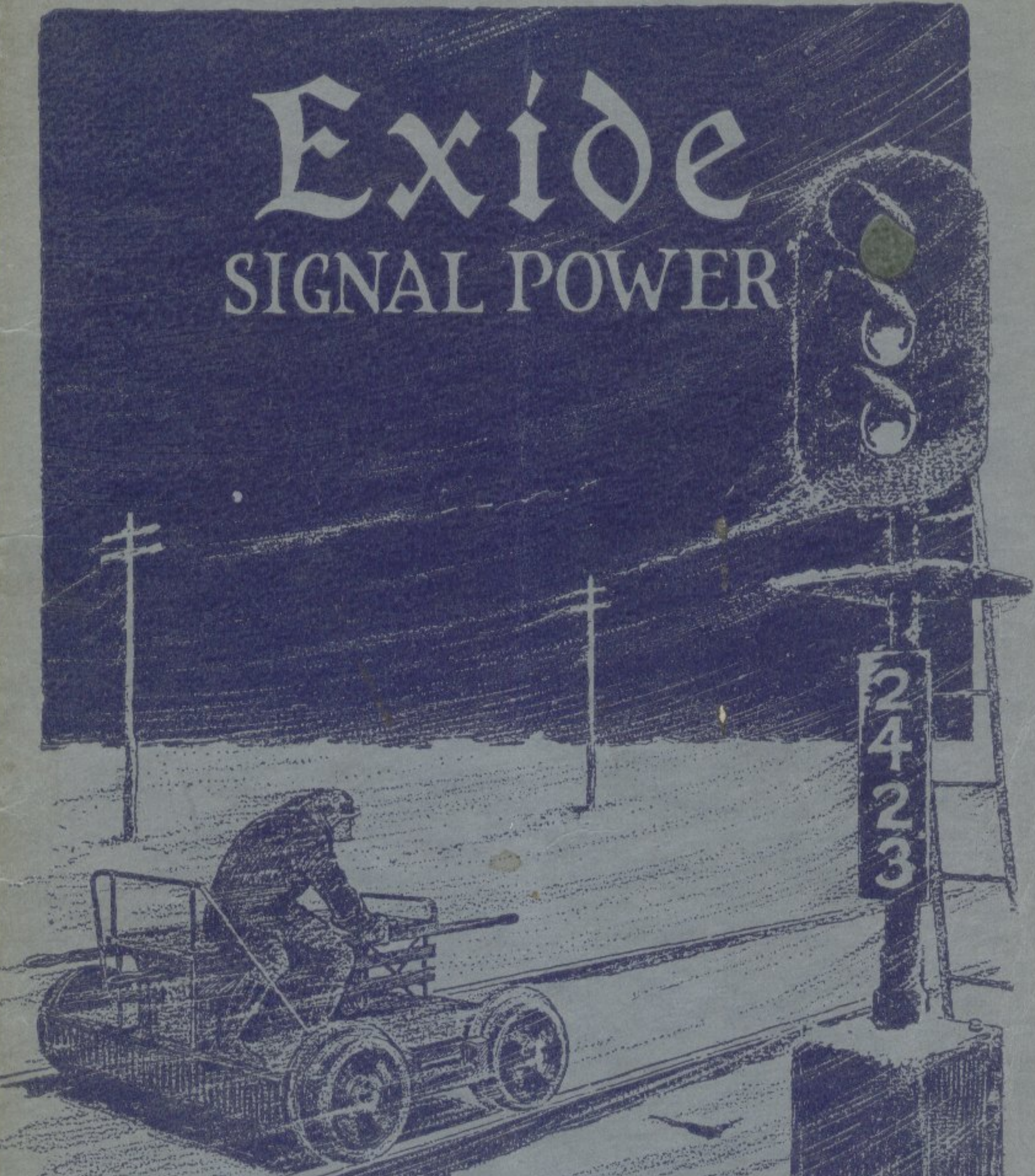
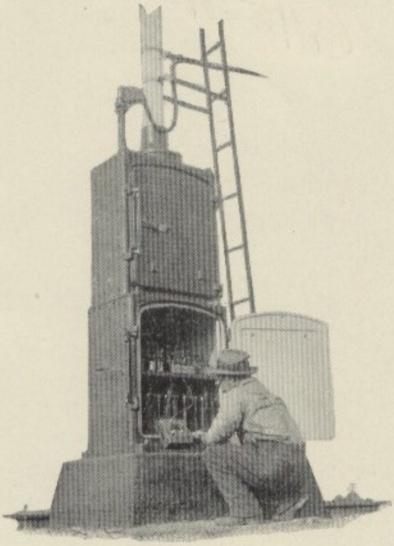
# Exide
## SIGNAL POWER




for the Maintainer

APRIL - 1929



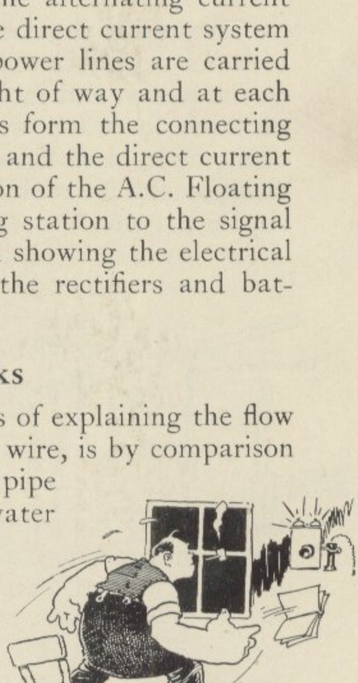
# EXIDE SIGNAL POWER
## for the Maintainer

ELECTRICAL power may be divided into two general classes—alternating current power and direct current power. For the generation and distribution of electrical power to the point of consumption, the alternating current system is the most feasible and economical because this form of power can be changed from one voltage to another by the use of a simple device called a transformer. For power consumption or utilization, the direct current system is usually given the preference due to its greater flexibility in this field.

The A.C. Floating Battery System of Exide Signal Power supply is a combination of the alternating current system of power distribution and the direct current system of power consumption. The A.C. power lines are carried on a pole line along the railroad right of way and at each signal location rectifiers and batteries form the connecting link between the A.C. power supply and the direct current signal circuit. Fig. 1 is a picturization of the A.C. Floating Battery System from the generating station to the signal and Fig. 2 is an elementary diagram showing the electrical relations between the A.C. power, the rectifiers and batteries, and the D.C. signal circuits.

### How It Works

One of the most popular methods of explaining the flow of electrical power in a conductor or wire, is by comparison or analogy to the flow of water in a pipe line, wherein the pressure of the water column is compared to the pressure or voltage of the electrical circuit and the amount of water that flows through the pipe is compared to the flow of current or amperes in the electrical conductor. This hydraulic similarity or analogy



can be applied to explain the principle and maintenance of the A.C. Floating Battery.

Fig. 3 is a simple water supply plant or system and consists of a boiler (B), a pump (P), a well or water supply (W), a storage tank (T) and valves at (IF) and (NF) where water is drawn off or used. Let us assume that it is to supply water for a manufacturing plant and that the plant operates twenty-four hours a day, and every day in the year, as does the railway signal system. Also, that in the manufacturing process a small steady stream or supply of water is required at all times and in addition there is a demand for an increased amount over short periods from time to time each day, in other words, there is both a continuous and an intermittent consumption of water, the continuous flow being controlled by the valve at NF and the intermittent at IF.

