

STORAGE BATTERIES—NICKEL-CADMIUM
ENGINE STARTING AND CONTROL
DESCRIPTION, REQUIREMENTS, AND PROCEDURES

	PAGE		PAGE
1. GENERAL	2	2.11 Substitution for Lead-acid Batteries	8
1.03 Gassing	2	2.12 Terminal Post and Case Care	8
1.04 Electrolyte and Electrolyte Neutralization	2	2.13 Intercell Connectors	8
1.05 First Aid for Electrolyte Contact	2	2.14 Initial Charges	8
1.06 Metallic Containers Electrically Alive	2	2.15 Initial Charge of Cells Shipped Dry	8
1.07 Soda or Sulfuric Acid Damaging	3	2.16 Advantages and Disadvantages	9
1.08 Disposition of Replaced Nickel-cadmium Batteries	3	3. REQUIREMENTS AND PROCEDURES	9
2. DESCRIPTION	5	3.01 Periodic Checks	9
2.01 Containers, Vents, and Mounting Trays	5	3.02 Float Voltages	9
2.02 Plate and Electrolyte Chemical Reactions	6	3.03 Electrolyte Level	10
2.03 Cell Voltage	6	3.04 Battery Connections	10
2.04 Battery and Cell Capacity	7	3.05 Exterior Cleanliness	10
2.05 Electrolyte Temperatures	7	3.06 Initial and Special Charges	10
2.06 Ampere-hour Efficiency	7	ILLUSTRATIONS	
2.07 Adding Water	7	Fig. 1—Typical Tray Assembly—Nicaid Type	6
2.08 Electrolyte Oil Layer	7	Fig. 2—Typical Tray Assembly—Nife Type	6
2.09 Specific Gravity	7	Fig. 3—Typical Tray Assembly—Alkaline Type	6
2.10 Electrolyte Deterioration	8	Fig. 4—Typical Cell Construction—Nicaid Type	11

CONTENTS	PAGE
Fig. 5— Typical Cell Construction—Nife Type	11
Fig. 6— Typical Cell Construction—Alkaline Type	12

TABLES

Table A—Nickel-cadmium Engine Starting and Control Batteries	4
Table B—Interval Chart for Nickel-cadmium Engine Starting and Control Batteries	9
Table C—Battery Float Voltage Ranges	10
Table D—Electrolyte Level	10

1. GENERAL

1.01 This section covers the description, requirements, and procedures of engine starting and engine control batteries of the nickel-cadmium type. See Table A for a listing of these batteries.

1.02 This section is reissued to include:

- (a) Information from Addendum 1
- (b) Information on engine control batteries
- (c) A table on voltage ratings and engine applications (Table A)
- (d) Fig. 3 showing typical tray assembly of alkaline type cells.
- (e) Fig. 4, 5, and 6 showing construction of typical Nicad, Nife, and Alkaline cells
- (f) Additional information on requirements and procedures.

Since this is a general revision, change arrows are omitted. This reissue affects Equipment Test List.

1.03 Gassing: Nickel-cadmium batteries will normally gas only on charge and then only

at potentials over 1.33 volts per cell. At potentials up to 1.47 volts per cell, the gassing is negligible. The gas given off is the same as that given off by lead-acid cells; namely, a mixture of hydrogen and oxygen.

Caution: *Avoid creating sparks, including those from static electricity, or the use of an open flame near batteries since the gas is explosive when sufficiently concentrated.*

1.04 Electrolyte and Electrolyte Neutralization:

Note: Protective goggles should be worn when handling electrolyte.

The alkaline electrolyte is corrosive and attacks most animal and vegetable products including clothing, the skin, and paint, as well as some metals, including aluminum and zinc, but excluding iron, steel, and nickel. It attacks glass very slowly (pyrex-type glass almost negligibly), so exposure of glass, other than the Pyrex type or porcelain should be for as short a duration as practicable, and glass or porcelain objects should be washed in water after any exposure to electrolyte. Since the acid resistant paint used on battery racks is not protected from the alkaline solution, extra care is necessary to avoid exposure of such paint to electrolyte. Boric acid is used to neutralize spilled alkaline electrolyte, but it should not be applied to metallic cell containers as it will promote rusting. Saturated solution or crystals of boric acid should also be used to neutralize electrolyte spilled on clothing.

