BATTERY BASICS

by B. Drake Stelle

The motorcycle battery. A little box about one-third the size of a car battery that often has to handle as much electrical draw as an automobile unit. It's undergone some significant changes over the past few years, but it's essentially still the same device it was 50 years ago—an electro-chemical contraption that stores chemical energy which can be released as electrical energy.

The battery supplies power to the starter and ignition system so the engine can be cranked and started. It supplies extra power when electrical requirements exceed the supply from the charging system. It acts as a voltage stabilizer in the electrical system. And the battery supplies power for the headlamp, brake lights and the many accessories that have found their way into the market.

A motorcycle battery (a lead-acid storage battery) contains three basic chemicals—(1) lead dioxide, the material on the-positive plates; (2) sponge lead, the material on the negative plates; and (3) sulfuric acid, the electrolyte.

The battery is activated and a voltage is developed when two unlike metals such as the positive and negative plates are immersed in sulfuric acid. The electrical energy flows from the battery as soon as there is a circuit between the positive and negative terminal posts, such as when a load like the motorcycle's headlamp is connected to the battery.

When the battery is connected to an external load, current flows and it is being discharged. As this happens, the lead in the active material of the positive plate combines with the sulfate of the sulfuric acid forming lead sulfate in the positive plate. Oxygen in the active material of the positive plate combines with hydrogen from the sulfuric acid to form water in the electrolyte. At the same time, a similar reaction is taking place at the negative plate.

As the discharge progresses, the sulfuric acid is being consumed and replaced by water. The electrolyte is being diluted and its specific gravity becomes lower. The specific gravity can be measured with a hydrometer, giving an accurate and convenient method of determining the state-of-charge of a battery.

During the discharge cycle, the active material of both plates is changing to lead sulfate. The plates are becoming more alike and the acid is getting weaker. This results in the voltage becoming lower since it depends on the difference between the two plate materials plus the concentration of the acid. Eventually the battery can no longer deliver electricity at a useful voltage and it is said to be discharged.

Fortunately, the lead-acid storage battery can be charged by passing electrical current through it in the direction opposite to the direction of the discharge. The chemical actions that take place within a battery during charge are basically the reverse of those that occurred during discharge. The active chemicals are restored to the charged state and the battery is again ready to deliver its full power. This discharge-charge cycle can be repeated many times over.

WHAT MAKES UP A MOTORCYCLE BATTERY?

Batteries are made with alternating positive and negative plates held apart by separators. Each battery cell contains a group of these positive and negative plates (called an element) immersed in electrolyte (dilute sulfuric acid). Each cell supplies slightly more than two volts. Three of these cells connected in series gives us a six-volt battery; six cells in series give us a 12-volt battery.

The *plate grids* are the supporting framework for the active materials of the plates. They also conduct the current to and from the active materials of the positive and negative plates. Made primarily from a lead alloy, most battery manufacturers use small amounts of antimony to stiffen the soft lead.

The *positive and negative plates* are made from a paste comprised of lead oxide, sulfuric acid and water. The paste used in the negative plates contains expanders to prevent them from contracting in use and becoming inactive. Then a forming charge is used which electrochemically converts the lead oxide of the positive plate to lead dioxide, and the lead oxide of the negative plate to a grey sponge lead.

The positive and negative plates are kept apart by *separators* to prevent short circuiting. A separator is a thin sheet of electronically insulating, finely porous material which permits the passage of charged ions of the electrolyte between the positive and negative plates. Most separators are made from resin impregnated cellulose fibers. Some are made from rubber or various forms of plastic. A few motorcycle battery manufacturers use polyester-based materials which permits ultra-thin separators. These allow the plates to be placed closer together which results in lower electrical resistance and the use of more plates in the battery to increase high rate discharge capabilities. The addition of glass fiber mats to the separators by one or two manufacturers retards the loss of active material from the positive plates which eventually would cause the battery to short circuit.

