TRACE ENGINEERING

OWNERS MANUAL

MODEL 2012

2 STAGE CHARGER - INTERNAL TERMINAL BLOCK

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INTRODUCTION

Trace Engineering Company is a privately owned company founded by four individuals with over fifty years combined experience in electronics design and manufacturing. Established in 1985 with the intent to provide technically superior products, it has become a leader in the field of high performance power inverters.

Historically, the earliest ancestors of the modern inverter were the mechanical vibrating voltage regulators. They were used on cars to regulate the output of their DC generators . The addition of inductors and voltage doublers allowed them to step up car battery voltage to run vacuum tube radios. Vibrator technology had some drawbacks. While surprisingly dependable they emitted considerable RF, could only handle low currents, and frequency was spring tension.

Vacuum tubes were successfully used by the military and others for high power inverters. However, these converted high voltage DC to high voltage AC. Vacuum tubes require high voltage to operate effectively and since most battery banks range from 12 to 48V, there is no high voltage source until the inverter is running. Besides, the power consumed to heat the filaments makes efficient tube inverters impossible.

The advent of the silicon junction resulted in several new devices that make designing efficient inverters possible. The first of these, the germanium transistor, is still used in many inexpensive, non-regulating square wave types.

The field effect transistor (FET) has been recently perfected to the degree that they are used in nearly all modern inverters. In just the time that Trace Engineering has been manufacturing power inverters the price performance ratio of the type of FET's used in the design of our 12 Volt models has improved over 300%. It is with this latest generation of power FET's that the Model 2012 has been designed and this advancement is largely responsible for high powers that are attainable in such a small package.

This manual attempts to explain more than simply how to install the inverter. It is hoped that the reader will be better served when provided with a broader understanding of its abilities and limitations. The manual is divided into sections, but the inverter operates as a whole. Information you are interested in may be included as part of an explanation in another section. So, read it all and if you have suggestions, comments or questions we would like you to send them to us.

Please send in your warranty for validation. You will be sent updates for this manual as well as new product information. Thank you for your confidence. All of its 654 parts (without options) should work together to reliably meet your needs.

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INSTALLATION

ENVIRONMENT - When selecting the operating environment for the inverter please don't think of it in the same terms as other equipment that works with it, e.g. batteries, diesel generators, motor generators, washing machines etc. It is a highly complex device. There are nearly 50,000 silicon junctions in its output devices and integrated circuits. The crystal oscillator runs at 4 megahertz. The drive circuitry timing is accurate to .1 millionth of a second. Genetically speaking, it is a cousin to stereo equipment, television sets or computers. Steps have been taken to improve tolerance to hostile environments. Circuit boards are covered with a protective coating. All electro-mechanical connections use special non-oxidizing compound. Metal components are plated. However, in a condensing environment (one in which humidity and/ or temperature change cause water to form on components) all the ingredients for electrolysis are present - water, electricity and metals. In a condensing environment the life expectancy of the inverter is indeterminate and the warranty is voided.

Install the inverter in a dry, protected location.

Locate the inverter as close to the batteries as possible in order to keep the batteries cables short. However, do not locate the inverter in the same compartment as the batteries. Batteries generate hydrogensulfide gas which is very corrosive to electronics equipment - and everything else. They also generate hydrogen and oxygen. If accumulated, this mixture would be ignited by an arc from the connecting of battery cables or the switching of the relay in the standby model.

Do not mount the inverter in a closed container. If unrestricted air flow is not available to cool the heat sink and the unit is run at high power, the protection circuitry will quickly reduce the surge power and eventually turn the unit off.

Using the four holes with grommets, the unit may be mounted in any position. However, the best continuous power performance will be attained by mounting it on a shelf with its heat sink near the edge.

In RV and marine installations it is advantageous to mount the inverter so that it is isolated from vibration.

Treat the inverter as you would any fine piece of electronic equipment.

Important - BEFORE SETTING ANY INTERNAL SWITCHES DISCONNECT THE INVERTER FROM THE BATTERY. Touch the heat sink to discharge any static charge in your body. Remove the two No. 6 screws from the lexan cover and set it to the side carefully.

CONFIGURATION/INTERNAL SWITCHES - The Model 2012 has several adjustable features. The following gives descriptions, factory settings and information for alternate settings.

Search Mode Threshold: In order to minimize the no load power drain, the inverter's output is reduced to small test pulses when there is nothing being run. This pulse is used to detect the presence of a load. The threshold at which a load is detected is adjustable. The factory setting is for the most sensitive position of 1 watt. There are conditions when this is not desirable. For example: household wiring may have enough capacitance to appear larger than 1 watts; when the inverter is used as an uninteruptable power supply the search mode is best defeated entirely.

In the search mode the inverter makes a ticking sound. In the 120V mode it makes a steady humming sound.

Sensitivity is adjusted by switch #1. It is the 4 element DIP (dual in-line package) switch located 1.5 inches up and 3 inches from the right hand side of the circuit board. Figure #2 gives the switch settings and corresponding thresholds.

Refer to figure #1 for the location of switch #1.

Use the wooden stick supplied to change switch settings.

Figure #2 - Search Mode Sensitivity

Switch #1

Threshold in Watts	1	2	3	4
1	ON	ON	ON	ON
2	ON	ON	OFF	OFF
6	ON	OFF	ON	OFF
16	ON	OFF	OFF	ON
40	ON	OFF	OFF	OFF
Defeated	OFF	--	--	--

Switch Position

Transfer mode (standby only): The decision to transfer from inverter mode to battery charger mode and return to inverter mode can set to function in either of two ways:

Grid Condition Transfer - This mode makes decisions to transfer based upon whether or not there is 117VAC at the inverter's 117VAC INPUT terminals. The factory setting transfers on grid condition.

Battery Voltage Transfer - The decision to transfer to battery charger mode can be based on battery voltage. This is the voltage transfer mode. The voltage transfer feature allows you to select the battery voltage at which transfer is made to charger mode and the voltage at which it returns to inverter mode. With the voltage transfer feature enabled, if there is no 117 VAC input to the inverter, the unit defaults to inverter mode. The factory voltage setting for transfer to charger mode is 11.4V. Return to inverter mode is set for 13.5V. Figure #2 gives the appropriate switch positions for the optional voltages. Switch #3 controls transfer settings.

Refer to figure #1 for the location of switch #2.

Use the wooden stick to change switch settings.

Battery charger (standby only): The battery charger is a constant current / voltage limited design. It charges at the set charge rate until the set battery voltage is approached. It then tapers to a zero charge rate at the set battery voltage. See the "Performance Graphs" section for charge rate curves. Factory settings are maximum charge voltage 13.6 volts, and maximum charge rate 110 amps. The battery charger can be defeated.

If DC loads are connected to the battery while the battery is charging, the charger will compensate for the load - up to 120 amps. Rather than limit the charge rate to the maximum the unit can deliver on a continuous basis, the charger is designed to be able to delivery greater charge rate than it is capable of sustaining continuously. Therefore, with large capacity batteries or large DC loads, is possible that the charger will thermally cycle.

Switch #2 sets charge rate, limiting voltage and battery charger enable/defeat.

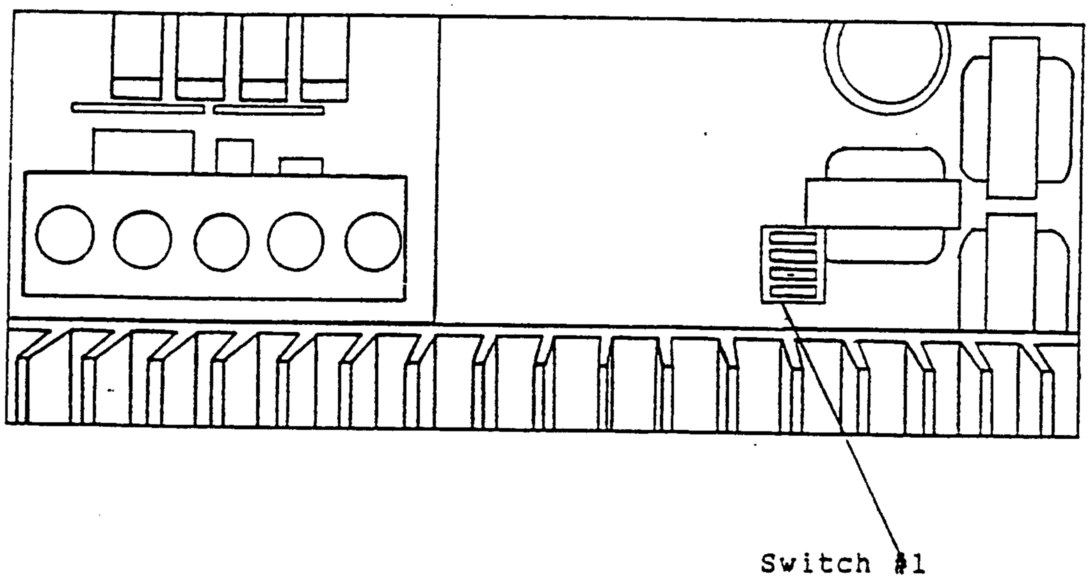
Figure #3 shows switch settings.

Refer to figure #1 for the location of switch #2.

Use the wooden stick to change switch settings.

