CONTENTS

JOHNSON CONTROLS

THE DYNASTY BATTERY

I. THE SEALED BATTERY

The Dynasty battery is an immobilized electrolyte, maintenance-free lead-acid battery which exhibits high capacity and a very long life when properly applied and charged.

The Dynasty battery has a high current capability, very wide operating temperature range, and absence of memory characteristics. As a result of these characteristics and its overall safety, the Dynasty battery is the preferred battery in a variety of portable and standby power applications.

This manual is intended to provide a better understanding of the Dynasty battery operation and charging techniques.

A. Lead-Acid Electrochemistry

The basic components in any fully charged lead-acid battery are lead dioxide (PbO_2) positive plates, a dilute acid (H_2O and H_2SO_4) electrolyte, and sponge lead (Pb) negative plates.

When a lead-acid battery is connected to a load, the stored chemical energy in the plate is converted to electrical energy. During this process the active materials in the plates react with the sulfuric acid in the electrolyte and become converted to lead sulfate ($PbSO_4$) and water. This water dilutes the electrolyte and lowers the specific gravity.

$$PbO_2 + Pb + 2H_2SO_4 = 2PbSO_4 + 2H_2O$$

A totally discharged lead-acid battery would have the active material in the plates mostly converted to lead sulfate with a very dilute electrolyte or water between the plates.

When a charger is connected to the discharged Dynasty battery, water in the electrolyte combines with the lead sulfate covering the plates to regenerate the active lead dioxide positive and sponge lead negative plates. Also regenerated is sulfuric acid raising the electrolyte specific gravity back to the fully charged battery starting point. This process results in a fully charged battery with the active materials ready for repeated reaction.

B. Terminal Voltage

The open circuit voltage of each cell of the Dynasty battery is approximately 2.12 volts. The cell voltage is higher for a battery that has just been taken off charge; but in all instances it should adjust to about 2.12 volts after a period of time.

As the battery is discharged, the terminal voltage will slowly decrease. For example, when the battery's rated capacity is removed over a 20 hour period, the terminal voltage would decrease to 1.75 volts per cell.

C. Capacity Rating

A convenient way to rate and compare batteries is to look at the ampere-hour rating of the battery. An ampere-hour (A.H.) is a unit of energy, therefore, the A.H. rating of a battery is a measure of how much energy is stored in that battery and available for use. Dynasty batteries are rated at the 20 hour rate at 25°C.

This means that a 10 A.H. battery is capable of supplying .50 amperes for 20 hours (.50 amps x 20 hours = 10 A.H.) to an end voltage of 1.75 volts per cell.

Lead-acid batteries are discharge rate sensitive which means that as the discharge rate or current increases, the available energy or capacity at that rate decreases. Using the above example to demonstrate this effect, that 10 A.H. battery would be able to deliver 5.30 amps for 1 hour (to 1.75 V/C) or 5.3 A.H.; roughly half of its rated capacity. To determine the Dynasty battery's capacity or operating time at various loads, consult the specification sheet for the Dynasty battery of interest.

D. Maintenance Free Battery Construction as Related to Life and Performance

LEAD-CALCIUM GRIDS EXCLUSIVELY – The Dynasty battery uses only lead-calcium alloys in the positive and negative grids. The advantages of such an alloy include long float life and low self discharge rate resulting in a long shelf life. This long shelf life is extremely important in products using long distribution networks where it may take up to a year before the batteries are given their first charge since installation and shipment from the factory.

THICK GRIDS AND BATTERY LIFE – One of the main determinants of battery float life is the positive grid thickness. The grid is the lead "screen" that holds the active material and conducts the charge and discharge currents. All other things being equal, the thicker the grid, the longer the float life.

The reason for this dependance of float life on grid thickness is that during normal charging and float operation of all lead-acid batteries, a small amount of the positive grid is oxidized or converted to an oxide. This oxidation slowly reduces the available amount of lead for carrying current and also reduces the contact of the active material to the grid. The net result is a loss of capacity with time.

This positive grid corrosion occurs throughout the life of the battery and is actually minimized by proper float operation. Other factors that influence positive grid corrosion are:

Temperature – Higher temperature increases corrosion and decreases life. Recommended operating temperature for Dynasty batteries is 77°F (70-80°F range is acceptable). Increasing the temperature by 15°F will reduce life by one half. Higher temperatures are especially bad if float voltage compensation is not used.

Float Voltage – Proper float voltage minimizes positive grid corrosion. Long term floating of a battery either below the recommended float range (undercharging) or over the recommended float range (overcharging) increases positive grid corrosion and decreases life.

Acid Specific Gravity – Higher specific gravity acid generally increases positive grid corrosion. This is a relatively small nonlinear effect.

Grid Alloy – Lead-calcium alloys have lower grid corrosion than lead-antimony alloys. Antimony acts as a contaminant in the cell causing an increase in float current which results in more positive grid corrosion.

Contamination – Not a problem with sealed lead-acid batteries but potentially of concern with wet cells. Organic contamination (oils, alchohol, etc.) increases positive grid corrosion.

Depth of Discharge – Thicker grids are better able to resist the mechanical forces generated by deep discharge cycling.

The bottom line is that thicker positive grids are better able to resist the corrosive effects that occur in the lead-acid battery and result in longer life. This is why automotive type SLI batteries with their thin grids optimized for engine starting are not suited for float or deep cycle operation.

