October 1987

MEETING NOTICE

The next meeting will be Oct. 16th, at *CRAGIN FEDERAL SAVINGS & LOAN* 333 W. Wesley St. Wheaton, Ill. -Time - 7:30 P.M. *sharp.* Guests are welcome and need not be members to attend the meeting.

FOR SALE

Electric Fiat
Good batteries
Relay switching
$500

Battery charger
Lester ferro-resonant
Modified 32 volt
$50 or best offer

Harry Kampert
381-5612

HAMFESTS 1987

Oct. 25 Sun. 8:00 a.m. $3.00
Waukesha Expo Ctr. Hwys. J &
FT off I-94 Waukesha Wisc.

Oct. 31 & Nov. 1st Two days
Norris Sports Ctr. Rt. 64 &
Dunham Rd. St. Charles, Ill.

Nov. 1st Sun. 7:00 a.m. $3.00
Lake County Fairgrounds
Rts. 45 & 120 Grayslake Ill.

* * *

A tire-care booklet from Bridgestone Tire & Rubber Co. creates a bit of confusion over the Japanese tiremaker's recommended rotation scheme for front-wheel drive cars. Bridgestone advises car owners to move the rear tires to the front wheels in a crisscross fashion, while moving the rear tires to the front wheels without crisscrossing them. If directions are followed, you end up with two tires on each of the front wheels and none on the rear wheels.

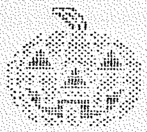
* * *

fold

F . V . E . A . A .

FOX VALLEY ELECTRIC
AUTO ASSOCIATION
624 Pershing St. Wheaton, Il 60187

FIRST CLASS



ADDRESS CORRECTION
REQUESTED

Minutes FVEAA Meeting 9/18/87 at Cragin Federal Savings & Loan Office, Wheaton, IL

President W. H. Shafer called the meeting to order at 6:35 PM.

There were 18 members present.

Treasurer V. Vana reported that there is $677.43 in the NOW checking account $776.45 in the savings account.

Irv Friedan reported on the necessary elements to make up a government grant request. President Bill stated that FVEAA had made up such a request in the past, but were not successful. Irv also reported that he has a Bradley GT 2 Electric with 48 volt on board charger.

Rick Lewandowski repoted on the exhibit of the ENR alternate energy at the State of Illinois fair in which the Club electric car was shown together with two 41 watt Photovoltaic cell arrays.

The Blackberry Historical Farm near Aurora has a 6 KW photovoltaic cell system in operation that is available for public viewing.

The club approved the use of the Club car to be exhibited during a Solar house tour of your secretary'home known as"Casa Zeus 2". A 41 watt photovoltaic cell array will also be shown.

Rick Lewandowski is to try to arrange to show our Club car at the Home and Energy Show at Harper college on September 25-27, 1987 in Palatine.

John Stockberger moved and John Ahern seconded a motion to approve the report of the nominating committee as to the slate of officers for our club in the coming year. This slate was reported in the minutes of the August 21 meeting. The motion was approved unanimously by the membership present.

John Stockberger presented a video-tape "Running with the Sun" by Sanford University and sponsored by National Semi-Conductor as well as the Electric Auto Association. John also reported on the Griffon Electric Van produced in England and sold in the USA by General Motors Corp.

Ken Myers presented a talk on battery charger design and stated the design is available on a floppy disc for the "hackers" in our club.

The meeting was adjourned at 9:55PM.

Respectfully submitted,

Kenneth R. Woods

Kenneth R. Woods, Secretary

PITFALLS IN PARADISE

Will Jones, Philadelphia Scientific

The sealed lead acid battery is going to have a tremendous impact on the battery business. It is already dominant in the consumer electronics market and in small UPS systems. It is also growing rapidly in the large Stationary and the deep cycle Marine markets, competing in the SLI and Solar markets and even dabbling in the Traction market which is the toughest one of all.

In some of these applications, like Stationary, charging conditions are well controlled and the batteries will seldom see voltages above 2.3 volts per cell. Under these conditions, most SLA batteries will perform very well, given competent design and manufacture.

In other applications, however, the batteries will inevitably be recharged at much higher voltages. For example, solar panels can produce over 3 volts per cell and typical motive power chargers have to generate over 2.5 volts per cell or they will not recharge a battery in a reasonable period of time.

The trouble is that, at these voltages, oxygen is not the only gas to be produced in the cell. Hydrogen is also produced. And the cell has no means of getting rid of this hydrogen which accumulates cycle after cycle until the atmosphere inside the cell is rich in the gas. That's when the trouble begins.

EXPERIMENTAL EVIDENCE

To illustrate: some time ago, our company was developing a new kind of charge regulator for a sealed, 2-volt cell used in a solar application. The design of the regulator was based on a pressure sensitive switch connected by a tube to the cell and set to interrupt the charge current when the cell reached a certain pressure.

