Simple NiCad battery charger

Protect your investment in Nickel-Cadmium cells (NiCad for short) with this simple charger. It's very reliable, easy to build and won't ruin the cells by over-charging, which is a common cause of NiCad battery failure.

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PRACTICALLY EVERYONE who owns and/or uses battery driven equipment that is used regularly is aware of the staggering cost of the batteries that seem to need replacement with monotonous regularity. They seem to have the perverse habit of running flat at the most inconvenient time (Murphy's law notwithstanding): they are getting dearer all the time: their output voltage drops quite rapidly with discharge and last, but most importantly, they deteriorate almost as quickly on the shelf; as when they are in use.

Since it's not always practical to use mains-powered battery eliminators, one solution is a battery with a high 'ampere-hour efficiency'; that is, one whose voltage is much less affected by the discharge rate than the dry cell type. Also, it's handy if the battery can be recharged. The NiCad cell meets both these requirements. Although they are pretty pricey to start with, NiCad cells are capable (if treated properly), of up to *five hundred* charge/discharge cycles!

Just multiply the cost of your last battery replacement by five hundred and see the money that can be saved.

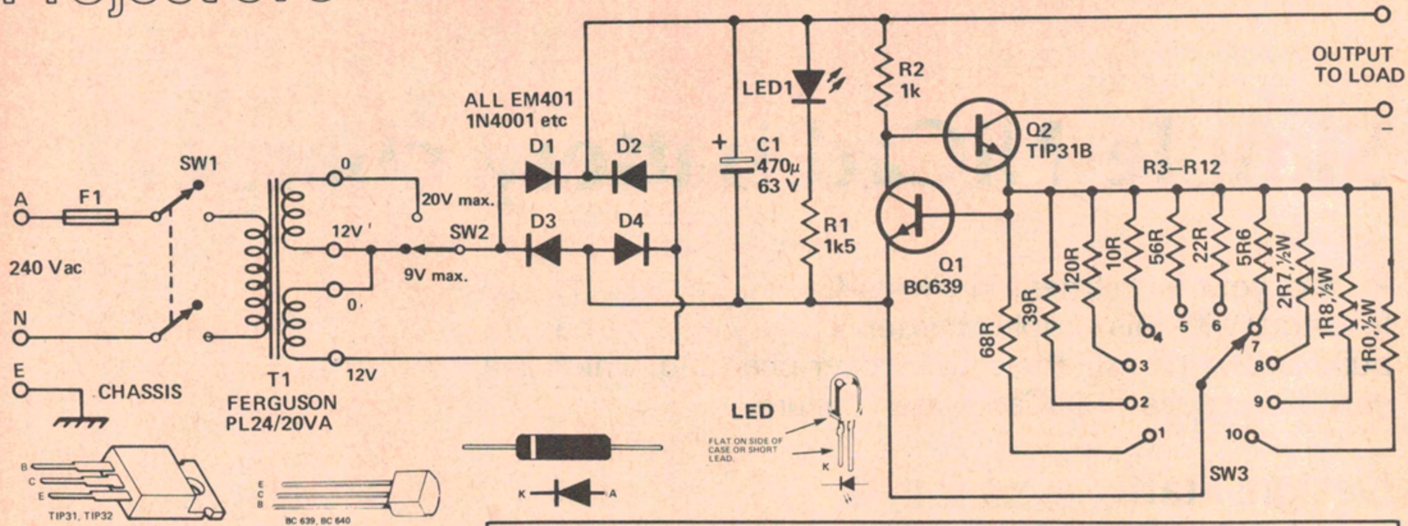
Care and feeding of NiCads

Now that you've been convinced of the economics of the matter, here are some basic but essential facts regarding NiCad cells.

The NiCad cell, like the lead acid unit, is a *secondary* cell or accumulator; i.e.: its chemical action is reversible. Passing direct current from an outside source (charger), converts electrical energy into chemical energy within the cell. The process is reversed when the cell is connected to an electrical load; the chemical energy stored within it during charging is converted to electrical energy which is dissipated by the load.

