during the charge, press the Stop key before removing the battery cable. FAILURE TO TAKE THIS PRECAUTION CAN CAUSE A SERIOUS ARC HAZARD AND A POTENTIALLY SERIOUS PERSONAL INJURY.

### 3.3 Basic settings

#### 3.3.1 Setting the precharge delay

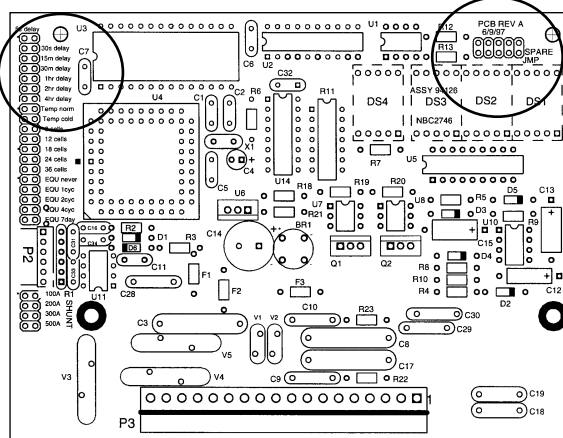


FIGURE 3.2-Precharge delay

Note: The COMPUCHARGE delay is designed to give users maximum flexibility in deciding the delay. Therefore, when multiple jumpers are put on the pins, the times are additive. Thus, if jumpers are on both one hour and 15 minute pins, the total time is one hour and 15 minutes. Extra jumpers are located on the upper right corner of the board, as shown.

#### 3.3.2 Activating cold storage

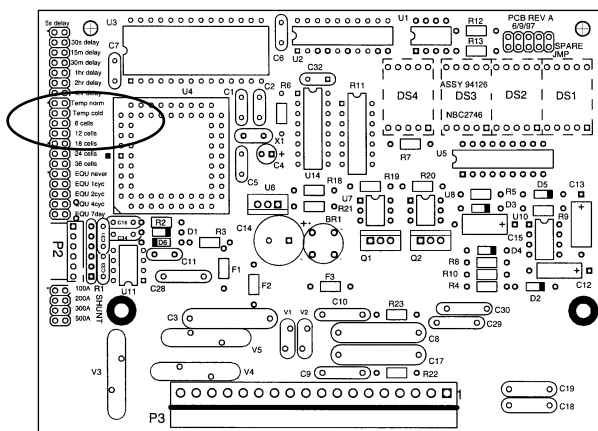


FIGURE 3.3-Cold storage

The precharge delay should be set to take advantage of lower utility rates or shift changes. To change the precharge delay:

- 1) Disconnect the AC power supply at the circuit breaker or fused safety disconnect.
- 2) Open the cabinet and locate the printed circuit board mounted behind the control panel.
- 3) Locate the bank of pins.
- 4) Move the jumpers to the desired setting, referring to Figure 3.2.
- 5) Close the cabinet and reconnect the AC power supply.

Users in cold storage applications can set the COMPUCHARGE to adjust its charge termination to extend the charge somewhat for these applications. Battery starting temperatures of below 55°F are considered cold storage. To select this option, add a jumper to the "temp norm" and "temp cold" pins.

- 1) Disconnect the AC power supply at the circuit breaker or fused safety disconnect.
- 2) Open the cabinet and locate the printed circuit board mounted behind the control panel.
- 3) Locate the bank of pins.
- 4) Move the jumpers to the desired setting, referring to Figure 3.3.
- 5) Close the cabinet and reconnect the AC power supply.

COMPUCHARGE will first initiate the watering cycle and then the equalize cycle.

## 4 SCOUT CONTROL

### 4.1 Description

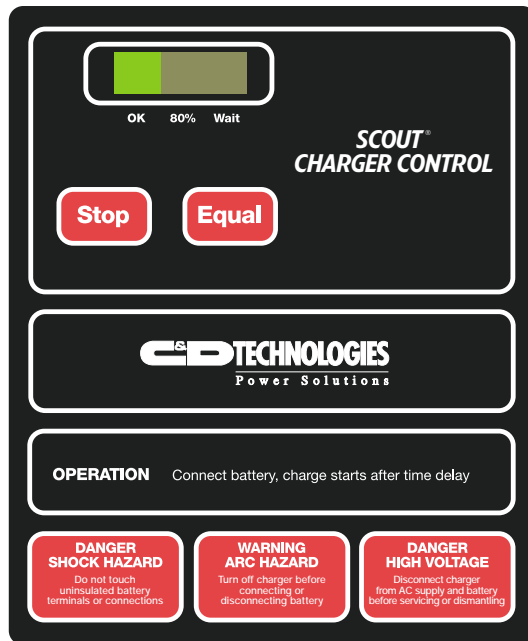


FIGURE 4.1-SCOUT control

The SCOUT is a microprocessor-based control that reduces the chance for overcharging by continually monitoring battery voltage. When it reaches gassing voltage, the system activates a timer, which will allow sufficient charge time to complete the recharge.

Other SCOUT features include:

- **Automatic start**—helps prevent operator errors
- **Maximum charge time**—helps prevent overheating
- **Safety features**—checks for correct battery before charge begins
- **Automatic equalization**
- **dV/dt termination**—prevents overcharging, undercharging and overheating

### 4.2 Basic settings

#### 4.2.1 Setting the number of cells

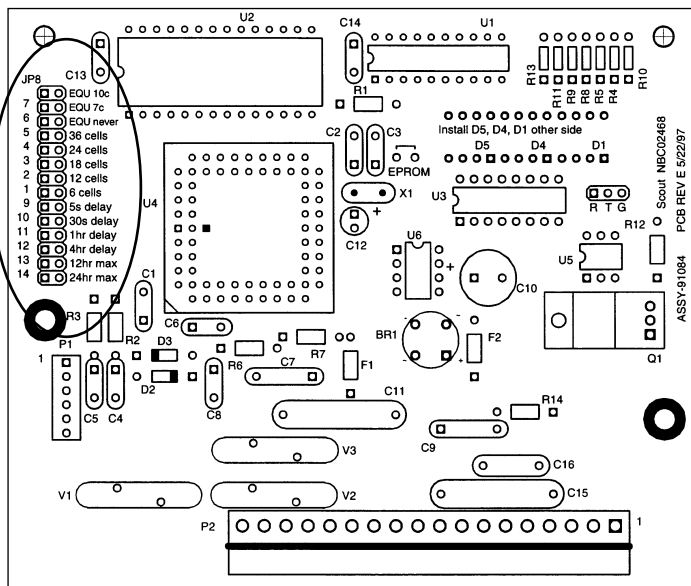


FIGURE 4.2-Printed circuit board panel with configuration jumpers circled

The SCOUT control is set up to work with a variable number of cells—6, 12, 18, 24, and 36. The SCOUT is shipped from the factory to be matched to the charger. Adjustment of this feature is needed only when the printed circuit board has been replaced.

To change the number of cells:

- 1) Disconnect the AC power supply at the circuit breaker or fused safety disconnect.
- 2) Open the cabinet and locate the printed circuit board mounted directly behind the control panel.
- 3) Locate the configuration jumpers as shown in Figure 4.2.
- 4) Move the jumpers to the desired number of cells, as shown in Figure 4.3.
- 5) Close the cabinet and reconnect the AC power supply.

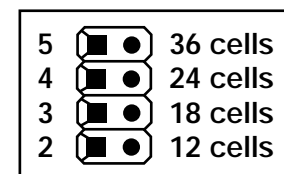


FIGURE 4.3-Close up of jumpers for changing cells

### 4.3 Operation

#### 4.3.1 Basic operation

The operating panel of a FERRO FIVE SERIES charger equipped with the SCOUT control contains an LED display and keypad for operator interface. An LED indicates the charger is ready to operate, another LED indicates the battery is being charged and a third LED indicates when gassing voltage is reached. An Equal key activates the equalization charge mode and a Stop key allows the charger to be turned off during a charge.

Chargers equipped with the SCOUT control do not have start switches. Charging automatically begins five seconds after the operator connects the battery, unless another delay is specified by the user (refer to Section 4.3.2).

When no battery is connected, the green LED will flash briefly every four seconds to indicate the charger is ready to begin charge. Once a battery is connected, the red LED will flash and glow steadily

when the charge is in progress. When the battery is 80 percent charged, the yellow LED is lit, and the red LED will be extinguished. When the charge is complete, the green LED will glow.

If equalize is selected, the charge is extended by three hours. The red LED will flash when the battery is connected and during the charge. During equalization, the yellow LED will flash and will continue to do so throughout the equalize cycle. When the charge is complete, the green LED will flash.

When an improperly sized battery is connected, the charger will not start. Refer to Section 7, Troubleshooting.

In the event of an accidental disconnect, the system will shut down automatically, protecting charger components.

If AC power is interrupted, charging will begin after a randomly timed startup delay, not exceeding three minutes,

#### WARNING

If it is necessary to disconnect the battery during the charge, press the Stop key before disconnecting the battery. FAILURE TO TAKE THIS PRECAUTION CAN CAUSE A SERIOUS ARC HAZARD AND A POTENTIALLY SERIOUS PERSONAL INJURY.

#### 4.3.2 Changing the five-second, factory-set delay

SCOUT controls are shipped with a preset, five-second safety delay. The delay can be changed to 30 seconds, one hour or four hours.

To lengthen the factory-set delay:

- 1) Disconnect the AC power supply at the circuit breaker or fused disconnect.
- 2) Open the cabinet and locate the printed circuit board mounted directly behind the control panel.
- 3) Locate the bank of configuration jumpers as shown in Figure 4.2.
- 4) Move the jumpers to the desired time pattern: 30 seconds, one hour or four hours. Refer to Figure 4.4.
- 5) Reconnect the AC power supply.

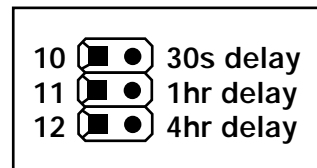


FIGURE 4.4-Delay time jumpers

4.3.3 Changing maximum charging time	The maximum charging time is set from the factory at 12 hours. This feature should not need adjustment for	use with FERRO FIVE FR SERIES or FERRO FIVE EFR SERIES chargers.
4.3.4 Manual equalizing	To administer an equalization charge, the operator connects the battery, waits for the red LED to flash or glow, then presses the Equal key. At the	conclusion of an equalization charge, the system automatically returns to the daily charge mode.
4.3.5 Automatic equalizing	<p>The SCOUT control can be set to automatically equalize: never, every seventh cycle or every tenth cycle. To activate automatic equalization:</p> <p>1) Disconnect the AC power supply at the circuit breaker or fused safety disconnect.</p> <p>2) Open the cabinet and locate the printed circuit board mounted directly behind the control panel.</p>	<p>3) Locate the bank of configuration jumpers shown in Figure 4.2.</p> <p>4) Move the switches to the desired equalization cycle as shown in Figure 4.5.</p> <p>5) Close the cabinet and reconnect the AC power supply.</p> <div><div>JP8</div><div>7</div><div>6</div><div><div><div></div><div></div><div></div></div><div><div></div><div></div><div></div></div><div><div></div><div></div><div></div></div></div><div><div>EQU 10c</div><div>EQU 7c</div><div>EQU never</div></div></div>
4.3.6 Cold applications	An additional 30 minute charge extension may be programmed for cold	applications using special combinations of the maximum charge time jumpers.

12 & 24 hour ➔

12 hour with 30 minute extension

No jumpers ➔

24 hour with 30 minute extension

FIGURE 4.5-Automatic equalize switch

## 5 OPERATION

### 5.1 Operating characteristics

As with all electrical apparatus, FERRO FIVE operating economics are influenced by electric utility rates, the user's choice of single-phase or three-phase power, and the electrical efficiency and power factor of the charger.

Electric utility rates are significantly lower during off-peak periods. However, to take advantage of these rates you may need a separate electric meter for

the off-peak service connection. Your local utility representative can help you determine the type of off-peak program that best fits your application.

Efficiency is the measure of the useful energy the charger makes available to the cell, as measured at the charger output. It is determined by the equation:

$$\text{Percent efficiency} = \frac{\text{Output power (kW)}}{\text{Input power (kW)}} \times 100$$

As the graph in Figure 5.1 illustrates, FERRO FIVE SERIES chargers achieve 89 percent efficiency. This means that for every kilowatt of AC input, they will deliver 890 watts of DC output to the battery and lose only 110 watts of energy as wasted heat.

The power factor is the ratio of the true power and the apparent power a charger actually requires to operate. The equation for determining power factor is:

$$\text{Power factor (PF)} = \frac{\text{True power}}{\text{Apparent power}} = \frac{\text{Watts AC}}{(\text{Volts AC}) \times (\text{Current AC})}$$

As a battery is placed on charge, there is an inrush of current to the battery. Charging increases battery voltage, and as the difference between the applied voltage and the battery voltage decreases, the flow of the

charger current also decreases. During the final hours of the charge cycle, the charging rate is significantly reduced. Figure 5.2 shows typical ferroresonant charging characteristics.

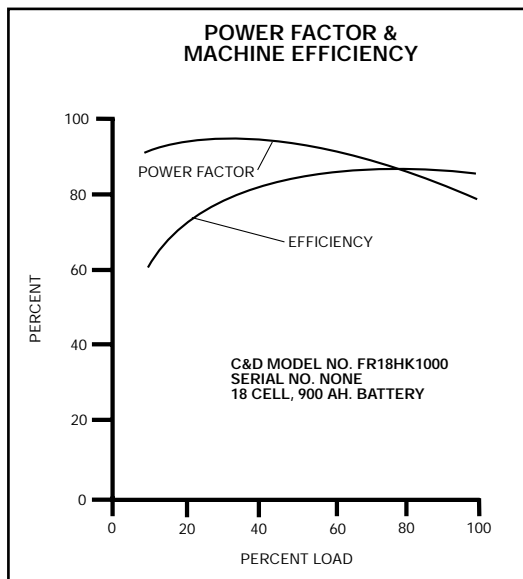


FIGURE 5.1-Typical efficiency and power factor performance for FERRO FIVE SERIES chargers

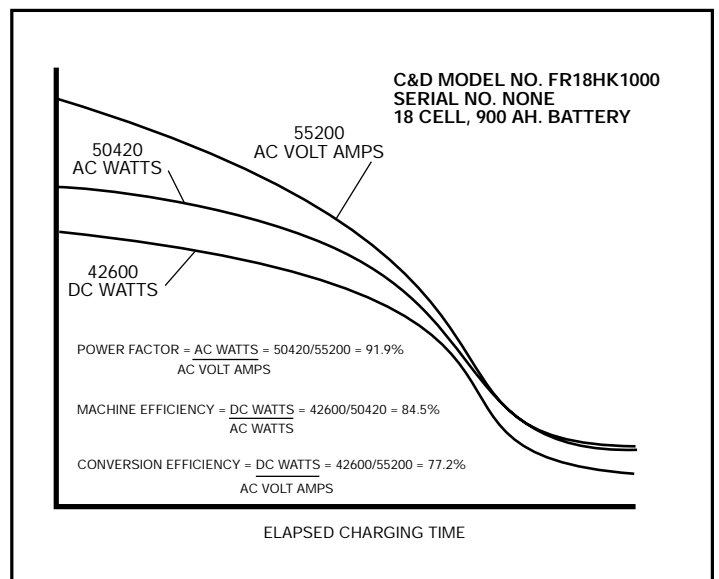


FIGURE 5.2-Typical ferroresonant charger curve



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## 5.2 Recommended charging procedures

Chargers require little attention beyond periodic removal of dust buildup and inspection for loose connections. Proper charging procedures are important to prevent damage to chargers, batteries and operators.

Proper charging procedures require lead-acid batteries receive:

- watering at the end of the charge, as needed, to maintain proper electrolyte level and concentration;
- an equalizing charge approximately every fifth charge to correct voltage imbalances among cells; (except FERRO FIVE LIBERTY SERIES and FERRO FIVE REVOLUTION SERIES which do not require equalizing charges.)
- periodic cleaning to remove corrosive spills;

- freshening charges if batteries remain out of service for three or more days.
- periodic inspection of their DC connectors to assure that they still make a good low resistance connection and have exposed metal which would present a hazard.

Operators should only connect batteries to chargers with matching voltage and sufficient power output. The charger power must be OFF before batteries are connected or disconnected.

Motive power batteries are designed to be discharged daily but should not be discharged by more than 80 percent of their capacity during an eight-hour work shift. This allows sufficient time for them to charge and cool before they are returned to service and extends cycle life.

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## 6 OPTIONS

### 6.1 Remote control

In some industrial settings, it is desirable to control chargers from a central location, such as a charging mezzanine. FERRO FIVE SERIES chargers can be assembled with remote control boxes. Systems equipped with remote control units function identically to the panel-mounted charger controls described in this manual.



FIGURE 6.1- RANGER remote control option

### 6.2 Series connected charging cables

C&D series connected charging cables provide a safe, convenient way to charge identically discharged batteries of the same size connected in series. The cables have either two plugs or two receptacles, **both** of which must

be connected before the charger will operate.

C&D offers series connected charging cables for all FERRO FIVE SERIES systems. They can be user-installed.

### 6.3 Parallel connected charging cables

Parallel connected charging cables make it possible to charge two batteries in parallel. The option consists of an extra set of cables which terminate in either a plug or receptacle and a fuse to protect against reverse connection of one battery.

In order to deliver an eight-hour charge to two batteries in parallel, the charger must be rated equal to or higher than the sum of the ampere-hour capacities of both batteries.

Ideally, similarly discharged batteries should be placed on the charger at the same time. If this is not possible,

press the Stop key (or turn the electro-mechanical timer to OFF) before connecting the second battery. For chargers equipped with RANGER II, COMPUCHARGE or other automatic controls, both batteries must be removed before restarting the charger. Use the turn-on time delay feature of the control to allow enough time to safely connect both batteries before the charger starts automatically. Chargers equipped with the electro-mechanical timer must be reset to the eight-hour mark. To avoid overheating, the progress of the charge should be carefully monitored.

### 6.4 Automatic watering systems

The C&D RANGER WATERING SYSTEM module interfaces with the RANGER II control to automatically activate watering systems at the proper point in the charging cycle. Because it mounts within the existing footprint of the charger, no extra room between chargers is required.

