Engineering News

ALTEC LANSING   1515 S. Manchester Avenue,   Anaheim, California

TECHNICAL LETTER NO. 174

DC CAPABILITIES OF ALTEC ALL SOLID-STATE AMPLIFIERS

PURPOSE OF TECHNICAL LETTER:

The purpose of this Technical Letter is to present the direct-current capabilities of ALTEC all solid-state amplifiers. Incorporated is information on: applicable amplifiers, classification and grouping of electric battery cells, battery capacity ratings, methods of battery recharging, types of suitable wet-cell and dry-cell batteries, and selecting the best batteries for your amplifier.

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ALTEC AMPLIFIER CHART

ALTEC MODEL NUMBER	TYPE OF AMPLIFIER	BATTERY GROUNDING	BUILT-IN TRICKLE CHARGING	AUTOMATIC TRANSFER TO DC IN AC FAILURE	DC VOLTAGE RANGE	TYPICAL DRAIN IN AMPERES (1/3 Max. Drain)	MAXIMUM DRAIN (AMPERES)	POLARITY PROTECTION
351C	Power	Negative modification	Yes, with modification	Yes, with modification	48-52			Incorrect polarity will not damage or operate amplifier
352A	Mixer/Power	Negative	Yes	Yes	12-14	2.9	5.0	See above
361B	Mixer	Negative	Yes, with modification	Yes, with modification	48-52			See above
1590A	Power	Negative	Yes	Yes	24-28	8.0	14.0	See above
1591A	Compressor	Negative	No	Yes	12-14 or 24-28		0.16 or 0.17	See above
1592A	Mixer	Negative	No	Yes	12-14 or 24-28		0.16 or 0.17	See above
9470A	Preamp Booster Line Program	Negative	No	DC ONLY (with 9550A Pwr. Supply)	24-28		0.13 (with +27 dBm output) or 0.07 (with +18 dBm output)	See O/I for correct terminals
9471A	Monitor	Negative	No	No	24-28		0.26	See above
9475A	Preamp Booster Line Program	Negative	No	DC ONLY (with 9550A Pwr. Supply)	24-28		0.13	See above
9476A	Monitor/Cue	Negative	No	DC ONLY	24-28	0.42	0.75	See above

MODIFICATION OF ALTEC 351C AND 361B AMPLIFIERS

ALTEC's 351C Power Amplifier and 361B Mixer Amplifier can be battery-operated with battery capacity maintained by trickle-charging. For Model 351C, battery operation is accomplished by adding a rectifier and resistor to the existing circuitry, as shown in Figure 1.

PRIMARY AND SECONDARY CELLS

An electric battery usually consists of two or more connected cells that convert chemical energy into electrical energy. The cell is the unit part of the battery, but the word "battery" is sometimes used to mean one cell. The essential parts of a cell are two dissimilar electrodes, immersed in an electrolyte in a suitable con-
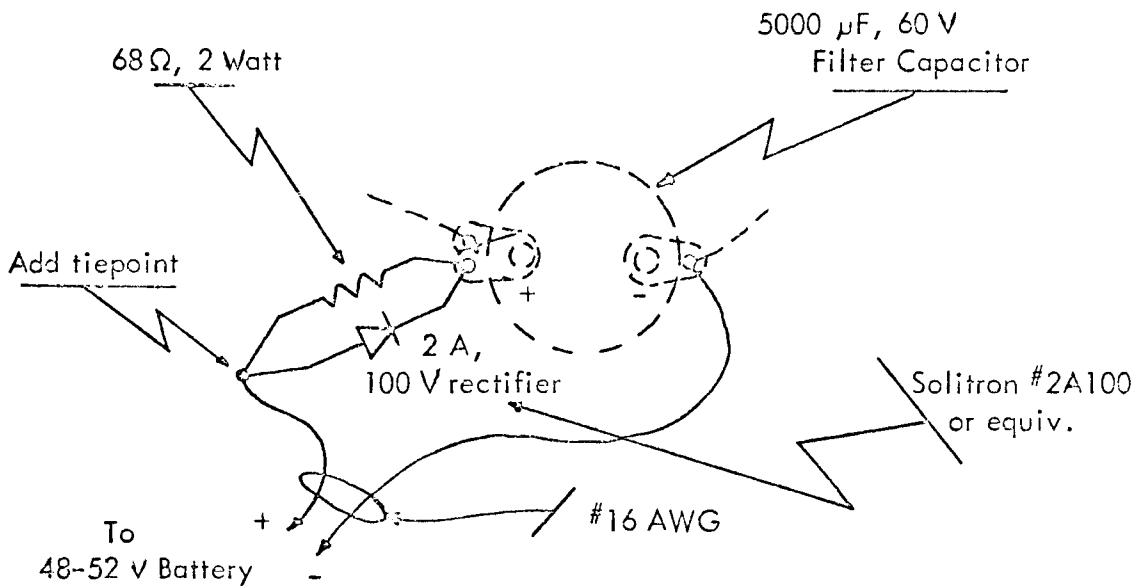
Figure 1. 351C Power Amplifier Modification

