Iron-nickel batteries

The **nickel-iron battery** (NiFe battery) is a storage battery having a nickel(III) oxide-hydroxide cathode and an iron anode, with an electrolyte of potassium hydroxide. The active materials are held in nickel-plated steel tubes or perforated pockets. The nominal cell voltage is 1.2V. It is a very robust battery which is tolerant of abuse, (overcharge, overdischarge, short-circuiting and thermal shock) and can have very long life even if so treated. It is often used in backup situations where it can be continuously charged and can last for more than 20 years. Its use has declined due to low specific energy, poor charge retention, and poor low-temperature performance, and its high cost of manufacture compared with the lead-acid battery.
http://en.wikipedia.org/wiki/Nickel-iron_battery

--
nickel-iron battery "how to make"

http://www.fieldlines.com/story/2006/12/5/16551/2063

One of the "problems" with Nickel-Iron batteries is that they last nearly forever. This means purchases - even for industrial battery banks - tend to be a one-time thing.

Another is that the batteries are less efficient than other technologies (in particular: lead-acid). So efficiency-conscious engineers don't tend to design with them.

As a result there isn't all that much demand for them - and thus not many (if any) manufacturers.

(I hear there is at least one still alive somewhere in the former Soviet Union.)

I've quite many times tried to start here
a discussion concerning ideas how to make
yourself nickel-iron batteries.

--

There are still some suppliers in the world.

In China:

http://www.changhongbattery.com/english/about.htm http://www.solar3000.com/inverter_battery.htm

There might be more manufacturers in China.

--

In America, EaglePicher made
nickel iron batteries some time ago:

http://www.epcompower.com/CPS/Products/Rechargeable/RechargeableChemistries.htm

---

A good recent discussion, 'how it is made':

http://www.uni-regensburg.de/Fakultaeten/nat_Fak_IV/Organische_Chemie/Didaktik/Keusch/chembox_edison-e.htm

Here comments by thunderhead:

"The industrial techniques available to Edison when he was making his original cells was not much beyond what we can obtain in the modern kitchen: I'm sure that a skilled constructor could get hold of his patents and make his batteries."

---

by thunderhead on Wed May 11th, 2005:

"The whole point is to get lots and lots of surface area. The best solution for the home constructor, as I see it, is to use wire. 0.09mm diameter wire would be about 1mMol per metre, and have a surface area per metre of 283 square mm."

- Hannu

> Trying to make nickel iron batteries at home is on my to-do list. I'd more or less repeat the experiment the Chembox link describes, but I'd use iron and nickel wire in sodium hydroxide solution to increase the surface area to something useful.
>
> I might buy the iron and nickel wire from someone like "wires.co.uk".
>
> http://www.wires.co.uk/acatalog/fe_bare.html

http://www.wires.co.uk/acatalog/ni_bare.html

I might spot-weld them with a MiG welder, onto iron and nickel rods got from welding suppliers, using iron and nickel wire in the MiG to do the welding.

Before I do that, though, I have to buy my wife the smallholding she has her eye on; sort out things like fresh water, since there is none; renewable central heating; an extension for the bigger family she wants; and of course various solar/wind/listeroid-biodiesel RE electricity sources; build invertors, battery regulators and turbine speed regulators; learn how to make fatty acid ethyl ester biodiesel for my kitcar (possibly using lime as a drying agent and to soak up free fatty acids); sort out agricultural machinery, because I am *not* going to dig 3 1/2 acres by hand; fix the rear propshaft on my 4WD before any more heavy weather comes through, since our road floods and is virtually impassable at the moment; and incidentally try and do some paying work.

(Many of those will be documented here. This site is useful because of all the stuff people put on it, and I'm sure I can put something back, if only a terrible warning of how *not* to do things.)

I bought my battery bank cheap off eBay. It cost me about £10 per kWh for 24kWh. One day it will need replacing, and then home-constructing nickel iron batteries will get to be a higher priority in our household. Or maybe there'll be another bargain on eBay.

One day I will look at electric powered cars, too, and again, nickel iron looks like the best technology for that. This time, though, I've gone the biodiesel route, since my job was sold to some American arms manufacturer and we emigrated in a hurry. I converted my kitcar to biodiesel in three days, and drove it out of the country: it was rather too much like "scrapheap challenge" anyway -- I would never have done that with electric.

In the meantime, if you have the time, I would love to hear how you get on. Really I would. And I suspect lots of other folks here would too, considering how often the subject comes up.

[Parent]

here is one of the US suppliers: http://beutilityfree.com/ ouch! it looks like 1500 bucks to get a decent a amount. Somewhere I have another Chinese one with prices. It is not the one on the post right now. I'll keep looking as they had the best prices
badmoon
I just wanna have some fun, maybe learn something new every day and make some friends in the process.

http://www.fieldlines.com/story/2006/12/5/16551/2063

Electrochemistry
Model - Edison Cell (Iron-Nickel-Battery)

Objectives: Dependence of Discharge Time on the Strength of Discharging Current, Capacity of the Cell

Peter Keusch

Datalogging and data analysis using the Program CHEMEX and the Analog-Digital-Converter CHEMBOX
IBK electronic + informatic

Chemicals: 20% potassium hydroxide solution

Apparatus and glass wares:

600 mL beaker
iron sheet metal 5 · 10 cm
nickel plate 5 · 10 cm
iron wire net
nickel wire net
DC voltage source
ammeter
voltmeter
switch

rheostat 100 Ω (variable resistor)
path cords
clamps

Hazards and safety precautions:

Potassium hydroxide solution is corrosive! Contact with skin can cause irritation or severe burns and scarring with greater exposures. Swallowing may cause severe burns of mouth, throat, and stomach.

Safety glasses and protective gloves required.

Theoretical background:

A secondary cell devised by Thomas Edison (1847-1931) having a positive plate of nickel oxide and a negative plate of iron both immersed in an electrolyte of potassium hydroxide.

The reaction on discharge and charge is:

$$2\,NiOOH + 2H_2O + 2e^- \underset{\text{charge}}{\overset{\text{discharge}}{\rightleftharpoons}} 2\,Ni(OH)_2 + 2OH^-$$

$$Fe + 2OH^- \underset{\text{charge}}{\overset{\text{discharge}}{\rightleftharpoons}} Fe(OH)_2 + 2e^-$$

$$2\,NiOOH + Fe + 2H_2O \underset{\text{charge}}{\overset{\text{discharge}}{\rightleftharpoons}} 2\,Ni(OH)_2 + Fe(OH)_2$$

Preparation:

The iron sheet metal is enclosed by an iron wire net, firmly fastened with wires to the iron plate. In the same manner a nickel plate is enclosed by a nickel wire net. The two electrodes are hung verically into a beaker filled with 20% potassium hydroxide solution. The surface area of the electrodes immersed in the electrolyte is approx. 75 cm^2. The ends of the wire net are wedged into slotted rubber plugs mounted on a stand. The metal plates allow accurate placement of the nets.

The iron net is connected to the negative terminal, the nickel net to the positive terminal of DC voltage source. The rheostat is adjusted in a manner that allows a current of 200 to 300 mA to flow (**Fig. 1**). The battery is charged for 30 minutes.

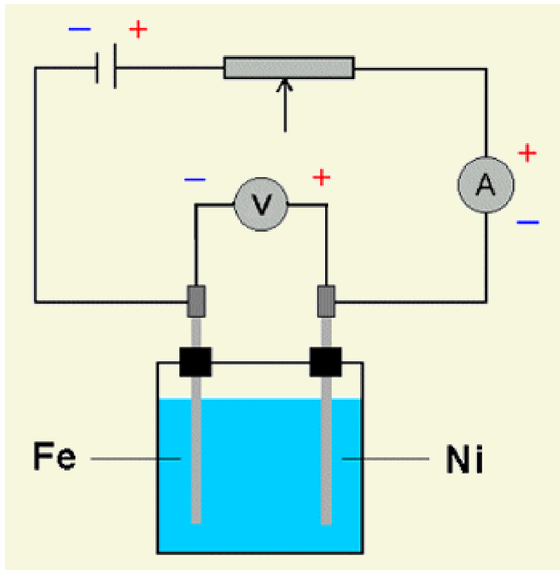


Fig. 1: Charging of the cell

At the two electrodes a gassing occurs. The voltage of the cell decreases within a day below a value 0.5 V (**Fig. 3**).

Next day the cell is charged for 10 minutes (as above described). The voltage rises to 1.7 to 1.9 V.

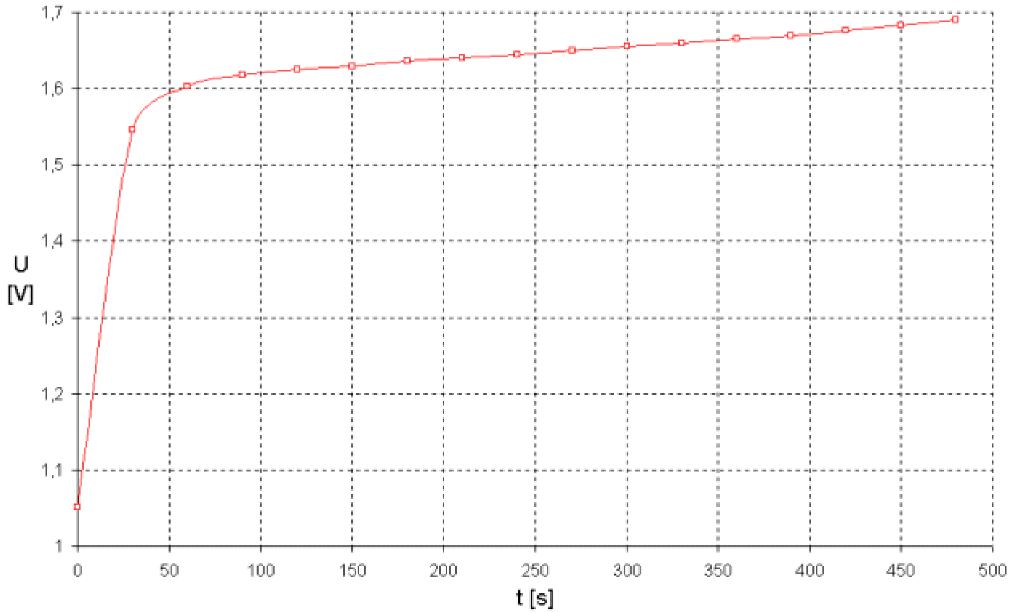


Fig. 2: Potential gradient while battery charging
(data logging with Cassy)

After power-off of the voltage source, one connects the nickel electrode via the ammeter, the rheostat and a switch to the iron electrode. The rheostat is adjusted in such a way, that a current of 20 mA flows (**Fig. 3**). The voltage decreases within of 3 minutes to 0.2 V. After interruption of the external electric circuit the voltage rises again slowly to 1 V.

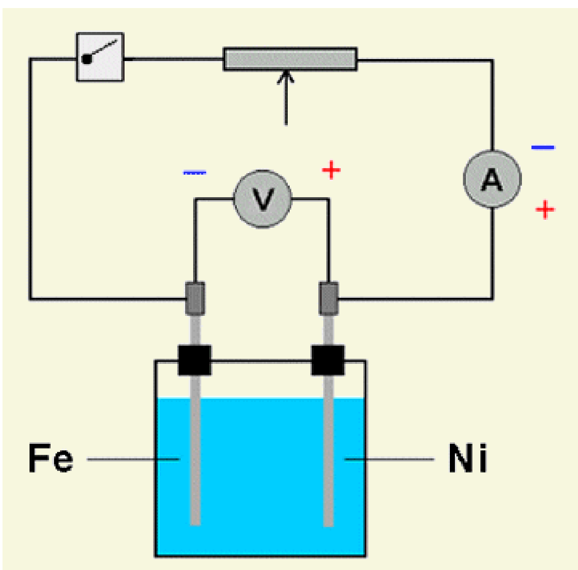


Fig. 3: Battery discharge

Experimental procedure:

Matching of the program CHEMEX

The positive terminal of the voltage source is connected via the rheostat and the ammeter to the nickel electrode. The iron electrode is connected to the negative terminal. The voltmeter displays a voltage of 1.5 V. The voltage produced by the electrochemical cell is used for the calibration. The program CHEMEX is switched to 'Options / Calibration /Sensor1'. One sets the first point of reference on 0 V. Afterwards the voltmeter is replaced by the CHEMBOX: the Ni-electrode is connected to the positive terminal, the Fe-electrode to the negative terminal of the 'Input Sensor1' of the CHEMBOX. As a second point of reference is taken the voltage value of the cell. In order to check the matching of the program is switched to the analog / digital display for voltage 1. If the appropriate voltage value is not displayed, the calibration is to be repeated.

Measurements:

After the cell was charged with a current of 100 mA, it is discharged at 20 mA. Next the re-charged battery is discharged at 30 and 40 mA. The changes in voltage are recorded at a 2 second interval.

The Edison cell exhibits a high self discharge. The voltage decreases to 1.0 V within approx. 250 seconds. Then it levels off as time goes on. Therefore the measurements are started at the time where a voltage of approximately 1.2 V has been reached.

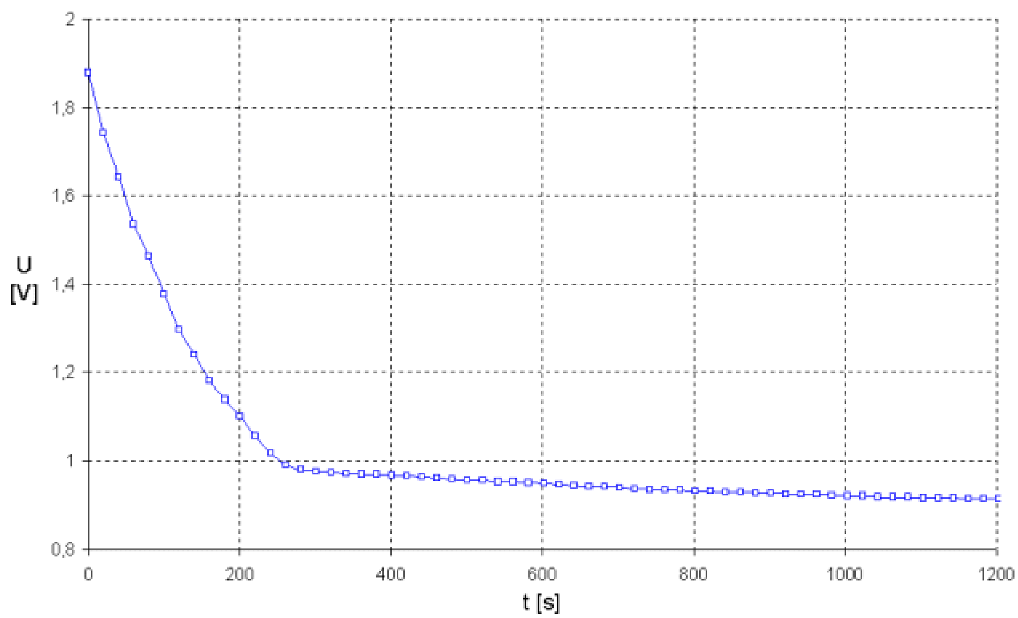


Fig. 4: Self discharge of the Edison cell

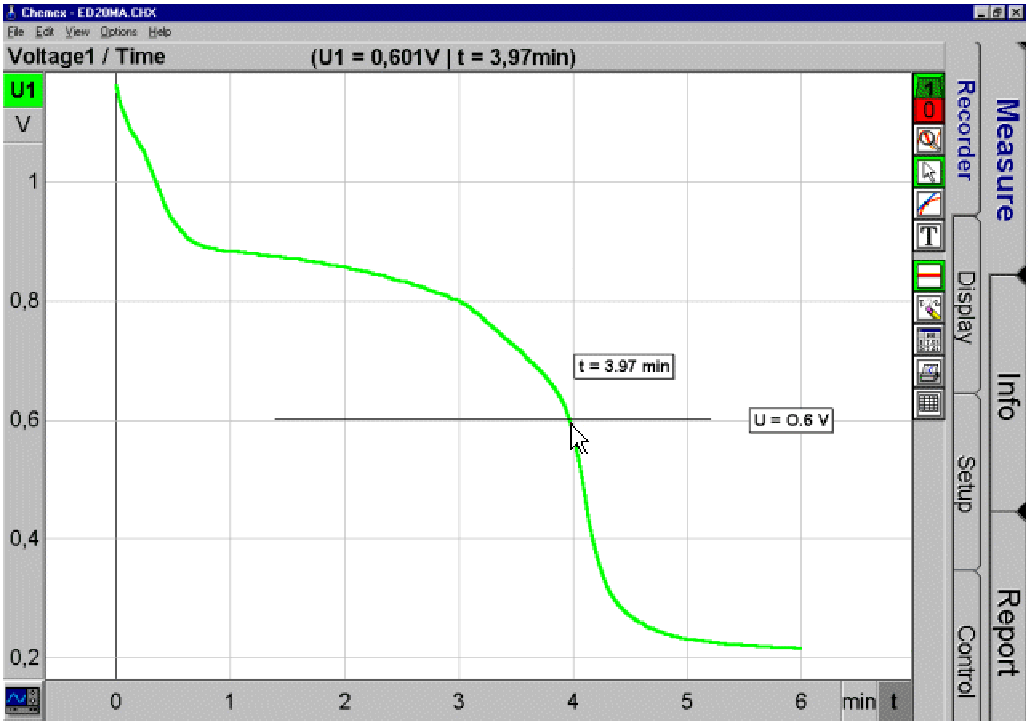


Fig. 5: Real-time plot - discharge with a current of 20 mA

Data analysis using Excel :

The pairs of measured values logged using the CHEMBOX/CHEMEX System are analyzed using the spread sheet program Microsoft Excel.