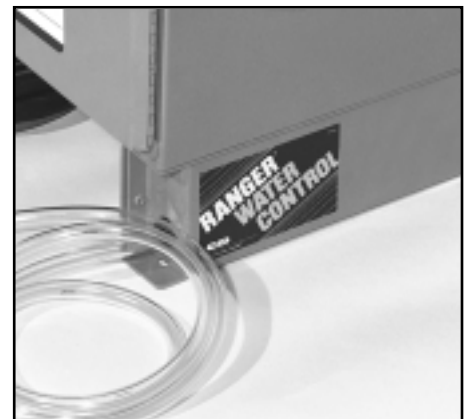


FIGURE 6.2-RANGER WATERING SYSTEM module mounted on charger

6.5 Computerized management system

6.5.1 RANGER MANAGEMENT SYSTEM 1000	RMS 1000 computer system is available to operators to achieve optimal rotation of batteries for maximum life,	and provides centralized annunciation of charger alarm conditions.
6.5.2 RANGER MANAGEMENT SYSTEM 2000	The RMS-2000, a computerized management system, is available for monitoring large RANGER Series and RANGER II Series installations. The easy-to-install system alerts the operator to abnormal battery operating conditions, helping to prevent costly battery damage caused by overdischarge and hot batteries. A variety of	standard reports facilitates usage and maintenance reviews. The two-way RANGER NET communications network gives centralized control over operating parameters, such as delayed start and automatic equalize. For more information on the RMS-2000, request a brochure from your local C&D representative.

6.6 Other options

**Fungus proofing:** The internal components of FERRO FIVE SERIES chargers used in high-moisture environments can be factory treated with a special fungus-resistant varnish. This option is only available on original equipment.

**Export service:** C&D manufactures chargers intended for export service in accordance with ANSI 42.25. Cabinets are fitted with a vapor barrier.

**Lead tagging:** C&D can affix

information tags on wiring and cables. Lengths over six-feet are tagged on both ends. A single tag is attached at the middle of shorter lengths.

**Lifting eyes:** Factory-installed lifting eyes make it possible to move FERRO FIVE SERIES chargers using a sling.

**Wall mounting bracket:** C&D offers wall mounting brackets as a user-installed option. See Figure 6.3 for dimensions.

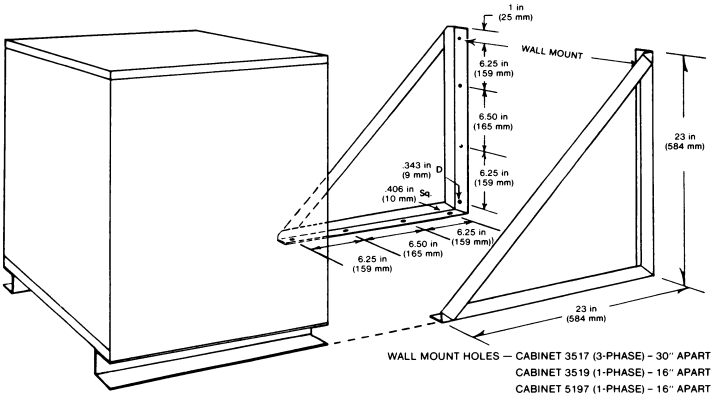


FIGURE 6.3-Wall mounting brackets

7 TROUBLESHOOTING

7.1 Procedure

The following charts are designed to help a qualified technician diagnose and remedy malfunctions in the RANGER II, SCOUT and COMPUCHARGE controls. In all cases, acknowledge the error message by pressing the Stop key.

**NOTE:** For RANGER II chargers, the abort condition clears when the battery is disconnected.

Principally, the chart covers the control; more extensive troubleshooting instructions for the charger are presented in Sections 7.4 through 7.8. Also refer to the wiring diagrams in Section 9.

**IMPORTANT:** This equipment must be serviced by qualified personnel familiar with both local and national electrical codes.

**WARNING:** Line voltages are present within the battery charger cabinet. When performing the following troubleshooting procedures, be sure to observe all appropriate safety precautions. ALWAYS BE SURE THE CHARGER IS TURNED OFF BEFORE DISCONNECTING A BATTERY.

### RANGER II CONTROL TROUBLESHOOTING CHART A

DISPLAY	CAUSE	ACTION
ABORT: disconnect bat Wrong battery size	1. Battery not matched to charger (wrong number of cells)	a. Verify battery and charger match.
	2. Battery has short-circuited cells or overdischarged	a. The charger can be "forced" on from this condition by holding the "up" arrow until the voltage reads an acceptable level.
	3. Control board not matched to charger	a. Check and reset board settings to match charger output voltage. Verify other settings.
ABORT: disconnect bat Charge > 12 hrs	1. Battery is too large for charger	a. Place battery on charger of proper size.
	2. Control board failure	a. If problem is repeated, contact C&D.
ABORT: disconnect bat Hot battery flt	1. Hot battery	a. Allow several hours for cool-down before restarting charge.
ABORT: disconnect PWR OFF, but charging	1. DC current continued to flow after contactor turned off	a. Check line contactor and replace if necessary.
ABORT: disconnect bat Operator STOP	1. Charge terminated by operator	a. Resume charge if necessary.
ABORT: disconnect bat Zero current flt	1. Operator disconnected battery	a. Reconnect battery and resume charge.
	2. Charger problem	a. Refer to flowcharts on Pages 29 through 33.
ABORT: press [Stop] NVRAM is trashed	1. Charger parameters lost	a. Remove and then restore AC power; re-enter parameters. If problem recurs, call C&D.
WDT RST: Restarting	1. Watchdog timer reset has occurred. The charger will automatically restart.	a. If problem recurs, call C&D.
ABORT: press [Stop] Replace RTC (lobat)	1. Real-time clock must be replaced	a. Call C&D.
ABORT: press [Stop] State machine flt	1. Control program found in an unknown state	a. Disconnect and reconnect charger. If problem persists, contact C&D.

### COMPUCHARGE CONTROL TROUBLESHOOTING CHART B

ERROR CODE	DESCRIPTION	ACTION
bU E	1. Battery voltage does not match the number of cells programmed	a. Check the battery to be sure it is the correct size. If it is and the battery voltage is low, pressing the Equal key will force the charger on. To clear this message, disconnect the battery.
uS E - or - uT E	1. The charger microprocessor needs to reset itself	a. Charger will reset itself after five seconds. It will begin from the Ready state.
bd E	1. During charge, the battery was disconnected	a. Charger will reset itself after five seconds. It will begin from the Ready state.
hotE	1. The battery temperature is too high	a. Let the battery cool down before connecting it to the charger. To clear this message, disconnect the battery.
12hE	1. The battery has been on charge more than 12 hours	a. To clear this message, disconnect the battery.
StPE	1. During the charge, user pressed the Stop key	a. To clear this message, disconnect the battery.

## SCOUT CONTROL TROUBLESHOOTING CHART C

RED FLASHING RAPIDLY AND:	CAUSE	ACTION
Yellow LED is lit	1. The wrong size battery has been connected	a. Disconnect the battery and check the jumper setting configuration for the number of cells. If necessary, change the number of cells by moving the jumpers and then cycle the power for the charger.
	2. Battery is overdischarged	b. Press the Equal key to force the charger on. While the key is pressed, the charger will remain on. After battery voltage rises, release Equal key, disconnect and reconnect the battery. The charger should start automatically in the normal manner.
Green LED is lit	1. The maximum charging time has been exceeded	a. Disconnect the battery.
Both yellow and green LEDs are lit	1. The Stop key has been pressed	a. Disconnect the battery.
All LEDs are lit constantly	1. Watchdog timer has reset	a. Disconnect AC power from the charger, wait 30 seconds and reapply. If problem persists, call C&D.
Green and yellow flashing	1. Low vpc at start of charge	a. Check charger fuses (all phases) to assure proper current flow.

## 7.2 Component testing

A visual inspection can often reveal many problems. In new chargers, look for connections that may have loosened during shipment. In previously operating systems, look for the whitish powder residue created by burning varnish, or a broken, melted or discolored wire.

When troubleshooting three-phase chargers, be sure to test all three sets of components.

Always read and follow all warning labels and turn off the charger before touching, removing or installing components.

C&D supports FERRO FIVE SERIES chargers with prompt field service and overnight delivery of most components. If you do not know the name of your nearest C&D representative contact:

C&D TECHNOLOGIES  
1400 Union Meeting Road  
P.O. Box 3053  
Blue Bell, PA 19422-0858 USA  
(215) 619-2700  
Fax (215) 619-7899

## TEST INSTRUMENTS AND TOOLS FOR TROUBLESHOOTING

- 0 to 200 mV scale VOM that reads up to 600 VAC and 250 VDC with minimum accuracy of 0.5 percent
- Clamp-on ammeter
- SB-175 or SB-350 shorting connector
- Wrench set
- Screwdriver set
- Jumper cables with alligator clips

Diode replacement requires a supply of thermal joint compound and a torque wrench capable of achieving the values in Table 7.2.

TABLE 7.1

## 7.2 Component testing (continued)

**AMMETER:** Confirm reading with a calibrated millivolt meter connected across the charger shunt.

### CAPACITORS:

#### CAUTION

Before testing, be sure the capacitor is discharged.

Test capacitors with a calibrated ohmmeter. Different sizes of capacitors require different ohmmeter range settings. Begin with the highest setting. Before testing, disconnect both leads to isolate the capacitor from the charger circuit. Be sure to reverse the leads for each check.

- **A good capacitor** deflects the ohmmeter needle toward zero then steadily rises toward infinite resistance.
- **An open capacitor** immediately shows infinite resistance.
- **A shorted capacitor** remains at zero resistance.

**CONTROL TRANSFORMER:** Output should be between 22 and 26 VAC.

**DIODES:** Test diodes with the ohmmeter set at either the 10X or 100X scale. Before testing, disconnect one

lead to isolate the diode from the charger circuit.

- **A good diode** shows low resistance when tested in one direction and high resistance when the ohmmeter probes are reversed.
- **An open diode** shows very high resistance in both directions.
- **A shorted diode** shows zero or low resistance in both directions.

**FUSES:** Remove the fuse from the fuse holder and test it with an ohmmeter set to any scale.

- **A good fuse** shows zero resistance.
- **An open or "blown" fuse** shows infinite resistance.

**RESISTORS:** Test resistors with an ohmmeter. Different values of resistors require different ohmmeter range settings. Begin with the highest setting. Before testing, disconnect both leads to isolate the resistor from the charger circuit.

- **A good resistor** shows a specific value.
- **An open resistor** shows an infinite resistance.
- **A shorted resistor** shows zero resistance.

## 7.3 Replacing components

Ammeters, ammeter shunts, capacitors, control transformers, fuses, line contactors, line contactor coils, electromechanical timer, power transformers and resistors can be user-replaced. Simply mate the leads of the replacement component with their appropriate connectors.

Printed circuit boards in RANGER II, COMPUCHARGE, SCOUT and automatic Start/Stop controls do not contain user-repairable parts. The entire printed circuit board must be replaced. A printed circuit board repair shop is operated by C&D. Contact your local C&D agent for this service.

C&D recommends replacing the entire rectifier assembly rather than individual diodes. Users attempting diode replacement **MUST** observe the following procedure:

- 1) Disconnect the charger from the AC line and battery.
- 2) Remove the rectifier assembly.
- 3) Clamp the heat sink portion of the assembly in a vise.
- 4) Remove the faulty diode.
- 5) Coat the mating surfaces of the diode and the heat sink with a suitable thermal joint compound.
- 6) Place the diode on the heat sink and hand tighten the diode connection hardware.
- 7) Torque diode connections to values shown in Table 7.2.
- 8) Remove excess thermal joint compound.
- 9) Reinstall the assembly and reconnect leads.

DIODE CONNECTION TORQUE VALUES			
1/4" studs	25 +2/-2 in-lb	1/2" studs	137 +4/-4 in-lb
3/8" studs	112 +4/-3 in-lb	3/4" studs	260 +5/-3 in-lb

TABLE 7.2

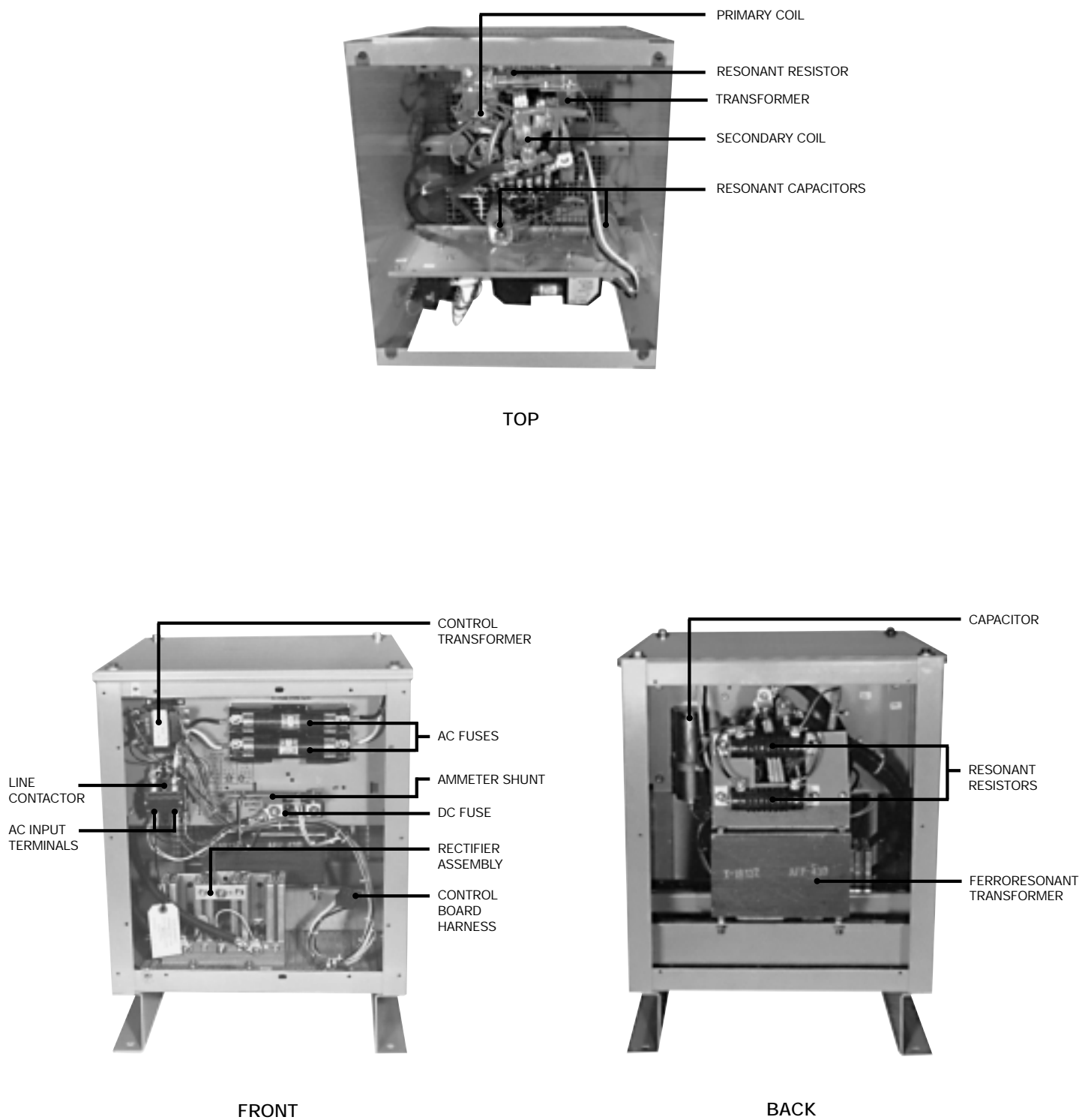


FIGURE 7.1- Component location, FERRO FIVE SERIES chargers, single-phase

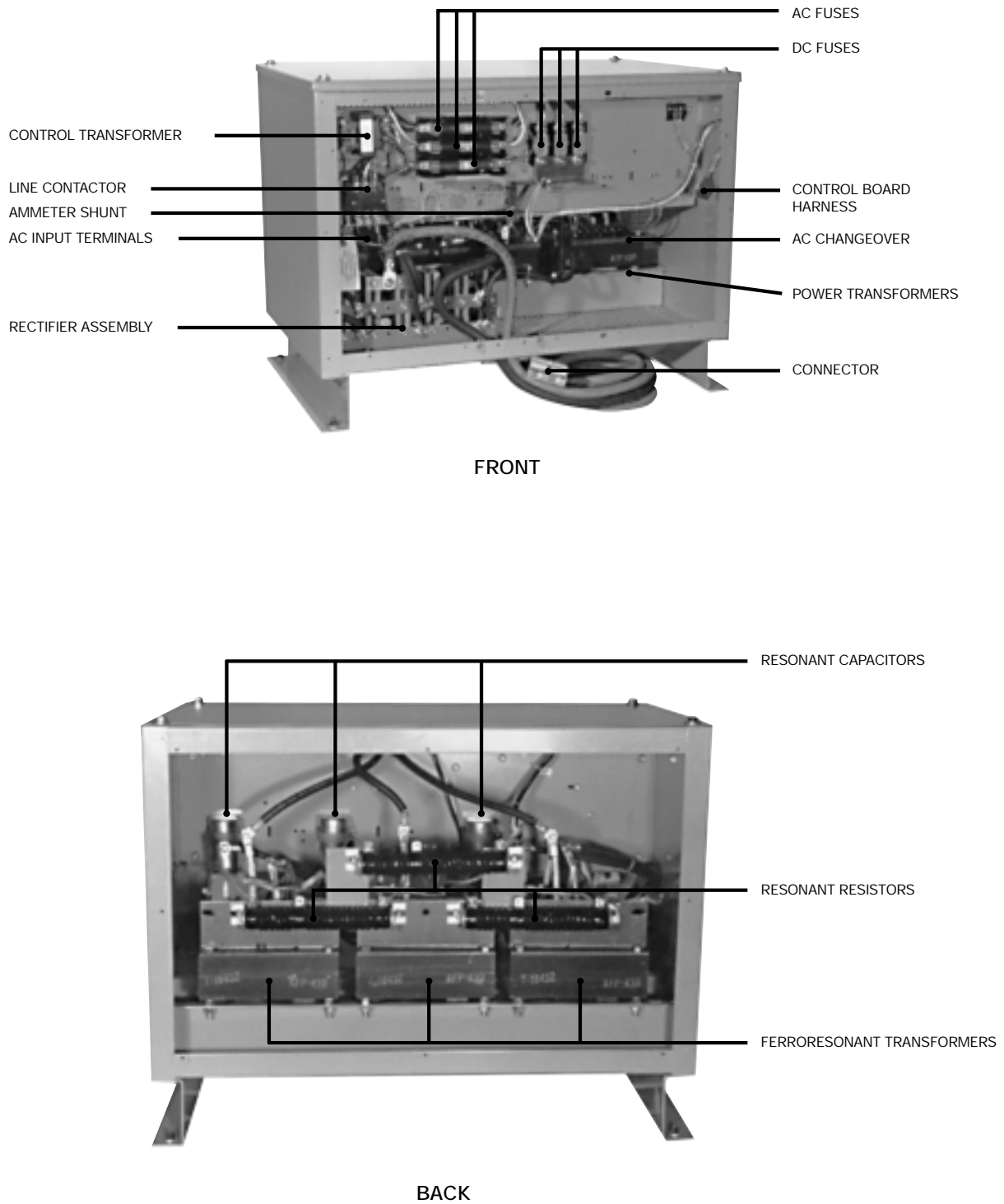
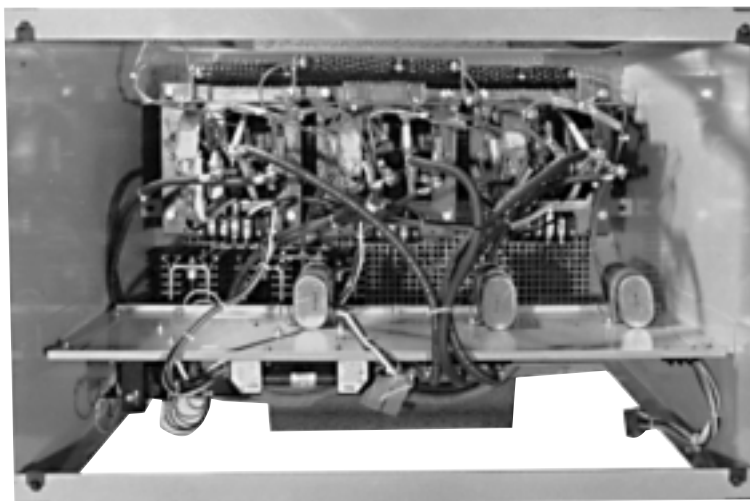


