A 'float' charger for NiCad batteries

This NiCad battery charger provides a happy medium between fast chargers and constant-current chargers. It's cheap, simple to build and will bring a battery to full charge from complete discharge in 12 hours — then keep it there. And your NiCads are safe from overcharging damage.

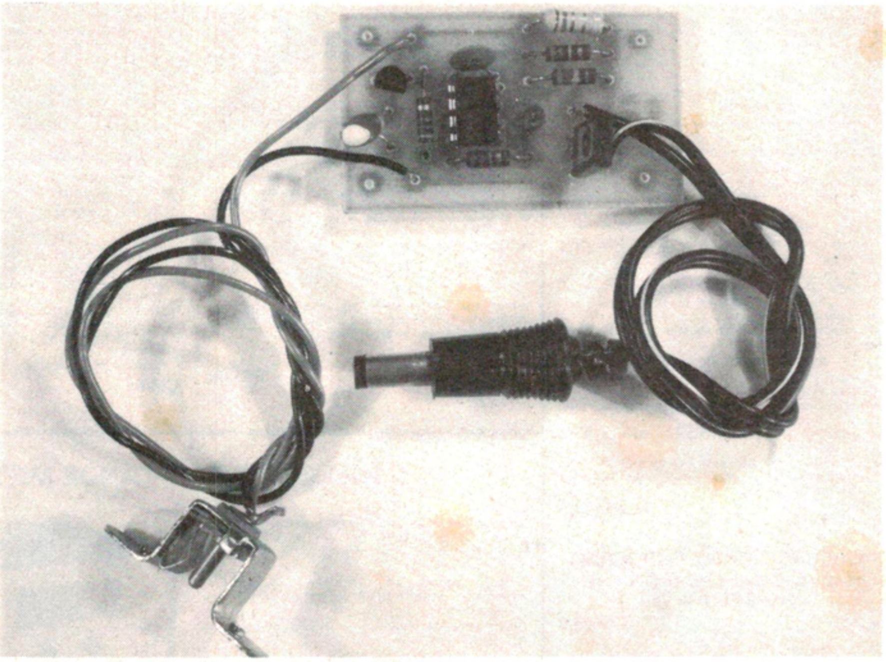
Jonathan Scott

AS YOU MIGHT INFER from the great range of chargers available and the number of projects describing them appearing in this and other magazines (should you ever read one, accidentally) there is more to charging NiCads than meets the eye. NiCads are rather finnicky things to deal with in that they basically require fairly continuous attention. The very best conditions are simply *use:* if you discharge and charge a set of NiCads once a week or so, they deliver hundreds of cycles quite happily.

However, this is not the case in many typical applications. They may be unused for weeks or months in the flashgun of your camera or as battery backup in instruments. They may, on the other hand, be left trickle-charging endlessly and never discharged more than 10%, as is the case in a torch used for two minutes every week. Neither form of disuse is good. You can get fast chargers, such as the ETI-563, or the recommended controlled current source type which will charge at the ten-hour rate, or very low current trickle charge types such as are incorporated in some electric toothbrushes or small torches. Trickle chargers are safe in that the NiCads are not actively harmed no matter how long you leave them connected, but the cells take three days to recover a full charge. The controlled current sort are able to charge a cell right up in about 14 or 15 hours, but will upset the cells in about 24 hours if left on. Fast chargers are damn quick, and fairly safe if they are the type which turn off and you set them for the correct time, but are more costly and bulky.

Hence we present yet another alternative. This project will bring a set of cells up to full charge from complete discharge in about 12 hours and then automatically drop to a trickle whenever the charging is done. This means full recovery in half a day with safety from overcharging damage. Hence the title, 'Float Charger'.

The circuit presented here is specifically designed for penlight size batteries ('AA') and is arranged to charge four cells in series, which is the number generally found in portable cassette players, etc. You're not locked-in to this set of circumstances however. You can charge different numbers of cells of amp-hour capacities between 250 mAh (¼ Ah) and 1 Ah simply by selecting the values of three resistors according to Table 1. The project will charge up to four cells from a 10 volt supply. For each additional cell, the supply needs to be increased by 1.5 V. i.e: six cells need 13 volts supply.



Simplicity plus! A handful of components, a 30 x 50 mm pc board . . . and no complications.

Although the project will charge cells of up to 4 Ah capacity it will work at full rate only on cells up to 1 Ah, but this is not a serious problem as most small appliances and backup systems use quarter or half amp-hour types.