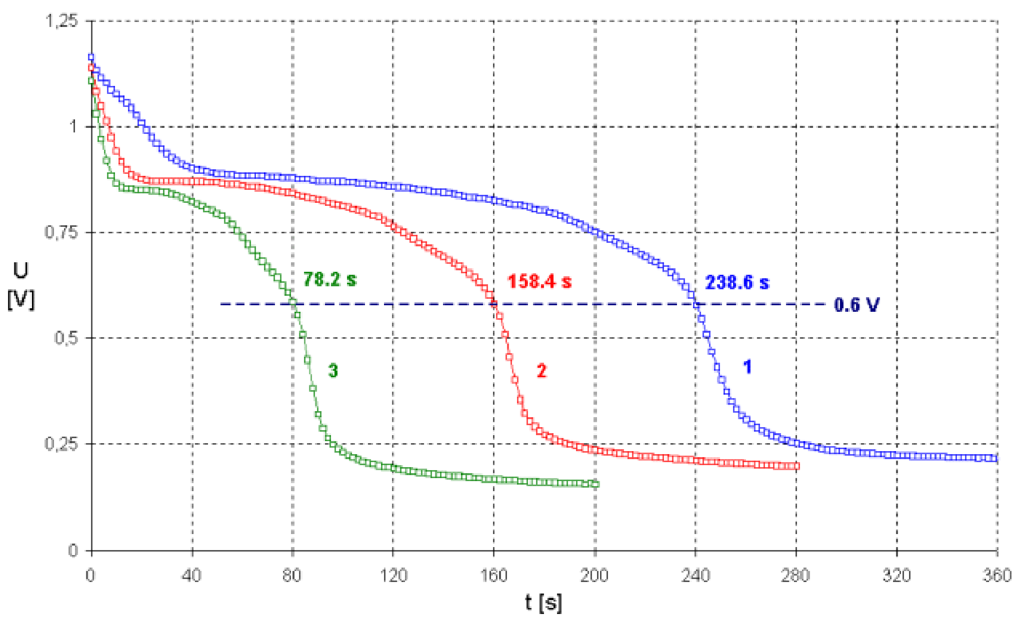


Fig. 6: Discharging at 20 mA (1), 30 mA (2) und 40 mA (3)

The voltage of the unloaded cell is approx. 1.2 V.

At the beginning of the discharge, the voltage decreases. Then it remains rather constant for some time, until it suddenly decreases within a couple of seconds. With a voltage of 0.6 V the battery is to be regarded as discharged. A linear relationship is evident between amperage and discharge time(**Fig. 7**).

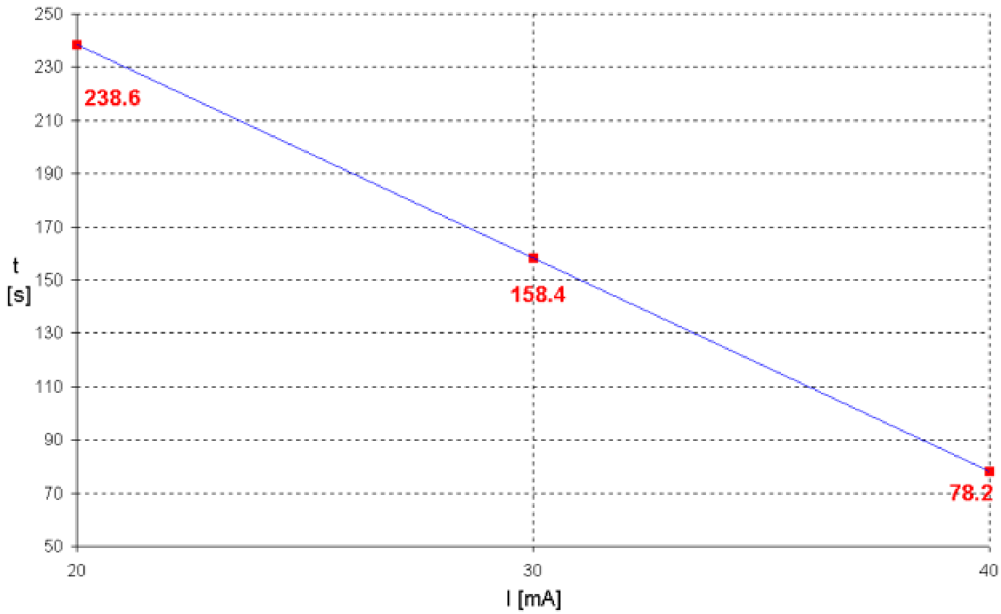


Fig. 7: Plot of amperage versus the discharge time

In order to discharge the cell initial currents $\mathbf{I_0}$ are adjusted by the selection of the resistance. The results are initial voltages $\mathbf{U_0}$ corresponding to the currents $\mathbf{I_0}$.

	I_0 [mA]	U_0 [V]
Measurement 1	20	1.162
Measurement 2	30	1.137
Measurement 3	40	1.107

Tab. 1: Initial currents and initial voltages when discharging

The time-dependent currents I(t) obtained during the discharge of the battery can be computed using the following relationship

$$I(n,t,U) = U \cdot I_0 / U_0$$

The values for **I (n,t,U)** are determined according to the above mentioned formula (**Tab. 2**) and a plot of **I** versus **t** is permitted (**Fig. 8**).

F5 =B5*20/1,162

	A	B	C	D	E	F	G	H	I	J	K	L
1	t [s]	20 mA	30 mA	40 mA		$I = U \cdot I_0 / U_0$						
2												
3												
4												
5	0	1,162	1,137	1,107		20,0000	30,0000	40,0000				
6	2	1,132	1,081	1,029		19,4836	28,5224	37,1816				
7	4	1,115	1,047	0,9695		19,1910	27,6253	35,0316				
8	6,04	1,102	1,012	0,9182		18,9673	26,7018	33,1780				
9	8,04	1,085	0,9738	0,8818		18,6747	25,6939	31,8627				
10	10	1,077	0,9417	0,8647		18,5370	24,8470	31,2448				
11	12	1,064	0,916	0,8561		18,3133	24,1689	30,9341				
12	14	1,055	0,8968	0,8518		18,1583	23,6623	30,7787				
13	16	1,042	0,8861	0,8518		17,9346	23,3799	30,7787				
14	18	1,025	0,8797	0,8497		17,6420	23,2111	30,7028				
15	20	1,008	0,8754	0,8497		17,3494	23,0976	30,7028				

Tab. 2: Spread sheet

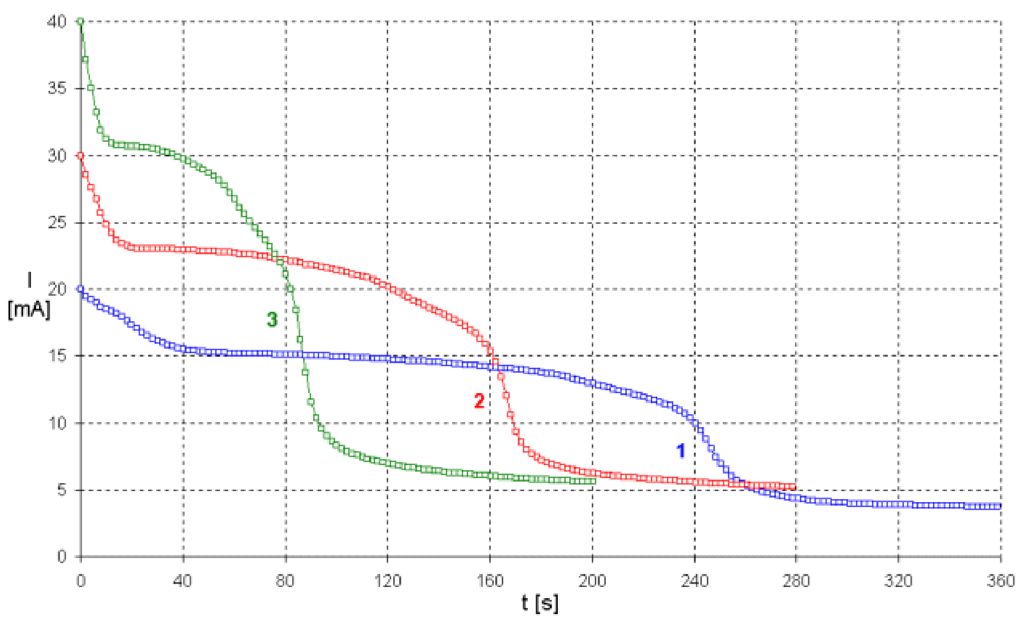


Fig. 8: Plot of amperage I versus time t

"Integration" of the current **I(t)** over the discharge time (time when cell voltage is 0.6 V) yields the capacity **C** of the battery. The capacity is found by calculating the appropriate area below the curves (**Tab. 3, 4**).

J5 | =(A6-A5)*F5-(F5-F6)*(A6-A5)/2

	A	B	C	D	E	F	G	H	I	J	K	L
1	t [s]	20 mA	30 mA	40 mA		$I = U \cdot I_0 / U_0$					Capacity C	
2												
3										3509,8065	3461,9861	2359,4178
4												
5	0	1,162	1,137	1,107		20,0000	30,0000	40,0000		39,463907	58,493166	77,142981
6	2	1,132	1,081	1,029		19,4836	28,5224	37,1816		38,674699	56,147757	72,213189
7	4	1,115	1,047	0,9695		19,1910	27,6253	35,0316		38,902435	55,386557	69,539662
8	6,04	1,102	1,012	0,9182		18,9673	26,7018	33,1780		37,604355	52,343383	64,97561
9	8,04	1,085	0,9738	0,8818		18,6747	25,6939	31,8627		37,286127	50,641979	63,233713
10	10	1,077	0,9417	0,8647		18,5370	24,8470	31,2448		36,850258	49,015831	62,178862
11	12	1,064	0,916	0,8561		18,3133	24,1689	30,9341		36,471601	47,831135	61,712737
12	14	1,055	0,8968	0,8518		18,1583	23,6623	30,7787		36,092943	47,042216	61,557362
13	16	1,042	0,8861	0,8518		17,9346	23,3799	30,7787		35,576592	46,591029	61,481481
14	18	1,025	0,8797	0,8497		17,6420	23,2111	30,7028		34,991394	46,308707	61,405601
15	20	1,008	0,8754	0,8497		17,3494	23,0976	30,7028		34,402754	46,137203	61,405601

Tab 3: Spread sheet

J3 | =SUM(J5:J124)

	A	B	C	D	E	F	G	H	I	J	K	L
1	t [s]	20 mA	30 mA	40 mA		$I = U \cdot I_0 / U_0$					Capacity C	
2												
3										3509,8065	3461,9861	2359,4178
4												
5	0	1,162	1,137	1,107		20,0000	30,0000	40,0000		39,463907	58,493166	77,142981
6	2	1,132	1,081	1,029		19,4836	28,5224	37,1816		38,674699	56,147757	72,213189
7	4	1,115	1,047	0,9695		19,1910	27,6253	35,0316		38,902435	55,386557	69,539662
8	6,04	1,102	1,012	0,9182		18,9673	26,7018	33,1780		37,604355	52,343383	64,97561
9	8,04	1,085	0,9738	0,8818		18,6747	25,6939	31,8627		37,286127	50,641979	63,233713
10	10	1,077	0,9417	0,8647		18,5370	24,8470	31,2448		36,850258	49,015831	62,178862
11	12	1,064	0,916	0,8561		18,3133	24,1689	30,9341		36,471601	47,831135	61,712737
12	14	1,055	0,8968	0,8518		18,1583	23,6623	30,7787		36,092943	47,042216	61,557362
13	16	1,042	0,8861	0,8518		17,9346	23,3799	30,7787		35,576592	46,591029	61,481481
14	18	1,025	0,8797	0,8497		17,6420	23,2111	30,7028		34,991394	46,308707	61,405601
15	20	1,008	0,8754	0,8497		17,3494	23,0976	30,7028		34,402754	46,137203	61,405601

Tab. 4: Spread sheet

A bar graph is selected (**Fig. 9**).

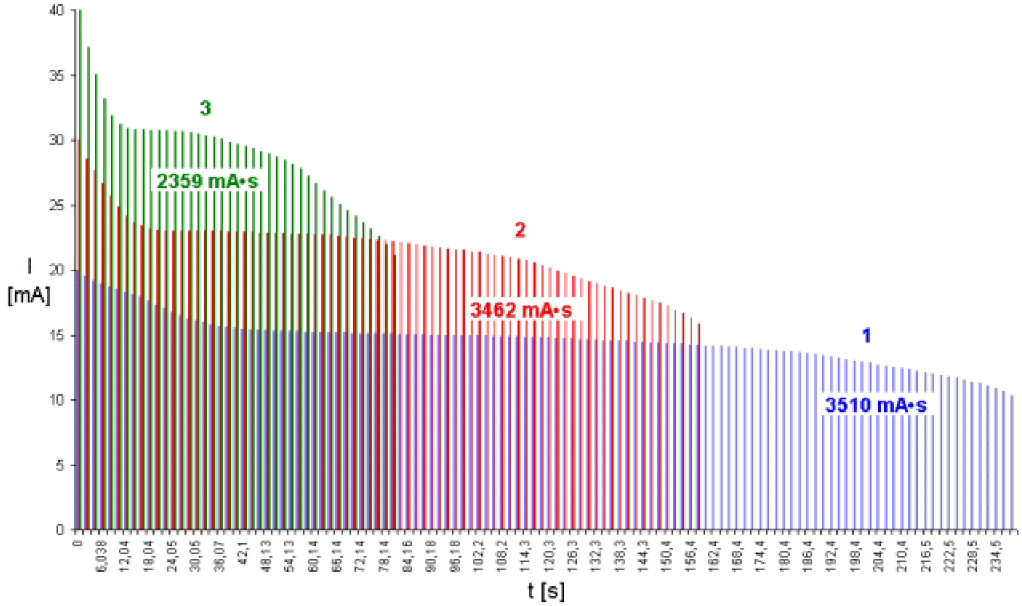


Fig. 9: Determination of the battery capacity

	I_0 [mA]	C [mA · s]
Measurement 1	20	3510
Measurement 2	30	3462
Measurement 3	40	2359

Tab. 5: Capacity of the battery

http://www.uni-regensburg.de/Fakultaeten/nat_Fak_IV/Organische_Chemie/Didaktik/Keusch/chembox_edison-e.htm

----

Lead-copper batteries

Home made
http://www.selah.k12.wa.us/soar/sciproj2005/KevinB.html

1. The Storage **Battery**: A Practical Treatise on the Construction, ... - Google Books Result

by Augustus Treadwell - 1906 - 257 pages
CHAPTER V **BATTERIES** IN WHICH ONE OR BOTH ELECTRODES ARE OF SOME OTHER METAL THAN LEAD II. — **LEAD-COPPER** GENUS THE advantages peculiar to accumulators of **...**
*books.google.com/books?id=oaA3AAAAMAAJ**...***

Battery Reference Book
by Thomas Roy Crompton - Technology & Engineering - 2000 - 800 pages
Initial efforts were directed toward Table 43.1 Nickel **battery** systems cost and performance summary Nickel-**iron Nickel**--inc **...**
Limited preview - About this book - Add to my library - More editions

Self-propelled Vehicles: A Practical Treatise on the Theory, Construction ... - Page 472
by James Edward Homans, Theodore Audel & Co - Automobiles - 1907 - 598 pages
... Edison **Battery**: Theory and Construction. — The recently perfected Edison **...**
Among such may be mentioned the so-called lead-zinc, **lead-copper** and **...**
Full view - About this book - Add to my library - More editions
Down loaded see the page it is good.

Do you have a contact in the USA that I can order from?
Need prices and amp-hour sizes available.
Also, self discharge rate information and expected life time.

----

http://www.utahbiodieselsupply.com/chemicals.php

I found this online.
http://home.cybertron.com/~edurand/Otherstuff/Edison.html

> I believe they are made in China and somewhere in Eastern Europe. These are the only new ones I've heard about - I know they're used in industrial applications, but an industrial battery is a large thing made to order. I haven't been able to trace the Eastern European manufacturer, but the Chinese ones are sold by Shenzhen Topway Solar Company:-
>
> http://www.solar3000.com/inverter_battery.htm
>
> I have also seen secondhand Eagle-Picher NiFe batteries taken from the

Dodge TEVan and advertised for sale:-

http://www.thesustainablevillage.com/servlet/display/product/detail/24154

Lastly, I've seen them on sale as Russian Army surplus stock:-

http://www.armyradio.com/arsc/customer/home.php?cat=87

If anyone buys one of these, or even gets prices, I'd love to know how they get on.

[Parent]

Re: Edison Battery Manual (3.00 / 0) (#6)
by kernow on Thu Jun 30th, 2005 at 10:00:13 PM MST
(User Info)

I picked up a load of 1.2V 45Ah NiFe cells made by 'Alcad' (ex-hospital UPS).

They measure 45 x 45 x 250 (mm) with M10 terminals.

