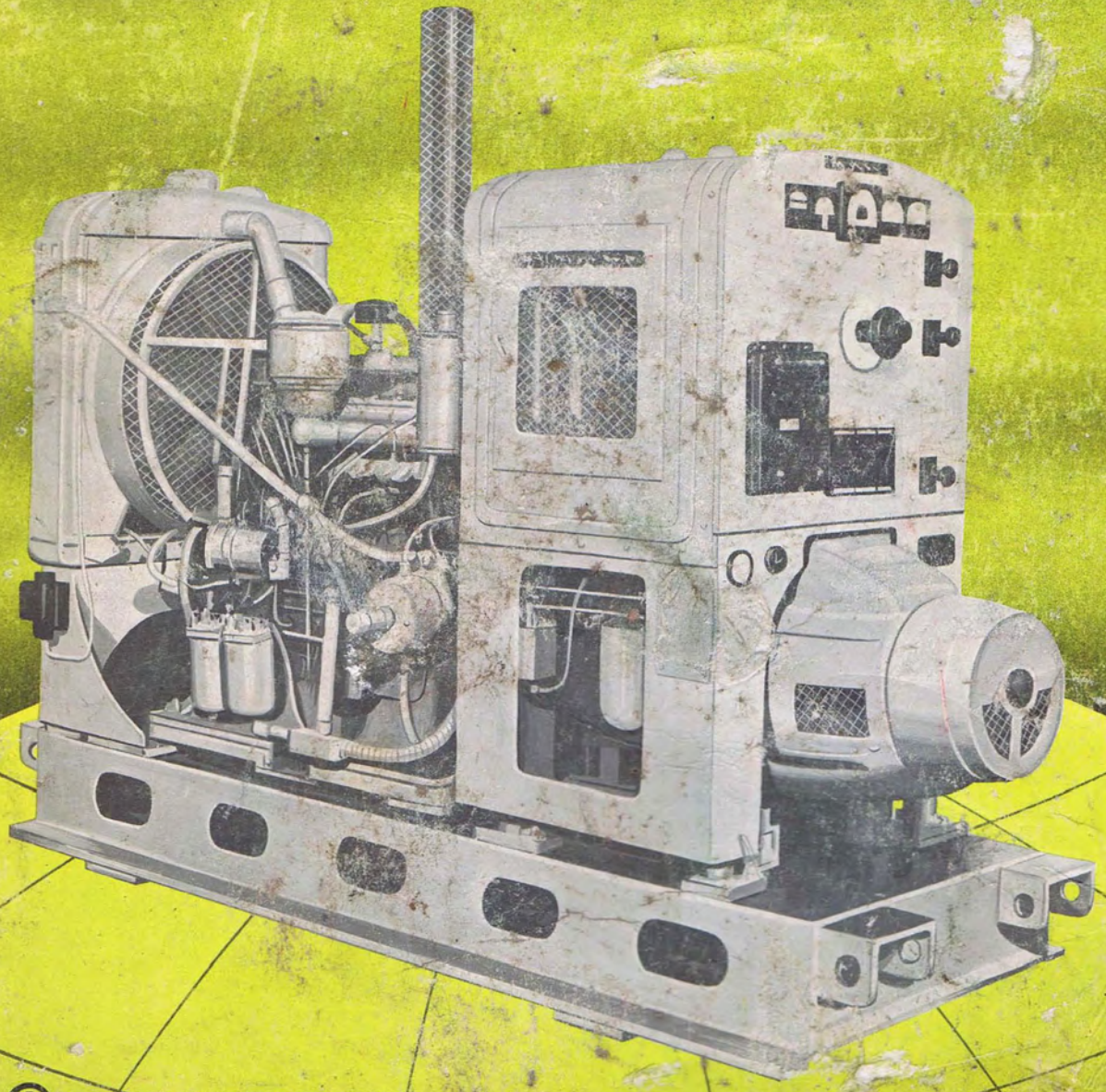
TELEPHONE POWER MAINTENANCE NOTES



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TELEPHONE POWER MAINTENANCE NOTES

INDEX OF MAIN SUBJECTS

SECTION A
GENERAL

DEFINITION - TELEPHONE POWER

Telephone power is all equipment in a toll or exchange central office or PBX that converts commercial alternating power to direct current at any required voltage, or A. C. power at various frequencies for ringing or signalling. At some locations where commercial power is not available engine generating equipment may be the only telephone power.

Also included under telephone power are batteries, emergency engine-generator sets and converters to operate the equipment when the regular commercial power supply is interrupted.

GENERAL TYPES OF EQUIPMENT

The following is a list of equipment classified as power:

1. Batteries
2. Counter EMF Cells & Resistors
3. Motor-Generator Sets
4. Rectifiers
5. Emergency engine-generators or alternators
6. Ringing, Converters, Static generators (subcycles)
7. Inverted-converters
8. Emergency cell switches and other switches
9. Circuit breakers, Automatic and manual
10. Motor start controllers
11. Meters and voltmeter relays
12. Transformers, reactors, capacitors, and filter equipment
13. Voltage regulators
14. Power panels, power boards, fuses
15. Wiring, busbars, and shunts

SECTION B
STANDARD POWER PLANTS

STANDARD PLANTS

All but the older plants are standardized. Standard plants are identified with number - letter codes. Those with the same code are wired the same. The only difference is the size of batteries and counter EMF cells, number and size of charging units, and minor details, such as alarm arrangements. The overall operation is the same. A BSP section outlining the method of operation is issued for each coded power plant.

We are continually getting new power plants so it is difficult to keep a list up to date. On the following pages are plants we are using now. Voltage and amperage ranges and the general application of the plants are listed. Also, the circuit drawing numbers and BSP sections covering the plants are listed.

Plant Code	Spec. No.	General Use	Voltage Range	Busy Hour Amps	Method of Operation	BSP Section	Drawings
101A	J59010	Battery Supply Units for Non-Multiple PBX's of the 551 Type Small Cord or Cordless PBX's	15-20 17-21) 19-24) 21-26)	10-15 Amp-hr 10 Amp-hr	Cable Pair or Metallic-Type Rectifier Charge	167-410-201	SD 80697-01 Chg-Disch Manual SD 81118-01 Chg-Disch Auto.
101D	J53104	Battery Supply for 551D Multiple PBX	15-20	30 Amp-hr	Cable Pair or Metallic-type Rectifier Charge		SD 80698-01
101E	J86566	102A and 111A Equipment	20-25	15 and 30 Amp-hr	Cable Pair or Metallic-type Rectifier Charge		SD 80733-01
101F	J86567	Centralized Battery Supply for Non-multiple PBX's Individual 554 and 605 PBX's	18-26 32-46	15-200 Amp-hr	Cable Pair or Metallic-type Rectifier Charge	167-419-201	SD 80740-01 Central Off. Chg. SD 81227-01 Rect. Chg.
101G	J86731	101 Key Equipment 1A Key Telephone System	18-28V 14-28V) Talking) 16-20V -) 60 Cycles) 9-11V -) 60 Cycles) 75-110V -) 20 Cycles)	0-0.6 Amp 0-0.9 Amp 0-1.4 Amp 0-1.4 Amp .050 Amp	Metallic-type Rectifier for Batteryless Operation and Ringing Generator	167-416-201	SD 81135-01 Plant SD 81130-01 Rect
101J	J86471	6A Key Telephone System 550 Type PBX	18 or 24 18 10	4 Amps DC 1.6 Amps AC 5 Amps AC	Auto-Metallic Type Regulation	167-419-301 167-419-202	SD 81334-01
-	J58819	755 PBX	18-25	15 Amp-hr	Cable Pair or Metallic-type Rectifier Charge		SD 80588-01 Chg-Disch SD 80750-01 Ring
102C	J86502	Combined 20-Cycle Ringing & 8-volt Battery Supply for Magneto & Type "D" Carrier	8.2-9.2 Battery 75-90V Ringing	20-40 Amp-hr Battery 0.2 Amp Ringing	Automatic Operation		SD 80238-01 SD 80083-01

Plant Code	Spec. No.	General Use	Voltage Range	Busy Hour Amps	Method of Operation	BSP Section	Drawings
103B	J86423	Message Register Step-by-Step	60-75	10,000 Busy-hour Calls	Regulated Tube Rectifier	167-606-301	See BSP Section
103B	J86423	Pos. & Neg. Tripping Supply & Pos. Message Register Supply Pos. Trip Supply	60-75 46-52	25,000 Busy-hour Calls 32,000 Busy-hour Calls	Regulated Tube Rectifier	167-606-301	See BSP Section
-	J86424	551 PBX	20-28	25 and 50 Amp-hr	Cable Pair or Metallic Rectifier Charge Type		
105A	J86579	740D PBX	40-56 or 44-50	3 or 10	Regulated Tube Rectifier Float		SD 80606-01 Rect SD 80616-01 " SD 80648-01 Chg-Disch
105D	J86446	48V Application up to 30 Amps such as 355 356 Dial Offices; 701, 711, 740, and 605 PBX's; No. 12 Swbds.	45-52	10,20, and 30	Regulated Tube Rectifier	167-210-301	SD 81134-01 Plant SD 81138-01 Rect
110A	J86572	701, 711, 606, & 702 PBX's; 350, 355, and 360 Dial Offices; No. 11 Manual, Small Repeater, and PBX Building Supply	45-50 22-26	10-240 10-120	Regulated Tube Rectifier	169-603-319 169-620-301 167-215-301 " " " 169-603-319 169-620-301	48 Volt SD 80714-01 or) Rect SD 81180-01) SD 80720-02 Disch SD 80722-02 Charge 24 Volt SD 80753-01 Disch SD 80755-01 Charge SD 80757-01 or) Rect SD 81181-01)
111A	J86470	701, 711, 606, & 702 PBX's; 350, 355, and 360 Dial Offices; No. 11 Manual, Small Repeater, and PBX Building Supply	22-26 44-52	0-600	Semiconductor regulated saturable Reactor Rectifier	167-620-301	48 Volt SD 81424-01 Chg-Disch 10-120 amp SD 81501-01 Chg-Disch 10-600 amp 24 Volt SD 81466-01 Chg-Disch 10-120 amp
220A	J86580 J86582	Large PBX's Large CDO's	45-50 22-26	10-200 0-15	Float with Diverter Pole Gen		SD 80601-01 Charge SD 80641-01 or) Disch SD 80664-01)
301C	J86573	Large Dial & Toll Offices	22-26 45-50	0-6000	Float with Motor-Generator Sets or Rectifiers	167-620-301 Auto Start	See BSP Section
			22-26	0-6000	Float with Motor-Generator Sets or Rectifiers	167-620-306 Man. Start	
302A	J86434	Large Dial and Toll Offices	45-50	100-6000	Start Control and Automatic Voltage Regulation	167-621-101 "	See BSP Section
403A	J86577	Plate Supply for Central Office & C2 Radio Telephone	125-135 Pos. or Neg.	0.1-0.6	Regulated Tube Rectifier with or without Dry Cell Reserve	167-639-301	SD 80760-01
403B	J86592	Stabilized Plate Supply	125-135 os.	0-0.1	Regulated Tube Rectifier with Dry Battery Reserve	167-639-306	SD-80605-03 Rect SD 80816-01 Plant

Plant Code	Spec. No.	General Use	Voltage Range	Busy Hour Amps	Method of Operation	BSP Section	Drawings
403C	J86436	V3 Repeater Plate Supply	125-135 Pos.	0-180	Regulated Tube Rectifier with Dry Battery Reserve	167-640-311	SD 81081-01 SD 81082-01
405A	J86585	Plate and Telegraph Supply	125-135 Pos. or Neg.	0.1-1.5	Float with Regulated Tube Rectifier	167-642-301	SD 80642-01 Pos. SD 80642-02 Neg.
Part of 805C	J86428	No. 5 Crossbar Coin and Misc.	125-135 Pos. or Neg.	3 Amp-Pos. 0.6 Amp-Neg.	Float with Regulated Tube Rectifiers (Dry Cell Reserve on Neg.)		SD 80992-01 Pos. SD 80993-01 Neg.
410A	J86584	Plate and Telegraph Supply	125-135 Pos. or Neg.	1-25	Float with Regulated Tube Rectifiers	167-643-301	SD 80942-01 Disch SD 80943-01 Chg
410B	J86465	130/152 Positive and Negative	130-152	1-80	8 and 24 Amp Rectifiers	167-643-302	SD 81293-01 Chg-Disch 63 cell SD 81294-01 Chg-Disch 66 cell SD 81295-01 Chg-Disch 70 cell SD 81301-01 Chg Control
420A	J86578	Types "J" and "K" Carrier Equipment in Auxiliary Stations Having A-C	130-160 Pos.	1-30	Float with Regulated Tube Rectifier	167-645-301	SD 80914-01 Charge SD 80915-01 Disch
420B	J86586	Types "J" and "K" Carrier Equipment in Auxiliary Stations Having No A-C	130-160 Pos.	0-15	Engine-Generators	167-645-306	SD 80910-01 Charge SD 80915-01 Discharge
425 + 425A	J86435	Backbone TD-2 Radio Plate & Filament Supply	12 Neg.	60-800	Float with Regulated) Metallic Rectifiers))	167-646-311	SD 81086-01
			136 Pos.	1-20	Float with Regulated) Tube Rectifiers))	167-646-301	SD 81084-01
			257 Pos.	1-20	Float with Regulated) Tube Rectifiers)	167-646-306	SD 81085-01
			136 Pos.	0.5-5 Plt. 30 Sig.	Float with Regulated) Tube Rectifiers))		
			12 Neg.	22	Metallic Rectifiers))		SD 81153-01
425B	J86452	Secondary Route TD-2 Radio Plate & Filament Supplies	136 Pos.	0.65	Metallic Rectifiers))	167-646-321 167-646-316	SD 81161-01 SD 81159-01
			257 Neg.	0.35	Metallic Rectifiers)		
426A	J86442	N1 Carrier Supply	110-140 Neg. 120-140 Pos.	0.5-40 Amp Pos. or Neg.	Float with Regulated Tube Rectifier	167-648-301	SD 81137-01
501A	J86527	Busy Signal and Idle Trunk Indicating Lamps	5-11.5 A-C	11.7, 59, 174, 236	Continuous Operation		SD 80324-01 or SD 80770-01

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Plant Code	Spec. No.	General Use	Voltage Range	Busy Hour Amps	Method of Operation	BSP Section	Drawings
504A	J86611	Continuous A-C Supply with Emergency Converters Operated on 24- or 48-volt Battery	115/230 A-C	50-1000VA	Automatic Transfer to Inverted Converters Operated from 24- or 48-volt Battery	167-670-301	SD 80844-01 SD 80845-01 SD 80856-01 SD 80869-01
504B	J86617	Continuous A-C Supply with Emergency Converters Operated on 48-volt Battery	115 A-C 115 A-C 115 A-C	500VA 1.5 KW or 5 KW	Automatic Transfer to Inverted Converter Operated from 48-volt Battery	167-670-306	SD 81026-01 SD 81097-01
505C	J86426	L1 Carrier Repeater Power Supply	500-2500 A-C	0.5	Operation Continuously from 2-motor Alternator Normally from A-C Motor on Line and During Emergencies from Battery Motor with Power Control Panel Regulating Coaxial Current	167-671-316 167-671-311 167-671-321	SD 80952-01 SD 80960-01 SD 81038-01 SD 81073-01
505D	J86448	L3 Carrier & TV Term. Eqpt. 230V A-C Supply	218-242	5-21KVA	Operation Continuously from 2-motor Alternator Sets	167-671-326	
505D	J86447	L3 Carrier Aux. Repeater Power Supply	0-4400	1.7 Amp	Power Control Regulating Coaxial Current	167-671-326	
506A	J86724	Low-voltage A-C Supply	20 ± 2	50VA to 1.5KVA	Transformer Units Operated Directly on Power Service Mains		SD 80846-01 or SD 80881-01 or SD 80929-01
507A	J86732	Low-voltage A-C Supply	17-24	50VA	Normal Operation from Transformer on Line and During Emergencies from Vibrator on Office Battery		SD 81133-01
610A	J86479	"N" and "O" Carrier	130V Pos. or Neg.	1.5	From 50V to 130V Converter		
610B	J86801	Coin Control	110-120V	.75	Solid State		
610C	J86803	Use instead of small plants or CEMF-CELLS	24V Pos. or Neg.	5.00	Transistorized		
702C	J86429	Toll	+125-135 -125-135	25-1000 5-1000	Motor-Generators or Rectifiers Operated Automatically	167-705-301 Auto 167-705-306 Manual	SD 81015-01 Disch
704B	J86583	Pos. & Neg. 34 & 48 Volts for Metallic Teleg. Supply & No. 1 Teleg. Service Board	34 or 48	2.5 and 8	Floated with Regulated Tube Rectifiers	167-706-306	SD 80776-01
704C	J86590	Pos. & Neg. 48 Volts for Large No. 1 Teleg. Service Boards	44-50	0-120 Pos. 8-120 Neg.	Floated with Regulated Tube Rectifiers	167-706-311	SD 80722-02 Chg SD 80774-01 Disch

Plant Code	Spec. No.	General Use	Voltage Range	Busy Hour Amps	Method of Operation	BSP Section	Drawings
801A	J86502	Combined 20-cycle Ringing Plant for Magneto & Type "D" Carrier	75-100	0.2	Continuously Operated Automatic Transfer to Reserve Supply		SD 80083-01
802A	J86524	135-cycle Ringing in Toll Systems	35	40 watts	Continuously Operated with Manual Transfer to Reserve		SD 80383-01
802B	J86523	1000-cycle Ringing in Toll Systems	6 Continuous 4.25 Interrupted	.015 .025	Continuously Operated with Manual Transfer to Reserve		SD 64527-01 SD 80284-01
803C	J86555	20-cycle Machine Ringing & Signaling Supply for Large Manual, Dial, & Toll Offices	84-88 Coin 115-120V	2.0, 4.0, or 6.0	Continuously Operated with Automatic Transfer to Reserve Supply	167-721-311	See BSP Section
804C	J86451	20-cycle Machine Ringing & Signaling Supply for No. 11 Manual and Dial & Toll Offices	84-88	1.0	Continuously Operated with Automatic Transfer to Reserve Supply	167-722-311	See BSP Section
805B	J86561	20-cycle Machine Ringing & Signaling Supply for No. 11 Swbd., 350A Dial, 701, 702,606 PBX, & Small SxS	84-88	0.6	Continuously Operated Automatic Transfer to Reserve Supply	Auburn	SD 80514-01 SD 80515-01 SD 80516-01 SD 80517-01 SD 80533-01 SD 80634-01 SD 81143-01
805C	J86428	20-cycle Machine Ringing, Signaling & 130-volt Supply for No. 5 Crossbar	84-88 +125-135 -125-135	0.5 3.0 0.6	Continuously Operated with Automatic Transfer to Reserve Supply	167-723-311 Ring & Sig. 167-723-316 130V Sup.	SD 80978-01 SD 80989-01 SD 80990-01 SD 80991-01 SD 80992-01 SD 80993-01
806A	J86544	20-cycle Ringing Supply for Toll or Manual Office with Option for Signaling Eqpt.	95-120	0.5	Continuously Operated with Automatic Transfer to Reserve Supply		SD 80446-02
806D	J86596	20-cycle Machine Ringing & Signaling Supply for 701A PBX, 350A, & 355A Dial Offices, & No. 11 Manual Offices	75-110 or 72-88 75-110	0.25 0.5	Continuous or Start-stop Operation with Key or Dial Transfer of Machines and Automatic Transfer to Reserve Supply	167-255-301	See BSP Section
806E	J86445	20-cycle Ringing Supply for 356A Dial Office	80-90	0.25	Start-stop Operation Subcycle with Single or Duplicate Motor-driven Interrupters, Automatic transfer to Inverter on Power Failure Automatic Transfer of Interrupters	167-724-321	SD 81131-01 SD 81132-01 SD 81139-01

Plant Code	Spec. No.	General Use	Voltage Range	Busy Hour Amps	Method of Operation	BSP Section	Drawings
806F	J86456	Ringing Current Tones and Signals for SxS Offices	84-88 102-110	0.25		167-724-326	See BSP Section
		Use			Method of Opr.	BSP	
806G	J86472	701B, 711B, 740E PBX			AC-DC Machine Ringing Equip.	167-460-301	SD 81337-01 Ringing

In addition to the above plants which are in general use, there are a number of equipments which are so small that no codes have been assigned.

Spec. No.	General Use	BSP Section	Drawings
	Small 24-volt Supplies		
J86589	Small Miscellaneous 24-volt D-C Applications (Tube Rect.)		SD 80612-01 SD 80791-01 SD 80804-01
J86403	24-volt Supply Obtained from Small 48-volt 100-type Plants		SD 80718-01 SD 80719-01
J86440	Small 24-volt Supply with Metallic Rect.	167-641-316 167-767-301	SD 81091-01
	Teletype Supplies		
J86431	Power Plant for 81C1 Teletypewriter Switching System	167-740-301 167-740-311	
J86453	Power Plant for 81D1 Teletypewriter Switching System	167-741-301 167-741-311	
	Miscellaneous A-C Supplies		
J86521	A-C Operated C1 Carrier Telephone Repeaters and C5 Carrier Telephone Terminals		SD 80589-01 SD 80724-01 SD 80962-01
	Small Ringing Equipments		
J86726	0.5-amp; 20-cycle Ringing, Signaling, & Static Tone Supplies for Emg. Toll; Static Tone Supply with Reserve for Man. Ring. Swbds.: & Static Tone Supply Without Reserve for Order Turrets and Information Desks 120-volt Coin Supply; Howler Interrupter		
J86454	Pole Mounted Reserve Power Plant for "O" Carrier	167-768-301	
	Miscellaneous Specifications		
J86433	6-volt, 15-amp Supply for Mobile Radio Land Receiver		SD 81027-01

TYPES - DESCRIPTION

The majority of batteries used in the Bell System are of the Lead-Acid type; plates are of lead and electrolyte is acid.

THEORY OF OPERATION (1)(2)

The storage battery stores chemical energy which is converted into electrical energy when the battery discharges. Recharging restores the chemical energy.

The following figures 1 to 4 show exactly what takes place in a storage battery when charging and discharging:

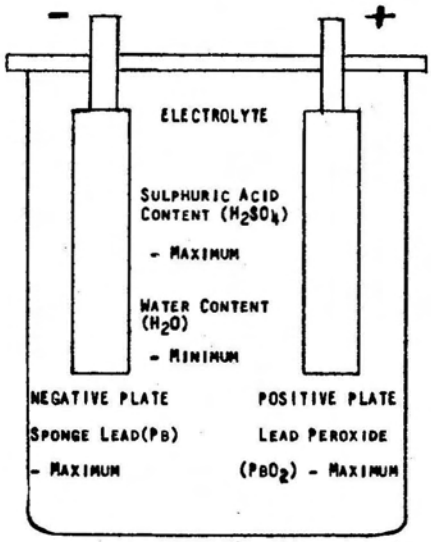


Figure 1 Charged

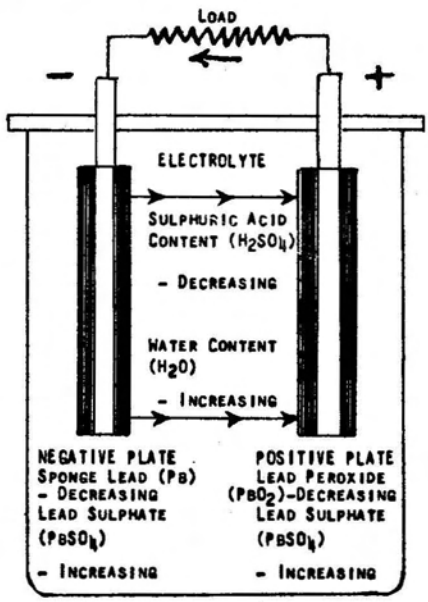


Figure 2 Discharging

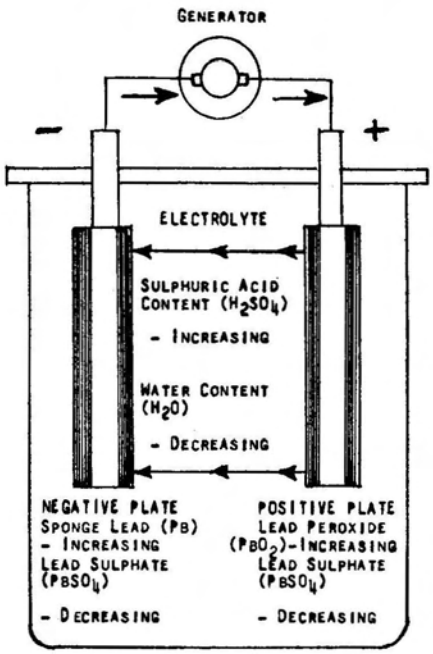


Figure 3 Charging

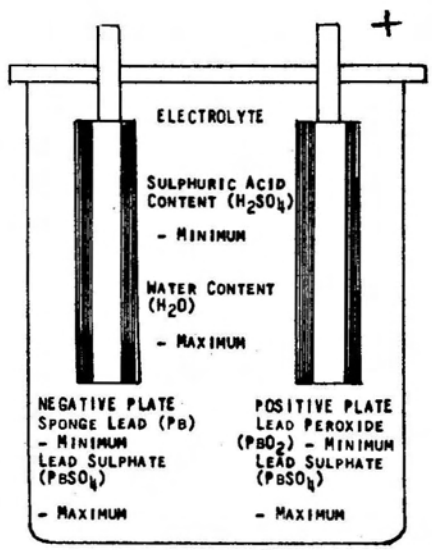


Figure 4 Discharged

(1) 157-601-101 - Theory & Operation, Lead-Acid Cell
(2) 157-621-101 - PBX Storage Batteries

GASSING

When the battery is fully charged (Fig. 1), extra charging reduces the water to hydrogen gas at one plate and oxygen gas at the other plate. This gas bubbles up through the electrolyte and out the vent.