The test rig consisted of an adjustable charger, a timer which could be set to mimic sunrise and sunset, a 2 volt sealed cell, a small constant current load and a simple water manometer attached to the cell to register pressure.

The regulator worked well. As the cell pressurized, the current was cut off and, as the pressure dropped back due to oxygen recombination, the current came on again. It consumed no energy, contained no delicate electronics, had built-in temperature compensation and, best of all, allowed the cell to control its own rate. We were well pleased.

In passing, we were also quite impressed with the rate of recombination of the cell. Once the regulator switched the charge current OFF the system would go bacl ON in a few minutes. The level change in the manometer was so fast that it was visible.

Then came the disappointments. To examine the performance limits of the system, we had raised the charge voltages to 2.5 volts and above and put the system on to continuous cycling. After a number of cycles it became clear that the cell was not behaving properly. It was becoming more and more sluggish and simply was not recombining as well as before. The time taken to depressurize was getting longer and longer: instead of taking a few minutes as it did at the outset, the cell was now taking over 12 hours!

HYDROGEN BUILDUP

Our initial reaction was that the cell had dried out or otherwise come to a sticky end. It took several more experiments to discover that we had created hydrogen on successive cycles inside the cell. (Quickly proved by extracting some of the gas with a syringe and igniting it over a flame.) We then developed the following model of what was going on in the cell.

The hydrogen produced in a sealed cell has nowhere to go when the oxygen is reabsorbed by the negative plate. Escape through the cell walls takes months rather than minutes. With each cycle, therefore, it becomes an increasing component of the cell's internal atmosphere. As the hydrogen content increases it acts to polarize or mask off the negative plate from the remaining oxygen. The effect is so severe that, in the extreme, the cell behaves more like a flooded cell than a recombinant one.

Dramatic support for this theory came when we introduced an oxidizing catalyst into the pressure tubing leading from the vent cap. The purpose of the catalyst was to recombine the hydrogen with some of the available oxygen before all of the latter was consumed on the negative plate. After a number of on/off cycles, the cell's sluggishness disappeared and there combination rate increased enormously, reducing the OFF/ON time back to its original value of a few minutes. We also noted that, in this condition the cell was so active that, whenever the charge was shut off, recombination would continue until the cell developed a negative pressure of several PSI.

We repeated this experiment to ensure replication and were able to condition the cell into either a sluggish, hydrogen-rich or an active, hydrogen-poor state.

MAXIMUM CURRENTS

We also found that hydrogen severly reduces the maximum charge rate of a cell. Our 140 ampere hour cell would easily recombine 2 amps continuously without pressurizing if a catalyst had been used to oxidize most of the residual hydrogen. In a hydrogen-rich atmosphere, however, the same cell could only continuously absorb around one-tenth of that current before pressurizing. In other words, the plates might as well have been 90% flooded.

CELL POLARIZATION

The ideal way to record the effect of hydrogen on a sealed cell would be to plot positive and negative plate polarizations for different internal atmospheres. To do this will be no easy task and we will leave it to the battery companies to confirm that, for the same current, a fully charged sealed cell can have a multitude of different voltages - largely variations of negative polarizations - depending on its internal atmosphere. We predict the negative Tafel shift will occur at a value well above 2.4 volts per cell in one extreme and as low as 2.2 volts in the other (1.300 specific gravity).

CONCLUSIONS

It is our firm opinion that sealed cells which get routinely charged at voltages above that at which hydrogen is formed (around 2.35 volts per cell at toom temperature) should be equipped with a catalyst in the gas space or risk serious loss of recombination efficiency.

Even with the catalyst, cells can be forced to pressurize and vent if the charge current is greater than about 1.5 amps per 100 ampere hours (usually the case in deep-cycle service). In these cases, to prevent venting, the charger should be shut off by a pressure switch connected to one or more of the cells.

Equipped with these two provisions, sealed lead-acid batteries become largely self-protecting against overcharge, even where the chargers themselves are unregulated. This is a startling advantage that even flooded cells do not have, and it opens up some interesting possibilities. For example, sealed batteries could begin to compete in the Motive Power and Golf special chargers.

Which goes to show that there are no such things as problems—only opportunities.

A New Chip For Charging Gelled-Electrolyte Batteries

Unitrode's sealed lead-acid battery charger IC, the UC3906, does a familiar job better, easier and with fewer parts.

By Warren Dion, N1BBH
108 West Main St, No 16
Terryville, CT 06786

Amateur Radio has become the traditional last resort when other communications means fail. This has not only been a justifiable source of pride, but also a beneficial way to ensure protection of our on-the-air privileges. It is a good idea, therefore, to keep a battery-powered rig in standby, headed up by a healthy, fully-charged battery. Indeed, with so much ham gear running on low-voltage dc, it's a good idea to run the whole shack on batteries. The introduction of the sealed lead-acid cell, and now the UC2906/3906, make it easier than ever.