E. The Charging Process and Recommendations

The Dynasty battery can be charged using any of the conventional charging techniques. Basically all that is required is that the charger **peak** output voltage be higher than that of the discharged battery. This voltage difference causes a current to flow which is accepted by the battery, converting the $PbSO_4$ coating the battery plates and the H_2O back into the original H_2SO_4; and restores the battery's initial capacity as the process is completed.

OVERCHARGING – If too high a charging voltage is used, causing continued high current flow after a full charge is attained, the water of the electrolyte is decomposed and the battery is aged prematurely.

UNDERCHARGING – When too low a charging voltage is used, the current flow will essentially stop before the battery is fully charged. This allows some of the lead sulfate to remain on the battery plates. This can eventually reduce the available capacity of the battery and prematurely age the battery.

Likewise, if stored in the discharged state for **extended periods,** the lead sulfate could become dense and permanently reduce the capacity of the battery.

RECOMMENDED CHARGING – To assure maximum battery service life and capacity, and favorable recharge times consistent with charger safety and economy, Johnson Controls recommends a constant voltage-limited current charging technique.

The charging voltages, initial current limits and final currents for different batteries are specified in Sections II and III. Typically,

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a JC640 battery (6 volts, 4.0 A.H. capacity) should be charged using 7.2 volts constant voltage peaks with the initial charging current ranging between 600 and 800 milliamperes (3 to 4 times is 20 hour rating current).

Figure 1 illustrates the effect of a current limiting device on the battery voltage when connected to a discharged battery. When the battery is first connected to the charger, the battery voltage is low and the charger will deliver maximum current. As the battery voltage rises, the charger will continue to delivery maximum current until the terminal voltage of the battery reaches the voltage limit of the charger. At this point, the charger voltage will remain constant and the current will decrease and reach a steady value as the battery reaches full charge. The battery is fully charged after a few hours with this low, steady current acceptance.

If a resistor is used as a current limiting device, a taper charger results. A taper charger is a type of charger where the output current is inversely dependant on output voltage (see Figure 2). This profile results because of the voltage drop decrease across the current limiting resistor (output voltage rises), the current drops off. The voltage will rise until it reaches the maximum voltage set point. It will take slightly longer to fully recharge a battery with a taper charger due to the longer time measured to get to the maximum voltage level. The advantage of such a charger is low cost.

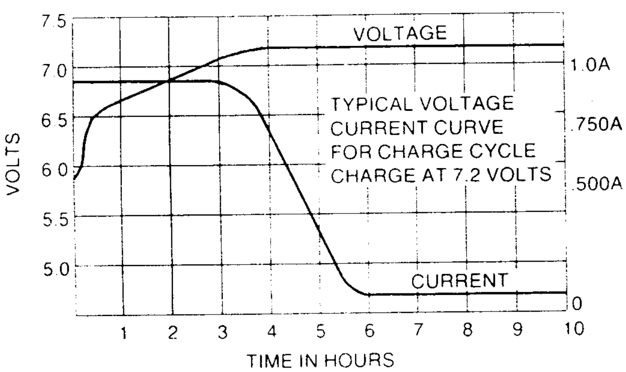


FIGURE 1

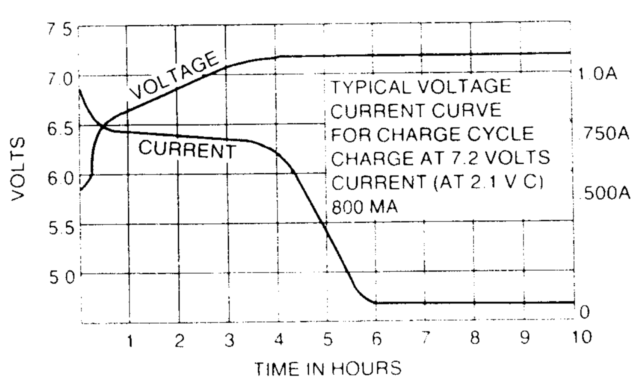


FIGURE 2

STANDBY POWER APPLICATION – CHARGING

II. STANDBY POWER APPLICATIONS

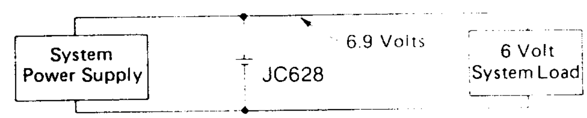
When the Dynasty battery is operated with a continuous charge, such as in emergency power applications, a voltage of 2.25 to 2.30 **peak** volts per cell is recommended. For a 6 volt Dynasty battery, this would be 6.75 to 6.9 volts, while a 24 volt system of Dynasty batteries would require 27.0 to 27.6 volts peak. This float voltage will result in maximum service life at currents as shown below.

Dynasty Battery Rated Capacity in Ampere Hours	Limit Initial Current to (3 to 4 x 20 hr. rate)	Approximate Current End-Of-Charge*
1.0	.15 to .20 Amps	5 to 1 ma
1.2	.18 to .24	8 to 1.5
1.9	.30 to .38	1.0 to 2.0
2.8	.42 to .56	1.5 to 3.0
4.0	.60 to .80	1.5 to 5.0
6.0	.90 to 1.20	3.0 to 6.0
10.0	1.50 to 2.00	4.0 to 8.0
25.0	3.80 to 5.00	10.0 to 20.0

* *Varies somewhat with temperature and age*

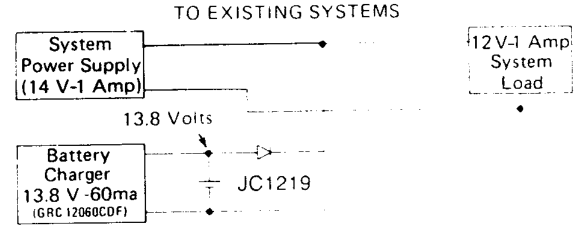
Several methods of setting up a float system are in common use. Shown below are three of the most popular arrangements.