CAUTION:
HYDROGEN GAST IS EXPLOSIVE. WATCH THE SAFETY PRECAUTIONS.

HOW THE BATTERY WEARS OUT OR DETERIORATES

Damage from Under-Charging

Deterioration of positive plate grids and self-discharge increase with low voltages. Battery reserve is reduced.

If the battery remains in discharged state (Fig. 4), the lead sulphate on the negative plate hardens and becomes insoluble. It will no longer return to sponge lead. The battery no longer can store chemical energy or produce electrical power. The specific gravity will be low. This condition is called sulphation.

Damage from Over-Charging

Excessive over-charging causes the active material to break loose from the plates and sift to the bottom of the jar as sediment. Also, plates will crack and warp causing internal short circuits.

The maintenance routines for batteries are aimed at getting maximum battery life by correct charging.

Damage from Heat

Heat causes rapid deterioration. Direct sunlight should not be allowed to fall on the batteries - use window shades. Ventilation should be as good as possible. Batteries should not be installed near heaters or radiators.

DO NOT ADD ACID OR TRANSFER ELECTROLYTE BETWEEN CELLS

Low gravity readings are caused by undercharging. Then the cells become sulphated. Adding acid to the cells or transferring electrolyte between cells in order to raise the gravity is harmful. It will cause the cells to fail sooner.

TYPES AND SIZES OF LEAD-ACID BATTERIES[1]

1. Open tank type with H-type plates 320 ampere-hour per positive plate. (Tank stands about 5 feet high.)

2. Open tank type with G-type plates 160 ampere-hour per positive plate. (Tank stands about 3 feet high.)

3. Rubber tank cell KS5562, 4000 to 7000 ampere-hour (stand on floor).

4. Rubber or plastic jar type KS5553 (antimony, KS15544 (calcium). Cells 180 to 1680 amphere-hour (mounted on battery racks).

5. Plastic jar type KS15886 (calcium) 50 and 100 A. H. Used in closely regulated plants for PBX's or CDO's, mounted in cabinets or on racks.

6. Small glass or plastic jar type KS5361, up to 100 ampere-hour sizes. (Used in PBX's and central offices, mounted in cabinets or on racks.)

7. Automotive type batteries (all sizes) used for engine starting.

WHAT IS ANTIMONY OR CALCIUM IN BATTERY?

Previous to 1950 most batteries were of the "antimony" type; that is, the hardening agent of the plate grids is antimony. (Lead by itself has little strength and antimony is added to harden the lead.)

All cells under the KS15544 and KS15886 specifications have calcium as the hardening agent.

(1) 157-601-701 - Table at Back of Section Covers Other Specifications of Batteries

DIFFERENCE BETWEEN ANTIMONY AND CALCIUM

The basic differences are:

1. Lower internal losses for calcium.
2. Less current required to keep calcium cell charged.
3. Because of low current rate, calcium cells do not produce much gas, so electrolyte mixing is slow. Specific gravity readings do not indicate true state of charge after water additions. It takes about 6 weeks for electrolyte to mix.
4. The calcium battery is not suitable for use where battery is cycled; that is, where charge-discharge occurs.

EXPLOSION PROTECTION

There are three types of explosion protection:

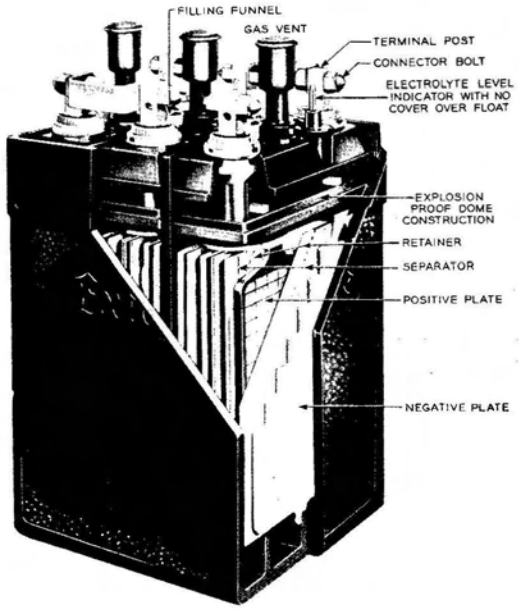


Figure 1

Explosion proof dome construction: a baffle diverts the gas to the vent, not allowing an accumulation of gas at the top of the cell.

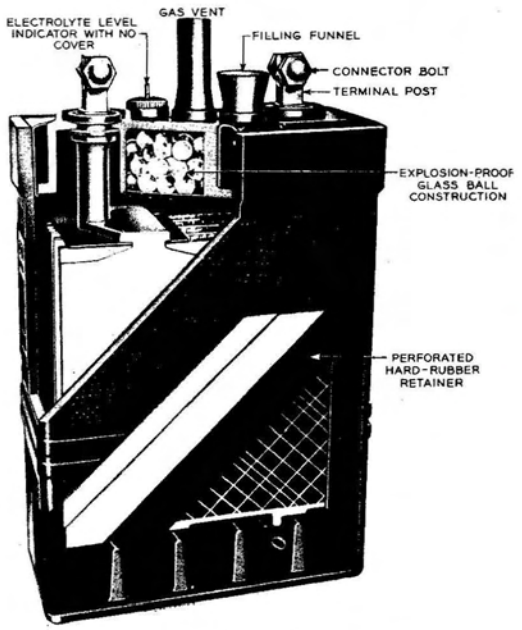


Figure 2

Glass balls fill up the space at the top of the cell. This reduces the volume of gas.

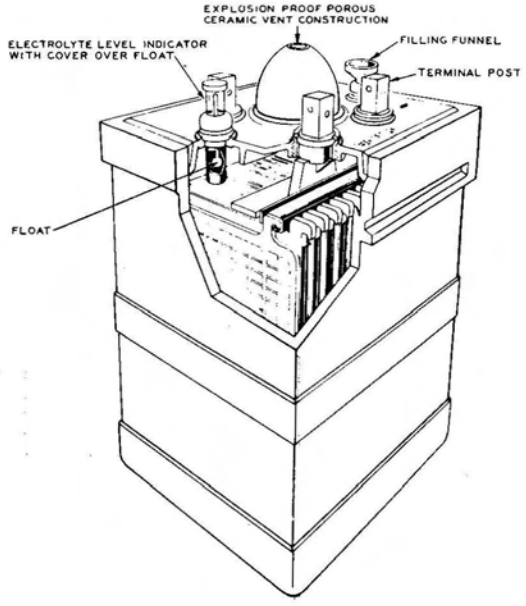


Figure 3

Ceramic porous vent: This type vent allows the gas to disperse as it leaves the cell. Also flame cannot pass by the vent to ignite the gas in the cell.

IMPORTANT
The cells must be correctly assembled as shown in the pictures if the explosion protection is to work. There should be no broken or missing parts.

SOME IMPORTANT POINTS FOR YOU TO CHECK ON TURNOVER OF NEW BATTERY BY WESTERN ELECTRIC [1][2]

1. You should get a copy of the readings before and after the initial charge by Western Electric Company. At the end of initial charge and when still at charge voltage, no cell voltage shall be more than 0.10 volt above or more than .06 volt below the string average, that is, the sum of individual-cell readings divided by the number of cells. For floated batteries, no cell voltage shall read above 0.10 volt or more than .04 volt below the string average. They should take these readings at least 3 days after initial charge, after 5 hours of float and within a week of turnover. The average specific gravity at turnover must be between 1.225 and 1.195 with water level not more than 1/4" down from maximum. The allowable spread is 10 points (.010) for large cells (over 100 ampere-hour size) and 15 points (.015) for small cells (under 100 ampere-hour size). If there is a question of the battery meeting these requirements, call the Maintenance Supervisor's office.

   NOTE: Give cells failing to meet turnover requirements 10 weeks of normal operation to come within limits. If they do not, the installer should reassume responsibility. For satisfactory operation all cells of the same string must be from the same manufacturer, must be of same capacity rating, must have plates of same material, that is, all lead-antimony or all lead-calcium, and must have the same nominal specific gravity.

2. Earthquake bracing should be installed properly. The bracing should have separation strips between every cell so that the cells cannot hit together during earthquakes.

3. Connector lugs should be tight and coated with "NO-OX-ID-A" grease.

4. Solderless terminal lugs that are used on leads to batteries and CEMF cells should be coated with one of the following:

   Cable Impregnating Wax
   Clear Varnish
   Acid Resistant Enamel

The above practice will prevent corrosion of the lugs and resulting "bad connections." (See W. E. Co. Handbook 18.)

OTHER TYPES OF BATTERIES

DRY BATTERIES [3]

The dry battery is a primary cell; that is, it cannot be recharged after once being discharged.

The cylindrical type cell is basically a carbon rod with a brass cap as the positive terminal, and a zinc can as the negative. The conducting material between is manganese dioxide moistened with sal ammoniac and zinc chloride. The voltage across a cell is about 1.5 volts.

Dry cells are also assembled in the block type to gain higher voltages and to conserve space.

AIR CELL BATTERIES [4]

The electrodes are of carbon and zinc and the electrolyte is a solution of caustic soda. An addition of water in the cell is necessary to activate the battery before putting it into use. The air cell is also a primary cell (not rechargeable).

(1) 157-601-201 - Storage Batteries - Installation of CEMF cells and enclosed-type lead-acid batteries
(2) 157-601-701 - Storage Batteries - Open & Enclosed Types
(3) 157-421-501 - Dry Cells & Dry Batteries 157-421-101 - Shows pictures of dry cells and has a table of ratings.
(4) 157-221-501 - KS 7777 KS 7778 & KS 15760 Air Cell Batteries

NICKEL-CADMIUM [1]

Positive plates are nickel and negative plates are cadmium. Batteries are in metal containers with caustic solution as electrolyte. They are used as starting batteries for emergency engine sets. A voltage of approximately 1.4 volts per cell is provided with this battery as compared to 2.0 volts for the lead-acid battery. This requires that more cells be used for the required voltage. The battery is more expensive but should last longer. Maintenance is less because the battery can stand up better under over-charging or under-charging.

This battery has a disadvantage that the electrolyte gravity does not show the state of charge.

A layer of oil covers the top of the electrolyte. Distilled water or any other water approved for use in lead-acid batteries may be used in this battery.

To maintain nickel-cadmium batteries see BSP 157-631-101 and 155-100 Plant Series for particular engine-alternator.

GENERAL PRINCIPLES [2]

The fundamental principles involved in battery maintenance are:

1. Maintain battery in healthy state of charge with as little excess charge as possible.
2. Maintain electrolyte level between maximum and minimum by addition of approved water.
3. Keep the battery clean.
4. Keep temperature within limits.
5. Recognize the danger that exists due to explosion of hydrogen gas. Practice safety.

WATER TESTS - HOW MADE [3]

The storage battery companies make water tests as part of their service. Ship water samples by express in new unused, 1 quart plastic, small neck bottles properly tagged and packaged. (Bottles may be obtained from local drug store.) Place information specified in B.S.P. 157-601-701 on tag.

Follow the procedure outlined below for each make of battery. (Locations having more than one make of battery, send sample to manufacturer of main battery.)

C & D Battery

Address sample to:

C & D Batteries, Inc.
Conshohocken, Pa.
Att: Water Test

Gould Battery

Address sample to:

Gould National Batteries
West Station Road
Kankakee, Illinois
Att: Chemical Laboratory

Exide Battery:

Address sample to:

Electric Storage Battery Co. (Exide)
Rising Sun and Adams Streets
Philadelphia 20, Pa.
Att: Supt. of Service Labs.

MAINTENANCE UNDER CONTINUOUS FLOAT ROUTINE [4]

The most important point in floating batteries is the voltage setting. The voltage per cell should average 2.17 volts.

The meter used for setting the float setting should be checked periodically for accuracy. (See also Section K in this booklet on meters.)

(1) 157-631-101 - KS 15578 Nickel-Cadmium Batteries - Engine Starting
(2) 157-601-101 - Storage Batteries - Theory & Definitions
(3) 157-601-701 - Water Tests
(4) 157-601-301 - Storage Batteries - Continuous Float Operation

The float setting should be exact.

Example:

Indiv. Cell Volts. (Avg.)	Volts	Cells	Avg. Volts
	22	10	21.70
2.17	24	11	23.87
		12	26.04
	48	23	49.91
		24	52.08
	120	56	121.53
	130	61	132.37
		62	134.54
		63	136.71
		66	143.22
	250	119	258.24

BOOST CHARGES - WHEN GIVEN

1. At least once a year.

2. If the specific gravity of any cell drops more than 4 points .004 in a 6 months period.

   NOTE: A false indication is given after adding water, particularly with calcium cells as explained previously.

3. If any cell drops below 2.13 volts with the average cell voltage at float voltage (average 2.17 volts/cell).

4. If the battery has an appreciable discharge (15% or more of the ampere-hour rating).

Emergency end cells immediately after discharge.

VOLTAGE OF BOOST CHARGE

Determined by the type of plant and whether there are counter cells or not.

LENGTH OF BOOST CHARGE

Determined from table in 157-601-301.

INDIVIDUAL CELL CHARGERS[1] (SEE ALSO SECTION K ON METERS & TEST INSTRUMENTS)

Individual cell chargers are available for charging low or rundown cells in a string one at a time. There are two sizes of chargers:

KS15687 - 20 ampere
J86264 - 210 ampere

With them you can charge a bad cell in a string without overcharging all of the cells. The newer plants are not installed with CEMF cells for charging. The only way a cell can be raised to a high charge voltage is with the single cell charger.

The chargers are protected with isolation transformers, circuit breakers, etc. They can safely be used on a working battery. Only these standard chargers should be used.

NOTE: When you charge a low calcium cell you will notice the following unusual result. Immediately after the charge is stopped, the cell voltage will be lower than before you started charging. It may take from one to eight weeks before you see the improvement from the charge. With antimony cells the improvement is usually right away.

ROUTINE READINGS AND RECORDS[2]

Readings of individual cell voltages and gravities should be regularly taken and used for comparison, and for recognizing the start of trouble. The records should be on standard forms and kept with the batteries.

The frequency of routines and forms for recording the readings is as follows:

(1) 169-621-301 - J86264 Rectifier - Single Cell Charger
(2) 157-601-301 - Storage Batteries - Continuous Float

Full Float Intervals of Routine Readings

Voltage	Minimum Frequency	Suggested Form For Recording See 157-601-301
Battery Average Float	Year	
Battery Volt or Pilot Cell Volts	Week or more often	
Individual Cell (include CEMF)	3 Months	
Specific Gravity		
Pilot Cell	1-1/2 Months	
Individual Cell	6 Months	
Boost Charge	Year or if required	
Clean and Inspect	3 Months	
Calibrate Voltmeter	6 Months	

NOTE: All readings are taken at float voltage. The routine of reading individual cell specific gravity is reduced from a 3 months to a 6 months interval.

The frequencies of the above routines are considered to be minimum frequencies. Trouble in the battery as indicated by abnormal voltage or specific gravity readings should require that a closer check of the battery be made.

It is the responsibility of the supervisor in charge to see that these routines are carefully followed. He should personally review the readings that are taken with the power man. It must be emphasized that the readings of voltages and gravities are important maintenance functions.

MAINTENANCE UNDER CONTINUOUS VARIABLE CURRENT CHARGE (1)(2)

WHAT IS THIS ROUTINE?

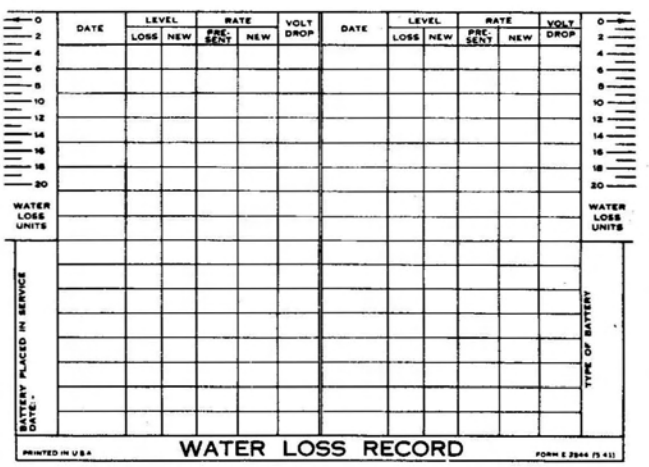
A set charge from the chargers causes the batteries to cycle; that is, the batteries are discharged during the peak load and recharged during the light-load period. The method is used when unregulated charging equipment is provided. Shorter life of the batteries can be expected, but they will last many years if properly charged.

HOW TO SET THE CHARGE?

It is very important that the batteries are properly recharged with each cycle without over-charging excessively. The method of setting the charger is determined by observations of the specific gravity and is outlined in 157-601-303.

MAINTENANCE UNDER THE WATER LOSS METHOD

A method of determining the charge setting by observing the rate of water loss is used in small PBX battery plants. A sticker-chart on the side of the jar is calibrated for water loss units. Section 157-601-304 gives tables of corrections to be made to the charger (raise or lower) in accordance with the number of units of water loss between routine visits.



(1) 157-601-303 - Storage Batteries - Continuous Variable Current Charge Operation

(2) 157-601-304 - PBX Storage Batteries - Continuous Variable Current Charge Operation Based on Water Loss

POINTS FOR YOUR APPRAISAL OF MAINTENANCE JOB

IMPORTANT POINTS

1. Float setting exact.
2. Water level within limits.
3. End cells fully charged. (Emer. Cells)
4. Tops of cells clean of dust and moisture. No spilled electrolyte.
5. No corrosion around battery connectors.
6. When were the voltmeters last checked? They should be checked about once every 6 mos.(1)
7. Have the connector bolts been checked for tightness? This should be done periodically as lead has a tendency to flow and loosen the connection.
8. Are records of routine readings properly kept? If there are cells with low readings, has boost charging routine been properly followed?
9. Glass or plastic jar cells are ones you can look into. You should see little or no sediment in floated batteries. When the batteries are cycled (charge-discharge), sediment is normal when the cells are older.
10. If the city water is being used in the batteries, the water must be tested at least every five years. The date of last test should be on record.

IS THE EQUIPMENT ADEQUATE?

STORAGE BATTERY RESERVE

Batteries are installed to give a certain period of reserve where the office can operate without AC power. In general the design is to provide:

1. Four busy hours for central office with permanently installed engine. Sometimes is between 3 and 4 hours if office is on a Power Network (tied into more than one power substation).
2. Twenty-four average hours (based on the average drain) for central office or CDO without permanently installed engine.
3. Twenty-four average hours at a PBX. (One normal business day.)

At remote, hard-to-reach locations such as microwave stations, the reserve may be 3 or 4 days.

WHY ARE SEMIANNUAL BATTERY DRAIN READINGS TAKEN? (2)

The readings give the necessary information for checking if battery reserve is long enough. Also, if the reactifiers or motor-generators are adequate for the load.

WHEN TAKEN?

Taken in June and December at all toll and exchange central offices. The drains are recorded on Form P527.

At normally unattended locations, readings during the day time are generally sufficient but an estimate of the evening and night loads should be included.

At locations such as summer resorts with seasonal peak loads that do not occur on these specified dates, readings should be scheduled for the time of the year when the peak drains occur.

HOW THE RESERVE HOURS ARE CALCULATED?

Battery reserve is determined from the battery discharge curves (Section M). They give the hours for a cell to reach a certain low voltage which gives an over-all battery voltage just within the emergency operating limits of the equipment being served.

(1) 157-601-301 - Storage Battery - Continuous Float

(2) 157-000-900PT - Exchange Load Readings. Form P-527 for Use in Recording Storage Battery Discharge Loads

Examples:

	Nominal Voltage	Emergency Limits	Minimum Cell Voltage
Step-by-Step Equipment	-52	44	1.85 volts for 24 cells
Step-by-Step Equipment	-50	44	1.75 volts for 27 cells
	-50	44	1.75 volts for 27 cells
"N" Carrier Equipment-Terminals	-52	44	1.85 volts for 24 cells
"N" Carrier Equipment-Terminals	+130	117	1.75 volts for 66 cells
"N" Carrier Equipment-Repeaters	+130	115	1.75 volts for 66 cells
"N" Carrier Equipment-Repeaters	-130	110	1.75 volts for 66 cells
			1.91 volts for 23 cells
Dial PBX	-50 or -52	44	1.83 volts for 24 cells
Local Switchboards	-24	20	1.82 colts for 11 cells

The voltage range of the equipment is shown on the SD drawing for the particular equipment.

IMPORTANT
One or more dead cells will materially affect the battery reserve. A low reading of voltage and/or gravity of a cell in a string indicates little or no available power. During a power failure this cell may actually change from a battery to a resistance reversing the voltage and reducing the over-all voltage of the string.

SAMPLE CALCULATION OF RESERVE

Example:

Drain of CDO Averages	50 Ampere
DC Ringing Machine Adds	8 Ampere
Emergency Lights Adds	5 Ampere
Total Average Power Failure Drain	63 Ampere

The power plant is a 110A plant with 24 KS15544 list 505 cells.

Minimum voltage of step-by-step equipment is 45 volts.

Per Cell - This is 45/24 1.87 volts. From chart in Table M closest to 1.87. (4th chart to 1.88 volts). The hours reserve is 24 HOURS.

REPLACEMENT OF BATTERIES

HOW REPLACED

A complete battery is a unit of property and is replaced under the C and X codes. An individual cell is a subunit and is replaced under the R codes.

The chief engineer prepares the projects to replace central office and toll office batteries and some multiple PBX batteries. (See battery replacement by types next page.)

WHEN REPLACED

Replacement of batteries by the Chief Engineer is made on recommendations by the plant department supported by tests. The plant department replaces all other batteries after thorough inspection and tests.

You can use the following table as a guide not an aim, for the expected life of storage batteries. The table is taken from 157-601-701. Careful maintenance should better these estimates:

Anticipated Life - Years

	Floated	Lightly Worked	Worked
KS-5553-01	15		
KS-15544 (Calcium type)	25		
KS-5553; KS-5562	14	8	6
KS-5378; KS-5520	14	8	6

Anticipated Life - Years (Contd.)

	Floated	Lightly Worked	Worked
KS-5361 L-120 to L-151A	8	7	5-1/2
KS-5361 L-100 to L-116	5	4	3
KS-15886 L-140 to L-151 (Calcium type)	25		
KS-15577 (Lead Acid Engine Batteries Over 150 A. H.	8	4	

TESTING OF STORAGE BATTERIES[1] (SEE ALSO SECTION K ON METERS AND TEST EQUIPMENT)

Recently testers have been made available for all but the very large sizes of storage batteries. Up to 100 ampere-hour size a KS-5730 tester is used in accordance with procedure outlined in Section 157-601-502. This tester discharges the battery one cell at a time at a high rate for one minute. If the cell voltage drops below a certain specified value (1.50 volts at 70° F.) replacement is recommended. A reading of 1.60 volts at 70° F. indicates that tests should be repeated in about 6 months.

FROM 100 AMPERE-HOUR TO 1680 AMPERE-HOUR SIZE (J87116 TESTER)[2]

A carbon pile rheostat is used to discharge cells in the battery one at a time in accordance with the routine outlined in 157-601-503. A single cell charger is used after the test to restore the charge to a cell before another cell is discharged. In this way the overall voltage of the battery is not reduced to any great extent. The normal operation of the office is not interferred with.

Whenever practical, recommendations for replacement of storage batteries should be supported by test data obtained with the above testers.

(1) 157-601-502 - Short Discharge Capacity Test for Storage Batteries - 30 to 200 Amp-Hr Capacity
(2) 157-601-503 - Single Cell Discharge Capacity Test for Storage Batteries, 180 to 1680 Amp-Hr Capacity

REPLACEMENT OF MULTIPLE PBX BATTERIES

The Chief Engineer will replace those in PBX's that have real estate parcel numbers. He needs certain information to write the job, such as: Number and type of cells, Type of power plant, Method of charge, Load reading covering a 24 hour period, Results of tests, condition and age.

The plant department replaces those in PBX's without parcel numbers. Before you order a new battery you should carefully check the charging plant for correct voltage, inspect the battery for deterioration and make a battery test.

REPLACEMENT OF ENGINE STARTING BATTERIES

The replacement of engine starting batteries in central offices or toll offices is covered in Section 157-621-801. As the battery is a unit of property a routine order must be written to charge the replacement to the C and X codes. The plant department writes the routine order and a copy is sent to the chief engineer.

REPLACEMENT COSTS OF BATTERIES

Table M can be used to judge the money involved in replacement of a storage battery. To the amounts in this table the labor cost and the cost of engineering must be added. This information is included to indicate the high cost of battery equipment and the importance of good maintenance.

SAFETY PRECAUTIONS

Important safety precautions that you must follow while working around batteries are:

1. Precaution against explosion of hydrogen gas which is produced during charging. (Adequate ventilation)
2. No smoking.
3. Precaution against static sparks. The body static electricity should be discharged before touching a cell.

4. Tools used around a battery should be taped to reduce danger of accidental short circuits.

5. Protective clothing should be worn to protect person against acid burns.

6. The eyes should be protected with goggles.

7. The cases of nickel cadmium batteries are not insulated. Care must be taken not to ground the cases.

8. To neutralize acid from a lead acid battery use soda. To neutralize electrolyte from nickel cadmium battery use boric acid.