For Model 361B, battery operation is accomplished by adding a rectifier and resistor, as shown in Figure 2.

tainer. The electrolyte is a water solution or paste of certain acids, alkalies, or salts that have been adapted to the purpose.
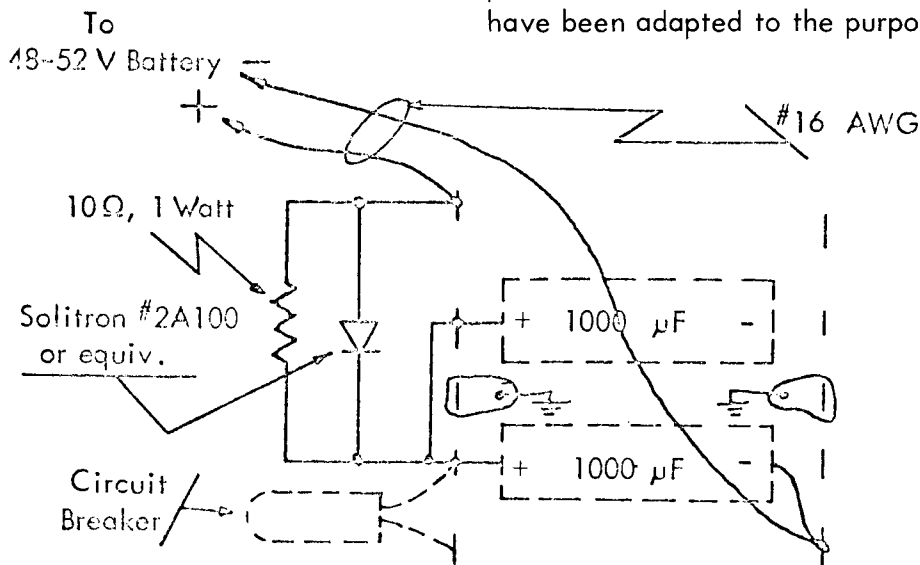
Figure 2. 361B Mixer Amplifier Modification

A number of different kinds of cells are in common use. These may be classified conveniently into two general groups as primary and secondary cells. The most familiar of the primary cells is the "dry cell". Secondary cells are generally spoken of as "storage cells". The distinction between primary and secondary cells is based on the nature of the chemical reactions that occur in them when they are used. Primary cells convert chemical energy into electrical energy, and in so doing they become exhausted. Dry cells, when no longer serviceable, are discarded, but some of the so-called "wet" cells can be renewed with new electrodes and electrolyte. Storage cells, on the other hand, convert chemical energy into electrical energy by reactions that are essentially reversible, that is, they may be charged by an electric current passing through them in the opposite direction to that of their discharge. During this process, electrical energy is transformed into chemical energy, which may be again used at a later time as electrical energy. Electricity is not stored as electricity by these cells. They store chemical energy and so potential electricity.

There are other cells, some of which are intermediate between primary and secondary cells. These are generally classed with the primary cells for practical reasons, although they possess some of the essential characteristics of the secondary cells.

GROUPING OF CELLS

Cells are used in groups of batteries; the number of cells and their size depending on the service required. Several arrangements are possible, and it is therefore desirable to arrange the cells in such a way as to secure the most economical service. Two factors are involved in arranging the cells: one is a voltage requirement and the other is the ampere capacity. When the cells are connected in series, that is, when the positive pole of one cell is connected to the negative pole of the next cell, the voltages of the cells are added. Two cells in series will give twice the voltage of one, assuming that the

cells, taken individually, are of the same voltage. The capacity (amperage) of a row of series-connected cells, however, is no greater than the capacity of a single cell. (See Figure 3.)
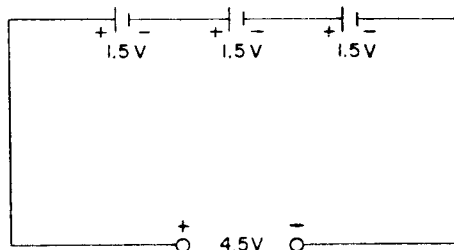

Figure 3. Cells Arranged in Series

Cells may also be connected in parallel, by connecting like poles together. The voltage of such a group is no greater than the voltage of a single cell, but the capacity is equal to the sum of the capacities of the individual cells (See Figure 4.)
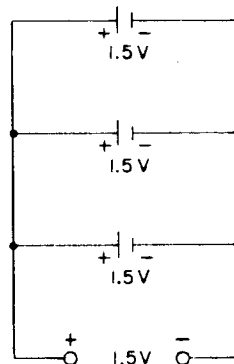
Figure 4. Cells Arranged in Parallel

Such an arrangement is not commonly made of storage cells, because it is better to use a single cell of the required capacity rather than a group of small ones connected in parallel.

When three or more cells are involved in series or parallel connections, the cells may be arranged in several rows connected in series, and these rows may then be connected in parallel (See Figure 5), or they may be arranged in parallel groups which are then put in series. (See Figure 6).