LEAST COMPLEX STANDBY POWER SYSTEM



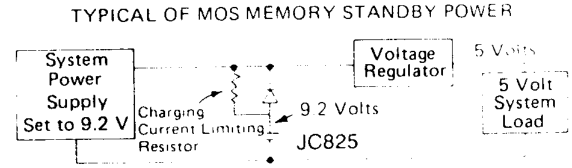
NOTE: The charging voltage and system operating voltage are the same. Usually the power supply must be capable of supplying a large charging current as well as operating the load when commercial power is restored.

OFTEN USED TO ADD STANDBY POWER TO EXISTING SYSTEMS



NOTE: The system power supply and charger battery circuits are separated. Following restoration of commercial power the load continues operation normally while the battery is independently charged.

TYPICAL OF MOS MEMORY STANDBY POWER



NOTE: The current limiting resistor limits the maximum current supplied to charge the battery following a commercial power outage. This allows the load to continue uninterrupted operation and use of a common power supply charging system.

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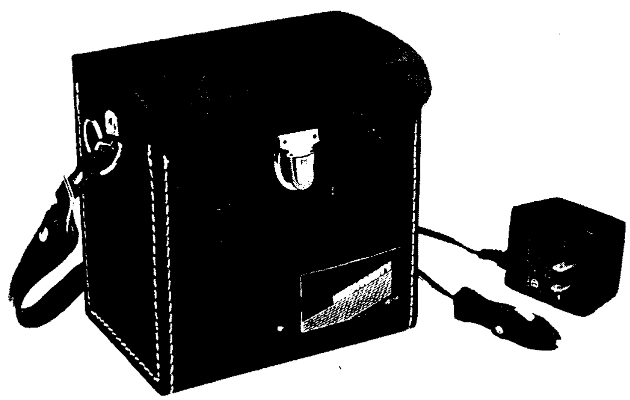
PORTABLE POWER APPLICATIONS – CHARGING

III. PORTABLE POWER APPLICATIONS

Optimum recharge time is obtained when a peak end-of-charge voltage of 2.4 volts per cell is used. This is the voltage measured when the battery has reached a full charge and the charger is still connected. For example, 7.2 volts peak would be measured on a 6 volt Dynasty battery (2.4 volts per cell x 3 cells).

When the battery is fully charged, as indicated by the end-of-charge current shown in the following table, the charger should be disconnected or switched to a float voltage of 2.25 to 2.3 volts per cell.

Dynasty Battery Rated Capacity in Ampere Hours	Limit Initial Current to (3 to 4 x 20 hr. rate)	Approximate End-Of-Charge Current
1.0	.15 to .20 Amps	10- 20 ma
1.2	.18 to .24	20- 40
1.9	.30 to .38	20- 40
2.8	.42 to .56	30- 60
4.0	.60 to .80	50-100
6.0	.90 to 1.20	60-120
10.0	1.50 to 2.00	80-160
25.0	3.80 to 5.00	100-300



COMMENTS ON CHARGING

IV. COMMENTS ON DYNASTY BATTERY CHARGING

The Dynasty battery is used in a variety of applications, many with unique operating or cost considerations. As a result, several solutions have been developed to assure the best battery performance possible under these conditions.

A. Constant Current Charging

When charger cost is the primary consideration, such as in some equipment modification programs, the trickle charge is occasionally selected for the battery emergency power source. This is a constant current charging technique, which in its simplest form, is like force feeding – the battery is forced to receive a constant amount of current regardless of its needs. Although charger component economy is achieved, it is sometimes done at the expense of recharge time or service life if the current is not properly set.

When trickle charging the Dynasty battery, a rate of 0.5 to 2.0 milliamperes per rated amp-hour capacity of the battery is recommended.

This range of currents will maintain the battery at maximum capacity but a very long period will be required to recharge the battery following use.

If the constant current is increased to shorten the recharge time, the battery will be continually overcharged. This will prematurely age the battery.

B. Constant Voltage Charging and Temperature Extremes

The Dynasty battery demonstrates exceptional performance at both low and high temperature extremes. As a result, it has been selected for a variety of unique applications where temperature is a significant factor. Usually it is the low temperature performance which is of most interest to the user.

Figure 1 shows the typical performance of a battery discharged at various temperatures after being charged at normal room temperature. For example, a JC6100 can deliver over 4 ampere-hours capacity at -40°F and over 11 ampere hours at +140°F though rated at 10 A.H. at 70°F.

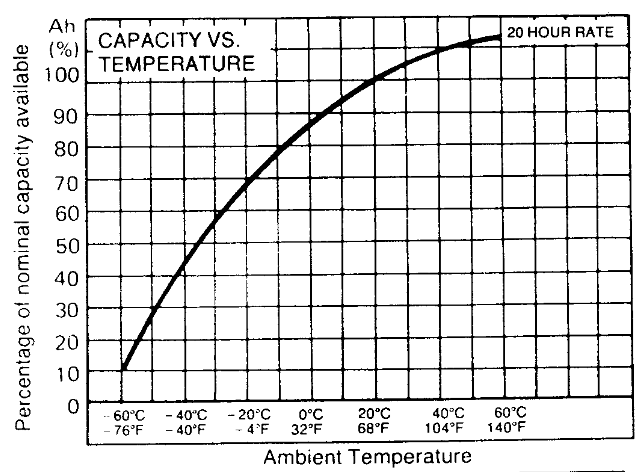


FIGURE 1

This chart is useful for portable power applications where the Dynasty battery is operated outdoors but charged at about 70°F and low temperature standby power applications where it occasionally warms up for a few days.