PRINCIPLE BELL SYSTEM PRACTICES SECTIONS

EDUCATIONAL

157-621-801 - Replacement Parts and Procedures, Enclosed-Type Lead-Acid Batteries
157-620-101 - Storage Batteries - Open Type
157-601-101 - Theory of Operation - Lead-Acid Cell
157-631-101 - Nickel-Cadmium Battery for Engine Starting - Description, Theory and Maintenance

MAINTENANCE

157-601-301 - Maintenance Under Full Float Routine
157-601-302 - Cycle Charge Manual Operation
157-601-303 - Continuous Variable Current Charge Routine (Set Charge)
157-601-304 - Maintenance Under Water Loss Method

GENERAL REQUIREMENTS

157-601-201 - Installation of CEMF and enclosed type, lead-acid batteries
157-601-701 - Open and Closed Types - (Provides anticipated life information, information on troubles in cells and a great deal of other material. Also it includes list of cells by KS number and capacity rating of cells.)
157-601-702 - Storage Batteries, post corrosion
157-421-501 - Dry Batteries
157-221-101 - Caustic Soda Batteries
157-221-501 - Air Cell Batteries

TESTING SECTIONS

157-601-502 - Short Discharge Test for Storage Batteries 30-200 Ampere-Hour Capacity
157-601-503 - Single Cell Discharge Capacity Test for Storage Batteries 180-1680
169-621-301 - Single Cell Charger

SECTION D
COUNTER EMF CELLS & RESISTORS

PURPOSE - WHAT DO THEY DO? (1)

A counter cell or load resistor does the following:

1. Reduces the voltage to the equipment to the proper value during over-charge of the batteries.
2. Provides a lower voltage supply from a higher one; for instance, 24 volts from the 48 volt supply.
3. Regulates the voltage. It does this by having one or more CEMF cells or load resistors in the discharge circuit normally. And then when the power fails they are shorted out. This gives us more battery reserve.

HOW MADE - HOW DOES IT WORK?

A counter is made of positive and negative plates both of the same material (nickle or stainless steel) in a caustic soda solution (sodium hydroxide).

Current flow between the plates causes a voltage drop from positive to negative of about 2 volts.

Water in the solution is used up by the forming of hydrogen and oxygen gas at the plates. The gas vents off from the cell and is Highly Explosive.

VOLTAGE DROP - SEE TABLES

The voltage drop across the cell varies some with the load, but not as much as a regular resistor. Resistors vary directly in proportion to the load (Ohms Law). Counter cells are used in plants with a large difference between the busy hour load and the light load. Resistors are used in plants with less than 10% load variations.

Many 130 volt plants now have load resistors instead of CEMF cells. They eliminate CEMF cell maintenance. The voltage drop of each resistor bank is ± 6 volts. Make adjustments as necessary to hold voltage drop within limits, per table shown on SD-80942-011.

COUNTER CELL PICTURES

Figure 1 Typical Two Post Cell

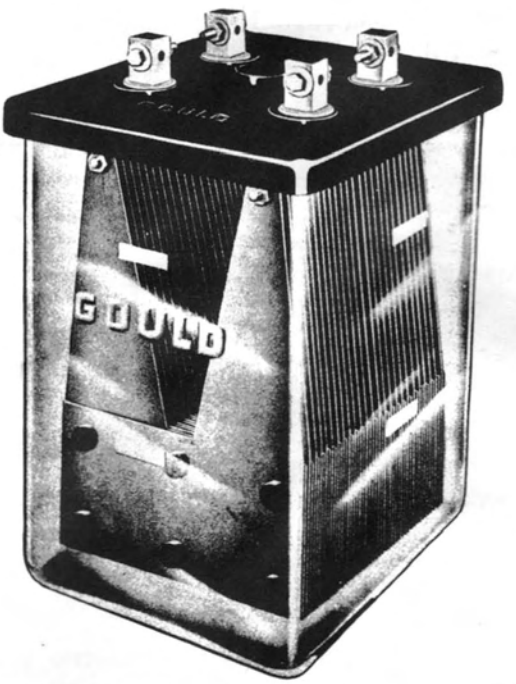


Figure 2 Typical Four Post Cell

(1) 157-321-101 - Counter Cells, Alkaline

WHY THE OIL LAYER ON THE TOP?

The layer of oil covers the top of the solution to prevent spraying out of the solution, or its contamination from the air. It is a type of mineral oil for CEMF cells.

MAINTENANCE OF COUNTER EMF CELLS [1]

WHAT HAS TO BE DONE?

1. Water additions to maintain the solution between the high and low marks on the jar. If the solution goes down to the bottom of the plates an explosion could occur.

TAP OR DISTILLED WATER?

Water should be approved tap water or distilled water. See section for testing by battery companies [2]. Water suitable for batteries is also all right for counter cells.

WHEN IS SOLUTION REPLACED?

Replace the solution when the voltage drop across the plates reaches 2.6 volts. As the solution gets older the voltage drop gets greater and greater. If it is not renewed when it reaches 2.6 volts the plates become pitted, the solution may boil over or possibly explode from excessive heat. Also, the plant will not operate properly because of the excessive drop. Failures have occurred due to the counter voltage becoming too high.

STEPS IN SAFELY REPLACING SOLUTION IN A COUNTER CELL ADJACENT TO WORKING CELLS

1. Provide for adequate ventilation.

2. Drape damp cloths around adjacent cells on aisle sides of the cell and adjacent cells. This will protect against flying glass if explosion should occur. (Do not cover the cells with cloths.)

3. Use goggles to protect the eyes and an apron to protect the clothing. Cotton clothing will not build up static charges; nylon and simular materials will. Therefore, the latter material should not be worn. Use slip proof neoprene gloves to handle the jars.

4. Discharge body static by touching grounded metal framework.

5. Short out cell by connecting leads to terminal posts of adjacent cells thru a shorting switch. When possible in addition to cell being worked on, short out adjacent cells also.

   Bring out leads for shorting away from the cell to a shorting switch so there will be no arc near cells. In doing this connect leads to the open switch before connecting to the cells.

6. Disconnect cell at terminals using taped tools.

7. Insulate the loose connections with tape, dry cloths, or rubber sheets.

8. Remove elements from jar being careful not to drip caustic solution on surrounding equipment.

9. Thoroughly clean the elements by washing with water.

10. Examine elements for loose bolts or other damage.

11. Flush old solution down drain with plenty of tap water.

    NOTE: In some localities this is not permissable, dispose of locally.

12. Wash jar and fill with approved water to 1-inch to 1-1/2 inches below top water level.

13. Mix sodium hydroxide crystals in jar amounts per BSP Section 157-321-701 adding the crystal slowly.

    NOTE: With plastic jars the solution must be mixed in a separate container.

(1) 157-321-701 - Counter Cells, Alkaline
(2) 157-601-701 - Storage Batteries

SOUTHERN REGION: Order sodium hydroxide alkaline solution from Western Electric Company as listed in supplies catalogue, Section C.

14. Replace jar on rack.
15. Replace elements in the jar reversing polarity of the plates by facing the elements in the opposite direction as previously.
16. Add oil amount per BSP 157-321-701 on top of solution.
17. Reconnect cell in circuit being sure of clean, tight connections.
18. Remove short from cell(s).

POINTS FOR YOUR APPRAISAL OF MAINTENANCE JOB

1. The voltage drop across the counter cells should be measured and recorded at the same time the battery cell voltage readings are taken; i.e., three months routine. A record of these voltages will make it unlikely that the solution change will be neglected when the voltage drop becomes too high.
2. Normal color of the cells is from white to various shades of grey; even black. The color does not seem to affect the performance of the counter cell. A semi-solid precipitate is sometimes present in the bottom of the jar and this is no cause for concern. Voltage drop alone is the measure of the correct performance of the cell.
3. As with the battery, the connectors should be clean and tight. The nuts should be tested for tightness periodically.
4. Excessive foaming indicates overloading of the cell or deterioration of the solution. In some cases the solution may actually spray out of the vents and run down the sides of the jar. In this case a prompt change of solution should be made.
5. Check power plants with resistors for voltage drop each time load is increased or decreased. Hold the voltage drop to ± 6 volts. Equipment failures can result from high IR drop. An oscillating voltage is created each time there is a power outage or the charging equipment is shut down.

ADEQUACY OF EQUIPMENT

RATING OF CELLS (1)

A counter cell has a maximum current rating that should be exceeded for only short periods of time.

Besides current rating, the cell has a "fill interval" rating. Example from table below: List 102 rating is 30 amperes for 7 days, List 140 is 30 amperes for 29 days.

TABLE OF RATINGS - KS 5170 CELLS

List	Wt. Comp. in Lbs.	No. Plates	Full Load Cont. Amps.	Fill Intervals Between High and Low Water Marks: Full Load Continuous	Fill Intervals Between High and Low Water Marks: Full Load For 10 Busy Hours
2		2	5	-	-
4		4	15	-	-
8		8	30	-	-
30		30	60	-	-
50		50	200	-	-
100	9	2	5	14 Days	34 Days
101	16-1/2	4	15	8 Days	20 Days
102	26	8	30	7 Days	17 Days
103	33	30	60	5 Days	12 Days
106	88	25	100	8 Days	20 Days
110	95	50	200	4 Days	10 Days
120	223	-	300	6 Days	14 Days
130	16-1/2	2	5	25 Days	60 Days
131	33	4	15	22 Days	53 Days
140	95	8	30	29 Days	70 Days
150	223	-	75	30 Days	72 Days
151	223	25	100	22 Days	53 Days

(1) 157-321-701 - Counter Cells - Alkaline

SAFETY PRECAUTIONS

SAME PRECAUTIONS AS WITH BATTERY

The safety precautions that apply to the storage battery also apply to the counter cell.

The danger of explosion is even greater with counter cells because there is no explosion protection.

MOST IMPORTANT SAFETY PRECAUTIONS

1. Smoking prohibited.
2. Precaution against static sparks. The body static electricity should be discharged before working on the cells.
3. Tools should be taped.
4. Protective clothing should be worn while working on cells.
5. The eyes should be protected with goggles.

CHANGING SOLUTION

When it becomes necessary to change the solution careful planning of the work will make the work safe.

1. The cell must be shorted out in the correct manner. (See preceding list of steps)
2. The room should be well ventilated.
3. Cells carrying current or storage batteries adjacent to the cell being worked on should be covered with several thicknesses of wet cloths.
4. To neutralize CEMF solution use boric acid solution.

ADAPTERS FOR GOULD CEMF CELLS

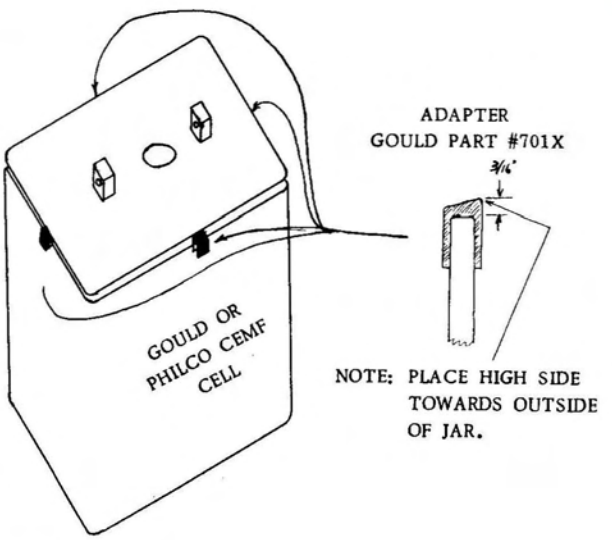
Nearly all CEMF explosions in recent years have involved Gould CEMF cells. These cells differ from Exide cells in the way the top rests on the jar. Exide tops rest on "seats" molded on the underside of the top. This leaves an air space between the jar and the top all the way around.

Gould tops fit snuggly on the jar with no air space. All the gas is concentrated at the vent where it leaves the cell.

New cells manufactured by Gould will be made the same as the Exide cells.

All older Gould cells should have rubber adapters placed on the edge of the jars to raise the covers 3/16 of an inch. See sketch below. The adapter lessens the danger of explosion.

INSTALLATION OF ADAPTERS ON GOULD AND PHILCO COUNTER EMF CELLS



PRINCIPLE BELL SYSTEM PRACTICES SECTIONS

EDUCATIONAL

157-321-101 - Description and Theory

MAINTENANCE

157-321-701 - Apparatus Requirements and Adjustment Procedure - Information for Changing Solution

SECTION E
MOTOR-GENERATOR SETS

TYPES - DESCRIPTION

The majority of motor-generator sets used in the Bell System are of the following three types:

M TYPE

Brushes are of metallic gauze and the commutator is lubricated with oil. These sets are now "manufacturer discontinued" but many sets are still in operation. The 'M' machine was designed for telephone work. Commutation is quiet, so additional filtering is not required while charging central office batteries. Cam-type regulators are installed with some sets to provide automatic regulation. These generators are not suitable for use in automatic power plants. The necessity for frequent applications of oil on the commutator and the cleaning necessary for the brushes and brush rigging increases maintenance time for these sets.

COMMERCIAL TYPE

Two manufacturers supply the bulk of commercial-type M-G sets for the Bell System; Hertner Electric and General Electric companies. These sets have carbon brushes and are driven with induction motors. They range in output from 100 amperes to 1500 amperes. Voltage regulation is accomplished by varying the field current with a voltage regulator. These are either the mechanically operated, cam-type (KS-5519), or the newer electronically operated (J-86250) regulator.

DIVERTER-POLE TYPE

M-G sets manufactured by Electric Products Corporations. The sets have carbon brushes. The voltage regulation is inherent in the generator. By the principle of saturation of the field coils, the voltage is kept within rather close floating limits. If the generator is run at full load or over there is a drooping of the voltage which could cause a low float voltage. This condition should be carefully watched. Past records at offices with diverter-pole generators indicate that battery life is somewhat below normal. This would indicate that the float voltage has not been accurately maintained.

MAINTENANCE OF MOTOR-GENERATOR SETS

The maintenance of motor-generator sets is covered in detail in the following Bell System Practices sections:

'M' Type M-G Sets	- 155-505-701
Commercial Type M-G Sets	- 155-512-701
Diverter Pole M-G Sets	- 155-612-701
Induction Motors	- 159-406-701

In brief the maintenance of M-G sets consists of:

1. Commutator and brush maintenance
2. Greasing and oiling
3. Cleaning
4. Maintenance of control equipment
5. Safety precautions.

COMMUTATOR AND BRUSH MAINTENANCE

It is very important to have good commutation. Sparking and chatter of the brushes is a condition that will get progressively worse and if allowed to continue unchecked will cause a complete failure of the generator.

NECESSARY CONDITIONS FOR GOOD COMMUTATION

1. Commutator free of grease, oil, moisture.
2. High polish on commutator surface.
3. Brushes free in their holders.
4. Brushes exerting correct pressure and correct angle.

5. Brushes staggered correctly.

6. Sufficient under cut of commutator mica.

7. No. out-of-round' of commutator surface or grooves, high bars, etc.

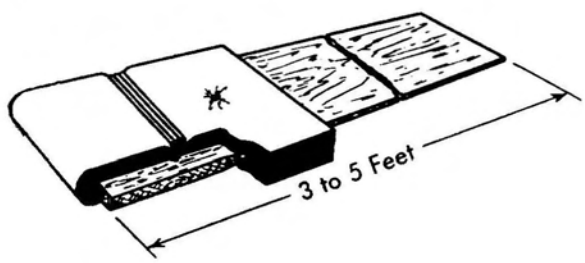
8. No contaminants in the atmosphere, I.E. fumes from petroleum spirits, gasoline, trichlorethylene, paint, sulfur acid spray and others. (2)

COMMUTATOR SHOULD BE POLISHED (1)

A polisher should be used for this purpose. In the sections a polisher is described that you can make. This polisher is a wooden paddle and layers of hardwoven canvas or duck (8 oz. weight). The paddle allows you to safely polish the commutator while the armature is rotating. Sufficient pressure can be exerted to effectively burnish the surface. Use this polisher often while the commutator is being "broken in" after being turned down, or when new brushes have been installed. As the surface glazes you can reduce the frequency. If the commutation is satisfactory, polishing only should be done.

WHAT IS APPEARANCE OF A GOOD COMMUTATOR?

The ideal commutator has a uniform chocolate brown or bronze color film highly polished to a glaze. You must not mistake this for a burned commutator. Never sand it off to get a clean looking surface. If the film starts to thread with bright copper streaks, the brushes in the streaked areas should be carefully checked. A particle of grit or copper under a brush will start cutting. The condition will get progressively worse.



BRUSHES SHOULD BE FREE IN THEIR HOLDERS

There should be no sticking or binding of the brushes. Periodically you should blow the copper and graphite dust out of the brush rigging. You should inspect the brushes to see that each brush works easily in and out of its holder.

BRUSHES SHOULD EXERT THE CORRECT PRESSURE (3)

In the BSP section there is a table for brush pressure expressed in pounds and grams for each type of brush in regular use. You should use a spring gauge to check the pressures every one or two weeks as you find necessary from your experience. Brush pressure too high will cause excessive brush and commutator wear. Brush pressure too low will let the brushes chatter, and will cause commutator wear even more than with pressure too high. Pressure should be kept as nearly alike for all brushes, and as close as possible to the pressure in the table.

CORRECT BRUSH ANGLE (4)

You should accurately set the brush angle to the angle specified in the section. They tell you how to do this in the section.

BRUSHES STAGGERED CORRECTLY (5)

The brushes should be staggered to use as much of the useful area of the commutator as possible. The correct method of staggering the brush is as follows:

Brush Holder 1 Positive ☐☐☐☐

Brush Holder 2 Negative ☐☐☐☐

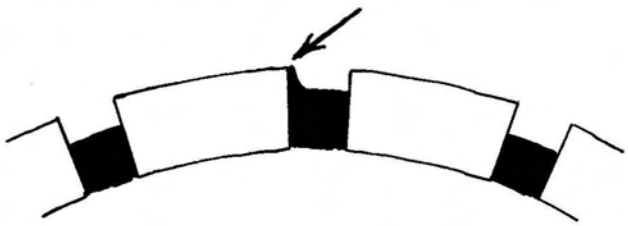
Brush Holder 3 Positive ☐☐☐☐

Brush Holder 4 Negative ☐☐☐☐

(1) 171-110-701 - Shows This Picture of Polisher
(2) 171-110-701
(3) 155-512-701
(4) 155-512-701
(5) 171-110-701

THE COMMUTATOR MICA MUST BE PROPERLY UNDER CUT

Most generators now are designed to operate with mica insulation between the commutator bars under cut 1/16 to 1/8 of an inch. If the mica protrudes above the commutator bars it interferes with commutation. If the under cutting is not done correctly a feather edge of mica may be left as shown below:



SHOP WORK ON COMMUTATOR

Even with the best of maintenance, in time the commutator will wear and groove and possibly become out-of-round. When this condition has advanced to the extent where commutation is no longer satisfactory, it is necessary to turn down the commutator. This is done on a lathe or with grinding equipment attached to the frame of the generator. Sand paper or hand grinding stones cannot satisfactorily be used to return the commutator to round condition. Generators of small size (around 100 ampere to 200 ampere output) can best be repaired by removing the armature from the set and turning the commutator on a lathe in a shop. Generators of larger sizes can best be repaired in place with the generator running at regular speed in its own bearings. This duplicates actual operating conditions of the generator. A number of shops in this area have the necessary equipment for turning down armatures in place. You should contact the maintenance supervisor's office for information on this matter.

When grinding work is done on the commutator in place, vacuum cleaning equipment should be used to insure that grinding dust does not fly around the room and into surrounding equipment.

GREASING AND OILING (1)

Grease should be added to a bearing very carefully. 155-512-701 gives this procedure:

1. Shut down machine.
2. Remove drain plug.
3. Add grease slowly until fresh grease comes out of the drain. Don't put in more than a gun load - and watch the shaft for grease oozing out there.
4. Start and run generator hot until grease stops draining out.
5. Clean out around drain and replace plug.

CORRECT TYPE OF OIL AND GREASE (2)

The type of oil or grease to be used in generators and motors is covered in 065-330-101.

NOTE: The type of oil used in oil ring bearings and waste packed bearings is now 220-260 S100 oil (not KS2245).

IMPORTANT - DO NOT OVER GREASE

Over greasing can be harmful. It will cause bearings to heat and force grease past the grease retainers into the windings of the motor or generator. It should be noticed how much grease is added with the grease gun. The bearing cavity should only be about 1/3 full. Where possible you should remove the bearing plate and apply grease manually to insure that the bearing is properly greased. Too much grease will make the bearings overheat.

IMPORTANT - DO NOT OVER FILL OIL BEARINGS

Additions of oil in the sleeve type bearings should be made with the set stopped to avoid over filling and leaking of oil. A gauge is usually provided to indicate correct level. The gauges are generally of the overflow type. If the bearing is filled to capacity with the set running some oil will overflow when the set is stopped. This is because while running a lot of the oil is around the bearing and splashed up on the cavity walls.

NOTE: The above two "cautions" are stressed because grease or oil on the

(1) 155-512-701 - Charging Generators, Commercial Type

(2) 065-330-101 - Materials - Greases, Oils & Cleaning Fluids

commutator or windings is very detrimental. They will damage insulation and destroy the mica of the commutator and cause commutator burn.

CLEANING OF MOTOR-GENERATOR SET

Cleaning of the set is an important maintenance function. As covered previously, oil or grease must be removed from windings and commutator, brushes must be free of copper and graphite dust.

PRESSURE CLEANING

You can use pressure cleaning equipment to good advantage to remove copper dust and other dust from the brush rigging and windings.

MAINTENANCE OF THE CONTROL EQUIPMENT

The control equipment maintenance includes the maintenance of:

Motor-driven field rheostat - 028-722-701
Starting compensator equipment - 026-305-701
Relays, vacuum tubes, etc., in regulation circuit

SOME COMMON MISTAKES IN M-G SET MAINTENANCE

1. Over-filling of grease bearings causing heating.

2. Over-filling of oil bearings causing leaking.

3. Excessive use of sandpaper on the commutator removing the oxide film.

4. Inadequate cleaning.

M-G SET TROUBLES

A table at the end of 171-110-701 tells you what to look for when you have trouble with commutators, slip rings or brushes.

POINTS FOR YOUR APPRAISAL OF MAINTENANCE JOB

1. The commutator should be an even chocolate brown color with no pitting, grooving or threading.

2. There should be very little sparking at the brushes.

3. If the brushes appear to be oscillating in and out of the brush holder, the commutator is out-of-round. You can generally detect the oscillation by carefully touching the top of a brush with a finger nail. A dial indicator gauge clamped to the frame of the generator and the armature slowly rotated by hand is the method of accurately measuring the extent of irregularity. The maximum allowable irregularity is about .005 inch. This degree of out-of-roundness will affect the commutation to the extent where the condition will become progressively worse. Out-of-round commutators cannot be satisfactorily repaired with sanding or hand-grinding stones.

4. The bearings or any part of the M-G set should not be excessively hot. If any part of the generator is hot to the touch (if the hand cannot be comfortably left on the set), you should make a check with a thermometer. The temperatures should be taken either by dipping in the oil of an oil ring bearing making sure the thermometer does not strike the shaft or interfere with the oil ring, or by placing the bulb of the thermometer as near to the area to be measured as possible and covering the part of the thermometer that is not in contact with a piece of felt or its equivalent. The allowable temperature is 80° C. (176° F.) for bearing and 90° C. (194° F.) for windings and frame. On some sets the allowable temperature rise (over ambient or surrounding temperature) is included on the name plate information.

5. The M-G set should be free of copper dust in the windings, and there should be no leaking oil or grease.

IS EQUIPMENT ADEQUATE?

The motor-generators should be adequate to carry the full load of the office. There should be a spare machine of large enough size to replace

the largest machine that is used for regular operation. For instance a 1200 ampere load carried by a 400 and 800 ampere generator requires that a spare generator of 800 ampere size be provided.

NOTE: Unusual heavy loads caused by storms, wet cables or other trouble conditions, are not used as the basis of checking adequacy of equipment - just normal busy hour loads.

SAFETY PRECAUTIONS

1. Work on machines that are in operation only when absolutely necessary. If such work is required see that the light is adequate.

2. Avoid possible accident from loose clothing when working on generators. Neckties and loose sleeves are especially hazardous.

3. When it is necessary to work on a machine follow these precautions:

   Shut generator down
   Remove AC fuses
   Disconnect generator from battery
   Post "Man At Work" sign on switches

4. Tools should be taped when working around energized bus bars or switches.

5. Polishing the commutator should be done with the paddle described previously so that the hands are clear of the rotating armature. Extreme care should be used in sanding commutators. Be careful of protruding parts that would cut the hands. Do not let the sandpaper get away. WEAR GOGGLES.

6. Generators that start automatically should be clearly labeled "Danger, Auto-Start."

PRINCIPLE BELL SYSTEM PRACTICES SECTIONS

155-512-701 - Charging Generators - Commercial Sets.
155-505-701 - "M" Type Generators
155-612-701 - Diverter Pole Generators
159-406-701 - Induction, Motors
159-405-701 - Motors - Direct Current. 1/4 Horsepower or Larger
171-110-701 - Commutators, Collector Rings, Interrupters and Brushes
171-110-802 - Brush Types
171-110-802 - Addendum - Brush Types
069-305-301 - General Cleaning of Equipment - Safe Work Practices
065-330-101 - Greases, Oils and Cleaning Fluids

SECTION F
RECTIFIERS

TYPES OF RECTIFIERS

The majority of rectifiers in use in the Bell System is of the following types:

1. Mercury Arc - Unregulated 30 or 50 ampere capacity, now rated "manufacture discontinued." The tubes can be replaced with silicon units using the existing transformer and control equipment.

2. Tungar - Gas-filled tube rectifier, unregulated up to 12 ampere capacity.

3. Booster Control - Regulated tube rectifier in the 110A power plant. In the 110A plant regulation is by motor-driven autotransformer controlling the voltage to the tubes.

4. Grid-Control Tube - Regulation is by the control of the grid of the tube.

5. Selenium Disc - The selenium-coated discs have the property of passing current in one direction only. The discs are of all sizes and are assembled in series, parallel combinations, to give wide range of amperage and voltage output. Regulation is generally accomplished by a circuit that converts the differences in battery voltage into increases and decreases in saturation of a coil. This raises or lowers the amperes output of the rectifier. In the older types of these rectifiers, the circuit is relay controlled. Newer types are electronically controlled. The latter type gives more rapid response to changes in voltage.