Figure #1 Switch Locations

STANDARD MODEL



STANDBY MODEL

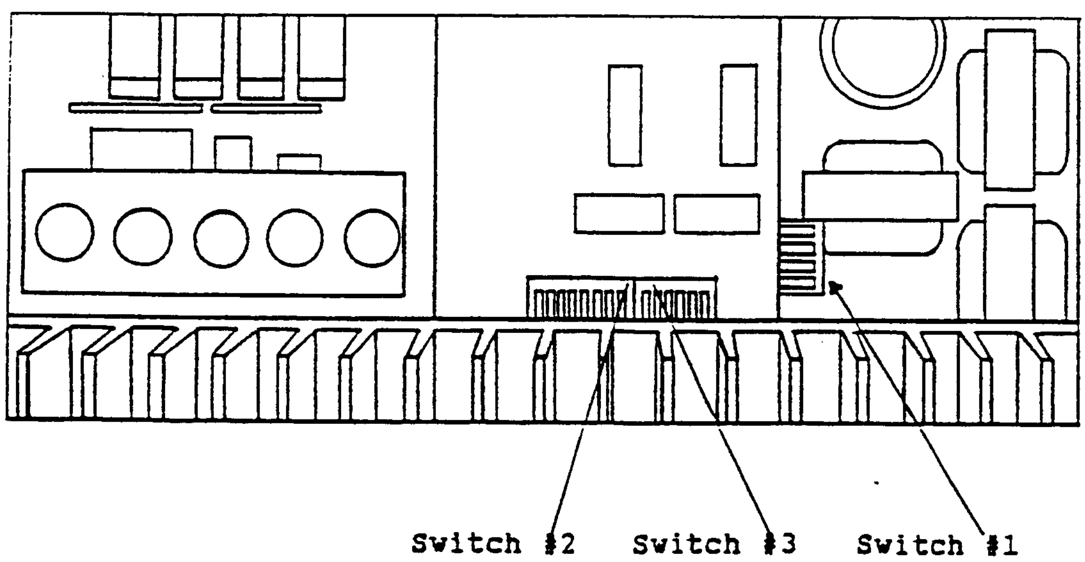


Figure #3 - Setting for Switches #2 and #3

Charger Parameters/Enable Functions

Switch #2

	1	2	3	4	5	6	7	8
Grid transfer enable	OFF	--	--	--	--	--	--	--
Battery transfer enable	ON	--	--	--	--	--	--	--
Battery charger enable	--	ON	--	--	--	--	--	--
Maximum charge rate 2	--	ON	--	--	--	OFF	OFF	OFF
Maximum charge rate 20	--	ON	--	--	--	OFF	OFF	ON
Maximum charge rate 40	--	ON	--	--	--	OFF	ON	OFF
Maximum charge rate 60	--	ON	--	--	--	OFF	ON	ON
Maximum charge rate 75	--	ON	--	--	--	ON	OFF	OFF
Maximum charge rate 90	--	ON	--	--	--	ON	OFF	ON
* Maximum charge rate 110	--	ON	--	--	--	ON	ON	OFF
* Maximum charge rate 120	--	ON	--	--	--	ON	ON	ON
Maximum charge voltage 13.1	--	ON	OFF	OFF	OFF	--	--	--
Maximum charge voltage 13.6	--	ON	ON	OFF	OFF	--	--	--
Maximum charge voltage 14.0	--	ON	OFF	ON	OFF	--	--	--
Maximum charge voltage 14.3	--	ON	ON	ON	OFF	--	--	--
Maximum charge voltage 14.7	--	ON	OFF	OFF	ON	--	--	--
Maximum charge voltage 15.0	--	ON	ON	OFF	ON	--	--	--
Maximum charge voltage 15.4	--	ON	OFF	ON	ON	--	--	--
Maximum charge voltage 15.7	--	ON	ON	ON	ON	--	--	--

Switch Positions

* Requires at least 164 peak AC volts input

Battery Transfer Settings

Switch #3

	1	2	3	4	5	6
Transfer to grid at 10.1	--	--	--	OFF	OFF	OFF
Transfer to grid at 10.4	--	--	--	OFF	OFF	ON
Transfer to grid at 10.7	--	--	--	OFF	ON	OFF
Transfer to grid at 10.9	--	--	--	OFF	ON	ON
Transfer to grid at 11.2	--	--	--	ON	OFF	OFF
Transfer to grid at 11.4	--	--	--	ON	OFF	ON
Transfer to grid at 11.6	--	--	--	ON	ON	OFF
Transfer to grid at 11.9	--	--	--	ON	ON	ON
Trans. to inverter at 12.9	OFF	OFF	OFF	--	--	--
Trans. to inverter at 13.2	ON	OFF	OFF	--	--	--
Trans. to inverter at 13.5	OFF	ON	OFF	--	--	--
Trans. to inverter at 13.7	ON	ON	OFF	--	--	--
Trans. to inverter at 14.0	OFF	OFF	ON	--	--	--
Trans. to inverter at 14.2	ON	OFF	ON	--	--	--
Trans. to inverter at 14.4	OFF	ON	ON	--	--	--
Trans. to inverter at 14.7	ON	ON	ON	--	--	--

Switch Positions

NOTE: "--" indicates that the switch may be set on or off.

BATTERY CONNECTIONS - **<u>THIS INVERTER IS NOT REVERSE POLARITY PROTECTED</u>**. This means that if the positive terminal of the battery is connected to the negative terminal of the inverter and vice versa the result is the instantaneous failure of nearly every power FET. To compound your misfortune, we can tell what has happened and it's <u>not covered under the warranty</u>. So, pay attention when making the battery connections.

The maximum peak current requirement is 950 amps. This is a considerable amount. If battery cables are too small and/or connections are loose, efficiency and maximum output power are degraded. Small cables or loose connections may also cause heating of the wire and/or terminals which could be dangerous.

Code your battery cables with colored tape or heat shrink tubing. Cable ends must have soldered, copper ring terminals.

Place the ring terminal over the bolt and directly against the inverter's copper terminal. Tighten the 5/16 nut to 20-25 ft./lbs.

<u>Never disconnect the battery cables while the inverter is delivering power or battery charger is operating.</u> Always turn the unit off first.

Battery cables cannot be too large. Figure #4 gives cable sizes that have losses from .1 to .5 at 160 amps input. A .5 volt loss in the cables results in approximately a 6% overall loss in efficiency. Don't use cables that are too small and degrade the efficiency that we have worked so hard to achieve and you have paid so much to have.

Figure #4 - Battery Cable Size vs. Loss

1800 Watts Output/160 Amps Input

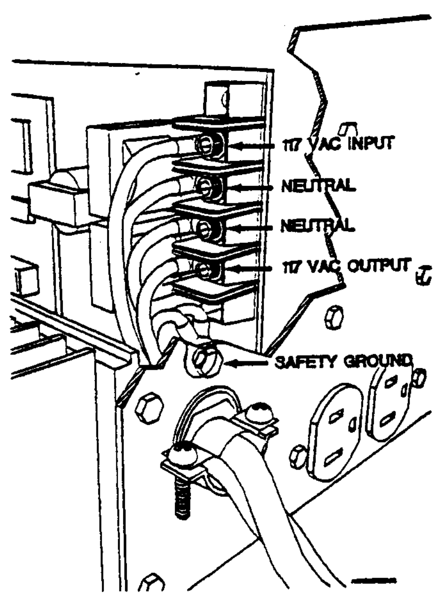
Total Volts Lost in Cables	Length of One Cable / Ft						Peak Output Volts Lost
.5	10	13	16	20	25	32	8.2
.4	8	10	13	16	22	27	5.9
.3	6	8	10	12	15	19	4.9
.2	4	5	6	8	11	13	3.3
.1	2	3	3	4	5	6	1.7
Cable Size	2	1	0	2/0	3/0	4/0	

117 VAC CONNECTIONS - The Model 2012 has one duplex AC outlet and a circuit board mounted terminal strip for 117 VAC connections. On the standard model the terminal strip is used for hardwiring the inverter's 117V output. With the standby option, the terminal strip is also used to hardwire the 117V input. Consult your local code for proper wire sizes, connectors, conduit, etc.

Hardwiring: <u>Disconnect the inverter from the battery</u>. Touch the heat sink to eliminate static charge. Using the Allen wrench supplied, remove the two #6 screws from the clear lexan cover and set it to the side. Using stranded 12 gauge wire at the inverter works best. Solder or crimp on ring terminals. Lead the wires thru the hardwire access fitting. Bend the ring portion of the terminals on the black (hot) and white (neutral) wires 90 degrees. Following the wiring diagram on the side, connect the hot and neutral wires to the terminal block and tighten securely with the Allen wrench . The green (safety ground) wire(s) is connected on the inside to the bolt labeled "Safety Ground". Note that chassis ground is connected to battery negative. This is a negative ground system.

If the factory supplied configuration needs to be altered to suit your requirements, this is a good time to read the section "Configuration/Internal Switches". Otherwise, replace the cover and reconnect the battery - **<u>CAREFULLY</u>**!

Pay attention with the standby model that the output side of the inverter's 117V wiring is at no time connected to the grid or generator. This is far worse than a short circuit. If the unit survives this condition, it will shut down until corrections are made. If the grid is in phase with the inverter when it is connected to the inverter's output, it will continue to run. This could lead to some confusion.



OPERATION

START-UP - When first connected to batteries the inverter will be in the off state. Whenever the batteries are connected, the momentary power switch must be pressed twice to turn the inverter on. Subsequently pressing the on/off switch alternately turns the inverter on and off. An amber LED indicator lamp blinks each time the power switch is pressed to acknowledge the unit has changed states.

PROTECTION CIRCUITRY - The inverter will auto- matically restart itself from the following overload conditions: low battery, high battery, shorted output, over current, over temperature.

The inverter will turn itself off and need to be restarted under the following conditions: (1) if it is put to the ultimate test and has its output connected to the grid; (2) if an attempt is made to start a very large motor; (3) if it encounters a load large enough that the protection circuit reduces the output wave form for approximately 15 seconds.

INDICATIOR LAMPS - There are 5 LED indicator lamps on the Model 2012. The standby option adds one more. The "ON/OFF" and the standby's "CHARGING" LED's are amber. The rest are red.

ON/OFF: This LED lights momentarily when the power switch is pressed to acknowledge that the inverter has either turned on or off depending on its previous state. With the standby model the ON/OFF switch also controls the battery charger function. When batteries are first connected it must be pressed twice.

OVER LOAD: When the load being run demands more current than the inverter can safely supply this LED lights. If the lamp is on while a load is running, it implies a reduced output voltage. Since the protection circuit is temperature compensated, a large load that runs satisfactorily when the unit is cold may begin to trip the protection circuit and light the overload lamp when the inverter is warm. If an overload condition exists for 20 to 30 seconds the inverter will turn itself off and need to be manually reset. The on/off button will need to be pushed twice - first time to clear the overload condition, the second time to turn the unit on.

OVER TEMPERATURE: If the temperature of either the power transformer or the heat sink rise above their designed operating limits, this LED will light until the inverter has cooled sufficiently and restarts itself.