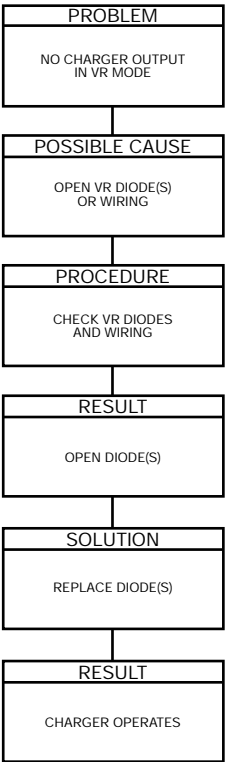
FIGURE 7.2-Component location, FERRO FIVE SERIES chargers, three-phase



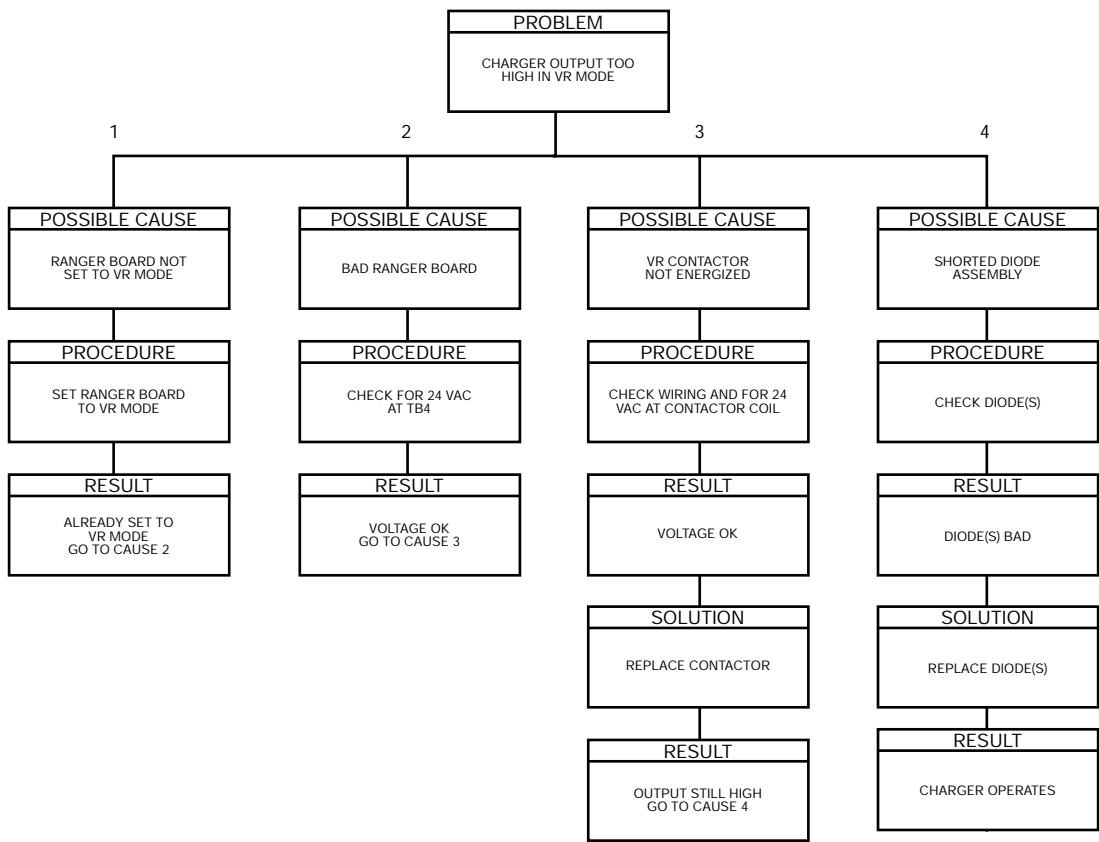


TOP

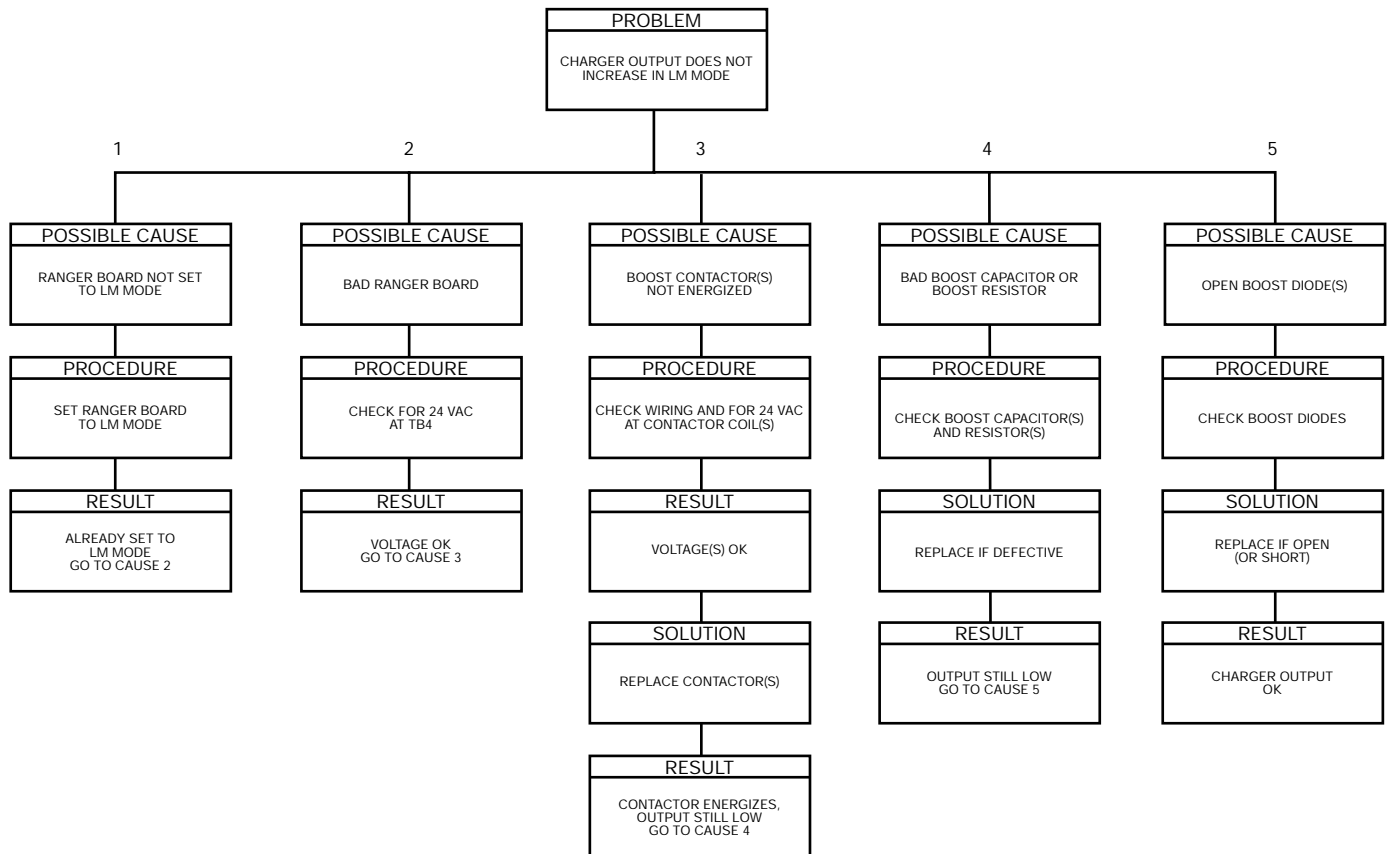
7.4 FERRO FIVE REVOLUTION SERIES: Troubleshooting a charger with no output



7.5 FERRO FIVE REVOLUTION SERIES: Troubleshooting a charger with output too high

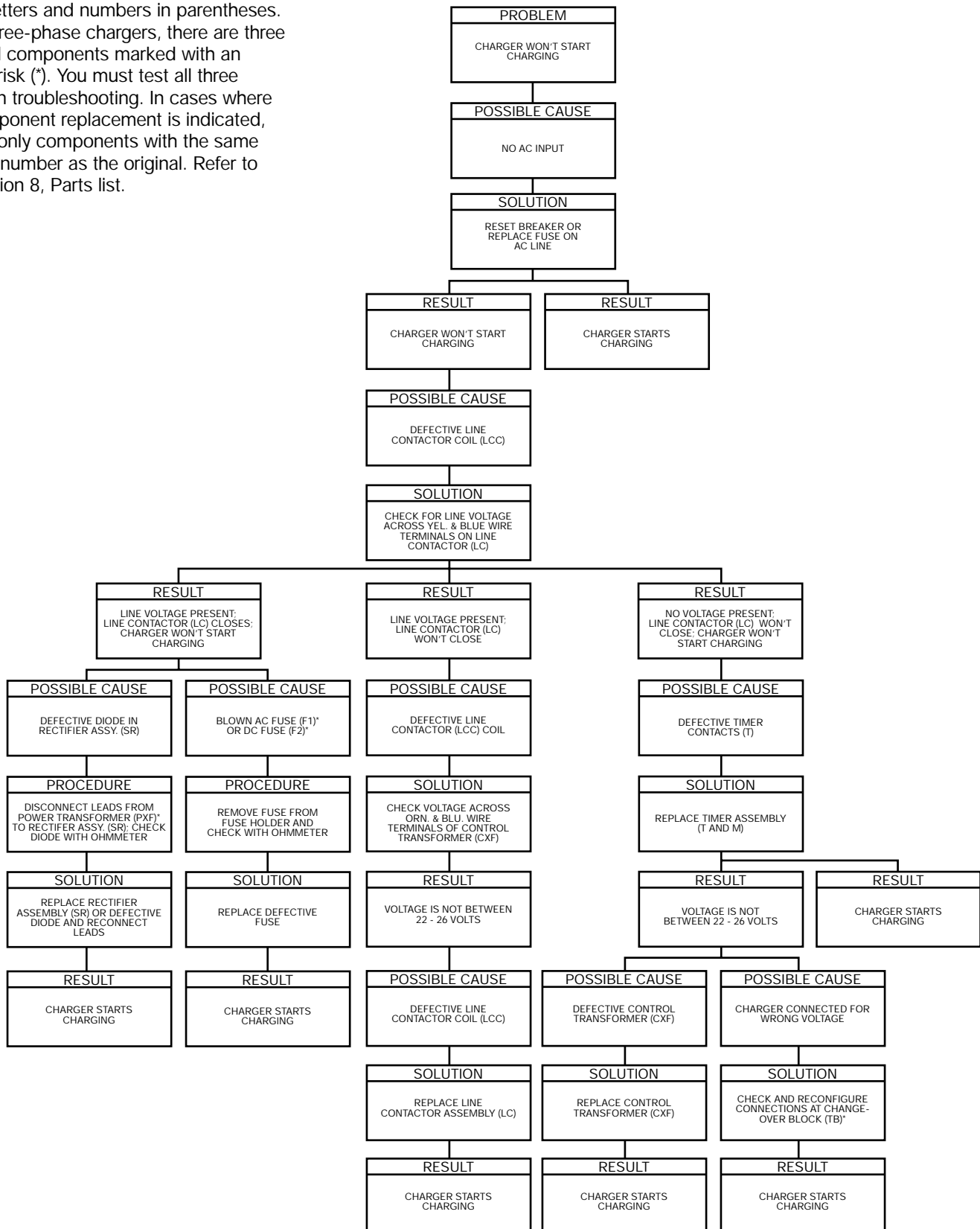


## 7.6 FERRO FIVE LIBERTY SERIES: Troubleshooting a charger when output does not increase

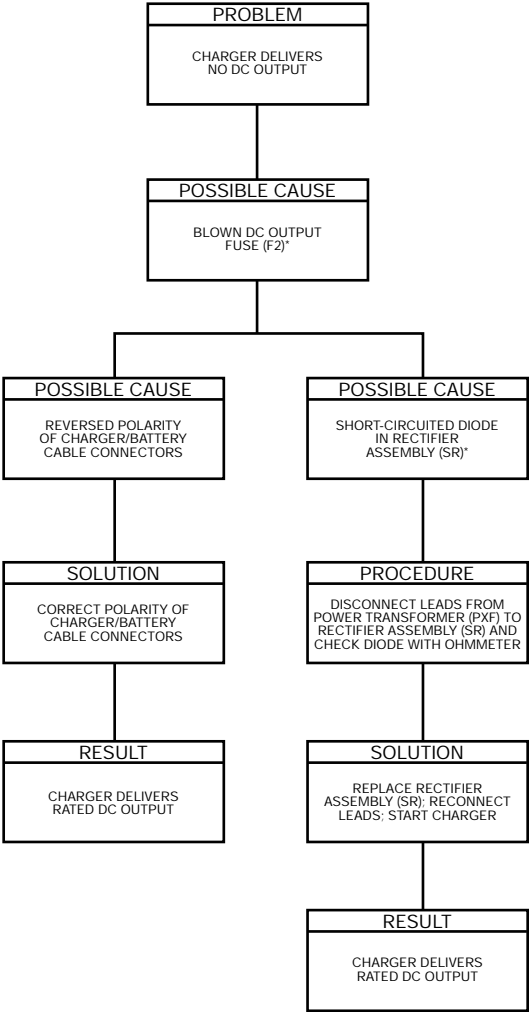


## 7.7 Troubleshooting a charger that will not start

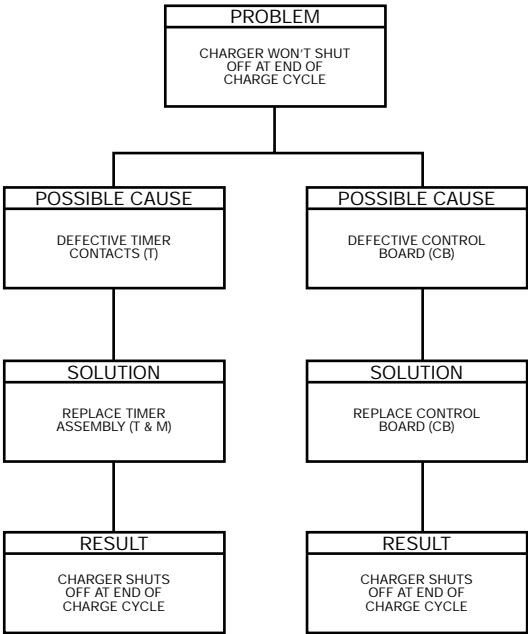
NOTE: In the following troubleshooting flow charts, components are designated by letters and numbers in parentheses. In three-phase chargers, there are three of all components marked with an asterisk (\*). You must test all three when troubleshooting. In cases where component replacement is indicated, use only components with the same part number as the original. Refer to Section 8, Parts list.