6. Solid State - The elements are germanium and silicon. Germanium diodes used in 100 and 200 ampere rectifiers are fan cooled. Silicon diodes now eliminate the forced air cooling. They replace the silenium discs for economy, longer life and higher efficiency.

7. Copper Oxide - Metallic rectifier similar in principle to the selenium rectifier. This type is used for charging engine starting batteries, emergency and cells, and in small PBX's.

TYPES OF REGULATION

1. Booster transformer (110A plant).
2. Grid control rectifier (105D plant).
3. Saturable reactor control (111A plant).
4. Silicon controlled rectifier (SCR transistor).

MAINTENANCE OF RECTIFIERS

The maintenance of rectifiers is covered in the 169-000-000 Plant Series of the BSP. There is a section for each rectifier found in standard plants. A table of check points for voltage measurements at different points of the circuit is generally provided to check the rectifier for proper operation.

Rectifiers in general require less maintenance than motor-generator sets because of fewer moving parts. Following are listed some of the rectifier components that have given trouble in the past:

TUNGAR RECTIFIERS, ELECTRON TUBE TYPE [1]

1. Faulty Tube Sockets - Loose or corroded connections at the sockets causing heat which burns out the tubes. This condition also results in low filament voltage which may cause the tubes to flash-over and burn out. It is necessary to make sure the sockets are in good condition with no voltage drop.

2. Flash-Over Relays - AC voltage fluctuation also causes the tubes to flash-over and operate the fuse or burn out the tubes. A relay is required to disconnect the

(1) 169-210-301 - Rectifiers, Electron Tube Type

rectifier before damage takes place. This is called a flash-over relay.

3. Heating of Toggle or Rotary Switch - Burning or oxidation at the contacts will cause heat which will get progressively worse. If it gets bad enough the switch will have to be replaced.

RECTIFIERS IN 105D PLANTS [1]

Maintenance is covered in section 167-210-301.

RECTIFIERS IN 110A PLANTS

Maintenance is covered in sections 167-215-301, 169-603-319 and 169-620-301.

NOTE: FIRE PREVENTION - A fuse wire kit is available for KS-5552 L-1, KS-15585 L-1, KS-15680 L-1 and KS-15685 L-1 autotransformers. It opens the AC current supply in cases of overheating caused by overloads.

CASES OF REPEATED TROUBLE

1. Hunting of Control Equipment [2] - The hunting causes wearing out of the autotransformer drive motor and brushes. It will result in unsteady battery voltage in the office and may cause objectionable noise in the AC power feeders. This condition is frequently found where the plant has been installed with "calcium type" batteries (see Section C on batteries). To reduce hunting new motors with low inertia rotors are available.
2. Autotransformer Brushes Too Short [3] - There have been many fires in these transformers due to brushes too short. The brushes should be carefully maintained to be sure that they don't wear down too far and develop heat.
3. Shear Pin on Shaft - The shear pin on the shaft between the autotransformer and the autotransformer drive motor is liable to be sheared during operation of the rectifier. Spare pins should be available for replacement. The shearing of pins might be caused by the limit switches of the autotransformer not working, or incorrectly adjusted.
4. Damage to Gears in Motor [4][5] - The small reversible AC motor for driving the autotransformer has a gear train for reducing the speed. It is necessary to lubricate this gear train as shown in the practice. On some installations the motors have been installed in such a way that extension tubes have to be installed on the oil holes. If the gear train wears out it is possible to order a new one rather than replace the whole motor.
5. Adjustment of "R" and "L" Relay - The electrical and mechanical adjustment of the polarized "R" and "L" relay is the most important adjustment in the plant. The BSP sections should be followed in adjusting the relays.

   NOTE: You should be sure the taps used on the T1 and T2 transformers match the AC voltage.
6. Selenium Stack Failures [6][7] - The method of testing for falling off of output is covered in the sections. The test consists of measuring the AC voltage input to the stacks.

   When replacing stacks the entire element must be replaced. On a 48-volt rectifier there are 4 stacks and on a 24-volt rectifier there are 2 stacks.
7. Some of the improvements to this plant are shown in 169-603-816. [8]

SELENIUM RECTIFIERS IN 301C AND 302A PLANTS

Cases of repeated trouble:

(1) 167-210-301 - Regulated Rectifiers
(2) 167-215-301 - Operating Methods
(3) 028-705-801 - Auto Transformer Brushes
(4) 159-426-701 - Gear Motor - Reversible AC Type - KS 5559
(5) 159-426-801 - Gear Motor - Replacement Parts
(6) 169-603-319 - Regulated Rectifier - Booster Control - J86207 P & S
(7) 169-620-301 - J86263 A & B Rectifier Regulated Metallic Type
(8) 169-603-816 - Modifications on 110A Plant Rectifiers

1. Hunting of Control Equipment - Adjustment of antihunt circuit should be accurately made.

2. Aging of The Stacks - The stacks age gradually during use. The output is gradually reduced and higher voltage taps on the transformer must be used. BSP 169-612-811 describes how to change the stacks.

VENTILATION

Temperatures in the power room around the rectifiers should not be too high. If necessary a fan to provide ventilation should be used to keep the air from getting too warm.

CLEANING THE STACKS

The rectifier stacks should be kept clean. The plates should be blown out or dusted periodically to improve the cooling and to eliminate the possibility of flash-over. Care must be taken when cleaning not to damage the stacks. The "petal" contacts in the stacks that connect to the selenium surface are easily damaged. This will cause a "hot spot" in the stack and may cause it to burn out.

GRID CONTROL RECTIFIERS

Rectifiers using a grid dry battery in the regulation circuit will fail if the grid battery becomes weak. Grid batteries must be replaced on a routine basis.

POINTS FOR YOUR APPRAISAL OF MAINTENANCE JOB

The rectifiers should operate properly producing rated load with good voltage regulation. The hunting should be a minimum. Some components require special attention to keep from having failures:

105 Plant
    Tube Sockets
110A Plant
    Autotransformer maintenance
    Motor maintenance
301C or 302A Plant
    Cleaning of stacks
405A, 410A and 410B Plants
    Load Resistor Adjustment (See D-1)
Grid Control Rectifiers
    Grid battery replacement

IS EQUIPMENT ADEQUATE?

In central offices the rectifiers should have enough capacity to handle the office load and there should be a spare rectifier for emergency.

In very small CX offices or CDO's a spare rectifier is not always provided. The battery reserve should be adequate to give enough time to repair the rectifier or obtain another rectifier.

In PBX's a spare rectifier is not generally provided. If the charging is "full float," the rectifier should be adequate to care for peak loads. In the 105-type power plants, rectifiers are rated at 8 amperes continuous and 10 amperes intermittent. Low voltage alarms operate at about 8-1/2 amperes so an additional rectifier must be installed to keep alarms from operating. An alarm delay option is available to eliminate alarms from high drains of short duration.

SAFETY PRECAUTIONS

1. Voltages inside rectifiers are higher than usually found around telephone plant. Extra precautions should be taken.

2. Opening the cabinet door disconnects the power from most rectifiers. The safety switch should not be disabled while working on the rectifier.

3. When point-to-point voltage readings are taken the voltmeter leads should be in good condition. The leads should be connected to the meter before connected to the equipment. Because of the unprotected high voltages, only experienced personnel should take the readings. The KS-14510, List 6 meter leads should be used. These leads have a retractable spring-loaded, insulated tube which covers the contact point for safety against accidental short circuits. Rubber gloves should be used.

PRINCIPLE BELL SYSTEM PRACTICES SECTIONS

See index to BSP sections. There is a section for each type of rectifier. Section numbers are in 169-000-000 series.

SECTION G
EMERGENCY ENGINES

TYPES AND CLASSIFICATIONS

Our engines are either stationary (permanently installed), or portable. Some of the portable sets are trailer mounted, and the smaller ones are carryable.

Of the stationary engines, some are designed for automatic start, and the others are started manually.

The engines use either gasoline fuel or diesel fuel. A few run on kerosene fuel.

The smaller portable sets are lubricated by adding oil to the gasoline in the fuel tank. The larger sets are lubricated by oil in the crankcase.

ENGINE TYPES

The principle suppliers of engines in Bell System service are:

Manufacturer	Type	Fuel	Size	KS No.
Permanently Installed				
Caterpillar	Series 268A	Diesel	350 kw	KS 15899
General Motors	Series 71	Diesel	20-60 kw	KS 5574 or KS 5750
General Motors	Series 71	Diesel	100 kw	KS 15890
General Motors		Diesel	225 kw	KS 15929
General Motors		Diesel	300 kw	KS 5665
General Motors	Series 567C	Diesel	750 kw	
General Motors	Series 567C	Diesel	1000 kw	
Hercules		Diesel	120 or 170	KS 15622
Hercules		Diesel	20 kw	KS 15621
Kohler		Gasoline	2.8 - 4 kw	KS 5667-01
Kohler		Diesel	10 kw	KS 15717
U.S. Motors	No Break MG 10D - 18	(Gasoline (Diesel	5 kw 10 kw	
Portable Sets				
Homelite	20A, 23A 24A, 32A	Gasoline	1-5 kw	
Kohler		Gasoline	.75 kw	KS 15688
Kohler		Gasoline	25 kw	
Kohler		Gasoline	75 kw	
Schrahm		Gasoline	75 kw	KS 5518

In addition to the engines supplied under contracts covered by KS specifications there are a number of locally purchased engines in this area:

Sterling Engine - Gasoline	
Sterline Engine - Diesel	- 155-199-904PT
Buda Engine - Diesel	- 155-199-932PT
U. S. Motors - Gasoline	- 155-199-956PT
Diesel	

Also there are a number of 2.5 kw portable sets purchased from the U. S. Army designated as PE 75, and manufactured by Briggs and Stratton.

ADVANTAGES OF DIESEL OVER GASOLINE

1. Diesel engines can be installed in a room with other equipment. A gasoline engine because of the fire hazard must be in a separate room.

2. Diesel exhaust can be piped into the boiler flue. Gasoline exhaust must be in a separate pipe.

3. The diesel fuel tank can be installed in the engine room in most locations. In a few, local ordinances prohibit this practice, or may limit the size of tank in the room. Gasoline tanks must always be installed underground.

4. Diesel engine exhaust fumes are objectionable but not deadly as is the case with gasoline.

5. The reliability of diesel engines is better because it does not have an ignition system. Ignition is probably the greatest cause of trouble in the gasoline engine.

6. Diesel fuel is not as dangerous as gasoline. It will burn, but it will not explode.

7. The heating of the diesel engine is not as great as the same size of gasoline engine. This results in less piping required for

the radiator, and less ventilation required.

8. Diesel engines similar to the General Motors series 71 model are equipped with air blowers which "supercharge" the engine. The loss in output at high elevations is considerably less for this type of engine.

DISADVANTAGES OF DIESEL

1. Higher first cost than gasoline.
2. Cost of repairs may be higher.
3. The fumes are objectionable and carry through the ventilation system of a building. Although not as dangerous, there are generally more complaints from diesel fumes than gasoline fumes.

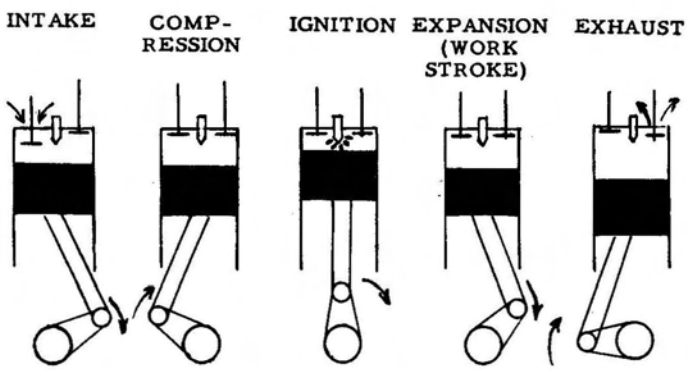
PRINCIPLE OF OPERATION

The engines are of two basic types:

4 stroke cycle - two revolutions (2 up strokes and 2 down strokes of each piston) to complete a cycle.

2 stroke cycle - one revolution (1 up and 1 down stroke of each piston) to complete cycle.

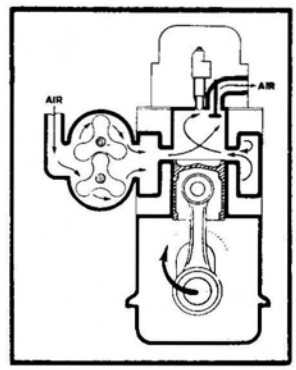
SERIES OF EVENTS IN A FOUR CYCLE GASOLINE ENGINE



SERIES OF EVENTS IN A FOUR CYCLE DIESEL ENGINE

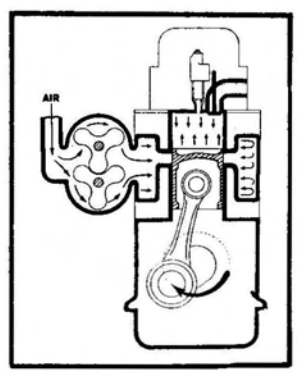
Same as above except there is no ignition. The fuel is injected into the cylinder in a highly atomized state at the top of the compression stroke. The fuel is ignited instantly by the heat developed by high compression.

SERIES OF EVENTS IN A TWO CYCLE DIESEL ENGINE (From General Motors Handbook) Also 155-128-101



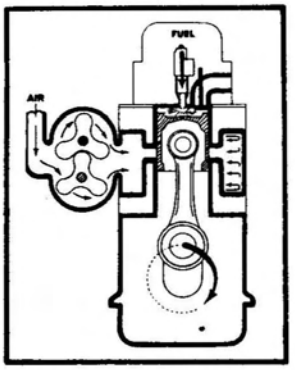
SCAVENGING

A series of ports cut into the circumference of the cylinder wall, above the piston in its lowest position, admits the compressed air from the blower into the cylinder as soon as the top of the piston uncovers these ports. The flow of air toward the exhaust valves sweeps out the burnt exhaust gases, leaving the cylinder full of clean air when the piston covers the ports on the upward stroke.



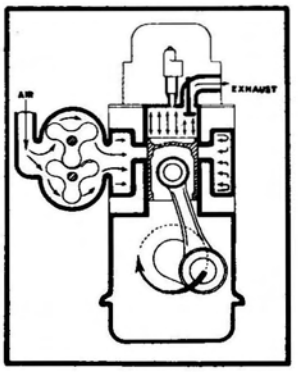
COMPRESSION

As the piston continues on the upward stroke, the exhaust valves close and the charge of fresh air is compressed to one-sixteenth of its initial volume. This happens on every upward stroke of the piston in a two-cycle engine.



INJECTION-COMBUSTION POWER

Shortly before the piston reaches its highest position, the required amount of atomized fuel is sprayed into the combustion space by the unit fuel injector. The intense heat, resulting from the high compression of the air, ignites the fine fuel mist immediately, and combustion continues as long as fuel enters the cylinder. The resulting pressure forces the piston downward.



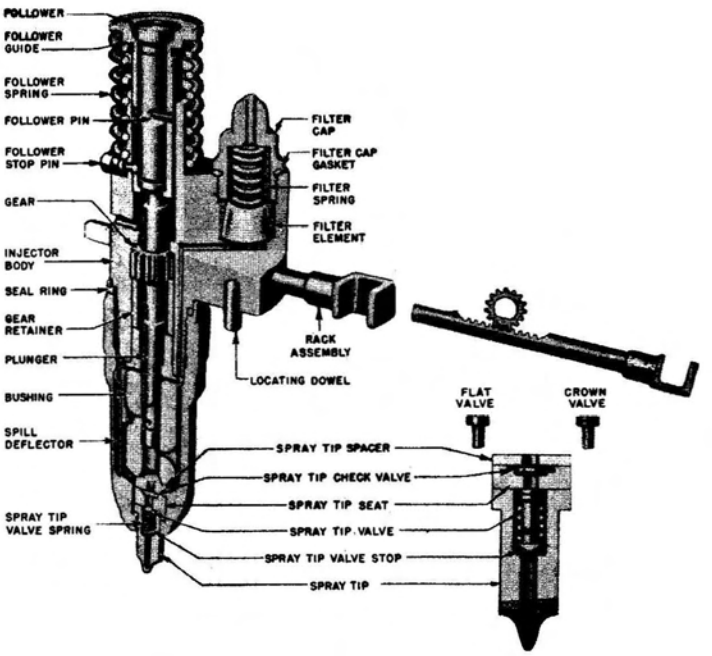
EXHAUST

The exhaust valves open before the piston reaches the bottom of the power stroke and the burnt gases escape into the exhaust manifold and the cylinder is swept with clean scavenging air as the downward moving piston uncovers the inlet ports. This entire combustion cycle is repeated in each cylinder for each revolution of the crankshaft. The quantity of fuel burned during each cycle is controlled by the injector, and is varied, either by the operator or the governor.

TWO TYPES OF FUEL SYSTEMS IN DIESEL ENGINES

UNIT INJECTOR

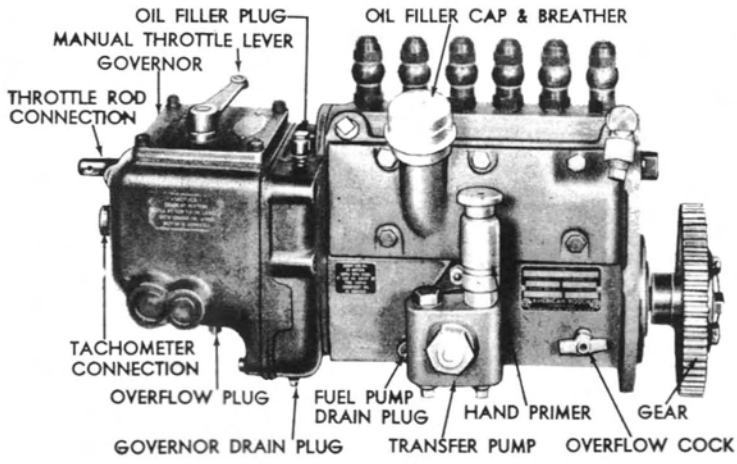
General Motors diesel engines and some of the Hercules engines use unit injectors. The injectors meter, pump to high pressure, and inject the fuel into the cylinder. There is one injector for each cylinder, mounted on top of the cylinder.



General Motors Unit Injector

BOSCH FUEL PUMP

The Buda engines and some of the Hercules engines have the Bosch fuel pump. A single pump unit on the side of the engine pumps fuel througx pipes to the cylinders. There is one pipe to each cylinder. On the top of the cylinder is an injector nozzle with a spring valve. The valve opens when fuel pressure is high enough. Then fuel is sprayed into the cylinder.



Bosch Fuel Injector Pump and Governor

EMERGENCY SHUT DOWN FEATURES

Engines in telephone use except for the small portable units, are usually provided with safety automatic shut-down equipment which stops the engine before damage from the following:

Low oil pressure
High water temperature
Over-speed

In addition to the above, automatic engines generally have other protection.

1. Overload of starting motor
2. Overcranking protection
3. Fuse alarms

MAINTENANCE OF ENGINE SETS

The maintenance of engine sets consists of the following:

1. Oiling and greasing of engine and alternator (or generator).
2. Cleaning or changing air, oil, or fuel filters.
3. Maintenance of commutator and slip rings, and brushes.
4. Routine exercise runs.

Information for oiling, greasing, changing filters, and maintenance of the commutators and slip rings is found in the Bell System Practices Plant Series for the particular engine. A table of frequencies is generally included. These frequencies should be followed carefully.

Additional information is given in the manual which is generally provided by the engine manufacturer for each set. This manual gives information needed for overhauling of the engines. This work is generally done by engine repair shops not by our people.

ROUTINE EXERCISE RUNS

BSP Section 155-199-902PT or particular engine section covers the performance of the exercise run. The following frequencies are specified.

(a) Engines in attended offices - -
Weekly - See engine BSP or 155-199-902PT for minimum running time.
Monthly - three hour load run.
Annually - (during third quarter of year) - seven hour load run.

(b) Engines in unattended offices - -
Most are auto-start. Exercised by cycle timer or remote start signal from toll office. See BSP for frequency of exercise runs.

(c) Portables lubricated with oil in crankcase - -
Quarterly - Load run using artificial load for one half hour or more. Information on artificial loads is in 171-123-101.

(d) Portables lubricated with oil mixed with the fuel - -
Quarterly - Mix enough fuel and oil for about a half hour of operation. Run with an artificial load until the mixture is used up.

IMPORTANT
During the exercise runs, if you have any doubt of the engine's proper performance or reliability, immediate steps should be taken to find the trouble and make repairs. If you have questions of how to arrange for repairs, you can get information from the Maintenance Supervisor's office.

At the time of the exercise run you should make certain other checks:

Starting battery check.
Brakes, leads, tires, etc. of trailer sets should be checked.

RECORDS

A record of the runs should be made on the forms shown in 155-199-902PT. You keep the records for the regular runs at the offices. Forward the record of the annual 7 hour run to the Maintenance Supervisor's office.

AVOID DEMONSTRATION RUNS AND SHORT TEST RUNS

Run engine long enough to warm lubricating oil and cooling water temperature to at least 120° F. If it doesn't there is condensation of Dilution of the lube oil also takes place.

USE OF RUST INHIBITOR (1)

Rust inhibitor should be used in all engines except where anti-freeze solution is used.

USE OF ANTI-FREEZE (1)

Anti-freeze solution is used where there is a danger of freezing.

WATER IN FUEL TANK

Periodically, you should make a check for the presence of water in the fuel tank. You can order a "water finding paste" for testing for water. A small portion is smeared on the bottom of the measuring rod. If water is in the bottom of the tank the past will turn from red to white. The past is available in a 3 oz. tube and is ordered as follows:

Water Finding Paste, Cat. No. 52167
Braun-Knecht-Heimann Co.
3745 Bayshore Blvd.
Brisbane, California

(1) 065-305-301 - Use of Rust Inhibitor and Anti-Freeze Solutions

POINTS FOR YOUR APPRAISAL OF MAINTENANCE JOB

1. The engine should be wiped clean of oil or grease, dust or dirt.

2. Oiling, greasing and filter change routines should be rigidly followed.

3. The electrical parts of the engine set should be properly maintained. Commutators, slip rings, brushes, contactors, battery charger, battery, etc. should be kept in good condition.

4. The engine should be run as shown in 155-199-902PT. Records of the runs should be kept. The record of the annual run should be sent to the Maintenance Supervisor's office.

5. Emergency shut down devices such as overspeed trips, high temperature, low oil pressure should be checked periodically.

6. There probably will be some hunting of engine when the engine is cold. However, after the engine is warmed up the governor should hold the speed constant.

7. The voltage should be held steady by the voltage regulation equipment.

8. The muffler and the exhaust pipe should periodically be drained of condensation.

SOME COMMON CAUSES OF ENGINE FAILURE

1. Leaks in fuel line - The fuel pump loses its prime and will not deliver fuel to the engine; or maybe not enough to run it under load. You have to check the pipes for leaks. If necessary hire a plumber to put pressure tests on the pipes.

2. Water in fuel tank - Check with water finding paste. If there is water above or 2 inches in the bottom of the tank it will be pumped into the engine.

3. Clogged fuel filters - Filters have to be changed regularly.

4. Clogged exhaust muffler or exhaust pipe - A lot of rusting takes place in the pipes of gasoline engines. The water must be drained out and periodically hand hole covers removed for cleaning out rust.

5. Grounding out of ignition (Gasoline engines) - Wiring is a source of possible trouble. Check to see if you are getting the proper spark at each plug.

6. Starting battery failures - Rectifier failures or dead cells. Engine can't be started.

7. Auto-start engines - Circuit trouble in automatic starting equipment. Engine can generally be started manually.

8. Improper Reading of Frequency Meter - The vibrating reed type frequency meter will give indications at harmonics of 60 cycles. For instance, 1200 RPM gives 60 cycle current. However, you get about the same indication on the frequency meter at 600 RPM and 900 RPM. Of course if you are used to running the engine, you can tell the difference by the sound, but if you're not used to it, it is possible to be fooled. If there is any doubt check with a portable tachometer.

9. Clogged carburators (gasoline engines).

10. Clogged injectors (diesel engines).

11. Faulty fuel tank gauge.

IS EQUIPMENT ADEQUATE?

The engine-alternator set in an office should be adequate in size to care for the essential telephone power; such as:

1. Charging equipment necessary to carry peak load (not including the reserve charging equipment)

2. Ringing equipment

3. Emergency lights

4. Carrier equipment

5. Radio and T. V. receivers and transmitters

6. Teletypewriter equipment

7. Switchboard busy-visual lamp supply

8. Ticket conveyors

9. Compressor-dehydrators

10. Essential building power - sump pumps, etc.

NON-ESSENTIAL LOAD

Heating and air conditioning equipment generally are not included in the essential classification. Also, the normal lighting, fans and blowers (except for blowers for tube cooling in some of the toll equipment) are not included. Elevators also are generally not included.

ANNUAL LOAD RUN

The annual load run should be made with the essential telephone power load. The engine should be loaded in the manner it would be loaded during actual power failures.

HOUSE SERVICE PANEL SWITCH ARRANGEMENT

In order to transfer load to the emergency engine without loading it with non-essential building load and lights, the telephone power load is usually controlled by a separate transfer switch. "Telephone Power Transfer Switch."

WHERE MANUAL TRANSFER TO ENGINE IS MADE

If the engine capacity is just enough to care for the telephone power load, it will be necessary to apply load to the engine in a manner to avoid overloading from the following:

1. Starting current of motor-generator set. You should not start the MG sets when the engine is already heavily loaded. The starting current of a motor is about three times the running current.

2. An overload caused by the regulating equipment starting and raising to full output all charging equipment in the plant. This happens because the battery voltage is dropping while the engine is being started. The rectifiers and MG sets should be under manual control and the output slowly raised to avoid overloading the engine.