When the Dynasty battery is operated continuously in standby power applications at temperature extremes (such as within walk-in coolers or in boiler rooms), it may be advantageous to adjust the float charging voltage to assure peak performance and long life. The temperature compensation coefficient needed to maintain a small float current at various temperatures is -.003V/cell/F°

from 77°F. For example, a 6 volt Dynasty battery operated at 100°F should be floated at 6.90 + [3 cells x -.003V/cell/F° x (100-77)] = 6.90 - .207 = 6.70 volts.

It must be remembered that operating at high temperatures even with temperature compensation will result in a shortened battery life. The life of the battery will be reduced by 1/2 for every 15°F rise in battery temperature from 77°F. This means that operating the battery at 92°F will result in a battery with only 1/2 the normal life and at 107°F, 1/4 the normal life would be expected.

C. Charging High Voltage Battery Systems

There are frequent requirements for use of the maintenance free Dynasty battery in standby power systems using 48, 120 and even 240 volts D.C. These requirements are usually encountered where wet lead-acid batteries were previously used. These wet lead-acid systems required not only maintenance to replenish the electrolyte but also occasional overcharging to equalize the cell capacities.

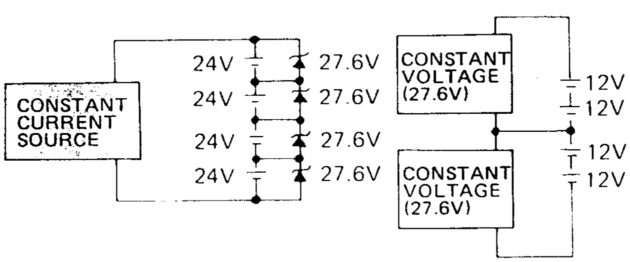
When these higher voltages are required, we normally recommend use of a low input voltage inverter. This provides more service life and simplifies the charging requirements. Maintenance and overcharging for cell equalization are not then required with the Dynasty battery.

Lead-acid batteries are made up of a number of 2 volt cells connected in series. As the number of cells in series increases, the possibility of slight differences in capacity between the cells also increases. These differences can result from age, storage history, temperature variations or abuse. When a single constant voltage charger is connected across an entire string, the same current flows through all cells in the string. Depending on the characteristics of the individual batteries, some may overcharge while others remain in a slightly undercharged condition. This type of charging of high voltage strings is not recommended for extended periods since it can have the effect of prematurely aging the batteries. The effect is similar to that which would result from charging one 10 A.H. and two 4 A.H. 6 volt batteries in series at 18 volts. The 4 A.H. batteries would be fully charged and starting to overcharge when the 10 A.H. battery was only 40 to 50% charged.

When use of the high voltage (such as 84 or 120 volts) string is essential, there are several steps which can be taken to minimize the effects on individual cell/battery differences:

1. Use Dynasty batteries of the same age.
2. Avoid installation near hot spots (i.e., heat sinks and power resistors).
3. Charge the string in 24 volt battery groups with a constant voltage of 2.25 to 2.30 volts per cell.

Typical charging techniques which have been utilized involve either individual constant voltage chargers connected in series or a constant current source with appropriate zener diode regulation across individual batteries or battery groups.

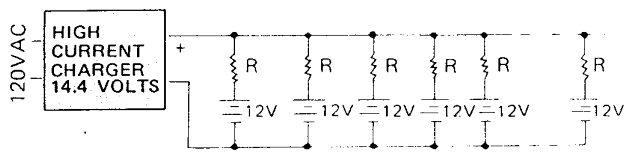


D. Charging Dynasty Batteries in Parallel

One significant advantage of the Dynasty battery is that it may be used in parallel with another battery of the same voltage.

When connected in parallel, the current from the charger will tend to divide almost equally between the batteries. No special matching of batteries is required. In testing, it has been found that if batteries of unequal capacity are connected in parallel, the current will tend to divide between the batteries in a ratio of capacities (actually, internal resistances).

When attempting to charge batteries in parallel where different states of charge are to be expected, such as in a master charging station, it is best to make provisions to insure that the currents will not vary too much between batteries. Adding a small resistance in series with each battery is all that is required.



R = 1.0 OHMS for .9 AH
.5 OHMS for 5.0 AH
.1 OHMS for 20 AH
VALUE OF R IS NOT CRITICAL

E. Battery Charge Time

The current acceptance of a Dynasty battery being charged will vary depending on the rate of the preceding discharge, time since discharge, depth of discharge and, to some extent, battery temperature.

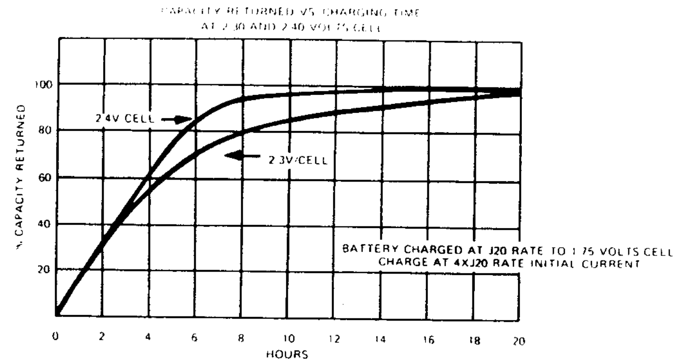
Though it is possible to charge Dynasty batteries very rapidly, this procedure is not normally recommended by Johnson Controls without a full understanding by the user of the results to be expected. Since the Dynasty battery will accept very high currents, we recommend current limiting the charger to reduce its component power ratings while improving its portability, economy and safety.