HIGH BATTERY: If battery voltage rises above 15.8V the inverter shuts down and lights this LED. When the voltage has dropped to 14.8V it restarts.

LOW BATTERY: In order to protect itself the inverter shuts down and lights this LED if battery voltage falls below 9V for more than 3 seconds. The unit resets itself after the voltage rises above 9V. Note: LBCO option available for battery protection.

CHARGING (standby option only): This LED indicates that the unit is in the battery charger mode.

STANDBY OPTION - The standby option is factory retrofittable to the standard unit. With it the inverter can be programed to switch to a battery charger mode when grid power is available. Or, it can transfer when battery voltage reaches a predefined level. These parameters are user selected: maximum battery charge rate, maximum charge voltage, transfer configuration (on low battery, on grid failure), low battery transfer voltage, high battery return voltage. See page 5 "Configuration/Internal Switches" for details. Once the batteries and grid are connected to the inverter, all standby functions are automatic.

The standby option is supplied with the Digital Voltmeter switch assembly installed. This simplifies the addition of the DVM option.

Battery charger: The performance of the battery charger is dependent upon the peak voltage available. In order to meet its ratings, 164 peak volts are required. A battery charger uses only the top portion of the input sine wave. Therefore, small variations in peak voltage result in large variations in the amount of the wave form that the charger has to work with. Standard grid power of 117V has a peak voltage of 164V.

It is difficult for a gasoline generator to deliver full peak voltage to the charger. A generator's rating is determined using the power of a complete wave form. When it is asked to produce the high peak currents needed by the charger to charge at its higher settings the generator's voltage wave form may be "flat topped". Running at reduced voltage is not harmful to the charger. The result is that simply increasing charger rate settings may not increase charger output. Typically, a 6000 watt generator is required to obtain maximum charge rate from the inverter. Auxiliary load on the generator may reduce the maximum charge rate.

The output of a modified sine wave or square wave inverter will not have sufficient peak voltage to allow maximum charge rates.

Be sure not to charge your batteries at higher voltages and/or currents than their manufactures recommend. This is a very powerful charger. If misused it may damage your batteries.

Transfer switching characteristics: On switching from grid failure to inverter mode, the inverter will try to "soft start" the load. This keeps the inverter from ever running loads greater than it is able to start. The "soft start" time is about 1/2 second. For use as an uninterruptable power supply the unit should run only off the batteries.

When switching from inverter to grid, the inverter waits several seconds to insure the grid is stable or the generator is up to speed and then makes the transfer in approximately 40 milliseconds.

DIGITAL VLOTMETER OPTION - If you have a standard unit this option is not available since most of its functions pertain to battery charging. If you have a standby unit it will already be equipped with the necessary switch assembly to make installation simple.

Installing the DVM option: Disconnect the battery, just in case you drop a mounting screw. Touch the heat sink to eliminate any static charge. Remove the lexan front cover and set it to the side carefully. Orient the board so the digital readout is at the top. The female connector on the DVM board aligns with the vertical row of pins located 3 inches from the left edge of the mother board. Notice the 4 standoffs that you will be bolting the DVM board to. Align the connectors carefully. Then check again to see that you have aligned the connector properly - the holes on DVM circuit board should match the standoffs on the mother board. Using the 4 #4 philips head screws supplied fasten the board in place. There are holes in the heat sink that will accept a slender screw driver and are positioned in line with the standoffs. Replace the front cover. Reconnect the battery - CAREFULLY!

Digital voltmeter functions:

Battery Voltage - Reads average battery voltage while in standby or inverter mode. Operates with the inverter on or off.

Charge Rate - Reads average battery charge rate.

Source Hz - This is the frequency of the grid or generator which is supplying the power to charge the batteries.

Peak Volts In - In order for the battery charger to deliver its rated current it must be supplied with 164 peak volts. If the source voltage is sinusoidal then the RMS equivalent is 117 VAC (164 / 1.41 = 117). If the peak voltage is above 200 volts, the meter will read "OFL". This condition is dangerous to household electronic appliances - TV's, VCR's, stereo's, etc. Correct this problem at the generator.

APPLICATIONS

RESISTIVE LOADS - These are the loads that the inverter finds the simplest and most efficient to drive. Voltage and current are in phase, or, in this case, in step with one another. Resistive loads usually generate heat in order to accomplish their tasks. Toasters, coffee pots, heaters and incandescent lights are typical resistive loads. While the inverter is happy to run these loads and manufacturers are happier still to publish efficiency curves based on them, chemical energy sources, such as propane, are often more practical to use.

INDUCTIVE LOADS - Anything that has a coil of wire in it probably has an inductive characteristic. Most electronics have transformers (TV's, stereos, etc.) and are therefore inductive. Typically, the most inductive loads are motors. And the most difficult load for the inverter to drive will be the largest motor you manage to start. With inductive loads the rise in voltage applied to the load is not accompanied by a simultaneous rise in current. The current is delayed. The length of the delay is a measure of inductance. The current makes up for its slow start by continuing to flow after the inverter stops delivering a voltage signal. How the inverter handles current that is delivered to it while it is essentially "turned off", affects its efficiency and friendliness with inductive loads. The best place for this current is in the load, and "impulse phase correction" routes it there. The return current of inductive loads is making its second pass thru the inverter. Whenever current is run thru transformers and semiconductors some is wasted as heat. Therefore, inductive loads are run less efficiently.

Induction motors (motors without brushes) require 2 to 6 times their running current to start. The most demanding are those that start under load, i.e. compressors and pumps. The largest of this type that the inverter will run is 1/2 to

3/4 hp. Of the capacitor start motors, typical in drill presses, band saws, etc., the largest you may expect to run is 1 to 1.5 hp. Since motor characteristics vary, only testing will determine if a specific load can be started and how long it can be run.

Universal motors are generally easier to start. The inverter may start up to 2.5 hp universal motors.

If a motor fails to start within a few seconds, or after running for a time it begins to lose power, it should be turned off. When the inverter attempts to start a motor, or any load, that is greater than it can handle it will turn itself off after about 20 seconds. The inverter looks at its RMS voltage output to make the decision to turn off.

CAPACITIVE LOADS - Current is delivered to a capacitive load before voltage is developed across it. This happens because the initial part of each wave looks like a short circuit to the inverter, and it is unable to develop voltage across a short circuit. When a power amplifier is first turned on, the large, empty filter capacitors connected across the inverter's output thru the amplifiers's transformer represent a capacitive load. The inverter has no trouble with this type of load.

PROBLEM LOADS - The Model 2012 can drive nearly every type of load. However, there are special situations in which the inverter may behave differently than grid power.

Very small loads: If the power consumed by the device is less than the threshold of the search mode circuitry, it will not run without the inverter being programmed to stay in the 117V state, or without a small companion load running with it. See the section "Configuration/Internal Settings".

Florescent lights & power supplies: Some devices when scanned by the load sensor cannot be detected. Small fluorescent lights are the most common example. (Try altering the plug polarity-turn the plug over). Some computers and sophisticated electronics have power supplies that do not present a load until line voltage is available. In these cases a "Mexican standoff" occurs with each unit waiting for the other to begin. To drive these loads either a small companion load must be used to bring the inverter out of its search mode or the inverter may be programed to remain in the 117V state. See the section "Configuration/Internal Switches".

Microwave ovens: Microwave ovens are sensitive to peak output voltage. The higher the voltage the faster they cook. Typical grid power varies from 155V to 180V peak. Inverter peak output voltage is dependent on battery voltage and load size. With a small load peak output voltage will be 12.2 times the battery voltage i.e. 160V at 13VDC, 147VDC at 12VDC. The high power demanded by a full sized microwave will drop the peak voltage several volts due to internal losses. Therefore, if battery voltage is low during cooking, the time needed to cook food will be increased.

Clocks: The crystal controlled oscillator will keep accuracy to within a few seconds a day. However, external loads in the system may cause the clocks to run at different speeds. The result being that for some periods the clocks keep time and then will mysteriously not. Most clocks do not draw enough power to trigger the load sensing circuit. In order to operate without other loads present, the load sensing will have to be defeated. See the section "Configuration/Internal Switches".

Searching: If the amount of power a load draws decreases after it turns on, and if the "on" load is less than the threshold of the load sensing, it will be turned alternately on and off by the inverter. For example: the load sensing threshold is set for 16 watts. A ten watt incandescent light is turned on. Cold, the light bulb looks like a 60 watt load, so the load sensing detects it and the inverter output goes to 117V. The filament of the bulb heats, increasing its resistance, and the power drawn drops to 10 watts. Since this is below the load sensing threshold the inverter returns to its search mode and the light goes out.

Ceiling Fans: The most slow turning fans run correctly but make an acceptable amount of noise. The high speed fans operate normally.

Dimmer Switches: Most dimmer switches lose their ability to dim the lights and operate either fully on or off.

Rechargable Devices: Sears "First Alert" flashlights fail when charged by the inverter. "Skil" rechargable products are questionable. Makita products work well. <u>When first using a rechargable device, monitor its temperature for 10 minutes to insure that it does not become abnormally hot.</u>

Electronics: AM radios will pick up noise, especially on the lower half of their band. Inexpensive tape recorders are likely to pick up a 120 hz buzz. Computers should not be run while large loads are being started. If a load is large enough to require "soft starting" it will "crash" the computer.

Low battery dropout: If your battery bank cannot deliver the necessary amperage to drive a particular load without falling below 9V for 3 seconds the inverter will turn off to protect the inverter. With the inverter off the battery voltage will rise and the inverter will resume operation. Since this happens quickly it can be mistaken for a problem with the inverter.

Medical Equipment - The Model 2012 Trace Engineering Inverter is not to be used to run either life supporting equipment or life saving equipment.

ESTIMATING BATTERY DRAIN - The following two formulas are for computing battery drain. The first assumes you know the rating of the load being driven in watts, the second in amps:

Battery drain (amp/hours) = (Watts X Minutes) / 662
Battery drain (amp/hours) = (Amps X Minutes) / 5.52

The table in figure #5 can be used to help estimate battery requirements.