Section J, EMERGENCY POWER PLANS goes into the above two points in greater detail. In it steps of starting engine and applying load are outlined.

CALCULATIONS OF LOAD ON ENGINE (1)

You might have to calculate the load on the engine if the engine is not equipped with a kilowatt meter. Or even if there is one, occasionally it's a good idea to check it against the ammeter and voltmeter readings.

The formula below is used for 3 phase sets:

$$\text{Kilowatts} \quad \frac{1.73 \times V \times I \times \text{Power Factor}}{1000}$$

V Average line voltage (generally 208 or 240).
I Average line current.
Power Factor is normally about .8 for central office load.

SAFETY PRECAUTIONS FOR ENGINES

1. No smoking near the engines.

2. Keep gasoline in red safety cans only.

3. Fuel line leaks must be promptly cared for. Spilled fuel and lubricating oil must be wiped up.

4. Do not crank the engine manually except in an emergency.

5. Care must be taken to avoid leaking of exhaust gases into the room. Damage to exhaust manifold, muffler, should be promptly repaired. This is especially important for gasoline engines because of the danger of carbon-monoxide gas. Carbon-monoxide is invisible and has little odor or taste. It is non-irritant. Its presence might cause a slight headache; but it might not give any indication to the senses of its presence.

6. Automatic engines should be labeled "danger auto-start."

7. Lifting of portable sets should be done with care. There should be enough men to safely handle the weight.

8. Portable engines should always be operated out doors.

PRINCIPLE BELL SYSTEM PRACTICES SECTIONS

065-320-301	- Engine Fuel
155-199-902PT	- Engine Generator Sets - Routine Exercise Runs
065-305-301	- Use of Rust Inhibitor and Use of Anti-Freeze Solution
171-123-101	- Artificial Loads - Test Loads for Power Equipment

Use BSP Index for Engine Sections - We will not list the BSP sections for each engine. There will be a section on operating methods and a section on apparatus requirements and adjusting procedure for most engines. The sections are indexed by their KS numbers. Care should be taken in all adjustments made on this equipment. It is suggested that any questions concerning special adjustments be referred to the maintenance supervisor's office.

(1) 171-123-101 - Test Loads for Power Equipment

TYPES - DESCRIPTION

Ringing machines are machines to produce the following voltages and signals:

1. Ringing power at 20 cycles AC.
   DC for coin collect and coin refund.
2. Positive and negative voltage at 110 volts DC for coin collect and coin refund.
3. Audible ringing signal.
4. Supervisory tones.
5. Interruptions for code ringing.

TYPES OF MACHINES

"P" TYPE (These machines are now "manufacture discontinued") (1)

The "P" machine is a motor-generator set. The larger sizes have both an AC motor and a DC motor. Two machines are provided but transfer is not automatic. The DC motor starts up immediately on power failures so a transfer of machines is not necessary. The single-phase AC motor will not start alone but requires an assist from the DC motor to start the rotation.

The generator windings are brought out to a commutator at one end for producing the 110 volt positive and negative (220 volt total) for coin collect and refund. The same windings are brought out at the other end to slip rings for the 20 cycle AC ringing voltage. Pulsating AC for "audible ringing" is obtained from a third slip ring divided into two segments placed between the two ringing slip rings.

On the same shaft as the motors and generator is a drum for producing high tones at about 480 interruptions per second and low tone at about 160 interruptions per second.

Connected to the generator shaft by means of a reducing worm gear with a ratio of about 120 to 1 is a slow speed shaft. On the low speed are drums for 60 interruptions per minute, 120 IPM, code ringing, and busy back signal.

The older "P" machines have commutator type drums and carbon brushes. On newer machines the commutator type drums have been replaced with mercury drums. In these drums mercury flowing as the drum is rotated produces the interruptions. Also, tone alternators are installed to provide the high and low tones and audible ringing.

SIZES OF "P" MACHINES

These machines are in three sizes:

P1/2	- 1 to 1.25 amps AC, .25 amps DC.
P1	- 3 to 4 amps AC, .38 amps DC.
P2	- 6 to 8 amps AC, .50 amps DC.

COMMERCIAL TYPE MACHINES (2)

These machines have replaced the "P" machines and are under the KS number 5396. They are used in 803C ringing plants.

The machines are equipped with mercury drums and tone alternators.

The arrangement of the generator is similar to the "P" machine; 110 positive and negative commutator at one end, and slip rings at the other end. These machines are equipped with mercury drums, and tone alternators.

The sizes are from 1/4 ampere to 6 amperes AC output.

Two machines are always provided; one is an AC machine, and one runs on DC provided by the central office battery. Transfer during power failures is automatic.

(1) 155-405-101 - Generators - Ringing and Coin Control - P Type
155-405-701
163-650-701 - Interrupters - Rotary Mercury Type

(2) 155-410-101 - Generators - Ringing and Coil Control - Commercial Type
155-410-701
163-650-701 - Interrupters - Rotary Mercury Type

KS 15532 RINGING MACHINES [1]

This machine is used in 804C ringing power plants. They were designed for use with No. 1 and No. 5 crossbar systems and No. 1 and No. 350-A step-by-step systems.

The machines have tone alternators and cam driven spring type interrupters. One is AC line driven and transfers automatically to a DC battery operated machine under AC power failures, dial tone failures or high or low ringing voltages.

The ringing machines are mounted on sliding shelf assemblies that fit into box-like receptacles in the power board.

1/2 AMPERE MOTOR GENERATOR SETS [2]

These machines are under the KS number 5133-01.

Two machines are provided; one driven by an AC motor (regular) and one driven by a DC motor (emergency).

RINGING CONVERTER [3]

QD Type - Holtzer Cabot and Electric Specialty Co.

This machine is a rotary inverted-converter type. It operates on 48 volt DC from the storage battery. It generates 20 cycle alternating current with an output of 1/4 ampere. A low speed interrupter shaft is driven from the armature with a worm and gear. Cams and spring contacts give 60 and 120 IPM and code ringing. Used in PBX's of 701 type and others.

KS 5546 Holtzer Cabot - Type CBD 2720 - 1/4 ampere output. Used in small CDO's.

KS 15804 [5] This machine's capacity is 0.25 amperes at 65-90 volts, 20 cycles. It is arranged for AC-DC ringing only, and is part of the 806G type power plant used in 701B, 711B and 740E PBX's.

STATIC RINGING GENERATORS [4]

Static ringing generators have no moving parts. The primary of a transformer is tuned to sustain 20 cycle harmonics of 60 cycle AC. When power is applied a start relay operates and remains operated as long as the 20 cycle is being produced. If 20 cycle is interrupted the relay releases and a new start is made.

Subcycle units are low power units - if heavily loaded, the voltage will drop too low for satisfactory ringing. The sizes are as follows:

KS 5585	7.5 watts	.1 amperes
KS 5523	15 watts	.2 amperes
KS 5593	40 watts	.5 amperes
KS 5756		.1 amperes
KS 15529		.25 amperes
KS 15670		.5 amperes

MAINTENANCE OF RINGING MOTOR AND CONCERTERS

POINTS FOR YOUR APPRAISAL OF MAINTENANCE JOB

The points brought out in Section E on M-G sets (charging) also apply to M-G sets (ringing).

These points are:

1. Commutator and slip rings should be polished with commutator polisher [6].
2. Appearance of commutator should be dark chocolate brown or bronze color, highly polished.
3. Brushes should be free in their holders.
4. Correct brush pressure and correct brush angle is necessary.
5. If commutator or slip rings have to be turned down the ringing machine should

(1) 167-722-311 _ 804C Ringing power plant & KS 15532 Ringing
163-720-701 Machine
(2) 163-701-701 - 1/2 Ampere Ringing Machines - Holtzer-Cabot Type
(3) 163-320-701 - Ringing Machines - QD Type
(4) 155-415-701 - Static Ringing Generator
(5) 163-530-701 - KS 15804 Ringing Machine
(6) 155-410-701 - Figure 3 - Shows Commutator Polisher

be taken to a shop for the work. The use of stones and sandpaper is not part of regular maintenance and should be avoided.

6. The commutator should be correctly undercut.

7. The set should be kept clean. Oil and grease leakage should be wiped-up. Copper dust and other dust should be cleaned out of the equipment. Vacuum and pressure cleaning equipment can be used to good advantage in keeping the machine clean.

8. Grease and oil should be carefully added. Too much grease and over filling of the oil bearings can cause damage to the machine. Oil and grease leakage on the windings or commutator will deteriorate the insulation and cause flash overs.

9. Worm and worm gear on low speed interrupter shaft should be checked periodically for wear. If the teeth are becoming thin new gears should be ordered so that they will be on hand when the worn ones have to be replaced.

SUBCYCLE RINGING MACHINES

The start relay will require attention. Dirty and burned contacts will have to be cleaned and burnished.

SAFETY PRECAUTIONS

The precautions listed under charging M-G sets (Section E) also apply to ringing M-G sets.

They are:

1. Work on machines that are in operation only when absolutely necessary. If such work is required see that the light is adequate.

2. Avoid possible accident from loose clothing when working on generators. Neckties and loose sleeves are especially hazardous.

3. When it is necessary to work on a machine follow these precautions:

   Shut generator down
   Remove AC fuses
   Disconnect generator from battery
   Post "Man At Work" sign on switches

4. Tools should be taped when working around energized bus bars or switches.

5. Polishing the commutator should be done with the paddle described previously so that the hands are clear of the rotating armature.

6. Generators that start automatically should be clearly labeled "Danger, Auto-Start."

PRINCIPLE BELL SYSTEM PRACTICES SECTIONS

155-405-301, 155-405-701, 155-405-101 — Generators - Ringing and Coin Control - P Type

155-410-701, 155-410-101 — Generators - Ringing and Coin Control - Commercial Type

167-722-311, 163-720-701, 163-720-801 — KS-15532 Ringing Machines

163-701-301, 163-701-701 — Holtzer-Cabot, 1/2 Ampere Ringing Machines

163-650-701 - Interrupters - Rotary Mercury Type

155-415-701 - Static Ringing Generators

163-704-701 - Ringing Machines - Small Capacity KS 5510, KS 5546, KS 5659

155-307-701 - Tone Alternators

163-320-701 - Ringing Machines QD Type

163-530-701 - KS 15804 Ringing Machine

SECTION I
POWER PANELS

POWER SERVICE EQUIPMENT INCLUDES:

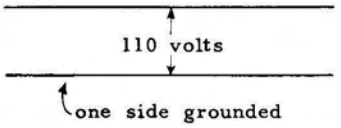
A.C. House service panels
Safety fuse boards
Fuse panels
Motor start and control panels

D.C. Battery control panels and switches
Voltage regulation equipment
End cell switches
Meters, ammeter and voltmeter relays

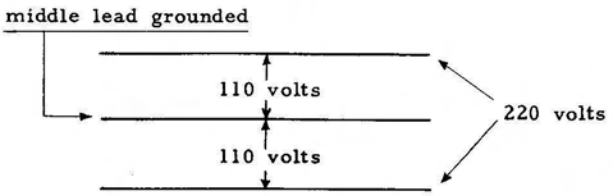
POWER SYSTEMS

The commercial AC power systems in this area are for the most part as follows:

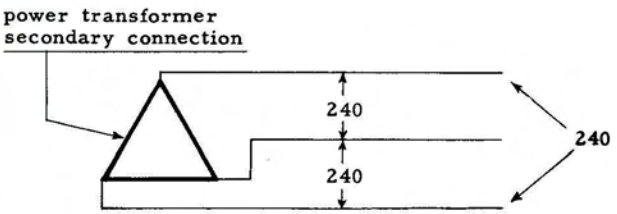
1. Single phase 2 wire.



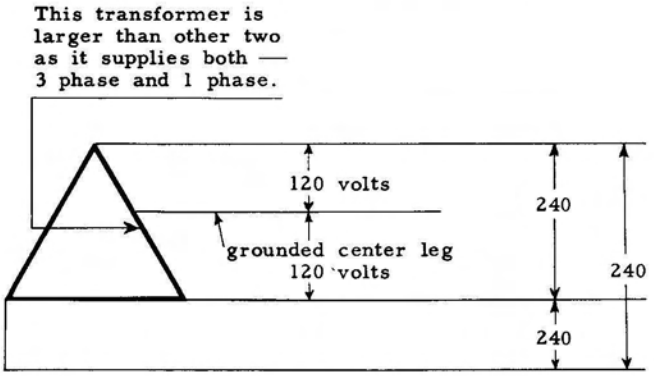
2. Single phase 3 wire.



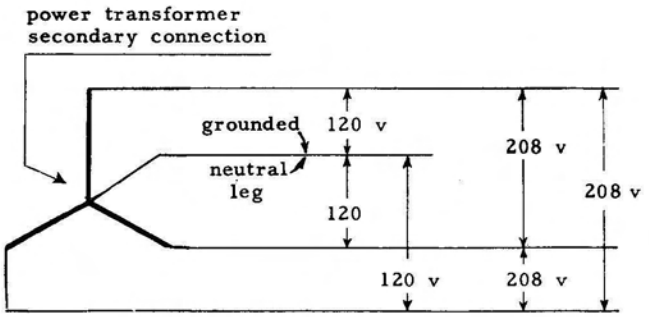
3. Three phase "delta" connection.



4. Three phase "delta" with single phase also.



5. Three phase "wye" or "star".



The single phase 120 volt "lighting" voltage is taken from all three phases -- line to grounded neutral leg.

You should know the type power system in your office. When portable engine equipment is used at an office, it is important that the equipment match the power service, for instance, a single phase engine cannot be used for a 3 phase load.

METERING OF POWER USAGE

Most of the power from the power company is under two schedules of rates.

1. Rates based on SEPARATE METERING of power and lights. Cost per kilowatt-hour for power is based on a "P" schedule, and for lights is based on a "L" or "A" schedule.

2. Rates based on COMBINED METERING, "C" schedule.

   If power usage is low, separate metering is the most economical.

   If power usage is high the combined rate is the most economical.

The power company, as part of their service, occasionally make checks to see which schedule is the most economical for the customer. It is suggested that you request a check by the power company if either of the following is the case at your office.

A large office (No. 1 step, No. 5 XBar, or larger) on 2 meter service.

A small office (CDO, toll repeater) on single meter service.

GROUNDING

Two types of grounds are used:

WATER SYSTEM GROUND -

There is now a trend to non-metallic pipe for water lines, If this type of pipe is used the water system ground is not usable.

DRIVEN GROUND -

If no water pipe ground is available rods driven into the ground are used.

BONDING OF POWER GROUND TO CENTRAL OFFICE GROUND

A good bond is required between the power ground and the central office ground if they are different. If a bond is not present, and a short circuit occurs in the power leads, the AC current flowing to ground will follow the conduit and building framework in the office to the central office ground. This has caused fires in a number of cases.

A physical check of the bonds in your office should be made. Where no bond is visible, or if you are not certain that a bond is present below the concrete slab, a bond should be installed.

MAINTENANCE OF POWER PANELS

Heating is the trouble most frequently found in power panels (switch panels, fuse panels, etc.).

Heating reduces the capacity of a fuse so that a fuse will operate at below its rated capacity.

Heating in switch of the knife switch, toggle switch or circuit breaker type is also the cause of a lot of trouble. If the source of heating is not eliminated, it will get progressively worse and worse until there is a burn-out of the switch.

HOT FUSES (1)

Due to poor contact. If poor contact exists the fuse will generally show it. For example - if the surfaces that contact in the fuse clip are discolored, the fuse has been making poor contact in the clips. If the contact has been tight, very little if any air can get to the contact surfaces and they will remain bright and clean. If only one end of the fuse is oxidized you have proof that poor contact is at this end.

If the end of a fuse cartridge is charred, you have a sure sign of poor contact on or near the fuse.

Installing a new, larger fuse will not help at all. The poor contact must be eliminated.

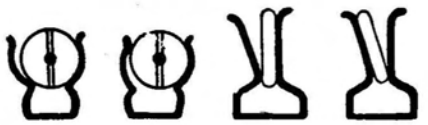
FUSE CLIPS

There are various size standard fuse clips for improving electrical contact and reducing heat between fuses and fuse clips. They are

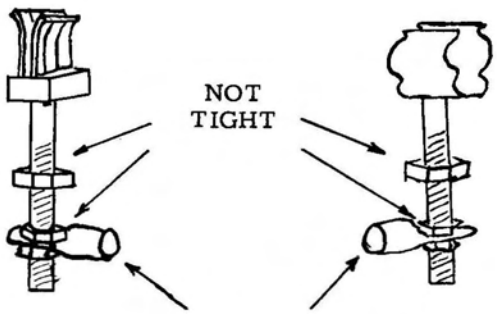
(1) 171-115-501 - Checking Loads on Fuses in Service

listed in the "C" section of the Catalogue of Supplies, and may be ordered out as required.

Poor contact due to misalignment of fuse clips. Some examples are shown below.



Poor contact due to loose connections.



EFFECT OF SURROUNDING TEMPERATURE

Surrounding temperature affects the fuse capacity. When a number of fuses are installed in an enclosure, the heating of the fuses reduces their carrying capacity.

HEATING IN SOLDERLESS CONNECTORS (1)

Solderless connectors that have loosened will, of course, also produce heat. The tightening of these connectors should be done in the correct manner. In the Western Electric H.B. 18 (7D) instructions it reads as follows:

> "Tightening of a solderless connector is not quite like tightening a bolt. The materials are softer and yield more under extreme pressure. Each connector has a correct wrench supplied for it. They are designed so that mechanically and electrically secure connections result when the screw or nut is tightened until the wrench presses firmly into the hand. A slight additional tightening does no harm. It is considered good practice to bear down until the wrench almost hurts the hand. Further tightening approaches the danger point where either the wire or the connector may be injured. You should not put an extension on the wrench or pad the hand to get extra tightening."

ALUMINUM BUS BARS

The use of aluminum for bus bars is standard. Aluminum should not be used where it is directly connected to shunts, to fuses, or switch studs. In these critical heat producing areas the copper to aluminum connection might give trouble. Copper bus bars are used in these places.

Aluminum also should not be used where the bus bar is connected directly to the posts of a battery.

If an aluminum bus bar is opened up, there is a special procedure for reconnecting it as follows:

> Aluminum contact should be cleaned (dry) with sandpaper or abrasive cloth to remove dirt, grease, etc. and to break down hard oxide. Then a coat of petrolatum is applied. A wire brush is used to break up oxide that has reformed. Clamp the connections together, within 5 minutes if possible, without removing the petrolatum.

ADJUSTMENT OF BLADES AND CLIPS OF KNIFE SWITCHES

Procedures for adjusting the blades and clips of knife switches is covered in section 030-740-701. It gives a table of "pounds of operating pull" for switches of different capacity. It is important that the switch be adjusted to operate with the designed pull. If they are too loose poor contact will result. If they are too tight, it may be difficult to operate the switch, especially if it stays unoperated for a long time.

LUBRICATION OF SWITCHES

Switch blades are now lubricated with a thin coat of petrolatum.

(1) 069-135-501 - Solderless Connectors

Periodically clean and relubricate them. Because, seldom operated switches get gummy and stick.

MEASUREMENT OF LOAD ON LEADS AND FUSES

Section 171-115-501 covers measurements of loads on fuses. It specifies that clip-on or other type ammeters be used to measure the loads. (See Section K in this booklet about obtaining meters.)

In Table M at rear of booklet, is a table of sizes and current carrying capacity of conductors. Normally in telephone work conductors are not loaded to full capacity as the voltage drop then becomes excessive. The current carrying capacity of copper bus bars can be calculated using 1000 ampere per square inch cross sectional area as basis.

INSPECTION OF FUSES AND FUSE PANELS

Section 026-371-501 covers routine inspection of fuse and fuse panels.

Section 171-115-501 tells us this <u>important point:</u>

"Replace all cartridge fuses that are in service for several years at near rated capacity."

The majority of fuse failures occur because of <u>Fuse Fatigue.</u>

FUSE FATIGUE

This is a gradual reduction of capacity because of fuse deterioration. The fuse deteriorates because of high heat.

<u>Remember</u> - A fuse is inexpensive in comparison with losing vital service - so replace the old fuses.

HOUSE SERVICE PANEL NOMENCLATURE

All switchboard sections, breakers, and switches shall be identified with standard nameplates; the characters to be engraved 3/16" type on laminated black and white bakelite, unless otherwise specified as to size and color.

The following information shall be used in determining nameplate arrangement and content:

(a) Each switchboard section shall be designated by the appropriate nameplate from the following list. These nameplates shall have 5/16" characters.

(1) MAIN POWER SERVICE
(2) BUILDING POWER DISTRIBUTION
(3) TELEPHONE POWER DISTRIBUTION
(4) POWER DISTRIBUTION (for combined telephone and building power)
(5) MAIN LIGHTING SERVICE, OA, OB, or OC
(6) LIGHTING DISTRIBUTION, PHASE, A, B, or C
(7) SUBSWITCHBOARD P-1A (typical for all subswitchboards)

(b) Nameplates for switches and breakers shall conform to the following arrangement and give the indicated information. The area of the nameplate to be referenced as follows: the top line to be (1), the second line to be (2), the lower left corner to be (3), and the lower right corner to be (4). As noted for (2) the location of telephone power equipment does not need to be shown, however, this space could be used, where necessary, for further information.

1 - Apparatus or service designation.
2 - Location (not necessary for most telephone power).
3 - Fuse or breaker trip size.
4 - Feeder designation.

(c) The main power, main lighting and all spare switches shall be designated as shown below:

<u>Nameplate for main power switch or breaker.</u>

1 - MAIN POWER
2 - 240V. 30 or 240V. 10
3 - Size of fuse, or breaker trip
4 - MP

Nameplate for main light switch or breaker.

1 - MAIN LIGHT, PHASE A (B or C)
2 - 120/240V., 10
3 - Size of fuse, or breaker trip
4 - MLA (MLB OR MLC to agree with phase)

Nameplates for all spare switches or breakers shall have the following information:

1 - SPARE
2 - BLANK (no lettering)
3 - SIZE, or breaker trip
4 - FEEDER DESIGNATION

(d) Lighting panel designation - The lighting panel designation shall correspond to the feeder designation except that the phase designator shall not be used; the panel energized from feeder "A-1A" would be "Panel 1A," etc. The panel nameplate as covered in the specifications, shall bear the feeder designation in addition to the panel designation.

(e) Power panel designation - All power panels and subswitchboards shall be designated in accordance with the feeder designation; i. e., power panel "P-1A" would be energized from feeder "P-1A," power panel "P-2A" from feeder "P-2A," etc. On all new buildings the power panel feeders should bear the first numbers and miscellaneous feeders should pick up in the numbering plan after all panels have been numbered.

(f) Feeder designation determination:

(1) All telephone power feeders shall be designated in accordance with the attached telephone power section.

(2) All power feeders shall be designated with a "P" for power, and a numeral or letter to indicate the location in the building, and a final letter to distinguish each individual feeder. See feeder designation paragraph below.

(3) All lighting distribution feeders shall be designated as follows, with exceptions as noted.

The feeder designation shall indicate power or lighting phase and the floor where ultimate point of service is located. In addition, all power and lighting feeders on each floor shall be designated by a letter of the alphabet, beginning with the letter "A" on each floor for both power and light panels. The first lighting panel feeder from Phase "A" terminating on the first floor would be "A-1A," the second would be "A-1B," etc. The first feeder from Phase "A" terminating on the second floor would be "A-2A," the second would be "A-2B," etc. For feeders from Phase "B" or Phase "C," substitute a "B" or "C" as the first character to correspond with the phase; for power feeders substitute "P" for the first character. When feeders terminate in the basement, use a "B" as the floor designator; for the roof use an "R". All miscellaneous feeders; i. e., ranges, hot-plates, reproduction machine, etc., shall be lettered from the end of the alphabet.

(a) The exceptions would be:

(1) The emergency lighting panel would always be Panel "E" and the feeder would be "A-BE," "A-1E," etc., to agree with phase and floor.

(2) The 48-volt D-C emergency relay feeder would always be designated with the letter "X," as "A-1X," "A-BX," etc., to agree with phase and floor.

(3) Subswitchboard feeders shall be designated as "P-1A1," P-1A2," etc., or "P-RB1," "P-RB2," etc., showing the power feeder designation from the main switchboard with the individual switch on the sub-board indicated by the last number of the designation.

(4) Lighting circuits shall bear panel designation plus circuit number; i.e., "1A-1," "1A-2," etc.

TELEPHONE POWER SECTION - TERMINOLOGY

The telephone power transfer switches shall carry the following feeder designations: "TP," "TPA," "TPB," etc., with "TP" to be the first, "TPA" to be second, etc.

All switches fed from the transfer switch shall bear a feeder designation corresponding to the transfer switch with a numeral added, such as, "TP-1," "TP-2" or TPA-1," "TPA-2," etc.

The main telephone power transfer switch shall have the following nameplates:

(a) Mounted over the center of switch:

(1) MAIN TELEPHONE POWER
(2) TRANSFER
(3) SIZE OF SWITCH
(4) DESIGNATION "TP," (etc.)

(b) Mounted on correct side:

(1) COMMERCIAL POWER
(2, 2, & 4) None

(c) Mounted on other side:

(1) EMERGENCY POWER
(2, 3, & 4) None

The main telephone power switch shall be as follows where the necessary information is available to the building engineer.

(1) TELEPHONE POWER CABINET #1
(2)
(3) FUSE, or TRIP SIZE
(4) TP-1, (etc.)

In cases where the information is not available, or the above plan is not consistent with the distribution, as would be the case with bus-duct system, the designation will be (1) MAIN TELEPHONE POWER OR A DESIGNATION APPROVED BY THE ENGINEER.

All other telephone power switches fed from the main telephone power transfer switch-bus shall be labeled in the standard manner; that is, sump-pumps, engine room exhaust fans, etc.