Also, unlimited current charging increases the electrolysis of the moisture (H_2O) in the electrolyte resulting in increased gassing and premature drying. It can also produce internal heating and hot spots which can also shorten the service life.

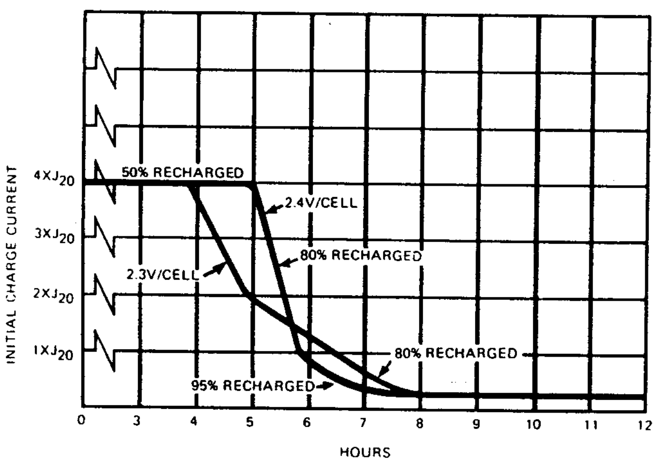
Normally the best overall performance and life is obtained when the current allowed to the battery is approximately 3 to 4 times to 20 hr. rated current (3 to 4 x J20) (i.e., .9 to .12 amp for 6 A.H. battery).

When the recommended constant voltage limited current charging technique is used, the recharge time can be estimated. Naturally, the time will vary with the current limit selected but approximately 110% of the capacity removed will have to be restored to fully recharge the battery. The charger can usually be sized such that the battery can be fully charged in less than 16 hours. However, 80% of the capacity is restored in approximately one-half the time required for a complete charge.

CAPACITY RETURNED VS. CHARGING TIME
AT 2.30 AND 2.40 VOLTS/CELL



EFFECT OF CHARGING VOLTAGE ON
CHARGING TIME
BASED ON INITIAL CURRENT
OF $4XJ_{20}$ FOR BOTH VOLTAGES



When the battery powered equipment cannot be removed from service to allow for normal charging times, we recommend the equipment be designed to allow for convenient removal and replacement of internally mounted batteries or use of an external battery pack. The Dynasty portable power packs are ideally suited for this type of application. While one battery pack is in use, the second pack can be "on charge" at the recommended rates.

By using two Dynasty batteries or power packs and the recommended charge rates, the maximum in safety, equipment "up time" and battery service life is obtained.

F. Measuring Charger Peak Output Voltage

A battery being charged acts similar to a capacitor in that it will attempt to charge to the peak output voltage of the charger.

Therefore, if the charger is not well filtered and has a high ripple, the battery will eventually charge to the peak value of the ripple voltage.

This ripple peak cannot be read on a standard volt-ohm meter. If a charger of this type were adjusted in the open circuit condition using a standard voltmeter, the charge peak output voltage would be greater than the recommended value.

When checking an unknown charger's output voltage, use an oscilloscope to check for ripple. An accurate voltmeter (± 1%) may be used provided a 500 mfd capacitor and 1,000 ohm resistor are connected across the charger output terminal.

G. Sealed Containers and Charging

It is an often overlooked fact that storage batteries will give off hydrogen as a by-product of their normal operation. This is true even of dry cells.

To minimize this effect, Johnson Controls has utilized lead-calcium, rather than lead-antimony, in the Dynasty maintenance free battery. This not only minimizes the gassing results from the electrolysis of the electrolyte moisture (H_2O), but also greatly extends the battery shelf and service life.

When batteries are built into equipment, provision must be made to prevent accumulation of hydrogen, potential ignition and overpressures. When commercial packaging techniques are employed, such as with television sets and emergency lighting equipment, ventilation is usually inherent in the cabinet design and no problem exists.

We are aware of Dynasty batteries discharged in closed containers, such as in underwater electronics, but always caution the designer to make provisions for battery gas generation, **especially when charging.**

TYPICAL CHARGER/POWER SUPPLY SCHEMATICS

V. TYPICAL CHARGER/POWER SCHEMATICS

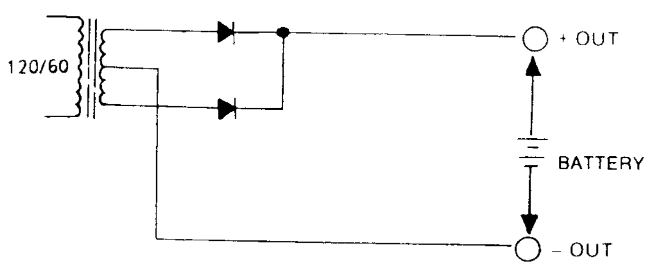
The Dynasty battery is a durable rechargeable battery and has a high resistance to damage from abusive discharge and charging practices. However, if the "designed-in" life is to be realized, the recommended charging techniques should be followed. This is especially true with respect to the recommended voltages for continuous charging of batteries in standby power applications.

The following presents several schematics for chargers which may be built as separate units or built into equipment. Several of these units may also be used as the system power supplier.

A. An Unregulated Charger

A popular charger is the wall plug-in type. These chargers do not incorporate voltage regulation and consequently must be disconnected after a prescribed time to prevent overcharging. This type of charger is also very sensitive to line voltage variations.