Before listing all the things that the '3906 can do for your favorite battery (the '2906 is the military version), let's review the facts of life—long life, as it pertains to the lead-acid cell. Lead-acid batteries with a gelled electrolyte are best kept charged and maintained by a charger at a *float* voltage (between 2.25 V and 2.30 V per cell). To obtain a full charge, the battery is charged to about 2.4 V per cell, but holding or forcing the cell to a higher voltage only hastens its demise. Therefore, a good charger must switch back to the float level when necessary. When terminal [illegible]ages exceed the float level, the battery [illegible]id to be in the *overcharge* region.

During fast charge, the charger must limit the current to a safe level known as the *bulk rate,* then taper off in the overcharge region to about 1/10 that. The bulk rate is designated in terms of the battery's full ampere-hours (Ah) capacity, and stated as a ratio. For example, a battery requiring four hours to charge at the bulk rate is said to be charging at C/4, though it actually takes longer because of tapering.

A battery's Ah capacity can fool you. Manufacturers often refer to it as the *20-hour rate*. Hence, a 20-Ah battery can be expected to deliver 1 A for 20 hours, but not 20 A for 1 hour!

The UC3906 "knows" about this, and a few other matters that may never concern you as a ham. It controls the bulk current, taper and limits the overcharge voltage, after which it dutifully maintains your battery at the float level. The '3906 knows when the power is on, when your battery needs a fast charge, if a dead battery is connected or the polarity is reversed. It can even allow for the battery's temperature sensitivity.

A Practical Application

This charger is a modified version of the battery pack and charger published in *The 1987 ARRL Handbook*.[1] The charger in this system lends itself to the use of the '3906, but it is compatible to that presented in the *Handbook;* it simply requires substitution of a revised circuit board. Thus, we already have all the ancillary hardware as well as a proven device to which we can compare our result.

Glossary

Battery—A group of cells connected together to increase current and/or voltage ratings.

Bulk Charging Rate—Current flow during the fast-charging part of the cycle. It is often expressed as the number of hours it takes to charge a cell fully at this rate. Theoretically, C/4 means that it would take four hours for a full charge. For a 10-Ah cell, charging at C/4, the charging current is 10/4 or 2.5 A.

Capacity (in ampere-hours, Ah)—A measure of the cell's ability to deliver current over a period of time. It is usually expressed as the 20-hour rate.

Float Voltage—Voltage at which a cell may be held indefinitely without damage, 2.25 to 2.30 V per cell.

Overcharge Voltage—Voltage to which a cell must be charged to achieve full capacity, about 2.4 V per cell.

Taper—A gradual reduction of charging current as full charge is approached.

A schematic for the charger is shown in Fig 1. The screened portion is the new board. First, let's walk through a charging cycle and see how the '3906 earns its living. Its initial task is to ensure that power is on and that a good battery is connected. Pin 5 monitors the supply voltage and enables the chip when the voltage reaches 4.5 V or more. Pin 12 senses the battery terminal voltage. If the voltage is too low (a dead battery) or of the wrong polarity, the charger is disabled. If this is the case, pin 11 is pulled high, sourcing a current of up to 25 mA which may be used to operate a s[illegible] initiate a rescue procedure.

[illegible]ing a good battery needs charging, the UC3906 puts two watchdogs to work: One regulates the charge current and the other looks at the battery terminal voltage. The current regulator senses the voltage across series resistor RS, and limits it to 0.25 V by controlling the current through RS. Thus, the bulk charging rate is determined solely, by the value of RS. For example, if RS = 1 Ω, the charger current is 0.25 A.

Battery terminal voltage is sensed at pin 13. This voltage is compared to the '3906's internal voltage reference, nomi[illegible] 2.3 V. Higher terminal voltages are accommodated by using voltage divider RA and RB, the values of which must be selected so that when the critical terminal voltage is reached, the voltage at pin 13 equals the reference. But how about the two critical voltages, overcharge and float. Well, initially, pin 10 is pulled to ground by placing RC in parallel with RB. This means that the battery voltage has to rise higher than the float level before pin 13 = 2.3 V. When this happens, pin 10 is latched open and RC is out of the picture.

When the terminal voltage rises to a level that is just below float, the voltage

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[1] Notes appear on page 29.