We have them set up as 4 banks of 10, they soak up ('spare') power from the genny (when we're welding or using power tools) and are also fed by a 150W Rutland Windgen and a 40W polycrystaline PV, which helps account for their (~.33% per hr / ~5% overnight) discharge.

They serve their purpose well - the duty cycle of the big genny has been slashed as there is now enough in the bank to run computers/lights/band rehearsal in the evening.

...but best of all, it doesn't matter if they are run **dead** every evening or someone leaves a light on! (that's the sort of abuse that killed £200 of lead-acids last year...)

-

Cheers for the link, BTW - they even look like mine :)

[Parent]

Re: Edison Battery Manual (3.00 / 0) (#7)
by kernow on Sun Jul 3rd, 2005 at 01:04:43 PM MST
(User Info)

A couple more comments that may be of use to anyone lucky enough to get their hands on NiFe cells:

To reach full charge, they need around 1.65V per cell (16.5V on a 12V battery).

When 'flat', a 12V battery sits at around 10.5V

The only problem we have is that occasionally if the bank is at full charge and holding at or above 15.5V, the inverter says 'Uh-oh! Over voltage!' and fails to start - easily remedied by flicking on a halogen (introducing a small load) which makes the voltage dip to a point where the inverter is happy.

And finally, but most important - buy yourself a new hydrometer and mark it clearly for use only with the NiFe cells.

The electrolyte is potassium chloride - you really don't want to mix even a tiny bit with sulphuric acid from a lead-acid cell (or vice versa).

-

My main reason for getting them in the first place is that nickle and iron are more environmentally benign than lead, cadmium etc.

[Parent]

Re: Edison Battery Manual (3.00 / 0) (#8)
by thunderhead (mail me from my homepage!) on Mon Jul 4th, 2005 at 08:37:01 AM MST
(User Info) http://www.simon.richardson.net/mailme.htm

The electrolyte is not potassium chloride, it is potassium hydroxide. But you certainly don't want to pollute it with sulphuric acid.

[Parent]

Re: Edison Battery Manual (3.00 / 0) (#9)
by newtman on Mon Jul 11th, 2005 at 10:51:27 PM MST
(User Info)

i have 2 sets of 20 1.2v nife nicads. really old 10 years and i need to replace the electrolyte in it. were can i get dry KOH potassium hydroxide electrolyte. i found a place but its in europe. it was a caving supplies store. i called all the places in the phone book they dont have any or know anything about nicads.

[Parent]

Re: Edison Battery Manual (3.00 / 0) (#10)
by thunderhead (mail me from my homepage!) on Tue Jul 12th, 2005 at 01:06:30 AM MST

(User Info) http://www.simon.richardson.net/mailme.htm

Some people make soap as a hobby. Some of their hobby supply shops sell potassium hydroxide and lithium hydroxide. Since it is to be used on people it might be more pure than other sources.

[Parent]

Re: Edison Battery Manual (3.00 / 0) (#11)
by Caradoc (g_owen_home@yahoo.com) on Thu Feb 9th, 2006 at 03:45:36 AM MST
(User Info)

The Chinese-manufactured NiFe batteries are now imported by Beutilityfree.com

Evidently, prices are a bit lower than in the lower right corner of this link:
http://www.beutilityfree.com/batteryNiFe/battery_flyer.pdf

Caradoc

[Parent]

Re: Edison Battery Manual (3.00 / 0) (#12)
by Caradoc (g_owen_home@yahoo.com) on Sat Apr 22nd, 2006 at 06:09:05 PM MST
(User Info)

Just found better/cheaper source. Details to follow. -Caradoc

http://www.fieldlines.com/story/2005/6/24/8395/43617

Revolutionary battery will make electric cars practical

by Kimberly Chapple

The call came in and the voice at the other end said, "You really ought to think about designing a new battery, Al. They've already developed pretty good motors and controllers to make the electric car practical, but they need a better battery." Click.

So began inventor Alvin Snaper's thinking of ways to achieve The Practical: Make a light battery with a quick recharge rate that is economical to produce and environmentally-friendly. And it looks like he and his crack design team--septuagenarians and octogenarians plucked from retirement in the sands of Las Vegas--have done it.

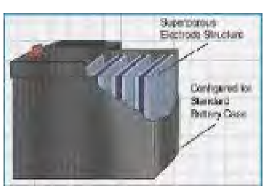
Inventor Alvin Snaper with batteries

Snaper, a *Designfax* reader whose first patent was used to make TANG and whose second was the IBM Selectric ball, is a self-described interdisciplinary type who struck out on his own after getting pats-on-the-back and "attaboys" for his inventions from his first two employers. Since then, he's received more than 600 patents on devices ranging from an aircraft collision avoidance system to an implantable pedia-cardia heart pump.

Three-quarters of Snaper's hand-selected Power Technology, Inc., Las Vegas, NV, team are retired engineers, chemists and scientists in their 70s or 80s who once worked at the nearby Nevada Test Site or for other area engineering concerns like Hughes Aircraft. "There was a tremendous amount of experience just sitting around in rocking chairs," says Snaper. "My chief mechanical engineer, just to keep himself busy, was working as a security guard. I told him to 'come on back and do what you *like* to do,'" he laughs.

And now the teammates may be laughing themselves to the bank. Their creation is a foam structure that Snaper believes will take a standard lead-acid battery, reduce the lead content by 90%, and make it twice as powerful, half the size, environmentally-friendly and cost-effective...quite *practical* for the electric car market. And they came up with this application *by accident*, as they weren't even working on *lead-acid* batteries. (Yes, he's still laughing.)

About two years ago, Snaper and his crew set out to update Thomas Edison's original nickel-iron alkaline battery used to power the first electric vehicles 100 years ago. While the invention of the electric starter and subsequent production of the internal combustion engine for the Model T doomed the electric car to obscurity, Edison's battery continued to be used in trains and electric buses. Meantime, the lead-acid battery as we know it today was produced along side of Edison's. And it's been used ever since.



The Power Technology Battery Design

"When Edison did it, he made extremely good batteries, with extremely long lives," explains Snaper, adding that there are 70-year-old Edison batteries that are still as good as new. When asked why no one's tried to enhance this quality design before, Snaper remarks that like the "gems in the dust" that make up his design team, he believes there are a lot of "little technological kernels and gems that have been left in the dust," overlooked as we race through technology's advances. By applying advances in materials science and electrochemical engineering, he was able to revisit the Edison battery design that had been produced commercially at the turn of the century.

To update the nickel-iron battery, the team divided the job into two tasks: 1) develop the structure, and 2) develop the chemistry. "It so happened that we finished the structure first, and we got that patent issued," explains Snaper, "and we suddenly realized that 'Hey, this structure is applicable to *any* battery chemistry,'" including the industry standard lead-acid battery.

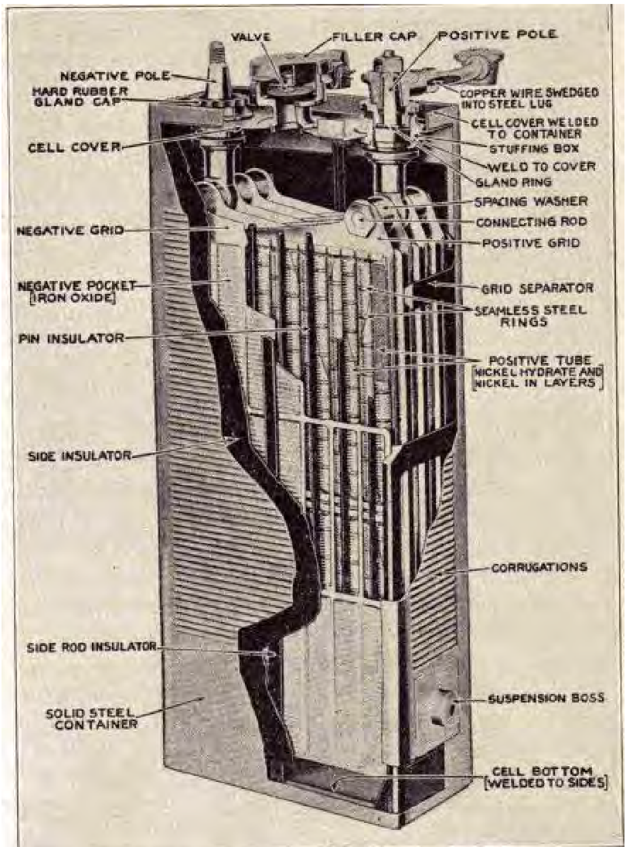
Comparison of Existing Electric Vehicle Battery Types with the Power Technology Battery (click image for enlargement)

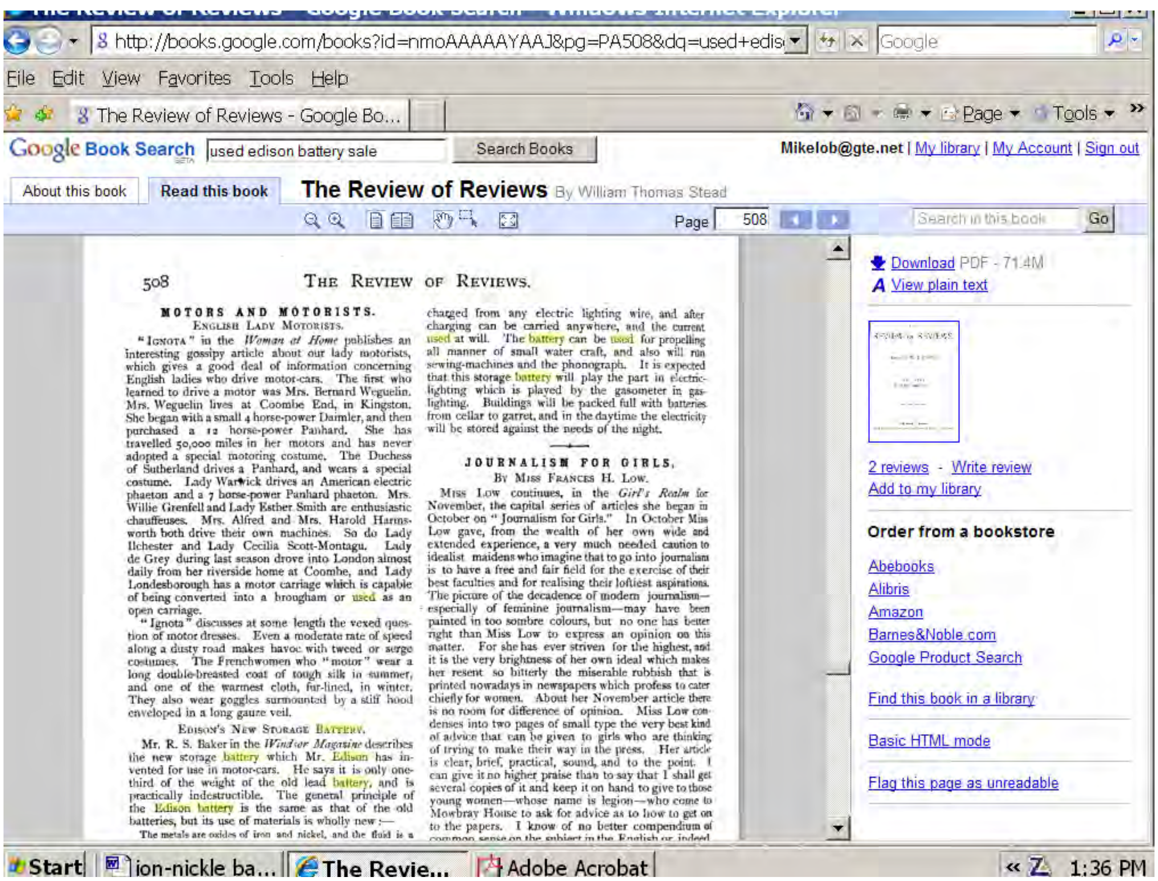
Snaper's target immediately shifted. The team halted work on developing nickel-iron chemistry in order to devote itself to getting foam structure into the much larger lead-acid chemistry market where the structure can be manufactured as a drop-in replacement for today's car battery. Snaper expects to hand manufacturing and marketing of the team's design to an OEM, so that the team can go on to finish the nickel-iron battery they started and "three or four other projects we're working on," he explains. (giggle, giggle, ka-ching, ka-ching)

For more information:

Circle 521 - *Power Technology, Inc.* or connect directly to their website via the *Online Reader Service Program* at http://www.OneRS.net/104df-521

http://www.designfax.net/archives/0401/0401yr.asp


VALVE
FILLER CAP
POSITIVE POLE
NEGATIVE POLE
HARD RUBBER GLAND CAP
COPPER WIRE SWEDGED INTO STEEL LUG
CELL COVER WELDED TO CONTAINER
STUFFING BOX
WELD TO COVER
GLAND RING
CELL COVER
SPACING WASHER
CONNECTING ROD
POSITIVE GRID
NEGATIVE GRID
NEGATIVE POCKET [IRON OXIDE]
GRID SEPARATOR
SEAMLESS STEEL RINGS
PIN INSULATOR
POSITIVE TUBE [NICKEL HYDRATE AND NICKEL IN LAYERS]
SIDE INSULATOR
CORRUGATIONS
SIDE ROD INSULATOR
SUSPENSION BOSS
SOLID STEEL CONTAINER
CELL BOTTOM [WELDED TO SIDES]

508 THE REVIEW OF REVIEWS.

MOTORS AND MOTORISTS.

ENGLISH LADY MOTORISTS.

"IGNOTA" in the *Woman at Home* publishes an interesting gossipy article about our lady motorists, which gives a good deal of information concerning English ladies who drive motor-cars. The first who learned to drive a motor was Mrs. Bernard Weguelin. Mrs. Weguelin lives at Coombe End, in Kingston. She began with a small 4 horse-power Daimler, and then purchased a 12 horse-power Panhard. She has travelled 50,000 miles in her motors and has never adopted a special motoring costume. The Duchess of Sutherland drives a Panhard, and wears a special costume. Lady Warwick drives an American electric phaeton and a 7 horse-power Panhard phaeton. Mrs. Willie Grenfell and Lady Esther Smith are enthusiastic chauffeuses. Mrs. Alfred and Mrs. Harold Harmsworth both drive their own machines. So do Lady Ilchester and Lady Cecilia Scott-Montagu. Lady de Grey during last season drove into London almost daily from her riverside home at Coombe, and Lady Londesborough has a motor carriage which is capable of being converted into a brougham or used as an open carriage.

"Ignota" discusses at some length the vexed question of motor dresses. Even a moderate rate of speed along a dusty road makes havoc with tweed or serge costumes. The Frenchwomen who "motor" wear a long double-breasted coat of tough silk in summer, and one of the warmest cloth, fur-lined, in winter. They also wear goggles surmounted by a stiff hood enveloped in a long gauze veil.

EDISON'S NEW STORAGE BATTERY.

Mr. R. S. Baker in the *Windsor Magazine* describes the new storage battery which Mr. Edison has invented for use in motor-cars. He says it is only one-third of the weight of the old lead battery, and is practically indestructible. The general principle of the Edison battery is the same as that of the old batteries, but its use of materials is wholly new:—

The metals are oxides of iron and nickel, and the fluid is a charged from any electric lighting wire, and after charging can be carried anywhere, and the current used at will. The battery can be used for propelling all manner of small water craft, and also will run sewing-machines and the phonograph. It is expected that this storage battery will play the part in electric-lighting which is played by the gasometer in gas-lighting. Buildings will be packed full with batteries from cellar to garret, and in the daytime the electricity will be stored against the needs of the night.

JOURNALISM FOR GIRLS.

BY MISS FRANCES H. LOW.

MISS LOW continues, in the *Girl's Realm* for November, the capital series of articles she began in October on "Journalism for Girls." In October Miss Low gave, from the wealth of her own wide and extended experience, a very much needed caution to idealist maidens who imagine that to go into journalism is to have a free and fair field for the exercise of their best faculties and for realising their loftiest aspirations. The picture of the decadence of modern journalism—especially of feminine journalism—may have been painted in too sombre colours, but no one has better right than Miss Low to express an opinion on this matter. For she has ever striven for the highest, and it is the very brightness of her own ideal which makes her resent so bitterly the miserable rubbish that is printed nowadays in newspapers which profess to cater chiefly for women. About her November article there is no room for difference of opinion. Miss Low condenses into two pages of small type the very best kind of advice that can be given to girls who are thinking of trying to make their way in the press. Her article is clear, brief, practical, sound, and to the point. I can give it no higher praise than to say that I shall get several copies of it and keep it on hand to give to those young women—whose name is legion—who come to Mowbray House to ask for advice as to how to get on to the papers. I know of no better compendium of

The Review of Reviews By William Thomas Stead

Ilchester and Lady Cecilia Scott-Montagu. Lady de Grey during last season drove into London almost daily from her riverside home at Coombe, and Lady Londesborough has a motor carriage which is capable of being converted into a brougham or used as an open carriage.

"Ignota" discusses at some length the vexed question of motor dresses. Even a moderate rate of speed along a dusty road makes havoc with tweed or serge costumes. The Frenchwomen who "motor" wear a long double-breasted coat of tough silk in summer, and one of the warmest cloth, fur-lined, in winter. They also wear goggles surmounted by a stiff hood enveloped in a long gauze veil.

EDISON'S NEW STORAGE BATTERY.