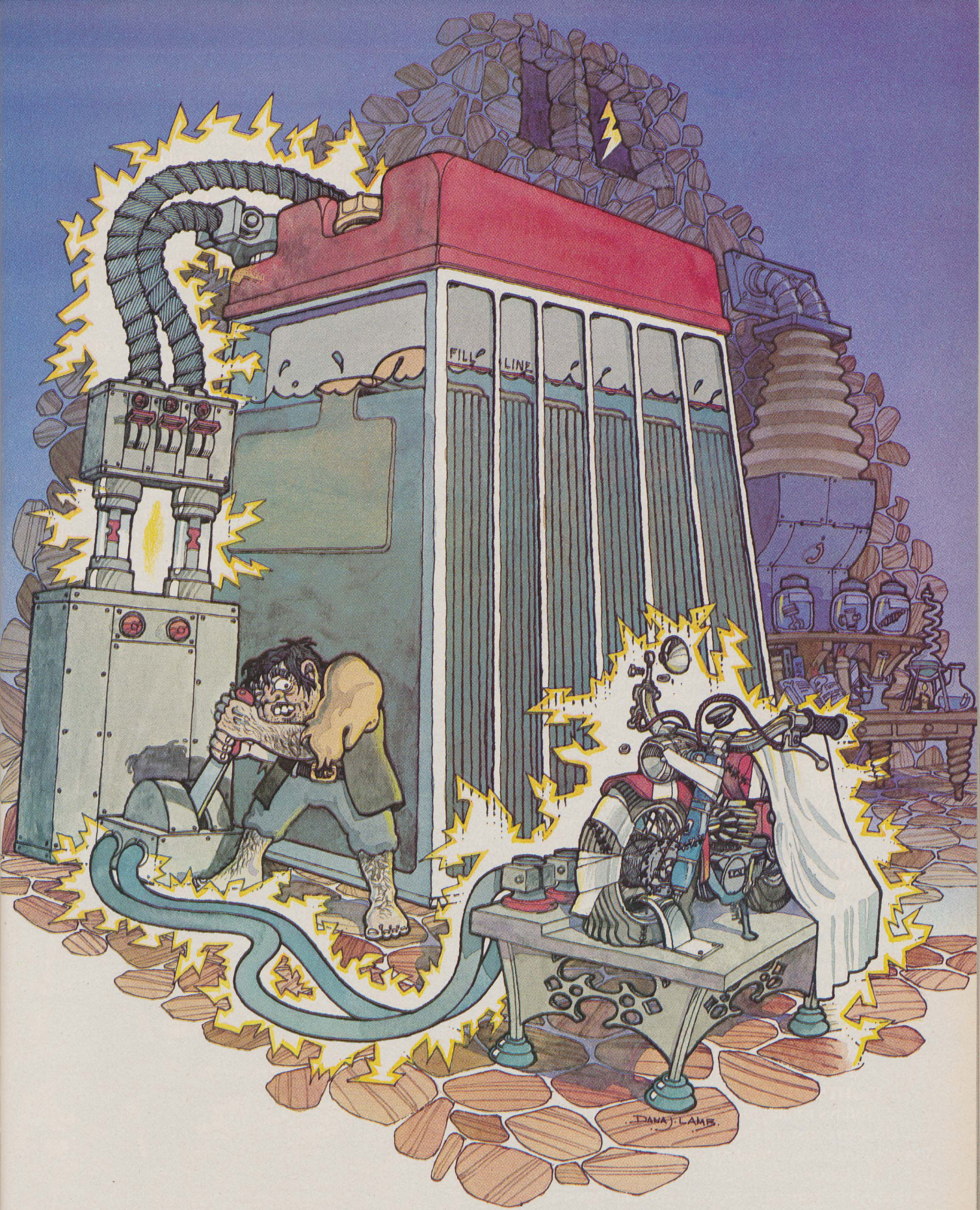
Separators have ribs on the side facing the positive plates. This provides greater acid volume next to the positives and minimizes the area of contact. The ribs also provide space to facilitate acid circulation and permit gas to rise to the top of the cell as it is formed.

In the most common method of *cycle battery construction,* a stack of alternate positive and negative plates, with a separator in between, is assembled. The lugs of the negative plates and a post strap are welded together and the lugs of the positive plates and a post strap are welded together. The post strap of each group of plates is used to connect them in a series with the plate groups of adjacent cells. The resulting assembly is called an *element*. There is one element per cell, though any number of plates can be used depending on the size limits of the battery and the performance desired.