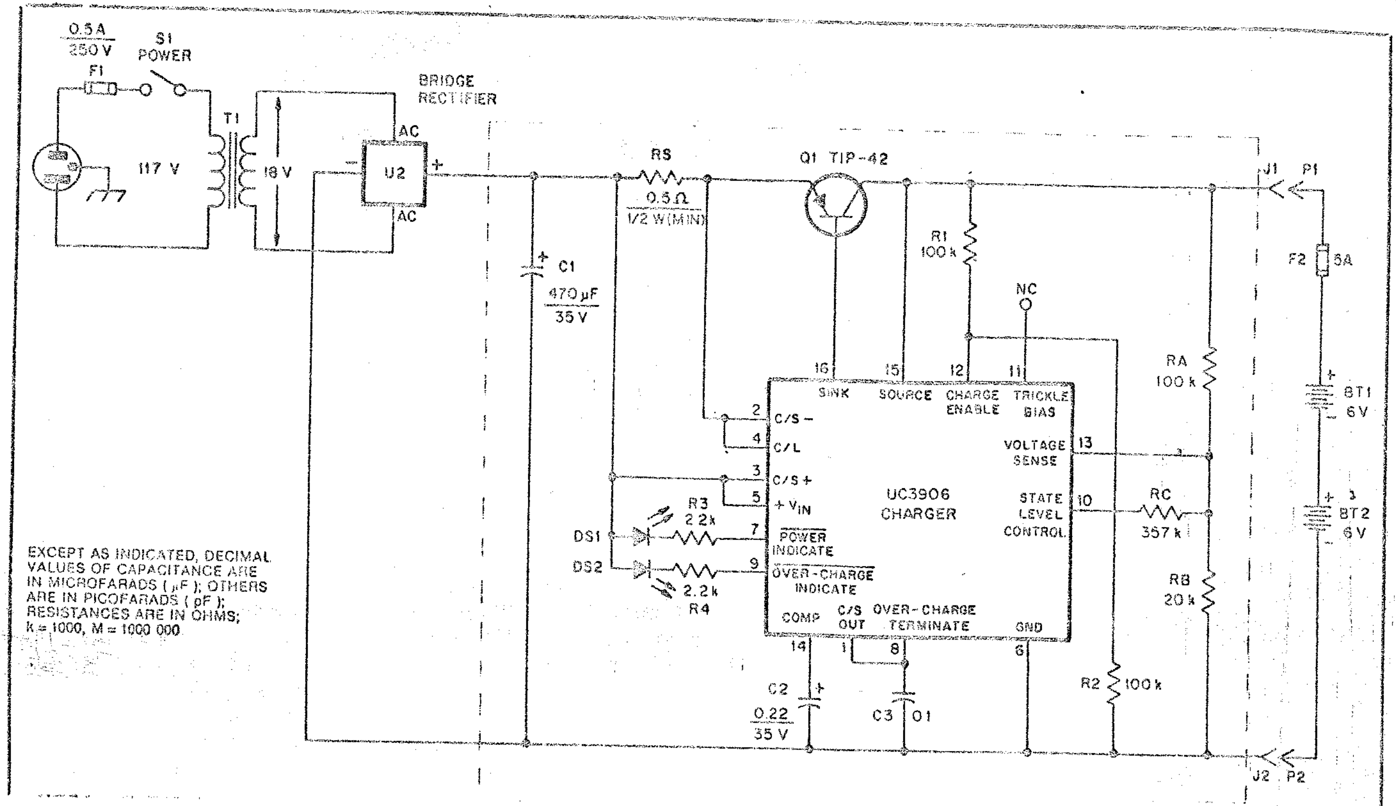

Fig 1—Schematic of the UC3906 charger. All resistors are ¼ W, 5% tolerance unless otherwise noted. Part numbers given in n-theses are Radio Shack catalog numbers. Those in brackets are Mouser Electronics stock numbers. Parts for this project may purchased from your local Radio Shack outlet or from Jameco Electronics, 1355 Shoreway Rd, Belmont, CA 94002, tel 415-592 897, and Mouser Electronics, 11433 Woodside Ave, Santee, CA 92071, tel 619-449-2222. The UC3906 is available from Hamilton/Avnet; call 800-421-0404 for a dealer in your area, or A&A Engineering, tel 714-952-2114.

BT1, BT2—Gelled-electrolyte, lead-acid battery, 6V, 4 Ah (Yuasa NP4-6 or equiv. Available from Glynn Electronics, PO Box 800, Middleboro, MA 02346.)
C1—Electrolytic capacitor, 470 µF, 35 V (272-1030).
C2—Electrolytic capacitor, 0.22 µF, 35 V (272-1012).
DS1, DS2—Red LED (276-062).
F1—Fast-acting fuse, 0.5 A, 250 V (270-1271).
F2—Fast-acting fuse, 5 A, 250 V (270-1278).
J1, J2—1300 series, Anderson Power Products, 145 Newton St, Boston, MA 02135.
P1, P2—1300 series, Anderson Power Products.
Q1—Power transistor, PNP, 90 W, TO-220 case, TIP-42 or equiv (276-2027).
RA—Resistor, ¼ W, 100 kΩ, 1% tolerance [29MF250].
RB—Resistor, ¼ W, 20 kΩ, 1% tolerance [29MF250].
RC—Resistor, ¼ W, 357 kΩ, 1% tolerance [29MF250].
RS—Resistor, 3 W, 0.51 Ω, 5% tolerance [28PR003].
S1—SPST switch.
T1—Transformer, pri 117 V, 60 Hz; sec 18 V, 1.2 A (273-1515).
U1—Battery-charger chip, Unitrode UC3906 or UC2906.
U2—Full-wave bridge rectifier, 100 PIV, 4 A (276-1171).