Load (watts)	Load (amps)	Typical Device	Time in Minutes: 5	15	30	60	120
60	.5	B&W TV	.5	1.4	2.7	5.4	9.1
100	.9	Computer	.8	2.7	4.5	9.1	18.1
200	1.7	Color TV	1.5	4.5	9.0	18.1	36.3
400	3.4	Blender	3.0	9.1	18.1	36.3	72.5
800	6.8	Skil saw	6.0	18.1	36.3	72.5	90.1
1000	8.5	Toaster	7.6	22.71	45.3	90.1	111.1
1200	10.3	Microwave	9.3	27.8	55.6	111.1	174.2
1800	15.4	Hot Plate	14.5	43.5	87.1	174.2	348.4
			Amp/Hours				

Figure 5 - Table of Watts out vs. Time vs. Battery Drain

PRODUCT DESCRIPTION

OVERVIEW - The Model 2012 was designed to excel in the following areas:

Efficiency: In order to run efficiently the primary types of power transfer losses must be minimized.

(1) **Transformer** losses - The transformer design significantly affects the ultimate efficiency. The characteristics that make a transformer efficient at high power make it inefficient at low power. This design favors high power efficiency and uses sophisticated search mode circuitry to maintain efficiency at low power. Special winding techniques previously used only in very high power inverters are employed and further enhance high power performance.

(2) **Transistor Losses** - The FET's (field effect transistors) used in the output stage act like resistors. The more that are put in parallel the lower their effective resistance. The lower the resistance the lower the losses. This unit uses 36 power FET's in its output stage - a lot. The signal that is used to turn them on and off is important to efficiency as well as reliability. A regulated switching power supply is dedicated to the output stage. With it, they are driven on and off very quickly with the proper voltage to optimize their characteristics.

(3) **Connector Losses** - All connections are tin plated copper to copper with a one square inch surface area. All primary currents are carried in copper buss bar.

(4) **Reactive Loads** - These loads, in which the current is out of phase with the voltage, require the inverter to carry some of the current delivered to the load twice. Efficiency is dependent upon how this current is handled. The "impulse phase correction" circuit returns most of this current to the load where it does useful work.

Reliability: Achieving reliability requires synthesizing a carefully controlled drive circuit design, extensive protection circuitry and sound construction techniques.

A description of the drive circuit design is beyond the scope of this manual, but has been touched upon in the above discussion of efficiency.

The protection circuitry monitors the following conditions: low battery, high battery, short circuit, over current, reverse output voltage and temperature.

Low battery voltage is not harmful to the inverter but could damage the batteries. High battery voltage is not harmful to the inverter either, but results in high peak output voltages which could damage electronic equipment. The over current protection is triggered when load demands exceed the safe operating area of the transistors. Reverse output voltage protection guards the unit from accidental connection to the grid. Limited lightning protections is supplied by surge protection devices in the secondary. Temperature protection is provided by solid state temperature sensors located on the heat sink and transformer. The power that a semiconductor can deliver is in part dependent upon its temperature. Therefore, the protection scheme adjusts the protection parameters linearly according to temperature. This makes the maximum power that can safely be delivered available at all times. If either sensor exceeds a threshold (heatsink-80 deg.C, transformer-110 deg.C) the inverter shuts down.

The construction method uses Motorola's "tight packaging technique". This refers not to the size of the unit, but rather the concept of keeping all drive signal paths as short as possible. With the minimal use of wires and nearly all circuitry contained on one double sided thru-hole plated printed circuit board, consistent performance and reliability are improved.

High Power: The ingredients for high power are a subset of those for high efficiency. High power is high efficiency at high currents. Attaining maximum performance requires protection circuitry that allows full use of the FET's safe operating area. To do this the unit monitors temperature, current and time. The transformer's low DC resistance, the low R-on (the "on" resistance of the FET's) and the smart protection circuitry combine to generate substantial power from the Model 2012's small package.

In order to run loads that require more start power than run power, the inverter must be able to deliver power well beyond its continuous rating for a short period of time. This is the "surge power". Its published value is often determined the marketing department. This is partly because there are no standards for surge power, and partly because it cannot be repre- sented by a simple or single number. For example, the Model 2012 will deliver 45 amps into a 7500 watt load with only 11V batteries. It will light over 6500 watts of incandescent bulbs. More importantly, the inverter can start any load that is on the edge of its time versus power envelope. Which is to say, anything that it can run for at least a few minutes.

Flexibility: The Model 2012 is designed to accommodate a wide range of options. All, except the standby option , may be installed by the user. The standby option can be retrofitted by the factory or an authorized service center.

Standby option (12SB) - Allows the inverter to operate as a programable battery charger. Automatic transfer and return can be set to be triggered by either grid condition or battery voltage. Low battery transfer and return voltages are adjustable. Battery charge rate and maximum charge voltage are user selectable.

Digital Voltmeter (12DVM) - Reads peak AC input voltage, battery voltage, charge rate, and AC source voltage frequency.

Remote Control (RC2000) - Provides duplicate control panel with indicator lights and a digital voltmeter that reads the same functions as the DVM option.

Remote Control (RC/2) - Provides an on/off switch and LED that indicates on, off, search mode and overload conditions. Standard cable as with the RC/1.

Low Battery Protector (LBCO/12) - Monitor battery voltage and current being drawn by the inverter to determine if the inverter should be shut down to protect the batteries.

Stacking Interface (SI/1) - Allows two units to be paralleled for 4000 watts @ 117V.

Turbocharger (ACTC) - Temperature activated fan cooling kit that increases the continuous power rating by 400 watts. It replaces the bottom cover and allows normal convection cooling.

Battery Cables (BC5) & (BC10) - 4/0 flexible 2100 strand cables. Color coded with crimped and soldered copper terminals. Two 5 foot or two 10 foot lengths.

MODEL 2012 SPECIFICATIONS

Rated Power @ 20 deg.C	3000 watts for 6 minutes 2000 watts for 20 minutes 1400 watts continuous
Efficiency	Over 90% from 60 to 1400
Motor Starting Current	45 RMS amps with 11 VDC battery
Input current search	.033 amps / .48 watts in mode .500 amps with search mode defeated 180 amps rated 950 amps short circuit
Load sensing (watts)	Programable @ 1, 2, 6, 16, 40 and defeated
Input voltage below	10.8 to 15.8 nominal 10.8 to 8.8 operation regulated output Below 8.8 subject to low voltage cutout with auto reset
Voltage regulation	120 VAC +/- 2 volts
Frequency regulation	Crystal controlled
Power factor	All conditions allowed 1 to 1
Wave form	Modified sine wave, dynamic impulse phase correction for inductive loads
Reverse polarity	900 amp maximum Small signal series diode protected
Output protection	Passive and dynamic energy push back absorbers
Protection circuitry (with auto reset)	High battery - above 15.8V with return below 14.8V Low battery - below 9V for 3 sec. Overcurrent -instantaneous limiting Linear temperature compensation

Environmental Characteristics	Operating ambient temperature 0 C to +60 C Non-operating ambient temperature -55 C to +75 C Altitude operating to 15,000 ft. Altitude non-operating to 50,000 ft
Dimensions	Height 6.25", width 10", depth 12.4"
Weight	38 lbs.