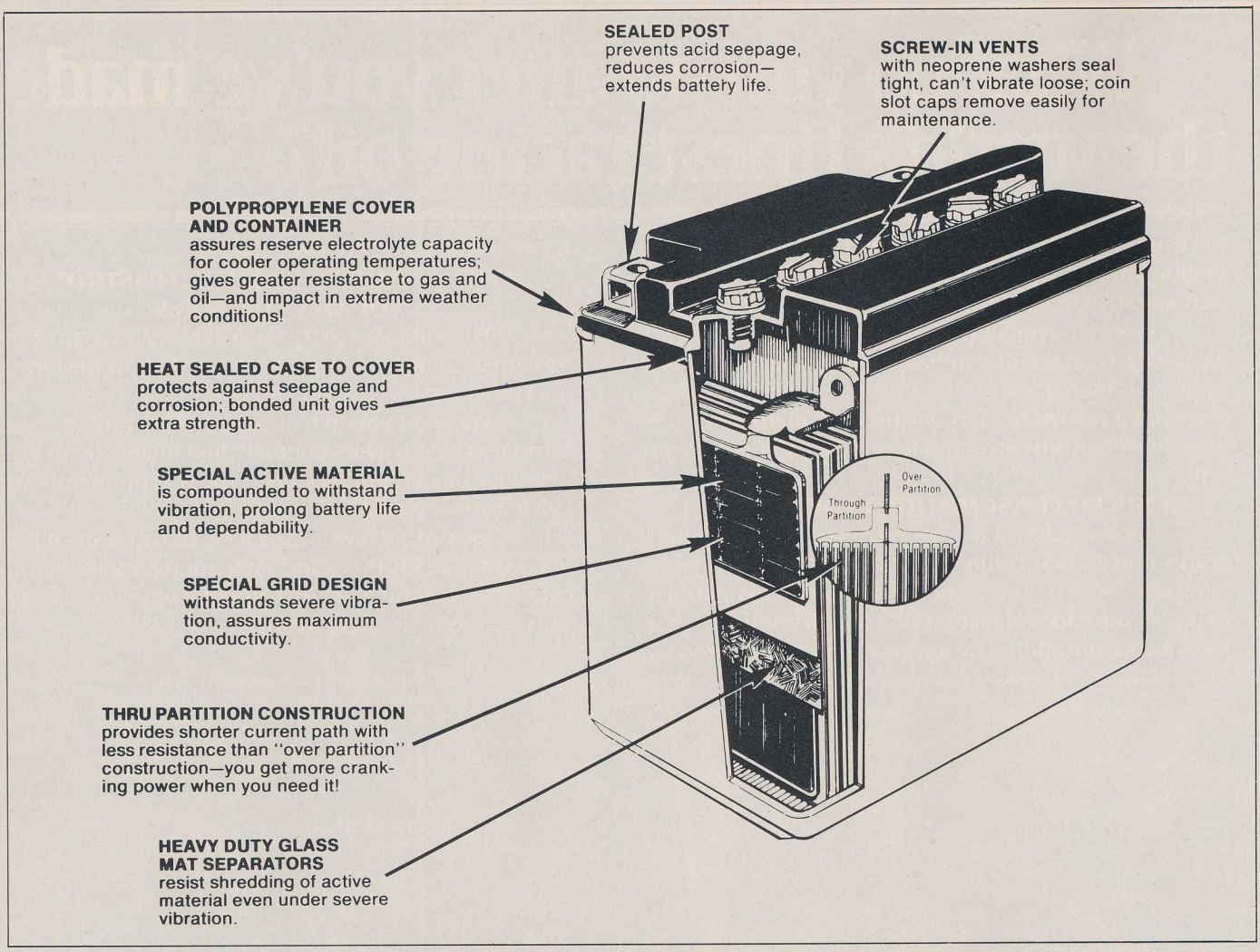
The elements are then placed in a *container* which is a one-piece case made of hard rubber or one of several different kinds of plastic. The container must be able to withstand extremes of heat and cold, have high impact resistance and resist acid absorption. A few motorcycle battery manufacturers have gone to the use of polypropylene instead of the usual polystyrene in order to gain greater resistance to flying stones and chemicals.

The case, together with the installed elements, is sealed with a one-piece cover made from a form of plastic. A heat sealing process is generally used to create a >

Illustration by Dana Lamb



How a Battery Works for You and How You can Keep it Working.