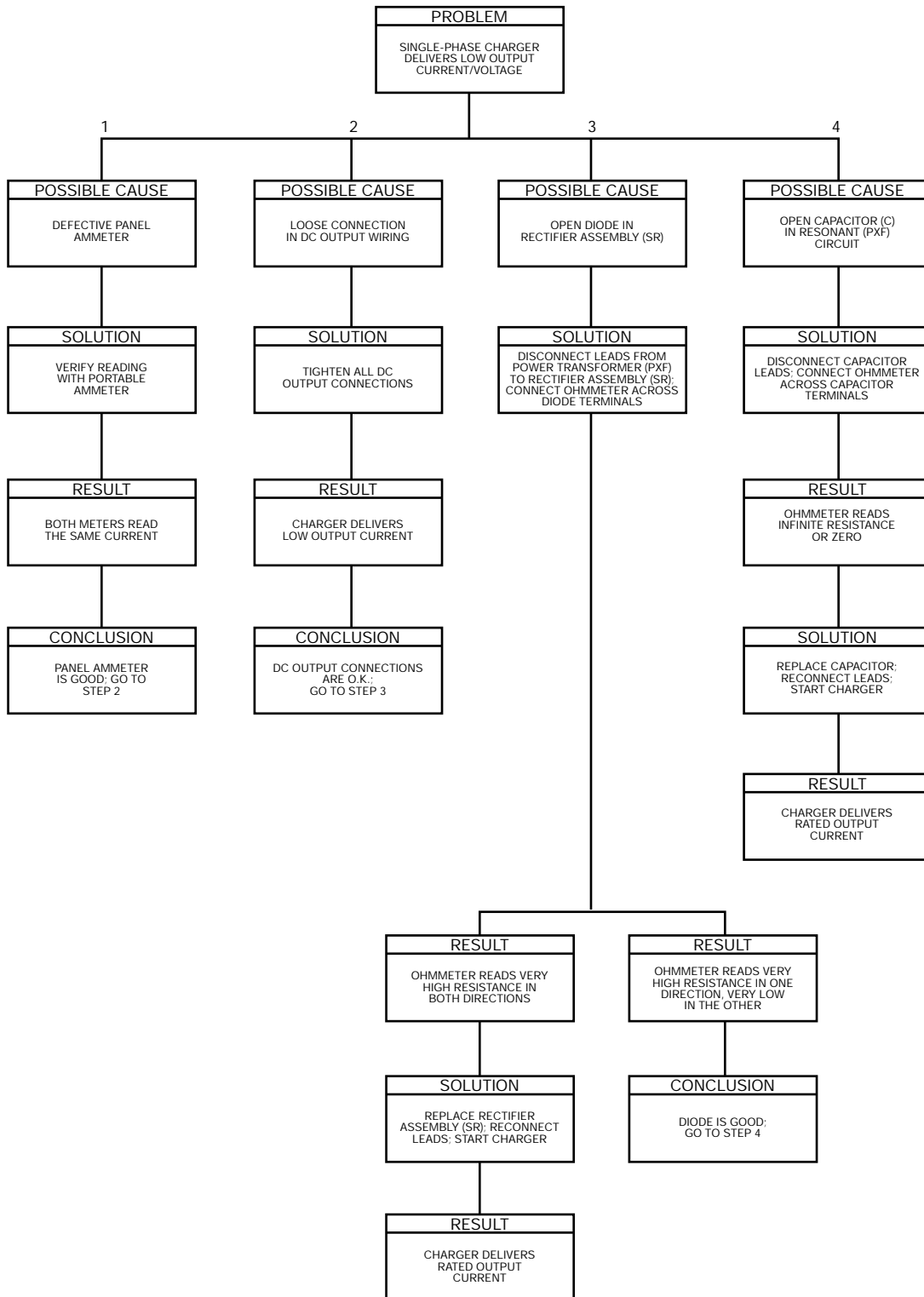
7.8 Troubleshooting a charger that produces no DC output



7.9 Troubleshooting a charger that will not stop

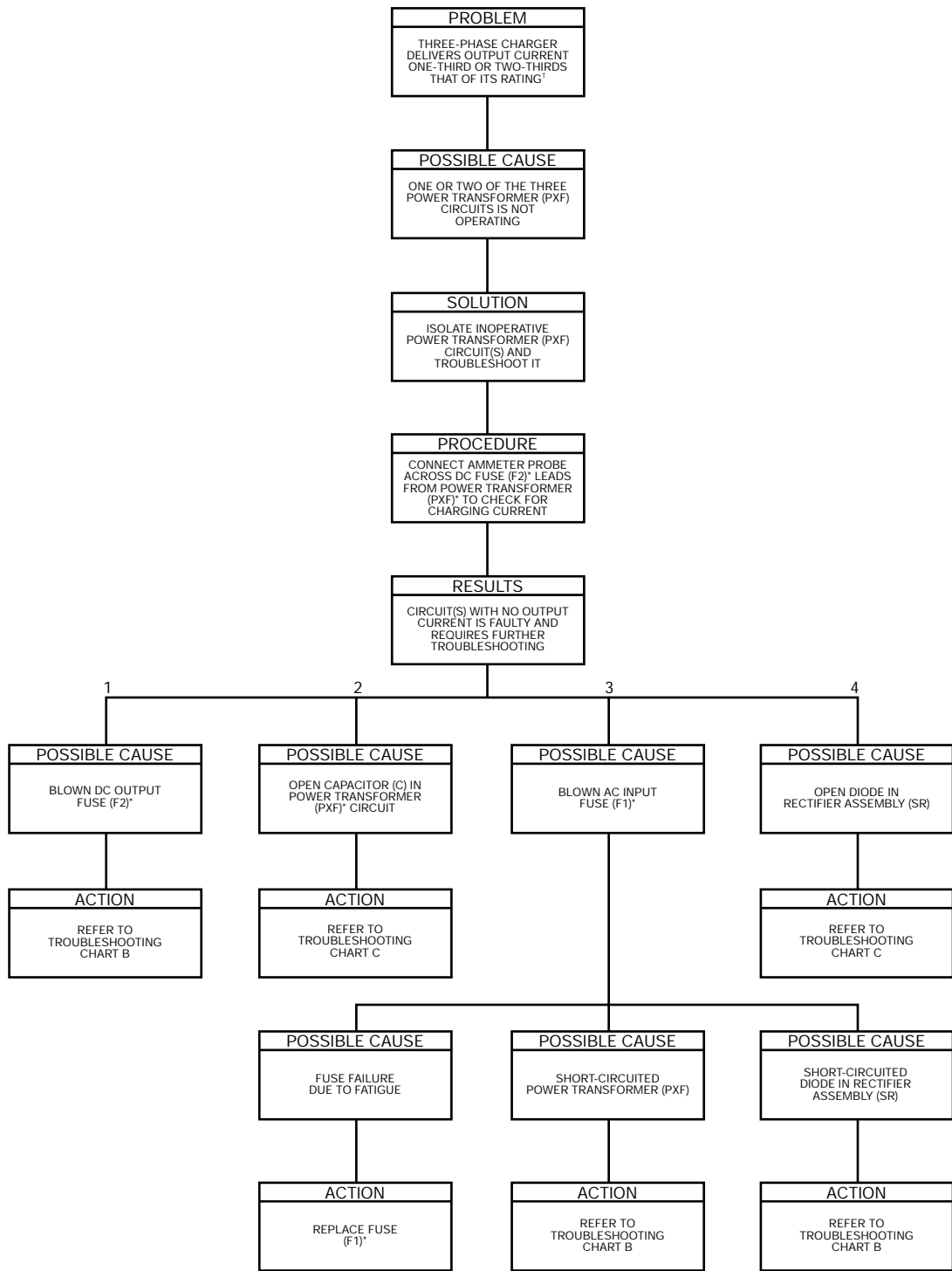


## 7.10 Troubleshooting a single-phase charger with low DC output





7.11 Troubleshooting a three-phase charger with low DC output



†Three-phase chargers have three power transformer circuits so they can deliver an output current (lower) even with one or two circuits inoperative. TROUBLESHOOTING TIP: If output current is approximately two-thirds of rated output, one power transformer circuit is inoperative. If output current is approximately one-third of rated current, two power transformer circuits are inoperative.

# 8 PARTS LIST

## 8.1 FERRO FIVE FR SERIES 120/208/240 and 480 VAC inputs

MODEL	AMMETER		LINE CONTACTOR			AC FUSE			DC FUSE		RECTIFIER			CXF JT-	PILOT LIGHT JL-	CONTROLS				
	SCALE	P/N JM-	POLE	RATING	P/N JR-	120	208/240	480	RATING	P/N JL-	AMPS	PIV	P/N JS-			TIMER JR-	TIMER ADAPTER NBC-	SCOUT NBC-	COMPU CHARGE NBC-	RANGER II NBC-
FR6AC255	100	381	2	30	510	12	7/6		100	630	125	300	225	253	698	509	2765	2468	2746	2382
FR6CE255	100	381	2	30	510		7/6	3	100	630	125	300	225	254	698	509	2765	2468	2746	2382
FR6AC375	200	327	2	30	510	20	10/10		200	620	125	300	225	253	698	509	2765	2468	2746	2382
FR6CE375	200	327	2	30	510		10/10	5	200	620	125	300	225	254	698	509	2765	2468	2746	2382
FR6AC450	200	327	2	30	510	25	15/12		200	620	125	300	225	253	698	509	2765	2468	2746	2382
FR6CE450	200	327	2	30	510		15/12	6	200	620	125	300	225	254	698	509	2765	2468	2746	2382
FR6CE510	200	327	2	30	510		15/12	6	200	620	125	300	225	254	698	509	2765	2468	2746	2382
FR6CE640	200	327	2	30	510		20/15	7	325	625	185	300	206	254	698	509	2765	2468	2746	2382
FR6CE750	300	328	2	30	510		20/20	10	325	625	185	300	206	254	698	509	2765	2468	2746	2382
FR6HK830	300	328	3	30	513		7/6	3	200	620	185	300	182	254	698	509	2765	2468	2746	2382
FR6HK1000	300	328	3	30	513		10/10	5	200	620	345	300	208	254	698	509	2765	2468	2746	2382
FR6HK1125	300	328	3	30	513		12/10	5	200	620	345	300	208	254	698	509	2765	2468	2746	2382
FR6HK1700	500	328	3	30	513		15/12	7	200	620	345	300	208	254	698	509	2765	2468	2746	2382
FR9CE255	100	381	2	30	510		8/8	4	100	630	125	300	225	254	698	509	2765	2468	2746	2382
FR9CE640	200	327	2	30	510		25/20	10	325	625	185	300	206	254	698	509	2765	2468	2746	2382
FR9HK830	300	328	3	30	513		10/10	5	200	620	185	300	182	254	698	509	2765	2468	2746	2382
FR9HK1160	300	328	3	30	513		15/12	7	200	620	345	300	208	254	698	509	2765	2468	2746	2382
FR12CE255	100	381	2	30	510		15/12	6	100	630	125	300	225	254	698	509	2765	2468	2746	2382
FR12CE375	200	327	2	30	510		20/20	10	200	620	125	300	225	254	698	509	2765	2468	2746	2382
FR12CE450	200	327	2	30	510		20/20	10	200	620	125	300	225	254	698	509	2765	2468	2746	2382
FR12CE550	200	327	2	30	510		25/25	12	200	620	125	300	225	254	698	509	2765	2468	2746	2382
FR12CE640	200	327	2	30	510		35/30	15	325	625	185	300	206	254	698	509	2765	2468	2746	2382
FR12CE750	300	328	2	40	511		40/35	20	325	625	185	300	206	254	698	509	2765	2468	2746	2382
FR12HK550	200	327	3	30	513		8/8	5	100	630	185	300	182	254	698	509	2765	2468	2746	2382
FR12HK640	200	327	3	30	513		10/10	5	200	620	185	300	182	254	698	509	2765	2468	2746	2382
FR12HK850	300	328	3	30	513		15/12	7	200	620	185	300	182	254	698	509	2765	2468	2746	2382
FR12HK1000	300	328	3	30	513		15/15	8	200	620	345	300	208	254	698	509	2765	2468	2746	2382
FR12HK1200	300	328	3	30	513		20/20	10	200	620	345	300	208	254	698	509	2765	2468	2746	2382
FR15HK830	300	328	3	30	513		15/15	8	200	620	185	300	182	254	698	509	2765	2468	2746	2382
FR15HK1200	300	328	3	30	513		25/20	10	200	620	345	300	208	254	698	509	2765	2468	2746	2382
FR16HK830	300	328	3	30	513		20/15	8	200	620	185	300	182	254	698	509	2765	2468	2746	2382
FR16HK1200	300	328	3	40	514		25/20	10	200	620	345	300	208	254	698	509	2765	2468	2746	2382
FR18CE255	100	381	2	30	510		20/20	10	100	630	125	300	225	254	698	509	2765	2468	2746	2382
FR18CE450	200	327	2	30	510		30/25	12	200	620	125	300	225	254	698	509	2765	2468	2746	2382
FR18CE510	200	327	2	30	510		35/30	15	200	620	125	300	225	254	698	509	2765	2468	2746	2382
FR18CE640	200	327	2	40	511		45/40	20	325	625	185	300	651	254	698	509	2765	2468	2746	2382
FR18CE750	200	327	3	60	616		60	30	325	625	185	300	206	254	698	509	2765	2468	2746	2382
FR18CE850	300	328	3	60	616		60	30	325	625	250	600	790	254	698	509	2765	2468	2746	2382
FR18HK640	200	327	3	30	513		15/15	6	200	620	185	300	182	254	698	509	2765	2468	2746	2382
FR18HK750	200	327	3	30	513		20/15	8	200	620	185	300	182	254	698	509	2765	2468	2746	2382
FR18HK850	300	328	3	30	513		20/15	10	200	620	185	300	182	254	698	509	2765	2468	2746	2382
FR18HK1000	300	328	3	30	513		25/20	10	200	620	345	300	208	254	698	509	2765	2468	2746	2382
FR18HK1200	300	328	3	40	514		30/25	15	200	620	345	300	208	254	698	509	2765	2468	2746	2382
FR18HK1360	300	328	3	40	514		30/30	15	200	620	345	300	208	254	698	509	2765	2468	2746	2382
FR18HK1600	500	382	3	50	515		35/30	15	200	620	345	300	208	254	698	509	2765	2468	2746	2382
FR18HK2175	500	382	3	40	514			25	325	625	590	300	657	254	698	509	2765	2468	2746	2382
FR20HK800	300	328	3	30	513		20/15	10	200	620	185	300	182	254	698	509	2765	2468	2746	2382
FR24CE225	100	381	2	30	510		20	10	200	620	125	300	225	254	698	509	2765	2468	2746	2382
FR24CE510	200	327	2	40	511		50/40	20	200	620	185	600	789	254	698	509	2765	2468	2746	2382
FR24BC750	200	327	3	90	615		80/70		325	625	185	600	789	254	698	509	2765	2468	2746	2382
FR24HK510	200	327	3	30	513		20/15	8	200	620	185	600	196	254	698	509	2765	2468	2746	2382
FR24HK640	200	327	3	30	513		20/15	10	200	620	185	600	196	254	698	509	2765	2468	2746	2382
FR24HK750	200	327	3	30	513		25/20	10	200	620	185	600	196	254	698	509	2765	2468	2746	2382
FR24HK900	300	328	3	40	514		30/30	15	200	620	345	600	209	254	698	509	2765	2468	2746	2382
FR24HK1100	300	328	3	40	514		35/30	15	200	620	345	600	209	254	698	509	2765	2468	2746	2382
FR24HK1360	300	328	3	40	514		35/30	15	200	620	345	600	209	254	698	509	2765	2468	2746	2382
FR36CE450	200	327	3	60	616		60/50	30	200	620	185	600	788	254	698	509	2765	2468	2746	2382
FR36HK450	200	327	3	30	513		20/20	10	200	620	185	600	196	254	698	509	2765	2468	2746	2382
FR36HK550	200	327	3	40	514		25/25	12	200	620	185	600	196	254	698	509	2765	2468	2746	2382
FR36HK750	200	327	3	40	514		30/30	15	200	620	185	600	196	254	698	509	2765	2468	2746	2382
FR36K935	300	328	3	30	513			20	200	620	345	600	209	254	698	509	2765	2468	2746	2382
FR36K1600	500	382	3	50	515			35	200	620	350	600	209	254	698	509	2765	2468	2746	2382

## 8.2 FERRO FIVE FR SERIES 575 VAC input

MODEL	AMMETER		LINE CONTACTOR			AC FUSE		DC FUSE		RECTIFIER			CXF JT-	PILOT LIGHT JL-	TIMER JR-	CONTROLS			
	SCALE	P/N JM-	POLE	RATING	P/N JR-	480	575	RATING	P/N JL-	AMPS	PIV	P/N JS-				TIMER ADAPTER NBC-	SCOUT NBC-	COMPU CHARGE NBC-	RANGER II NBC-
FR6M255	100	381	2	30	510		3	100	630	125	300	225	255	698	509	2765	2468	2746	2382
FR6M375	200	327	2	30	510		5	200	620	125	300	225	255	698	509	2765	2468	2746	2382
FR6M450	200	327	2	30	510		5	200	620	125	300	225	255	698	509	2765	2468	2746	2382
FR6M510	200	327	2	30	510		5	200	620	125	300	225	255	698	509	2765	2468	2746	2382
FR6M640	200	327	2	30	510		6	325	625	185	300	206	255	698	509	2765	2468	2746	2382
FR6M750	300	328	2	30	510		6	325	625	185	300	206	255	698	509	2765	2468	2746	2382
FR6L830	300	328	3	30	513		3	200	620	185	300	182	255	698	509	2765	2468	2746	2382
FR6L1000	300	328	3	30	513		3	200	620	345	300	208	255	698	509	2765	2468	2746	2382
FR6L1125	300	328	3	30	513		3	200	620	345	300	208	255	698	509	2765	2468	2746	2382
FR6L1700	500	328	3	30	513		5	200	620	345	300	208	255	698	509	2765	2468	2746	2382
FR9M640	200	327	2	30	510		10	325	625	185	300	206	255	698	509	2765	2468	2746	2382
FR9L830	300	328	3	30	513		3	200	620	185	300	182	255	698	509	2765	2468	2746	2382
FR9L1160	300	328	3	30	513		5	200	620	345	300	208	255	698	509	2765	2468	2746	2382
FR12M255	100	381	2	30	510		6	100	630	125	300	225	255	698	509	2765	2468	2746	2382
FR12M375	200	327	2	30	510		6	200	620	125	300	225	255	698	509	2765	2468	2746	2382
FR12M450	200	327	2	30	510		6	200	620	125	300	225	255	698	509	2765	2468	2746	2382
FR12M550	200	327	2	30	510		10	200	620	125	300	225	255	698	509	2765	2468	2746	2382
FR12M640	200	327	2	30	510		10	325	625	185	300	206	255	698	509	2765	2468	2746	2382
FR12L550	200	327	3	30	513		3	100	630	185	300	182	255	698	509	2765	2468	2746	2382
FR12L640	200	327	3	30	513		3	200	620	185	300	182	255	698	509	2765	2468	2746	2382
FR12L850	300	328	3	30	513		3	200	620	185	300	182	255	698	509	2765	2468	2746	2382
FR12L1000	300	328	3	30	513		5	200	620	345	300	208	255	698	509	2765	2468	2746	2382
FR12L1200	300	328	3	30	513		5	200	620	345	300	208	255	698	509	2765	2468	2746	2382
FR15L830	300	328	3	30	513		5	200	620	185	300	182	255	698	509	2765	2468	2746	2382
FR15L1200	300	328	3	30	513		10	200	620	345	300	208	255	698	509	2765	2468	2746	2382
FR16L830	300	328	3	30	513		5	200	620	185	300	182	255	698	509	2765	2468	2746	2382
FR16L1200	300	328	3	40	514		10	200	620	345	300	208	255	698	509	2765	2468	2746	2382
FR18M255	100	381	2	30	510		10	100	630	125	300	225	255	698	509	2765	2468	2746	2382
FR18M450	200	327	2	30	510		10	200	620	125	300	225	255	698	509	2765	2468	2746	2382
FR18M510	200	327	2	30	510		15	200	620	125	300	225	255	698	509	2765	2468	2746	2382
FR18M640	200	327	2	40	511		20	325	625	185	300	651	255	698	509	2765	2468	2746	2382
FR18EM750	200	327	3	60	616	30	25	325	625	185	300	785	255	698	509	2765	2468	2746	2382
FR18EM850	300	328	3	60	616	30	25	325	625	250	600	785	255	698	509	2765	2468	2746	2382
FR18L750	200	327	3	30	513		5	200	620	185	300	182	255	698	509	2765	2468	2746	2382
FR18L850	300	328	3	30	513		5	200	620	185	300	182	255	698	509	2765	2468	2746	2382
FR18L1000	300	328	3	30	513		6	200	620	345	300	208	255	698	509	2765	2468	2746	2382
FR18L1200	300	328	3	40	514		10	200	620	345	300	208	255	698	509	2765	2468	2746	2382
FR18L1360	300	328	3	40	514		10	200	620	345	300	208	255	698	509	2765	2468	2746	2382
FR18L1600	500	382	3	50	515			200	620	345	300	208	255	698	509	2765	2468	2746	2382
FR18L2175	500	382	3	40	514			325	625	590	300	657	255	698	509	2765	2468	2746	2382
FR20L800	300	328	3	30	513		6	200	620	185	300	182	255	698	509	2765	2468	2746	2382
FR24EM510	200	327	2	40	511	35	30	200	620	185	600	789	255	698	509	2765	2468	2746	2382
FR24EM750	200	327	3	90	615	35	30	325	625	185	600	790	255	698	509	2765	2468	2746	2382
FR24L510	200	327	3	30	513		5	200	620	185	600	196	255	698	509	2765	2468	2746	2382
FR24L750	200	327	3	40	513		6	200	620	185	600	196	255	698	509	2765	2468	2746	2382
FR24L900	300	328	3	40	514		10	200	620	345	600	209	255	698	509	2765	2468	2746	2382
FR24L1100	300	328	3	40	514		10	200	620	345	600	209	255	698	509	2765	2468	2746	2382
FR24L1360	300	328	3	40	514		10	200	620	345	600	209	255	698	509	2765	2468	2746	2382
FR36EM450	200	327	3	60	616	30	25	200	620	185	600	789	255	698	509	2765	2468	2746	2382
FR36L450	200	327	3	30	513		6	200	620	185	600	196	255	698	509	2765	2468	2746	2382
FR36L550	200	327	3	40	514		10	200	620	185	600	196	255	698	509	2765	2468	2746	2382
FR36L750	200	327	3	40	514		10	200	620	185	600	196	255	698	509	2765	2468	2746	2382
FR36L935	300	328	3	30	513		15	200	620	345	600	209	255	698	509	2765	2468	2746	2382