In all of our new buildings and in particular those being built for No. 5 crossbar equipment, it has been necessary to provide a second telephone power transfer switch. This transfer switch supplies equipment which requires access to the emergency alternator power, yet it is desirable that it be undisturbed on routine maintenance operations of the alternator. Provide nameplates for this transfer switch, as follows:

(a) To be mounted above the center of the switch: a plate inscribed on laminated red and white bakelite with 3/16" characters.

OPERATE ONLY ON ACTUAL COMMERCIAL POWER FAILURE

A standard nameplate:

(1) SPECIAL TELEPHONE POWER
(2) TRANSFER
(3) SIZE or BREAKER TRIP
(4) TPA, (etc.)

To be mounted on correct side of transfer switch:

(1) COMMERCIAL POWER
(2, 3, & 4) None

Mounted on other side:

(1) EMERGENCY POWER
(2, 3, & 4) None

Switches served from this transfer switch will show telephone power plant designation where possible. Most cases, to date, have served a transformer which in turn serves distribution switches located in a telephone power distributing section of the main switchboard. If the switch serving the transformer is "TPA-1," it shall be labeled (1) Transformer (2) 240V to 240/120V, (3) fuse size, (4) "TPA-1." The switches fed from the secondary of the transformer shall be "TPA-11," "TPA-12," etc. For the No. 5 crossbar offices where this means is used to supply 115V AC to the 115V AC power cabinet designate the secondary serving switch as follows:

(1) 504-B POWER PLANT (obtain date from telephone power equipment engineer)

(2)
(3) FUSE, or TRIP SIZE
(4) TPA-11 (as an example)

The following items are essential in an over-all attempt to make the House Service Panel less complex in appearance and facilitate its use by the plant maintenance forces.

(a) Designate each switchboard section with large nameplates to indicate type of service, telephone power, building power, lighting, etc.

(b) Standard nameplates on all switches and breakers.

(c) Tape all switchboards having transfer switches to indicate bussing. Use the following colors of Scotch tape #471 as standard.

BLUE - ALL LIGHTING
ORANGE - COMMERCIAL AND BUILDING POWER
RED - TELEPHONE POWER
YELLOW - EMERGENCY ALTERNATOR

All taping to be done by the building engineer.

(d) A switchboard directory for the telephone power only. This directory to fit a standard 8-1/2" x 11" frame on the front of the switchboard. The directory and the frame to be furnished by the building engineer. The service information and equipment served by each switch shall be added by the wire chief, with the view in mind that local terminology will be more valuable than strictly technical information. The directory as sent out by the building engineer will have the following information for each switch:

(1) Switchboard section
(2) Feeder designation
(3) Nameplate information
(4) Space for the wire chief to add any information he desires, such as, transformer, ultimate service, power plant designation, etc.

(e) A set of operating instructions with particular regard to procedures to be followed on telephone power transfer operations during routine emergency alternator runs and actual commercial power failure shall be provided. The responsibility for preparing these instructions shall rest with the wire chief.

POINTS FOR YOUR APPRAISAL OF MAINTENANCE JOB

1. Are regular checks for heat around switches, bus bars, fuse panels being made? Where heating is found, the source should be eliminated as soon as possible.

   If it is suspected that the heat is caused by overloads, measurements should be taken if possible. The load information should be given to the Maintenance Supervisor to be taken up with engineering.

2. Old fuses operating at near rated capacity should be replaced. It might be necessary for engineering to authorize a larger fuse.

3. Fuse clips, switch blades and clips should be kept in good adjustment.

SAFETY PRECAUTIONS

1. Wear rubber gloves when working on high voltage circuits.

2. Put a rubber mat in front of live front power panels where voltage to ground exceeds 150 volts.

3. Work in house service panel enclosures is generally done by electrical contractors. It may sometimes be necessary for our people to make emergency repairs. Wear rubber gloves. An approved tester should be used to test for voltages.

4. When working on power circuits open the switch on the panel, and remove the fuses. Hang a warning sign on the switch.

   "Danger, Man Working on Circuit
   Do Not Insert Fuse or Close Switch"

5. Do not wear rings, metal wrist bands or watches while working on power panels.

6. Use fuse pullers when changing fuses.

7. Wear goggles or safety spectacles.

GROUNDING OF PORTABLE EQUIPMENT

Portable electric equipment operation on 90 volts or over must be grounded (National Electric code). Three prong, polarized plugs are standard in all central offices.

PRINCIPLE BELL SYSTEM PRACTICES SECTIONS

030-740-701 - Knife Switches
026-356-701 - Contactors, Emergency Cell Switches, Relays and Starters
030-741-701 - Palmer Switches
040-632-701 - Ammeter Relays
040-254-701 - Voltmeter Relays
030-785-701 - KS 15610 and KS 15624 Switch Panels (end cell switch for 302A power plants)
030-787-701 - Emergency Cell Switches (Motor Driven Knife Blade Type)
030-787-701 - Emergency Cell Switches (Emg. Cell etc.)
171-115-501 - Checking Load on Fuses in Service
026-371-501 - Routine Inspection of Fuses and Fuse Panels

SECTION J
EMERGENCY POWER PLANS [1]

You should make an emergency power plan for operating the telephone equipment during failures of commercial power. The plans should cover all toll and exchange central offices and vital PBX locations under your control. It should be in writing and posted or filed where everyone concerned can have access to it and be familiar with it.

Emergency operation will be by one or more of the following:

1. Storage batteries.
2. Portable engine.
3. Permanently installed engine.

The plan should state the approximate number of hours that the batteries will operate the equipment during commercial power failures. In some cases power failures will affect an entire area with the possibility that several offices will be without commercial power at the same time. Knowledge of the reserve will let you plan the use of available portable engines. This knowledge will also be used to determine if additional portable engines should be rushed to the area.

Other emergency measures:

1. Renting portable engines.
2. Renting engine driven welding equipment.
3. Renting automotive type storage batteries.

POWER FAILURE ROUTINE

Types of equipment differ at the different locations, so an individual plan is required for each location. The sequence of steps in restoring power should be definitely established and the steps should be posted near the power equipment. Personnel should be trained in the emergency procedure.

TYPICAL EXAMPLE

At a location where a permanently installed, manually started engine is installed the procedure would be:

1. Start and transfer the emergency ringing machine, if this is not automatic.
2. Switch the emergency end cells into battery to raise the voltage.
3. Turn on emergency DC lights, if this is not automatic.
4. Disconnect all charging machines from the AC lines, and set the machines for manual control.
5. Silence all unnecessary alarms by operation of the alarm cut off key.
6. Be sure to let the supervisor in charge know of the failure so that additional men can be called in.
7. Call the local power company to find out the expected length of the power failure.
8. Start the engine, unless it is indicated that an immediate return to commercial power can be expected. Of course, if AC operated equipment such as carriers, etc. are out of service, the engine should be started as soon as possible.
9. When the engine is operating normally, the telephone power transfer switch should be thrown: Start the charging machines.

   IMPORTANT
   The starting of motor-generator sets should be manual for the following reason: The battery voltage will drop during the time the engine is being started. Under control of the voltage regulator, all sets will start, and the engines will be overloaded. The correct method of starting would be to first start the largest

(1) 171-120-301 - Power Failure Routine

set needed for the load, but leave unloaded until the other sets required to handle the load are started. This procedure is important because starting current of the sets are high, and the starting of sets connected to an engine already loaded should be avoided. It might not be possible to return all the amperage lost by the batteries during the power failure.

10. Call plant emergency headquarters and report the facts.

11. Start other equipment essential to the operation of the office such as sump pumps, water pumps, compressor-dehydrators, etc.

12. If the engine is not now at full output, extra lighting or other equipment may be started.

STEPS IN RETURNING TO COMMERCIAL POWER

1. After commercial power has been restored for at least 15 minutes, the return to commercial power should be started.

2. Remove load and stop all motor-generator sets.

3. Throw telephone power switch from emergency to commercial power.

4. Return ringing machines and emergency lights to normal.

5. Stop engine.

6. Restart motor-generator sets.

7. Return emergency end cell switches to normal.

8. The engine should be thoroughly checked over:

   Exhaust stack and muffler drained
   Starting battery checked
   Engine and alternator wiped clean
   Radiator checked
   Lube oil checked

9. The central office batteries should be checked. If there has been an appreciable drain on the batteries, a boost charge should be started. The emergency end cells should be "charged by load."

PORTABLE EMERGENCY ENGINES

Portable emergency engine-driven generator sets are of several types. The transportation of these units from the location where stored to points required should be under the direction of the district plant managers.

All portable engine-trailer sets are equipped with auto hitches and can readily be towed behind light trucks; however, in the case of trailers equipped with brakes it is necessary to use a Group 7 or larger truck for towing. Trailer brakes are of the 6 Volt electric type.

The 2.5KW Homelite type engine generator sets are provided with lift handles, are mounted on spring type skids and weigh approximately 130 pounds. Separate transformers, wire and safety type gasoline cans are available with each set.

Type PE-75T engine generator sets are army-type sets mounted on a welded steel skid base. They weigh approximately 300 pounds. Separate transformers, wire and safety type gasoline cans are available with each set.

APPLICATION

Portable engine-driven generator sets are to be used as an emergency source of supply for maintaining central office power plant equipment in case of a failure of the commercial source of supply.

The portable sets are assigned for storage at certain locations where they can readily be placed in service or be picked up for transportation to other locations as required.

Due to the weight of these portable sets, all precautions should be taken to assure that accidents are not incurred in handling them. All safety requirements shall be observed in their handling, transportation and use.

Portable emergency engine generator sets shall not be operated inside any building or inclosed area. They should be located outdoors as close as possible to the power plant service panel or item of equipment they are to serve.

CAUTION: Gasoline fumes, including those in the crank case of gasoline engines, may be explosive. Exhaust gases are dangerous to life when inhaled. Avoid ignition of explosive gases and the breathing of exhaust fumes. Fuel should never be left in gas tank of portable engines. Approved type safety cans are available for emergency supply.

Any oil mixtures for portable engines which have been stored for longer than 3 months should be disposed of and a new mixture used. Old mixtures become gummy and cause poor operation.

The method of operating portable sets for emergency use or for routine testing, shall be in accordance with Bell System Practices or operating instructions covering the particular set.

Routine exercise runs on engine generator sets shall be made in accordance with Bell System Practices Section 155-199-902PT.

The 3-phase 3-wire 230-volt AC or 3-phase 4-wire 120/208 volt AC portable generators are indicated as such. All other portable generators are single phase 115 or 115/230 volts AC.

Transfers between exchanges; accounting for transfer of portable engines is explained in detail in Plant Instructions, Transfers of Central Office Equipment Accounting and Record Procedures.

NOTE: The maintenance and storage of these engines is the responsibility of local supervision. They should be ready for immediate use. Each set should be stored at the location listed in this memo, or there should be an SN65 showing the new temporary location.

The maintenance supervisor's office must be notified of permanent transfers of any portable engine sets.

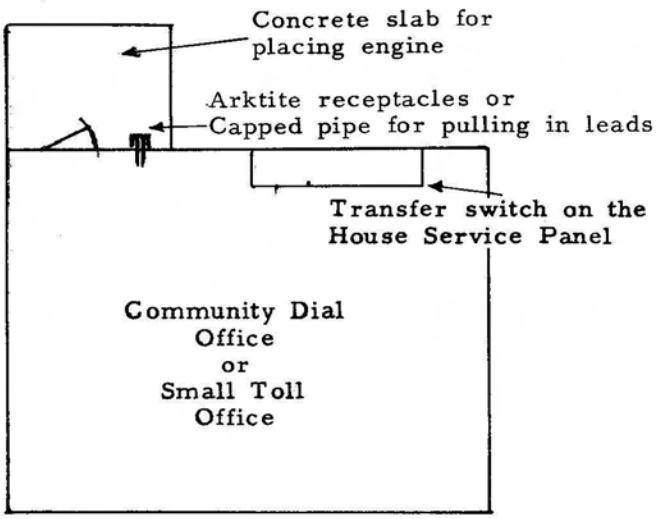
POWER FAILURE ROUTINE WHERE NO ENGINE IS INSTALLED

A power failure plan should be established for each location. The plan should cover the procedure to be followed in obtaining and connecting up the engine.

A 1-1/2 ton truck or bigger is usually required to move the engine trailers. The proper hitch must be on the truck to connect to the trailer. The leads are generally stored on the trailer. Some of the trailers are equipped with hand pumps and hose which can be dropped into the buried fuel tank for refilling the trailer fuel tank during operation. This feature is particularly valuable at the microwave stations when trailers are used to replace the regular engine.

TYPICAL ARRANGEMENT FOR OPERATING PORTABLE ENGINES

Most locations have the facilities for operating portable engines shown below:



A safe transfer to the engine is possible if a double throw transfer switch is installed. The engine leads are connected to the emergency side of the switch and then the switch can be safely operated.

If a transfer switch is not provided care must be taken to be sure the commercial AC

is disconnected (disconnect switch open) before connecting engine leads. The leads should be connected to the load by firmly fastening to the equipment side of the switch.

Portable engines must always be operated outside the building because of the danger of carbon-monoxide gas and fire.

The hazard of electric shock is great, especially in rainy weather. Rubber gloves should be used. Leads with defective insulation should be repaired or replaced.

After the power failure is over, the portable engine should be checked, cleaned and returned to its home location. The starting batteries, leads and all other parts of the equipment should be returned to good condition.

POINTS YOU SHOULD THINK ABOUT IN FORMING EMERGENCY PLAN FOR OFFICE

1. Approximate hours storage battery reserve (see Section C on storage batteries).

2. Capacity of permanently installed engine if provided.

3. Available portable engines (see 155-199-902PT Appendices).

DON'T CONSIDER

The previous record of reliability of the commercial power. No matter how reliable the power has been, power failures can happen anywhere. For instance, a seven hour power failure recently occurred downtown in one of our larger cities.

The point is, are we prepared to meet the emergency of the power failure.

AREA EMERGENCY STOCK

We have some items of power equipment in the Area Emergency Stock. The Maintenance Supervisor's office should be contacted if you need these items in an emergency. The items include the following equipment of the most common types:

Rectifiers
Rectifier Stacks
Ringing Machines

We also have some storage batteries that are held in "C" stock. They are stored for us by the battery company.

SECTION K
METERS AND TEST INSTRUMENTS FOR POWER

TYPES - DESCRIPTION AND WHERE YOU CAN BORROW THEM

CURRENT MEASURING INSTRUMENTS

Ammeters - Two meters are held in the Maintenance Supervisor's office. These meters are used with an external shunt of the right size for the current to be measured. There are various sizes of shunts available.

Clip-on Ammeter - You can instantly measure the current in a conductor by clipping the jaws of the meter around the conductor. The meter uses the "field" around the wire to measure the current flowing in it.

Clip-on meters are held at the Maintenance Supervisor's office. The meters read both AC and DC current.

NOTE: The frame of the clip-on ammeter is not insulated. Use rubber gloves for safety.

Recording Ammeters - Types available:

Bristol Recorder - This type has a wind-up motor which turns a 24 hour circular "Smoke" chart. The chart must be "fixed" with a chemical solution. A few of these meters are distributed through the area.

Esterline-Angus Recording Meters - This type has a wind-up motor which turns a strip chart and records current or voltage for as long as seven days without attention.

General Electric, Type CF2 Recorder [1] - The clock mechanism is run by a telecron motor connected to an AC lighting receptacle. A strip chart records current for as long as 7 days without attention. The recording is by a series of dots on the chart, a dot every 2 seconds. The recorder is inkless. The marks on the chart are made by typewriter ribbon.

This recorder is the latest type. All new meters purchased should be of this type.

VOLTAGE MEASURING INSTRUMENTS

Battery maintenance section 157-601-301 covers the importance of periodically checking the accuracy of the voltmeter used for floating the batteries. There are various types of meters you can use for checking the meters on the power board.

Weston Model 1 - A number of these meters are available. Most Toll offices have a meter of this type.

Weston Model 931 - The new No. 1 step-by-step offices and the No. 5 and other crossbar offices are getting a Model 931 meter with scales 0-30, 0-75, 0-150 and 0-300 and one Model 931 with a single scale 0-3 volts.

S9A Meter - For anti-static solution - ANSTAC 2M - Addendum 100-510-701. [2]

There is also at the Maintenance Supervisor's office a Model 1, Model 931 and a Model 622 (Secondary Standard) meter.

Checking Individual Cell Volts - For checking the voltage of individual cells in a battery, the Model 931 with a single scale 0-3 volts has recently been standardized. With this meter .02 volts can be read directly and .01 volts can be estimated. The model previously standard was a Model 280. Each scale division of the latter meter is .05 volts. The 280 meter is not accurate enough to make the close voltage checks now required for batteries.

SPEED MEASURING INSTRUMENTS

Hasler Speed Indicator - The button is pressed on the instrument and the revolutions during a certain length of time are counted and show on the scale as RPM. Hasler Speed Indicators are a required tool at most of the larger offices.

Tachometer - This instrument reads speed continuously as long as the meter is pressed

(1) 171-122-301 - Power Load Recording - Using the GE Co. Type CF2 Recording Ammeter

(2) 100-510-701 - Individual meters

to the shaft. A portable tachometer is available at the Maintenance Supervisor's office.

DIAL INDICATORS

The dial indicator is an instrument to measure irregularities on a surface; such as, the surface of a commutator or slip rings. Most panel offices have a dial indicator for maintaining the panel equipment. The Maintenance Supervisor's office has a dial indicator which is available for use.

BATTERY TESTING EQUIPMENT (1)

A "Minute Man" KS 5730 Battery Tester that tests cells up to 200 ampere-hour size can be obtained from the Maintenance Supervisor's office. There are several other testers distributed through the area.

A J87116 Battery Tester which tests cells up to 1680 ampere-hour size can be borrowed by contacting the Maintenance Supervisor's office.

SINGLE CELL CHARGERS

About 13 Single Cell Chargers, KS 15687, rated at 20 amperes are distributed throughout the area.

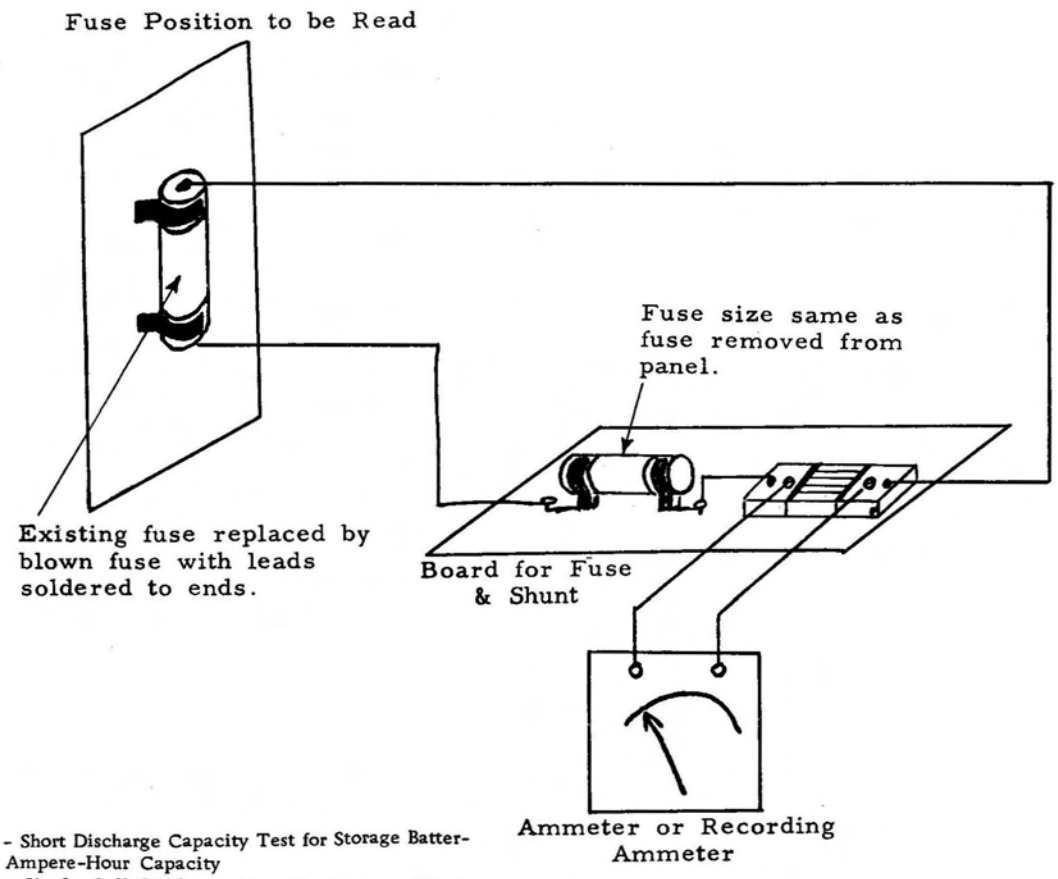
A J86264 Single Cell Charger rated at 210 amperes output can be obtained through the Maintenance Supervisor's office.

METER REPAIRS AND CALIBRATION

Meters and instruments are calibrated and repaired by The Western Electric Co. on the "Red Ball Plan."

AMPERE MEASUREMENTS IN WORKING CIRCUITS

Measurements of current in a working circuit are covered in 171-115-501. The work must be very carefully done. The correct method for connecting a shunt into a working circuit is illustrated below. Put a temporary short across the fuse clips while the dummy inserted. Conductors must be heavy enough to carry the load.



(1) 157-601-502 - Short Discharge Capacity Test for Storage Batteries - 20-200 Ampere-Hour Capacity
157-601-503 - Single Cell Discharge Capacity Test - 180 to 1680 Ampere-Hour Capacities

SECTION L
POWER PERSONNEL - TRAINING

POWER PERSONNEL

In the past a power man was needed for regular power coverage at the larger power plants. In addition to maintenance duties he operated the equipment. This included starting and stopping generators, controlling their output, regulating voltages, operating switches, etc.

Now, power plants are more and more automatic. Generators and rectifiers start automatically, regulate automatically and switches and contactors are automatic. Full time power coverage is not required with these plants.

However, when automatic power plants fail, finding and correcting the trouble is more difficult than before. Circuits are very complicated and involved, in fact, some are more involved than many of the circuits in the switchroom. Now, more than ever before, the men must be trained to work on these plants. Electronic control circuits are replacing relay circuits. There are closer voltages that must be maintained.

POWER TRAINING

The need for adequate power training is now fully recognized. Power training is included with central office, PBX, and Toll major training courses.

As part of the training, circuits are completely traced out and a sequence of relay operations is made. On-the-job training with the equipment is then given so that the operation is fully understood. Formal power classes can be arranged thru your training coordinator.

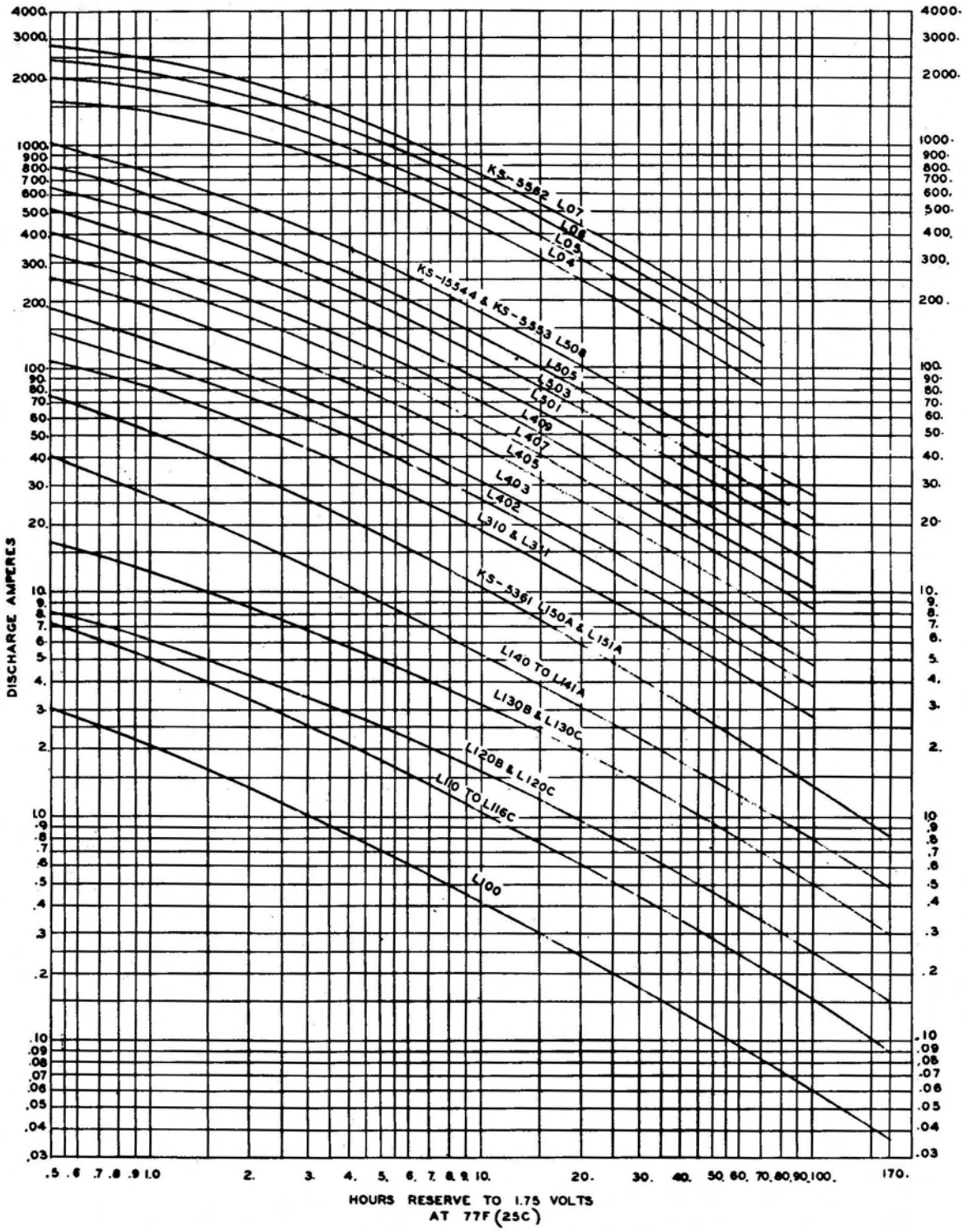
POWER TRAINING FILMS

The following is a partial list of training films that are available at plant schools. (See your film catalog for the complete list.)