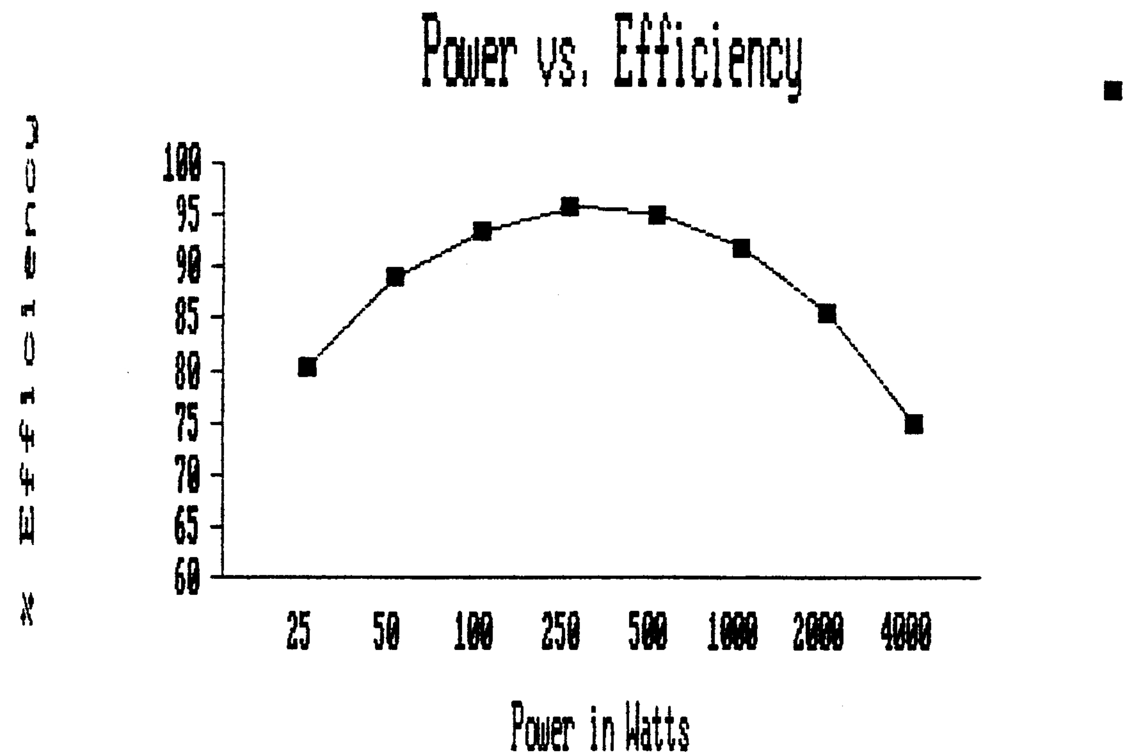
Standby Option Specifications

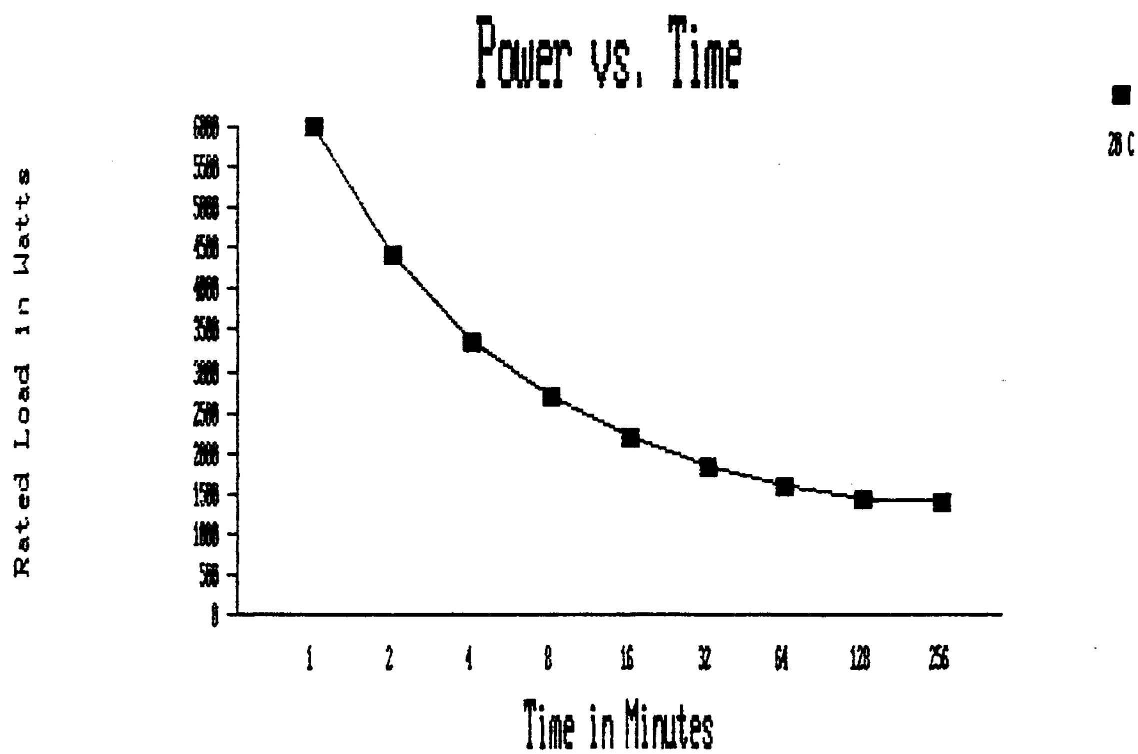
Maximum charge rates	Programmable at 2, 20, 40, 60 75, 110 and 120 amps
Maximum charge voltage	Programmable at 13.1, 13.6, 14.0, 14.3, 14.7, 15.0, 15.4 or 15.7 volts
Transfer voltages	To inverter - programmable at 12.9, 13.2, 13.5, 13.7, 14.0, 14.2, 14.4 or 14.7 volts To grid - programmable at 10.1, 10.4, 10.7, 10.9, 11.2, 11.4, 11.6 or 11.9 volts
Transfer Relay	1 hp 30 amp
Power Consumption	.011 amps / .13 watts

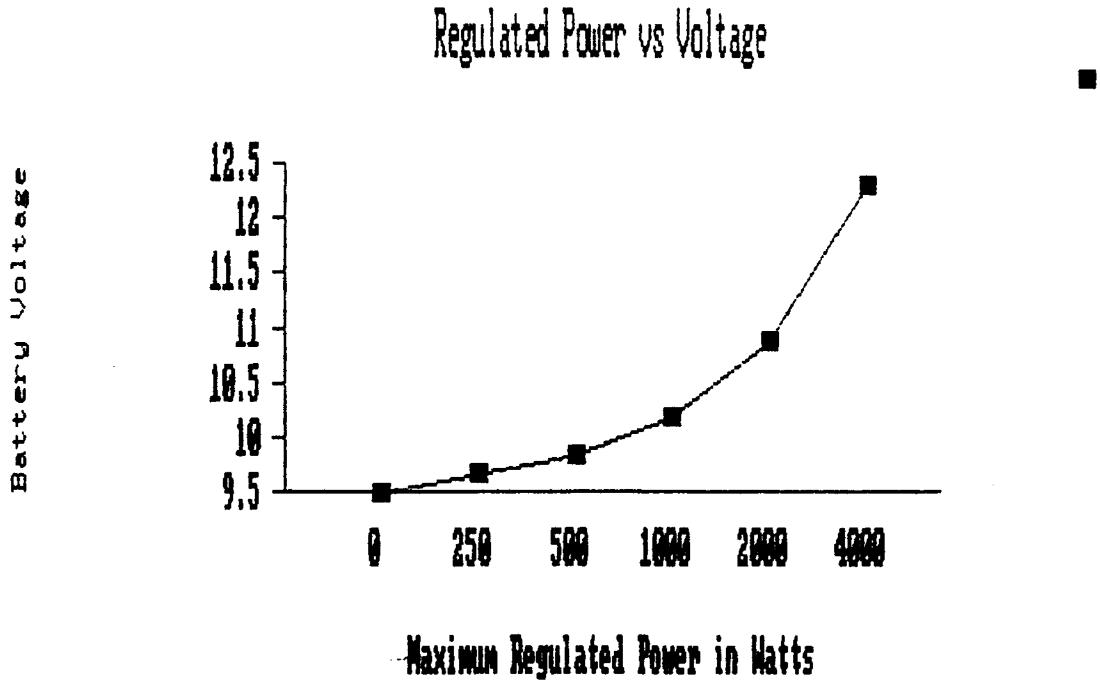
Digital Volt Meter Specifications

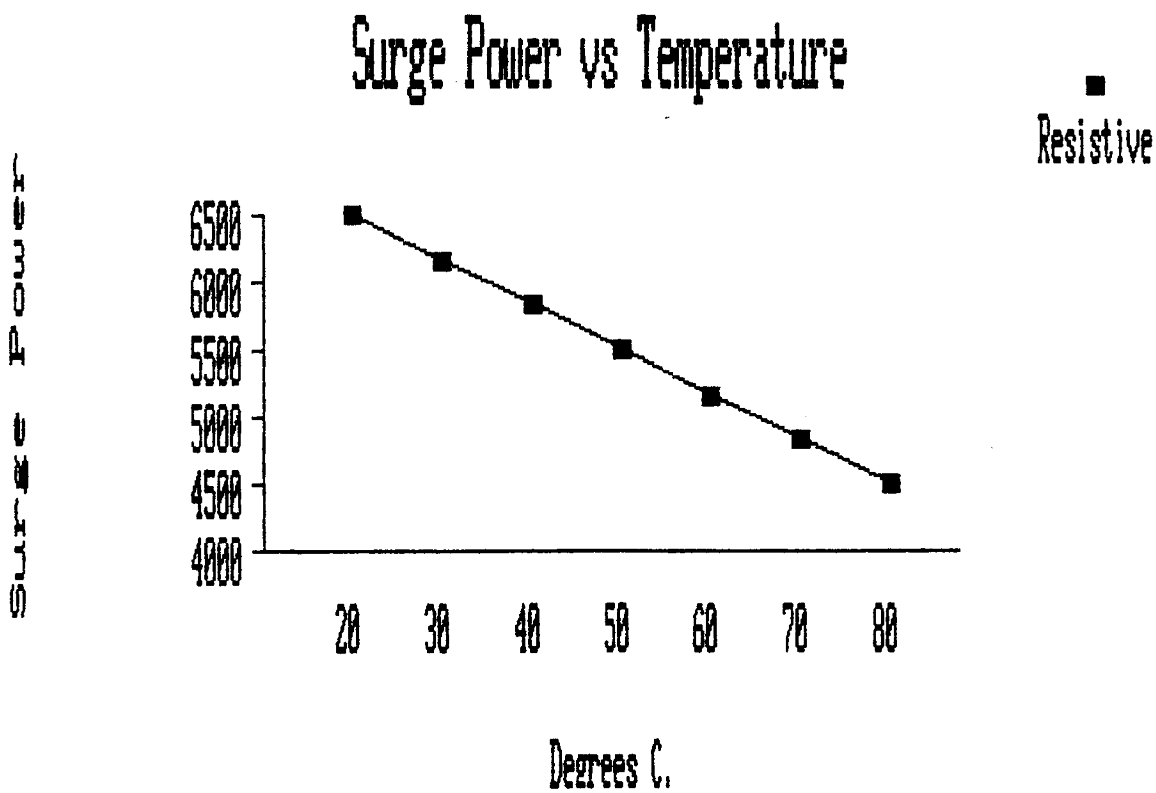
Frequency	40 to 70 Hz +/- 3 digits
Battery Voltage	9 to 16 volts - +/- 3 digits
Peak Voltage	100 to 199 volts - +/- 2%
Charge Rate	0 to 20 amps - +/- 10% 20 to 80 amps - +/- 5% 80 to 120 amps - +/- 10%

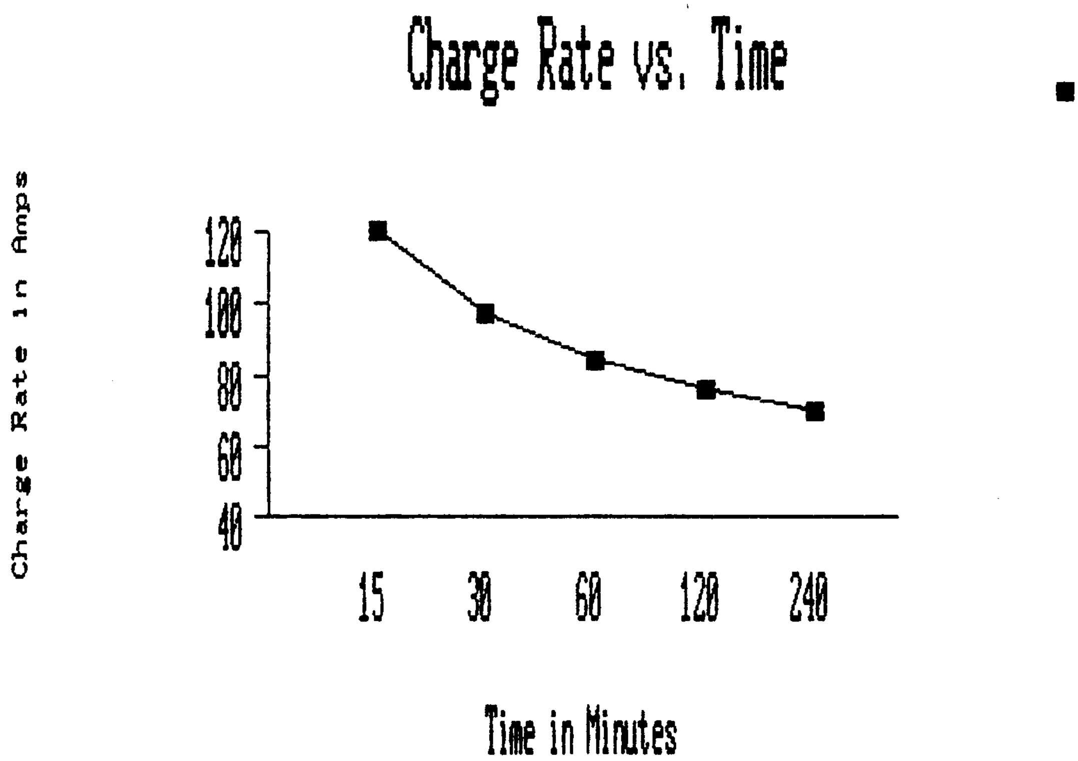
All specifications subject to change without notice.