A typical circuit is shown below.

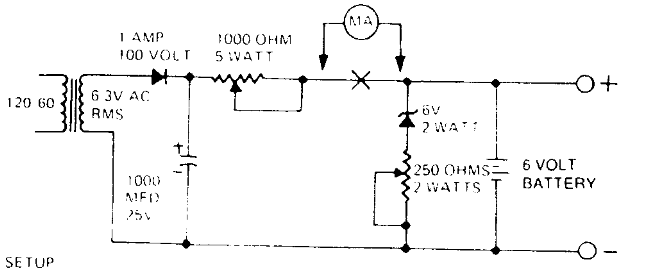


The charger transformer has a reactance such that the peak output voltage decreases when large currents are initially accepted by the battery. As the battery terminal voltage rises, and its current acceptance is reduced, the charger peak output voltage continues to rise. A ratio of 5 or 6 to 1 between start and finish currents is about the maximum for this type charger.

For example, if the charger is designed for a final charge current of 80 ma at 2.4 volts per cell, the highest initial current obtainable would be about 400 ma.

B. The Simplest Single Voltage, Regulated Charger

This single voltage zener diode regulated charger is very popular as a low power, low cost charger in standby power applications. From a cost standpoint, it is practical for up to about 120 milliampere output. Although recharge time is relatively slow with respect to several of the other chargers, it is much faster and preferred over constant current trickle charging.



SETUP
1 REMOVE BATTERY
2 SET CURRENT ADJUST CONTROL TO 1,000 OHMS
ADJUST 250 OHM CONTROL SO THAT THE VOLTAGE OUTPUT IS 6.9 VOLTS + 2%
ADJUST THE 1,000 OHM CONTROL UNTIL THE CURRENT THROUGH THE ZENER DIODE EQUALS 1 2 OF THE MAXIMUM RATED CURRENT
5 REATTACH BATTERY

Due to the large filter capacitor, this charger can also supply the holding voltage for sensitive relays, etc., drawing up to 5 to 10 milliamperes.

C. A Simple Single Voltage Regulated Charger

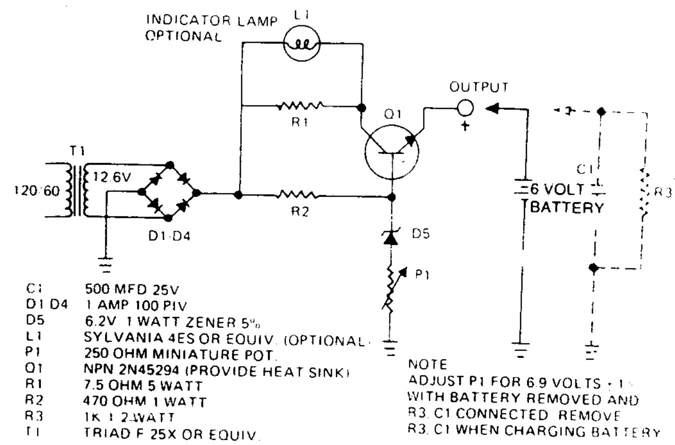
The following circuit, as shown, should be used as a charger and not as a combined power supply and charger. The adjustment shown (P1) is used to change the output voltage by slight amounts compensate for the tolerances in the zener diode voltage.

Since it is designed only as a charger, there is no filter capacitor in the circuit. Consequently, to set the voltage output with a meter, a capacitor and resistor should be placed across the output to obtain the proper reading of the peak voltage. Once this voltage is set, the capacitor and resistor may be removed. The small resistor used when setting the voltage simulates the load of a fully charged battery.

An indicator light is shown in this circuit. This light will gradually dim as a battery becomes fully charged. The use of the indicator lamp is strictly optional but does allow an estimate of the battery's state of charge.

If this circuit were also to be used as a power supply, a filter capacitor of about 400 mfd to 1000 mfd and 50 wvdc could be connected from the input of R2 to common.

Using the components shown, the supply will deliver to up to approximately 800 milliamperes to a discharged battery.

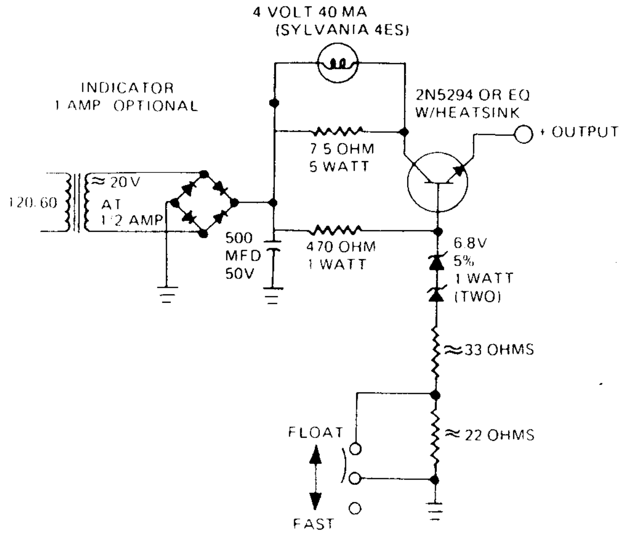


D. Dual Voltage Regulated Charger/Power Supply

The schematic below is essentially the same as that of the preceding paragraph except that it is set up for a 12 volt battery, has a filter capacitor, and can manually be switched between 14.4 volts (2.4 volts per cell) and 13.8 volts (2.3 volts per cell).