The NiCad cell needs a fairly constant charging current, this current being a function of the cell's capacity and the charging period. Cell capacity is expressed in Ampere-hours, abbreviated Ah, this being the current delivered by the cell, multiplied by the number of hours it will do so before reaching the discharged state. Take for example the 'AA' size NiCad cell which is equivalent to the U11 dry cell in dimensions and output voltage. It has a nominal capacity rating of 0.5 Ah; i.e: it will deliver half an amp for one hour; or 50 mA for 10 hours, 5 mA for 100 hours and so on.

However, there are physical limitations at higher current levels — one cannot expect to draw 50 A for 36 ▶



seconds or even 5 A for six minutes!

In fact, it is accepted practice to load the cells to only one tenth of the nominal Ah rating; i.e: if your circuit draws 50 mA average current, you should use at least a 0.5 Ah NiCad battery as a power source.

Similarly, to recharge a NiCad cell or battery to full capacity requires the same current-by-time multiplication sum. For example, to recharge an 'AA' NiCad cell it needs 0.5 A for one hour or 250 mA for two hours and so on.

Once again, owing to certain limitations — danger of cell rupture in particular — fast charging of our 0.5 Ah AA cell at 5 A for six minutes is definitely not on! Under certain circumstances NiCads can receive a 'rapid' charge and actually benefit, but perhaps we'll leave that subject till another time.

At this point we come to the basic problem of charging NiCad cells.

Danger of Overfeeding

Due to the nature of the NiCad cell, overcharging causes permanent damage. And it is quite hard to determine by ordinary means (such as a voltmeter) precisely where full charge occurs and overcharging begins. So it would seem that one must disconnect the cell from charging at, or before, the moment of full charge occurring!

Fortunately, there is a way around this problem which involves using a pre-determined low value of charging current. It is not a well known fact, but if the charging current is kept at one sixteenth of rated capacity then no permanent damage occurs, regardless of how long the cell remains on charge. In other words, you could leave your AA size NiCad cell connected to the charger for any convenient period, as long as the current was maintained at (500/16) mA

HOW IT WORKS — ETI 578

This charger consists of a step-down transformer, T1, a full-wave rectifier with capacitor-input filter (D1-D4 and C1), followed by a constant-current regulator involving Q1, Q2 and resistors R2 to R12, R3-R12 being selected by SW3 to provide the required charging current.

To understand how the constant-current regulator works, let's examine a simplified version of the circuit above - see Figure 1, below.

As the circuit stands, base current for Q2 will flow through R1 and Q2 will be turned on. Emitter current from Q2 will flow through R2, and if the voltage drop across R2 is above about 0.5 - 0.6 V, Q1 will turn on. Current through R1 will then be shared between the base of Q2 and the collector of Q1.

Now, with a load connected across the "constant current" terminals, collector current will flow through Q2 via R2. Thus, the voltage across R2 will attempt to rise. However, the base-emitter voltage of Q1 cannot vary greatly from a value of 0.6 V — this is a characteristic of the transistor. Thus, more base current will flow in Q1. This results in a greater collector current in Q1, which "robs" some of the base current from Q2, reducing its collector current. Thus, we have negative feedback and the current through the collector of Q2, which is also the load current, will settle to a value such that about 0.6 V is maintained across R2. Therefore, a constant current is delivered to the load, the value of which is entirely determined by the value of R2.

The power dissipated in R2 is kept quite low as the voltage across it will be no greater than about 0.6 V, thus low wattage resistors may be used.

In the project's circuit diagram above, Q1 and Q2 can be readily identified as they are identical with those in Figure 1. Base current to Q2 is supplied by R2 (a 1k resistor) and the output, or charging, current is determined by the resistor selected by SW3, from resistors R3 to R12.