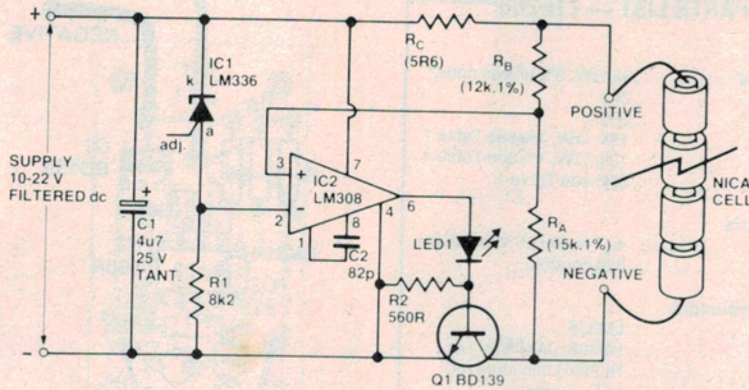
The project can be incorporated inside a piece of equipment or it can be built into some dedicated charger at very little cost (under $10) and will run off any power supply of 10 to 22 volts (according to what's required). e.g: a plugpack, car battery, power supply, etc. In addition, there are no controls or presets to adjust at all. Some chargers of this type require calibration against a digital meter or similar, but this one is born calibrated. It may be fabricated on its own pc board or incorporated in the power supply of something you are building.

Construction

Construction of this project is largely left up to you as far as boxes and connectors go because of the many possibilities you have open. The prototype was left unencapsulated, and has been fitted with a plugpack receptacle on the input end and a similar plug on the output as it has been designed to go between a small cassette player and a plugpack originally provided to charge the cells inside the player. A car cigarette lighter plug could just as easily be fitted to allow use in a car. If you do not intend to use a carefully polarised input connector, a diode in series with the input is a good idea as the unit will be damaged if exposed to reverse polarity.

The first thing to do before constructing the project is to select values for the three resistors R_A, R_B and R_C according to Table 1, given the size (Ah capacity) and number of the cells to be charged. If your application has a number of cells not covered in the table, use the formulae given there to find values. ▶

HOW IT WORKS — ETI-268



The 'ideal' charger for NiCad batteries is a precision voltage source in series with a fixed resistance — where the voltage source is a little above the battery terminal voltage when fully charged. Thus, when a discharged battery is connected, the charge current is maximum, reducing to a 'trickle' when the battery is fully charged. That's what this project has been designed to do. It makes use of a low cost precision reference element, an LM336, and a comparator driving a series-pass transistor to control the charge current applied to the batteries.

The precision voltage reference, IC1, looks to 'the outside world' as a zener diode. The 'adj.' terminal permits adjustment of either the terminal voltage (over a very small range) or the temperature coefficient (how the terminal voltage drifts with variation in temperature). The 8k2 resistor, R1, provides current for IC1 which produces a fixed potential of between 2.390 V and 2.590 V below the positive supply rail at its anode. This is fed to pin 2, the inverting input, of the 308 (IC2) which is here arranged as a comparator.

The non-inverting input of IC2 (pin 3) is fed by a voltage that depends on the sum of the terminal voltage of the cells being charged and the current fed to them. Three resistors — R_A, R_B and R_C — sample the cell terminal voltage and charging current, providing a fixed sum of these variables. The output of IC2 drives the base of Q1 via LED1. Q1 controls the charging current fed to the cells. The sum of the voltage drops across R_C and R_B is maintained at the same voltage as that across IC1. As the terminal voltage of the cells rises with charging, the voltage drop across R_C will decrease, but the voltage drop across R_A/R_B will increase. The ratios have been set so that the drive to the base of Q1 decreases as cell voltage rises.

The LED between the base of Q1 and the output of IC2 serves two purposes. It provides the voltage offset required between the IC's output and the negative supply rail as the 308 cannot drive its output right down to the negative rail; and secondly, it gives an indication that the charger is operating. (You can check that the load is correctly connected by looking for an increase in intensity when connection to the cells is made). Resistor R2 keeps Q2 turned off when required and ensures that there is some current flowing in LED1 even when the load draws no current. Capacitor C1 removes any hash from the supply which might upset the 308 in a noisy environment. Capacitor C2 provides compensation for IC2.

Neither capacitor is critical in value, but C1 should be a tantalum type if you intend to run the charger in harsh electrical environments such as a car or near RF equipment. A 308 was chosen for IC2 as it has a very low offset voltage and a high input impedance.