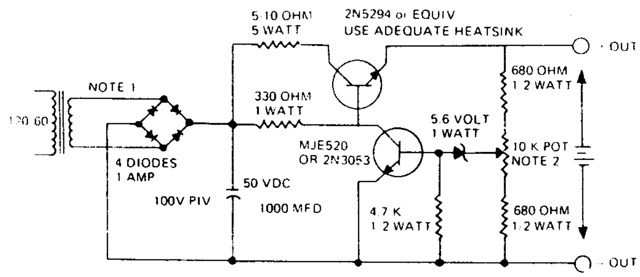
The actual value to the resistors used to adjust the output voltage will have to be determined by experimentation and will depend on the zener diode voltage tolerance and the transistor used. To select the resistors, the one for float voltage must be selected first, grounding the free end which will eventually connect to the second resistor. Then add the second resistor to raise the voltage to 14.4 volts. Since this circuit has a 500 mfd filter only, a 1,000 ohm resistor is required to simulate the battery for voltage calibration. Small fixed loads up to 50 milliamperes can be supplied when the charger is used as a low current power supply.

In this circuit, as well as most others, the current limiting resistor (7.5 ohms below) is sized to give the required current when the battery is at 2.1 volts per cell. There will be an initial current peak higher than recommended for the particular battery. The time at this high current is too short, however, to cause any problems.



E. Adjustable Voltage, Regulated Charger/Power Supply

The circuit below can be used for any of the battery systems of up to 30 volts. With components shown, up to one amp can be supplied to charge batteries and power electronics. However, at 1 amp, the current limiting resistor will reduce the output voltage proportionally.



If the unit is to be used only for battery charging, the 1,000 mfd filter could be replaced by a 250 mfd capacitor.

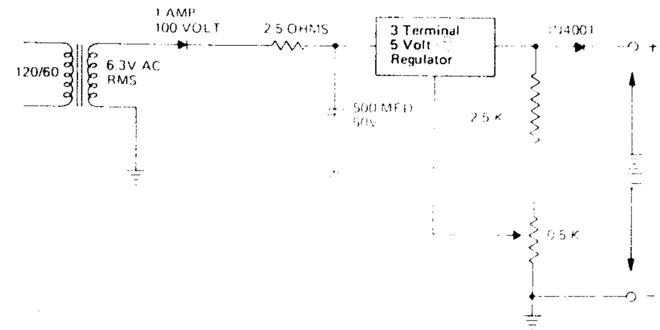
Use a transformer with a 3 to 10 volt RMS rating higher than the maximum DC voltage desired.

F. Charger/Power Supply Using Three Terminal Regulators

The three terminal regulators were originally introduced as local voltage regulators for use on computer logic cards. However, they are also proving useful in low power battery chargers and power supplies. Some of these devices are essentially blowout proof due to internal current limiting and automatic thermal shutdown.

The circuit shown is suitable for charging of 6 volt batteries and supplying a continuous load of approximately 50 to 100 milliamperes. If higher continuous load currents are required, a transformer allowing for full wave rectification and a larger filter capacitor may be incorporated.

Since the regulator is capable of delivering up to one amp, a resistor is incorporated (2.5 to 10 ohms) to control the current to the battery.



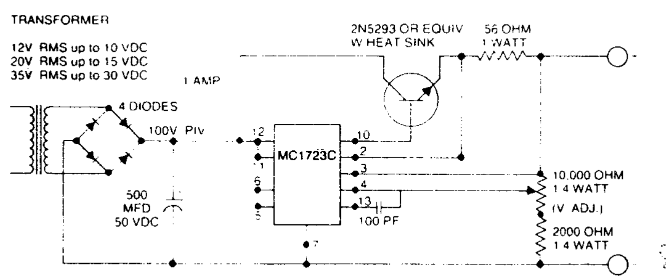
Voltage adjustment is accomplished with the .5K potentiometer. As the wiper is raised above the common, the output voltage is increased.

This voltage should be adjusted when a fully charged battery (or equivalent circuit) and the designed constant load are connected.

G. Charger/Power Supply Using an Integrated Circuit

This circuit uses a low cost integrated circuit as the regulating element with an external power transistor to carry the necessary current and dissipate power.

With the components shown in the drawing, the circuit may be used to charge batteries up to 24 volts and provide continuous power for equipment. Five hundred milliamperes is the maximum recommended continuous load as this will assure at least 200 milliamperes will be available for charging the battery. Depending on the continuous load current and a transformer voltage, a larger capacitor might be needed in order to keep the ripple voltage to 10 MV or less.



For higher currents the 2N5293 pass transistor can be replaced by a darlington circuit such as the MJ1000.

In some applications it may be desired to connect a series diode in the positive output circuit to prevent discharging the battery through the voltage adjustment potentiometer (2.5K) when commercial power fails or during shipment of completed equipment.

H. Charging from the Automobile Electrical System

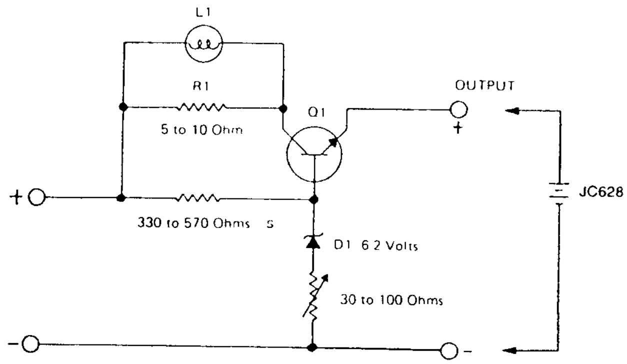
The Dynasty battery system of less than 10 volts can be conveniently charged from an automotive or boat electrical system.