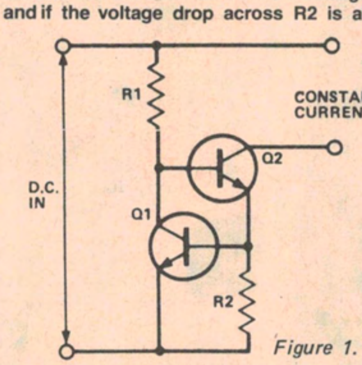


Figure 1.

PARTS LIST — ETI 578

Resistors all ¼W, 5% unless noted

R1	1k5
R2	1k
R3	68R
R4	39R
R5	120R
R6	10R
R7	56R
R8	22R
R9	5R6
R10	2R7, ½W
R11	1R8, ½W
R12	1R0, ½W

Semiconductors

Q1	BC639
Q2	TIP31B
D1-D4	1N4001, EM401 or similar, 1A diodes
LED1	TIL220R or similar red LED plus mount

Capacitors

C1	470u, 63V electrolytic

Miscellaneous

F1	¼A fuse and fuse holder to suit (240 Vac rated)
SW1	DPST switch, 240 Vac rated
SW2	SPDT switch
SW3	single pole, 10 or 12 position switch
T1	Ferguson PL24/20VA or similar, 12+12 V sec. at 800 mA.
pc board	ETI-578

Metal case to suit (we used a David Reid Electronics type, No.4., measuring 140 mm deep by 120 mm wide by 95 mm high); two "flat pack" heat sinks (Dick Smith H-3402 or similar) mains cable and three-pin plug; terminal block and cable clamp; rubber grommet; four rubber feet; piece of 1.6 mm thick cardboard; spaghetti sleeving; hookup wire; output terminals; solder lugs, nuts and bolts, two standoffs, Scotchcal front panel.

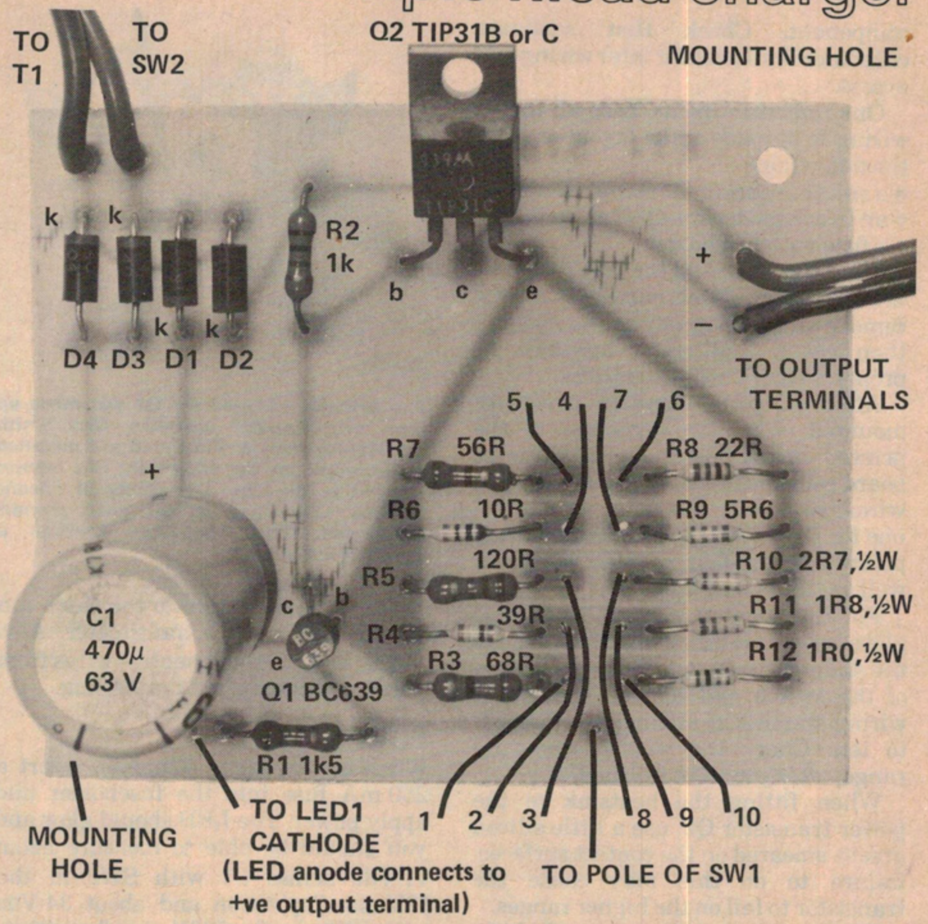
or 31 mA. Note that it would take at least 16 hours to fully recharge the cell.