regulator takes control away from the bulk-current regulator and goes into the overcharge state. The current then tapers as the voltage continues to rise toward 2.4 V per cell, the point at which the float state is instituted. As the charging current tapers, the voltage across RS drops proportionately. Another watchdog looks at this voltage to see when it goes below 0.025 V. When 0.025 V is sensed, a latch is toggled and pin 10 is ungrounded. Float conditions are established and the battery-terminal voltage drifts back toward 2.3 V per cell, which is maintained until the battery becomes discharged or the power is switched off and back on. Following either of these events, the latch is reset and the cycle repeats itself.

DS1 and DS2 are optional. DS1 is the input-power indicator and lights when the supply voltage equals or exceeds 4.5 V. DS2 is the overcharge indicator and lights when the battery is in the overcharge region (over 2.3 V per cell). When the charger reverts to the float state, DS2 goes out. Since the tapering charging current slows down the process, it is normal for this light to remain lit for several hours.

Construction Notes

Construction is straightforward. If you start from scratch, I recommend that you refer to the *Handbook*. Lead dress requires nothing more than ordinary neatness. Though the circuit board lends itself to perfboard construction, a modified PC board and parts kit is available from A & A Engineering.[2] Their version of this project allows any size battery to be charged.

Q1 requires additional radiating surface for cooling. To facilitate this, Q1 is located at the edge of the circuit board so that its tab can be screwed down to the metal enclosure. Since the tab is hot electrically as well as thermally, it must be insulated from the case with a thick mica washer and insulated screw. The easiest way to do this is to use a TO-220 mounting kit. Scrape the paint from the area where the tab will be mounted and be sure there are no rough spots or sharp points that could pierce the mica insulator. Mount Q1 first, then position the PC board so that no strain is put on the transistor leads. Fig 2 shows the internal contents of the charger; note Q1's placement.

The values of the voltage divider resistors, RA, RB and RC, are critical. The of junk-box resistors could seriously shorten the life of your battery. Use metal film, 1%-tolerance resistors. If you can obtain closer tolerance resistors, do so.