1.05 First Aid for Electrolyte Contact: If any electrolyte gets into the eyes or on the skin, it shall be removed without delay by flushing the affected area with large amounts of plain tap water. When electrolyte has splashed into an eye, as soon as possible, water should be poured into the inner corner of the eye, and at least one quart of water allowed to run over the eye and under the eyelid. Sometimes, a nearby drinking fountain can be used. In case of eye injury, the injured person should be placed under the treatment of a physician, preferably an eye specialist, as soon as possible.

1.06 Metallic Containers Electrically Alive:

The outer surfaces of *metallic* cell containers are electrically alive. They should not touch each other or be grounded. Only taped or otherwise insulated tools should be used when working on

the cells, and no metal objects should be laid on the cells. Most containers are now made of plastic.

1.07 Soda or Sulfuric Acid Damaging: Soda or sulfuric acid is detrimental to the cells. Thermometers that have been used in lead-acid cells should not be used with nickel-cadmium cells. Hydrometers are not required and should not be used with nickel-cadmium cells. Specific gravity readings are not indicative of the state of charge.

Caution: Sulfuric acid will ruin nickel-cadmium cells. Funnels or other accessories which have been used with

sulfuric acid (lead-acid cells) shall not be used.

1.08 Disposition of Replaced Nickel-cadmium Batteries:

Caution: Nickel-cadmium batteries contain cadmium and possibly other objectionable pollutants.

Replaced nickel-cadmium batteries **shall** be disposed of in accordance with approved practices for disposition of pollutants. See the supervisor for instructions as to location for sending batteries for disposal.

TABLE A

NICKEL-CADMIUM ENGINE STARTING AND CONTROL BATTERIES

LIST NO.	MFR	AMP-HR CAPACITY AT 5-HR RATE	VOLTAGE	ENGINE APPLICATION
KS-15578 1 1E 1W	Nife	60 50 45	32 32 32	KS-5667, 5 and 8 kW KS-5667-01, 8 kW
2 2E 2W	Nife	123 105 100	12 12 12	KS-5525-01, 50 and 70 kW
3 3E 3W	Nife	95 80 80	6 6 6	KS-5525-01, 10 and 25 kW
4W	Nife	80	32	KS-15717, 10 kW
5 5E 5W		95 81 80	12 12 12	KS-5574-01, 20 thru 60 kW KS-15884, 30 thru 45 kW
6 6E 6W 6W	Alkaline Nife	141 120 105 95	12 12 12 12	KS-5574-01, 40 thru 60 kW KS-15884, 60 thru 100 kW
7 7E 7W 7W	Nife Alkaline	141 120 76	32 32 32	KS-5636, 20 thru 60 kW KS-5750, 20 thru 60 kW KS-15521, 20 kW KS-15890, 30 thru 100 kW
8 8E 8W 8W	Nife Alkaline	221 180 180	32 32 32	KS-5665, 150 kW KS-15622, 120 and 170 kW
9 9E 9W	Nife	246 195 200	32 32 32	KS-5665, 200 kW
10 10E 10W	Nife	280 228 220	32 32 32	KS-5665, 300 kW
11W 11W	Nife Alkaline	200	48	KS-15777, 500 kW KS-15899, 350 kW KS-15954, 350 kW
12W	Nife	250	24	KS-15992, 750 kW

TABLE A (Cont)