To protect the manufacturing process against a failure of water supply in case of a breakdown in the boiler room or the pump, and in order to meet the heavy intermittent demands for water without a sudden change in the speed of the pump each time the intermittent valve is opened and closed, a storage tank becomes a necessary part of the water supply system.

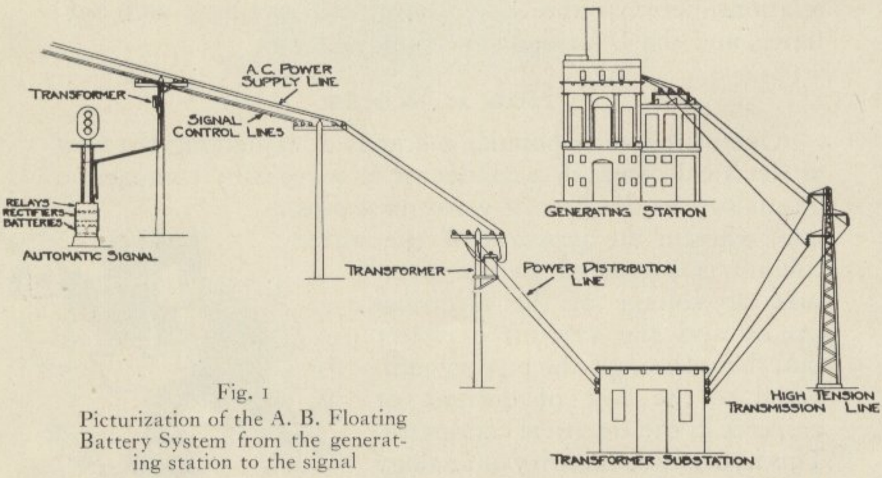



Fig. 1
Picturization of the A. B. Floating Battery System from the generating station to the signal

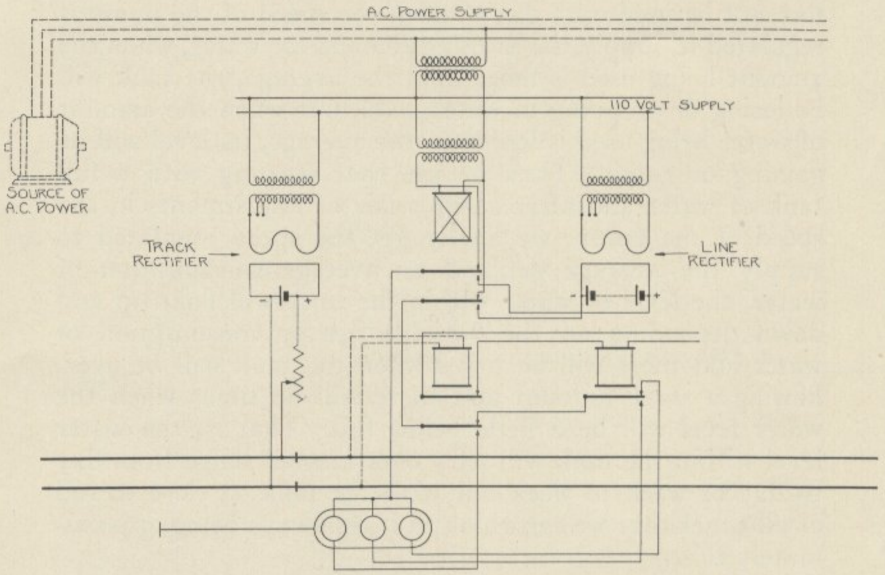


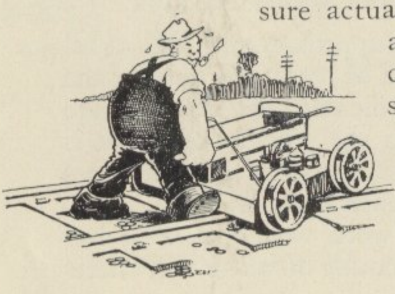

Fig. 2. Elementary Diagram

The best and most economical way of operating this water supply plant is to regulate the speed of the pump so that the tank will be kept approximately full at all times, but without an excessive overflow of water from the tank. As a guide in adjusting the speed of the pump, there is an overflow pipe at the top of the tank and if the operator sees that there is a continual overflow or waste of water he will know that the speed of the pump is too high; also there is a pressure gauge calibrated in feet or level of the water in the tank and the operator can note the pressure gauge at any time and know the level of water within the tank.

In order to maintain the tank approximately full at all times, the speed of the pump would be regulated to meet the average demand for water as indicated by the pressure gauge. As on any railroad system the amount of traffic is not the same each day and the signal system therefore does not do the same amount of work each day, so in the manufacturing process the amount of work varies more or less from day to day and the same amount of water will therefore not be used each day; and if the speed of the pump is regulated to supply the average demand for water, when the amount being used is more than the average, the tank will be losing or dropping in water level, but when the amount of water being used is less than the average, its level will be gaining or rising. Thus we see that starting with a full tank of water and after a few trials or adjustments in the speed of the pump, we finally get the speed regulated to supply the average demand or average consumption of water, the level of water within the tank will float up and down depending on the variable use or consumption of water and there will be times when the tank will be overflowing a small amount and there will be times when the water level will be a little below full. That is, the water level within the tank will vary over a small range from day to day or week to week but with the tank so close to full at all times that we can think of it as always being approximately full.

We have introduced and discussed the principles and maintenance of the water supply plant, because in its construction and operation it is something we can easily and fully understand as we are enabled to see the whole operation with our eyes. The principles and maintenance of the A.C. Floating System of Signal Power Supply are practically the same as the water supply plant and a thorough consideration of what has been said about the water supply plant will help us to gain a better understanding or visualization of the A.C. Floating Battery System, just what it is and how it should be maintained.

In this water supply plant the water and the steam pressure actuating the pump corresponds to the alternating current power; the pump corresponds to the rectifier; the storage tank to the storage battery; the steady stream or flow of water at NF to the steady or normal load on the signal system, such as the relays, the hold clear current of a semaphore signal,