Mr. R. S. Baker in the *Windsor Magazine* describes the new storage battery which Mr. Edison has invented for use in motor-cars. He says it is only one-third of the weight of the old lead battery, and is practically indestructible. The general principle of the Edison battery is the same as that of the old batteries, but its use of materials is wholly new :—

> The metals are oxides of iron and nickel, and the fluid is a solution of potash. The chemical process involved in charging is one of the little understood marvels of science. As the electric current flows into the battery, little atoms of oxygen, called, with fine imagery, *ions* (wanderers), detach themselves from the iron oxide and go through the potash solution and attach themselves in some strange way to the nickel, producing the high oxide of nickel which so puzzled the Patent Office examiners. The nickel half of the cell swells lightly and the iron side shrinks a little. The battery having been charged, it may be taken anywhere, and upon connecting up the wires, the indefatigable *ions* of oxygen travel back from the nickel, through the potash solution, in their former place with the iron, and thus until the current is all given off; then they are ready for another expedition.

The potash solution is as harmless as water, has no disagreeable smell, and does not eat away either of the metal plates. The single cell of the battery is a steel box, 11½ in. long by 5 in. broad by 2 in. deep, open at the top. Inside of this are arranged the thin frames of steel, one half containing little packets of iron oxide, and the other a nickel oxide, and they are all immersed in the solution of potash. It can be

extended experience, a very much needed caution to idealist maidens who imagine that to go into journalism is to have a free and fair field for the exercise of their best faculties and for realising their loftiest aspirations. The picture of the decadence of modern journalism—especially of feminine journalism—may have been painted in too sombre colours, but no one has better right than Miss Low to express an opinion on this matter. For she has ever striven for the highest, and it is the very brightness of her own ideal which makes her resent so bitterly the miserable rubbish that is printed nowadays in newspapers which profess to cater chiefly for women. About her November article there is no room for difference of opinion. Miss Low condenses into two pages of small type the very best kind of advice that can be given to girls who are thinking of trying to make their way in the press. Her article is clear, brief, practical, sound, and to the point. I can give it no higher praise than to say that I shall get several copies of it and keep it on hand to give to those young women—whose name is legion—who come to Mowbray House to ask for advice as to how to get on to the papers. I know of no better compendium of common sense on the subject in the English or, indeed, in any other language.

Secondhand Books on Sale.

I HAVE a large stock of secondhand books on sale at greatly reduced prices. The volumes are well and strongly bound, and in good condition. Those wishing to secure books for founding libraries will find amongst them a large number of standard works on very advantageous terms. Lists may be obtained from the SECRETARY, REVIEW OF REVIEWS CIRCULATING LIBRARY, Temple House, Temple Avenue, E.C.

THE *Young Woman* for November opens with a chatty sketch of the American artist acclimatised in England who has been entrusted with the task of painting the Coronation picture—Mr. Edwin A. Abbey. He confesses, "I always fear the result of work which is done too easily. I find that almost invariably I have to do it over again."

MOTORS AND MOTORISTS.

ENGLISH LADY MOTORISTS.

"IGNOTA" in the *Woman at Home* publishes an interesting gossipy article about our lady motorists, which gives a good deal of information concerning English ladies who drive motor-cars. The first who learned to drive a motor was Mrs. Bernard Weguelin. Mrs. Weguelin lives at Coombe End, in Kingston. She began with a small 4 horse-power Daimler, and then purchased a 12 horse-power Panhard. She has travelled 50,000 miles in her motors and has never adopted a special motoring costume. The Duchess of Sutherland drives a Panhard, and wears a special costume. Lady Warwick drives an American electric phaeton and a 7 horse-power Panhard phaeton. Mrs. Willie Grenfell and Lady Esther Smith are enthusiastic chauffeuses. Mrs. Alfred and Mrs. Harold Harmsworth both drive their own machines. So do Lady Ilchester and Lady Cecilia Scott-Montagu. Lady de Grey during last season drove into London almost daily from her riverside home at Coombe, and Lady Londesborough has a motor carriage which is capable of being converted into a brougham or used as an open carriage.

"Ignota" discusses at some length the vexed question of motor dresses. Even a moderate rate of speed along a dusty road makes havoc with tweed or serge costumes. The Frenchwomen who "motor" wear a long double-breasted coat of tough silk in summer, and one of the warmest cloth, fur-lined, in winter. They also wear goggles surmounted by a stiff hood enveloped in a long gauze veil.

EDISON'S NEW STORAGE BATTERY.

Mr. R. S. Baker in the *Windsor Magazine* describes the new storage battery which Mr. Edison has invented for use in motor-cars. He says it is only one-third of the weight of the old lead battery, and is practically indestructible. The general principle of the Edison battery is the same as that of the old batteries, but its use of materials is wholly new:—

> The metals are oxides of iron and nickel, and the fluid is a solution of potash. The chemical process involved in charging is one of the little understood marvels of science. As the electric current flows into the battery, little atoms of oxygen, called, with fine imagery, *ions* (wanderers), detach themselves from the iron oxide and go through the potash solution and attach themselves in some strange way to the nickel, producing the high oxide of nickel which so puzzled the Patent Office examiners. The nickel half of the cell swells lightly and the iron side shrinks a little. The battery having been charged, it may be taken anywhere, and upon connecting up the wires, the indefatigable *ions* of oxygen travel back from the nickel, through the potash solution, to their former place with the iron, and thus until the current is all given off; then they are ready for another expedition.

The potash solution is as harmless as water, has no disagreeable smell, and does not eat away either of the metal plates. The single cell of the battery is a steel box, 11½ in. long by 5 in. broad by 2 in. deep, open at the top. Inside of this are arranged the thin frames of steel, one half containing little packets of iron oxide, and the other a nickel oxide, and they are all immersed in the solution of potash. It can be charged from any electric lighting wire, and after charging can be carried anywhere, and the current used at will. The battery can be used for propelling all manner of small water craft, and also will run sewing-machines and the phonograph. It is expected that this storage battery will play the part in electric-lighting which is played by the gasometer in gas-lighting. Buildings will be packed full with batteries from cellar to garret, and in the daytime the electricity will be stored against the needs of the night.

JOURNALISM FOR GIRLS.

BY MISS FRANCES H. LOW.

MISS LOW continues, in the *Girl's Realm* for November, the capital series of articles she began in October on "Journalism for Girls." In October Miss Low gave, from the wealth of her own wide and extended experience, a very much needed caution to idealist maidens who imagine that to go into journalism is to have a free and fair field for the exercise of their best faculties and for realising their loftiest aspirations. The picture of the decadence of modern journalism—especially of feminine journalism—may have been painted in too sombre colours, but no one has better right than Miss Low to express an opinion on this matter. For she has ever striven for the highest, and it is the very brightness of her own ideal which makes her resent so bitterly the miserable rubbish that is printed nowadays in newspapers which profess to cater chiefly for women. About her November article there is no room for difference of opinion. Miss Low condenses into two pages of small type the very best kind of advice that can be given to girls who are thinking of trying to make their way in the press. Her article is clear, brief, practical, sound, and to the point. I can give it no higher praise than to say that I shall get several copies of it and keep it on hand to give to those young women—whose name is legion—who come to Mowbray House to ask for advice as to how to get on to the papers. I know of no better compendium of common sense on the subject in the English or, indeed, in any other language.

THE *Young Woman* for November opens with a chatty sketch of the American artist acclimatised in England who has been entrusted with the task of painting the Coronation picture—Mr. Edwin A. Abbey. He confesses, "I always fear the result of work which is done too easily. I find that almost invariably I have to do it over again."

601 Higgins Bldg., Los Angeles, Cal.; Corry & Mitchell, 1320 Healey Bldg., Atlanta, Ga.

GREENFIELD TAP & DIE CORP. OF CANADA, LTD.—Front & York Pl., Galt, Ont., Can. Manufacturer of taps, dies and screw plates. Business established 1905. President, Francis G. Echols; vice-president, Frederick H. Payne; secretary, James A. Carrick; treasurer and general manager, Luther W. Smith; sales manager, L. W. O'Connor.

GREENPORT.—Trade name for gas engines manufactured by J. S. Gaffga & Co., Greenport, N. Y.

GREENWOOD ADVERTISING CO.—Knoxville, Tenn. Manufacturer of electric signs. President, A. Greenwood; treasurer and manager, H. C. Williams.

GRENZIG, J. A.—359 Jay St., Brooklyn, N. Y. Manufacturer of portable drills and hammer stands.

GRETHER.—Trade name for portable searchlight manufactured by Frank W. Morse, 289 Congress St., Boston, Mass.

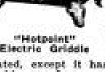
GRETHER FIRE EQUIPMENT CO.—Dayton, Ohio. Manufacturer of electric hand lanterns. President and general manager, William Grether; vice-president and secretary, Fred E. Grether; treasurer, A. E. Millard; sales manager, William O. Schleinitz.

GREYHOUND.—Trade name for electric sewing machine manufactured by the New Home Sewing Machine Co., Orange, Mass.

GRIDDLES, ELECTRIC, HOTEL TYPE.—Griddles of this type are constructed on the same plan as the smaller electric frying and cooking utensils, and are of such size that the heating elements are divided into groups controlled by individual switches accordingly as more or less surface of the griddle is needed. Some types take as much as 6000 watts when under full operation.

Manufacturers:

Bramhall, Deane Co., 261-265 W. 36th St., New York, N. Y. "Deane."
Canadian Edison Appliance Co., Ltd., Downie St., Stratford, Ont., Can. "Hotpoint," "Edison."
Duparquet, Huot & Moneuse Co., 108-114 W. 22nd St., New York, N. Y.
EDISON ELECTRIC APPLIANCE CO., INC., 5600 W. Taylor St., Chicago, Ill. Griddles are made in three sizes. The top of the one shown, G218, is made of aluminum and measures 18 ins. in width and depth and 10 ins. in height. Another type, G634, has a frying surface of 18x54 ins. and is 10 ins. in height. Still another type, G954, similar to the one illustrated, except it has a polished steel cooking surface, measures 18x36 ins. All are strongly made of steel and cast iron. The bodies are of heavy gauge steel and equipped with heating elements, controlled by three-heat switches. Satisfactorily used for cakes, eggs, chops, steaks, etc., by thousands of hotels and restaurants. See display adv. page 1292-3.—Adv.


"Hotpoint" Electric Griddle

Electric Heating & Mfg. Co., Westlake & Republican Sts., Seattle, Wash. "Apfel's."
Simplex Electric Heating Co., 85 Sidney St., Cambridge, Mass.
Weeks Mfg. Co., H. G., Hamilton, Ohio.

GRIDDLES, ELECTRIC, HOUSEHOLD TYPE.—Griddles of this type have the heating element in the base and are made to operate on about 800 watts. They are usually operated through a cord and plug attached to a special circuit.

Manufacturers:

Bramhall, Deane Co., 261-265 W. 36th St., New York, N. Y. "Deane."
Canadian Edison Appliance Co., Ltd., Downie St., Stratford, Ont., Can. "Hotpoint," "Edison."
EDISON ELECTRIC APPLIANCE CO., INC., 5600 W. Taylor St., Chicago, Ill. "Hotpoint," "Edison." (See display advertisement on pages 1292-1293.)
Globe Stove & Range Co., The, Kokomo, Ind. "Globe."
Power Mfg. Co., The, Marion, Ohio. "Primm."
Simplex Electric Heating Co., 85 Sidney St., Cambridge, Mass.

GRIDS FOR STORAGE-CELL PLATES.—In modern storage-battery construction the active materials used in the plates are applied to a skeleton framework in such a manner that they fill pockets in this framework, which is called the grid. In the case of lead storage batteries, this construction gives what are called Faure or pasted plates, and the grids are made of hard or antimonious lead and are usually cast in molds. Various constructions have been devised with the idea of affording secure pocket-like supports for the active material. The grid usually consists of thin bars shaped so as to retain the pellets of active material within its pocket-like openings. In the case of alkaline storage cells, such as the Edison battery, the grid is made of nickel-plated steel and the pellets of active material are specially prepared and inserted in the grid under heavy hydraulic pressure.

On top of the grid, in any type of battery, is an extension or lug which is connected to the crossbar or connecting strap joining the similar plates of the cell and serving to conduct the current to the grid. In some cases the grid is of heavier cross section in the upper portion so that it will distribute the current to the various pellets more uniformly than if it were of the same section throughout.

GRIDS, RESISTANCE.—Resistance grids are resistors made of cast iron or steel usually in the form of a flat open zigzag grid provided with terminal lugs for mounting side by side in a rheostat frame. They are used where resistance must be inserted in a circuit carrying a fairly heavy current. Cast iron is particularly suitable for this purpose, because it combines a fair amount of resistance with considerable conductance and is not so readily oxidized or disintegrated when heated even to red heat, which is not uncommon in grid resistors that must dissipate a large amount of power. On account of this heating the adjacent grids are spaced apart and usually hung vertically to give ample opportunity for radiation and ventilation; the rheostat is entirely open if there is not likelihood of combustible material coming in contact with it, or protected by open-mesh wire screen or other ventilated cover to guard against ignition of such material. Resistor grids are used extensively with electric railway motors, slip-ring induction motors, elevator, crane and hoist motors, rolling-mill and other heavy-duty motors, and for similar intermittent or continuous resistance service.

Manufacturers:

AUTOMATIC ELECTRICAL DEVICES CO., 120-122 W. 3rd St., Cincinnati, Ohio.
Boston Armature Works, 77 Washington St., N., Boston, Mass.
Canadian Edison Appliance Co., Ltd., Downie St., Stratford, Ont., Can. "Hotpoint," "Edison."
Canadian General Electric Co., Ltd., 212 King St., W., Toronto, Ont., Can.
Columbia Machine Works & Malleable Iron Co., Atlantic Ave. & Chestnut St., Brooklyn, N. Y.
EDISON ELECTRIC APPLIANCE CO., INC., 5660 W. Taylor St., Chicago, Ill. "Hotpoint," "Edison." (See display advertisement on pages 1292-1293.)
National Lead Co., 111 Broadway, New York, N. Y.
Standard Electric Machinery Co., Baltimore, Md. "Standard-Baltimore."
Union Electric Mfg. Co., 120 Reed St., Milwaukee, Wis. "UEMCO."
WESTINGHOUSE ELECTRIC & MFG. CO., East Pittsburgh, Pa. (See display adv. pages 1396-1462.)

GRIESHEIM-ELEKTRON CELL.—One of the most important German cells for the electrolytic production of alkali and chlorine from salt solution. The anodes are of magnetite, the cathodes of iron, and the diaphragm of a specially prepared cement.

GRIEVE.—Trade name for boiler furnace grate manufactured by the Combustion Engineering Corp., 11 Broadway, New York, N. Y.

GRIFFIN WHEEL CO.—Chicago, Ill. Manufacturer of wheels for electric street and interurban cars. President, F. L. Whitcomb; vice-president, C. K. Knickerbocker; secretary and treasurer, S. L. Frost. Main office and factory, N. Sacramento Blvd. & C. & N. W. Tracks, Chicago, Ill. Branch offices, Detroit, Mich.; Denver, Colo.; Boston, Mass.; Kansas City, Mo.; St. Paul, Minn.; Los Angeles, Cal.; Tacoma, Wash.

GRIFFITHS & SON, JAMES A.—1815-17 Buttonwood St., Philadelphia, Pa. Manufacturers of ejectors, injectors, valves and other power plant specialties.

GRILLS, ELECTRIC.—These cooking appliances as used on the table consist of a combination frier, broiler, toaster and hot plate. The heating element is so arranged that food may be cooked either above or below it, or in both places at the same time. With some of these appliances a vessel is provided for boiling water or steaming eggs, or for using the grill as a chafing dish; in some cases a small oven can be secured as an accessory. These grills may be used for preparing almost any food in any form, but only in relatively small quantities. They are attractively finished, usually having a nickel or copper finish, and are quite suitable for use on the table, the food being served hot directly from the cooking dish.

Manufacturers:

AMERICAN ELECTRICAL HEATER CO., Detroit, Mich. "American Beauty" electric grill, equipped with three heats; made of sheet steel, beautifully finished in polished nickel. Handles


"American Beauty" Grill

of ebony finish. Has open coil type of heating element. Furnished complete with a 6-ft. triple conductor cord, having detachable porcelain plug and attachment plug.—Adv.
Bramhall, Deane Co., 261-265 W. 36th St., New York, N. Y. "Deane."
Canadian Edison Appliance Co., Ltd., Downie St., Stratford, Ont., Can. "Hotpoint," "Edison."
Canadian General Electric Co., Ltd., 212 King St., W., Toronto, Ont., Can.
Curtainless Shower Co., Inc., 507 5th Ave., New York, N. Y. "Reddy."
EDISON ELECTRIC APPLIANCE CO., INC., 5600 W. Taylor St., Chicago, Ill. Two styles are manufactured—a round and rectangular grill. Of the glowing, open-coil reflector type, they boil, broil, fry and toast. The round model


"Hotpoint" Radiant Grill

has three heats, adjustable to "high, medium and low." Made of pressed steel and finished in polished nickel. Have deep under dishes with broiling grid, shallow dish, and cover to fit either dish; complete with cord and lamp socket attachment plug. The round grill illustrated (Cat. No. 136G1) is also made in single heat (Cat. No. 116G1). See display adv. pages 1292-3.—Adv.
Equator Mfg. Co., 144 York St., Hamilton, Ont., Can. "Equator."