LIST NO.	MFR	AMP-HR CAPACITY AT 5-HR RATE	VOLTAGE	ENGINE APPLICATION
13W 13W	Nife Alkaline	95	24	KS-19583, 30 kW KS-19584, 45 kW KS-19585, 75 kW KS-19586, 115 kW KS-19587, 115 kW (amb. temp. above 40°F)
14W 14W	Nife Alkaline	142	24	KS-19587, 115 kW (amb. temp. below 40°F)
15W		100	24	KS-19896, 200 kW KS-20542, 200 kW
16W		10	24	KS-19896, 200 kW KS-20542, 200 kW
17W	Alkaline & Nife	54	24	KS-20460, 2100 kW and 2500 kW
18W	Alkaline & Nife	95	24	KS-20460, 2100 kW and 2500 kW
KBI-1	Nife		24	KS-19583, 30 kW KS-19584, 45 kW KS-19585, 75 kW KS-19586, 115 kW
MDP-2	Nife	17	24	KS-19587, 115 kW
MA5	Sonotone	36	24	KS-19896, 200 kW

2. DESCRIPTION

2.01 Containers, Vents, and Mounting Trays:

Some containers are made of nickel-plated steel, painted on the outside with alkaline resistant paint or varnish. Most cells now have plastic cases and are thus insulated electrically (see 1.06). In many types, the translucent plastic container allows the electrolyte level to be visible. Each steel cell is fitted with a spring-loaded vent cap which should be kept closed to reduce the contact of the electrolyte with air. Plastic cells are normally equipped with flame arrestor vents which are very similar to the antiexplosion feature of lead acid cells.

Caution: *The gas vents in the vent caps must be open to release gas. If gas pressure cannot escape, the battery may explode.*

Shipping vent plugs are to be discarded. They may be removed by using a pair of pliers and a combined rocking and turning motion or where short plugs are furnished, they can be pried out with two screwdrivers. Cells are usually mounted in wooden or plastic cases called trays (see Fig. 1, 2, and 3). Wooden trays are coated with paint or varnish. Trays are arranged to prevent adjacent cells from touching each other. Cells are shipped filled and with a layer of oil over the electrolyte

to reduce contact of the electrolyte with air (see 2.08 and 2.10).

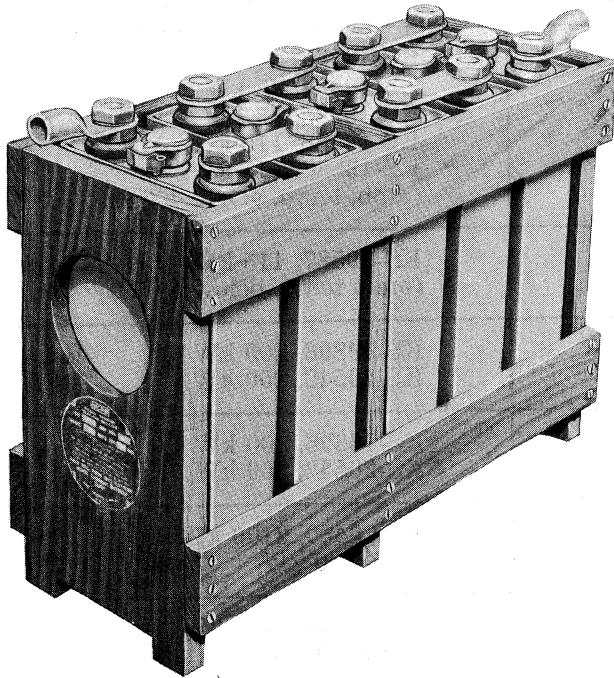


Fig. 1—Typical Tray Assembly—Nicad Type

2.02 Plate and Electrolyte Chemical Reactions:

In a fully charged state, the positive plates contain nickel hydroxide in a high state of oxidation and the negative plates contain finely divided cadmium metal. In a discharged cell, the positive plates contain nickel hydroxide in a low state of oxidation and the negative plates contain cadmium hydroxide. The electrolyte, which is a solution of chemically pure caustic potash, KOH, takes no apparent part in the chemical reactions. Changes in specific gravity at the positive and negative plates cancel out so as to leave the electrolyte unchanged in specific gravity both on charge and discharge.