- 4 -

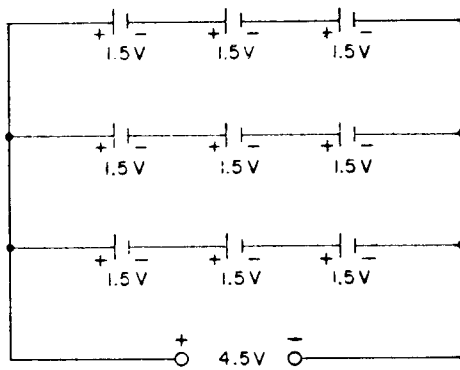Figure 5. Cells Arranged in Series, and then in Parallel.

The voltage and capacity of either of these groups is the same, but the former is preferred for storage batteries and the latter is the best arrangement for dry cells. The paralleling of series-connected groups of storage batteries is found in uses where exceptional capacity is required, or for charging when the voltage of the source would not be sufficient to charge the cells if they were all connected in series.
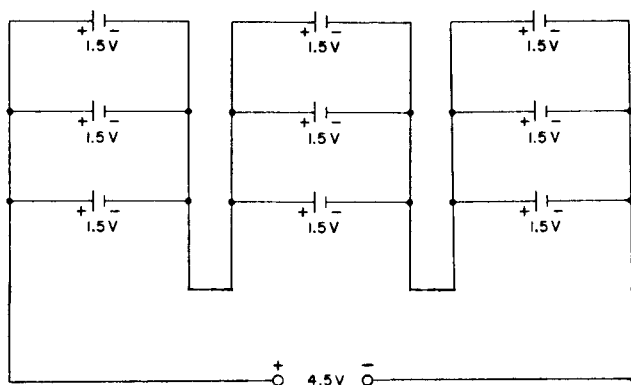

Figure 6. Cells Arranged in Parallel, and then in Series.

BATTERY CAPACITY RATING AND SERVICE

The capacity of a cell is the ability of the cell to maintain its open-circuit voltage under full-load conditions. Capacity may be thought of as the theoretical total energy available in the cell. Capacity ratings for a particular cell are usually expressed in terms of milliampere-hour or ampere-hour ratings for a given current drain and endpoint voltage. This rating does not indicate the actual hours of service that a cell will provide, but rather it indicates the theoretical total energy available from the cell. The average hours of service depend on the load, the cutoff or endpoint voltage, the size of the cell, the shelf-life period, discharge cycle, and on the operating and storage temperatures.

METHODS OF CHARGING

Direct current alone can be used for charging. If alternating current only is available, it must be converted into direct current.

There are two basic systems of charging in general use: constant-current and constant-voltage. The latter method is usually modified slightly by the addition of a fixed resistance of small value in series with the battery in order to limit the starting current and to improve the finishing rate. Such a system is called a semi-, or modified, constant potential system.

The positive terminal of the charging source is connected to the positive terminal of the battery so that the charging current flows through the battery in the direction opposite to that of the discharge current.

CONSTANT CURRENT METHOD

In the constant-current system, the current is held constant by means of a rheostat in series with the battery or by controlling the voltage of the source. The current is maintained at the normal rate by adjusting the rheostat, cutting out or decreasing the resistance as the charge progresses. This increases the voltage impressed on the battery. The value of the current flowing through the battery is dependent upon the difference between its voltage and that impressed on it.

When the voltage of the battery and the charging system are the same, no current will flow; when

the voltage of the battery is lower than that of the charging system, current will flow into the battery and charge it; and when the voltage of the battery is higher than that of the charging system, current will flow out of the battery and discharge it. As the voltage of the battery increases gradually with the progress of the charge, it is apparent that the voltage impressed across its terminals must be increased in order to maintain a constant value for the charging current. For batteries of the lead-acid type, the specified current is maintained until all cells are gassing freely and then is reduced to a much lower value designated as the finishing rate, at which the charge is continued to the end. The value of the finishing rate for automotive batteries is approximately 40% of the 8-hour starting rate.

In order to obtain most efficient results with batteries of the lead-acid type, the voltage of the charging circuit should be approximately 2.5 Volts per cell at normal temperatures (70°F) with current flowing at one-half the value of the finishing rate. When the voltage of the circuit exceeds this value, the maximum resistance of the rheostat must be sufficient to permit a reduction in voltage to this value. It is desirable that the ampere capacity be sufficient to permit a current value of four or five times the normal, provided that the charging circuit can safely carry that current.

CONSTANT-VOLTAGE METHOD

In the constant-voltage method, the voltage is maintained at a constant fixed value per cell. The value of the starting current of a completely discharged battery when first put on charge is much in excess of the so-called normal rate. During the charge, as the voltage of the battery gradually rises, the current falls off to a value much below that of the finishing rate of the constant-current system. The average value of the current is about equal to that of the normal rate.