### 8.3 FERRO FIVE EFR SERIES 120/208/240 and 480 VAC inputs

MODEL	AMMETER		LINE CONTACTOR			AC FUSE			DC FUSE		RECTIFIER			CXF JT-	PILOT LIGHT JL-	CONTROLS				
	SCALE	P/N JM-	POLE	RATING	P/N JR-	120	208/240	480	RATING	P/N JL-	AMPS	PIV	P/N JS-			TIMER JR-	TIMER ADAPTER NBC-	SCOUT NBC-	COMPU CHARGE NBC-	RANGER II NBC-
EFR6AC470	200	327	2	30	510	20	10/10		200	620	125	300	225	253	698	509	2765	2468	2746	2382
EFR6CE470	200	327	2	30	510		10/10	5	200	620	125	300	225	254	698	509	2765	2468	2746	2382
EFR6AC560	200	327	2	30	510	25	15/12		200	620	125	300	225	253	698	509	2765	2468	2746	2382
EFR6CE560	200	327	2	30	510		15/12	6	200	620	125	300	225	254	698	509	2765	2468	2746	2382
EFR6CE640	200	327	2	30	510		15/12	6	200	620	125	300	225	254	698	509	2765	2468	2746	2382
EFR6CE800	200	327	2	30	510		20/15	7	325	625	185	300	206	254	698	509	2765	2468	2746	2382
EFR6CE940	300	328	2	30	510		20/20	10	325	625	185	300	206	254	698	509	2765	2468	2746	2382
EFR6HK1040	300	328	3	30	513		7/6	3	200	620	185	300	182	254	698	509	2765	2468	2746	2382
EFR6HK1250	300	328	3	30	513		10/10	5	200	620	345	300	208	254	698	509	2765	2468	2746	2382
EFR9CE640	200	327	2	30	510		25/20	10	325	625	185	300	206	254	698	509	2765	2468	2746	2382
EFR12CE320	100	381	2	30	510		15/12	6	100	630	125	300	225	254	698	509	2768	2465	2746	2382
EFR12CE470	200	327	2	30	510		20/20	10	200	620	125	300	225	254	698	509	2765	2468	2746	2382
EFR12CE560	200	327	2	30	510		20/20	10	200	620	125	300	225	254	698	509	2765	2468	2746	2382
EFR12CE690	200	327	2	30	510		25/25	12	200	620	125	300	225	254	698	509	2765	2468	2746	2382
EFR12CE800	200	327	2	30	510		35/30	15	325	625	185	300	206	254	698	509	2765	2468	2746	2382
EFR12CE940	300	328	2	40	511		40/35	20	325	625	185	300	206	254	698	509	2765	2468	2746	2382
EFR12HK690	200	327	3	30	513		8/8	5	100	630	185	300	182	254	698	509	2765	2468	2746	2382
EFR12HK800	200	327	3	30	513		10/10	5	200	620	185	300	182	254	698	509	2765	2468	2746	2382
EFR12HK1060	300	328	3	30	513		15/12	7	200	620	185	300	182	254	698	509	2765	2468	2746	2382
EFR12HK1250	300	328	3	30	513		15/15	8	200	620	345	300	208	254	698	509	2765	2468	2746	2382
EFR12HK1500	300	328	3	30	513		20/20	10	200	620	345	300	208	254	698	509	2765	2468	2746	2382
EFR18CE320	100	381	2	30	510		20/20	10	100	630	125	300	225	254	698	509	2765	2468	2746	2382
EFR18CE560	200	327	2	30	510		30/25	12	200	620	125	300	225	254	698	509	2765	2468	2746	2382
EFR18CE640	200	327	2	30	510		35/30	15	200	620	125	300	225	254	698	509	2765	2468	2746	2382
EFR18CE800	200	327	2	40	511		45/40	20	325	625	185	300	651	254	698	509	2765	2468	2746	2382
EFR18HK800	200	327	3	30	513		15/15	6	200	620	185	300	182	254	698	509	2765	2468	2746	2382
EFR18HK940	200	327	3	30	513		20/15	8	200	620	185	300	182	254	698	509	2765	2468	2746	2382
EFR18HK1060	300	328	3	30	513		20/15	10	200	620	185	300	182	254	698	509	2765	2468	2746	2382
EFR18HK1250	300	328	3	30	513		25/20	10	200	620	345	300	208	254	698	509	2765	2468	2746	2382
EFR18HK1500	300	328	3	40	514		30/25	15	200	620	345	300	208	254	698	509	2765	2468	2746	2382
EFR18HK1700	300	328	3	40	514		30/30	15	200	620	345	300	208	254	698	509	2765	2468	2746	2382
EFR18HK2000	500	382	3	50	515		35/30	15	200	620	345	300	208	254	698	509	2765	2468	2746	2382
EFR24HK640	200	327	3	30	513		20/15	8	200	620	185	600	196	254	698	509	2765	2468	2746	2382
EFR24HK940	200	327	3	40	513		25/20	10	200	620	185	600	196	254	698	509	2765	2468	2746	2382
EFR24HK1125	300	328	3	40	514		30/30	15	200	620	345	600	209	254	698	509	2765	2468	2746	2382
EFR24HK1375	300	328	3	40	514		35/30	15	200	620	345	600	209	254	698	509	2765	2468	2746	2382
EFR24HK1700	300	328	3	40	514		35/30	15	200	620	345	600	209	254	698	509	2765	2468	2746	2382
EFR36HK690	200	327	3	40	514		25/25	12	200	620	185	600	196	254	698	509	2765	2468	2746	2382
EFR36HK940	200	327	3	40	514		30/30	15	200	620	185	600	196	254	698	509	2765	2468	2746	2382

# 9 WIRING DIAGRAMS

## 9.1 Wiring diagram guide for FERRO FIVE FR, LIBERTY, and REVOLUTION SERIES charger models

MODEL NO.	FR	LIBERTY	REVOLUTION
FR6AC255	NBC-2243	NA	NA
FR6CE255	NBC-2244	NA	NA
FR6AC375	NBC-2243	NA	NA
FR6CE375	NBC-2244	NA	NA
FR6AC450	NBC-2243	NA	NA
FR6CE450	NBC-2244	KBC-5702	KBC-5717
FR6CE510	NBC-2244	KBC-5686	KBC-5717
FR6CE640	NBC-2244	NA	NA
FR6CE750	NBC-2244	NA	NA
FR6HK510	NBC-2247	NA	NA
FR6HK830	NBC-2247	NA	NA
FR6HK1000	NBC-2247	NA	NA
FR6HK1125	NBC-2247	NA	NA
FR6HK1700	NBC-2247	NA	NA
FR9CE255	NBC-2244	NA	NA
FR9CE640	NBC-2244	NA	NA
FR9HK830	NBC-2247	NA	NA
FR9HK1160	NBC-2247	NA	NA
FR12CE255	NBC-2244	KBC-5702	KBC-5717
FR12AC375	NBC-2243	KBC-5702	NA
FR12CE375	NBC-2244	KBC-5702	NA
FR12AC450	NBC-2243	KBC-5702	KBC-5718
FR12CE450	NBC-2244	KBC-5702	KBC-5717
FR12CE550	NBC-2244	KBC-5686	KBC-5717
FR12CE640	NBC-2244	KBC-5686	KBC-5717
FR12CE750	NBC-2244	KBC-5686	KBC-5717
FR12HK550	NBC-2247	KBC-5704	KBC-5719
FR12HK640	NBC-2247	KBC-5704	KBC-5719
FR12HK750	NBC-2247	KBC-5704	KBC-5719
FR12HK850	NBC-2247	KBC-5704	KBC-5719
FR12HK1000	NBC-2247	KBC-5704	KBC-5719
FR12HK1200	NBC-2247	NA	NA
FR15HK830	NBC-2247	NA	NA
FR15HK1200	NBC-2247	NA	NA
FR16HK830	NBC-2247	NA	NA
FR16HK1200	NBC-2247	NA	NA
FR18CE255	NBC-2244	NA	NA
FR18CE450	NBC-2244	NA	NA
FR18CE510	NBC-2244	NA	KBC-5717
FR18CE640	NBC-2244	KBC-5686	KBC-5717
FR18CE750	NBC-2244	KBC-5686	KBC-5717
FR18CE850	NBC-2244	KBC-5686	KBC-5717
FR18HK640	NBC-2247	KBC-5704	KBC-5719
FR18HK750	NBC-2247	KBC-5704	KBC-5719
FR18HK850	NBC-2247	KBC-5704	KBC-5719
FR18HK1000	NBC-2247	KBC-5704	KBC-5719
FR18HK1200	NBC-2247	KBC-5687	KBC-5719
FR18HK1360	NBC-2247	KBC-5687	NA
FR18HK1600	NBC-2247	NA	NA
FR18K2175	NBC-2249	NA	NA
FR20HK800	NBC-2247	NA	NA
FR24CE255	NBC-2244	NA	NA
FR24CE330	NBC-2244	KBC-5686	KBC-5717
FR24CE510	NBC-2244	KBC-5686	KBC-5717
FR24BC750	NBC-2244	NA	NA
FR24HK330	NBC-2247	KBC-5704	NA
FR24HK510	NBC-2247	KBC-5704	KBC-5719
FR24HK640	NBC-2247	KBC-5704	KBC-5719
FR24HK750	NBC-2247	KBC-5704	KBC-5719
FR24HK900	NBC-2247	KBC-5687	KBC-5719
FR24HK1100	NBC-2247	KBC-5687	NA
FR24HK1360	NBC-2247	KBC-5687	NA
FR36CE450	NBC-2244	NA	NA
FR36HK450	NBC-2247	NA	NA
FR36HK550	NBC-2247	NA	NA
FR36HK750	NBC-2247	NA	NA
FR36K935	NBC-2249	NA	NA
FR36K1600	NBC-2249	NA	NA

MODEL NO.	FR	LIBERTY	REVOLUTION
FR6M255	NBC-2245	NA	NA
FR6M375	NBC-2245	NA	NA
FR6EM450	NBC-2246	KBC-5703	KBC-5722
FR6EM510	NBC-2246	NA	KBC-5722
FR6M640	NBC-2245	NA	NA
FR6M750	NBC-2245	NA	NA
FR6L830	NBC-2249	NA	NA
FR6L1000	NBC-2249	NA	NA
FR6L1125	NBC-2249	NA	NA
FR6L1700	NBC-2249	NA	NA
FR9M640	NBC-2245	NA	NA
FR9L830	NBC-2249	NA	NA
FR9L1160	NBC-2249	NA	NA
FR12EM255	NBC-2246	KBC-5703	KBC-5722
FR12EM375	NBC-2246	KBC-5703	NA
FR12EM450	NBC-2246	KBC-5703	KBC-5722
FR12EM550	NBC-2246	NA	KBC-5722
FR12EM640	NBC-2246	NA	KBC-5722
FR12EM750	NBC-2246	NA	KBC-5722
FR12KL550	NBC-2248	KBC-5705	KBC-5721
FR12KL640	NBC-2248	KBC-5705	KBC-5721
FR12KL750	NBC-2248	KBC-5705	KBC-5721
FR12KL850	NBC-2248	KBC-5705	KBC-5721
FR12KL1000	NBC-2248	KBC-5705	KBC-5721
FR12L1200	NBC-2249	NA	NA
FR15L830	NBC-2249	NA	NA
FR15L1200	NBC-2249	NA	NA
FR16L830	NBC-2249	NA	NA
FR16L1200	NBC-2249	NA	NA
FR18M255	NBC-2245	NA	NA
FR18M450	NBC-2245	NA	NA
FR18EM510	NBC-2246	NA	KBC-5722
FR18EM640	NBC-2246	NA	KBC-5722
FR18EM750	NBC-2246	NA	KBC-5722
FR18EM850	NBC-2246	NA	KBC-5722
FR18KL640	NBC-2248	KBC-5705	KBC-5721
FR18KL750	NBC-2248	KBC-5705	KBC-5721
FR18KL850	NBC-2248	KBC-5705	KBC-5721
FR18KL1000	NBC-2248	KBC-5705	KBC-5721
FR18KL1200	NBC-2248	KBC-5691	KBC-5721
FR18KL1360	NBC-2248	KBC-5691	NA
FR18L1600	NBC-2249	NA	NA
FR18L2175	NBC-2249	NA	NA
FR20L800	NBC-2249	NA	NA
FR24EM330	NBC-2246	NA	KBC-5722
FR24EM510	NBC-2246	NA	KBC-5722
FR24KL330	NBC-2248	KBC-5705	NA
FR24KL510	NBC-2248	KBC-5705	KBC-5721
FR24KL640	NBC-2248	KBC-5705	KBC-5721
FR24KL750	NBC-2248	KBC-5705	KBC-5721
FR24KL900	NBC-2248	KBC-5691	KBC-5721
FR24KL1100	NBC-2248	KBC-5691	NA
FR24KL1360	NBC-2248	KBC-5691	NA
FR36EM450	NBC-2246	NA	NA
FR36L450	NBC-2249	NA	NA
FR36L550	NBC-2249	NA	NA
FR36L750	NBC-2249	NA	NA
FR36L935	NBC-2249	NA	NA

### Notes:

- For standard FR, KL diagram is NVC-2248 and L diagram is NBC-2249
- For standard FR, EM diagram is NBC-2246 and M diagram is NBC-2245
- For FERRO FIVE LIBERTY SERIES and FERRO FIVE REVOLUTION SERIES, KL and L diagrams are the same, except L has only 575 VAC input
- For FERRO FIVE LIBERTY SERIES and FERRO FIVE REVOLUTION SERIES, EM and M diagrams are the same, except M has only 575 VAC input
- Both L and KL, or M and EM versions may exist for models listed

## 9.2 Wiring diagram guide for FERRO FIVE EFR SERIES models

MODEL NO.	EFR
EFR6AC470	NBC-2243
EFR6CE470	NBC-2244
EFR6CE560	NBC-2244
EFR6CE640	NBC-2244
EFR6CE800	NBC-2244
EFR6CE940	NBC-2244
EFR6HK1040	NBC-2247
EFR6HK1250	NBC-2247
EFR9CE640	NBC-2244
EFR12CE320	NBC-2244
EFR12CE470	NBC-2244
EFR12CE560	NBC-2244
EFR12CE690	NBC-2244
EFR12CE800	NBC-2244
EFR12CE940	NBC-2244
EFR12HK690	NBC-2247
EFR12HK800	NBC-2247
EFR12HK1060	NBC-2247
EFR12HK1250	NBC-2247
EFR12HK1500	NBC-2247
EFR18CE320	NBC-2244
EFR18CE560	NBC-2244
EFR18CE640	NBC-2244
EFR18CE800	NBC-2244
EFR18HK940	NBC-2247
EFR18HK1060	NBC-2247
EFR18HK1250	NBC-2247
EFR18HK1500	NBC-2247
EFR18HK1700	NBC-2247
EFR18HK2000	NBC-2247
EFR24HK640	NBC-2247
EFR24HK940	NBC-2247
EFR24HK1125	NBC-2247
EFR24HK1375	NBC-2247
EFR24HK1700	NBC-2247
EFR36HK690	NBC-2247
EFR36HK940	NBC-2247

STEP 1 - REMOVE ALL CHANCEOVER JUMPERS FROM TB1 AND CXF.

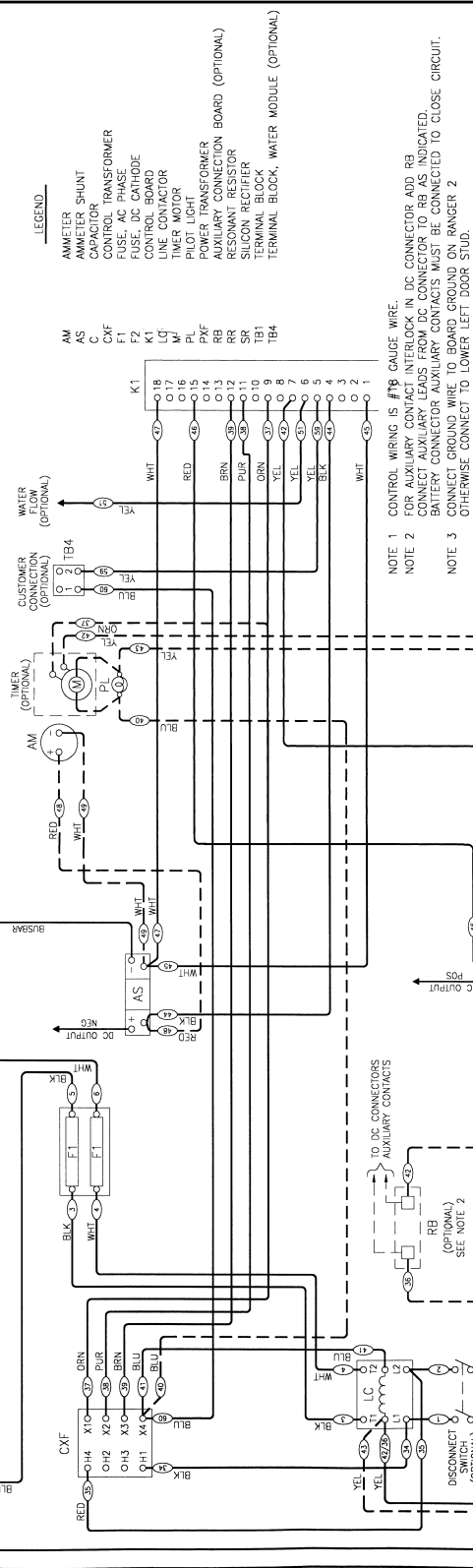
STEP 2 - FOR 120 VAC INPUT  
ON TB1, CONNECT TERMINALS 1 & 4, 3 & 5 AND 5 & 7  
ON CXF, CONNECT TERMINALS H1 & H3 AND H2 & H4.