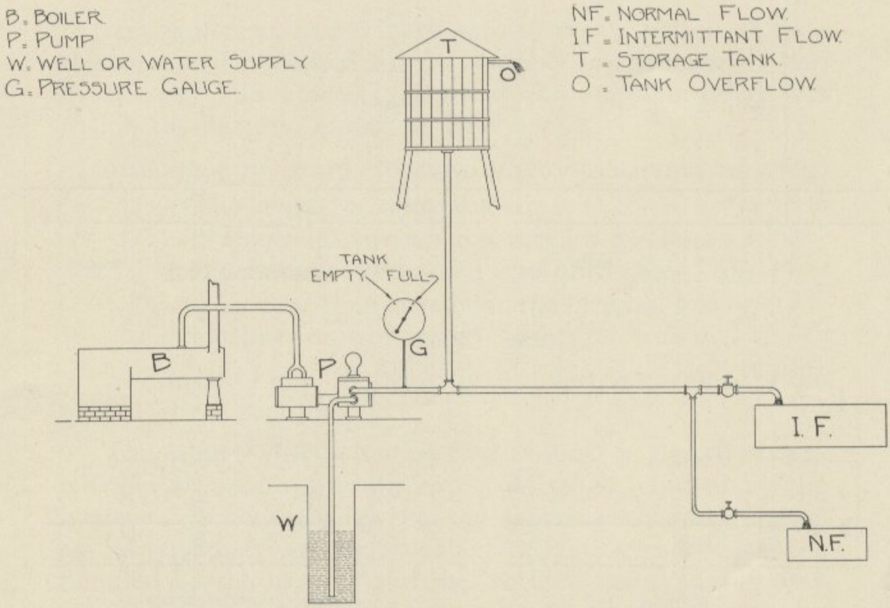



Fig. 3. Hydraulic Analogy of the A. C. Floating Battery System

the output to a track circuit (unoccupied), or the signal light current where it is continuously lighted with direct current. The intermittent discharge or supply of water at IF corresponds to the intermittent load or discharge on the signal system such as the extra discharge to a track circuit while it is occupied by a train, the motor current of the semaphore motor clearing a signal, or the signal light current in approach lighting. The loss of water in the operation of the plant due to leakage and evaporation corresponds to the internal loss or local action within the storage cell or battery.

## Rectifier Output

Figure 4 shows a rectifier and battery connected into a track and a signal circuit. Assuming that all adjustments are O. K., that is that the output of each rectifier is just what it should be, we will discuss these two circuits and see where the total output or current from each rectifier is going.

In the unoccupied track circuit the rectifier is furnishing

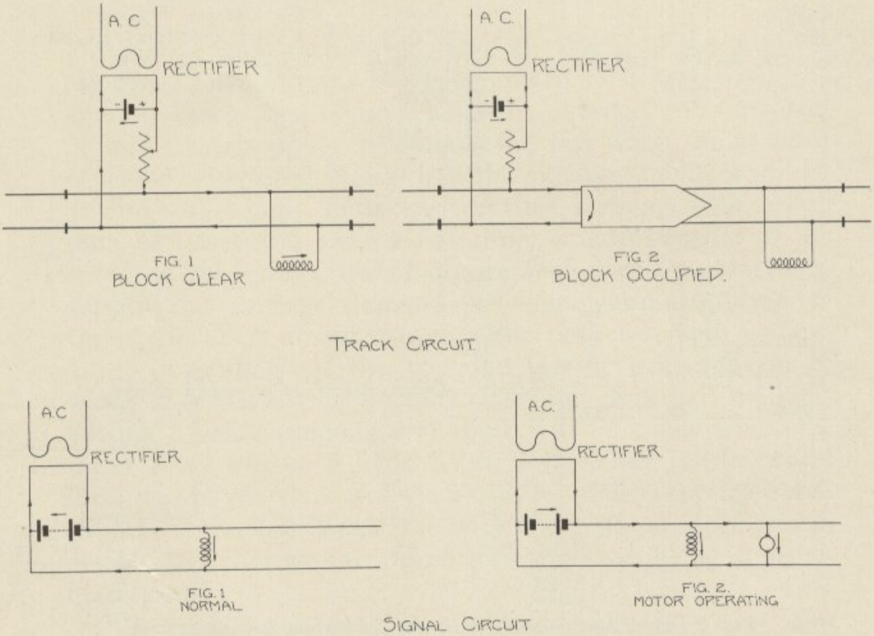



Fig. 4. Diagrammatic Explanation of Rectifier Output

the steady or normal output to the track circuit, and the rectifier is also sending some current to the battery. In other words, the battery is on charge. When a train occupies the circuit, the battery discharges to furnish most of the extra current drawn by the train, acting as a shunt across the rails, that is, when the circuit is occupied the battery is discharging.

In the signal circuit as shown, the rectifier supplies the steady or normal load and is also charging the battery when there are no signal movements. When an intermittent load, such as motor, or an approach-light is connected across the circuit, the battery discharges to drive the motor or light the lamp. Thus we see that in any signal system using a motor or approach lighted signals and in track circuits, there are intermittent loads requiring intermittent currents or discharges from the battery, and we also know that to keep the battery approximately fully charged at all times, the rectifier must supply a charging current to the battery sufficient to put back into it over a period of time the amount discharged by the battery intermittently, and in addition, an amount to equal the small internal loss within the battery, known as local action.

Summing up, there are three different currents required:

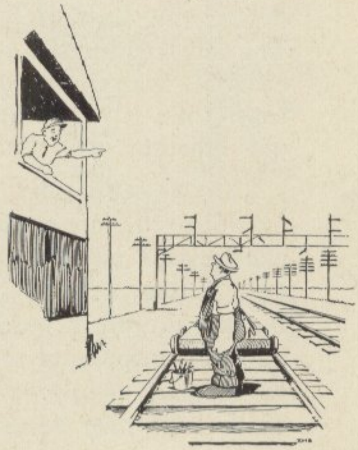
(1) The steady or normal load.
(2) A charging current to return to the battery the amount discharged intermittently.
(3) A current to make up for the internal loss or local action within the battery.

The total or sum of these three different currents is the output of the rectifier.

The above discussion is based upon a signal system wherein there are intermittent loads to be handled by the battery. In continuously lighted signals employing power-off relays, there are no so-called intermittent loads to be handled by the battery and the rectifier has to supply only (1) and (3) of the three currents mentioned above; namely, the steady or normal load and the local action of the battery, the battery in this case being practically "stand-by" or "emergency" power.

## Adjusting the Floating Rate

As in the water supply plant the speed of the pump is regulated to meet the average demand for water and the water level in the tank rises and falls, but with the tank approximately full at all times, so in the A. C. Floating Battery System the output of the rectifier is adjusted to meet the average demand for power and the amount of charge within the battery varies up and down, but with the battery approximately fully charged at all times, and without an excessive amount of overcharge or waste of power.



QUESTION: Assuming that an A. C. Floating Battery installation has just been made, at what current rate or output should the rectifier be set?

DISCUSSION: First of all, inasmuch as it is a new installation, the rectifier should be set at its safe maximum rate in order to rapidly fully charge the battery (for we should never attempt to start floating a partially discharged battery). After the battery is fully charged then we are ready to start "floating."

As has been pointed out above, the rectifier must supply the steady or normal load plus current to make up for the intermittent load if there is any, and an additional small amount to make up for the local action of the battery. Now if we knew what each of these currents were we could add them together and their sum would be what we would adjust the rectifier for. We can measure the steady or normal load with an ammeter. We do not know how much the local action is; that will depend upon the type, size and temperature of the battery. Neither do we know the current rate necessary for the intermittent load. So, it is seen that there is no way of knowing at first just what rectifier output is required. The correct adjustment or setting of the rectifier can be found by trial, that is, by gradually reducing the rectifier output from time to time until the voltage at the battery terminals indicates that the adjustment of the rectifier is correct.

ANSWER: In any new installation, adjust the rectifier output to the safe maximum rating of the rectifier and do not change this adjustment until the battery is fully charged (the battery is fully charged when the voltage reaches a maximum and in order to determine this read the voltage and put it down on the record sheet. When two readings a week apart of approximately the same value are obtained, the battery may be considered fully charged). Then at convenient intervals reduce the output of the rectifier in safe steps until the voltage directly at the battery terminals averages 2.15 per cell and generally ranges between 2.10 and 2.20 volts per cell.