For batteries of the lead-acid type, the maximum voltage for unmodified constant-potential charging should not exceed 2.35 Volts per cell, and the minimum should not exceed less than 2.25 Volts per cell. With the average voltage thus established at approximately 2.3 Volts per cell, a battery in any state of discharge may be put on charge, and it will automatically receive the proper charge without reaching the free gassing point or excessive temperature. Caution is necessary, however, as slight variations in the line voltage produce large variations in the charging current. The "modified" constant-voltage method of charging, described below, is a safer method.

MODIFIED CONSTANT-VOLTAGE

The very large charging current at the beginning of an unmodified constant-voltage charge makes it necessary to limit the initial or starting current, and to accomplish this a fixed resistance of small value is placed in series with the battery. This is then known as a semi-constant-voltage or a modified constant-voltage system.

In practice, when using the modified constant-potential method, the voltage may be kept constant at any value from 2.5 Volts to 3.0 Volts per cell, although 2.63 Volts is the value commonly used in the United States for an 8-hour charge of lead-acid cells.

TRICKLE CHARGE

A trickle charge, as the name implies, is a continuous charge at a low rate sufficient to compensate for the internal losses of the battery and suitable to maintain the battery in a fully charged condition. Low-rate charges are satisfactory for lead-acid batteries provided the total amount of charge received by the battery is sufficient to cover the local action. Several applications have been made of trickle-charging. One of them is to put lead acid batteries in so-called "wet" storage. At regular

intervals, the filling plugs should be removed and water added to cells, if necessary. At the beginning of the charge the specific gravity of each cell should be read and recorded, and this operation should be repeated at intervals. The charging current may then be reduced to the lowest limit that will keep the specific gravity constant.

The term trickle charge is also applied to very low rates of charge which are sufficient not only to compensate for the internal losses of the battery but to restore intermittent discharges of small amounts.

WET CELLS

LEAD-ACID SECONDARY BATTERIES

The lead-acid battery is the most common of the storage type; it is the kind of battery used for starting automobile engines. The capacity of a lead-acid storage cell, expressed in ampere-hours, is the product of the rate of discharge, in amperes, and the number of hours the cell will maintain that rate. The cell must be fully charged at the start of the discharge, when determining its capacity. The ampere-hours which may be obtained from a battery are greater for a long, low-rate or intermittent-rate discharge, than for a short, high-rate discharge. This is because the voltage drops faster at the higher rates.

The lead-acid batteries are given a so-called normal capacity rating, which is the ampere-hours obtainable under certain working conditions. This so-called normal capacity is not the capacity obtainable under all conditions. For example, a battery may be given to normal 8-hour rating in ampere-hours, but greater capacity can be obtained if the discharge rates are made lower. On the other hand, if the rates are above normal, the capacity for such a rate of discharge will be less. On test, a cell that will give 8 hours at normal rate of discharge will usually give only 1 hour to 1 1/4

hours at four times normal. During the first half to three-quarters of the life of a lead-acid cell, its capacity increases. This increase may be from 10 to 25 percent above rated capacity, depending upon the type of plates and other factors such as porosity. After reaching maximum capacity, the capacity gradually decreases and the battery is normally considered as worn out when its capacity falls to less than 80 percent of rating.

The open-circuit voltage of the lead-acid storage cell is between 1.95 and 2.15 Volts; and if a cell is allowed to remain on open circuit a sufficient length of open-circuit voltage of a cell is no guide as to the state of charge. During discharge the external voltage of a cell drops below the open-circuit voltage by an amount that varies with the rate and duration of the discharge.

The capacity of a lead-acid cell decreases with reduction of temperature. At the 8-hour rate, the loss amounts to about six-tenths of 1 percent of the 77°F capacity for each degree of reduction in temperature. At higher rates, the percentage of loss is somewhat greater. The specific gravity of the electrolyte varies also with temperature in the proportion of an increase of 3 to 4 points (.004) in specific gravity for every temperature drop of 1.0 degree. High temperatures increase the internal losses in a cell and high average temperatures decrease the useful life somewhat.

The ampere-hour efficiency of a storage cell is the ratio of the discharge, in ampere-hours, to the charge, in ampere-hours, required to bring the cell back to the same state of charge. The ampere-hour efficiency can be reduced to almost any low value by excessive and unnecessary overcharge. Aside from this, the legitimate ampere-hour efficiency varies with a number of conditions: the age and condition of the plates, the temperature, the rate of charge, the elapsed time between charge and discharge, the ratio of the amount of discharge

to the cell capacity, and the particular states of charge and discharge between which the cell is worked. Under average conditions, an ampere-hour efficiency of 85 to 90 percent can usually be obtained in service requiring a discharge of a major proportion of the 8-hour rating.

DRY-CELLS

COMPARISON OF CARBON-ZINC, ALKA-LINE-MANGANESE-ZINC, AND MERCURY BATTERIES

Carbon-zinc cells yield 15 to 20 Watt-hours per pound, manganese-alkaline cells give 30, and mercury units produce 45. However, in any application, the current drain should not exceed the battery rating or the battery will die before it has yielded its normal quantity of electricity.

Ordinary carbon-zinc dry cells require frequent "rest" periods. During use, the cells' internal impedance increases due to the formation of hydrogen gas. This gas must be given a chance to dissipate or the useful life of the cells is shortened.