2.03 Cell Voltage: The voltage produced per nickel-cadmium cell is less than that produced per lead-acid cell so that more nickel-cadmium cells are required for any required voltage. Nickel-cadmium cells may be smaller so that the battery of either type can occupy the same space. See 3.02 for float voltage requirements. The usual comparison

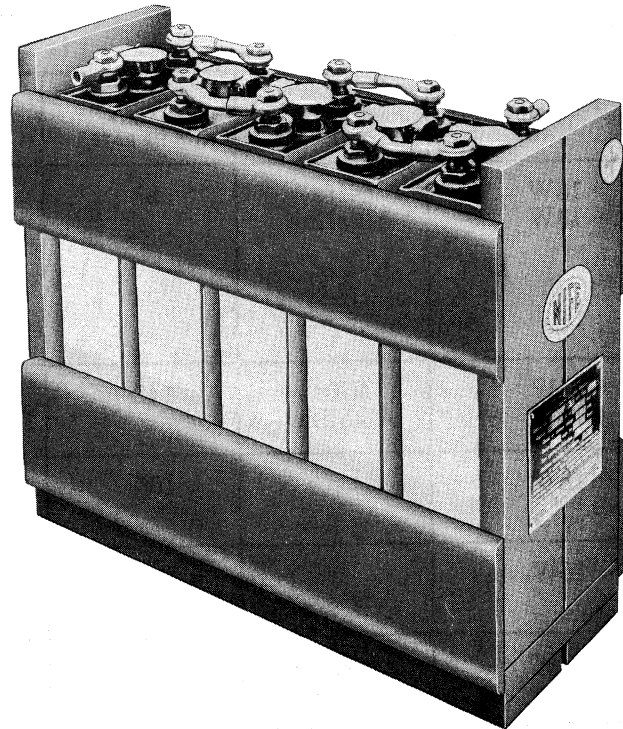
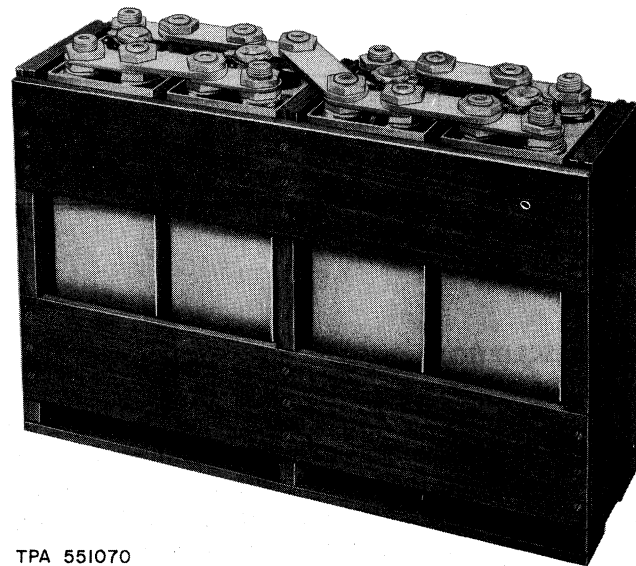


Fig. 2—Typical Tray Assembly—Nife Type



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Fig. 3—Typical Tray Assembly—Alkaline Type

of number of cells for different nominal battery voltages are as follows:

NOMINAL VOLTS	NUMBER OF CELLS	
	LEAD ACID	NICKEL CADMIUM
6	3	5
12	6	10
24	12	20
32	16	25

2.04 Battery and Cell Capacity: The capacity of KS-15578 batteries is shown on the nameplate. The capacity of any given cell is almost the same at all discharge rates from 3 to 20 hours. Engine starting requires short time cranking ability of the battery at high discharge rates for a short period. The practical discharge rates therefore bear little resemblance to the 5- or 8-hour capacity rates. Nickel-cadmium batteries are capable of delivering these very high discharge rates without damage. This explains why the capacities required of nickel-cadmium batteries may be much less than the capacities of lead-acid batteries for engine starting service. Nickel-cadmium engine starting batteries do not have this advantage in central office and PBX service where lower discharge rates are usual. The effect of different temperatures on the capacities of nickel-cadmium batteries are as follows:

TEMPERATURE DEGREES F	PERCENTAGE OF 5-HOUR CAPACITY*
115	108
100	105
77	100
32	95
0	70
-10	60
-20	50

*These percentages are for batteries having 1.240 specific gravity electrolyte.