1913 Vehicle Batteries

Edison and Lead Batteries Continue with Few Alterations, But Developments Awaited for Near Future

Manufacturers Are Busy Improving the Electro-Chemical Qualities to Increase Life and Capacity of Product

BATTERIES constructed for the work of propelling electric vehicles have not experienced any radical development during the year just closed. Whatever improvements have been made have been in the nature of small changes which tend to strengthen the battery and to lengthen its life. A great deal of chemical experimentation has been going on, as it always is, in this branch of electrical work, but few mechanical changes have been made. In this respect more than one step forward is expected to be taken by several companies during 1913.

One of the principal problems of the battery field is the guarantee situation. No settled position has been adopted by the host of makers, but several companies have made advances toward that goal. While some companies do not guarantee their product on the reasoning that once it leaves the hands of the makers and is subjected to the careless treatment of a driver, it is impossible for the maker to stand behind it, several concerns give a 1-year guarantee. The Ironclad Exide battery is even guaranteed for 2 years, or rather a period of 600 cycles during that time. In all probability this problem will be solved in the near future.

The Edison battery for vehicle-propulsion purposes is made in five sizes designated respectively A4, A6, A8, A10 and A12. The numeral in each designates the number of positive plates per cell, thus A6 has six positive plates and seven negative plates giving a total of 13 plates. There is always one more negative per cell than positive plates, thus A12 has twenty-five plates, twelve positive and thirteen negatives.

The Edison vehicle battery differs from all other storage batteries in that it is a non-acid type, in other words it is an alkali battery, but is more generally known as the nickel-iron battery because these elements are used as filling materials in the plates.

Another characteristic of the Edison battery is that the active material in the positive plates is filled into little perforated steel tubes so that with the vibration that the vehicle is subjected to when in operation this filling material cannot be shaken out and so the battery capacity is preserved, because whenever this active material is shaken out in any battery the battery capacity drops. The material in the negative plate is also put into little compartments, not tubes, but long, rectangular-shaped perforated pockets made of cold-rolled steel, nickel-plated, the same material as used in the tubes of the positive plate.

Look for a moment at each of these little tubes for a positive plate. Each tube is 4.25 inches long and approximately .375 inch in diameter. There are thirty of them in each plate. They are mounted vertically in two rows, one row across the top half of the plate and the other in the bottom half. These little tubes are made with the utmost accuracy. The tube is made from cold-rolled nickel-plated steel ribbon most carefully prepared for the job. It is then wound spirally by machinery, specially designed for this work, and when in tube form there are eight little steel rings slipped over the outside and spaced equidistantly, to add strength and to prevent any explosion.

Next comes the filling of this little tube, which is carried out with the utmost accuracy, for their must not be any variation, one must be filled identically with all others. In filling two substances are put in, one is pure metallic nickel in the thinnest flake form and the other is nickel hydroxide. These two are put in in layers, first nickel hydroxide and then the pure nickel flake. There are exactly 350 layers of each, 700 in all. This filling is done by specially designed automatic machinery. Each tube has exactly 700 layers. Tubes are regularly taken from each filling machine, cut in half longitudinally and examined with a microscope to see that this filling has been accurately done. When filled the tubes are carefully inspected, measured for length and the ends closed.

Next the negative plate: This is made up of long, rectangular-shaped pockets and each is filled with finely powdered iron oxide, which is put in with practically as great accuracy as to quantity as the filling in the little tubes of the positive plate. Twenty-four of these little pockets make up a negative plate.

In each cell of the battery the negative and positive plates are alternated, with narrowest strips of hard-rubber insulation between them. The jar into which the plates are placed is a cold-rolled steel one with all joints autogenously welded. The jar walls are corrugated to add strength. The jars or cells are in turn assembled in very light trays for convenience in battery handling.

The leading virtue of the Edison battery is its long life, due to the tube-and-pocket construction of the positive and negative plates which prevents falling out of active material because of vibration, and of heat in charging and discharging. The battery is also much lighter than the other types. The battery will stand very high charging rates and can be discharged at any rate to meet the service without injury. The tube-and-pocket construction permits of this. The battery is sold with a 4-year guarantee on cell capacity and a 1-year guarantee covering the defects in workmanship or material. When fully charged the voltage per cell is 1.85 and to get the required voltage for charging a battery it is necessary to multiply this by the number of cells in the battery. A twenty-four-cell battery requires 45 volts; a sixty-cell battery 111 volts.

Four Types of Exide Batteries

The Electric Storage Battery Company, Philadelphia, Pa., for 1913 offers four types of storage batteries for vehicle propulsion, namely, the Exide, Hycap Exide, Thin Exide and Ironclad Exide. Each type is furnished in various sizes, which depend on the numbers of plates used in each cell of the battery, the various models are classified under the heads MV and PV, according to the plate sizes. Taking up these four types in turn, the exide MV battery comes in eight sizes having seven, nine, eleven, thirteen, fifteen, seventeen, nineteen and twenty-one plates, respectively. No matter how many plates are used the voltage of each cell is the same only the amperage being subject to change, increasing with the total surface of the plates in the cell. The Exide MV sizes just enumerated have respective capacities of 84, 112, 140, 168, 196, 224, 252 and 280 ampere-hours. Exide PV comes in four sizes with five, seven, nine and eleven plates, respectively, the capacities of these batteries being 48, 72, 96 and 120 ampere-hours, respectively. The Exide type of battery is heavier than the Hycap and the Thin Exide types; it is more economical for trips of small mileage, especially if it is to be used on trucks and subjected to hard work. The Hycap Exide type has somewhat thinner plates than the Exide type, but like the latter comes in two plates sizes MV and PV. Nine sizes of MV cells are available, having nine, eleven, thirteen, fifteen, seventeen, nineteen, twenty-one, twenty-three and twenty-five plates, respectively, with capacities of 110, 138, 165, 193, 220, 248, 275, 303 and 330 ampere-hours. The PV cells come in three sizes with nine, eleven and thirteen plates, respectively, resulting in capacities of 93, 115 and 128 ampere-hours. The Thin Exides having, as its name implies, thinner plates than the two preceding types, is furnished in eleven MV sizes, which have from eleven to thirty-one plates, each type having two more plates than the preceding one. The capacities of these batteries vary from 130 to 390 ampere-hours.

thorough overhauling and is therefore ready for work when her turn comes to put to sea again.

MOTORS AND STORAGE BATTERIES.

At the present time all submarines are propelled under water by electric induction motors, the electrical energy being supplied from accumulator cells. Big advancement has been made in the design of the electrical equipment for submarine installation, and especially in the method of control.

The present motors are ruggedly built, have their armatures mounted upon the main shafting of the engines and are well insulated. They are of the interpolar, direct-current, ventilated type, capable of running in either direction and under variable load without adjustment of the brushes. A potential difference of about 70 volts is allowed at the field terminals to provide for speed regulation when running as a motor and for adjustment of voltage when running as a generator. They are often run at an overload of as much as ninety per cent. without injurious heating.

The first controls to be used were plain knife switches. These are now all enclosed to eliminate the danger of sparking, and in some cases oil baths provided. The starters for the main motors are of the contactor type, master-drum control with interlocking features. This type is advantageous in that it permits the location of the control to be had in the most convenient place. Its only drawback is the complexity of its construction, but with the high voltage now handled it has become an absolute necessity. Automatic circuit breakers of the latest type are provided wherever necessary.

STORAGE BATTERIES.

Although the efficiency of the motor has been greatly advanced the problem of the storage battery still remains one of much dissatisfaction and it is quite improbable that the inherent defects of it will ever be overcome.

There are two distinct types of storage batteries in general use at the present time; the first is known as the lead battery and the second as the Edison battery.

The lead battery is the only type that has been used aboard submarines up to the present time. I understand, however, that there is now one, if not more of the boats, having the old batteries replaced by the Edison cells.

The lead batteries, as their names would imply, have active plates of lead material using sulphuric acid of a density of about 1.23 as an electrolyte.

There are several methods of manufacturing the lead plates, the three forms best known being the Planté plate, the Pasted plate and the Ironclad plate, this latter being a particular form of the Pasted plate.

The Planté is manufactured with the lead made into a fine grid which is cast, grooved, or spun in such a way as to afford a large superficial area for the electro-chemical action to take place upon. The grid is then subjected to this electro-chemical process which reduces the exposed lead surface to peroxide of lead for the positive plates and to spongy lead for the negative plates.

The Pasted plate is manufactured by pressing a pasty composition of lead and a small percentage of antimony into the annular spaces of a structural frame formed of network. The plates are then subjected to an electro-chemical process as before, reducing the plates to peroxide of lead for the positive plates and spongy lead for the negative plates.

The Ironclad plates are formed into positive plates only. They consist of hard-rubber compound frames supporting hard-rubber tubes set side by side. The active material is formed by running antimony lead rods full length in the center of the rubber tubes, which are perforated, and otherwise filling in the tubes with red lead. It is then reduced into a positive plate by electro-chemically reducing the material to peroxide of lead.

In the batteries of the submarines the Planté positive plate is used in combination with the Pasted negative plate, or else the Ironclad positive plate is used with the Pasted negative plate; these combinations seeming to give the most satisfactory results.

The Edison storage battery uses nickel oxide as the active material for the positive plates and iron oxide for the active material for the negative plates. The electrolyte used is caustic soda.

The positive plates are made up of a steel frame supporting perforated steel tubes which contain a quantity of nickel hydrates for forming the active material.

The negative plates are made up of two perforated steel sheets forming pockets between them in which is contained iron oxide for the active material.

In addition to the enormous amount of weight, in round numbers about 59 tons, and the valuable space which it occupies, the lead battery is objectionable upon the score of its inherent dangers. There is the ever present danger of explosive gases collecting with the contingent result of battery fires and terrific explosions, the only means of fighting which seems to be to leave the ship and let them burn. There is also the continual danger from the generation of chlorine gas, which is a deadly poison and which is liable to be generated at any time if salt water finds its way to the batteries, and, lastly, the danger to the hull itself from leaking or the slopping over of sulphuric acid which immediately attacks the steel plates of the horseshoe tank, and, unless the installation has been made in such a way as to afford perfect inspection, which is not the general case, the metal is soon eaten through by the chemical action of the acid.

The advocates for the Edison battery are claiming for this type the entire elimination of all these bad features of the lead battery. This, however, is not true, for the Edison battery is quite as liable of generating the explosive gases and having fires as is the lead battery, although it is free from the deadly fumes of chlorine gas and the trouble of the leaking acid.

On the other hand, the lead battery has an average discharge voltage at the three-hour rate of about 1.83 volts per cell, whereas the Edison battery has at the three-hour rate of discharge of but from 1.1 to 1.2 volts. This, then, would mean that with the Edison battery the number of cells would have to be increased about 60 per cent. and would require considerably more floor space.

The weight of the Edison battery is also much higher than that of the lead battery, and this is an all important factor. In view of this fact, then, and that the Edison battery is less than 72 per cent. as efficient as the lead battery, it would seem that to install new equipment that requires more weight and space than that which is already installed, and which therefore must necessarily detract from the efficiency of other factors now contained, would be far removed from the ideals that we are trying to gain in submarine development, because it would be in this case making a sacrifice of other factors and only getting for our trouble a decreased radius of action.

The cost of the Edison battery is much more than the lead battery, but on this score the life of the Edison battery greatly exceeds that of the other, so the price may be conceded to be in favor of the Edison battery, if anything.

For the extra high container which is sometimes furnished (designated by *H* the over-all height for B-type is 2 in. greater and for A-type 3 in. greater than the figures given in the above table.

The over-all height with filler cap open is about 1½ in. greater than the height with filler cap closed.

If a battery is to be used for stationary service a clearance of 6 in. above cells should be allowed so as to permit the proper filling of the cells in place. In vehicles from which the battery is removed for filling the clearance need be only ¾ in.

OPERATION.—An Edison battery should never be operated in any manner except in accordance with the instructions received from the Edison Storage Battery Co. Disobeying these instructions may result in forfeiture of the guarantee with regard to the life of the cell. As the detailed instructions differ somewhat for various services, only general directions which apply to all services are noted below.

Charging. — The batteries are now usually shipped in a charged condition. The initial charge should continue for 12 hours at the normal rate. A similar overcharge should be given after 30 days of service, one after 60 days of service, and another after each renewal of electrolyte. The normal charging rates are given above in the section on *Rating and Performance;* the time of a normal charge is 7 hours. The boosting rate may be as high as desired provided the temperature does not exceed 115° F. in any of the cells. The best results are obtained when the temperature is kept between 75 and 95° F. Under average operating conditions the charge in ampere-hours necessary to replace a discharge is from 15 to 25 per cent greater than the discharge. The Edison Storage Battery Co. recommends that if an ampere-hour meter is used, it should be set to operate 20 per cent slow on charge.

Precautions as to Gases. — The battery should be well ventilated while charging, and no open flame or arcing contact should be allowed near the cells while charging or immediately afterward, as the evolved gases may be exploded.

Standing Idle. — An Edison battery may be allowed to stand idle in any state of discharge provided the level of the electrolyte is kept above the plates. After long idleness an overcharge may be required to bring the battery up to rated capacity.

Watering Cells.—The level of the electrolyte must be kept above the plates by adding distilled water from time to time. The frequency of adding water will depend upon the amount and rate of charging. The manufacturers of the battery supply an indicating filler which is of assistance in preventing slopping and over-filling.

Cleaning. — The trays and containers must be kept dry, and dirt or other foreign material must not be allowed to collect between or under cells. Dirt and dampness may cause leakage which may result in corrosion of the containers. The outside of the cans may be cleaned with a steam or air blast. If a container becomes leaky it should be returned to the manufacturer for repair.

DIMENSIONS, WEIGHT AND COST. —The Edison battery is made in two standard types, the plates of the A-type being approximately 4¾ by 9¼ in and those of the B-type 4¾ by 4⅝ in. Plates of other dimensions can be obtained for special purposes. The sizes of cells are commonly designated by the type letter and a number which indicates the number of positive plates, as for instance, an A-6 cell has 6 positive and 7 negative plates. The several sizes of cells together with data on the dimensions and weight of each are given in the following table:

DIMENSIONS AND WEIGHTS OF EDISON CELLS

Size of cell	Over-all dimensions of cell, in inches			Weight in pounds	
	Length	Width	Height	Complete cell	Average per cell with trays and connectors
B-2	1.5	5.1	8.8	4.6	5.5
B-4	2.6	5.1	8.8	7.4	8.7
B-6	3.8	5.1	8.8	11.0	12.0
A-4	2.7	5.1	13.4	13.3	14.5
A-5	3.2	5.1	13.4	16.8	18.5
A-6	3.8	5.1	13.4	19.0	21.0
A-8	5.0	5.3	14.0	27.0	30.0
A-10	6.2	5.5	14.0	34.0	37.5
A-12	7.4	5.5	14.6	41.0	45.0

For services, such as the lighting of railroad cars, which require that the batteries work for long periods without the addition of water, the A-type plates are assembled in containers (designated by H) about 3 in. higher in each case than those indicated in the table, in order to obtain additional space above the plates for the electrolyte. The weight per cell is then about 15 per cent greater than the above.

Before the war the cost of Edison cells assembled in trays was approximately $0.91 per pound, including weight of trays and connectors. This is equivalent to a cost of approximately $410 per kilowatt at the normal (5-hour) rate of discharge or $105 per kilowatt at the one-hour rate of discharge. The manufacturers guarantee that these cells will show at least their rated capacity after being used a specified time, the usual guarantee period for A-type cells being at least 4 years and for B-type cells, at least 5 years.

BIBLIOGRAPHY. — Crocker and Arendt, *Storage Batteries;* Holland, W. E., *Effect of Low Temperature on the Alkaline Storage Battery,* Central Station, Nov., 1911; *The Edison Storage Battery, Its Conception and Method of Manufacture,* Com'l Car Jour., Jan., 1914; Turnock, L. C., *Preparation of the Active Materials and Electrolytes of Alkaline Accumulators,* Met. and Chem. Eng., 15, p. 259, Sept., 1916; Publications of the Edison Storage Battery Co., especially *The Edison Alkaline Storage Battery* (1919).

BATTERIES, STORAGE, APPLICATIONS OF. — (*See also Ba teries, Storage, Alkaline Type; Batteries, Storage, Lead Type.*) The followi list shows some of the more important applications of storage batteries; the are briefly treated in the following pages.

Central Stations:

- Emergency reserve — "Stand-by service."
- Load or voltage regulation.
- Taking peaks.
- Day load on small systems.
- Exciter reserve.
- Remote-control switch operation.

Isolated Plants:

- Mine hoists, steel mills and other heavy motor regul tion; see Index.
- Carrying entire load during certain hours of light load.
- Load and voltage regulation in office buildings or hotel where electric elevators are in service.
- Giving 24-hour service in residences.
- Operation of drawbridges.