Carbon-zinc cells today are made in four types, depending on the intended service. The general-purpose variety is most common, and is usually called a flashlight battery. The second type is designed to operate under light drain and to maintain relatively constant terminal voltage for a longer period than can the first type. It's used in transistor circuits. The third special kind of cell is made for photoflash use, where it's subjected to an intermittent but very high current drain. The fourth type was developed for heavy-duty industrial use.

Manganese-alkaline-zinc cells can be up to 75% more efficient than carbon-zinc cells. This efficiency is chiefly useful in high-current applications. Precautions must be taken in substituting them for ordinary cells. They cause corrosion when in contact with aluminum or copper terminals if there is any leakage of the caustic potassium hydroxide electrolyte. Stainless or nickel-plated steel terminals should be used. In spite of this disadvantage, manganese-alkaline cells are being used increasingly in receivers and amplifiers. Because they have a relatively constant internal impedance, they can be discharged to lower-than-usual voltages without causing distortion.

Mercury cells are best when stable operation is required. Their output voltage remains nearly constant throughout their useful life. They are generally designed for use at room temperatures or above, although a special wound-anode type is available for use at low and freezing temperatures.

CARBON-ZINC BATTERIES

The carbon-zinc dry cell is the oldest, most familiar, and most widely used type of dry cell. Carbon-zinc dry cells and batteries are available in a wide range of voltage and current capabilities and with wide various terminal configurations. The closed-circuit voltage or working voltage of a carbon-zinc cell falls gradually as it is discharged. The service hours delivered are greater as the cutoff or endpoint voltage is lower. Typical cutoff voltages range from 0.8 to 1.1V per 1 5V cell, depending on the application.

The service capacity of a carbon-zinc battery is not a fixed number of ampere-hours because the battery functions at different efficiencies, depending upon the conditions imposed on it. The service varies with current drain, operating schedule, and cutoff voltage. It is also, of course, affected by the operating temperature and storage conditions of the battery prior to use. Typical voltage discharge characteristics of a carbon-zinc battery are shown in Figure 7.
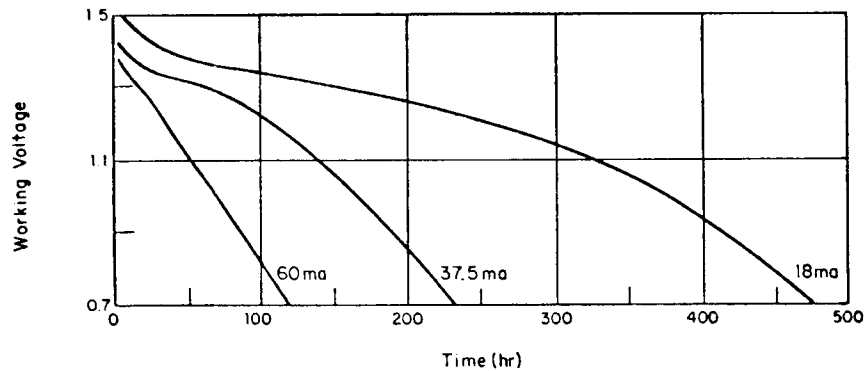
Figure 7. Typical Voltage Discharge Characteristics of Carbon-Zinc
D-Size Battery, Discharged 4 Hours per Day.

The chemical efficiency of a carbon-zinc battery improves as the current drain decreases. This points up an important application principle: use as large a battery as is possible consistent with physical limitations. Over a certain range of current density, service life may be tripled by halving the current drain. This is equivalent to using a larger battery for a given application and so reducing density within the cells. This is true down to the point beyond which shelf-deterioration becomes an important factor. The service capacity depends on the relative time of discharge and recuperation periods. The performance is normally better when the service is intermittent. Continuous use is not necessarily inefficient if the current drain is very light.

Carbon-zinc batteries are normally designed to operate at 70°F. The higher the battery temperatures during discharge, the greater the energy output. However, high temperatures reduce shelf life, and prolonged exposure to temperatures above 125°F causes very rapid disintegration of the battery.

Shelf life is the period of time, at a storage temperature of 70°F, after which a given battery retains a specified percentage (usually 90%) of its original energy content. Shelf life is reduced by high temperatures because of wasteful zinc corrosion and side chemical reactions within the cells and because of moisture loss from the cells through evaporation. The shelf life of a battery stored at 90°F is about 1/3 that of one stored at 70°F.

Service life at low temperatures is reduced because of decreased chemical activity in the cell. The effects are more pronounced for heavy current drains than for light drains. When a standard carbon-zinc battery has reached a temperature of 0°F, little service is obtained except at light drains. At -10°F, the battery is usually inoperative unless special low temperature electrolytes are used. Since a battery does not reach the temperature of its surroundings immediately, insulation is helpful.

Low or even freezing temperatures are not harmful to carbon-zinc cells, as long as there is not repeated cycling from low to higher temperatures. Low-temperature storage is very beneficial to shelf life. A storage temperature of 40° to 50°F is effective. There is no relation between continuous duty service and intermittent service. It is, therefore, impossible to rate the merits of different batteries on intermittent ser-

vice by comparing results of continuous duty tests.