2.05 Electrolyte temperatures from -20°F to $+115^{\circ}\text{F}$ are satisfactory. For short periods, as during a special charge, temperatures up to 145°F can be tolerated. Temperatures down to -40°F do no damage other than temporarily reducing the capacity.

2.06 Ampere-hour Efficiency: The ampere-hour efficiency is the electrochemical effectiveness of the cell on cycle operation. It is the current

output times hours of discharge, divided by the current input times hours of charge required to restore the cell to full charge. For nickel-cadmium batteries, the required recharge is usually specified as 140 percent of the discharge. There are also long term losses due to local action which are normally corrected by float operation.

2.07 Adding Water: Distilled water or any other water approved for use in lead-acid batteries may be used for additions. Water containers should be kept clean and closed. No water container should be used that has previously held acid or other chemicals. Condensed steam from boilers in which water softeners were used may be unsatisfactory. Addition of water should seldom be required (see 2.10).

2.08 Electrolyte Oil Layer: The thickness of the oil layer is not critical and need not be measured. It is a pure mineral oil which prevents exposure and evaporation of electrolyte to the air.

2.09 Specific Gravity: The specific gravity reading is not indicative of the state of charge. Cells may be shipped with electrolyte at any specific gravity from 1.160 to 1.300 at the discretion of the battery manufacturer. The higher specific gravity is preferred for very cold locations and the lower for warm locations. There is no appreciable change in specific gravity during charge or discharge. In case of spillage, which reduces the level below the top of the plates, add water to cover plates and order new electrolyte for the entire cell. When ordering electrolyte, be sure to include the KS number, the list number, and the name of the cell manufacturer. Cells will suffer no harm while waiting for the new electrolyte but cells should be discharged as completely as possible before dumping the old electrolyte.

Caution: Do not allow cells to stand empty (without electrolyte) as this can damage the plates and could eventually lead to a fire hazard. If some electrolyte has been spilled, fill cells with suitable water until new electrolyte is available.

After refilling, cells should receive a 200-percent charge. In no case shall electrolyte be dumped in an unauthorized manner that may result in pollution, damage, or hazard. Cells awaiting new electrolyte should not be used in service.

2.10 Electrolyte Deterioration: If the electrolyte were exposed to the air, it would fail ultimately and would need to be replaced due to **carbonation** caused by absorption of carbon dioxide from the air and from water used for maintaining the proper solution level. However, the vent caps and the layer of oil over the electrolyte reduce exposure of the electrolyte to the air to a minimum. The recommended operating routine uses practically no water. As a result, the rate of carbonation is so low that replacement of electrolyte because of carbonation is no longer considered a normal problem.

2.11 Substitution for Lead-acid Batteries: The nickel-cadmium battery may be substituted (for engine starting) for a lead-acid battery, using the same control equipment and with no adjustments other than the slight change in float voltage. Nickel-cadmium batteries are much less critical of maintained voltage and are not harmed by overcharge. High charge rates that do not heat electrolyte excessively and do not cause excess water loss, cause no harm to nickel-cadmium batteries. High discharge rates, even those present on a short circuit on the cell, cause no harm. Standing for long periods either partially or wholly discharged causes no permanent damage to the nickel-cadmium battery.