The schematic below is for a typical "car to Dynasty battery" charger of this type. The component values should be selected to assure the charging voltage and maximum currents recommended for the battery system are not exceeded.

The charging voltage is a function of the zener diode and its trimming resistor R3. The zener selected should be about one volt less than the desired charging voltage. The current limiting feature is accomplished by the resistor R1. A sensitive lamp (Sylvania 6ES or equivalent) can be connected across R1 if a charge rate indicator is desired.

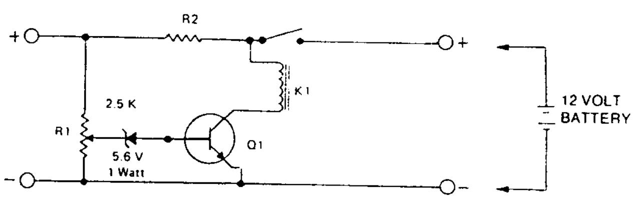
The series pass transistor Q1 serves not only to regulate the charging voltage but also to isolate the Dynasty battery from the electrical system during engine cranking when the automotive battery voltage is depressed.

This charger is most convenient when designed to operate from the cigarette lighter receptacle.



The normal charging voltages for 12 volt Dynasty batteries are 13.5 to 14.4 volts.

Since the automotive electrical system voltage will typically vary from 14.4 volts while driving to 13 volts at idle and as low as 9 volts when starting the engine, this necessitates two features required in the charger for 12 volt batteries: minimum voltage drop between the electrical system and the Dynasty battery to assure maximum charge acceptance, and, prevention of the Dynasty battery discharging into the auto electrical system during idle and engine cranking. These features and current limiting are included in the following schematic.



The power rating of transistor Q1 is naturally dependent on the current required by relay K1. The resistor R2 is dependent on the recommended current limiting for the batteries being charged. Typical values are between 5 to 10 ohms at 5 watts.

Resistor R1 adjustment allows relay K1 to close at 13.5 volts and above enabling the charging of the battery. Below 13.5 volts, the relay should de-energize to its normally open position, disconnecting the battery and preventing its discharge.

Additional safety may be included through use of an appropriate fuse in the charger.

I. SCR Chargers and Their Use with Dynasty Batteries

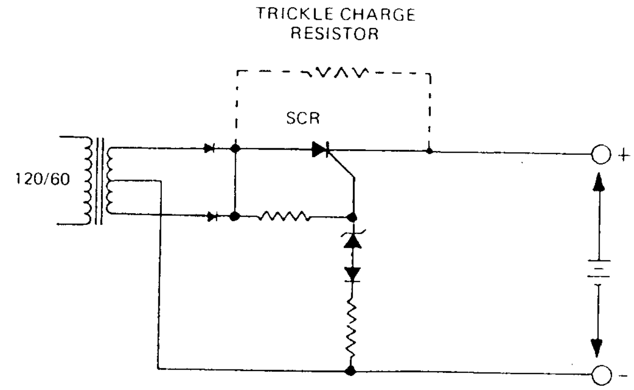
Generally, well filtered, voltage regulated DC supplies are preferred for recharging sealed batteries.

Quite often SCR chargers continue to apply high current pulses to a battery after it is fully charged. These pulses can be damaging over a period of time because the battery is forced to accept the high current levels when it is fully charged and cannot efficiently accept these pulses. The high current pulse drives the battery into an overcharge mode which shortens battery life. However, as the required current from a charger increases, the economics of an SCR charger become more significant.

In float service, such products as emergency lights (where there is no standby current drain) can utilize SCR chargers for use with the Dynasty batteries. A simple addition to the circuitry (in some cases, a 5c resistor) can trickle charge a battery at very low current (i.e., one ma per A.H. rating) at the end of a charge cycle, thereby, preventing the high current pulses which are characteristic of an SCR charger.

If you find that economics dictate the use of an SCR charger, please contact Johnson Controls to discuss the charging circuit and give us the opportunity to suggest the proper setup.

Below is a typical example of this type of circuit.



J. General Comments on Charger Construction

1. Where a heatsink is noted, this should be at least six square inches of minimum 1/16" thick copper or aluminum. Free air circulation is recommended. A 50°C rise in heatsink temperature above ambient air temperature is a safe figure for most applications.

2. Once a circuit is set up, fixed resistors may be substituted for potentiometers. However, close attention should be given to the tolerances of the fixed resistors and voltage and current readings should be rechecked after substitution.

3. Transformer voltages are not critical, but they must be high enough. If you wish to substitute a transformer with a slightly higher rated voltage than shown on the diagrams, check to make sure that components are not overheating.

4. For other battery voltage combination not shown in the diagrams, a voltage of 2.3 volts per cell in float and standby service is used and 2.4 volts per cell for cycle alternate full-charge/full-discharge service.

5. In applications where batteries are being used in float or standby type service some of the time, and cycle service part of the time, a voltage between 2.3 and 2.4 volts per cell can be selected. The recommended setting for batteries being used in "mixed" service is 2.33 volts per cell.

The preceding schematics are presented only to provide guidance in designing chargers which are compatible with Dynasty batteries from Johnson Controls.

Johnson Controls, Inc. cannot assume responsibility for charger power supplies built to the preceding schematics or liability for events associated with their use.

For additional assistance, contact Johnson Controls, Inc., Dynasty Application Engineering Department.

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Specifications subject to change without notice.