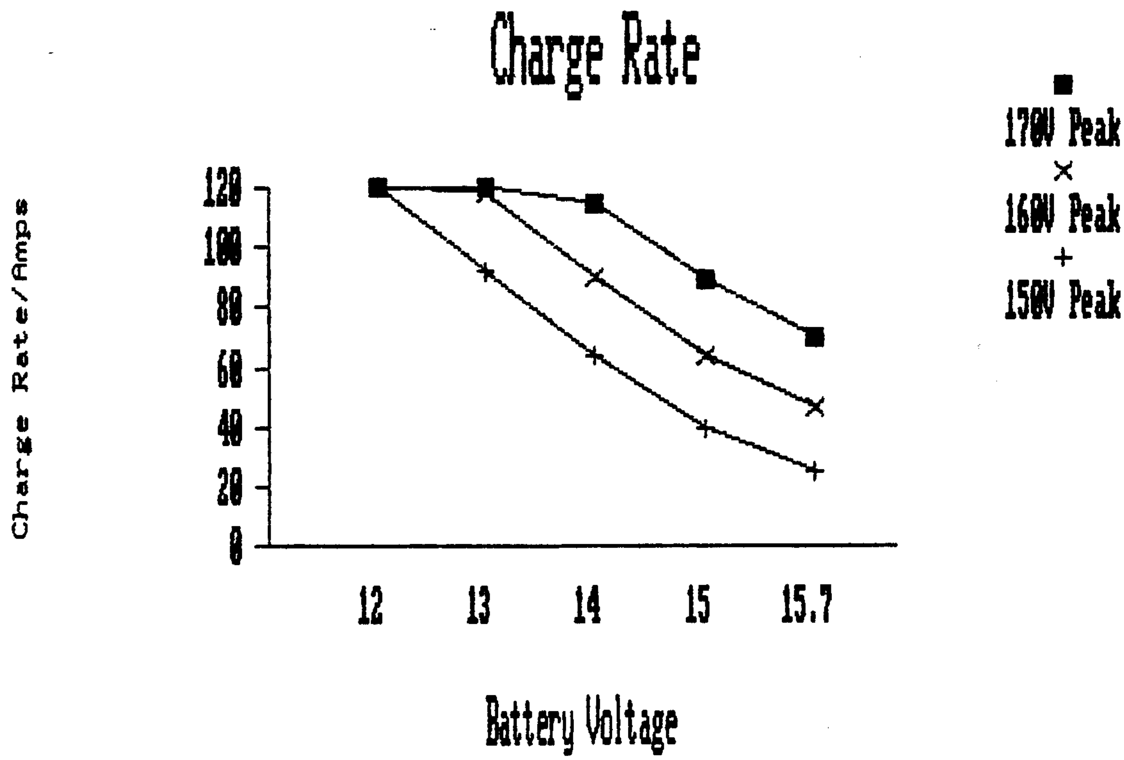

Power vs. Efficiency
% Efficiency
100
95
90
85
80
75
70
65
60
25
50
100
250
500
1000
2000
4000
Power in Watts


Power vs. Time
Rated Load in Watts
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1
2
4
8
16
32
64
128
256
Time in Minutes

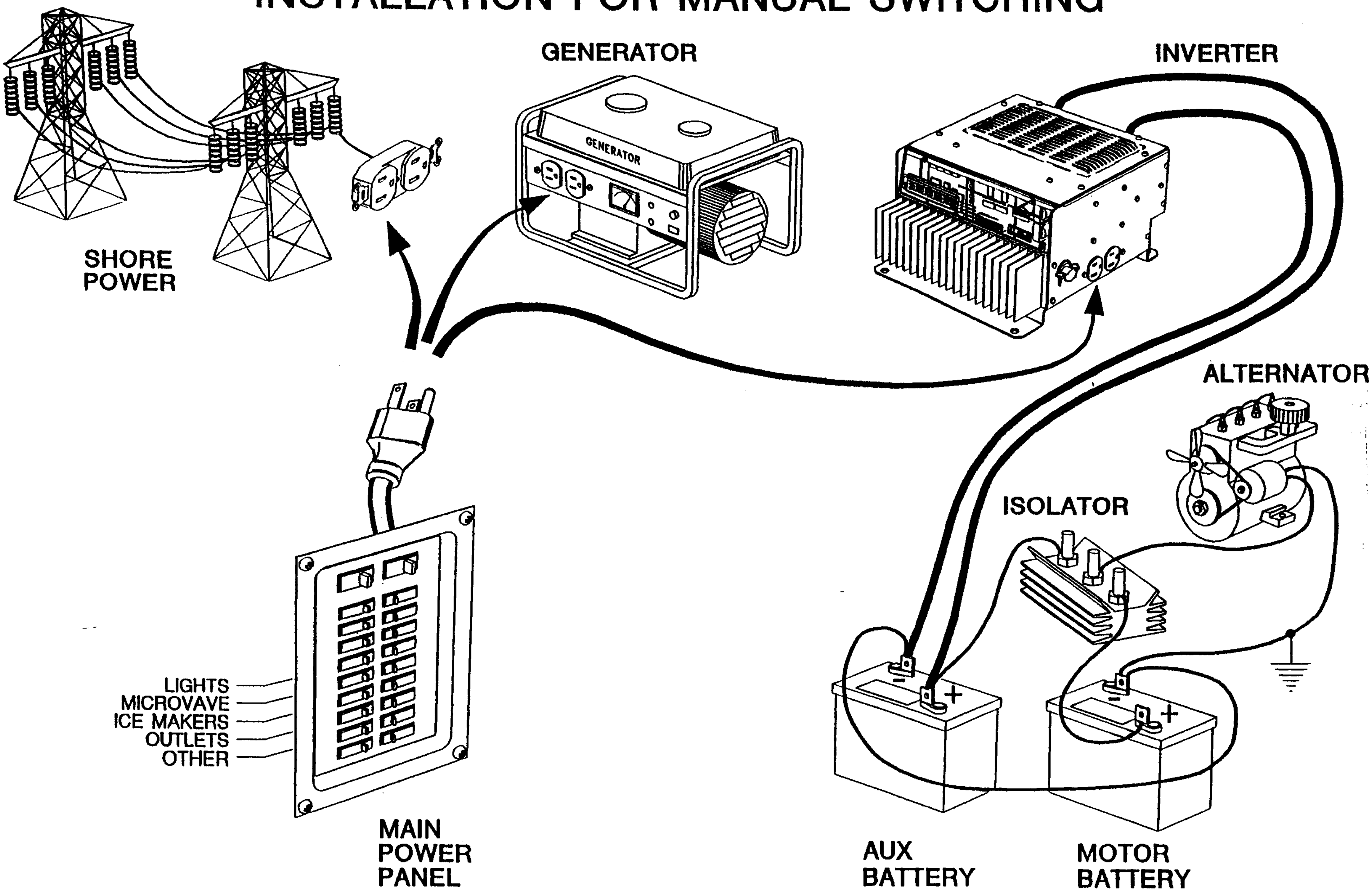

Regulated Power vs Voltage
Battery Voltage
12.5
12
11.5
11
10.5
10
9.5
0
250
500
1000
2000
4000
Maximum Regulated Power in Watts


Surge Power vs Temperature
Resistive
Surge Power
6500
6000
5500
5000
4500
4000
20
30
40
50
60
70
80
Degrees C.