Another fallacy concerning dry batteries is that relative "quality" or service capacity of a battery can be determined by amperage readings. This is not true, and in most instances gives results which are totally misleading. The size "D" photoflash round cell and the flashlight cell are identical in size and shape. However, the photoflash cell, which will show more than twice the amperage of the flashlight cells, runs a poor second to them in service capacity in typical flashlight uses.

Dry batteries can be meter-tested to check present condition. A meter test, however, will give no indication of remaining service capacity unless the exact history of the battery is known and can be compared on a capacity vs. meter reading basis with other batteries tested in similar service.

A loaded voltmeter is considered the best spot-check device, since open circuit voltmeter readings give no indication of internal resistance, and a short circuit amperage reading is damaging, especially to "B" batteries. A loaded voltmeter should impose a drain of approximately half the recommended maximum drain specified for battery types.

ALKALINE-MANGANESE-ZINC PRIMARY BATTERIES

Alkaline cells are made in a cylindrical shape and in several physical sizes which are interchangeable with the popular carbon-zinc cell sizes. For most drains, alkaline cells give more service than carbon-zinc cells, but less than mercury cells. However, alkaline cells are superior to mercury cells on relatively heavy drains. Alkaline cells give relatively constant ampere-hour capacity over a wide range of current drains and discharge schedules. In addition to the primary type, a rechargeable alkaline battery is also available as a dry-type battery. Discussions of the rechargeable battery follows this section on primary types.

On heavy or continuous drains, the alkaline cell is most spectacular and shows an excellent advantage over carbon-zinc cells on a performance-per-unit-cost basis. The cells are hermetically sealed and encased in steel. The ampere-hour capacity is relatively constant over a range of current drains and discharge schedules. Nominal voltage of an alkaline-manganese dioxide primary cell is 1.5V. The closed circuit voltage of an alkaline primary battery falls gradually as the battery is discharged, as shown in Figure 8.
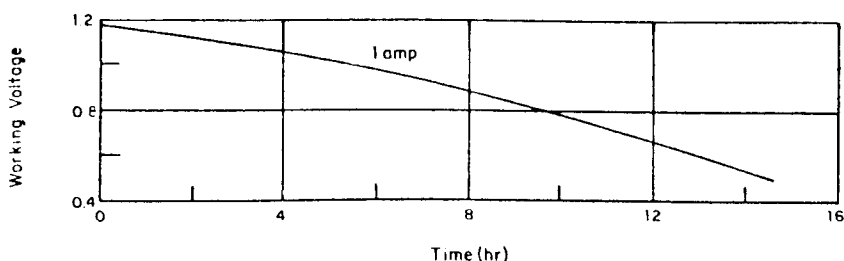

Figure 8. Voltage Discharge Characteristic of Alkaline-Manganese-Zinc Primary Battery (D-Cell) Discharged 24 Hours per Day.

Similar to carbon-zinc batteries, the service hours delivered by alkaline-manganese primary batteries are greater as the endpoint voltage is lower. Service capacity remains relatively constant as the discharge schedule is varied. Capacity does not vary as much with current drain as for the carbon-zinc battery. The alkaline-manganese primary cell is for applications requiring more power or longer life than can be obtained from carbon-zinc batteries. Alkaline cells contain 50 to 100 percent more total energy than a carbon-zinc cell of the same size.

In a conventional carbon-zinc cell, heavy current drains and continuous or heavy-duty usage impair its efficiency to the extent that only a small fraction of the built-in energy can be removed. The chief advantage of the alkaline-manganese system lies in its ability to work with high efficiency under continuous or heavy duty, high-drain conditions where the standard carbon-zinc cell is unsatisfactory. Under certain conditions, alkaline cells will provide as much as ten times the service of standard carbon-zinc cells. Discharge characteristics of the two battery types are compared in Figure 9.
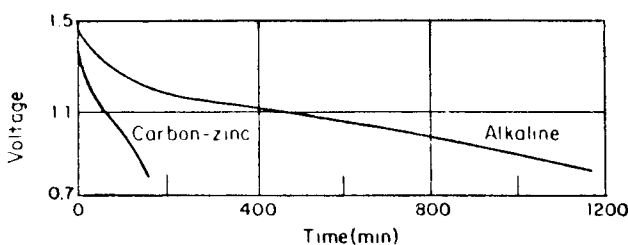

Figure 9. Comparison of Discharge— Characteristics of Alkaline-Manganese and Carbon-Zinc (D-Size) Cells for 500 mA Continuous Drain at 70°F

Although alkaline-manganese cells will outperform carbon-zinc batteries in any type of service, they may not show an economic advantage over standard cells at light drains, or under intermittent-duty conditions, or both. For example, with intermittent use at current drains below about 300 mA for the D-size cell, alkaline cells, while performing very well, will begin to lose their economic advantage over the conventional carbon-zinc batteries.