Caution: *Many flooded nickel-cadmium starting batteries have metric threads and will not accomodate nuts with American or English threads. If a changed nut does not screw on easily, do not force it or the threads will be stripped. Using socket wrenches of improper size may cause the corners of the nut to be damaged, or the wrench could slip and short out the terminal of the battery.*

2.12 Terminal Post and Case Care: Cells should be kept dry and clean using a dry cloth to avoid dampness that might rust metallic containers. If cells are received with grease or petrolatum smeared on containers or terminals, it should be left on to retard rusting of metallic containers and to assist in retarding the creepage of electrolyte. In some cases, carbonate, which appears as a white crystalline deposit, may appear around some of the terminals due to leaks in the seal around the posts. This deposit may cause a conductor path to grounded objects such as racks and stands. It should be wiped off with a dry cloth. The nut

over the seal should be tightened to stop the leakage. All new plastic cells should be checked for loose post seal nuts when they are received.

2.13 Intercell Connectors: While nickel-plated steel or copper intercell connectors have none of the cold flow experienced with the lead alloy or lead-coated copper intercell connectors of lead-acid cells, connections of nickel-cadmium cells should be inspected occasionally for tightness, using an insulated wrench.

Caution: *At no time shall the battery intercell connectors be filed, scraped, abraded, or brushed. To do so will tend to remove the nickel plating, exposing the copper beneath to ready corrosion.*

2.14 Initial Charges: Nickel-cadmium cells installed within a year of shipment from the factory should receive an initial charge equal to 100 percent of nameplate rated capacity. This charge should be at as high rate as practicable but not in excess of 120 percent of the 5-hour discharge rate. See 3.06. Where time exceeds a year, special recommendations should be obtained from the battery manufacturer.

2.15 Initial Charge of Cells Shipped Dry: When for any reason cells have been shipped dry with solution in separate containers, a more extensive initial charge is required. After pouring the solution to minimum level, allow cells to sit approximately 12 hours and readjust the electrolyte level. The charge should be at as high a current rate as feasible but not to exceed the 5-hour discharge rate (capacity divided by 5) and continued until 140 percent of the 5-hour capacity of the battery has been applied. This would be a charge of 7 hours if at the 5-hour rate. Allow the battery to sit for several hours, preferably 12 hours, and repeat the above 140 percent charge. During charging, reduce the rate if necessary to prevent the temperature of the solution exceeding 115°F. After completion of the total 280 percent of charge, fill to the maximum level with the provided solution and add oil.

2.16 Advantages and Disadvantages

(a) The advantages of nickel-cadmium cells are as follows:

High discharge rate capability for short periods

Long life

No equivalent of sulfation

Great mechanical strength

No corrosive spray

Little, if any, swelling of plates

No buckling of plates

Very low water consumption

No gassing on discharge

Low rate of self-discharge

Low voltage drop on discharge

Not damaged by temperature

No shedding of active materials

Simple and inexpensive maintenance

No deterioration of plate separators

No specific gravity records necessary

May be operated at high or low temperature

Not damaged by remaining idle in any state of charge or discharge

Low trickle charge rate.

(b) The disadvantages are as follows:

Higher initial cost

Impossibility of checking state of charge by specific gravity readings

Possibility of need for electrolyte renewal on services other than float or engine starting

Requires more cells for the same voltage output

Metal containers, when used, are electrically alive and offer some hazard unless insulated

Lower ampere-hour efficiency on cycle service.

3. REQUIREMENTS AND PROCEDURES

3.01 Periodic Checks: Table B contains the intervals of the periodic checks which must be made and mandatory work which must be performed.

TABLE B

INTERVAL CHART FOR NICKEL-CADMIUM ENGINE STARTING AND CONTROL BATTERIES

DESCRIPTION OF OPERATION	INTERVAL	REFERENCE PARAGRAPH
Cell and battery float voltage	3 months	3.02
Electrolyte level	12 months	3.03
Battery connections	3 months	3.04
Inspect and clean	3 months	3.05
Full capacity charge	—	3.06