FOR 208 VAC INPUT  
ON TB1, CONNECT TERMINALS 2 & 4 AND 5 & 7.  
ON CXF, CONNECT TERMINALS H2 & H3.

FOR 240 VAC INPUT  
ON TB1, CONNECT TERMINALS 3 & 4 AND 5 & 7.  
ON CXF, CONNECT TERMINALS H2 & H3.

CAUTION

**AC FUSES MUST BE CHANGED WHEN CHANGING VOLTAGE. SEE LABEL IN CHARGER.**



WIRE NUMBERS USED: 1-12, 34-42, 44-47, 50, 51, 59, 60.

WIRE NUMBERS USED: 1-12, 34-42, 44-47, 50, 51, 59, 60.

[illegible]

01/10/89	R.D. WEBER	01/10/89
CHECKED	P.S. ALEXANDER	03/10/89
CHARTER POWER SYSTEMS, INC. 3043 WALTON ROAD, PHILADELPHIA, PA 19140-0210		

APPROVED	03/10/89
D.H. MUHLRAD	
8503874613	

CONNECTION DIAGRAM

UNIT 755, 0145 WESLEYAN DRIVE, WILMINGTON, OH 44097-0005	FR AC RANGER 2, SCOUT, COMPUCHARGE 3
--	--------------------------------------

SIZE D  
BLANK SIZE  
NBC-2243

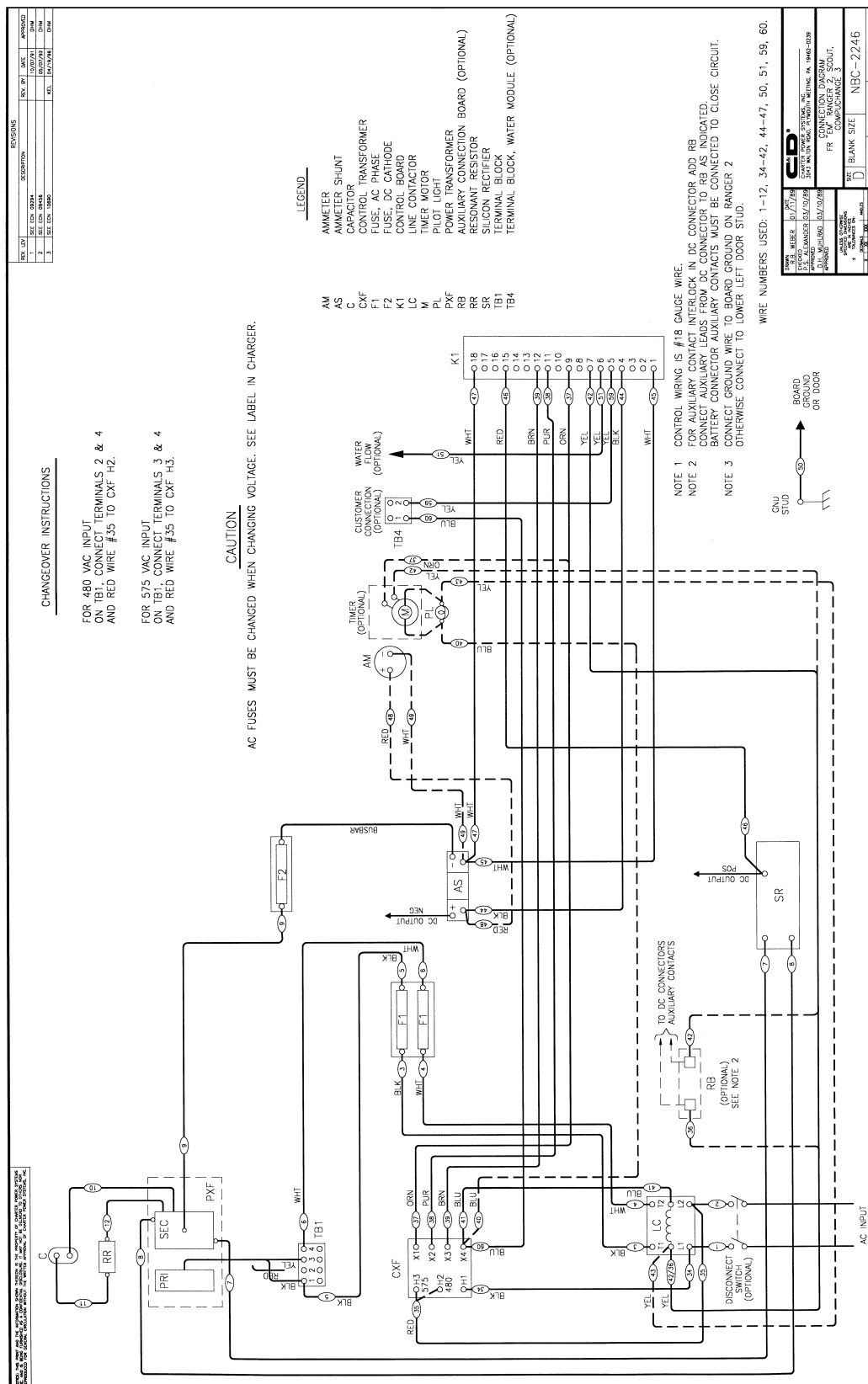
X	10	XXX	SCALE NONE	REV. LEVEL 2	SHEET 1 OF 1
		0.020 (0.010)			







### 9.3 Wiring diagrams for FERRO FIVE FR SERIES (continued)



STEP 1 - REMOVE ALL CHANGEOVER JUMPERS FROM T1, T2, T3 AND CXF.

STEP 2 - FOR 208 VAC INPUT  
ON T1, T2 AND T3 CONNECT TERMINALS 1 & 4, 2 & 5 AND 5 & 7.  
ON CXF CONNECT TERMINALS H1 & H3 AND H2 & H4.

FOR 240 VAC INPUT  
ON T1, T2 AND T3 CONNECT TERMINALS 1 & 4, 3 & 6 AND 6 & 7.  
ON CXF CONNECT TERMINALS H1 & H3 AND H2 & H4.

FOR 480 VAC INPUT  
ON T1, T2 AND T3 CONNECT TERMINALS 3 & 4 AND 6 & 7.  
ON CXF CONNECT TERMINALS H2 AND H3.

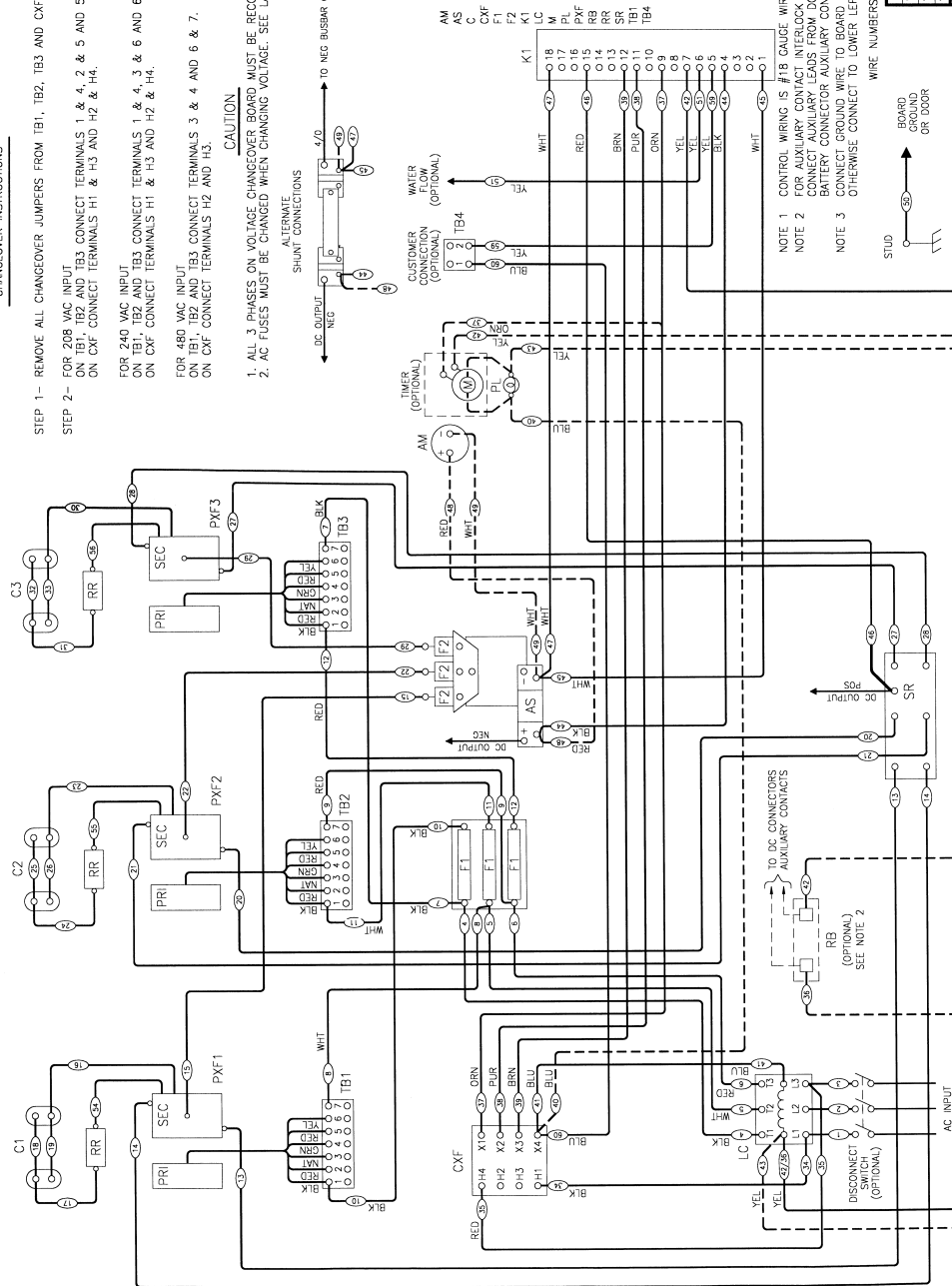
**CAUTION**

1. ALL 3 PHASES ON VOLTAGE CHANGEOVER BOARD MUST BE RECONNECTED WHEN CHANGING VOLTAGE.  
2. AC FUSES MUST BE CHANGED WHEN CHANGING VOLTAGE. SEE LABEL IN CHARGER.

**CAUTION**

- WARNING:** 1. ALL 3 PHASES ON VOLTAGE CHANGEOVER BOARD MUST BE RECONNECTED WHEN CHANGING VOLTAGE.  
2. AC FUSES MUST BE CHANGED WHEN CHANGING VOLTAGE. SEE LABEL IN CHARGER.

### ALTERNATE T CONNECTIONS



NOTE 1 CONTROL WIRING IS #18 GAUGE WIRE.

NOTE 2 FOR AUXILIARY CONTACT INTERLOCK IN DC CONNECTOR ADD RB CONNECT AUXILIARY LEADS FROM DC CONNECTOR TO RB AS INDICATED. BATTERY CONNECTOR AUXILIARY CONTACTS MUST BE CONNECTED TO CLOSE CIRCUIT.

NOTE 3 CONNECT GROUND WIRE TO BOARD GROUND ON RANGER 2 OTHERWISE CONNECT TO LOWER LEFT DOOR STUD

BATTERY CONNECTOR AUXILIARY CONTACTS MUST BE CONNECTED TO BATTERY COOLING WIRE TO BOARD GROUND ON RANCS 2

WIRE NUMBERS USED: 1-42, 44-47, 50, 51, 54-56, 59, 60.

**U.S. DEPARTMENT OF JUSTICE**

**CHARTER POWER SYSTEMS, INC.**

3043 WALTON ROAD, PLYMOUTH MEETING, PA 19452-0100

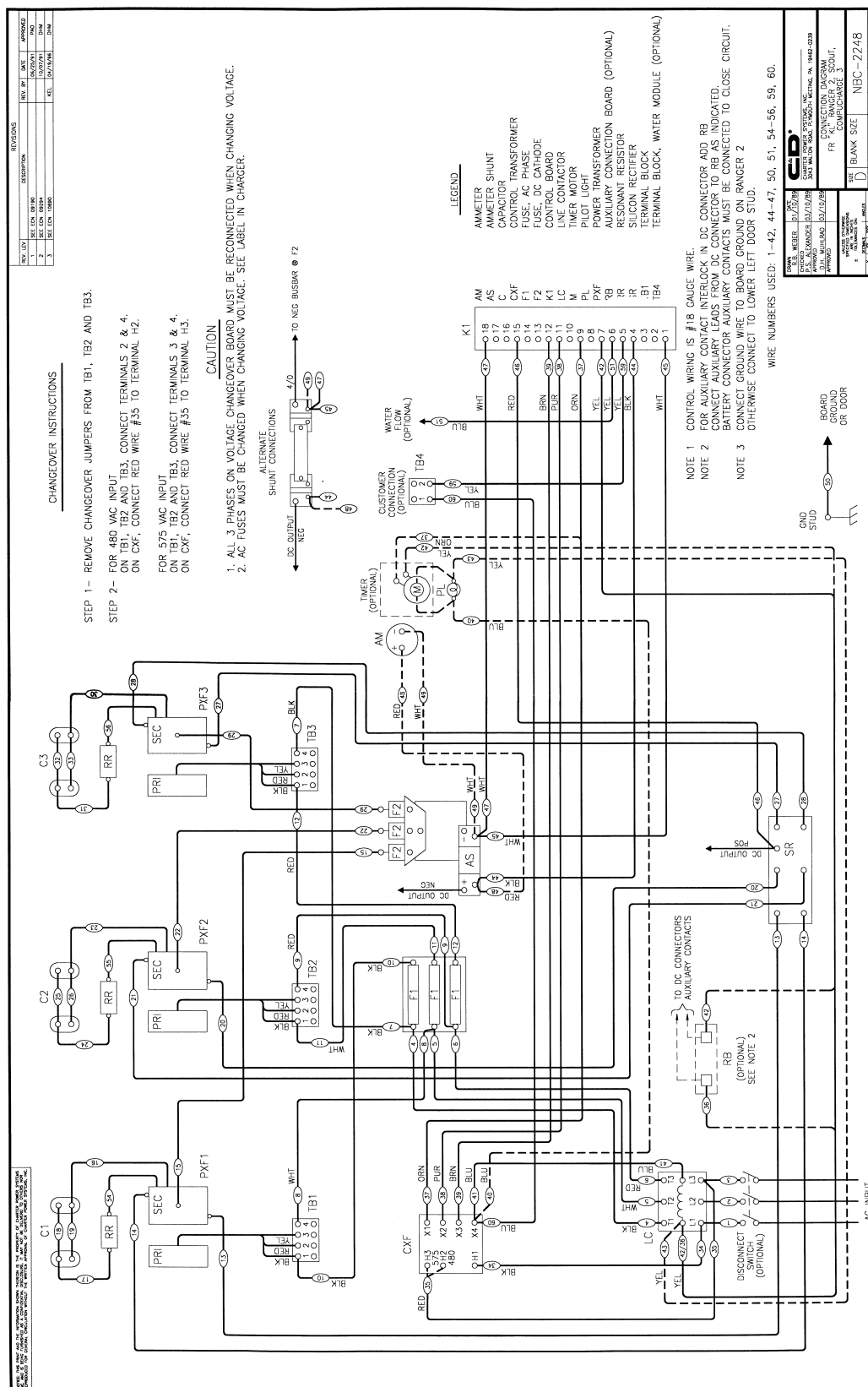
CONNECTION DIAGRAM  
FR "HK" RANGER 2, SCOUT,  
CONQUEROR, &