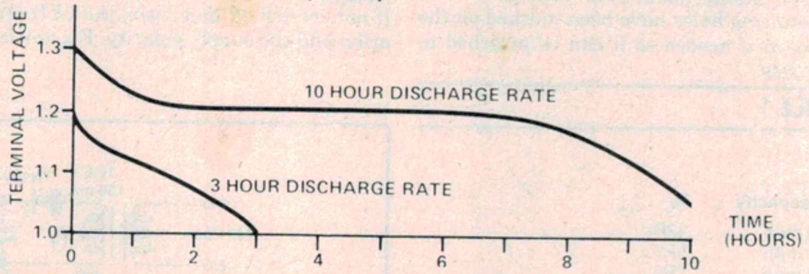
The output of the 308 is current-limited internally and since the load current is equal to the beta of Q1 times the current sourced to its base, the output is current-limited to a value of around 300 mA or so. If the charger output is likely to be shorted (or if the possibility exists), Q1 should be placed on a small heatsink, for safety's sake. Under normal operating conditions charging penlight (AA) cells, Q1 does not require a heatsink. Should you wish to upgrade the unit for higher charging currents, a Darlington-pair device should be substituted for Q1, with suitable heatsinking attached.

THE NICKEL-CADMIUM CELL (NiCad)

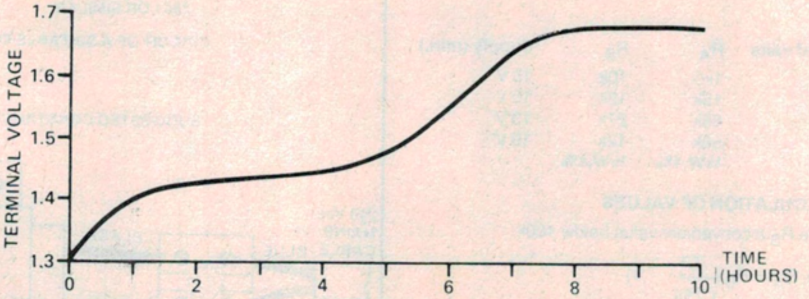
NiCad cells use a potassium hydroxide electrolyte. In a typical unit the positive and negative plates are both perforated steel. The positive plate is filled with nickel hydroxide, the negative plate with finely divided cadmium mixed with a little iron to prevent it flaking and losing porosity. The electrolyte has a specific gravity of 1.15-1.2, depending on the type of service. It does not undergo any chemical change during discharge. Very little electrolyte is needed and the positive and negative plates are very closely spaced.

NiCad batteries are made in a wide variety of sizes and amp-hour capacities. Miniature ones for use in cameras, calculators etc up to large heavy duty types similar to car batteries. They may be operated over a wide temperature range — similar to that of lead-acid batteries. At low temperatures, the amp-hour capacity does not diminish as much as with lead-acid batteries. However, the electrolyte may freeze.

As NiCad batteries may be sealed, they can be used in any position. The no-load terminal voltage of a nickel-cadmium cell is typically 1.3-1.4 volts. This drops to about 1.2 volts under load, and to about 1.1 volts when discharged. As the electrolyte does not change during discharge (as it does in lead-acid batteries), the number of amp-hours obtained from a NiCad battery is much less affected by the discharge rate than are lead-acid batteries.



Going down. Typical discharge characteristics of NiCad cells.



Juicing up. Typical charging characteristics of NiCad cells.

As NiCad batteries can be made quite small, and can be recharged, they are eminently suitable for use in portable electronic equipment such as calculators, tape recorders, hand-held transceivers, camera flash units etc. They can withstand considerable vibration, are free from sulphating or similar problems, and can be left in any state of charge without ill effect.

Charging should be done with a constant-current charger. The charging rate for the quickest charge should be no more than 1.5 times the 10 hour discharge rate. Most manufacturers recommend a charge rate and a trickle or 'float' charge rate and this is best adhered to.