The important thing of course is, you can't overcharge at this rate. The ETI-578 NiCad Charger is designed with this in mind. It provides a controlled charging facility for any one of ten types of commercially available NiCad cells. Table 1 shows the actual current ranges and the corresponding cell type numbers.

We used a simple voltage regulator and pre-determined values of current limiting resistors to get a ten-range constant current source. The output of the charger is very easily checked upon completion by connecting a current meter directly across the output. Remember that since this is a *constant current* source, the output current remains practically the same even if the output is shorted. The voltage goes up and down of course depending on the load.

One feature we have added is a switch (SW 2) to vary the input to the current regulator so that you can charge a string of cells, to a maximum of 16 (totalling about 20 V when charged).

Incidentally, the small sealed lead-acid batteries that have recently become available can also be charged using the ETI-578. These are generally available in ratings ranging from 2 Ah to about 9 Ah in 6 V and 12 V sizes.



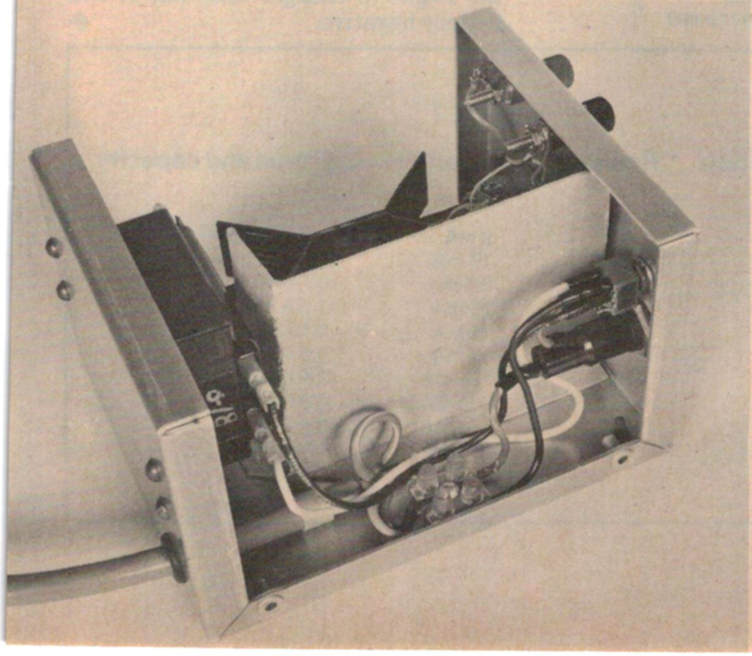
Component overlay for the pc board. Take care with orientation of the semiconductors.