Other uses are:

- Regulation of long feeders; see *Trolley Systems, Ove head.*
- Propulsion of pleasure cars, trucks, street cars, sul marine boats, launches, industrial trucks and tractor mine, and industrial locomotives, etc.
- Gas-engine ignition.
- Railway passenger-car lighting; see *Lighting of trains b Electricity.*
- Railway signaling, see *Signaling, Railway.*
- Telephone and telegraph (q.v.).
- Portable and small stationary lamps.
- Fire and burglar alarm (q.v.).
- Electroplating.
- Dental and other surgical work.
- Automobile starting, lighting and ignition; see *Ignition Electric; Starting and Lighting Systems for Automobile*

Extent of Application in the United States. — The first applicatio in America of storage batteries to central-station service was in 1886. In 192 there were in service in the United States, for central-station "stand-by" wor 193 storage batteries of the lead-lead acid type, having a combined capacity o approximately 177,000 kw-hr. at the one-hour rate of discharge. Most of thes are of the Faure or Pasted type, some are of the Planté type, or a combinatio of Planté and Faure types.

There were in service in the United States in 1920 approximately 700,00 cells of the lead-lead acid type, operating telephones, lighting railway cars and operating signals.

At the end of 1920 there were in operation lead batteries for other uses approxi mately as follows:

For automobile, starting lighting and ignition 15,000,000 cells aggregating approximately 3,000,000 kw-hr.

For farm lighting plants 3,000,000 cells aggregating 1,000,000 kw-hr.

For electric passenger cars, street trucks, mine and industrial locomotives industrial trucks and tractors, 1,166,000 cells aggregating 444,000 kw-hr.

by Charles William Taussig - Radio - 1922 - 447 pages
Page 143
The electrolyte of an **Edison battery** is **made** from a 20% solution of potassium hydroxide in distilled water, with a small percentage of lithium hydroxide **...**

Railway Age - Page 13
Railroads - 1935
Outstanding reliable performance is the chief characteristic of the **Edison Battery**. No other **battery made** in this country can compare with it — because none **...**

A Word about the Edison Battery.

In this article we cannot do otherwise than confine our attention to batteries of the usual lead pattern, since we have had no personal experience with cells of the nickel-steel variety, such as the Edison, and it is as yet impossible to obtain anything but the most conflicting evidence concerning what these batteries have actually proved themselves to be capable of doing in the hands of commercial vehicle users. So much has, however, been said at various times about the marvellous, and very revolutionary, possibilities of the Edison battery, that a few words should nevertheless be devoted to the subject. Already a fully-illustrated description of the cells themselves has appeared in THE AUTOMOTOR JOURNAL (on January 2nd, 1904, p. 12), and as far as we are aware no very radical changes have since then been made in the construction. We understand that special plant is now in use both in America and in Germany for turning out the batteries in large numbers, so that doubtless at an early date we shall be able to give our readers some reliable information about them. In composition they differ radically from those of the lead-lead kind, for not only are the plates made of nickel and of iron, with active material of the oxides of those metals, but, instead of being immersed in an acid electrolyte, the liquid employed is a strong alkaline (potash) solution.

Very exaggerated reports have received circulation as to what the Edison battery will do if it comes up to expectations, for not only is it popularly supposed to be more durable than any other form of accumulator, but many people believe that its relative weight and size will offer considerable advantages. As a matter of fact, however, its weight in relationship to its capacity is very much about the same as other traction-batteries, while the space which is occupied by it (in its present form) is a good deal in excess of that needed by a lead battery. Its superior merits, if any, can, therefore, only depend, to any very marked extent, upon its greater hardiness and longer life, since, apparently, its cost of construction must essentially be higher. Durability of accumulators is, as we have shown, quite one of the most important points connected with the electric vehicle problem, and consequently the Edison battery will still be watched with very great interest, however much it may be regretted by everyone that the word "revolution" has been used when speaking of its possible effect upon road traction.

Improved Prospects for Electric Traction.

It cannot be said that any very radical improvements have been made of recent years in the construction or design of batteries when regarded on broad principles, and therefore it can hardly be maintained that the electric vehicles of to-day differ materially from those which failed to prove their commercial utility in this country formerly. The position has, however, undergone a marked change for the better, with the result that the future prospects of the electric vehicle, *in certain spheres*, are unquestionably brighter now than they ever have been previously. This is due, in part, to the reduced cost at which the plates can now be manufactured—raw material being cheaper and works management more efficient—and to some extent, it results from the vast strides that have been made throughout the entire automobile industry in reducing frictional losses by the use of accurate ball-bearings, and by all-round improvement in the design of transmission mechanisms. The vehicle of to-day runs much more easily than it did, and requires less energy to start it moving, so that on this score alone the capacity of the accumulators, and therefore their weight, on an electric car does not need to be as high as it used to be; nor are the strains as heavy upon the battery. Above all, however, the chances of success have been greatly improved by the special knowledge which has been acquired as to how the battery should be treated when used for vehicle propulsion, and as to the precise demands which are made upon it under different conditions of working. These things, as we have already indicated in previous paragraphs, have been studied in all their complex details by one or two of the leading battery makers, as well as by a few persevering concerns who have bought their experience more or less dearly, so that a small handful of men now exist whose experience is invaluable and essential. They, and they alone, can make a close estimate in advance as to what the working expenses should be under any particular condition of operation that may be placed before them; they, and they alone, can say whether a certain type of machine—a 5-ton lurry, a 2-ton van, a light delivery van, or a hackney cab—could or could not be run economically in any individual locality; and it is only under their close personal supervision that profitable working can subsequently be ensured.

Another contributory influence tending towards cheap electric traction in London—and the same may be said about a few other large cities—is the very much lower cost of electricity from the large central supply stations. It is not so many years since *4d.* per unit was deemed to be a very reasonable price for current, whereas *1d.* per unit is now almost equally high. Several special quotations have, to our knowledge, been given recently by some of the big supply companies for electricity at an even lower figure than that. Needless to say, this item alone has a very substantial bearing on the working costs of electric cars.

Some Sample Practical Figures.

Turning now to some actual figures, showing how totally dissimilar may be the conditions under which different types of vehicle have to work in practice, and showing, too, how great an effect speed may have upon the working expenses of the batteries, we cannot do better than quote some of those obtained by us recently from one of the Electrobuses in regular service in London, and from a delivery van operating in the Metropolitan district. For the moment, it will be unnecessary to describe the construction of either vehicle, or to refer in detail to the precise types of accumulator employed. Suffice it to say, therefore, that the Electrobus weighed about 7 tons all told (the battery representing about $1\frac{1}{2}$ tons), that the route over which it was run was that between Victoria and Liverpool Street Stations—the only gradients of any moment being at the top of Whitehall (Charing Cross) and on either side of Ludgate Circus—and that ammeter readings were taken at 5-second intervals during the entire double journey (about 8 miles). Similarly, it should be stated that the van, with its $2\frac{1}{4}$-ton load, weighed close upon 5·2 tons (of which about 1 ton represented the battery), and that a full-discharge run was made of $31\frac{3}{4}$ miles through South London to Balham, Clapham Junction, Clapham Common, and Chelsea, and through North London to Kilburn, Cricklewood and Welsh Harp. On both days, the weather was wet and the roads were heavy, so that all the readings are probably perceptibly higher than they would have been on a dry day.

action is completely reversed. The negative O ions are attracted to the positive Ni_2O_3 and the higher oxide NiO_2 is reformed while the positive H ions are attracted to the negative FeO and reduce it to iron

$$Ni_2O_3 + FeO = 2NiO_2 + Fe$$

the result of charge and discharge is a transfer of oxygen from one plate to the other; the strength of the electrolyte is not changed so that the quantity required is less than for an equivalent lead cell.

After the battery has been completely charged, the hydrogen and oxygen appear as gases which bubble up through the electrolyte just as in the lead cell.

187. Construction of the Plates.—The positive or nickel plate shown in Fig. 173 consists of a nickel-plated steel grid carrying perforated steel tubes, one of which is shown in diagram B. These tubes are heavily nickel plated and are filled with alternate layers of nickel hydroxide and flaked metallic nickel. The hydroxide is acted on electrochemically and becomes nickel oxide. This oxide is such a poor conductor of electricity that the flaked nickel is added to bring the inner portions of the oxide into metallic contact with the surface of the tubes and thereby reduce the internal resistance of the cell.

Each tube has a lapped spiral seam to allow for expansion, and is reenforced with steel rings to prevent the tube from expanding away from and breaking contact with the enclosed active material.

The negative or iron plate shown in Fig. 173 consists of a nickel plated steel grid holding a number of rectangular pockets filled with powdered iron oxide. Each pocket is made of two pieces of perforated steel ribbon flanged at the side to form a little flat box which may be filled from the end.

188. Construction of an Edison Battery.—A number of like plates are connected in parallel to form a group, there being one more plate in the negative than in the positive group. Two sets of plates are then sandwiched together as shown in Fig. 174, adjoining plates being separated from one another by strips of hard rubber. End insulators *A* are provided with grooves which carry the edges of the plates, and thereby act as spacers and at the same time insulate the plates from the steel tank. The outside negative plates are insulated from the tank by sheets of hard same material and is welded to the rest of the tank after the plates have been put in place. This cover carries two terminals, as well as a combined gas vent and filling aperture *A*. When the cover *b* is closed, the hemispherical valve *a* closes the aperture and prevents the escape of electrolyte, but allows the gases generated on overcharge to escape as soon as the pressure in the tank becomes high enough to raise the valve.

The electrolyte used consists of a 21 per cent. solution of potash in distilled water to which a small amount of lithia is

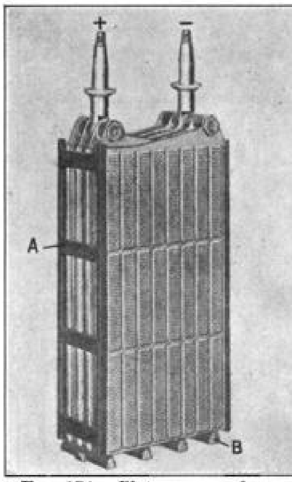


FIG. 174.—Plate groups of an Edison cell.

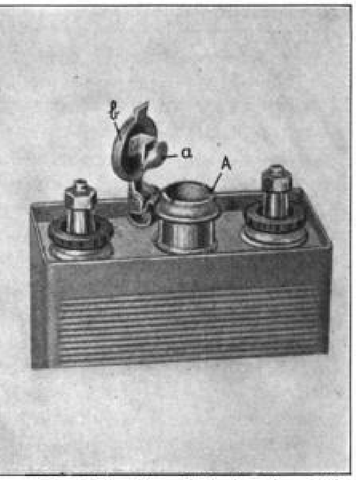


FIG. 175.—Top of the jar of an Edison cell.

added. No corrosive fumes are given off from this electrolyte so that no special care need be taken in mounting the cells.

189. The Voltage of an Edison Battery.—Fig. 176 shows how the voltage of an Edison battery changes when the battery is charged and then discharged. The voltage characteristics are similar to those of a lead battery.

There is no lower limit to the voltage of an Edison battery because in it there is nothing eqivalent to sulphation, but discharge is not continued below a useful lower limit.

190. Characteristics of an Edison Battery.—These batteries are rated at a 7-hour charging rate and a 5-hour discharge rate with the same current in each case, the ampere-hour efficiency being about 82 per cent. at this rate and the internal heating not more than permissible. A higher rate of discharge may be used so long as the internal temperature does not exceed about 45° C.; continual operation at higher temperatures shortens the life of the cell. A longer charge rate than 7 hours should not be used because, with low currents, the iron element is not completely reduced; this however does not permanently injure the cell but makes it necessary to overcharge the cell at normal rate and then discharge it completely to bring it back to normal condition.

Because of the comparatively high internal resistance of the

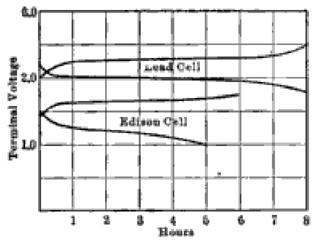


FIG. 176.—Charge and discharge curves of a lead cell and an Edison cell.

Edison battery, the volt efficiency is lower than in the lead cell, as may readily be seen from Fig. 176, and, since the ampere-hour efficiency is not any higher, the watt-hour efficiency of the Edison cell is also lower.

The great advantages of the Edison cell are that it is lighter than the lead cell and is more robust, it can remain charged or discharged for any length of time without injury, and so little sediment is formed that the makers seal it up. Since no acid fumes are given off, the cell may be placed in the same room as other machinery without risk of corrosion of that machinery.

The chief disadvantage of the Edison cell, in addition to its high cost, is that its efficiency is lower than that of the lead cell.

purposes we are confronted with the difficulty that it is impossible to operate it at high power outputs. This is on account of the high internal resistance. A 50-ampere-hour lead battery of three cells will weigh about 45 pounds, compared to about 37 pounds for a four-cell Edison battery of the same capacity. It is not an uncommon practice to take as much as 135 amperes from a lead battery of this size with a terminal voltage of 5.2. The output is then $5.2 \times 135 = 702$ watts, or 0.94 horsepower. The internal resistance of the Edison battery is such that it would be entirely out of the question to provide a battery which would yield this same power with the same voltage drop; i.e., at the same efficiency. If we decide to allow a much greater drop we might use the Edison A-6 cell. This has an internal resistance of about 0.0024 ohm per cell. If we should take 194 amperes from four of these cells in series the drop due to internal resistance would be about 1.9 volts, giving a terminal voltage of about 3.62 volts. The power would be the same as before, or 702 watts. The weight of the four Edison cells would be 80 pounds, or nearly double that of the lead cells. The watt hour efficiency would be quite low.

An even more serious difficulty is the fact that the starting torque of the motor with the Edison cells would be far less than that with the lead cells. Thus the resistance of the motor used with the above cells would be about 0.0085 ohm. The internal resistance of the cells would be 0.0096 ohm and the current in case the motor did not start at once would be about 310 amperes. The internal resistance of the lead cells would be only about 0.006 ohm and the starting current would be 415 amperes. Since the starting torque increases even faster than in proportion to the current it will be seen that the starting torque with the lead cells would be about 35 per cent. greater than with the Edison battery. Thus the "leeway" or the "factor of safety" is considerably less with the Edison battery and the lead plate type is generally employed in starting systems.

Comparison of Two Unit and Single Unit Outfits.—Since most of the outfits in use to-day fall within one or the other of these two classes a somewhat detailed comparison of their charsist of thin sheet copper covered with an amalgam of zinc, and the positive plates are made up of laminæ of lead held together by leaden rivets and perforated with numerous small holes, these positives being formed by the Planté process.

Waddell-Entz Accumulator. The copper-alkali-zinc primary battery of Lalande, Chaperon and Edison being reversible in action, can be used as a storage battery. Waddell and Entz have constructed accumulators on this principle. When discharged, the positive plate consists of porous copper; the electrolyte is decomposed, metallic zinc being deposited on the negative plate, the porous copper of the positive plate is oxidized, and the liquid

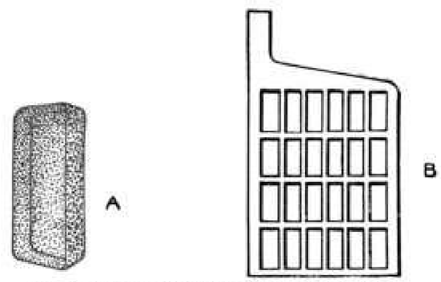


Fig. 8. Construction of Edison Battery Plate.

becomes converted into a solution of caustic potash (potassium hydrate).

This storage battery has been used with considerable success for traction purposes, but its E. M. F. is so low, being only about .7 volt, that it would require 170-180 cells for the ordinary 119 volt electric-lighting circuit, allowing for loss of potential in the battery and conductors. This number is three times as great as is required with the lead battery. This is a serious objection in this or any other low voltage cell.

The Edison Storage Battery manufactured by the Edison Storage Battery Company of Newark, N. J., consists of a positive plate of super-oxide of nickel (NiO_2) and a negative plate of iron, suspended in about a 20 per cent solution of caustic potash (KOH).

The mechanical construction of both plates (positive and negative) is the same, and the grids are made of nickel-plated steel, shaped as represented at B, Fig. 8. Each opening in the grid is filled with a perforated shallow pocket A or box of nickel-plated steel which contains the active material, and projects out beyond the body of the grid.

The active material is made up in the form of briquettes; one briquette being placed in each pocket. A perforated cover of nickel steel is placed over each pocket. After the plates are fully assembled they are subjected to a pressure of about 100 tons,

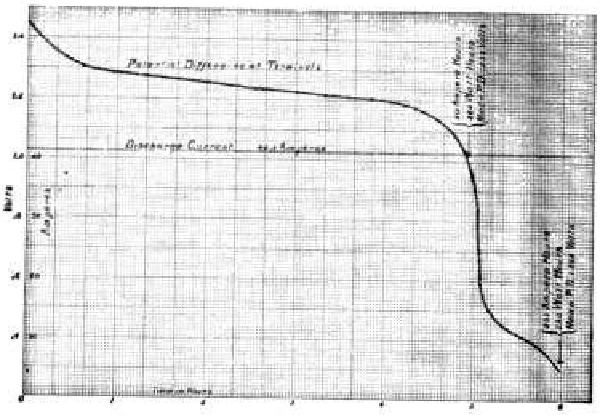


Fig. 9. Curve of Voltage of Edison Cell During Discharge.

which firmly forces all parts into a practically solid mass, making good electrical contact between the pockets and the grid, at the same time turning the edges of the pockets over their respective covers. The active material or briquette consists of a finely divided compound of nickel mixed with about an equal amount of flaked graphite, for the positive plate, and for the negative plate it consists of a finely divided compound of iron, with an equal amount of flaked graphite. This graphite has no chemical connection with the action of the cell but is used simply to increase the conductivity of the briquettes.