In the A. C. Floating Battery System the voltmeter corresponds to the pressure gauge in the water supply system and is the most satisfactory way of checking the floating rate, upon the assumption that the meter is reading correctly or that its error is known and is allowed for. Gassing of the electrolyte corresponds to the overflow of the water tank, and the maintainer after a little practice and experience, can note the amount of gassing and tell whether the floating rate is insufficient or excessive. When the floating is about correct, a slow stream of gas bubbles will be seen rising from the top corners of the outside negative plates and the positive plates will be dark brown in color. Large bubbles gathering and breaking at the surface of the electrolyte, indicate that the floating rate is too high.

It has been found through a number of years of experience that if the voltage maintained at the battery terminals averages about 2.15 volts per cell, the floating rate is correct. The voltage should not be continually below 2.10 volts per cell or continually above 2.20 volts per cell, or 10.5 to 11.0 volts for a five cell battery. There may be variations in the A. C. line voltage and traffic conditions that will cause variations in the voltage at the battery terminals. During periods of low A. C. voltage and heavy traffic, the voltage at the battery terminals will fall below 2.10 volts per cell, and during periods of high line voltage and light traffic the battery voltage may rise above 2.20 volts per cell. These variations do not interfere with proper and correct floating, because the rectifier is adjusted for average conditions and the battery will be maintained in an approximately fully charged state.

Do not be too hasty in adjusting or changing the output of the rectifier. If after a few checks at each location, the voltage continues to be above 2.20 volts, then reduce the rectifier output a little. On the other hand, if the checks show the voltage to be below 2.10 volts each time, then the rectifier output must be increased a small amount. When checking a location take into account the traffic just prior to the check, also other conditions that would affect the voltage at the battery terminals, such as a failure in the A. C. supply. Try to maintain an average of 2.15 volts per cell. Thus if the record card shows that the voltage of a battery on several successive checks has been between 2.10 and 2.13, this of course, is lower than the average of 2.15 and the output of the rectifier should be slightly increased.

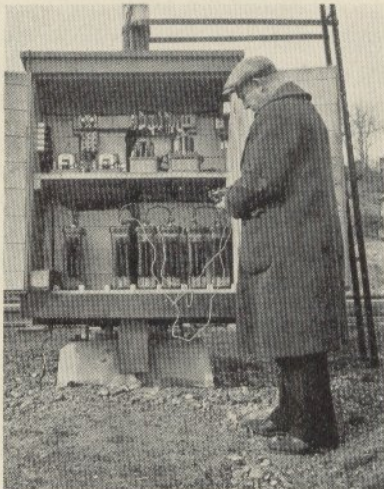
In general the operation of automatic block signals causes very slight variation in voltage at the battery terminals from day to day and once the rectifier is adjusted for an average of 2.15 volts per cell, the voltage at each inspection will generally be found to be between 2.10 and 2.20 volts. This is particularly true of the continuously lighted light signal because there are no intermittent loads on the battery tending to cause the voltage at the battery terminals to vary from day to day.

## Four Ways of Checking the Sealed Glass Jar Battery

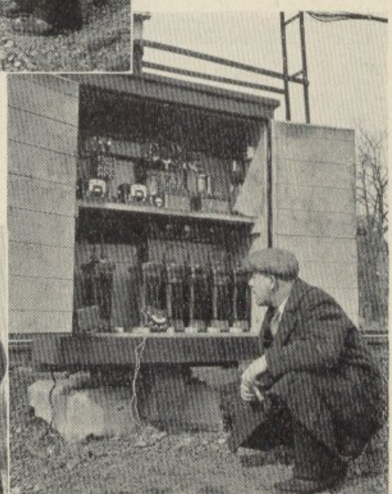
The sealed glass jar type of construction permits a visual inspection of the internal condition of the cell or battery and therefore furnishes two additional easy simple checks upon the state of charge and the floating rate. In all there are four ways of checking the sealed glass jar type of storage battery.

1. By taking voltage readings.
2. By visual inspection:
   (a) Noting the amount of gassing.
   (b) Noting the color of Plates.
3. By taking specific gravity readings.

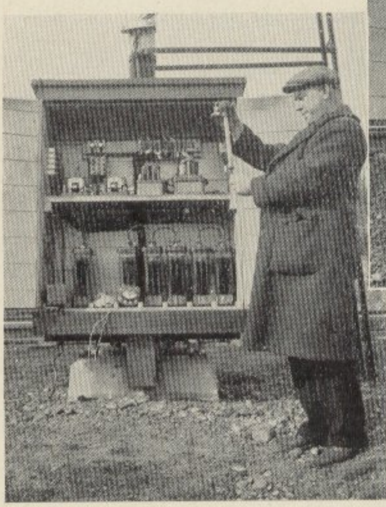
One example will illustrate the use of all four methods: On one occasion an inspection was made of a 5-cell battery



1. Taking Voltage Readings



2. Visual Inspection
   (*a*) Noting amount of gassing
   (*b*) Noting color of plates



3. Taking Specific Gravity Readings

It is easy to determine the state of charge of Exide Batteries in the A. C. Floating Battery System

housed in the same case with the relays. On opening the door it was readily seen that the battery was "off color," the color of the positives being a light instead of a dark brown. A voltage reading was taken and showed 1.95 to 1.97 volts per cell and there was no sign whatever of gassing. The specific gravity of the electrolyte was from 1.135 to 1.145. Taking into consideration the service in which the battery was used, any one of these checks would alone indicate that the floating was not right, but with the four checks all pointing to the battery being in a low state of charge, there was no question of this being so.

## Specific Gravity

As long as the proper average floating voltage is maintained, the battery will be kept in a fully charged condition. However, if at any time there is any doubt about this, a specific gravity reading will serve as an additional check.

## Special Installations

In some special installations, such as highway crossing signals, located near yards or stations where trains stand on the circuit over long periods of time, the voltage at the battery terminals may vary over wide limits. A train may occupy the circuit a sufficient length of time to lower the battery voltage to say 2.00 volts per cell or even lower. At other times when the circuit is occupied very little, the voltage at the battery terminals may rise as high as 2.30 volts or higher. In such installations it is not possible to keep the voltage at the battery terminals between 2.10 and 2.20 volts per cell at all times—neither is it necessary.

Strike a setting of the rectifier that will maintain the battery at an average of about 2.15 volts per cell. A single inspection or check on the voltage does not tell the true story. It is the average of several checks taken over a period of time which gives the true floating voltage.

## Battery Record Card

Too much cannot be said in favor of keeping a record card at each battery installation and recording thereon at regular intervals whatever readings are taken by the main-

**BATTERY RECORD CARD**
**A. C. FLOATING BATTERY SYSTEM**

Railroad ______________ Location No. ______________ Used for ______________

Type & Size of Battery ______________ Date Installed ______________

Rectifier: Type ______________ Serial No. ______________ Date Installed ______________

| Year 19____ Date | Individual Cell Voltages Cells | | | | | | Rectifier* Output in Milliamperes | | Quantity Water Added | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | Found | Left | | |
| | | | | | | | | | | |

* Measure and record rectifier output only before and after any change in the adjustment is required, either increasing or decreasing the output. Cell voltages should be recorded before making any change in the rectifier.