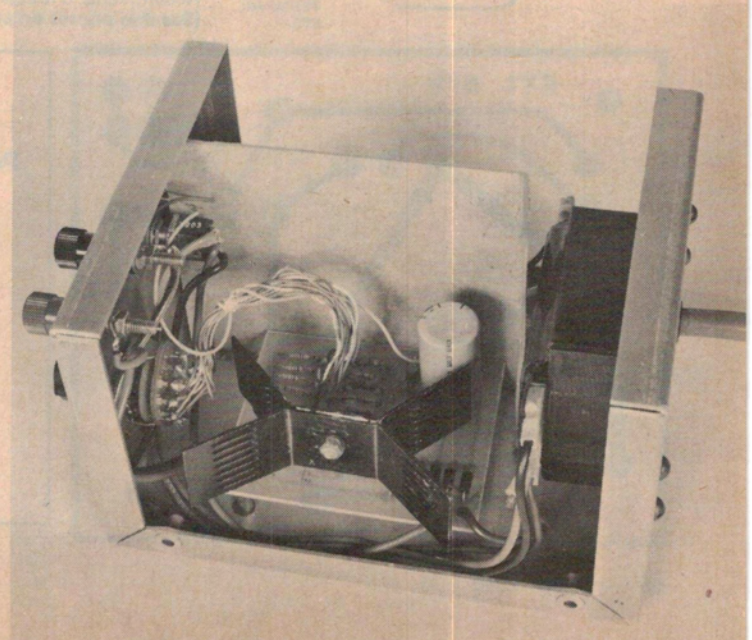
Construction

This should be very straightforward. Layout is absolutely uncritical so you can use any available case or box. We have not included any constructional details on suitable connectors between the output terminals and the cells because in most cases connection can be made via flying leads to the battery holder in the equipment itself.

Having collected all the necessary parts, start by laying out all the major components in position in the box. A little effort at this stage can save a lot of teeth-gnashing, filing, drill-snapping and other time wasting later on. Using a fine felt pen or soft lead pencil mark the holes for *every* chassis-mounted ▶

Internal views of the completed project. Note that a 1.6 mm thick cardboard 'divider' separates the mains wiring from the other components as a safety measure. It stands the full height of the chassis and may be glued or bolted in position. The view at left shows the general arrangement of the mains wiring (see also the diagram over the page). Sleeve all exposed connections. Use a rubber grommet at the mains lead entry, then a cable clamp and two-way terminal block. The earth lead is longer than the other two and is secured under a bolt used for it alone. The picture at right shows the pc board wiring to the major components.





component. Check that adequate clearance is allowed for later wiring and access.

One important point; keep all mains wiring to one side of the layout and use the following:-

- a suitable anchor for the mains cable,
- an insulated terminal block, and
- a fuse with fuseholder

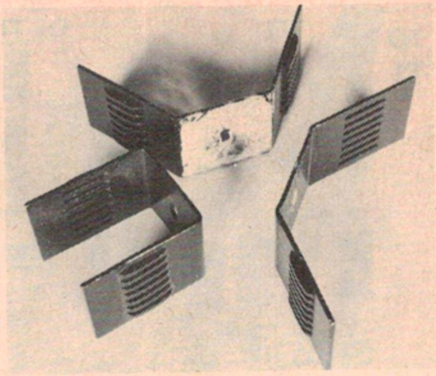
Having marked all the hole positions, drill and shape each one as necessary; remove all burrs and stray bits of metal, then check that all components fit properly before installing them.

After all panel-mounted parts are mounted, with the exception of the printed circuit board, assemble the pc board components. Fit the pcb-mounted wires (twelve for the range switch and one for the front panel LED). Check the polarity of the four rectifier diodes as well as the 470 uF capacitor.

Fit the printed circuit board into place using stand-off pillars. Identify the slider contact and the No. 1 position of the switch and connect the switch wiring starting at number one through to ten. Check the wiring, range by range, after you have finished.

When fitting the heatsink to the power transistor Q2, use a little silicon grease smeared on the contact surfaces; failure to do this may cause the transistor to fail on the higher ranges.

Fit the mains cable, terminal block, mains switch, and the fuse. Identify the earth lead and make a secure connection to the metalwork of the case.