The finished plates have a thickness of about $\frac{1}{40}$ inch across the web, and across the pockets of about $\frac{1}{10}$ inch.

The size of the plate varies with the capacity of the cell, having a greater or less number of pockets. The containing jar is also made up of nickel-plated steel sheets.

The initial voltage of discharge after recent charge is 1.5 volts.

The mean voltage of full discharge is 1.1 volts.

This cell has an energy capacity or weight efficiency of 14 watt-hours per pound of complete cell.

Charging and discharging rates are alike, that is to say, the cell may be charged at a normal rate in $3\frac{1}{2}$ hours; or it may be charged at a high rate in one hour, without apparent detriment beyond lowering the efficiency.

The current enters the cell at the positive plate and oxidizes the nickel compound to the peroxide state, and reduces the iron compound to spongy iron.

The electrolyte in this cell simply acts as a path for the passage of the oxidizing and reducing irons, and its own chemical composition does not change.

The cell is not appreciably influenced by changes in temperature. It is claimed that it may be fully discharged to the zero point of E. M. F. without injury, can be charged in reverse direction, then recharged to its original condition and suffer no loss in its storage capacity. The curve given in Fig. 9 shows a six hour discharge of an experimental cell, at a constant current of 42.5 amperes.

MANAGEMENT OF STORAGE BATTERIES.

In describing the handling of storage batteries, the various types of lead cells will be considered, as they constitute a very large majority of cells in commercial use.

The Battery Room. In the installation of a battery, the first point to be considered is its location. The room for this purpose should be dry, well ventilated and of a moderate temperature, otherwise the evaporation of the electrolyte will be excessive. The floor, walls and ceiling must be of some acid proof material, brick or tile being preferable, and the floor so made as to drain readily; an outlet being provided for the drainage system. If the room should be an old one, and have a wooden floor, the floor should be coated with asphaltum paint, and lead trays placed below the batteries; any wood work or iron work in the room should be likewise treated.

The room should be sealed from the rest of the building, and located near the generating machinery and distribution switchboard, so that the copper cables may be low in cost. The windows in the battery room should be either of ground or painted glass, so that no direct rays of the sun may strike the cells, as the heat may crack the cells (glass) or increase the activity of the acid, which is not desirable.

In case the battery installation is in a cold climate, some device for keeping the electrolyte at a moderate temperature must be used. A simple plan is to suspend an incandescent lamp in the

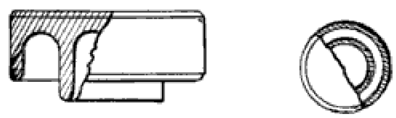


Fig. 10. Glass Insulator for Battery Support.

cell and have it connected to some automatic device which will put it out when the electrolyte is at the desired temperature or light it when the electrolyte is too cold.

Setting up the Cells. The battery is usually placed on the floor, or upon strong wooden shelves; Fig. 11 shows a form adapted to cells of medium size. Iron stands are sometimes used for large and heavy cells, but they must be protected from acid fumes and drip by several coats of an acid-proof paint. Wooden stands should be varnished, painted or soaked in paraffin for the same reason. It is important to have every cell accessible for inspection, cleaning and removal, it being desirable to reach both sides of the cell. There should also be sufficient head room between shelves so that the elements may be lifted out.

It is highly important that the cells be thoroughly insulated from each other, to avoid leakage of current. This is accomplished by standing each cell on four insulators of porcelain or glass of the design shown in Fig. 10. Porcelain is preferable to

Edison Battery. No description of the storage battery would be complete, however, without at least a mention of the Edison battery, as it marks the first successful attempt to get away from the use of lead. Much misconception exists regarding the status of this battery and this has been due to a variety of causes. In the first place Mr. Edison was misled into placing it on the market prematurely through depending entirely upon electric vehicle makers for his knowledge of vehicle conditions. At that time, the electric was an extremely crude machine, and its abilities fell very far short of what its builders usually claimed for it. The Edison battery was designed to run the car of the builder's claims—this imaginary vehicle that existed nowhere else than in his mind, and it consequently proved a disappointment when applied to the running of the car that did exist. In view of the vast number of inventions for which he has been responsible, Mr. Edison's name is a fetich to the public where anything electric is concerned. He was besieged with newspaper reporters the moment the new battery was announced, and all kinds of impossibilities were predicted of it by the reporters, many of the alleged interviews never having taken place at all. From time to time, these stories were republished, frequently with added exaggerations, so that the public was sadly misled.

Even in its original state, the Edison cell gave great promise and there is no reason to believe that this will not be carried out. It has been the constant subject of study and development on the part of Mr. Edison since that time, and meanwhile, electric vehicle conditions have been brought to a somewhat closer approach to the rosy description of the makers several years ago. The Edison cell has been in constant use on a number of commercial vehicles ever since it was first introduced and it is now being manufactured on a large scale for general use. As it differs totally from the lead cells already described, a little information concerning its construction will be of interest.

Nickel-plated sheet steel is not only used as the container, or *can*, as it is called, but is also the material of which the grids are composed. The active material of the positive electrode consists of alternate layers of nickel hydrate and pure metallic nickel in flakes, the latter to serve as the conductor. This material is held in small perforated tubes, a number of which are forced into the sheet steel grid. They stand vertically and parallel. A nickel-plated sheet steel grid also forms the foundation of the negative electrode, into which a number of flat perforated metal pockets containing iron oxide are pressed. The electrolyte is a 21-per cent solution of caustic potash in distilled water. The voltage of the cell is only 1.25 volts, but its construction is so very much lighter than the lead cell, that there is a saving in weight in a battery of Edison cells when compared with a lead battery of the same voltage and capacity, despite the added number of the former required to give the same potential. Its active life in service is said to be much longer and it will stand more abuse than the lead cell, not being damaged through standing discharged. As it will doubtless prove a factor of importance in the electric vehicle business now that it has been placed on the market generally, it is something about which the owner of an electric should be informed.

The perennial appearance of the "fake" storage battery announcements in the daily papers doubtless does more to injure the interests of the builder of electric automobiles than any other single cause. Investigation of the subject would reveal the fact that progress thus far has not gone beyond the point where it is practicable to run a vehicle more than 100 miles on a single charge. Assuming favorable conditions, the low average may be set at 40 miles, so that electric automobiles of the pleasure type in daily use may be rated as capable of 60 to 70 miles on a charge, as a whole. But the prospective purchaser of an electric who will not take the trouble to look into the matter a bit and who gulps down the newspaper story as gospel truth is extremely reluctant to invest in a 60-mile car, when he sees published accounts of world-revolutionizing batteries with a 200-mile radius.

According to the imaginative and technically ignorant reporter, these world-beaters "weigh hardly anything and only need a connection with any old electric wire to renew their marvelous store of energy in a few minutes." These stories are of the same ilk as those that predict the utter exhaustion of the world's coal supply in the next ten thousand years, except that no one takes the latter seriously, while many are waiting for the materialization of the miraculous battery. The electric vehicle is an excellent investment for city use as it is, and just now central electric lighting and power stations batteries were serviceable for 9 or 10 years with negligible replacements. The best results have been obtained with batteries which were not overcharged. The increased capacity of axle-generator equipments of recent years has resulted in greatly overcharging batteries, with a serious shortening of their life.

Overcharge of these batteries requires that water be added frequently, and if this is not carefully done the insulation of the tanks is injured. Overcharge also results in a greater deposition of sediment from positive plates and a shortening of their lives.

209. Frequency of cleaning. Train-lighting batteries which are properly charged can be kept in operating condition for 3 years without being opened up for cleaning. After cleaning the first time such batteries should be cleaned at intervals of 2 years. With many railroads the practice is to make the first cleaning 2 years after placing in service, with subsequent intervals of 1 year between cleanings.

ALKALINE STORAGE BATTERIES

210. Classification. There are but two practical types of alkaline storage batteries in commercial use: one is the Hubbell, used in the miners' lamps of the Portable Electric Safety Light Co.; the other is the Edison storage battery.

211. The Hubbell battery differs from the Edison in principle, only in using a negative plate of cadmium instead of the iron of the Edison battery. Hubbell apparently was the first to use nickel threads incorporated in the nickel-oxide active material, and this is one of the essential steps in the production of a practicable battery plate with this active material. The nickel oxide of the original Edison battery, contained flake graphite to increase the conductivity; the graphite was seriously affected by electrolyte action, and these plates were short lived. In the present type of Edison battery, flake nickel replaces the graphite of the earlier type. In December, 1914, the first few of these batteries had completed 5 years of service.

212. Theory of the Edison battery. The active materials of the Edison battery consist of nickel peroxide for the positive plate and finely divided iron for the negative plate. The electrolyte is a 21 per cent. solution of potassium hydrate in water to which is added a small amount of lithium hydrate. To overcome the passivity of iron a certain amount of mercury is incorporated with the iron of the negative plate; a suitable compound is also incorporated with the nickel hydrate which is the salt from which the nickel peroxide is electrolytically formed. The nickel oxide is a relatively poor electrical conductor and, for this reason, layers of flake nickel are added in the mass to increase its conductivity. Catalysis plays a large rôle in the action of the Edison battery. A complete and correct theory of these reactions has probably not yet been given. Essentially, however, it is the following:

$$8OH + 3Fe = Fe_3O_4 + 4H_2O \quad \text{(Negative Plate)} \quad (11)$$

$$8K + 6NiO_2 = 3Ni_2O_4 + 4K_2O \quad \text{(Positive Plate)} \quad (12)$$

$$8KOH + 6NiO_2 + 3Fe = Fe_3O_4 + 2Ni_3O_4 + 8KOH \quad \text{(Both Plates)} \quad (13)$$

or,

$$6NiO_2 + 3Fe = Fe_3O_4 + 2Ni_3O_4 \quad (14)$$

The above formula, read from left to right, indicates discharge; read in the reverse direction, it indicates charge.

Both the iron and nickel oxides probably do not exist as such, in the electrolyte, but are hydrated. In the charge of the battery, potassium is not deposited, and there are none but concentration changes in the electrolyte in the pores of the active materials. There is no appreciable change in electrolyte density from the charged to discharged state of the Edison battery. At the latter end of charge a higher oxide of nickel is formed, which is unstable on standing. This oxide decomposes to NiO_2 with time. A freshly charged Edison battery shows a higher voltage on discharge than one which has been standing.

213. Positive-plate construction. The positive plate consists of a nickel-plated steel frame into which are pressed perforated tubes filled with alternate layers of nickel hydrate and metallic nickel in very thin flakes. The tube is formed from a thin sheet of steel, nickel plated and perforated, and has a spirally lapped joint. The active material is tamped into the tubes, nickel hydrate and nickel flake being fed alternately and the tubes when filled have their ends pressed together in such a way to permit them to be mounted in the frames. The tubes have small steel bands slipped over them

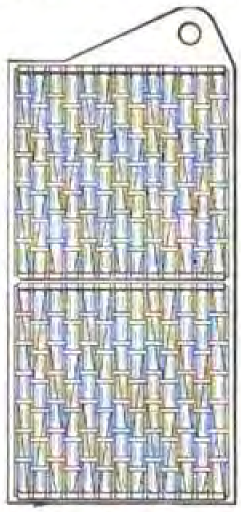


FIG. 51.—Edison positive plate.

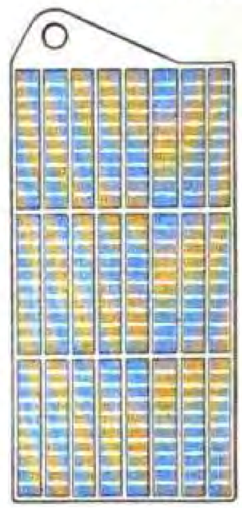


FIG. 52.—Edison negative plate.

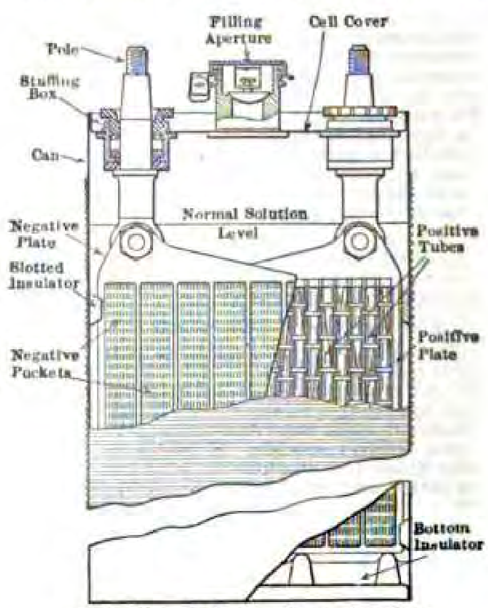


FIG. 53.—Edison cell construction.

to prevent expansion away from the active material. Such a plate is shown in Fig. 51.

Type of cell	B-2	B-4	B-6	A-4	A-5	A-6	A-8	A-10	A-12
No. positive plates	2	4	6	4	5	6	8	10	12
No. negative plates	3	5	7	5	6	7	9	11	13
Weight (lb. per cell)	4.6	7.4	11.0	13.3	16.8	19.0	27.0	34.0	41.0
Capacity (amp.-hr.)	40	80	120	150	187.5	225	300	375	450
Charge amp. for 7 hr.	7.5	15	22.5	30	37.5	45	60	75	90
Discharge amp. for 5 hr.	7.5	15	22.5	30	37.5	45	60	75	90
Avg. volt per cell discharge at above rate	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Amp.-hr. efficiency	82	82	82	82	82	82	82	82	82
Watt-hr. efficiency	60	60	60	60	60	60	60	60	60
Watt-hr. per lb. of cell	10.4	13.0	13.7	13.3	13.4	14.1	13.1	13.2	13.2

215. Negative-plate construction. The negative plate comprises a grid of nickeled steel with oblong openings into which are placed perforated steel boxes or pockets containing finely divided iron with mercury. See Fig. 52. These boxes are assembled in the grid and subjected to pressure to weld the joints and to corrugate their surfaces. The iron is precipitated as a chemical compound and the nickel hydrate and this iron compound are converted electrolytically to nickel peroxide and metallic iron respectively, in the forming of plates.

216. The assembly of the cell is shown in Fig. 53. The plates are supported on hard-rubber spacing and insulating pieces. The lugs of the plates are punched and are mounted upon a steel pin with a terminal post. The ends of the pins are threaded and the plates, separated by washers, are held together by steel nuts. The elements are contained in a nickel-plated sheet-steel case, the walls of which are corrugated to add stiffness and also to assist in cooling the cells in action. The cover also is of

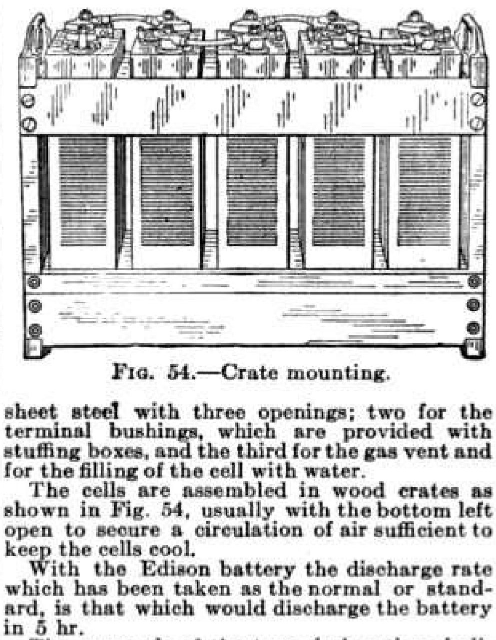


FIG. 54.—Crate mounting.

sheet steel with three openings; two for the terminal bushings, which are provided with stuffing boxes, and the third for the gas vent and for the filling of the cell with water.

The cells are assembled in wood crates as shown in Fig. 54, usually with the bottom left open to secure a circulation of air sufficient to keep the cells cool.

With the Edison battery the discharge rate which has been taken as the normal or standard, is that which would discharge the battery in 5 hr.

The numerals of the type designations indicate the number of positive plates in a cell, and each positive plate of the vehicle size is capable of giving 7.5 amp. for 5 hr.

217. Charge and discharge curves. The characteristic normal charge and discharge curves for an Edison battery are given in Fig. 55. It will be noted that the average voltage on discharge is approximately 1.2 volts; the initial open-circuit voltage is approximately 1.5

volts, and the final voltage at the end of discharge is approximately 1 volt. The first part of charge shows a characteristic voltage rise, and there is a subsequent decrease in voltage with continued charge, followed by another rise. There is no extremely sharp rise in the final voltage of the Edison cell, and it is therefore somewhat difficult to determine the end of

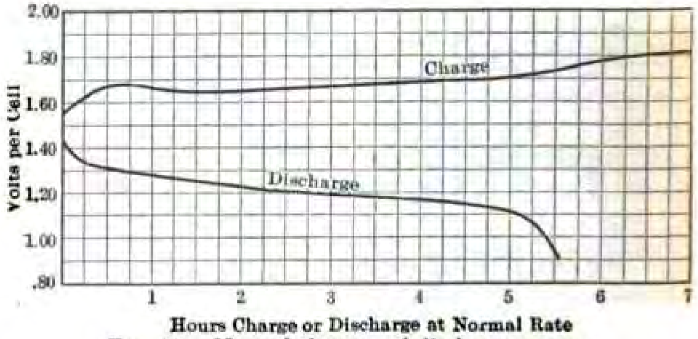


FIG. 55.—Normal charge and discharge curves.

charge. If an Edison cell is known to have been considerably discharged, it is always well to continue the charging current for the full 7-hr. period, as the battery is not injured by overcharge unless the temperature passes a critical point.