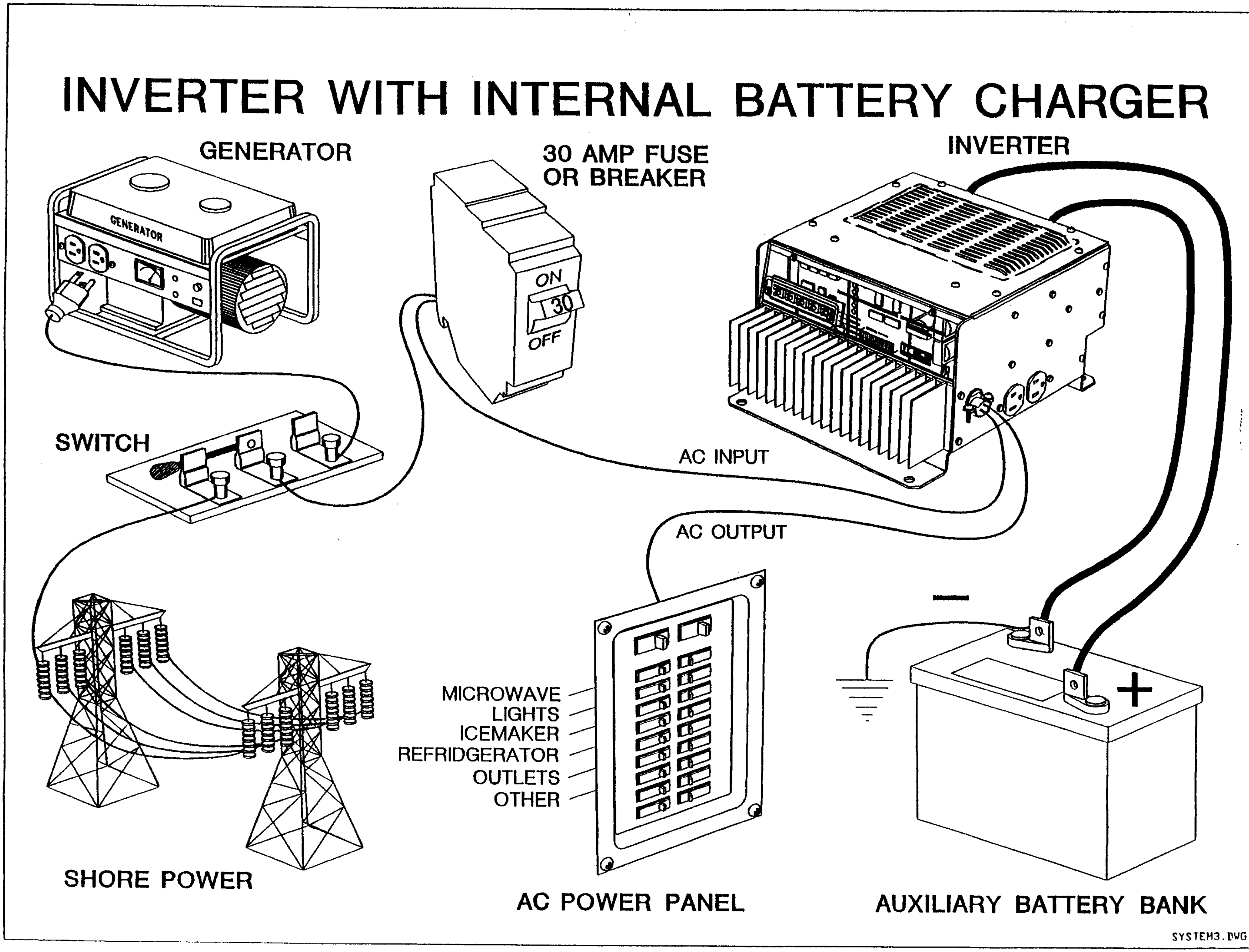

Charge Rate vs. Time
Charge Rate in Amps
120
100
80
60
40
15
30
60
120
240
Time in Minutes

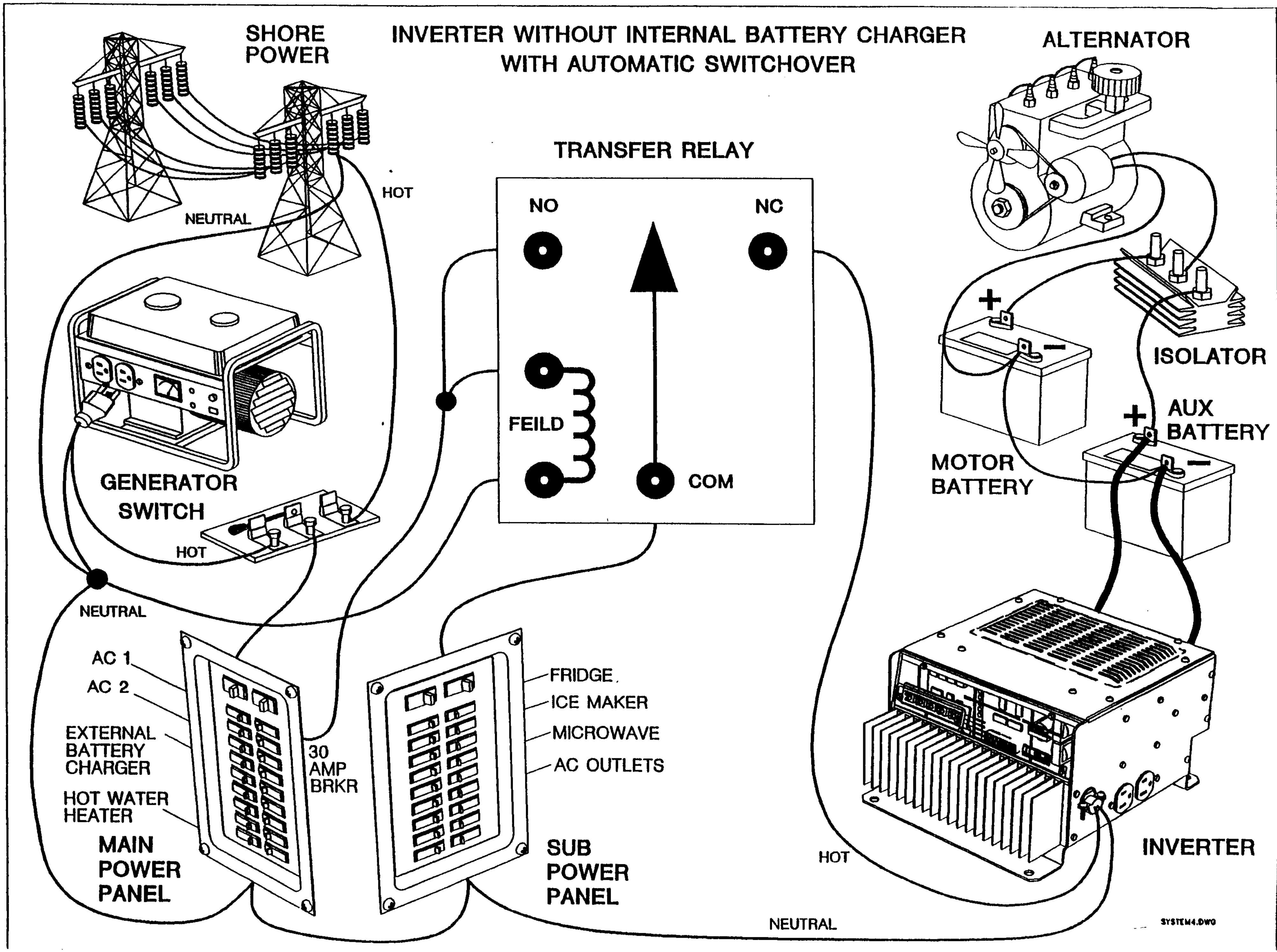

Charge Rate
170V Peak
160V Peak
150V Peak
Charge Rate/Amps
120
100
80
60
40
20
0
12
13
14
15
15.7
Battery Voltage