Exide
BATTERIES

THE ELECTRIC STORAGE BATTERY CO.
PHILADELPHIA, PA.

Printed in U.S.A.

Form 5155—J 346—5-'29—15M

Fig. 5. Battery Record Card

tainer as a part of his routine inspection. Figure 5 shows a battery record card that is being furnished by The Electric Storage Battery Company. This record card has columns for date of inspection, individual cell voltages, rectifier output, quantity of water used, and a remarks column wherein the maintainer may record any additional readings or information thought desirable. The card is printed on both sides, and is ruled for fifty-two lines. When one of these cards is filled out on both sides, there is a complete record that can be gone over and studied with considerable benefit to all concerned. This card is not only valuable as a record but is a great help and assistance in maintenance. In fact, it has been proved in actual practice that better maintenance and consequently the most reliable service can be obtained with the use and aid of some suitable form of record card.

## Cleanliness

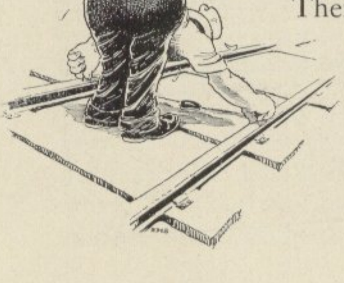
Keep the battery and its surroundings clean and dry.

If the glass jars are kept clean by wiping them off as often as is found necessary to do so, the visual inspection can be more quickly and easily made.

A clean battery and clean compartment indicates good maintenance.

## Voltmeters

There is hardly any other branch of service wherein the voltmeter is put to a more severe test than in railway signal maintenance; and for this reason all possible precautions should be exercised in their care and handling and the maintaining of their accuracy.



There should be a box or compartment on the motor car especially adapted for holding the meter. The compartment should be lined with some form of padding or shock absorbing material to protect the meter against vibration and shocks from the motor car.

In order to keep the voltmeter in calibration or know how much it is off and therefore how much allowance to make for the error in the meter when taking readings, the maintainer should from time to time check his meter with those in the adjoining sections as well as with the signal supervisor's and signal inspector's instruments. One of the most frequent abuses to a volt-ammeter is that of thoughtlessly taking a reading with the meter leads connected to the wrong scale; for instance, placing the 3-volt scale across a circuit of considerably higher voltage. The milliammeter coil is often burned out by unintentionally connecting it across the circuit. Strict care should be taken to make sure the leads are connected to the proper scale before attempting to take a reading.

## Suggestions for Installing the Battery

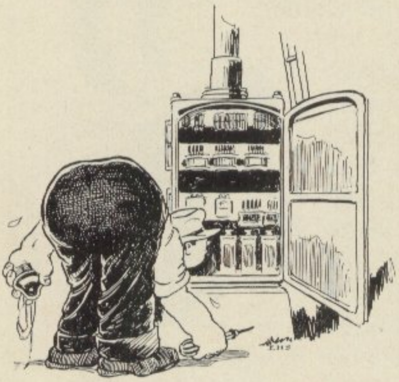
1. Before making up the battery terminal connections all surfaces which are to be bolted together should be scraped bright, and then coated with pure vaseline. Vaseline also should be applied to the studs of the bolt connectors, and after making up connections wipe off surplus vaseline that squeezes out.

2. Arrange cells so that the positive terminal of one cell adjoins the negative of the next. The top of cover adjacent to positive is marked "POS" for positive, and the top of cover adjacent to negative terminal is marked "NEG," or the positive terminal is painted red and the negative terminal painted black.

3. After applying vaseline to the bolts and studs connect the cells together with the flexible rubber covered intercell connectors furnished with the battery. Bolt the connectors to the cell terminals, with the lug under the head of the bolt and not under the nut, so as to avoid twisting.

4. Covers of cells should be separated from each other

and from contact with sides of battery shelter and cells held in place by cleats between the cells and along the ends and sides of the rows to prevent the cells from moving along the shelf or floor of the battery shelter.



5. Arrange connections so that the positive terminal of the rectifier or charging source will connect with the positive terminal of the battery, and negative of charging source to negative of battery.

6. After all connections are completed, check over each one to make sure the polarity is correct, or preferably take a voltmeter reading of each cell starting from the positive end of the battery to determine that the positive terminal of each cell is connected to negative terminal of adjoining cell.

7. When the power is turned on, adjust the rectifier output to the safe maximum rating of the rectifier. This adjustment should not be disturbed until the voltage of the battery will not rise any further.

## Suggestions for Maintaining Batteries

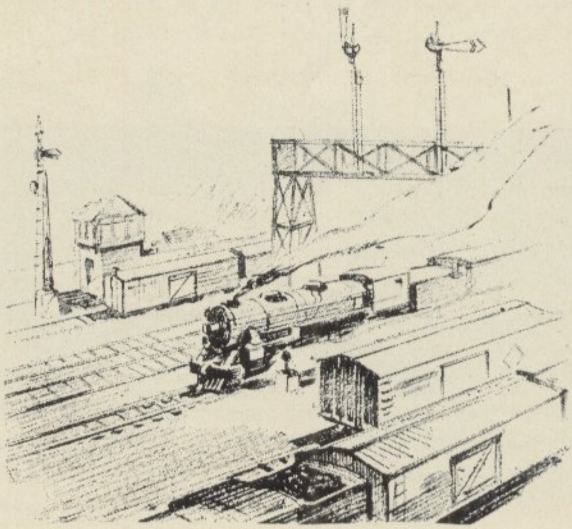
1. Maintainers taking over a new installation should determine that the rectifiers are set at a safe maximum, record the signal location on the battery record forms furnished, and without making any adjustment of the rectifier output, record individual cell voltages until two or three consecutive voltage readings taken at least a week apart are of the same value. At convenient intervals thereafter reduce the output of the rectifier in safe steps until the voltage directly at the battery terminals generally stays between 2.10 and 2.20 volts per cell. The voltage may vary below or above these limits according to traffic conditions, power interruptions, etc., but should not be continually downward or upward. The proper average is 2.15 volts per cell.

2. It is essential that the voltmeter used be kept in calibration, because an unknown error is more than likely to have considerable effect on the efficient and economical operation of the system.

3. As a check on the accuracy of a voltmeter, if the battery is floating approximately correct, a slow stream of gas bubbles will be noted rising from the top corners of the outside negative plates, but large bubbles will not be gathering and breaking at the surface of the electrolyte, and the positive plates will be dark brown in color.

4. Do not make too frequent adjustments of rectifier outputs. Strike an average that will maintain reasonable voltage, and only check from time to time. It is not necessary to take a reading of the output of the rectifier, except in case of adjustments.

5. Always keep the separators covered with solution. Use pure water only for replacing evaporation. It should only be necessary, if floating properly, to add water twice a year—in the early fall and in the spring—and this will avoid the danger of water freezing in cold weather. If water must be added during freezing weather, use a syringe



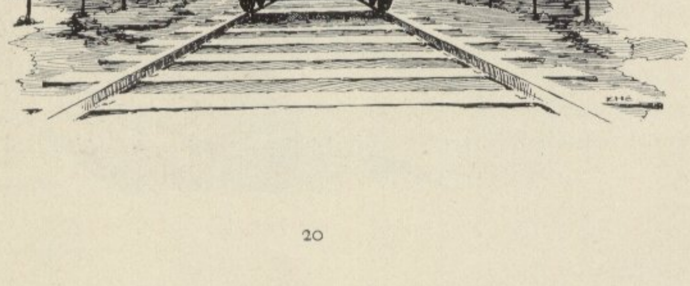
to stir up the entire solution so as to mix in the water and prevent freezing. When water is added bring the level up to the level line on the side of the jar only.