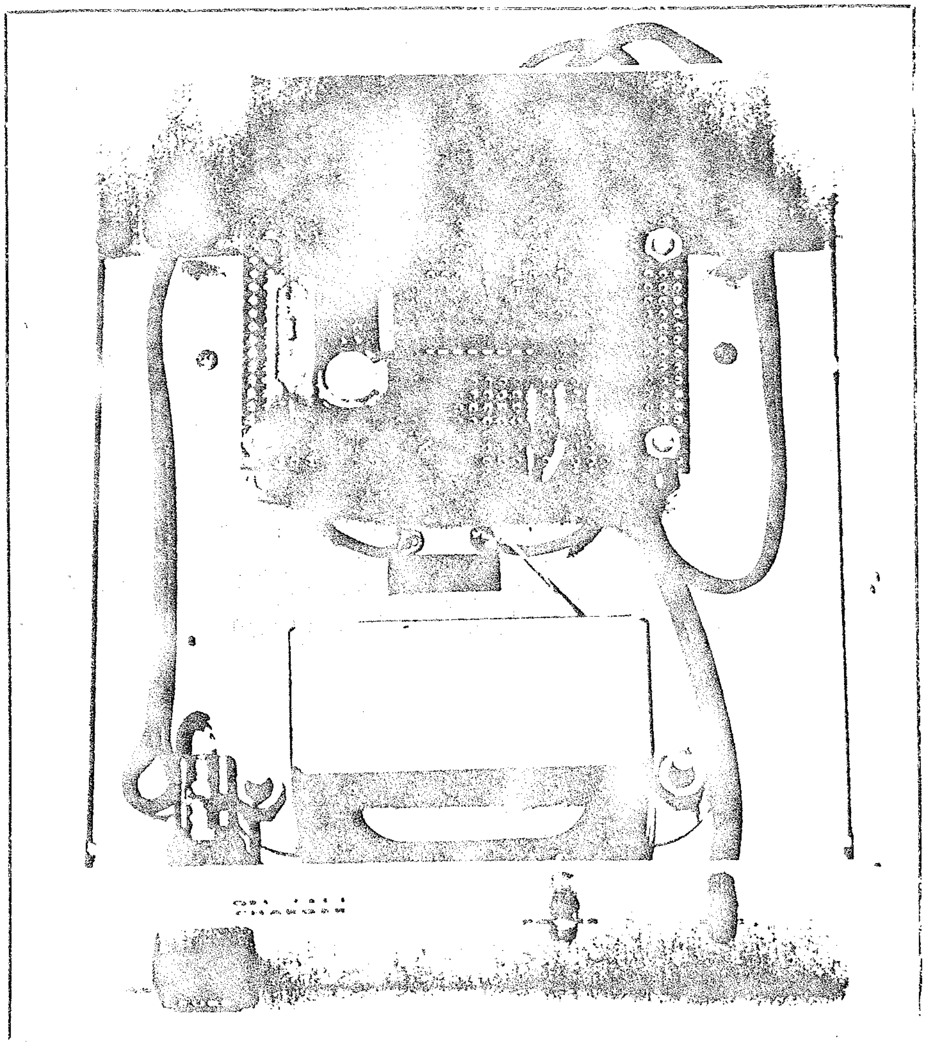

Fig 2—A view of the charger circuit board. This is an ideal weekend project that will provide hours of usefulness and pay for itself when compared to the price of a good battery.

If not, and you have access to a digital ohmmeter with a 3½-digit resolution, match RA and RB. The ratio is more important than the absolute value and should be close to 5:1 for a 12-V battery. Since you may have to settle for less than a perfect match, it's best to select a higher value for RB. The value of RC, though important, is not as critical and any 1%-tolerance resistor will do. Table 1 is a BASIC program to facilitate calculation of the critical values used in Fig 1.

The value of RS is chosen to provide an eight-hour charging rate (C/8). This is a compromise between the fullest charge and the shortest practical time. All other component values are noncritical, and 5%-tolerance resistors are recommended. C2 introduces a short time delay to prevent circuit oscillation. C3 prevents the latch from being interrupted.

The supply voltage used in the *Handbook* charger is chosen to exceed the minimum required by its LM317T regulator under worst-case conditions. The pass transistor in the '3906 version will work with an emitter-to-collector voltage of less than 1. It is feasible, therefore, to reduce the worst-case supply voltage to as little as 16 V, which means that Q1 runs cooler. This is not necessary if Q1 is well heat-sinked, but is worth considering in a new design. Table 2 lists the operating characteristics of a charger using the values shown in Fig 1.

Expanded Uses

The '3906 is more versatile than the Table 2 specifications imply. If your requirements differ, you can still use the circuit in Fig 1 by calculating new values derived from the formulas in Table 3. These formulas are a rationalization of those in the manufacturer's application note.

A note of caution: The output-drive current of the '3906 chip is limited to 25 mA. This may not be enough to drive Q1 to meet higher charging-current demands, and a higher gain, more powerful current amplifier may have to be substituted in its place.

Among other complications, the lead-

Table 2

The Operating Characteristics of a 4-Ah, 6-Cell Lead-Acid, Gelled-Electrolyte Battery

Overcharge voltage limit	14.445 V
Float Voltage	13.8 V
Bulk Charging Current	0.5 A
Charging Rate	C/8
Disabling (fault) voltage	4.6 V

Table 1

C64/128 BASIC Program for Calculating Charger Circuit Values

```
1 REM COMPUTES CRITICAL VALUES FOR LEAD-ACID BATTERY CHARGER CHIP UC2906/3906
3 PRINT"(CLR)":PRINT"UC2906/3906 BATTERY CHARGER CHIP CALCS."
4 PRINT"FOR LEAD-ACID BATTERIES.":PRINT
6 VR=2.3:PRINT
10 INPUT "NUMBER OF CELLS=";N
20 VF=2.3*N
30 INPUT"AMPERE-HOUR RATING=";AH
40 INPUT "FAULT VOLTG.(2.3 MIN.)=";VL
50 PRINT:PRINT"RA MUST BE BETWEEN 47000 & 100000 OHMS"
60 INPUT "RA";RA
70 RB=(VR/VF*RA)/(1-VR/VF)
80 VO=1.0467*VF
90 RC=RA/((VO/2.3)-1-(RA/RB))
100 R2=(230000/VL)/(1-2.3/VL)
110 PRINT"RB="INT(RB)
120 RC=RA/((VO/2.3)-1-(RA/RB))
130 PRINT"RC="INT(RC)
140 R2=(230000/VL)/(1-2.3/VL)
145 IF R2<0THEN PRINT"R2  ERROR, CHOOSE HIGHER FAULT VOLTAGE":GOTO160
150 PRINT "R2="INT(R2)
160 RL=2/AH
170 RH=2.5/AH
180 PRINT"RS= ANY VALUE BETWEEN"INT(RL*1000)/1000" & "INT(RH*1000)/1000
190 PRINT
200 PRINT"TO TRY ANOTHER VALUE FOR RA, HIT ANY KEY"
210 GETA$:IFA$=""THEN210
220 PRINT:GOTO 60
```