INVERTER WITHOUT INTERNAL BATTERY CHARGER INSTALLATION FOR MANUAL SWITCHING

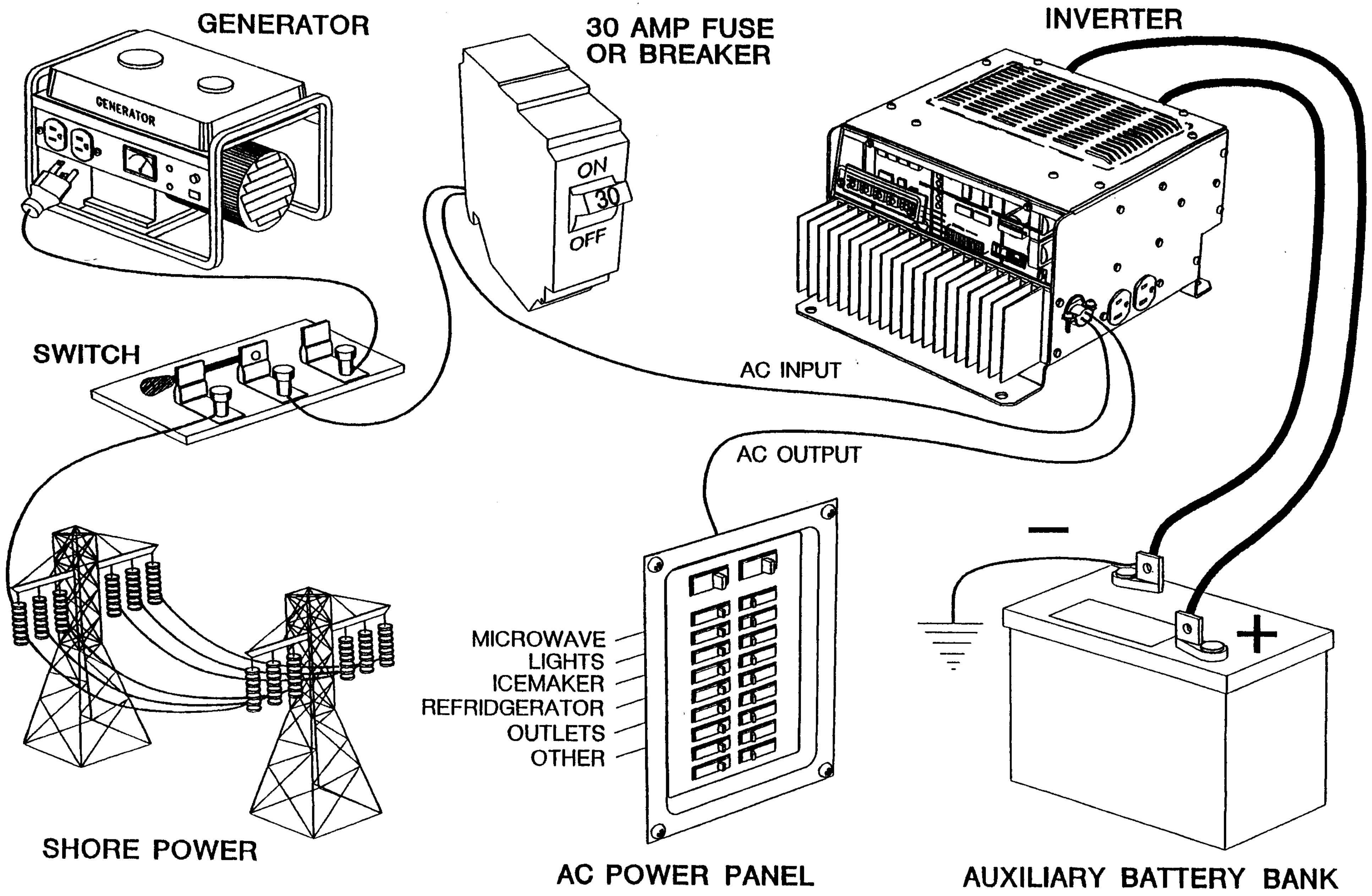


SYSTEM2.DWG

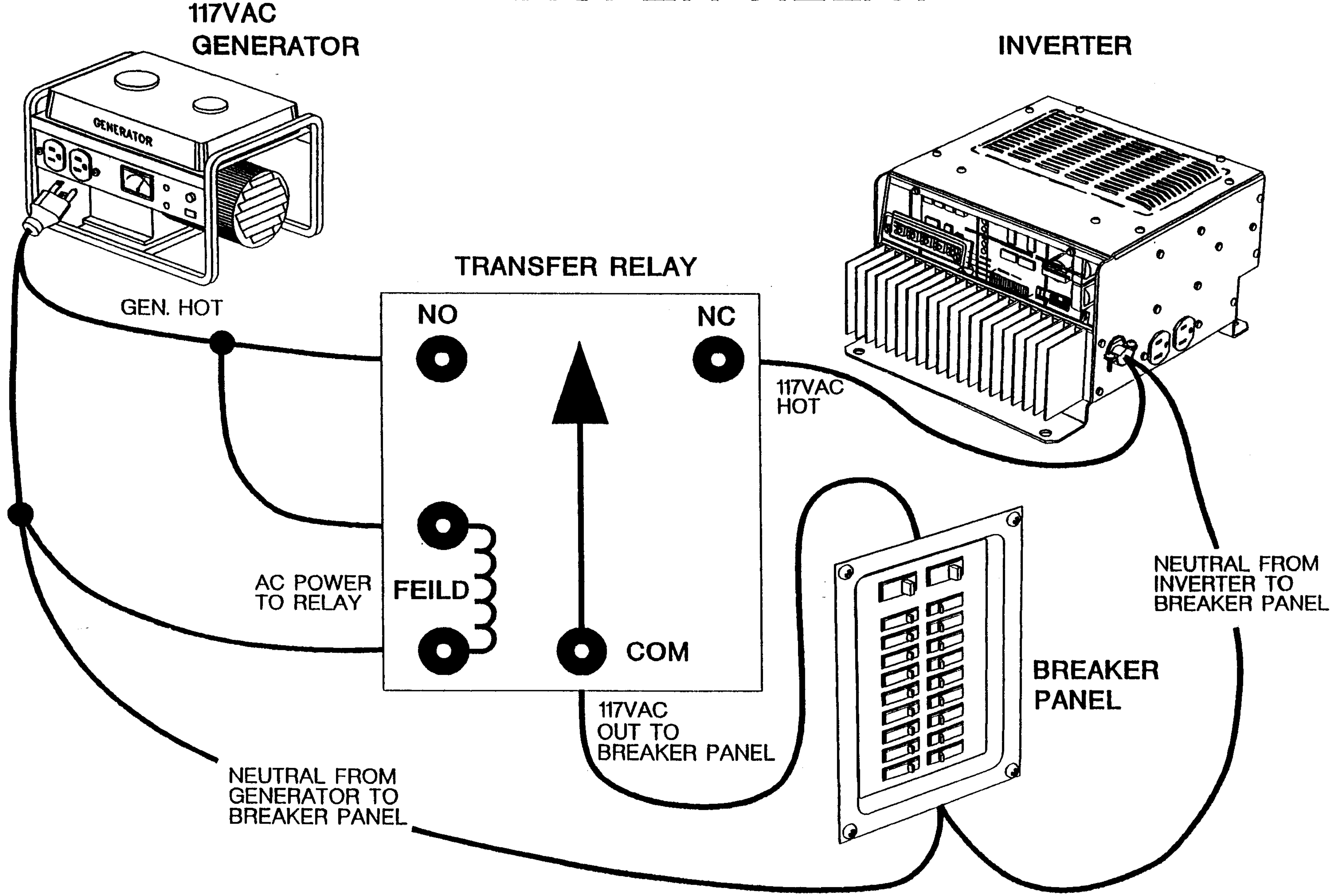

INVERTER WITH INTERNAL BATTERY CHARGER
GENERATOR
GENERATOR
30 AMP FUSE
OR BREAKER
ON
30
OFF
INVERTER
SWITCH
AC INPUT
AC OUTPUT
—
+
MICROWAVE
LIGHTS
ICEMAKER
REFRIDGERATOR
OUTLETS
OTHER
SHORE POWER
AC POWER PANEL
AUXILIARY BATTERY BANK
SYSTEM3.DWG


INVERTER WITHOUT INTERNAL BATTERY CHARGER
WITH AUTOMATIC SWITCHOVER
SHORE POWER
NEUTRAL
HOT
TRANSFER RELAY
NO
NC
FEILD
COM
ALTERNATOR
ISOLATOR
AUX BATTERY
MOTOR BATTERY
GENERATOR SWITCH
HOT
NEUTRAL
AC 1
AC 2
EXTERNAL BATTERY CHARGER
HOT WATER HEATER
MAIN POWER PANEL
30 AMP BRKR
FRIDGE.
ICE MAKER
MICROWAVE
AC OUTLETS
SUB POWER PANEL
HOT
INVERTER
NEUTRAL
SYSTEM4.DWG

INVERTER WITH INTERNAL BATTERY CHARGER



TRANSFER RELAY



Limited Warranty

Trace Engineering Company warrants all Trace Engineeering products against defects in material and workmanship for a period of two (2) years from date of purchase by the original retail purchaser from an authorized Trace Engineering dealer, or two (2) years from date of manufacture, which ever is longer. This warranty extends to all purchasers or owners of the product during the warranty period. Trace Engineering does not, however, warrant its products against any and all defects: (1) Arising out of materials or workmanship not provided or furnished by Trace Engineering, or (2) resulting from abnormal use of the product or use in violation of instructions, or (3) in products repaired or serviced by other than Trace Engineering repair facilities, or (4) in components or parts or products expressly warranted by another manufacture. Trace Engineering agrees to supply all parts and labor or repair or replace defects covered by this warranty with parts or products of original or improved design, at its option in each respect, if the defective product is returned to any Trace Engineering authorized warranty repair facility or to the Trace Engineering factory in packaging providing at least as much protection from damage as the original packaging, with all transportation costs and full insurance paid by the purchaser or owner.

ALL REMEDIES AND THE MEASURE OF DAMAGES ARE LIMITED TO THE ABOVE, AND CONSEQUENTIAL OR INCIDENTAL DAMAGES ARE EXCLUDED, EVEN IF TRACE ENGINEERING HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, ANY AND ALL OTHER WARRANTIES EXPRESS OR IMPLIED, ARISING BY LAW, COURSE OF DEALING, COURSE OF PERFORMACE, USAGE OF TRADE, OR OTHERWISE, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED IN DURATION TO A PERIOD OF TWO (2) YEARS FROM THE DATE OF PURCHASE BY THE ORIGINAL RETAIL PURCHASER.

SOME STATES DO NOT ALLOW LIMITATIONS ON HOW LONG AN IMPLIED WARRANTY LASTS, SO THE ABOVE LIMITATION MAY NOT APPLY TO YOU. SOME STATES DO NOT ALLOW THE LIMITATION OR EXCLUSION OF INCIDENTAL OR CONSEQUENTIAL DAMAGE, SO THE ABOVE MAY NOT APPLY TO YOU. THIS WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS, AND YOU MAY ALSO HAVE OTHER RIGHTS WHICH VARY FROM STATE TO STATE.

Warranty Procedure

TO VALIDATE your warranty the attached warranty card must be filled out and mailed to Trace Engineering within ten (10) days from the date of purchase. It is also advised that you KEEP YOUR BILL OF SALE as proof of purchase, should any difficulties arise concerning the registration of the warranty card.

WARRANTY REGISTRATION is tracked by MODEL AND SERIAL NUMBERS ONLY, not by owner's name. Therefore, any correspondence or inquiries made to Trace Engineering MUST include the model and serial number of the product in question. Be sure to fill in the model and seial number in the space provided below and and keep this portion of the warranty card in a safe place for future reference.

WARRANTY SERVICE must be performed ONLY AT AN AUTHORIZED TRACE SERVICE CENTER, OR AT THE TRACE ENGINEERING FACTORY. It is recommended that advance notice be given to the repair facility to avoid the possibility of needless shipment. UNAUTORIZED SERVICE PERFORMED ON ANY TRACE PRODUCT WILL VOID THE EXISTING FACTORY WARRANTY ON THAT PRODUCT.

FACTORY SERVICE: If you wish your Trace Engineering product to be serviced at the factory, it must be shipped FULLY INSURED IN THE ORIGINAL PACKAGING OR EQUIVALENT; this warranty will NOT cover repairs on products damaged through improper packaging. If possible, avoid sending products thru the mail. Be sure to include in the package:

1. Complete return shipping address (P.O. Box numbers are not acceptable).
2. A detailed description of any problens experienced, including the make and model numbers of any other equipment in the sysem, load, operation environment, time of unit operation and temperature.

Repaired products will be returned freight C.O.D. unless sufficient return shipment funds are included with the unit.

Products sent to the factory from outside the U.S. MUST include return freight funds, and the sender is fully responsible for all customs documents, duties, tariffs and deposits.

RECORD THE MODEL AND SERIAL NUMBER BELOW AND RETAIN FOR YOUR FILES:

Trace ENGINEERING

MODEL ____________________

SERIAL NUMBER ____________________

DATE OF PURCHASE ____________________

Detach this page and mail to the Trace Engineering

Please fill in the following information:

Models and Options: ____________________
Serial Number. ____________________
Purchase Date ____________________

Owners Name ____
Address ____
City ________________ State ________ Zip ________
Phone (   ) ______ - ___________

The following information is appreciated but not required:

Dealer Name ____
Address ____

In what application is your Trace product being used?

- ☐ Home
- ☐ Home with Generator
- ☐ Home with Grid Power
- ☐ Sailboat
- ☐ Powerboat
- ☐ RV
- ☐ UPS
- ☐ Construction site
- ☐ Commercial Power Backup
- ☐ Other

What other products would you like to see Trace manufacture?

____

Comments: ____
____
____

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visit our website at: www.traceengineering.com