SIZE	BLANK SIZE	1.00 0.00
COMPUCHARGE 3		

D	UNION JAIL	NBC-224
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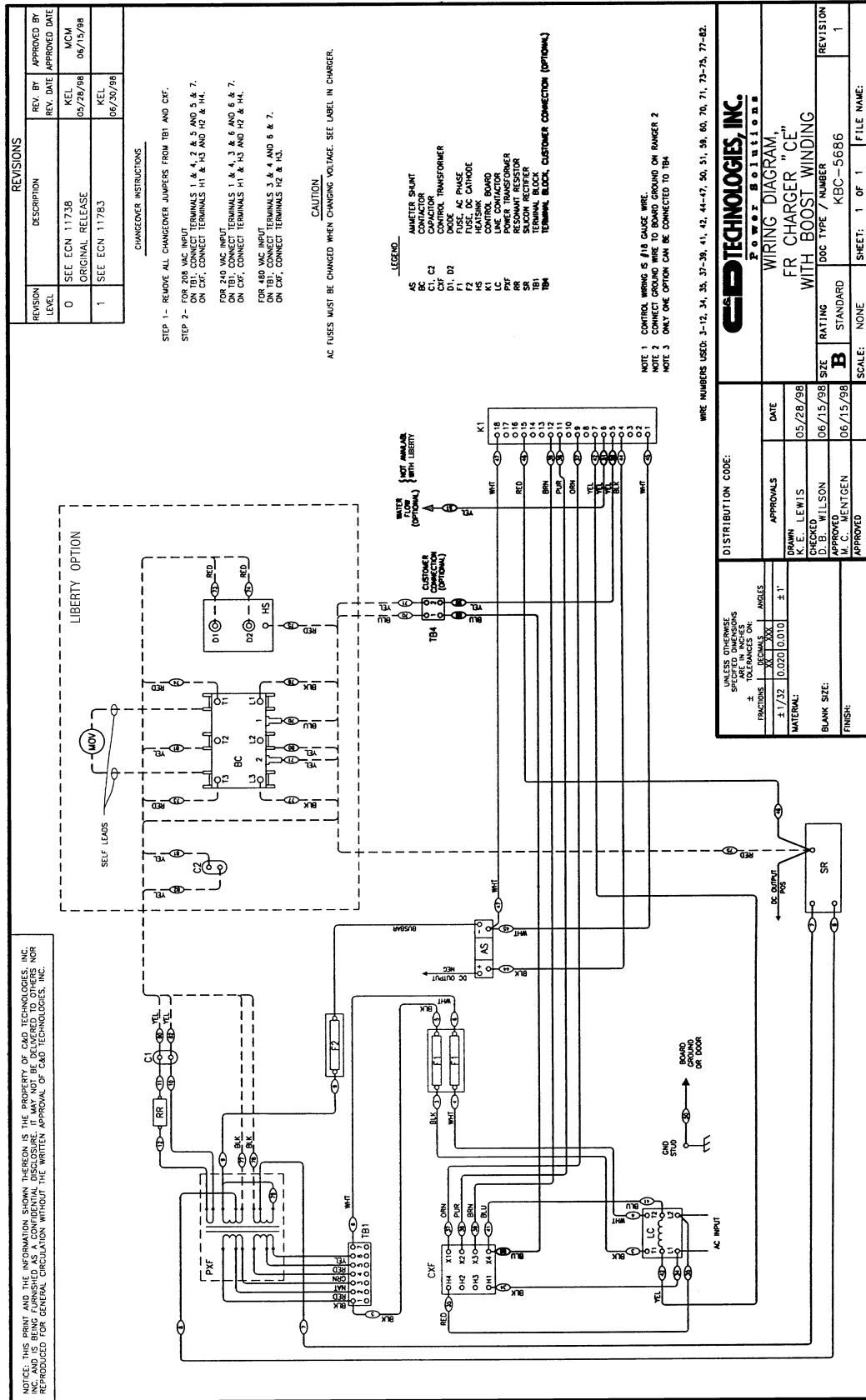
DATE	REV. LEVEL 2	REV. 1
10-01-01	1	1

### 9.3 Wiring diagrams for FERRO FIVE FR SERIES (continued)

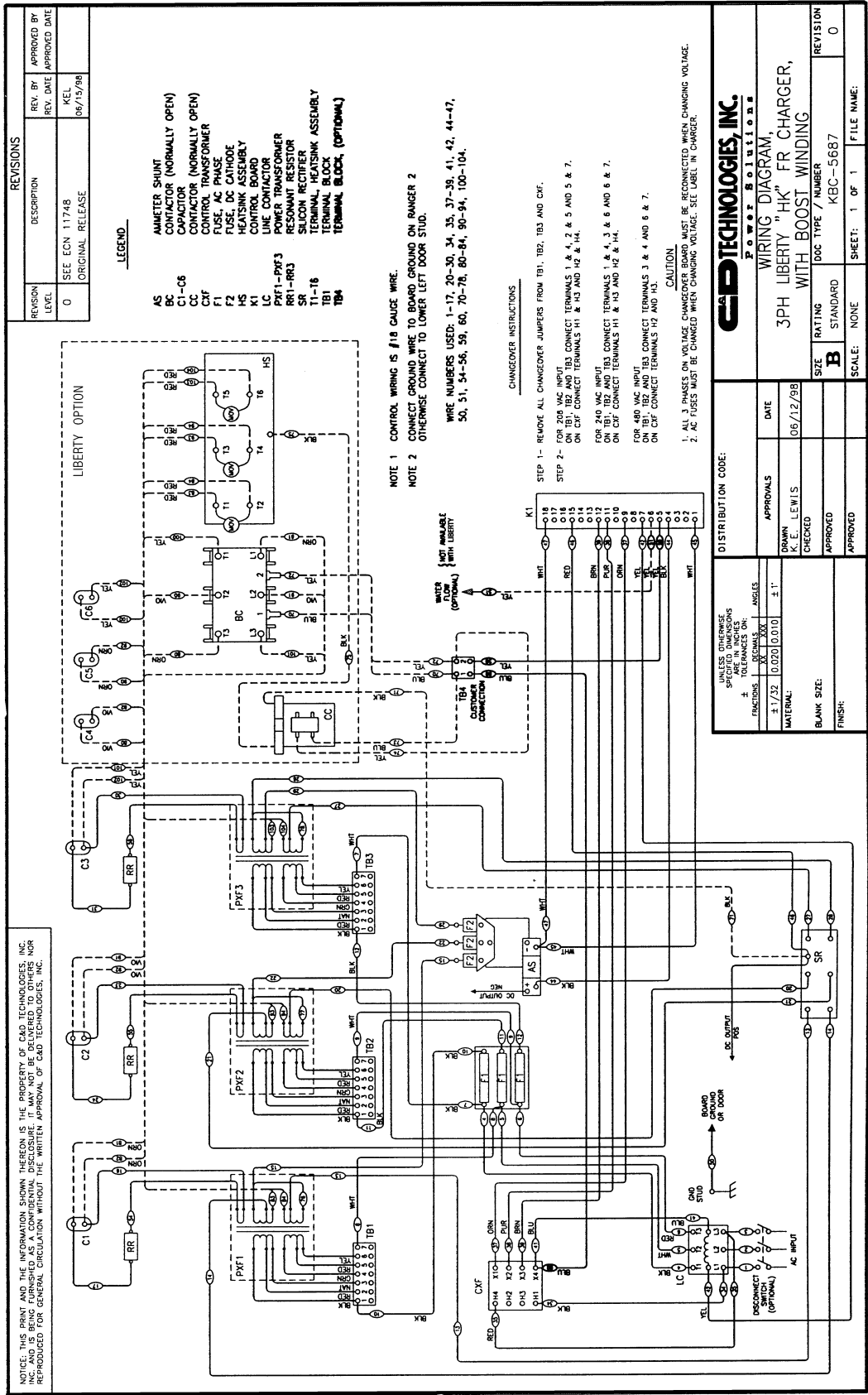




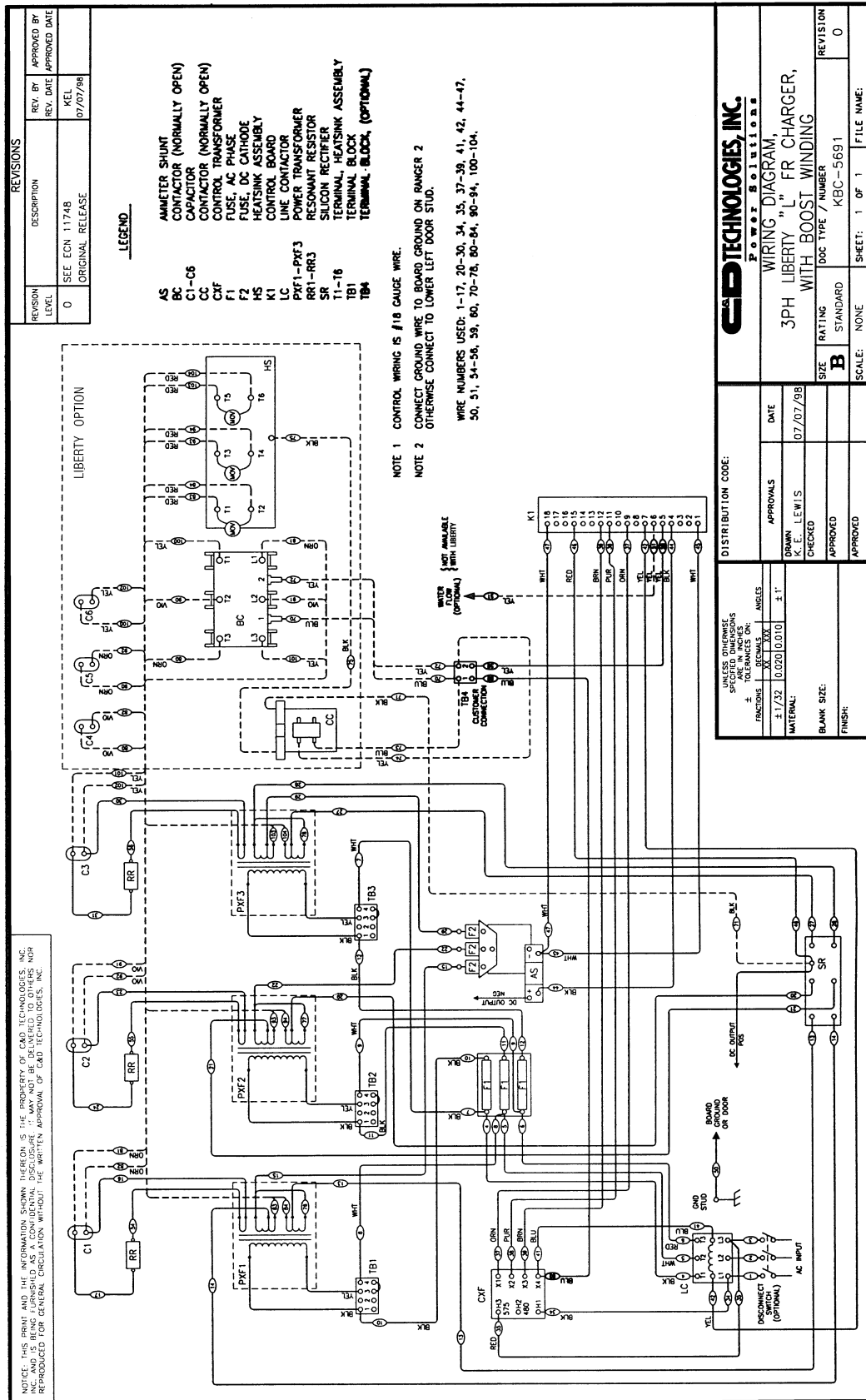
## 9.4 Wiring diagrams for FERRO FIVE LIBERTY SERIES