6. Never add electrolyte or acid unless some should become spilled and then only on instructions from your signal supervisor.

7. In case a battery should become discharged to any great extent because of a power failure, or for some other reason, increase the output of the rectifier to the safe maximum rating in order to get the battery back to full charge as quickly as possible.

Note.—Before increasing the output of the rectifier, take an ammeter reading of the rectifier output and write it on the record card so that when the battery reaches full charge the ammeter can again be used and the output of the rectifier reduced to its original or proper floating rate.

8. Keep the battery and its surroundings clean and dry.



# The Storage Battery
# What It Is and How It Works

## Types of Batteries

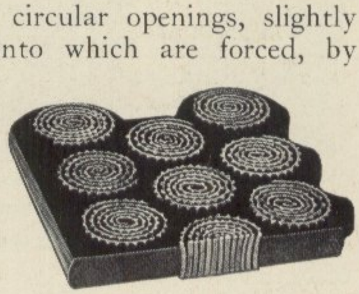
There are three types of lead storage batteries in commercial use: (1) the Plante or formed plate type, (2) the Faure or pasted plate type, and (3) the Exide-Ironclad type. Each of these types of batteries is used in Railway Signal Service.

The well-known Chloride Accumulator, with the Manchester positive and the Box negative, is an example of the first type.

In the Manchester positive plate the grid is a cast lead-antimony alloy, which possesses two important characteristics: First, unlike pure lead, this alloy resists the "forming" action of the electric current during charge and discharge, and therefore retains its strength, shape and dimensions. The Manchester grid is, therefore, permanent throughout the entire life of the plate, thus providing the necessary support for the active material and the necessary conducting metal for carrying the current to and from all parts of the plate during charge and discharge.

Second, this alloy is far more rigid than pure lead, and therefore, resists the mechanical strains which occur and retains its original shape without growth or buckling.

The grid is provided with circular openings, slightly tapering toward the center, into which are forced, by hydraulic pressure, the rosettes or buttons of soft lead which constitute the active portion of the plate. These buttons are formed of strips of pure lead, corrugated crosswise and rolled into a spiral. After



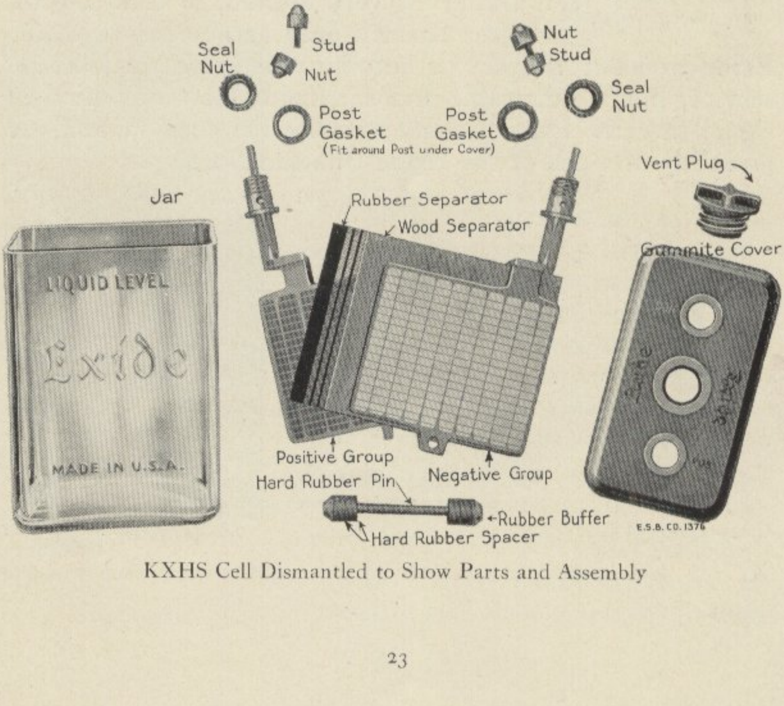
being forced into place in the grid they are subjected to the "forming" process, whereby the active material or lead-peroxide is developed electro-chemically on the transverse surfaces. The expansive action of this forming process, combined with the "hour-glass" shape of the openings, securely locks the buttons in place.

The fact that there is always available a supply of solid lead in the rosettes or buttons that can be converted into active material (lead peroxide) as it is needed, accounts for the extreme ruggedness and long life of this type of positive plate. On page 21 is shown the Manchester button and a section of the Manchester positive plate; and on page 22 a cell of the closed glass jar type DMGO and EMGO batteries as designed for Railway Signal Service. These DMGO and EMGO batteries are entirely sealed, except for a small opening in the vent plug to allow the gas (but not the electrolyte) to escape. They are entirely suited for any kind of stationary service, whether the work be heavy or light, whether they are "floated" or "cycle charged"; for low voltage switch machines, automatic signals, or telephone or telegraph service, etc.


Cell of
DMGO Signal Battery

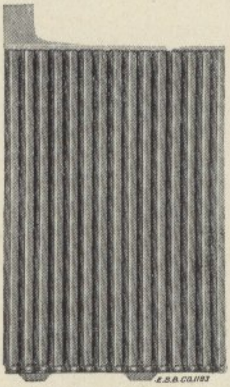
The second type, or pasted plate, gets its name from the fact that the active material is worked or mixed to the consistency of a paste or mortar and is pasted or rubbed into a latticework supporting frame of alloy called the "grid." When the factory charge is given, the active material or paste of the positive plate is converted into lead peroxide. Page 23, showing the parts and assembly of the KXHS Exide cell, is an example of the pasted plate type of battery.


Cell of KXHS Signal Battery




KXHS Cell Dismantled to Show Parts and Assembly

Another type of battery which is neither a formed nor a pasted plate type, but which partakes of the ruggedness and long life of the formed or Plante type of battery, is the Exide-Ironclad Battery.

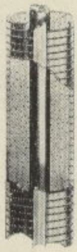


Exide-Ironclad Positive Plate

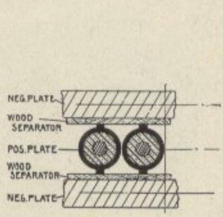
Notice the slotted rubber tubes which contain the active material; also the two feet which raise the plate above the supporting ribs

The positive plates of the Exide-Ironclad Battery differ from all other types and makes of batteries in that the active material is contained within hard rubber tubes. The hard rubber tubes are finely slotted in order to permit the acid to reach the active material, but the slots are of such small dimensions that the escape of the active material is very greatly retarded. Thus the active material of the positive plates is held firmly in place, with the result that the plates are extremely rugged and give a very long life in active service.

Where the space available for the battery is very limited, so that a compact battery only can be installed, the Exide-Ironclad Battery is recommended for interlocking service, but is adaptable and satisfactory for any kind of signal service. Pages 24 and 25 show the construction and assembly of a cell of the Exide-Ironclad Battery.