Table 4

Resistor Values for a 14-V Battery Pack

RA	120 kΩ
RB	20 kΩ
RC	392 kΩ
RS	See Table 3
R2	3 Ω

Note: Above are stock, 1% values.

acid cell is temperature sensitive. To accommodate this characteristic, the voltage reference on the chip has a temperature coefficient that matches that of the cell. Self heating within the chip is negligible. If it's placed in approximately the same environment as the battery, it will compensate for temperature shifts and you don't have to do anything else.

This chip will work with any lead-acid battery it is implemented to serve, including the big, ugly wet battery that starts your car. Use the formulas in Table 3 to determine a new set of values and use a large pass transistor with plenty of drive.

The Seven-Cell Battery

There's no such thing, but maybe there should be—you can make one. The seven-cell battery has become the *de facto* standard among glider pilots who depend on batteries to power critical navigational and communications gear during flights that often exceed eight hours duration. (Does this sound like a parallel to a long power outage?) Maybe hams would do well to emulate the pilots.

Here is why a 14-V battery is better:

- Many 12-V radios are designed to work with vehicular batteries that are being charged continuously at about 14 V.
- A 12-V battery on discharge is putting out less than 12 V.
- Power input to your rig's final varies as the square of the applied voltage. Compare a battery that is delivering power at 13 V to one at 11 V. The power ratio is (13^2 / 11^2), or almost 40% higher.

If you decide to create a seven-cell battery, be sure the extra cell matches those in the batteries in series with it. Most of all, it should be of the same manufacture. Table 4 lists values that will keep a 14-volter in good shape.

If this seems like a lot of hassle to charge a battery, try comparing the cost of a good battery to the nonrecurring cost of a good charger. (Maybe we should call it a "battery maintainer.") Furthermore, it saves the embarrassment of having to shake your head in frustration when someone is relying on you to get the message through during an emergency.

Notes

[1] M. Wilson, ed., *The 1987 ARRL Handbook* (Newington: ARRL, 1986), p 27-34.

[2] PC boards and a kit of parts are available from A & A Engineering, 2521 W La Palma, Unit K, Anaheim, CA 92801, tel 714-952-2114. PC boards and the parts kit (item no. 150-KIT) cost \$49.95. The PC board can be purchased separately for \$7.95 (item no. 150-PCB), and the Unitrode IC, UC3906 is \$7.50. All orders add \$2.50 for shipping and handling. The ARRL and QST in no way warrant this offer. [QST]