An example of motorcycle battery construction. (Courtesy Yuasa.)

permanent seal that cannot be broken by heat or shock. A fool-proof seal between case and cover is vital to a motorcycle battery's performance. If any acid does leak between the cover and partitions, short-circuiting between the cells would greatly increase the self discharge rate of the battery. The cover also has *vent wells* which allow gas to escape from the cell without forcing electrolyte from the battery. *Vent plugs* are designed for easy removal and replacement when water is added to the battery. The *terminal posts* are generally top mounted and are of a universal size so that all cable clamps fit any battery.

DESIGN CHALLENGES

The manufacturers of motorcycle batteries must, by necessity, work with products of limited physical dimensions. Unlike an automobile, a cycle has little space to house a battery. Though they must be small and light, a motorcycle battery is often called upon to handle an electrical draw close to that of a car's. The proliferation of electrically powered motorcycle accessories, along with the steadily increasing displacement of the engines has placed great demands on the battery.

One of the biggest challenges was to build a battery with enough high rate discharge capacity to crank 750–1100 cc engines. As battery size and capacity have become smaller, a larger portion of the battery is discharged when it cranks up the larger engines. The introduction of the

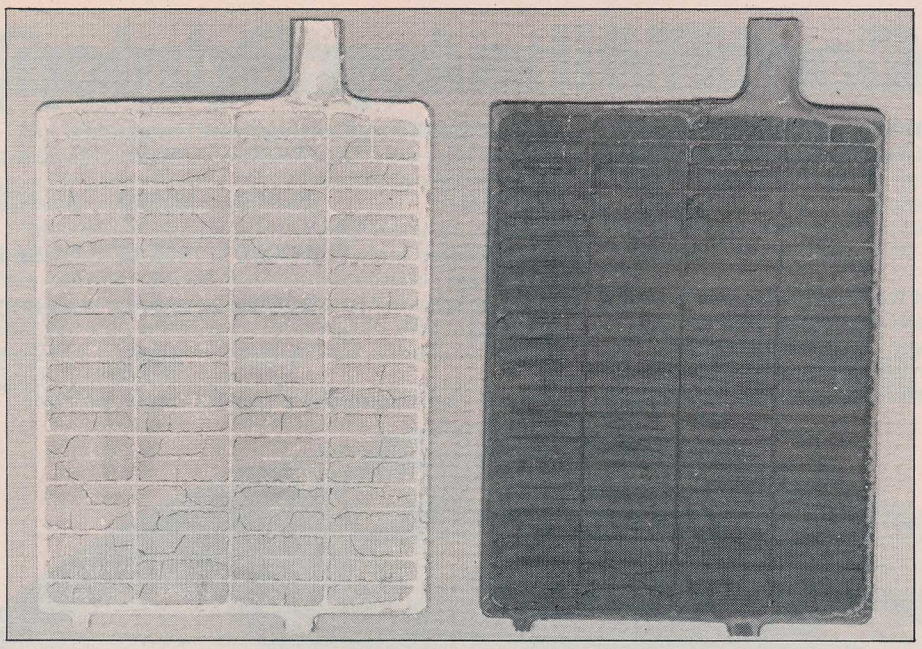
A. Effect of Thin Separator to Battery Size: (Example: 12N12A-4A-1 size, 42 plate battery)

Separator	Thickness (Approx.)	No. of Separator / Battery	Total Thickness of Separator	Difference
Regular Type	0.7mm / pc.	36 pcs.	0.7 x 36 = 25.2mm	21/6mm = 5/6 inch
Thin Type	0.1mm / pc.	36 pcs.	0.1 x 36 = 3.6mm	

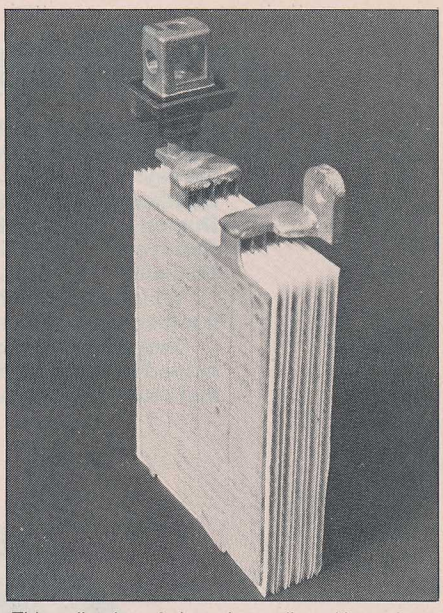
The length of existing 12N12A-4A-1 is 5 5/16 inches. 5/6 inch is around 15 percent of the existing 12N12A-4A-1 length.