PARTS LIST — ETI-268

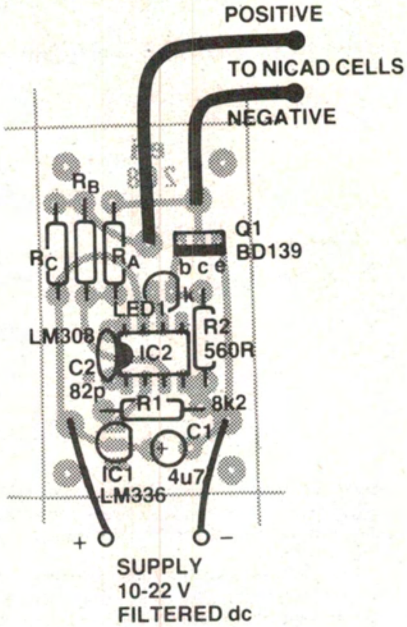
Resistors .... all ½W, 5% unless noted
- R1 .... 8k2
- R2 .... 560R
- R_A .... 15k, ¼W, 1% see Table 1
- R_B .... 12k, ¼W, 1% see Table 1
- R_C .... 5R6 see Table 1

Capacitors
- C1 .... 4u7 or 10u 25 V tantalum
- C2 .... 82p ceramic

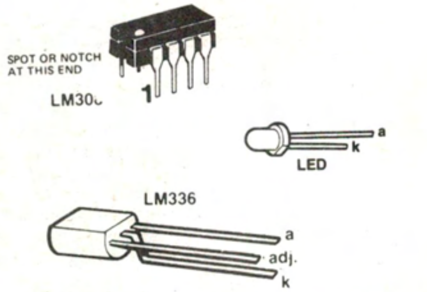
Semiconductors
- IC1 .... LM336
- IC2 .... LM308, uA308 (or /A)
- LED1 .... RL209R miniature red LED, or similar
- Q1 .... BD139

Miscellaneous
ETI-268 pc board; supply input and charger output connectors to suit (see text); small heatsink (see text) if necessary; hookup wire etc.

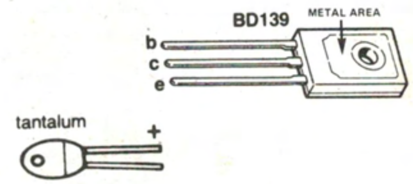
Price estimate
$7 — $8



Overlay. Showing component positioning on the pc board. Components are placed on the non-copper side of the board. Watch the orientation of C1, IC1, IC2, Q1 and LED1. Check these with the component pinouts.



IC1. The LM336 is available in a plastic case, similar to the TO-92 style and marked LM336Z or LM336BZ, or in a metal case, like a TO-39 style and marked LM336BH. The plastic-cased variety is most common and cheaper. Above is the pinout, showing lead connections.



Next, fit the components to the pc board according to the overlay, being sure to get the ICs, LED, transistor and tantalum capacitor the correct way around in each case. If you intend to charge cells larger than penlight size, or there is a possibility of more than momentary shorting of the output, leave enough length in the leads of Q1 and fit a small heatsink, about 2 cm² in area.

Mounting holes have been marked on the pc board if needed so it can be attached to a chassis.

Once assembled, fit the wires and connectors. A small clear or amber plastic pill bottle makes an excellent case for this project if no particular location is necessary. The wires can be knotted and slipped through two small holes in either end.

Turn on

Apply power and see that LED1 illuminates. If not, switch off and check the LED orientation and the supply polarity. Fix any faults and start again. Then connect the cells. A small increase in brightness of the LED should be noticeable as you make the circuit.

Note that you cannot normally judge correct operation by inserting a current meter in series with the batteries as this upsets the sensing by virtue of the slight voltage drop across the meter terminals. Instead, measure the voltage across R_C, and divide by the resistance to determine current flowing. ●

TABLE 1

(A)

Cell capacity	R_C
250 mAh	12R
500 mAh	5R6
1000 mAh	3R3

(B)

No. of cells	R_A	R_B	Supply (min.)
2	1k5	10k	10 V
4	15k	12k	10 V
6	68k	27k	13 V
10	56k	12k	19 V
	¼W, 1%	¼W, 1%	

CALCULATION OF VALUES

Make R_B a convenient value below 100k

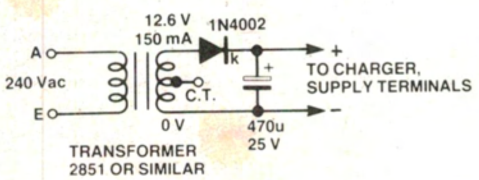
then, $R_A = R_B\left(\frac{C}{1.754} - 1\right)$

where C is the number of cells.

Go through the routine, reselecting a new value for R_B, if R_A does not come out within one or two per cent of a common value.

$R_C = \frac{3}{I_{nom.}}$

where $I_{nom.}$ is the nominal 10 hour charge rate.



CIRCUIT OF A SUITABLE POWER SUPPLY

SUGGESTED CONSTRUCTION OF POWER SUPPLY