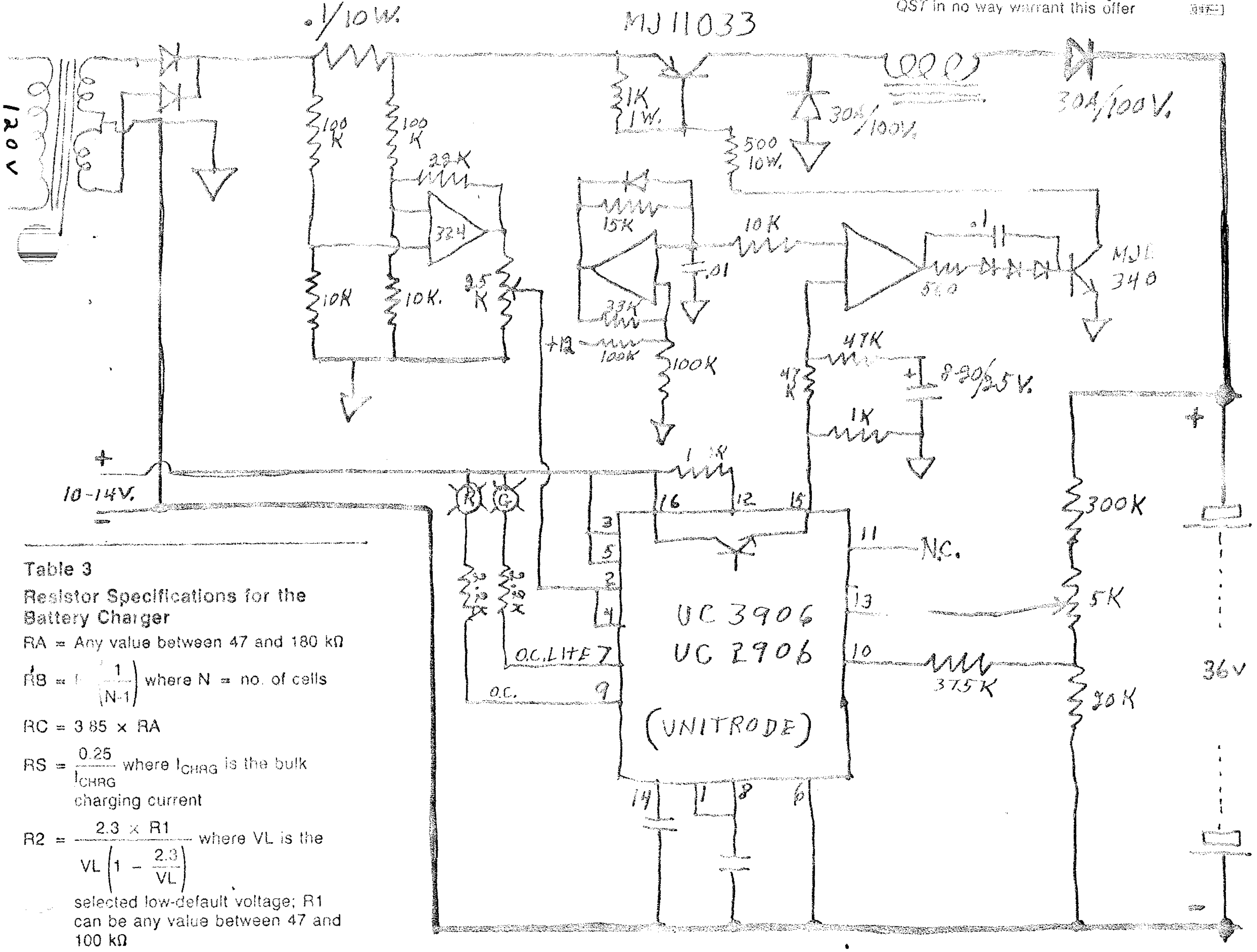

Table 3

Resistor Specifications for the Battery Charger

RA = Any value between 47 and 180 kΩ

$RB = RA\left(\frac{1}{N-1}\right)$ where N = no. of cells

$RC = 3.85 \times RA$

$RS = \frac{0.25}{I_{CHRG}}$ where I_{CHRG} is the bulk charging current

$R2 = \frac{2.3 \times R1}{VL\left(1 - \frac{2.3}{VL}\right)}$ where VL is the selected low-default voltage; R1 can be any value between 47 and 100 kΩ

AUTOMATIC 2 STAGE BATTERY CHARGER 9/18/87 K.M.

Gabe: Per our conversation

7-20-87

The following is a list of equipment from a Hybrid Electric Motor Vehicle I constructed about eight yeas ago:

COMPONENT	SIZE	WEIGHT	COST
1. G. E. Aircraft DC Starter Generator. Type CN77 M' F' r's No. 2CM77B10 SR. No. WKB 5003 AFW	30 V DC - 400 amp 3000 to 8000 RPM 16 spline involute 25/32 inch	75 lbs.	$ 400.00
2. Motor Drive Assembly	16 spline involute to 1" keyed shaft	12 lbs.	$ 125.00
3. Generator - Bendix Aircraft Type P2-SR No. 25401 M' F' R' No. AF57892	28 V DC - 200 amp Keyed shaft 3/4 inch 1 7/8 inch long.	36 lbs.	$ 130.00
4. Engine - Tecumseh HM80 Recoil start	8 HP - Keyed shaft 1" X 2.875"	48 lbs.	$ 175.00
5. Batteries - General - G TII4N Series 250	6 V 200 AH	60 lbs.	$ 70
	(six each)	360 lbs.	$ 420
6. Battery Charger - Lester Model 8/50	36V DC 30 amp	34 lbs.	$ 175.00
7. Relays - SPST - GE M416	300 amp	1 lbs	$ 15.00
	(five each)	5 lbs.	$ 75.00
8. Relays - Potter Brumfield 4PDT	5 amp.	6 oz.	$ 5.00
	(five each)	30 oz.	$ 25.00
9. Reactor	300 amp.	2 lbs.	$ 35.00
10. Fuses - KAA 400 Buss	400 amp.	-	$ 9.00
	(three each)		$ 27.00
11. Diode - 1N3214	300 amp/600V	-	$ 25.00
	(three each)	-	$ 75.00
12. Heat Sink Mounting	800 lbs. Clamp	-	$ 45.00
	(three each)	-	$ 135.00
13 000 copper wire with 4/0 AWG lugs	Various lengths 15', 5', 3', 2'	50 lbs.	$ 100.00
14. Miscellaneous meters, 24v dc motors, diodes	Various	10 lbs	$ 100.00

If interested, call Bob Crosby   Work 621-5930   Home 983-8553