Cross-section of Exide-Ironclad Tube




Horizontal section of a portion of one positive plate with a separator and negative plate on both sides

Side view of one tube

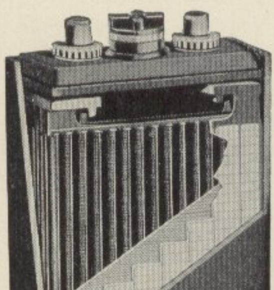
## Parts of a Battery

A jar containing one or more positive plates, one or more negative plates, separators and electrolyte, constitutes a cell. In this cell the positive plates, with the strap and post or lug, are called a positive group. In the same way the negative plates form a negative group. The positive group and the negative group, together with the separators, are called an element, and when an element is immersed in electrolyte, the combination becomes a cell.

One or more cells used for a certain purpose of function becomes a battery. Thus, one cell in a track circuit is called a track battery and five cells connected in series in the signal circuit are also called a battery.

## Chemical Action on Discharge and Charge

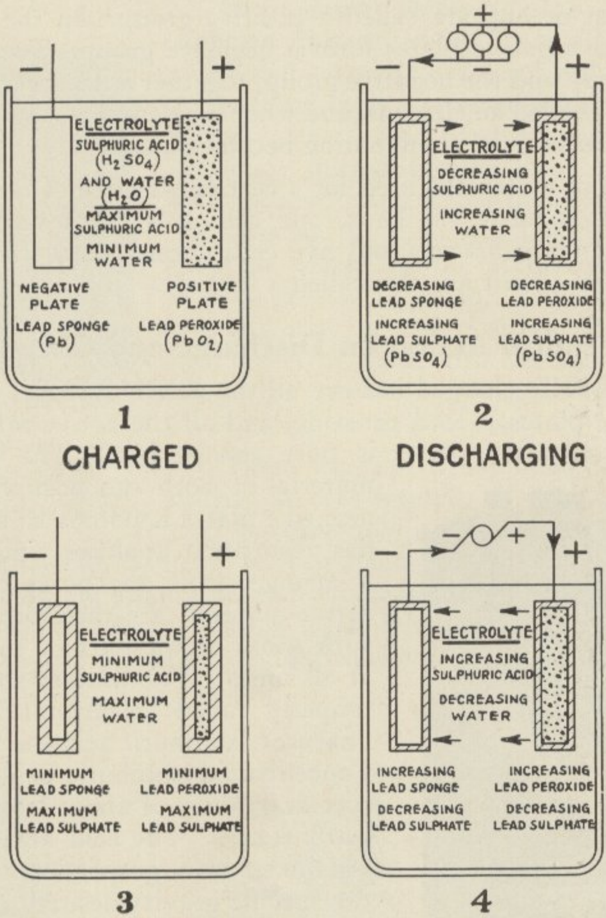
In a fully charged battery all the active material of the positive plates is lead peroxide, and all the active material of the negative plates is pure sponge lead. The active material of both the positive and negative plates is porous so that it has absorption qualities similar to a sponge, and the pores of the active material are therefore filled with some of the battery solution at all times. The battery solution properly called "electrolyte" is a mixture of sulphuric acid and water. Concentrated sulphuric acid has a specific gravity of about 1.830 and water 1.000. The acid and water are mixed in a proportion to give the specific gravity desired. Thus, to obtain electrolyte of 1,210 gravity the proportion would be about 1 part of concentrated sulphuric acid to about 4 parts of water.



A Cell of an Exide-Ironclad Battery cut away to show construction

In a fully charged battery all the acid is in the electrolyte and the

## CHEMICAL ACTION IN A CELL ON CYCLE OF DISCHARGE AND CHARGE




specific gravity is at maximum. As the battery discharges the acid separates from the electrolyte which is in the pores of the plates forming a chemical combination with the active material changing it to lead sulphate. As the discharge continues additional acid is drawn or diffused from the electrolyte into the pores of the plates and further sulphate is formed. This process continues while the battery is discharging and it can be readily understood that as the acid separates from the electrolyte and changes the active material of the plates to sulphate the specific gravity will gradually decrease, because the proportion of acid in the electrolyte is decreasing.

On charge the reverse action takes place and the acid is driven out of the plates back into the electrolyte. This return of the acid to the electrolyte increases the specific gravity, and while a battery is being charged the specific gravity will continue to rise until all the acid is driven out of the plates back into the electrolyte.

After all the acid is driven out of the plates any further charging will not raise the gravity any higher, as all the acid in the battery is in the electrolyte and the battery is said to be fully charged. Thus, in a fully charged battery, the positives are lead peroxide, the negatives spongy lead and the specific gravity a maximum, because all of the acid is in the electrolyte. In a discharged battery the positives are lead sulphate and lead peroxide (some of the lead peroxide having been reduced to lead sulphate by the action of the acid). Similarly, the negatives are lead sulphate and spongy lead and the electrolyte is weaker (lower gravity) because some of its acid is combined with the negative and positive plates in the form of lead sulphate.

Practically speaking, on discharge the plates absorb acid and on charge they return the acid absorbed to the electrolyte. Page 26 showing a cell charged, discharging, discharged and charging, illustrates clearly the chemical action which takes place on charge and discharge.

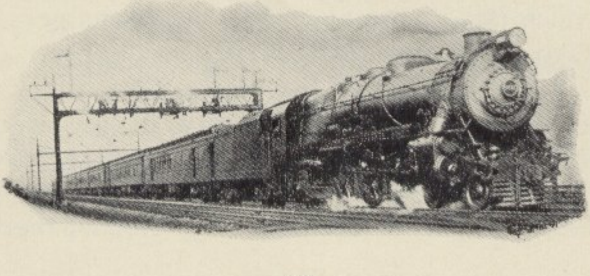
When a cell is fully charged (Fig. No. 1), the negative plate is lead sponge, Pb, and the positive plate is lead peroxide, $PbO_2$, the specific gravity of the electrolyte (sulphuric acid, $H_2SO_4$, and water $H_2O$), is at its maximum. Chemical energy is stored in the cell in this condition.

If the cell is put on discharge (Fig. No. 2), the $H_2SO_4$

of the acid is divided into $H_2$ and $SO_4$. The $H_2$ passes in the direction of the current to the positive plate, and combines with some of the oxygen of the lead peroxide and forms $H_2O$; the $SO_4$ combining with the liberated Pb of the positive plate to form lead sulphate. The $SO_4$ also forms lead sulphate at the negative or lead sponge, Pb, plate. As the discharge progresses both plates are finally reduced so that they contain considerable lead sulphate, $PbSO_4$ (Fig. No. 3). The water formed has diluted the acid lowering the specific gravity of the electrolyte. When the plates are entirely sulphated current will cease, since the plates are identical, and any electric cell requires two dissimilar plates in electrolyte. In common practice, however, the discharge is always stopped before the plates have become entirely reduced to lead sulphate.

During charge (Fig. No. 4), the lead sulphate $PbSO_4$, on the positive plate is converted into lead peroxide, $PbO_2$, while the lead sulphate on the negative plate is converted into sponge lead, Pb, and the electrolyte gradually becomes stronger as the $SO_4$ from the plates combines with hydrogen from the water to form acid, $H_2SO_4$, until no more sulphate remains and all the acid has been returned to the electrolyte. It will then be of the same strength as before the discharge and the same acid will be ready to be used over again during the next discharge.