Alkaline-manganese primary batteries exhibit excellent low-temperature performance characteristics. They considerably exceed the capabilities of the best military-type carbon-zinc battery using a special low-temperature electrolyte. For example, at -40°F, with a starting drain of 225 mA, to a cutoff of 0.93V, discharged 80 min. per day, the alkaline D-size cell provides on the average over two and a half times the service of the best carbon-zinc type D cell with low-temperature electrolyte.

Shelf life of alkaline batteries is excellent. After one year storage at 70°F, these batteries can be expected to supply in excess of 90% of rated capacity.

ALKALINE-MANGANESE-ZINC SECONDARY BATTERIES

Alkaline-manganese-zinc secondary batteries are a relatively new rechargeable power source. They are maintenance-free, hermetically sealed, and will operate in any position. These batteries have been specifically designed for applications where low initial cost and a low operating cost are of primary importance.

The total number of times the alkaline-manganese-zinc secondary battery can be recharges is less than can be obtained with the nickel-cadmium rechargeable system, but the initial cost is only a fraction of that of nickel-cadmium batteries.

The discharge characteristic of the alkaline-manganese-zinc secondary cell battery is similar to that of a primary battery. The battery voltage decreases slowly as power is withdrawn from the battery. The shape of this discharge curve changes slightly as the battery is repeatedly charged and discharged. The total voltage drop for a given power withdrawal increases as the number of charge and discharge cycles increases. See Figure 10.

proportionately. Conversely, if the power demands are increased, the cycle life will decrease more than in proportion to the increased power demand.

During the early part of its cycle life, there is a very large power reserve in an alkaline-manganese-zinc secondary battery. This usually amounts to between 100% and 200% of the rated ampere-hour capacity of the battery.

FOR BATTERY WITH 10 CELLS IN SERIES

CELL SIZE	LOAD RESISTANCE (ohms/cell)	CHARGE RATE (milliamperes)
"D"	2.25	250
"G"	1.125	500

CONSTANT CURRENT CHARGING
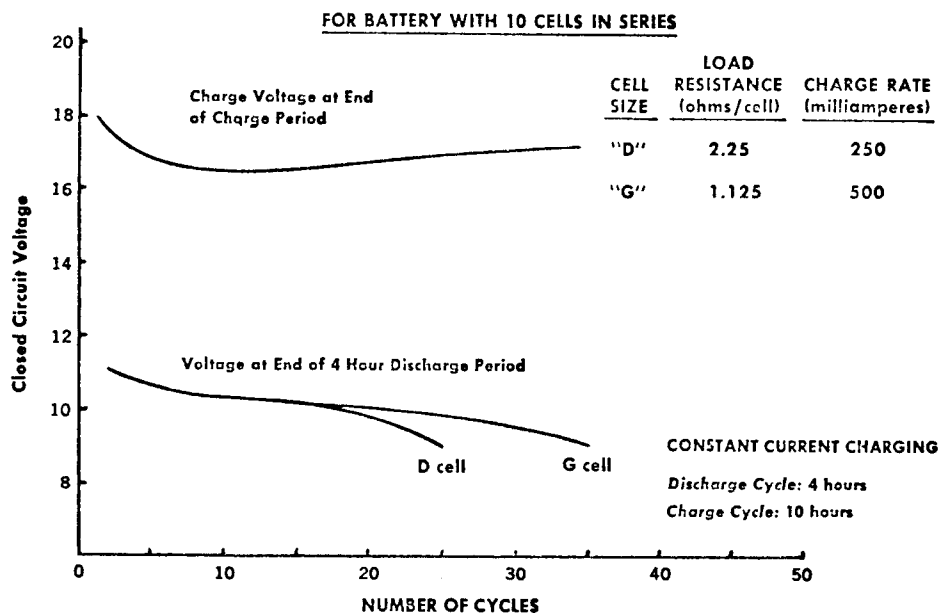
Discharge Cycle: 4 hours
Charge Cycle: 10 hours

Figure 10. Discharge and Charge Voltage Characteristics of Alkaline-Manganese-Zinc Secondary Battery Containing Ten "D" or "G" Size Cells.

When one of these new alkaline-manganese-zinc secondary batteries is discharged for 4 hours at the maximum recommended discharge current and then recharged at constant current for 10 hours at the recommended charging current, the complete discharge and charge cycle can be repeated 25-35 times before the battery will fall below 0.9 Volt per cell in any 4 hour discharge period, depending on cell size. Decreasing either the discharge current, or the total ampere-hour withdrawal, or both, will increase the cycle life of the battery more than

During these early cycles, the battery terminal voltage may measure 1.0 to 1.2 Volts per call after the battery has delivered its rated ampere-hour capacity. If it is discharged beyond its rated capacity, however, total battery cycle life will be reduced. Nevertheless, this reserve power can be used in situations where immediate power is more important than maximum total battery life. During the latter part of the cycle life, there is little or no reserve power and the terminal voltage of the battery will fall to between 0.9 and 1.0 Volt per cell.