3.02 Float Voltages: Nickel-cadmium cells should be floated between 1.40 and 1.45 volts per cell (open circuit voltage is approximately 1.30 to 1.35 volts per cell). See Table C for the battery float voltage ranges. Where there is no voltage regulation, voltage should be corrected frequently by small changes in charger setting until correct value is obtained. Thereafter, voltage should be noted often enough to assure that proper float is being maintained. The minimum voltage of any cell in string shall be at least 1.40 volts. Check individual cell voltage and total battery voltage by using a Weston Model 931 dc voltmeter and 6-foot test cords. Where these 6-foot test cords are not long enough for proper voltage measurements, the 10-foot Weston No. 168023 test cord should be used in conjunction with the black 6-foot test cord and Weston voltmeter. Cell and battery float voltages readings shall be read every 3 months. Float charge at the specified voltage will normally insure that the battery will be maintained in a charged condition.

TABLE C

BATTERY FLOAT VOLTAGE RANGES

NOMINAL BATTERY VOLTAGE	NUMBER OF CELLS	BATTERY FLOAT VOLTAGE RANGES
6	5	7.00 to 7.25
12	10	14.00 to 14.50
24	20	28.00 to 28.60
*24	19	27.20 to 27.80
32	25	35.00 to 36.25
48	38	53.35 to 55.15

* For sonotone, MA5 type battery only.

3.03 The *electrolyte level* shall be maintained between the minimum and maximum required (see Table D) by the addition of distilled water or water approved for storage battery use. The electrolyte level should be checked semiannually, but the addition of water should seldom be required.

(a) If plastic jars with high and low level lines are used, maintain the electrolyte level between the lines.

(b) Electrolyte levels are measured above the plates of cells in metal jars by using a transparent tube or pipette which is furnished with each battery for measuring electrolyte level and noting that there is still oil on top of the electrolyte. The tube is inserted through a vent hole until stopped by the top of the plates. The top of the tube is then closed with the finger and the tube lifted to show the electrolyte and oil. Use a scale in conjunction with a glass tube to measure the electrolyte level. Spillage should be avoided. If the top of the plates has been exposed to air, add water immediately to cover the plates.

Note: If the electrolyte level of any of these batteries now in service is found to be higher than that shown as a maximum, it will not be necessary to remove electrolyte to lower the level to meet such a maximum.

TABLE D

ELECTROLYTE LEVEL

KS-15578 LIST NO.	ELECTROLYTE LEVEL	
	MAX (INCHES)	MIN (INCHES)
1	1	1/2
2 to 7	1-3/4	3/4
8 to 9	2	3/4
10	3	3/4
1E	1-1/4	1/2
2E to 7E	1-1/2	3/4
8E to 10E	1-3/4	3/4
1W to 16W	3/4	Top of plates
MDP-2	3/4	Top of plates
KBI-1	1/4-inch above plates after charge	—
MA 5	1/4-inch above plates after charge	—

3.04 Battery Connections: All connections shall be tight. Periodically, the battery connections should be cleaned and coated with NO-OX-ID A compound or acid free petrolatum (vaseline).

Gauge by eye and feel.

3.05 Exterior Cleanliness: The exterior of the cell shall be clean and dry. Inspect and clean every 3 months (see 2.12). The flame arrestor vents can be cleaned in warm water.

3.06 Initial and Special Charges: The battery should be charged at installation and whenever the battery fails to start the engine or there is other evidence of undercharge. Unless otherwise specified, this charge in ampere-hours should be 100 percent of nameplate capacity rating. Charging rates as high as 120 percent of the 5-hour discharge rate (capacity divided by 5) are satisfactory provided temperature is not excessive (see 2.05), and provided gassing does not cause overflow of the cells. Low rates within the capability of the furnished charger are usually satisfactory but, in some cases of very deep discharge at low discharge rates, higher charge values may be necessary. Open-circuit voltage is about 1.30 to 1.35 volts per cell. This charge should be made when the engine is not running.

A battery that will not retain a charge and must have frequent special charges should be replaced (see 1.08) unless it is determined that a change of electrolyte is required (see 2.10).