9.4 Wiring diagrams for FERRO FIVE LIBERTY SERIES (continued)

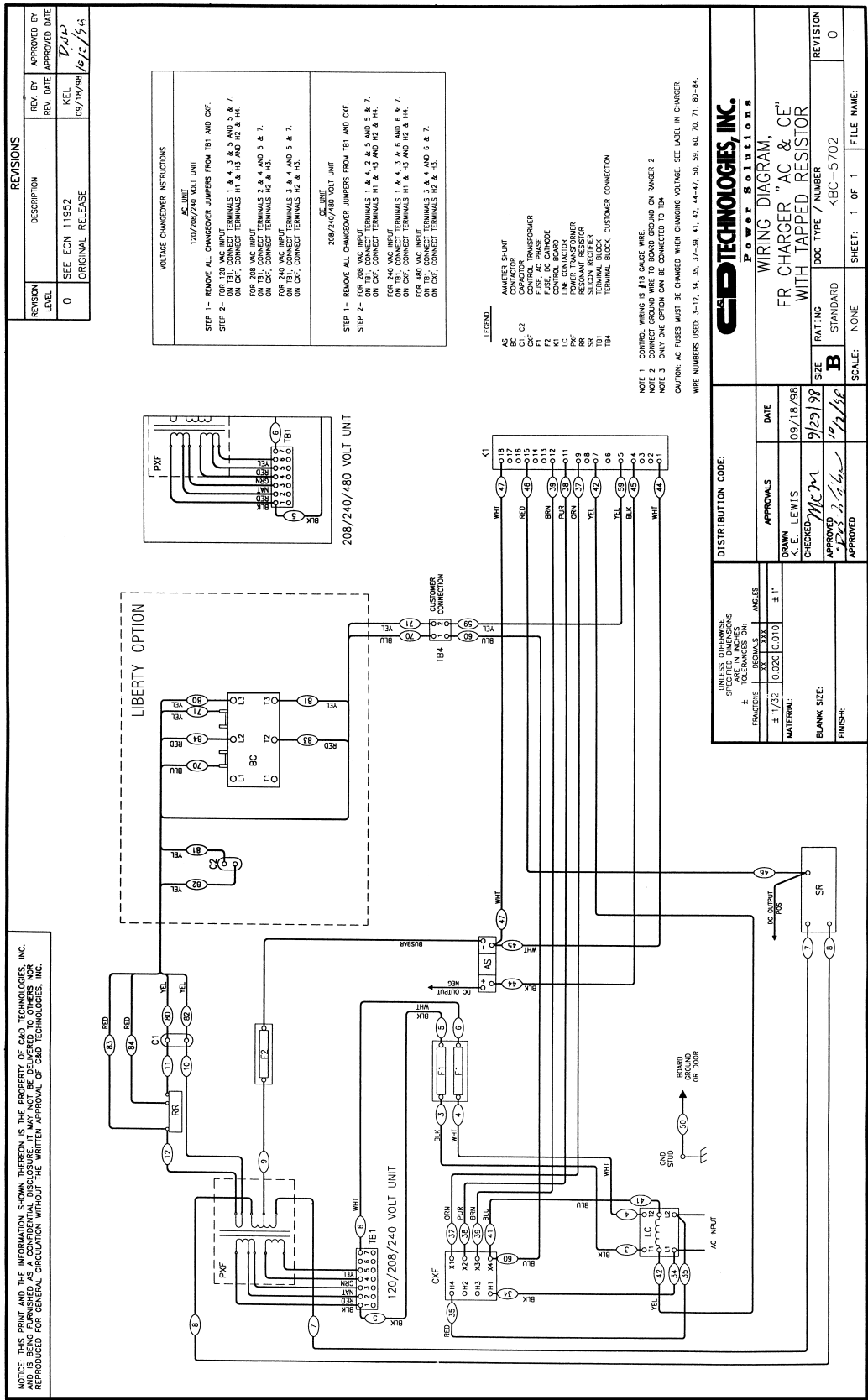


## 9.4 Wiring diagrams for FERRO FIVE LIBERTY SERIES (continued)

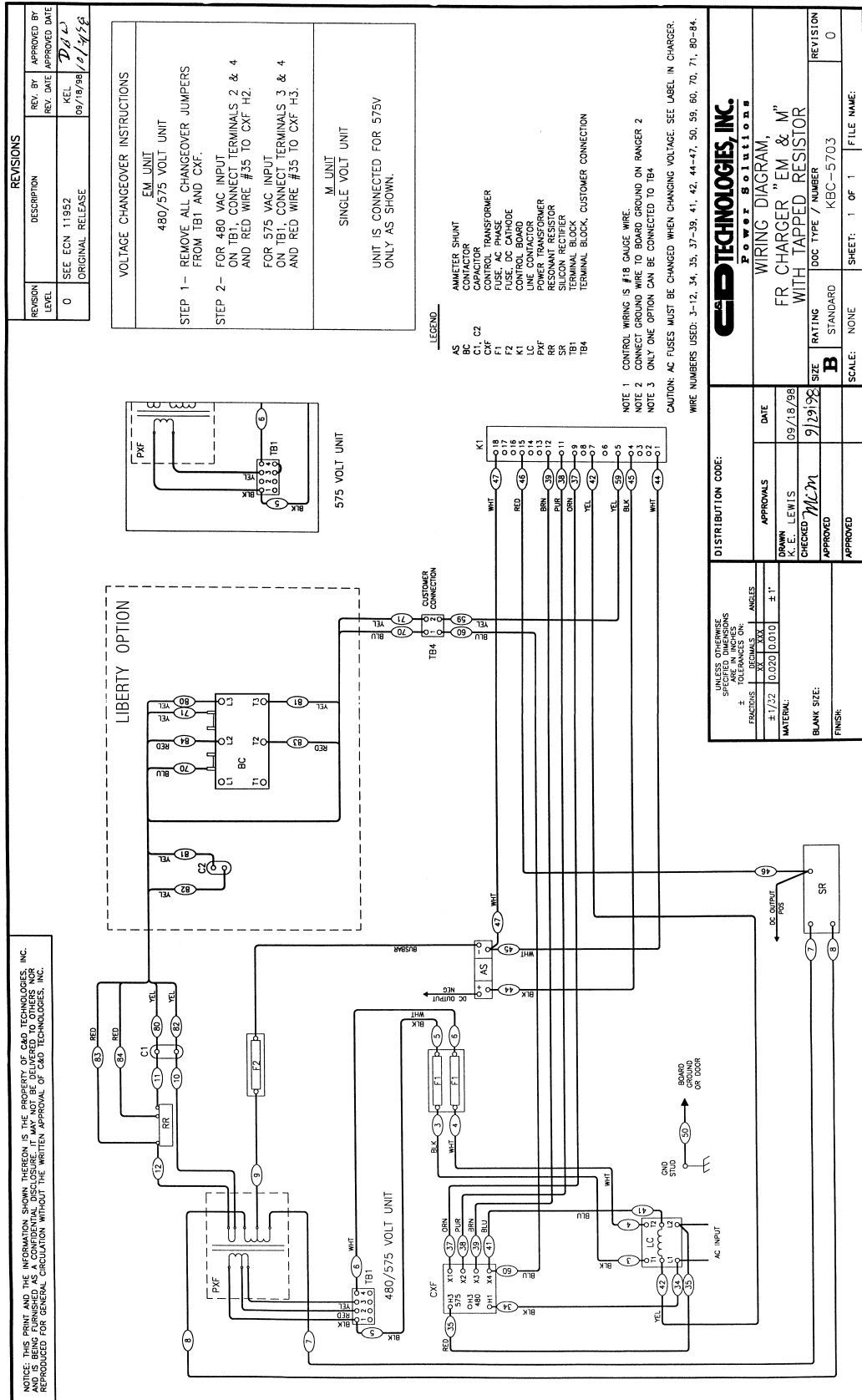




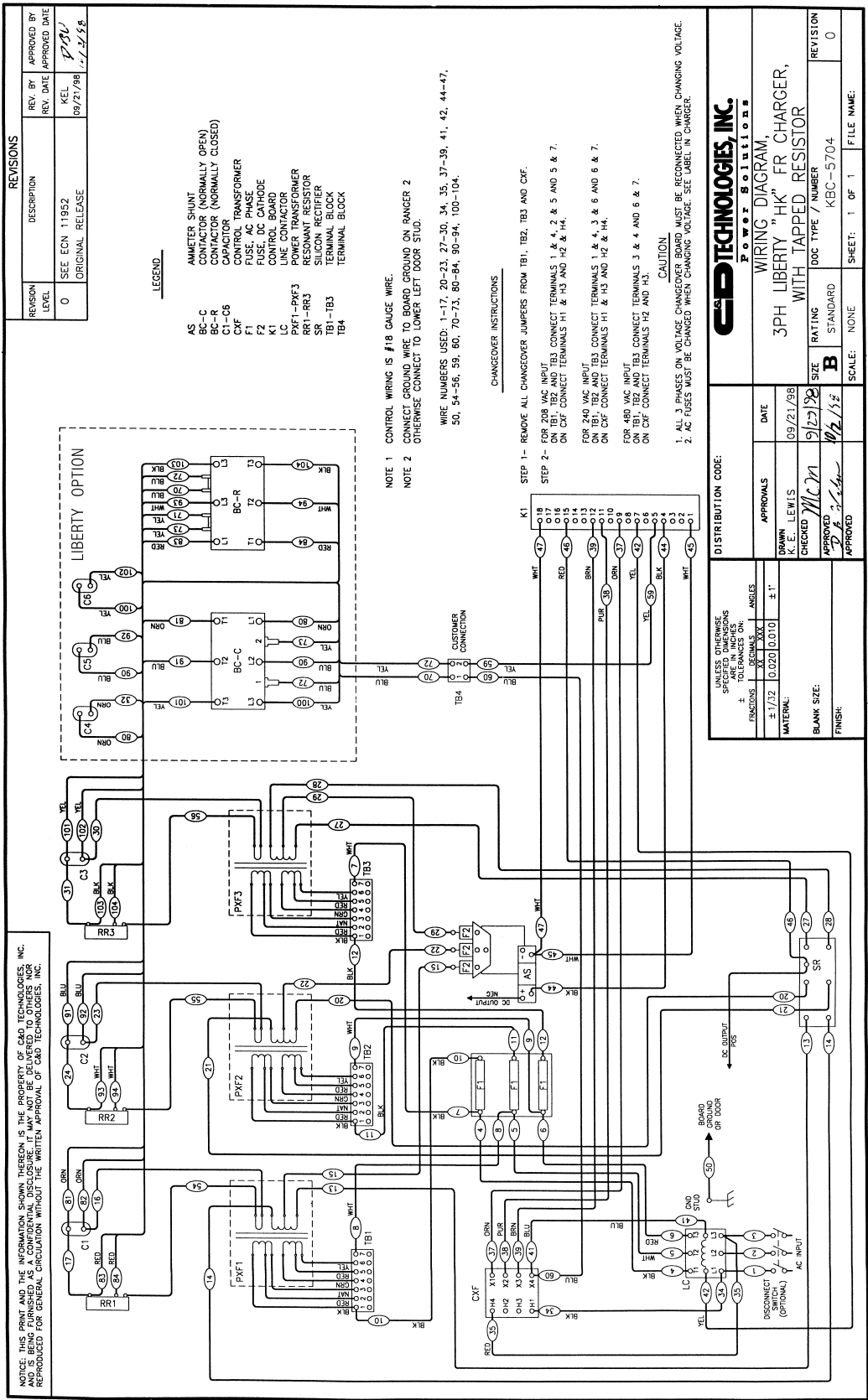
9.4 Wiring diagrams for FERRO FIVE LIBERTY SERIES (continued)



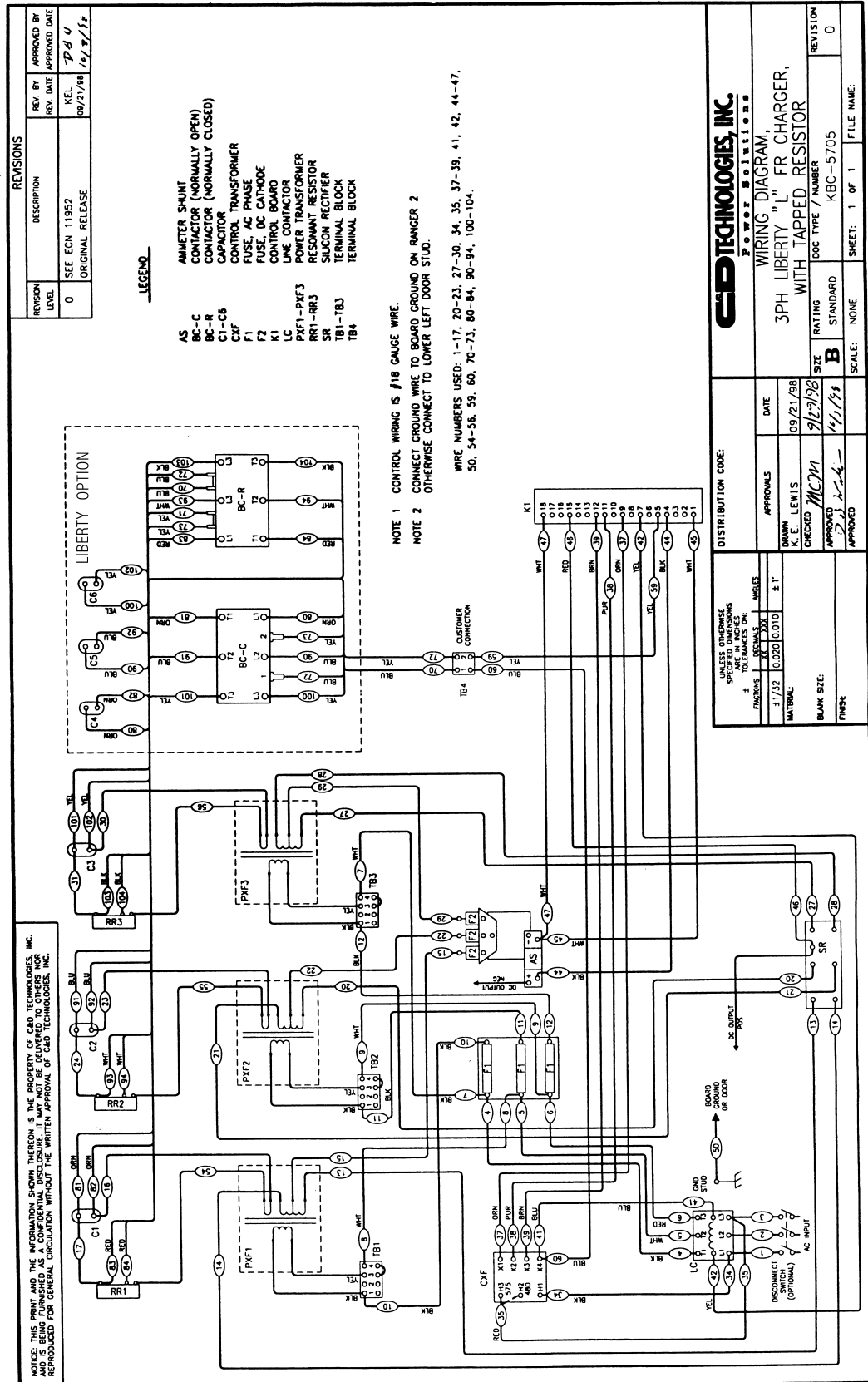
9.4 Wiring diagrams for FERRO FIVE LIBERTY SERIES (continued)



9.4 Wiring diagrams for FERRO FIVE LIBERTY SERIES (continued)

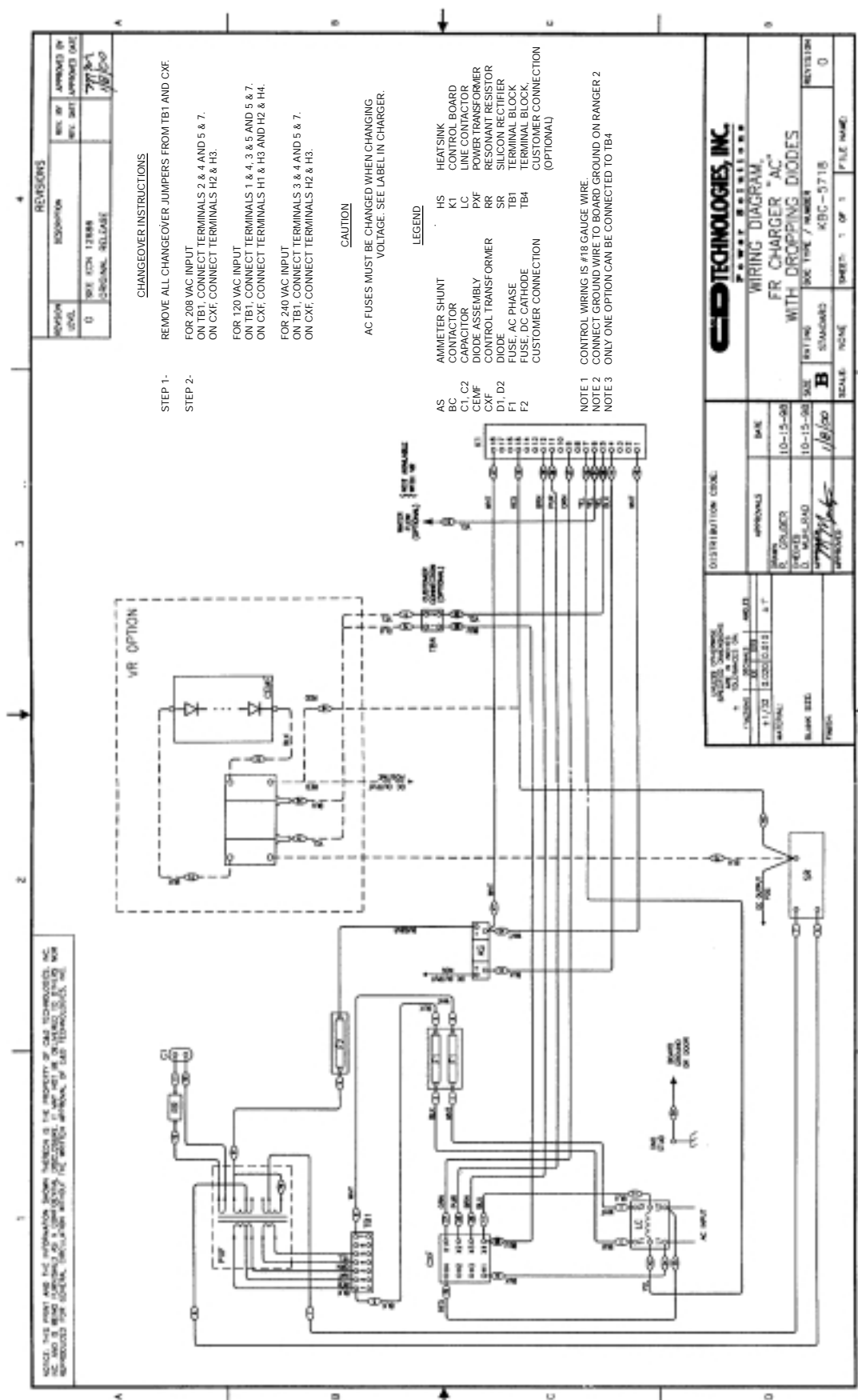


## 9.4 Wiring diagrams for FERRO FIVE LIBERTY SERIES (continued)

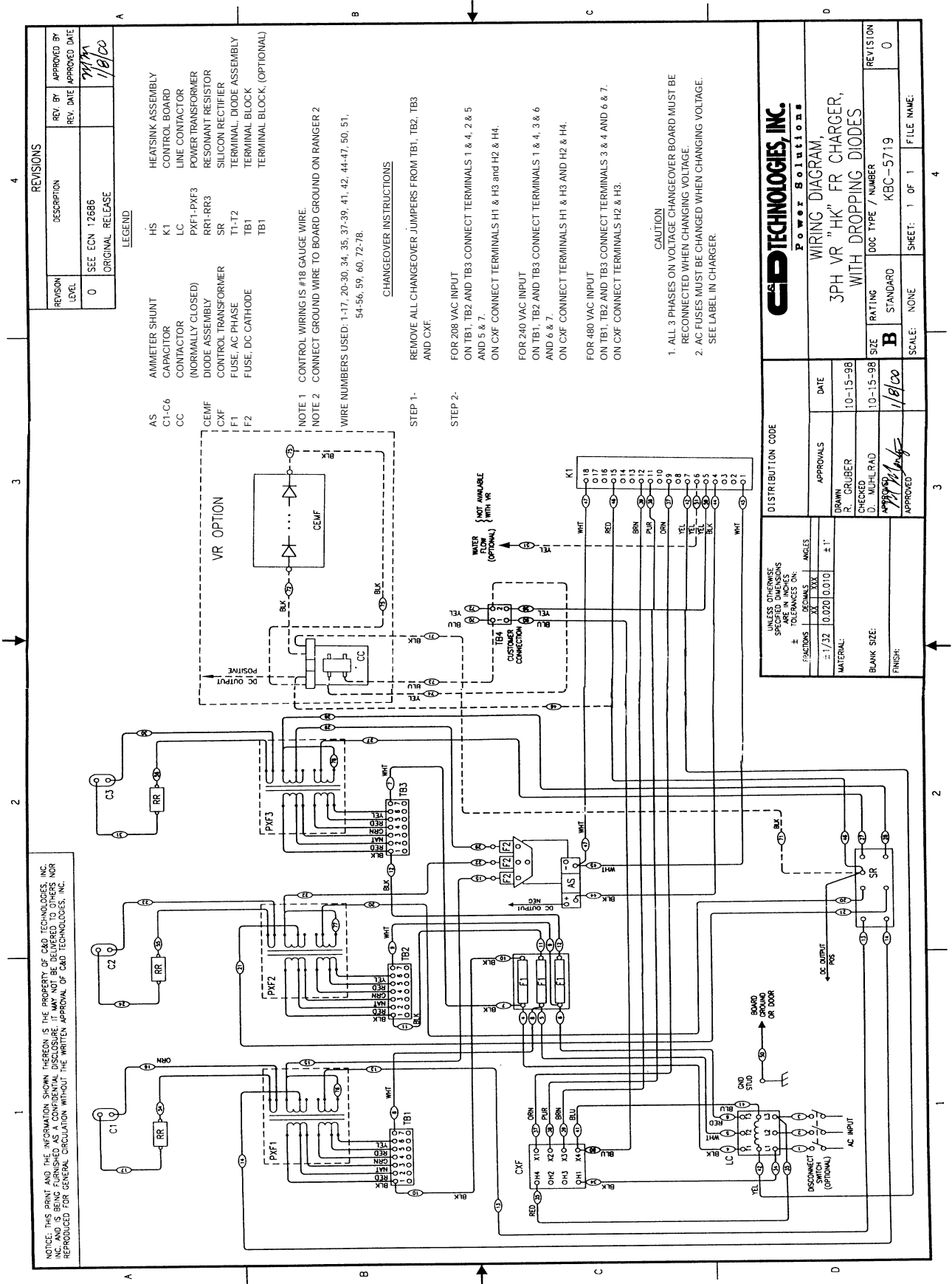




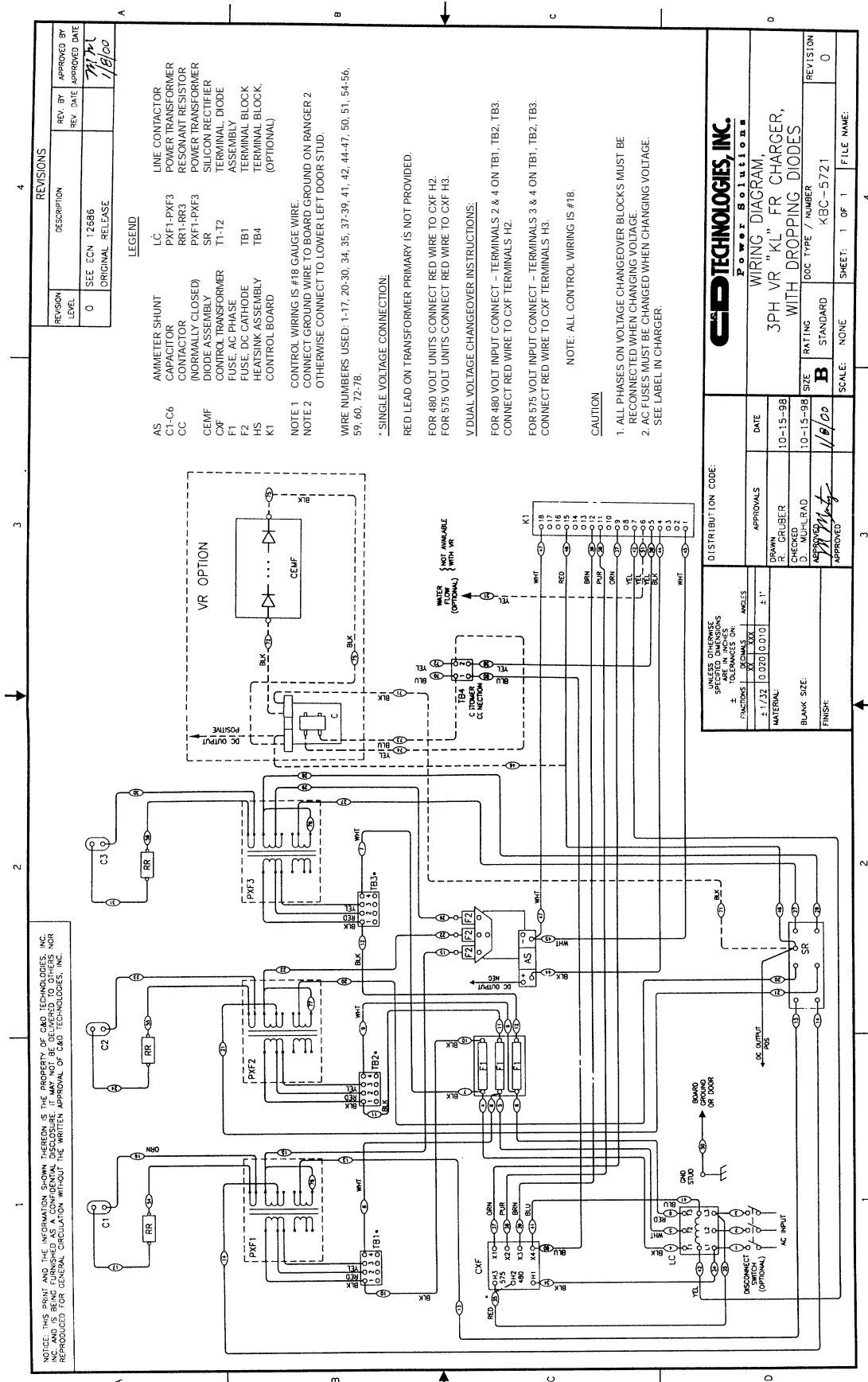
## 9.5 Wiring diagrams for FERRO FIVE REVOLUTION SERIES (continued)



9.5 Wiring diagrams for FERRO FIVE REVOLUTION SERIES (continued)



### 9.5 Wiring diagrams for FERRO FIVE REVOLUTION SERIES (continued)







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