Summarizing, it is now seen that on discharge some sulphuric acid is taken from the electrolyte to form lead sulphate and water, and in so doing the specific gravity of the electrolyte is lowered; and on charge some of the water in the electrolyte is taken to form sulphuric acid and to



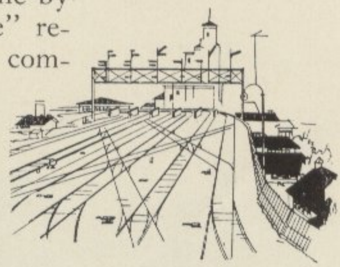
oxidize the positive plates, and in so doing the specific gravity of the electrolyte is raised.

A properly "floated" battery is kept at or near its fully charged condition at all times. Thus a floated battery is kept or maintained in its most healthy state or condition and is always ready and in a condition to give a maximum of capacity in case of failure of the A. C. power.

## "Floating" and "Trickle Charge" Defined

The terms "floating" and "trickle charge" are not always understood. These two terms are often used as if they had the same meaning, but there is quite a difference between them, as will be explained.

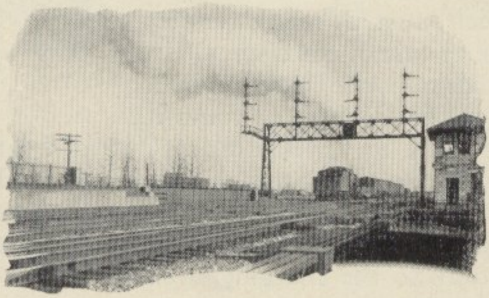
In a storage battery there is a small internal loss that is independent of the amount of work done by the battery. The term "trickle charge" refers to the current requirements to compensate or make up for the internal losses only. For example, suppose that it is desired to hold in reserve a battery which must be ready for immediate use in case of emergency. In order to maintain the battery in a fully charged condition at all times it will be necessary to "trickle charge" it at a rate that will just make up for the internal losses only. The rate of charge is called the "trickle rate," and the process is called "trickle charging." In "trickle charging" the battery is connected only to the charging circuit.



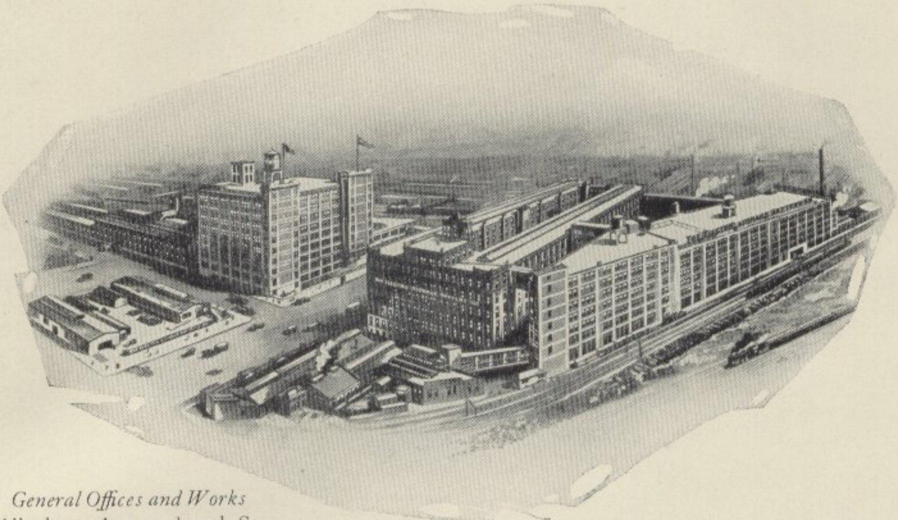
The term "floating" implies that the battery is continuously connected both to the charging source and the service circuits and is in parallel to them so that at one moment it may be receiving a charge and at the next, due to changed circuit conditions, supplying current to the signal circuits. The "floating rate" is the sum of the "trickle rate" and the average current necessary to put back into the battery the amount taken out intermittently during signal movements or functions.

## The A. C. Floating Battery System Defined

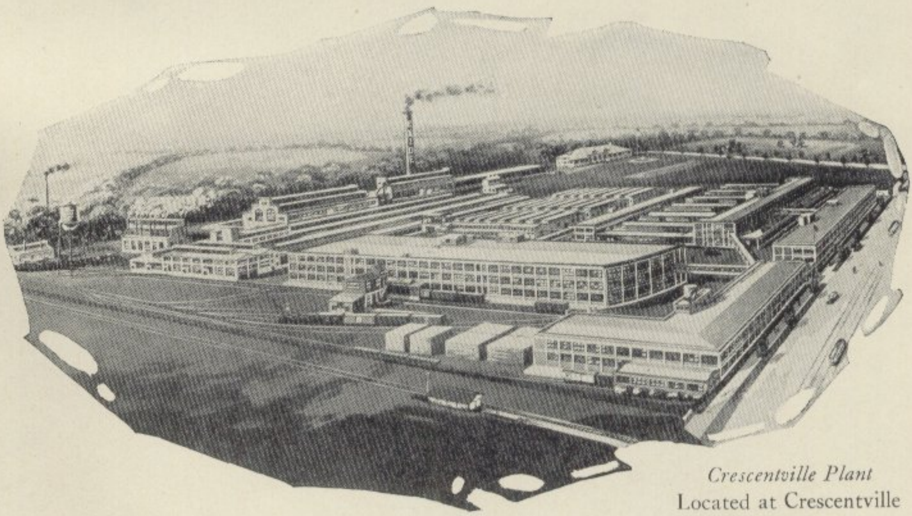
The A. C. Foating Battery System of Exide Signal Power supply is a method of supplying power to railway signal systems. It consists of an A. C. transmission line and rectifier at each battery location. An appropriate number of storage batteries are permanently located and connected to the direct current signal circuits and in floating relationship to them and an A. C. rectifier. This is a patented system controlled by The Electric Storage Battery Company.



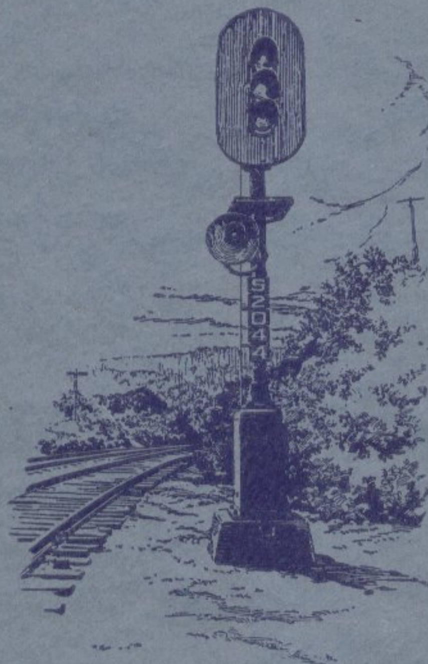
# Where Exide Batteries Are Made



*General Offices and Works*
Allegheny Ave. and 19th St.
Philadelphia



*Crescentville Plant*
Located at Crescentville
Philadelphia

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