Caution: *The nickel-cadmium type battery should not be sent to a garage or service station for charge, because of the possibility of contamination of the electrolyte.*

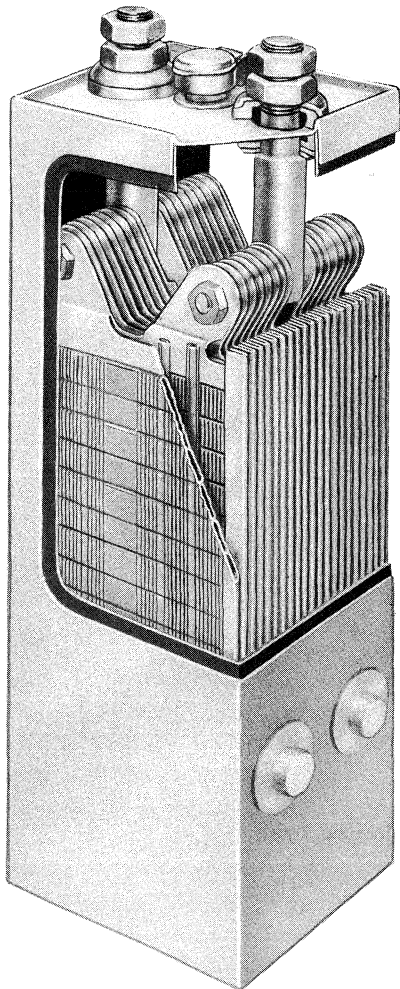


Fig. 4—Typical Cell Construction—Nicad Type

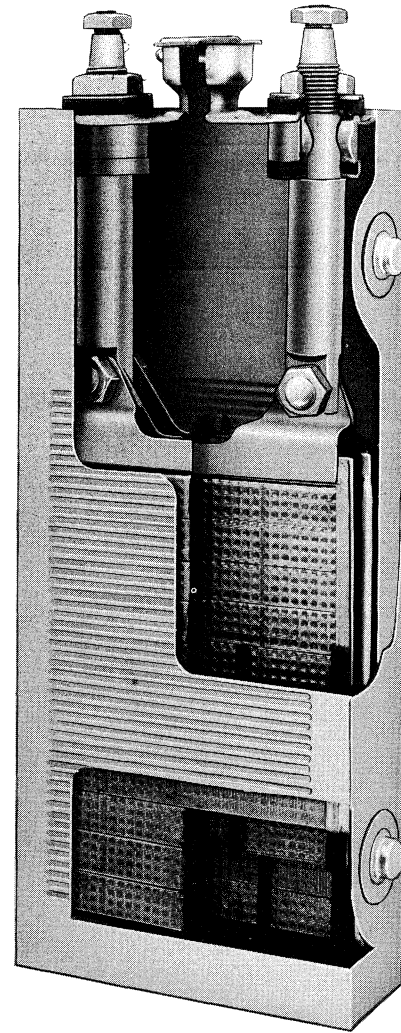
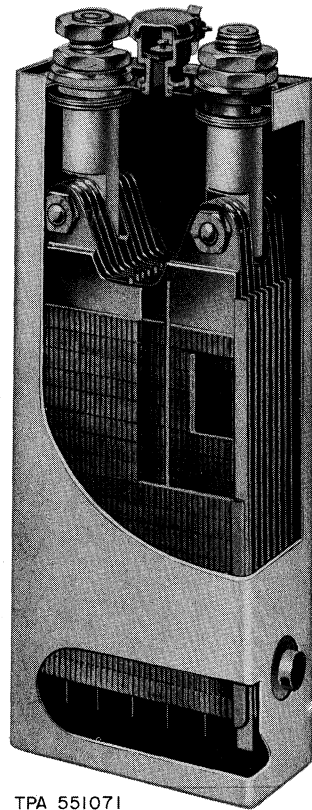


Fig. 5—Typical Cell Construction—Nife Type



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Fig. 6—Typical Cell Construction—Alkaline Type