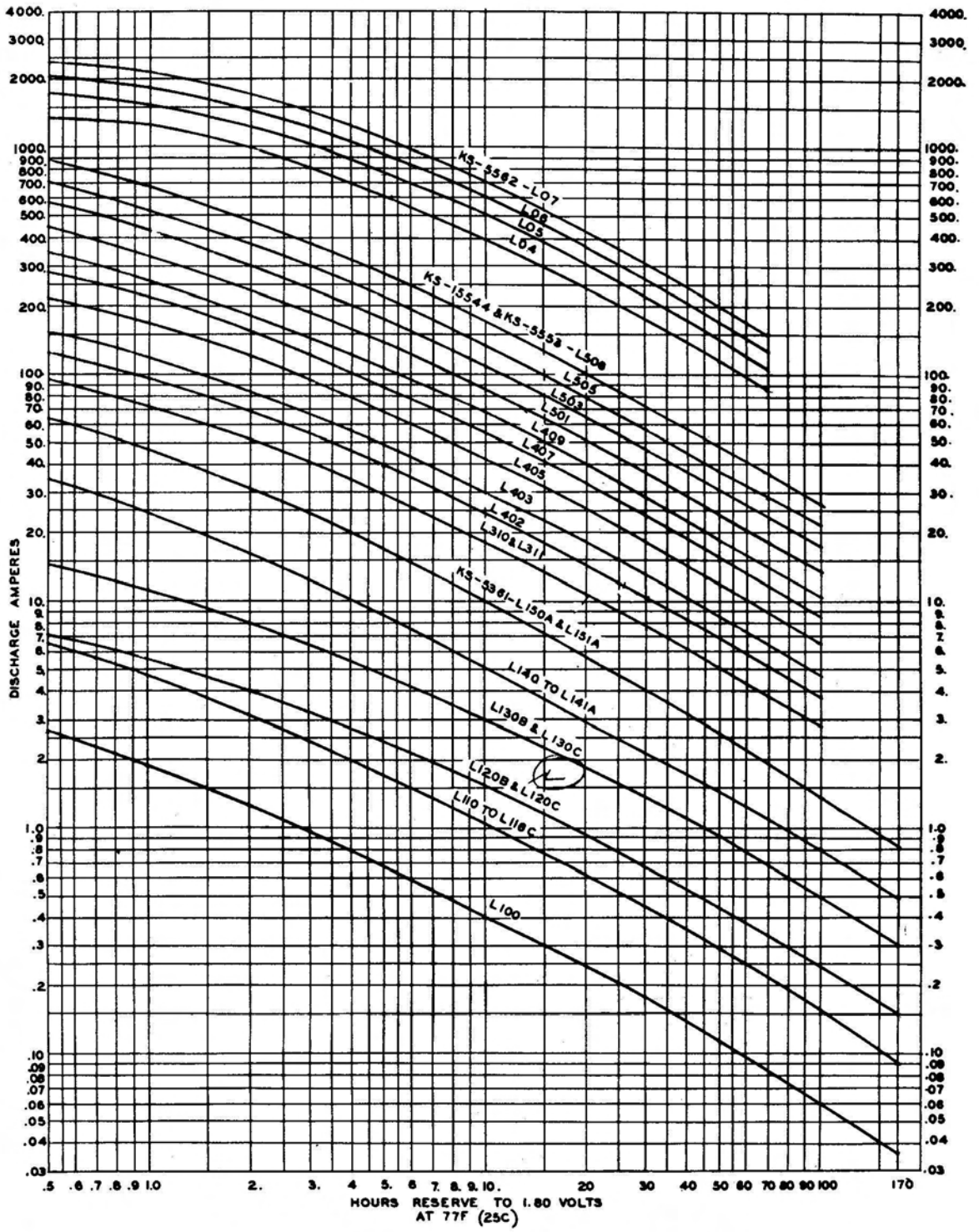
Battery Maintenance
Commutation of DC Machines
Diesel the Modern Power
Power - A Safety Film dealing with working around central office power equipment

Also these elementary electrical films:

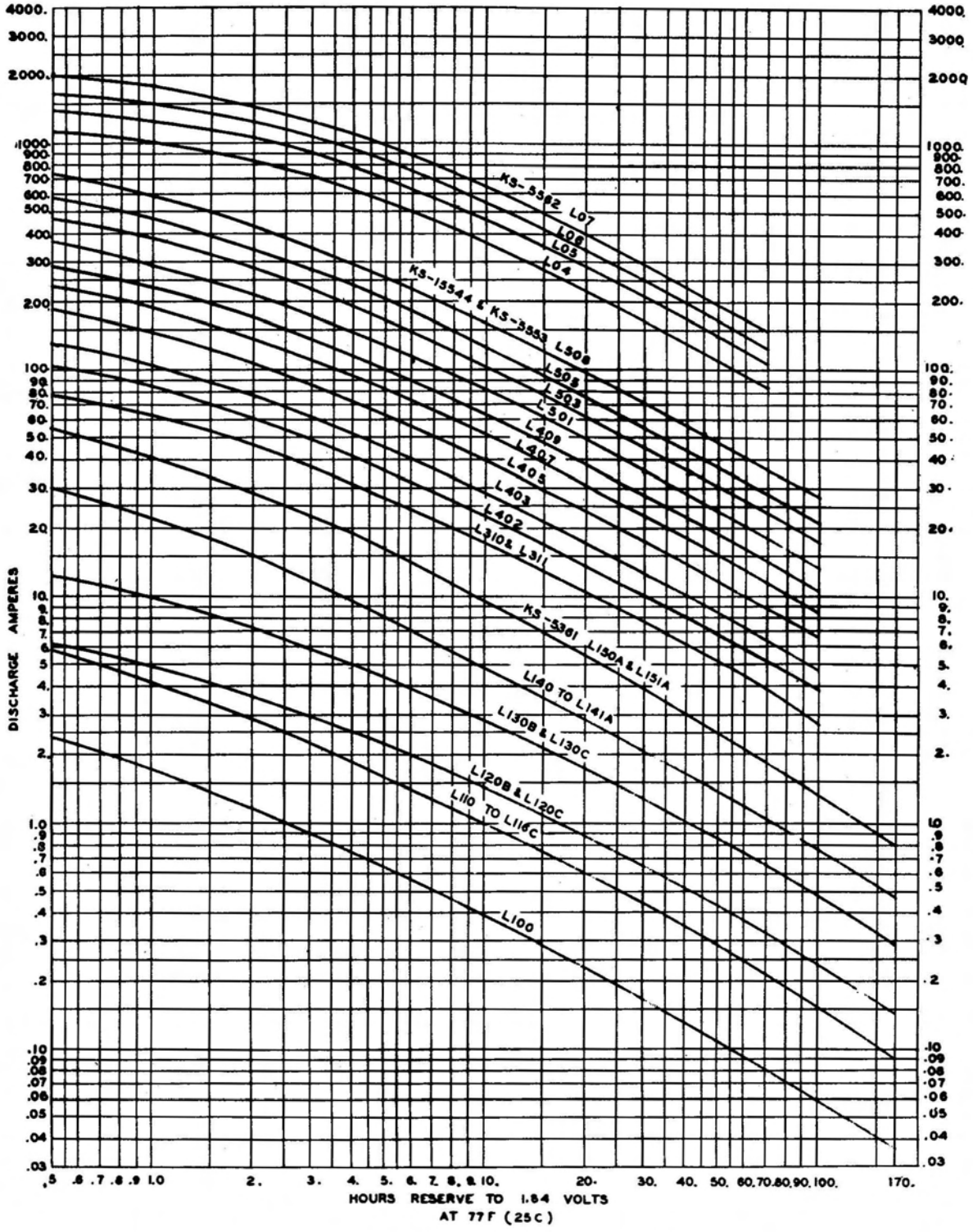
Amperes, Volts, Ohms
Basic Electricity
Current and Electromotive Force
Elementary Electricity
The Diode
The Triode



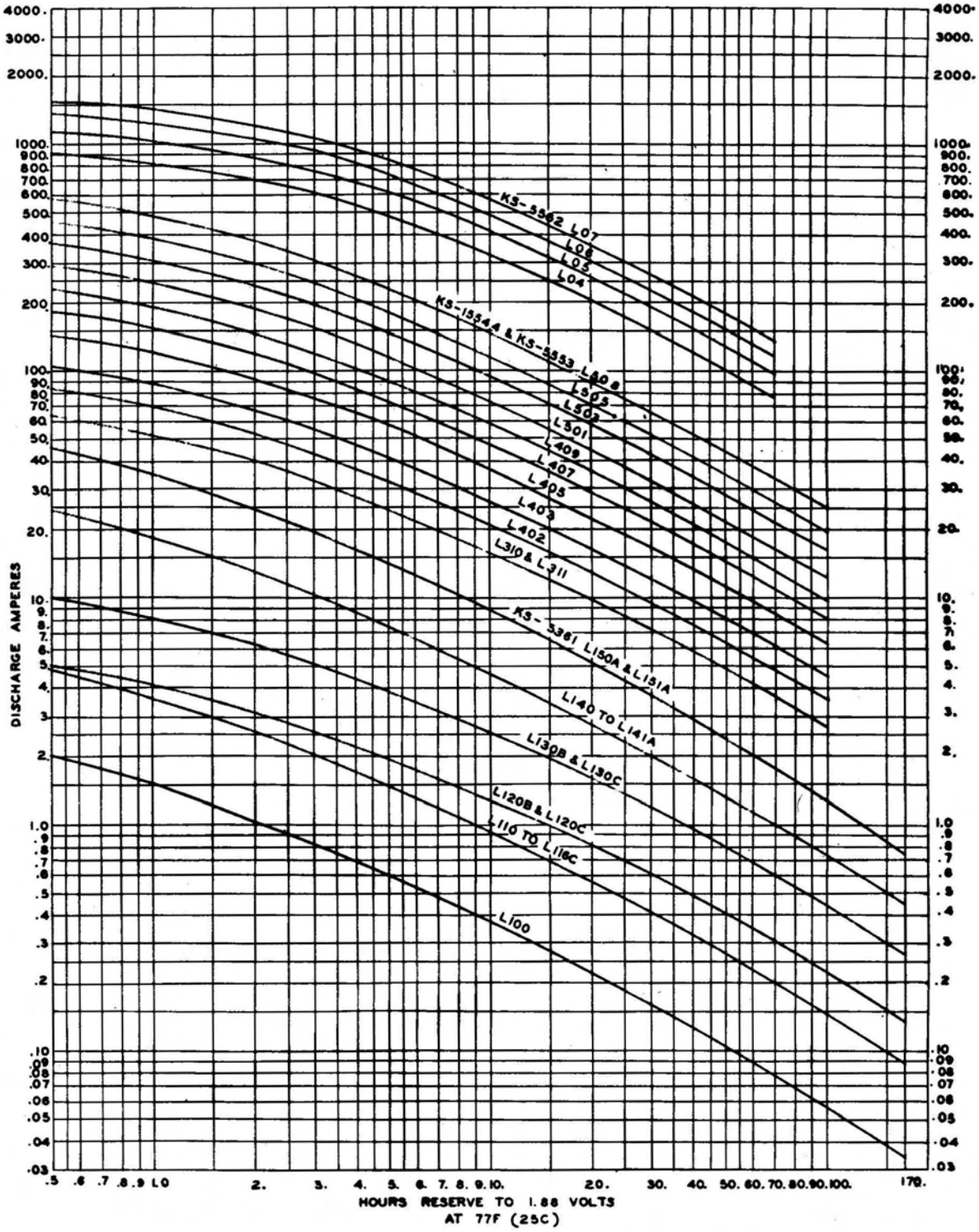
BATTERY DISCHARGE CURVES
TO 1.75 VOLTS PER CELL



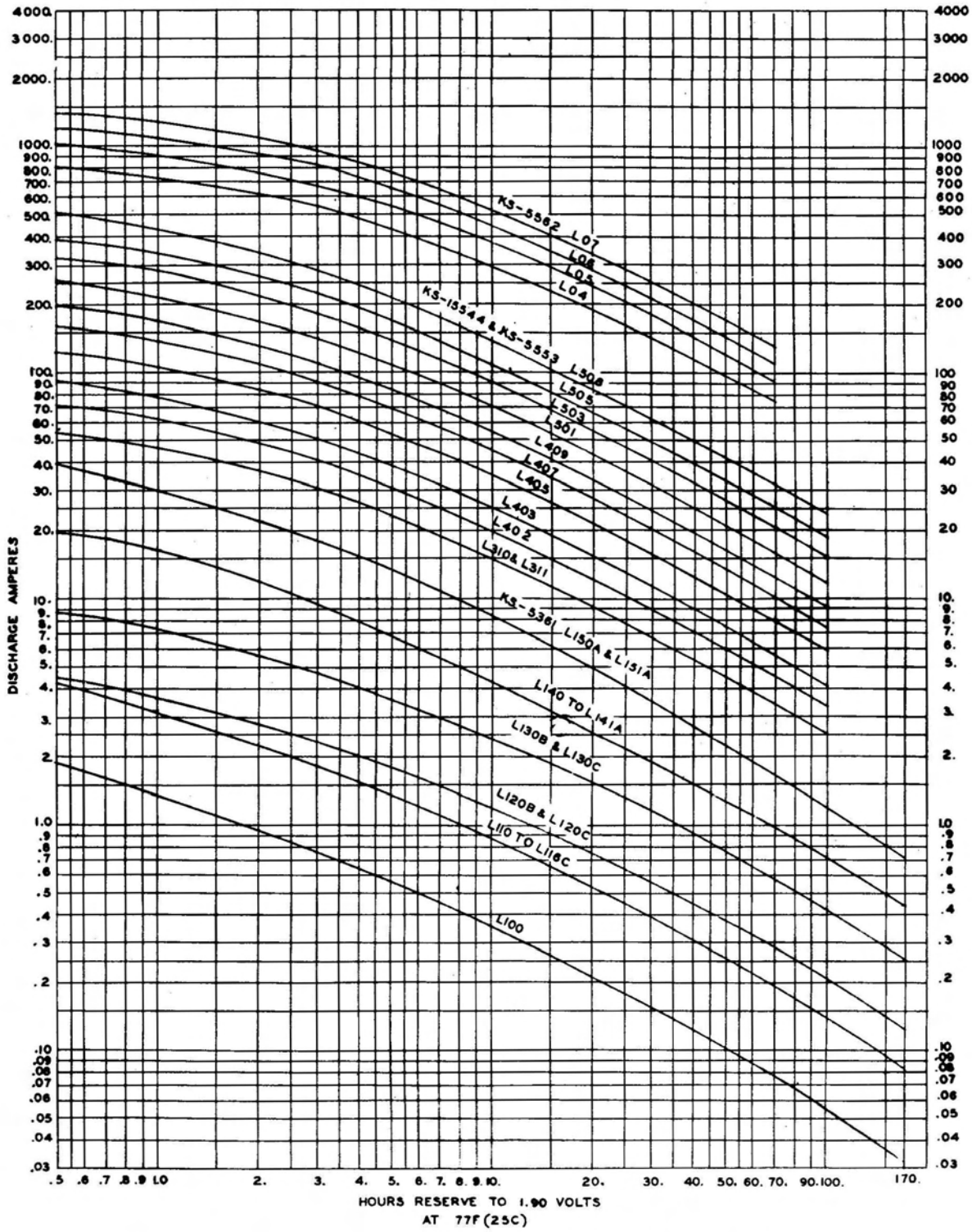
BATTERY DISCHARGE CURVES
TO 1.80 VOLTS PER CELL



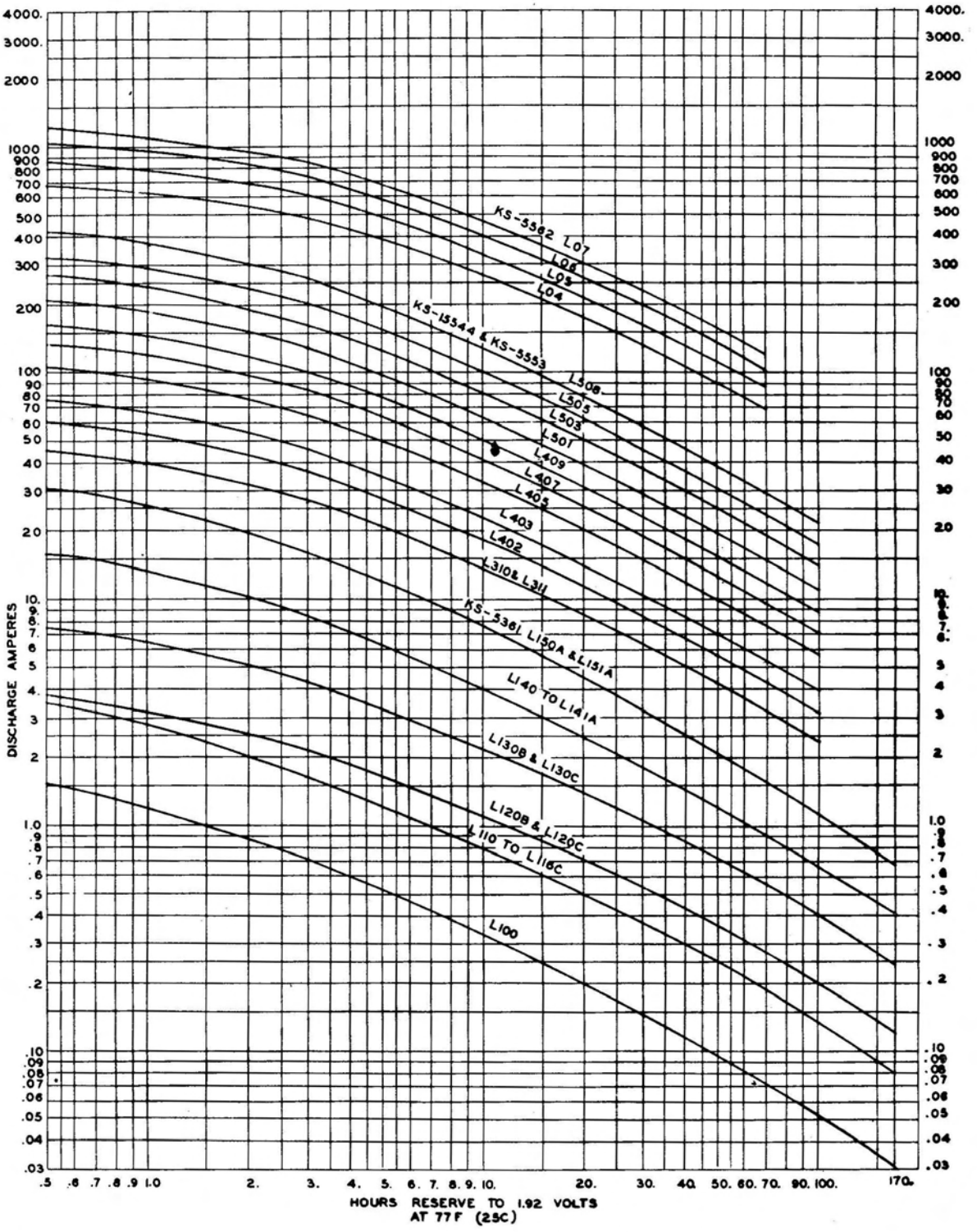
BATTERY DISCHARGE CURVES
TO 1.84 VOLTS PER CELL



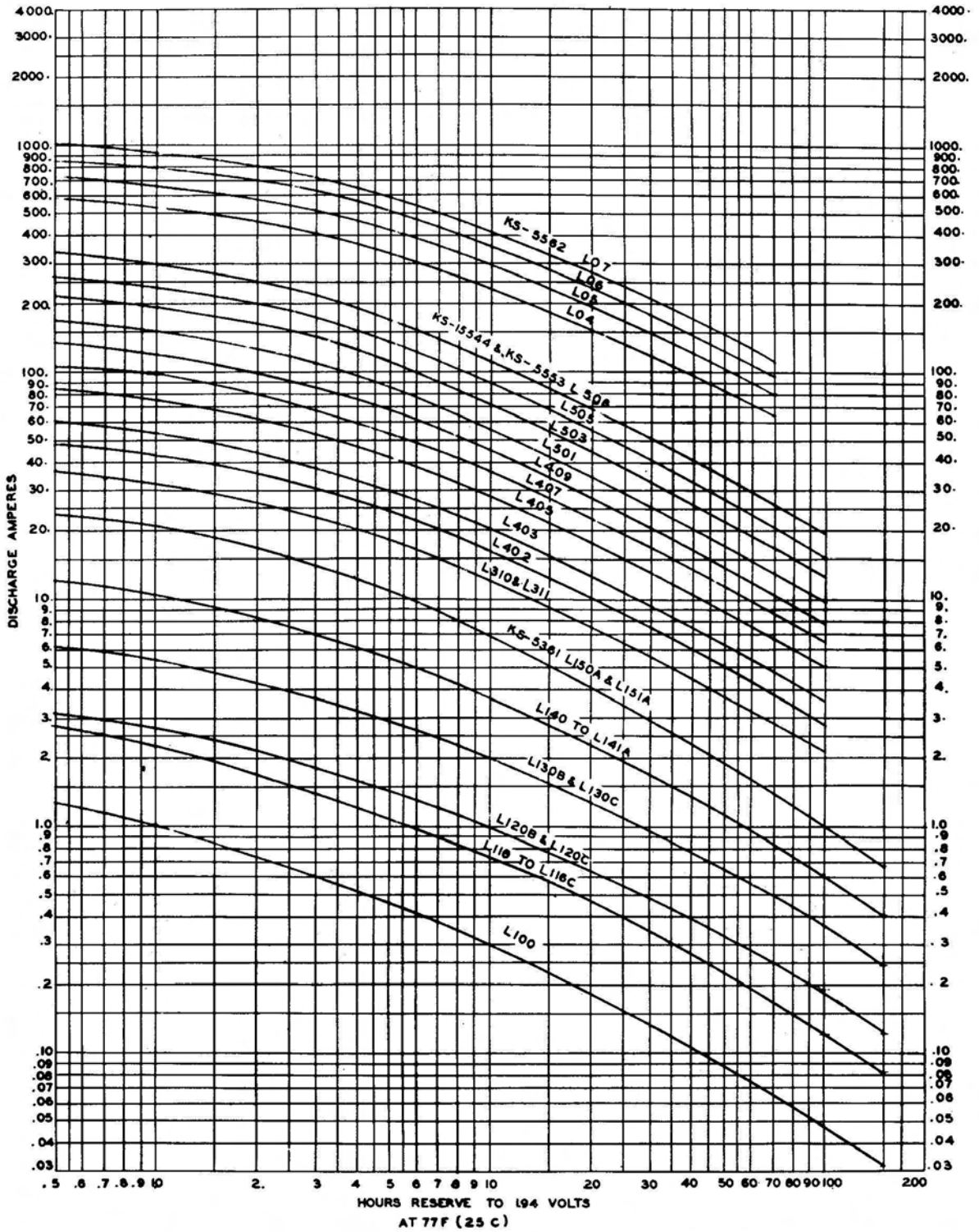
BATTERY DISCHARGE CURVES
TO 1.88 VOLTS PER CELL



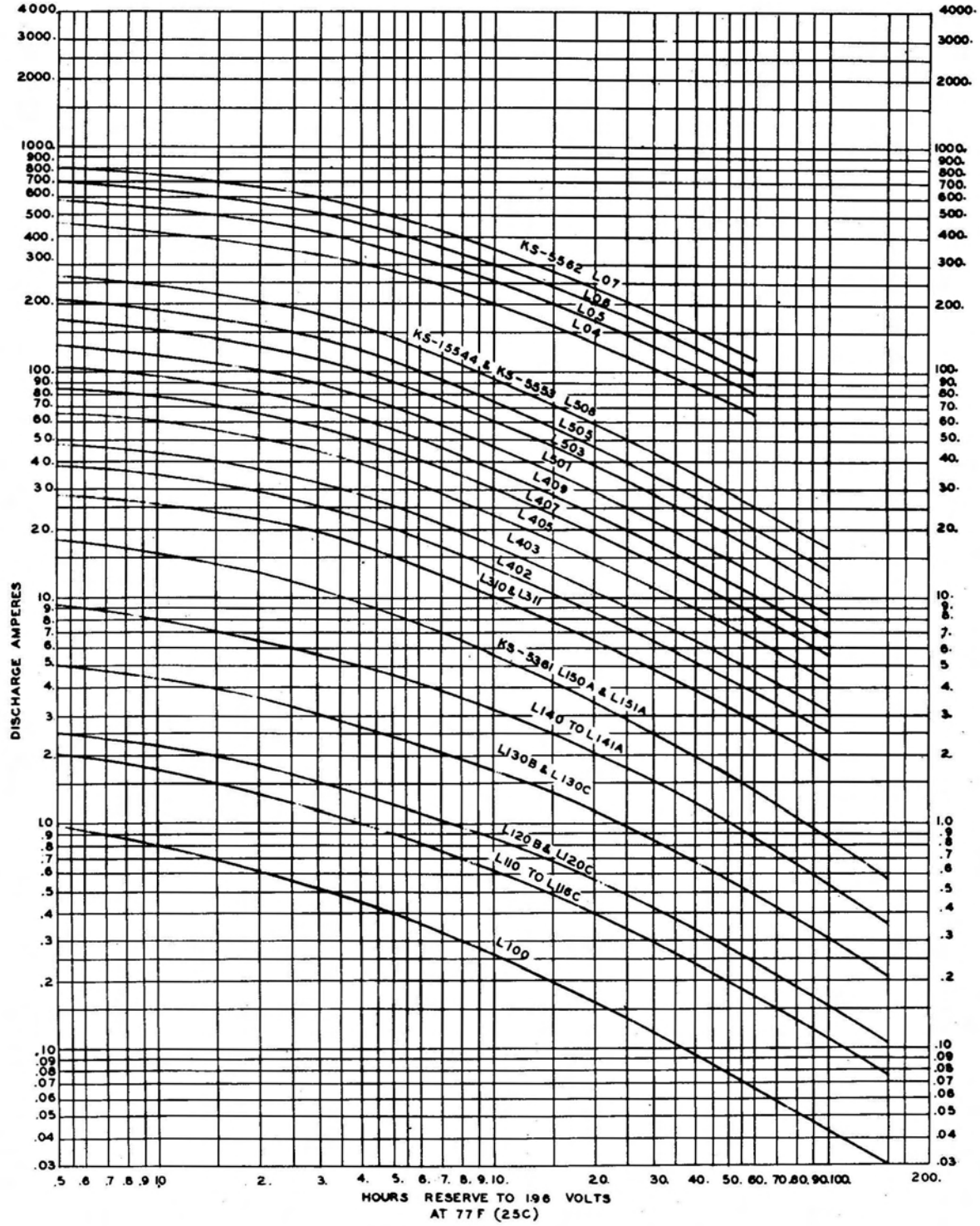
BATTERY DISCHARGE CURVES
TO 1.90 VOLTS PER CELL