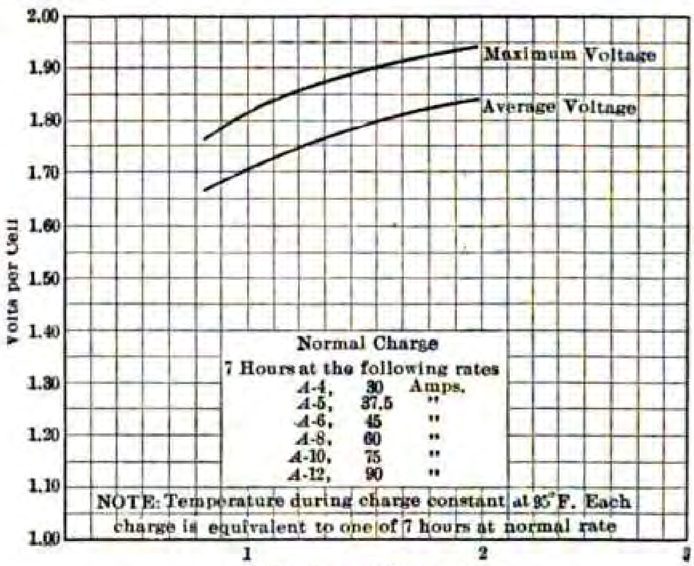


FIG. 56.—Temperature influence on charging voltage.

218. Charging curves. Maximum and average voltages of charge as influenced by charging rate, are shown in Fig. 56. In these curves, the cell is presumed to have a constant temperature of 95 deg. Fahr. and the duration of charge is 7 hr. The voltage on charge decreases considerably with increasing temperatures.

219. Characteristic discharging curves. Characteristic discharge curves for Edison type "*A*" cells are given in Fig. 57. It will be noted that the ampere-hour capacity of an Edison cell does not suffer very greatly with increasing discharge rates, if the terminal voltage be carried low enough. For practical purposes, however, the last portion of the discharge at high rates would have no value because of its great falling off from the open-circuit voltage.

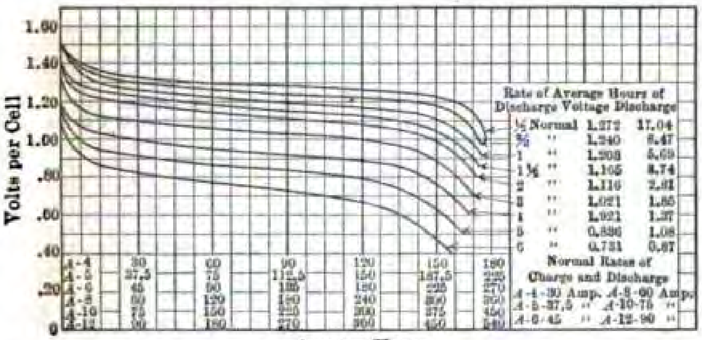


FIG. 57.—Typical discharge curves, type "*A*" cells.

220. Standing discharged. No injury is done to the Edison battery if it is completely discharged and allowed to stand in this condition. This is one of the principal distinguishing features of the Edison battery. The cell, however, loses in capacity by standing as shown in Fig. 58, and is most easily brought back to its condition of full capacity by giving it a very considerable overcharge. The usual practice is to ship the Edison battery in a discharged condition, and it requires several cycles of charge and discharge to bring it to its full capacity.

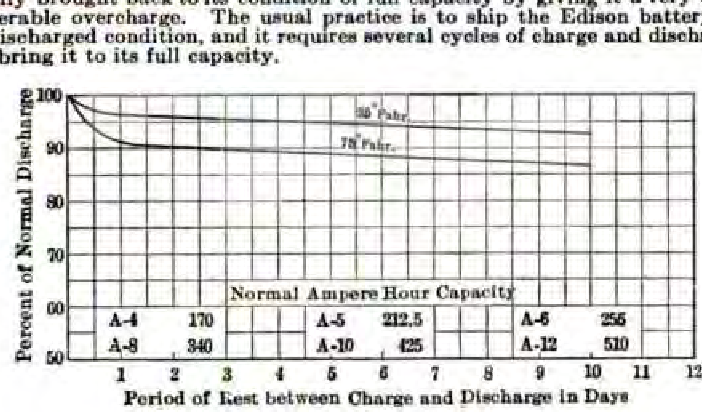


FIG. 58.—Loss of capacity.

221. Overcharge. The Edison battery is not injured by overcharging unless its temperature exceeds 105 to 110 deg. Fahr. High temperatures seriously affect the capacity and life of Edison negative plates, and the manufacturer's guarantee does not hold for overheating from this cause. A continuance of overcharge increases the capacity on the subsequent discharge, but this increase in capacity is obtained at the expense of efficiency. The effect of continued charge is shown in Fig. 59.

222. Effect of temperature. There is a marked falling off in capacity of the Edison battery with low temperature, especially at high discharge

219. Characteristic discharging curves. Characteristic discharge curves for Edison type "*A*" cells are given in Fig. 57. It will be noted that the ampere-hour capacity of an Edison cell does not suffer very greatly with increasing discharge rates, if the terminal voltage be carried low enough. For practical purposes, however, the last portion of the discharge at high rates would have no value because of its great falling off from the open-circuit voltage.

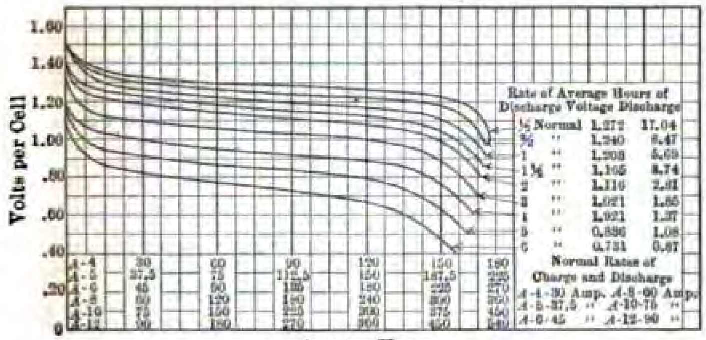


Fig. 57.—Typical discharge curves, type "*A*" cells.

220. Standing discharged. No injury is done to the Edison battery if it is completely discharged and allowed to stand in this condition. This is one of the principal distinguishing features of the Edison battery. The cell, however, loses in capacity by standing as shown in Fig. 58, and is most easily brought back to its condition of full capacity by giving it a very considerable overcharge. The usual practice is to ship the Edison battery in a discharged condition, and it requires several cycles of charge and discharge to bring it to its full capacity.

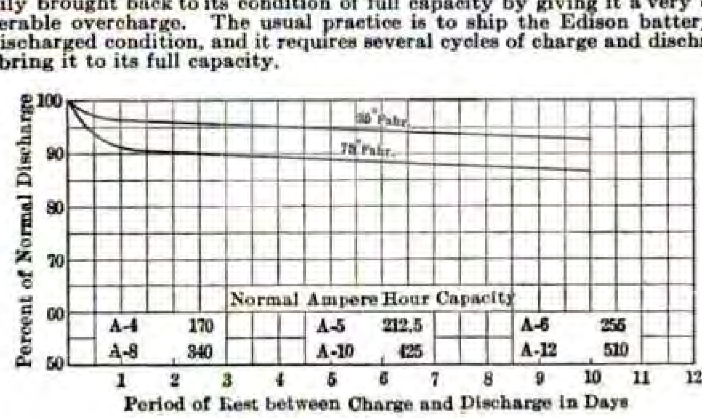


Fig. 58.—Loss of capacity.

221. Overcharge. The Edison battery is not injured by overcharging unless its temperature exceeds 105 to 110 deg. Fahr. High temperatures seriously affect the capacity and life of Edison negative plates, and the manufacturer's guarantee does not hold for overheating from this cause. A continuance of overcharge increases the capacity on the subsequent discharge, but this increase in capacity is obtained at the expense of efficiency. The effect of continued charge is shown in Fig. 59.

222. Effect of temperature. There is a marked falling off in capacity of the Edison battery with low temperature, especially at high discharge rates. For this reason the battery compartments of electric vehicles using these batteries must be carefully insulated against cold, if low temperatures are to be met. If the battery has attained a low temperature from long standing, it will tend to heat up on discharge, because of the high internal resistance, and if this heat is retained by the insulation, a fairly complete discharge can be obtained.

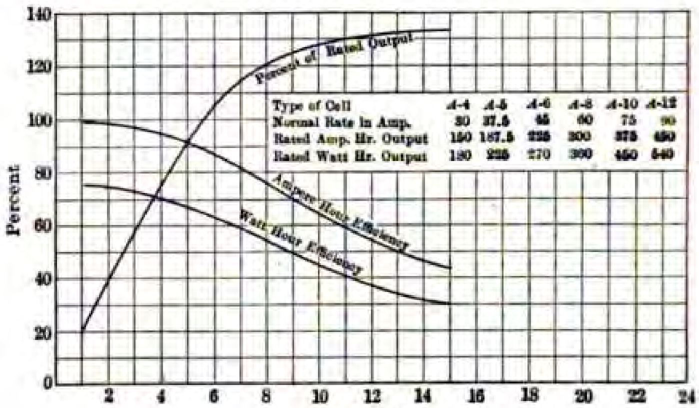


Fig. 59.—Influence of overcharge.

223. Deterioration of electrolyte. Water must be frequently added to the electrolyte of an Edison battery, to replace that lost by decomposition and evaporation. The amount of water required for this purpose is considerably greater than with a lead battery, because of the poor ampere-hour efficiency and the higher temperatures reached on charge. Distilled water must be used for this purpose, but even with its use, the electrolyte becomes gradually converted to potassium carbonate through the absorption of carbon dioxide from the air. For this reason also, it is perferable to use water which has been freshly distilled. As the electrolyte deteriorates from the above

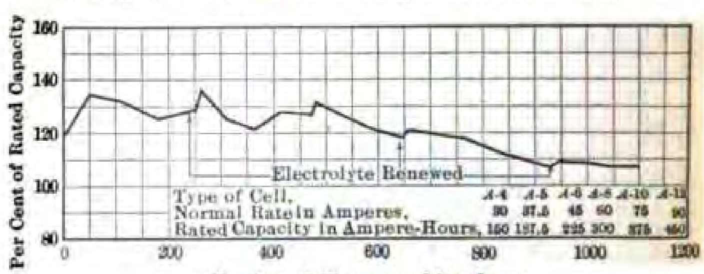


Fig. 60.—Log of life test.

mentioned cause, the capacity of the battery falls off, and, after about 250 cycles of charge and discharge, the electrolyte should be renewed. After each electrolyte renewal there is a temporary increase in capacity as shown in Fig. 60.

224. Testing. Tests on Edison batteries should be carried out as described in Par. **101** to **105**, with certain obvious changes. There is no appreciable variation of electrolyte density, and the end point of charge is also determined with greater difficulty than with the lead battery. A itable neutral or test electrolyte for an Edison battery is a nickel-oxide ibe, such as those used in the standard positive plates.

225. Application. The "*B*" type cells are used for ignition and lighting [gasoline motor cars; they are not commercially used for motor starting n account of the high internal resistance. The vehicle-type cells are used or electric vehicle propulsion, storage battery street cars, mining locomotives nd industrial trucks; they are not used for load regulation on account of the eavy drop in voltage at high discharge rates, this factor also limiting their se in other power applications.

226. Operation. The life of the Edison battery is guaranteed under ertain restrictions as to its operation. The operating instructions of the Edison Storage Battery Co. should be carefully followed if the battery ompany is to be held to its guarantee. A temperature of 115 deg. Fahr. hould not be exceeded under any circumstances, as high temperatures will eriously injure the negative plates.

227. Initial or first charge. Edison batteries are usually shipped in a lischarged condition. Before placing them in service they should receive a continued charge at the normal or 5-hr. rate, for a period of 12 hr. or more.

228. Regular charge. If the battery has received a complete discharge, the charge should be started at the normal rate and continued for a period of 7 hr., or until each cell, under normal temperature conditions, has reached a voltage of at least 1.8 volts per cell. The ampere-hours of charge should exceed the ampere-hours of discharge by approximately 40 per cent., and the battery should receive in addition, an overcharge of several hours at the end of each month of service.

229. Replacing evaporation. The electrolyte must be kept well above the plates by adding water whenever necessary, to maintain the level. Always use distilled water for this purpose.

230. The outside of the cells and the trays must be kept clean and dry. Dampness under certain conditions will cause the containers to pit under electrolytic action.

231. Standing idle. If an Edison battery is to be placed out of commission it need not receive any special attention, other than to see that the electrolyte is brought to the proper level. The battery can stand either charged or discharged equally well. To obtain the full capacity, however, after a long period of standing it is necessary to overcharge the battery.

232. Life of Edison battery. A log of a life test as published by the Edison Storage Battery Co. is shown in Fig. 60, the statement is made that the conditions of the test are harder than would normally be met in service. The battery is more durable than the vehicle types of lead battery. It is doubtful if it approaches the durability of the heavy Planté types of lead cells.

BIBLIOGRAPHY

233. Selected reference literature on batteries.

Cooper, W. R.—"Primary Batteries." London, 1901.
Transactions American Electrochemical Society.
LeBlanc, M.—"Electrochemie." Leipzig, 1911.
Plante, G.—"The Storage of Electrical Energy." London, 1887.
Schoop, P.—"Die Secundare Elemente." Halle, 1895.
Treadwell, A.—"The Storage Battery." New York, 1898.
Zacharias, J.—"Die Akkumulatoren." Jena, 1901.
Dolezalek, F.—"Theory of the Lead Accumulator." New York, 1904
Jumau, L.—"L'Accumulateur Electrique." Paris, 1904.
Lyndon, L.—Storage Battery Engineering." New York, 1911.
Bulletins of the Battery Manufacturers.
Bibliography of References on Storage Batteries since 1899, compiled by G. S. Maynard, to be published by N. Y. Public Library in 1915.

earlier **...** Positive-plate **construction**. The positive plate consists of a **...**
Full view - About this book - Add to my library - More editions
----

See page 46 of :

http://books.google.com/books?id=FghJAAAAIAAJ&pg=PA205&dq=%22edison+battery%22+manufacture+and+repair&lr=&as_brr=1&ie=ISO-8859-1#PPA46,M1

Storage Batteries Simplified, Operating Principles--care and Industrial ... - Page 205
by Victor Wilfred Pagé - Storage batteries - 1917
53 Exide Batteries, **Repair** of... 68 Exide Double Seal 69 Exide Single Seal 69
... 140 Jar of **Edison Battery** 50 Joining Dry Cells 16 Lamp-Bank Resistance 109

coins as source of nickel

As of December 14, 2006, the value of the metal in a United States nickel coin reached USD$0.055759, an 11.5% premium over its face value.[4] This was due to the rising costs of copper and nickel[5] and the U.S. Dollar losing its value. In an attempt to avoid losing large quantities of circulating nickels to melting, the United States Mint introduced new interim rules on December 14, 2006 criminalizing the melting and export of cents and nickels. Violators of these rules can be punished with a fine of up to $10,000, five years imprisonment, or both.[6]

Both the US pre-1982 cents and all US nickels have a metal content at market worth more than face value of the coins. As of June 13, 2008, the US nickel has $0.06013 in metal content; all circulating US nickels carry a 20.3% premium over face value in metal content metal at market prices. The intrinsic value of pre-1982 US cents, weighing 3.11 grams, are worth $0.02414, 141.4% above face value in metal content at market prices. However, post-1982 US cents, which weigh 2.5 grams, are 97.5% zinc and 2.5% copper (coated over the zinc) by weight. These have an intrinsic value of $0.00508 as of June 13, 2008, or 49.2% *less* than face value.

According to the US Mint, the costs of producing and shipping one-cent (penny) and 5-cent (nickel) coins during fiscal year 2007 were $0.0167 per cent and $0.0953 per nickel. Canada switched to making plated steel coins in the year 2000, where the face value of some older coins is below the metal content of those coins. In a similar move on February 8, 2008, a bill was introduced in the U.S. House of Representatives that would allow for changing the metal components in U.S. coins due to the rising cost of commodities and the declining U.S. Dollar.[7] No such bill has yet been signed into law.

Nickels minted from 1942-1945 during World War II contain 1.75 grams (0.05626 oz) silver. The silver content of these "war nickels" as of October 25, 2008 is worth USD $0.51.

http://en.wikipedia.org/wiki/Westward_Journey_Nickel_Series#Westward_Journey_Nickel_Series

----
Like today's version, the first **nickel coin** contained only 25-percent nickel; **....** They display three known control marks and have nickel-copper **contents ...**

----

1. Elementary Treatise on Electric Batteries - Google Books Result
   by Alfred Niaudet, L. M. Fishback - 1882 - Electric batteries - 266 pages
   IRON-COPPER BATTERY. In Volta's battery it is the zinc which is continuously dissolved ; it is therefore logical to search for something which may replace **...**
   *books.google.com/books?id=xfcJAAAAIAAJ**...***