B. Less Electric Resistance Increases Cranking Power:

Separator	Electric Resistance of each Separator ohms / decimeter / 2 pc.)	Total Battery Internal Resistance (milli ohms)	5 Sec. -Volts at 100 Amps. Discharge Temp: -5°F.
Regular Type	0.0025	10.2	8.3
Thin Type	0.0008	4.1	9.3



These are battery plates. The dark plate is a positive plate and the light-colored plate a negative.



This collection of plates is a cell, and it produces about two volts. A terminal is shown at one end, while the other connects to the next cell.

ultra-thin separators (0.1mm compared with 0.7 mm of traditional fiber separators) made from polyester-based material allowed the manufacturer to put more plates in each cell. This not only produced more high rate discharge capacity, but it also reduced performance-robbing electrical resistance because the plates could be placed closer together. The new, thin polyester separators are also stronger and more flexible than the old fiber-based units, another contributor to battery reliability and performance.

Another important design innovation in motorcycle battery construction is the "through-the-partition" intercell connection system. Instead of connecting the element terminal posts by going over the cell walls, some manufacturers extrude the lead through holes in the walls. The connection is then welded resulting in hermetically sealed conditions between cells while at the same time assuring solid electrical contact with each other. This construction method also means that the electrical current has a shorter distance to travel between cells, thus reducing resistance and contributing to higher cranking power. "Through-the-wall" construction has also reduced the amount of lead needed in the battery, an important weight-saving factor.

Another important innovation in the manufacture of motorcycle batteries is the use of glass fiber mats on the separators. In this high vibration environment, a major problem had been the dropping to the bottom of the battery of active plate material. Eventually this material, which is created by the constant charge-discharge cycle, would build up on the bottom of the case and short circuit the battery. The glass fiber mats, however, hold the active material in place and thus eliminates a major cause of battery failure. They are also porous enough to allow gas to rise and escape through the top of the unit.

As the motorcycle battery has become smaller in size and capacity, keeping it charged is more of a problem. Unless the bike is driven often and sufficient distances, the battery will become discharged quickly—especially if it's cranking a big engine and powering a lot of accessories. So battery care and attention are necessary to avoid problems. The battery's state of charge should be checked frequently with an easy-to-use hydrometer. A trickle charger is a good thing to have on hand. When water is required, use drinkable water, not brackish iron-contaminated water. Be sure to keep the posts on the battery top clean. More than 80 percent of all battery problems can be eliminated by proper charging and water refilling. And when the bike is stored, the owner should disconnect the cables and keep it in a cold place to avoid self-discharge.

WHAT'S AHEAD?

Today, a properly maintained motorcycle battery installed in a sound electrical system can last for three to four years. Many nagging problems have been overcome by manufacturers over the past few years. But what can we expect from the next generation of motorcycle batteries?

The appeal of maintenance-free units has not had a big effect on the motorcycle market. Since the lack of charging is the single biggest threat to a cycle's battery, the promise of not having to add water now and then hasn't struck a responsive chord with motorcycle owners. Thus the more expensive to manufacture calcium/lead maintenance-free units don't appear to be the wave of the future.

Gel-cell batteries, though they offer the advantage of a non-liquid electrolyte, have high electrical resistance that reduces performance. The sheer size of such a battery for motorcycle use would make it totally impractical.

Perhaps someday we'll see a completely sealed motorcycle battery, similar to today's dry cells. But don't hold your breath. Meanwhile, we have a crop of the best-performing, most powerful and most compact motorcycle batteries ever offered to choose from. With proper care and feeding, one of today's premium-grade units will provide excellent performance and long life. ◙

An example of a simple, inexpensive hydrometer. The small balls inside the suction tube are different densities. The more balls that float in the battery's electrolyte, the greater the specific gravity of the fluid, and that indicates more charge.