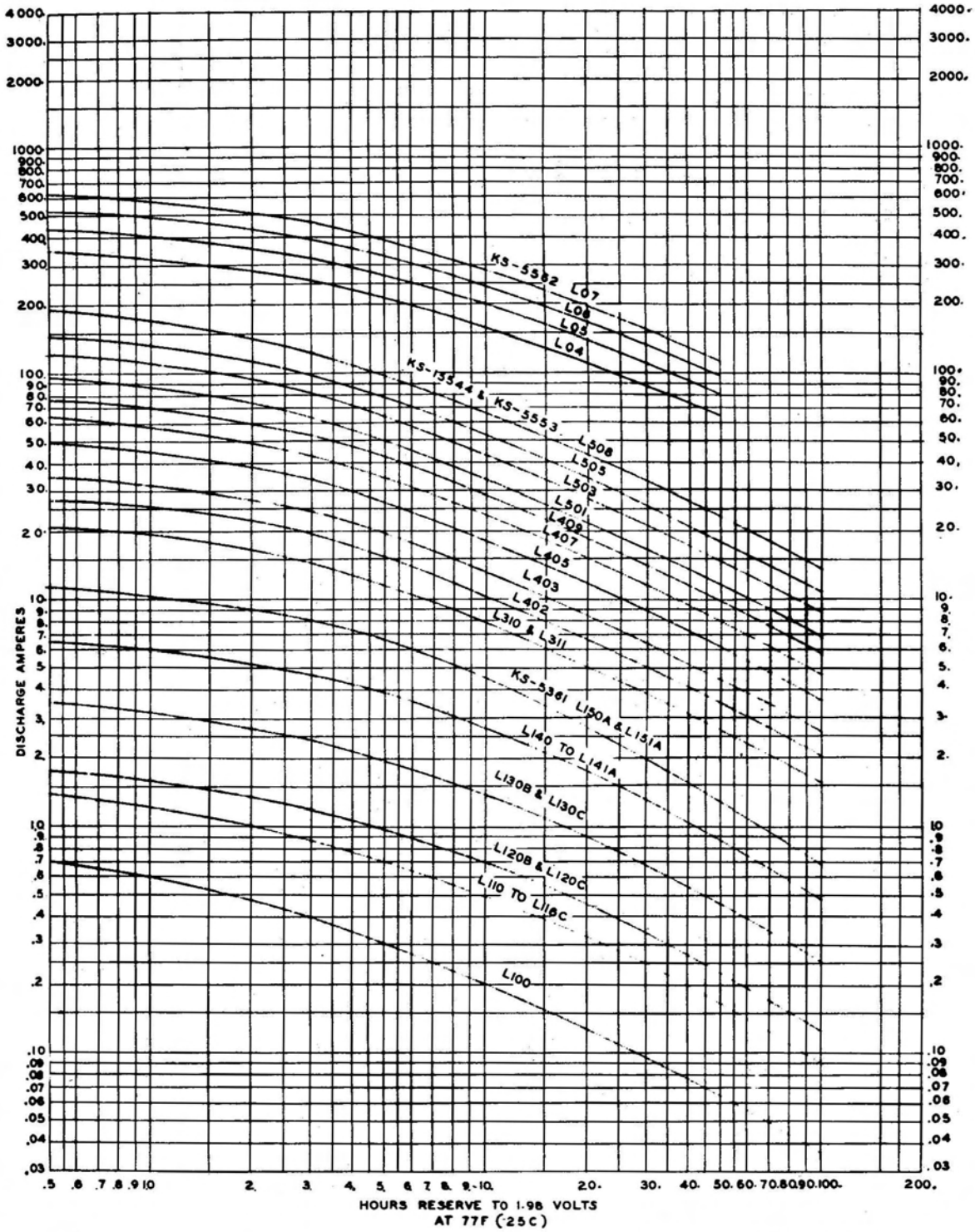
BATTERY DISCHARGE CURVES
TO 1.92 VOLTS PER CELL



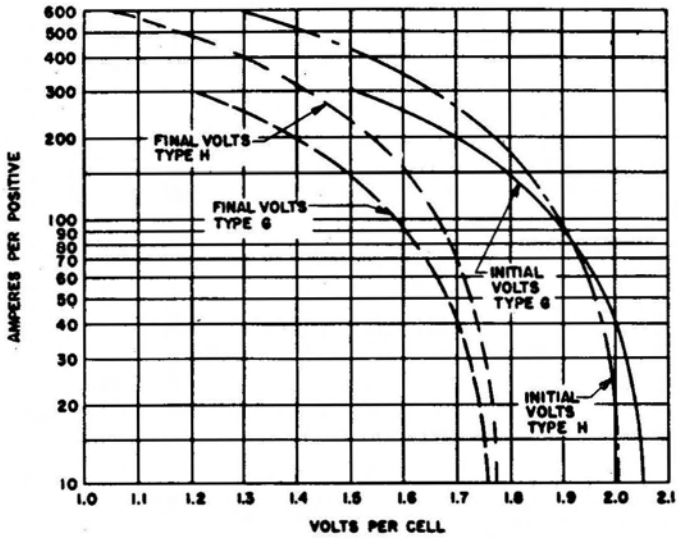
BATTERY DISCHARGE CURVES
TO 1.94 VOLTS PER CELL

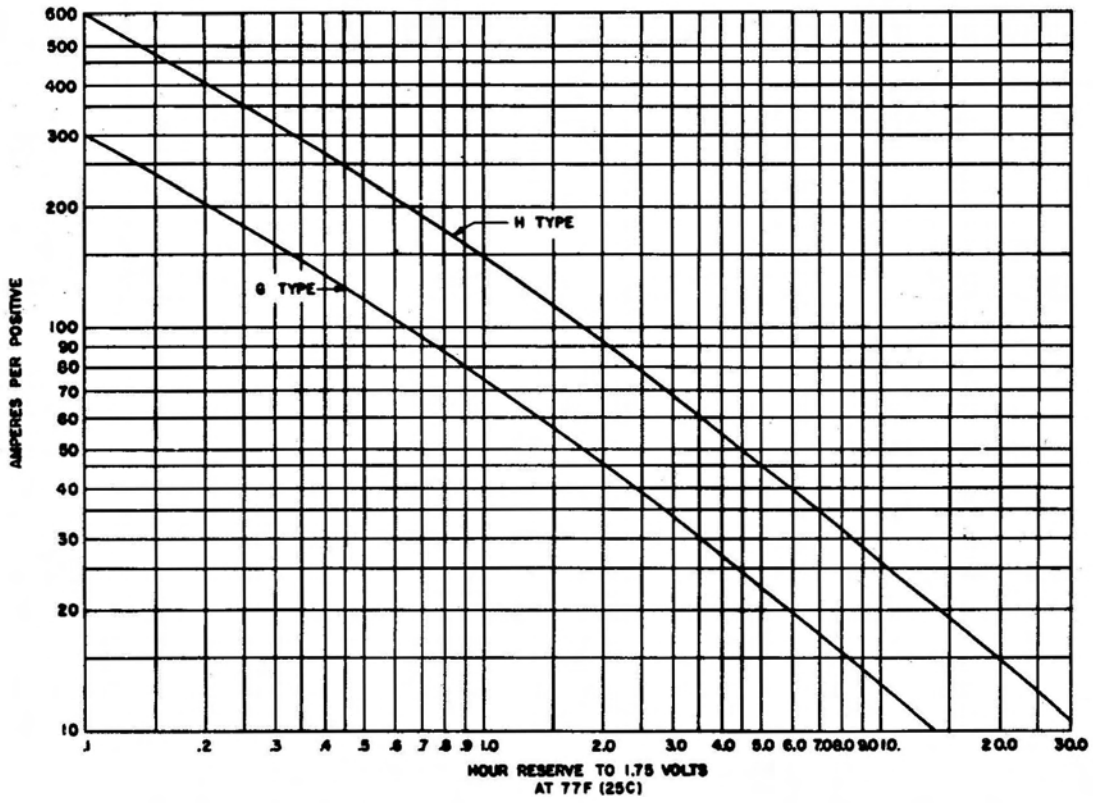


BATTERY DISCHARGE CURVES
TO 1.96 VOLTS PER CELL

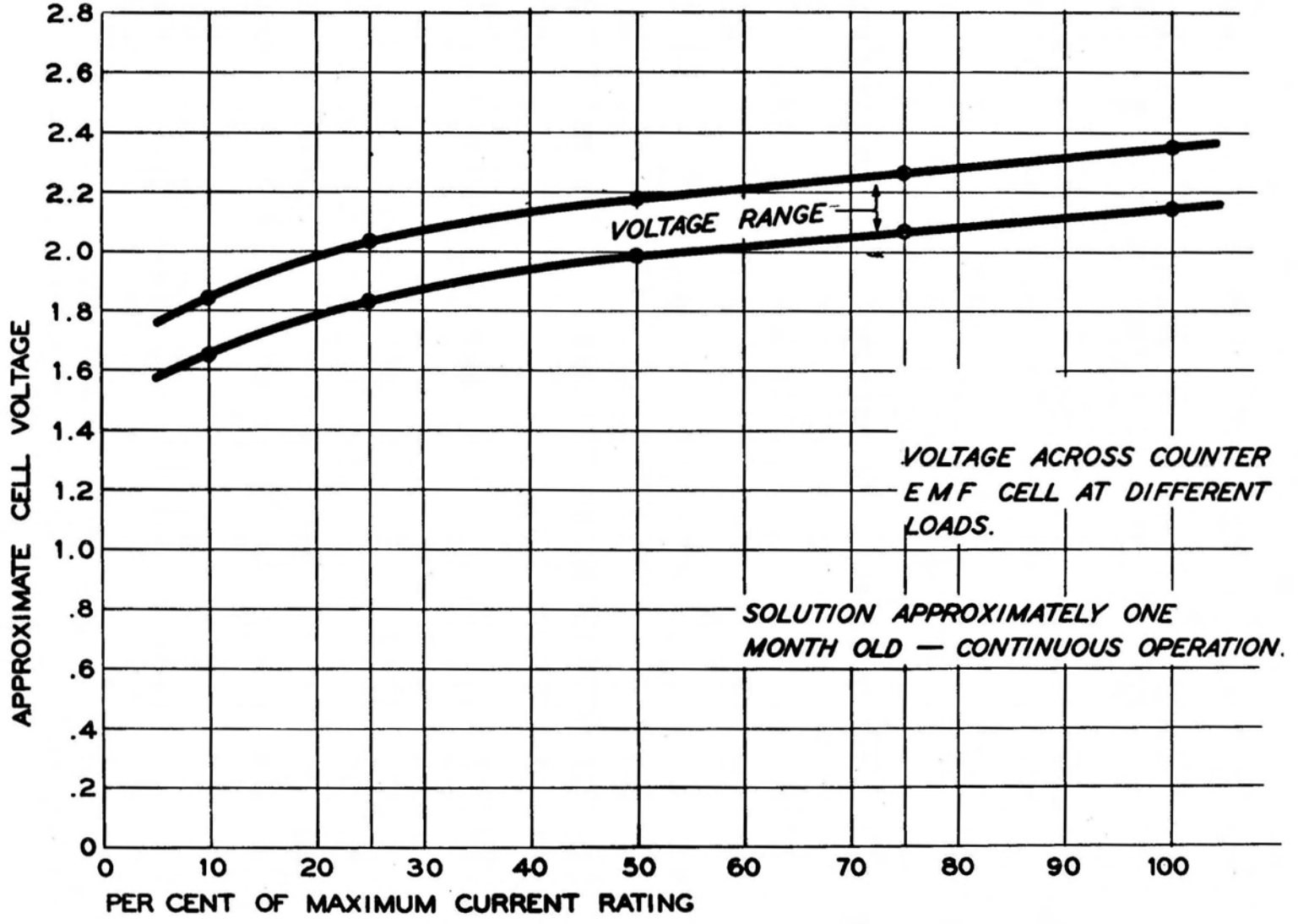


BATTERY DISCHARGE CURVES
TO 1.98 VOLTS PER CELL





PASTED TYPE G & H BATTERIES DISCHARGE CURVES


APPROXIMATE CELL VOLTAGE
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
VOLTAGE RANGE
VOLTAGE ACROSS COUNTER EMF CELL AT DIFFERENT LOADS.
SOLUTION APPROXIMATELY ONE MONTH OLD — CONTINUOUS OPERATION.
0
10
20
30
40
50
60
70
80
90
100
PER CENT OF MAXIMUM CURRENT RATING

WIRING AND CABLE CAPACITIES

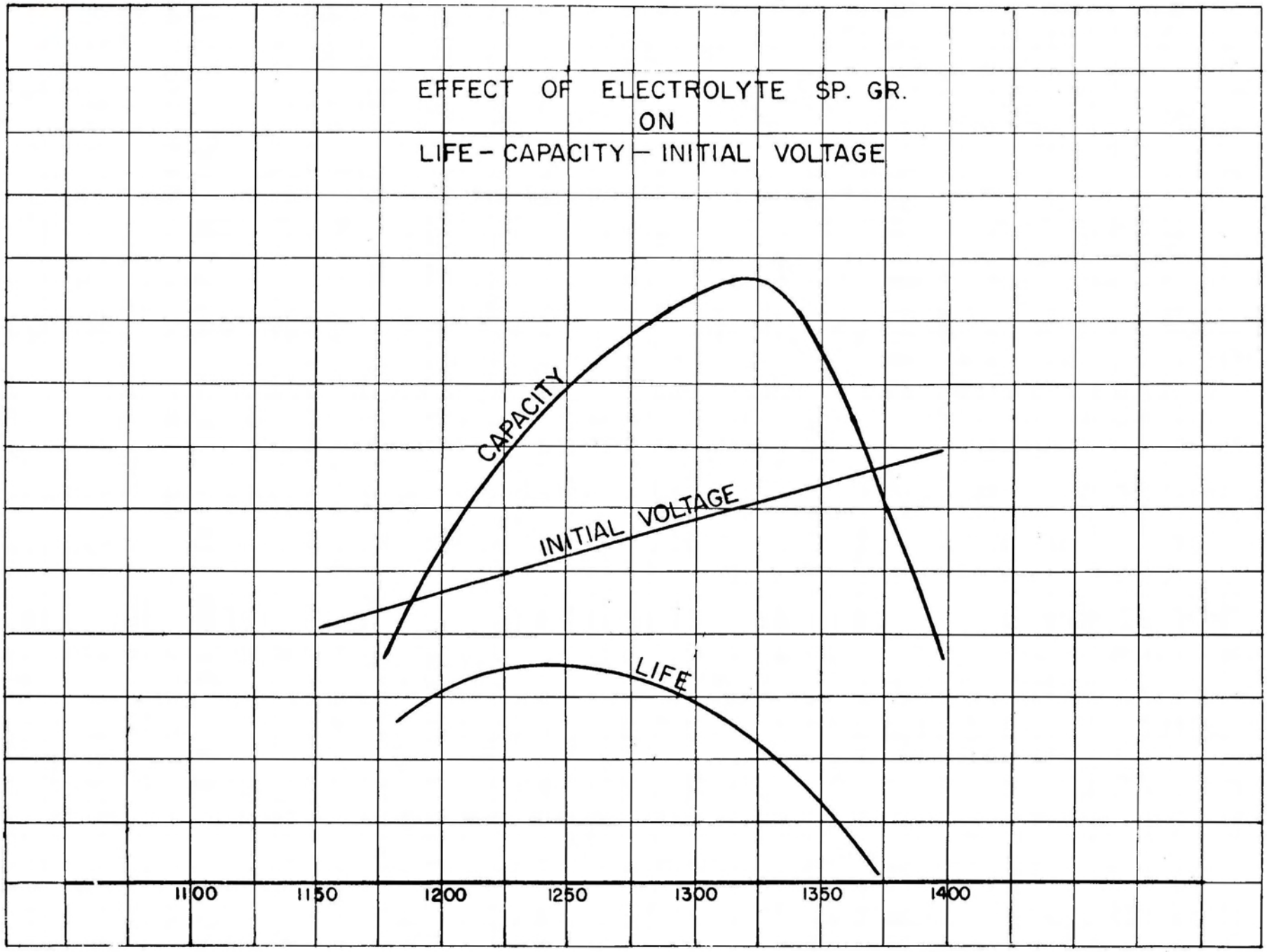
Size Awg No.	Copper Area in Cir. Mils	Amp. Cap'y	Diam. Bare Cond. Inch	DC Resis. 1000 Ft. In Ohms At 25C = 77F	60 Cyc. React. 1000 Ft. In Ohms	Diam. Over Insul.	Bend. Radius Inch Min.	Weight 1000 Ft. Pounds RH	Diam. Over Lead Sheath	Weight 1000 Ft. Pounds Lead Sh.
14	4,107	15	.064	2.68	.056	.19	1/4	26	.25	135
12	6,530	20	.081	1.68	.051	.21	1/2	35	.27	153
10	10,380	30	.102	1.06	.051	.24	1/2	49	.32	260
8	16,510	45	.146	.679	.044	.31	1	84	.38	337
6	26,250	65	.184	.427	.045	.40	1	126	.47	548
4	41,740	85	.232	.269	.045	.45	1	190	.52	655
2	66,370	115	.292	.169	.039	.51	1 1/2	278	.58	770
1	83,690	130	.332	.134	.041	.59	1 1/2	364	.64	930
0	105,500	150	.373	.106	.037	.63	1 1/2	443	.68	1060
2/0	133,100	175	.419	.0842	.040	.68	3 1/2	540	.73	1210
3/0	167,800	200	.470	.0668	.038	.73	3 1/2	663	.78	1370
4/0	211,600	230	.528	.0525	.035	.79	3 1/2	814	.84	1570
	300,000	285	.630	.0374	.035	.93	5	1139	1.00	2270
	400,000	335	.728	.0278	.036	1.03	5	1473	1.10	2720
	500,000	380	.813	.0222	.034	1.12	5	1815	1.19	3160
	600,000	420	.893	.0187	.032	1.23	7	2177	1.33	3980
	700,000	460	.964	.0159	.034	1.30	7	2512	1.40	4420
	800,000	490	1.031	.0139	.033	1.37	7	2848	1.47	4850

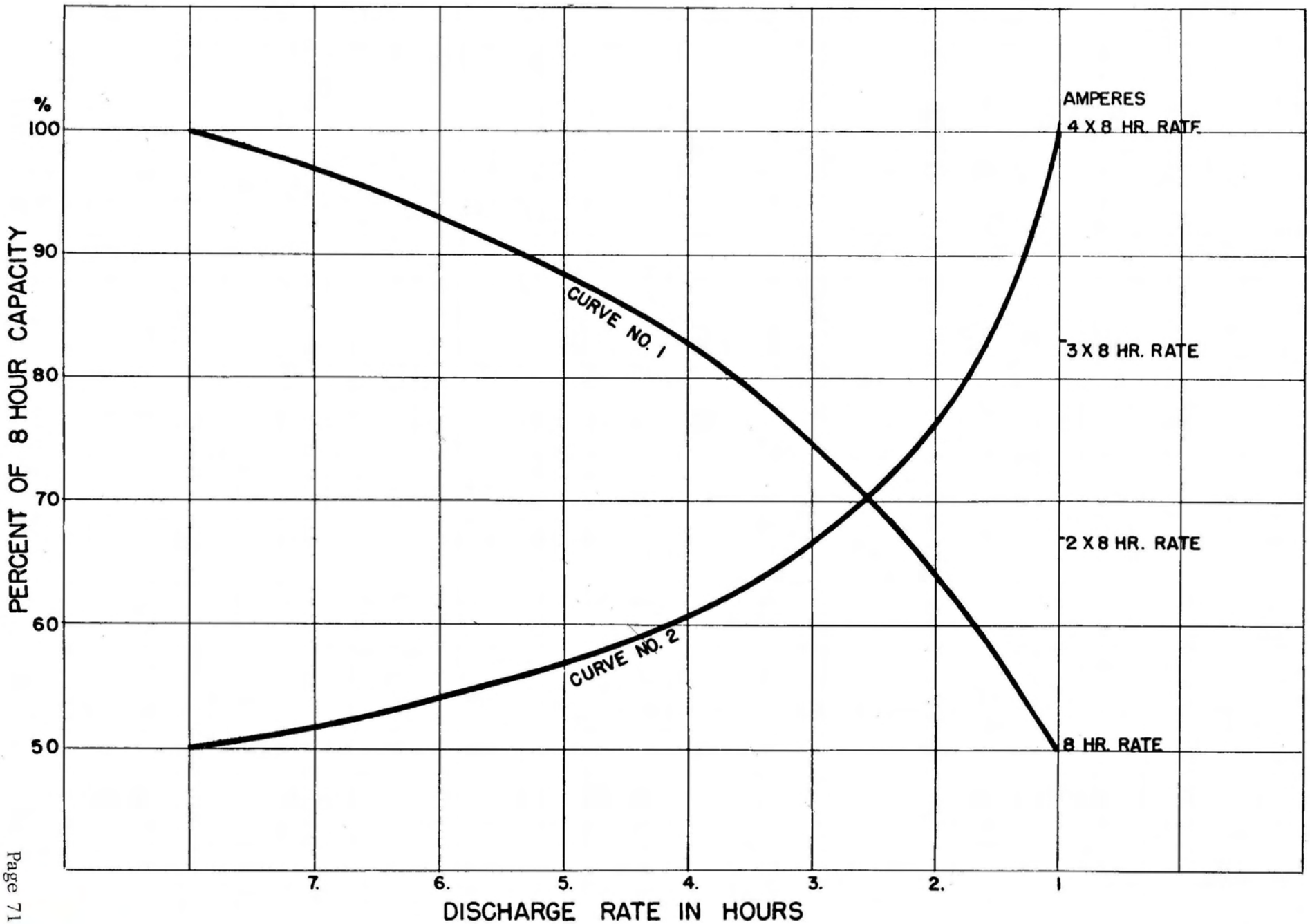
$$\text{Voltage Drop} = \frac{10.8 \times \text{Amps.} \times \text{Feet (Loop)}}{\text{Circular Mils}}$$

CAPACITY FOR COPPER BUS BARS - The capacity of copper bus bar is 1000 amperes per square inch cross sectional area.

TEMPERATURE CONVERSION TABLE
CENTIGRADE TO FAHRENHEIT

C	F	C	F	C	F	C	F
0	32	25	77.0	50	122.2	75	167.0
1	33.8	26	78.8	51	123.8	76	168.8
2	35.6	27	80.6	52	125.6	77	170.6
3	37.4	28	82.4	53	127.4	78	172.4
4	39.2	29	84.2	54	129.2	79	174.2
5	41.0	30	86.0	55	131.0	80	176.0
6	42.8	31	87.8	56	132.8	81	177.8
7	44.9	32	89.6	57	134.6	82	179.6
8	46.4	33	91.4	58	136.4	83	181.4
9	48.2	34	93.2	59	138.2	84	183.2
10	50.0	35	95.0	60	140.0	85	185.0
11	51.8	36	96.8	61	141.8	86	186.8
12	53.6	37	98.6	62	143.6	87	188.6
13	55.4	38	100.4	63	145.4	88	190.4
14	57.2	39	102.2	64	147.2	89	192.2
15	59.0	40	104.0	65	149.0	90	194.0
16	60.8	41	105.8	66	150.8	91	195.8
17	62.6	42	107.6	67	152.6	92	197.6
18	64.4	43	109.4	68	154.4	93	199.4
19	66.2	44	111.2	69	156.2	94	201.2
20	68.0	45	113.0	70	158.0	95	203.0
21	69.8	46	114.8	71	159.8	96	204.8
22	71.6	47	116.6	72	161.6	97	206.6
23	73.4	48	118.4	73	163.4	98	208.4
24	75.2	49	120.2	74	165.2	99	210.2
						100	212.0


EFFECT OF ELECTROLYTE SP. GR.
ON
LIFE - CAPACITY - INITIAL VOLTAGE
CAPACITY
INITIAL VOLTAGE
LIFE
1100
1150
1200
1250
1300
1350
1400



NO JOB IS SO IMPORTANT
AND NO SERVICE IS SO URGENT-
THAT WE CANNOT TAKE TIME
TO PERFORM OUR WORK SAFELY.

BELL SYSTEM

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