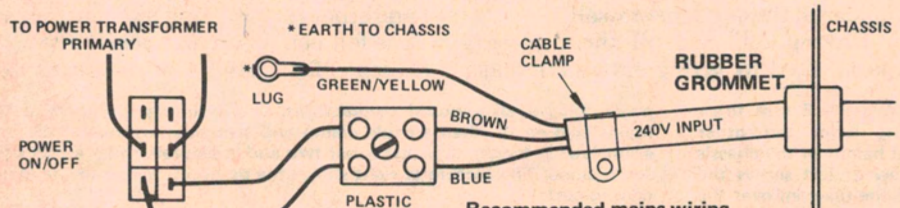


The heatsink we used for Q2 was made up from two 'flatpack' heatsinks, Dick Smith No. H3402, bent as illustrated and mounted back-to-back on the transistor. This ensures they fit in the case. Use plenty of silicone heatsink compound to get good thermal conduction. The unmodified heatsink is shown at lower left.

Check this connection to the earth pin on the plug with a multimeter. Also check the active and neutral wires from the transformer to the mains plug.

Powering up

When all wiring is complete, insert a 250 mA fuse into the fuseholder and apply power. The LED should glow and you should be able to measure about 17 Vdc across C1 with SW2 in the "9V max." position and about 34 Vdc with SW2 in the "20V max." position. The reading should be within about 10-15%, if not, switch off and check your wiring immediately.



Recommended mains wiring (See also photos on previous page)

Assuming that everything is OK and your charger has not vaporised in the first five seconds carry out the following functional checks:

- connect a multimeter across C1 and short the output terminals while observing the meter reading. This should change only slightly, no matter which range has been selected. Typically, with SW2 on '20 V max.' on the 10 Ah range, the readings should be about 34 V with the output unloaded and 27 V with it short circuited. Switch off after this test.
- Set the meter to read current and connect it across the output, positive lead to positive terminal. Set the charge range switch to position 1 and the meter to a suitable current range. Switch the charger on. Check the reading against the figure given in Table 1. Repeat this check range by range, not forgetting to change the meter ranges of course!

If most of the ranges check out OK (within 10%) but one or two are a long way out, it's most probably caused by an incorrect value series limiting resistor (R2 to R11).

If the first two or three ranges are fine but the output is insufficient on the higher ones, either Q1 or Q2 is faulty. Finally, short the output, switch on, and leave running for a few minutes. Test the temperature of Q2 by placing your finger tip against the body of the transistor. If an imprint of the manufacturer's name is left in your flesh, overheating is indicated! Check that the heatsink is attached tightly to the transistor.

When connecting up the unit for use do not forget to observe correct polarity; the positive terminal on the charger connects to the positive on the battery, the negative charger terminal to the battery negative. ●

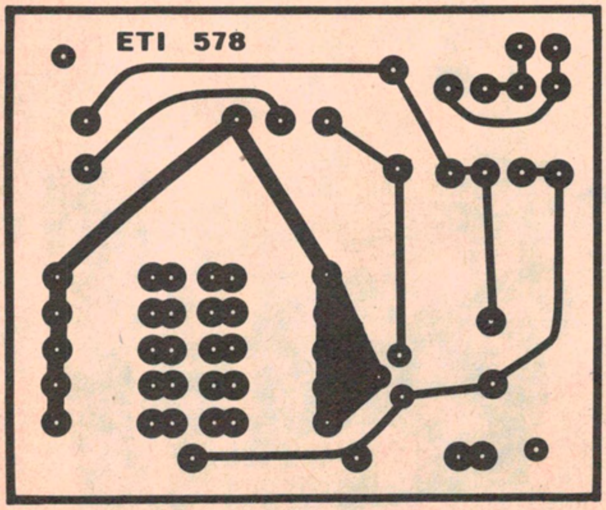


TABLE 1

Position	Resistor	Current	Cell type and capacity
1	R3	9 mA	150 mA hour Button cell
2	R4	17 mA	280 mA hour Button cell
3	R5	5.5 mA	90 mA hour, PP3
4	R6	75 mA	1.2 A hour, PP9
5	R7	11 mA	0.18 A hour, AAA
6	R8	31 mA	0.5 A hour, AA
7	R9	125 mA	2 A hour, C
8	R10	250 mA	4 A hour, D
9	R11	375 mA	6 A hour
10	R12	625 mA	10 A hour