Alkaline-manganese-zinc secondary batteries have excellent charge retention characteristics. A new battery is shipped fully charged and has the charge retention characteristics of a primary battery. It must be discharged to its rated capacity before it will be capable of standing any overcharge.

For best results, it is recommended that an alkaline-manganese-zinc secondary battery be recharged by applying the recommended charging current for a time long enough to replace about 125% of the ampere-hours removed on the previous discharge. This figure is not critical. Although a new battery may be overcharged for moderate periods of time without damage, best results will be obtained if overcharging is kept to a minimum.

An alkaline-manganese dioxide secondary battery must not be discharged completely. For best results, the rated capacity of the battery should not be exceeded on discharge. During deep discharge, a secondary electrochemical reaction takes place. This reaction is not reversible and will seriously reduce the battery cycle life.

MERCURY BATTERIES

Mercury cells are especially suited to provide maximum power output in minimum space. Their flat discharge curve makes them an ideal source of power where voltage regulation is an important consideration. Typical voltage-discharge characteristics are shown in Figure 11.

Mercury batteries are generally suitable for use at temperatures above normal room temperature, ranging up to about 130°F. The nature of their electro-chemical system does not make them as well suited for operation at lower temperatures. Severe capacity loss results at about 40°F and near 32°F, they will give very little service except on light drains.

Mercury batteries that have been exposed to low temperatures will again give normal service after being allowed to warm to room temperature. Mercury batteries have excellent shelf life. The service capacity after one year of storage at 70°F is more than 90% of the capacity of the fresh mercury battery.

Mercury batteries are available with two formulations designed for different field uses. In general, the 1.35V cells, or batteries using these cells, are recommended for voltage reference sources and for use in applications where higher than normal temperatures may be encountered. The 1.4V cells, or batteries made up of these cells, are used for commercial applications of all types other than the two just mentioned. The 1.4V cells should be used for long-term continuous low-drain applications if a very flat voltage characteristic is not needed.

The mercury cell has a good high-temperature characteristic. It can be used up to 130°F, although operation at 200°F is possible for a few hours.

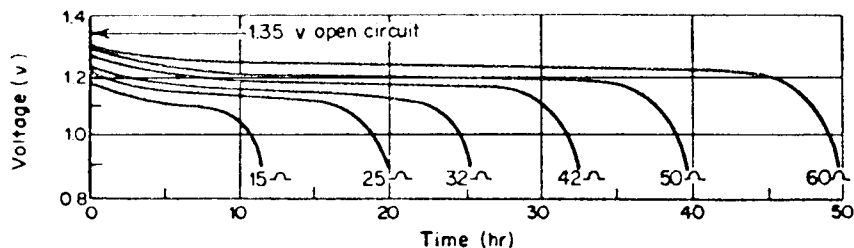Mercury batteries do not perform well at low temperatures. There is a severe loss of capacity

Figure 11. Typical Voltage-Discharge Characteristics of Mercury Cells under Continuous Load at 70% F. At 1.25V, equivalent Current Drains for Resistances are: 15 Ω, 83 mA; 25 Ω, 50 mA; 32 Ω, 40 mA; 42 Ω, 30 mA; 50 Ω, 25 mA; 60 Ω, 20 mA.

at about 40°F, and near 32°F, the mercury cell gives very little service except at light current drains.

SELECTING THE BEST BATTERIES FOR YOUR AMPLIFIER

The selection of the best batteries for your amplifier is based on various factors relative to the kind of service required of the amplifier. Start with the voltage requirement, which is 12, 24 or 48V dc, depending on the model amplifier used, as shown on the ALTEC amplifier chart. Also listed on this chart is the maximum drain in amperes for each amplifier. Next, estimate the dc operating time schedule. Ease of battery selection will be facilitated if 4 or 8 hours per day or continuous operation for all dry-cell types, and up to 8 hours per day for lead-acid types can be used. This is because battery company catalogue specifications give data for specific batteries, usually based on 4, 8, and continuous hour service for dry-cells, and 8 hour ratings for commonly available lead-acid batteries. If more than 8 hours of dc operation is required, such as operating up to 14 days without ac power during a Civil Defense Emergency, it is generally recommended that a combination of lead-acid secondary batteries

and a gasoline engine powered generator be employed. Charge-discharge cycle time periods for secondary batteries and discharge-rest cycle time periods for some types of primary batteries will probably be the most important factors you will encounter in determining battery life and service reliability. Also to be considered is the space available to accommodate batteries, and, in the case of wet-cells, space allowed for maintenance. Adequate ventilation must be maintained for wet-cell battery fume elimination. Where any form of portability is a factor, both size and weight are of major importance. The selection of batteries is also contingent on the ambient temperature range where the batteries are stored and operated, and battery shelf life characteristics.

In many applications, it will be apparent that more than one type and size of battery will adequately operate amplifiers as you require. Once the choice has been limited by the preceding factors, consider battery cost. Initial battery price and the cost of necessary accessories such as chargers and generators, plus the estimated cost of battery use per unit of time, will help make the final selection of the best batteries for your amplifier.

By Jack Schechtman