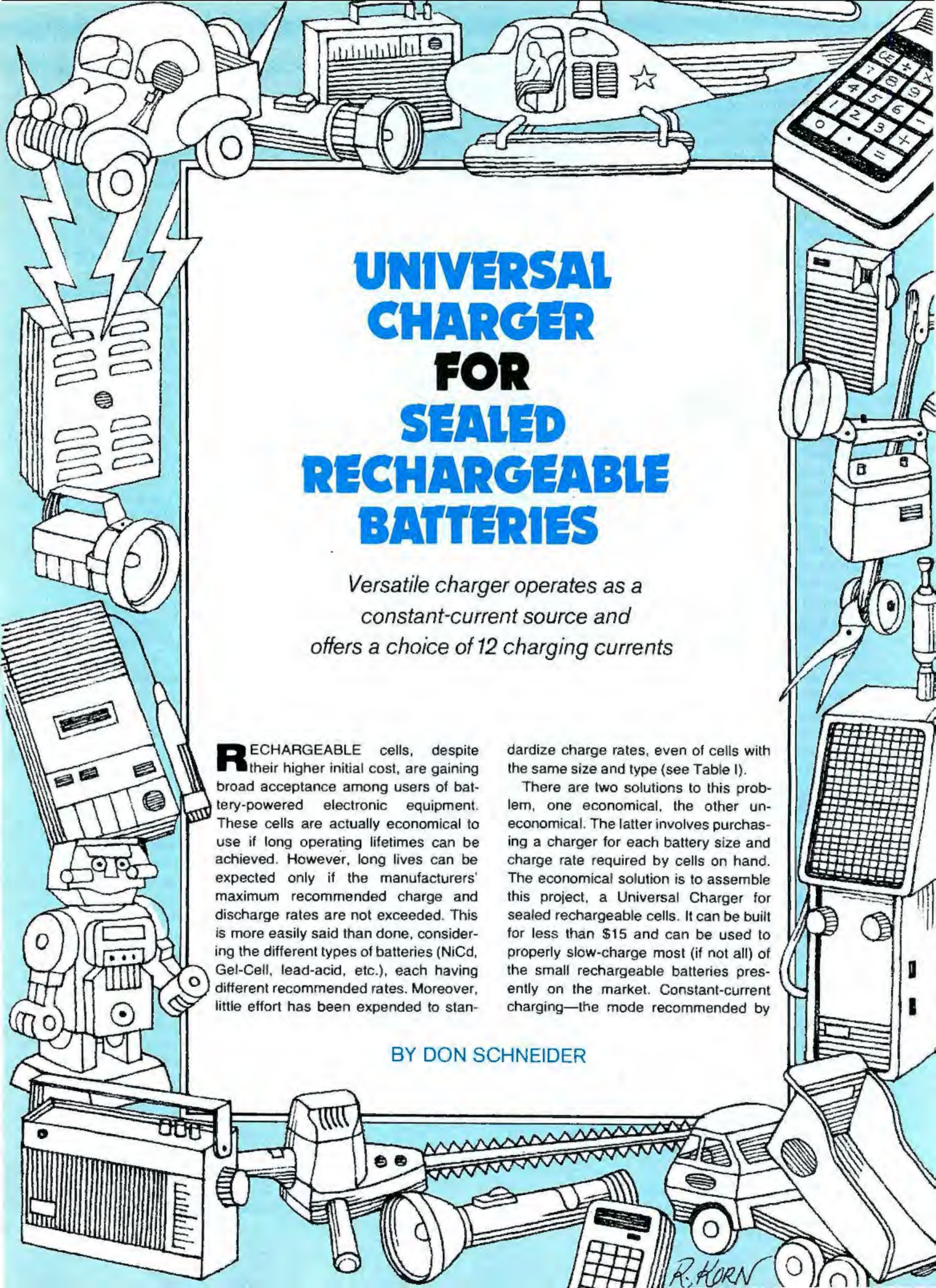

UNIVERSAL CHARGER FOR SEALED RECHARGEABLE BATTERIES

Versatile charger operates as a constant-current source and offers a choice of 12 charging currents

BY DON SCHNEIDER

RECHARGEABLE cells, despite their higher initial cost, are gaining broad acceptance among users of battery-powered electronic equipment. These cells are actually economical to use if long operating lifetimes can be achieved. However, long lives can be expected only if the manufacturers' maximum recommended charge and discharge rates are not exceeded. This is more easily said than done, considering the different types of batteries (NiCd, Gel-Cell, lead-acid, etc.), each having different recommended rates. Moreover, little effort has been expended to standardize charge rates, even of cells with the same size and type (see Table I).

There are two solutions to this problem, one economical, the other uneconomical. The latter involves purchasing a charger for each battery size and charge rate required by cells on hand. The economical solution is to assemble this project, a Universal Charger for sealed rechargeable cells. It can be built for less than $15 and can be used to properly slow-charge most (if not all) of the small rechargeable batteries presently on the market. Constant-current charging—the mode recommended by many battery manufacturers—is employed, and up to twelve 1.2-volt cells can be charged in series at any one time.

About the Circuit. The Universal Charger is shown schematically in Fig. 1. When power switch *S1* is closed, transformer *T1* steps down ac voltage from the power line. Modular bridge rectifier *RECT1* converts the ac into pulsating dc which is filtered by *C1*. Light-emitting diode *LED1* acts as a pilot light for the project. Zener diode *D1*, Darlington transistor *Q1*, and resistors *R2* through *R14* form a constant-current source which charges the depleted cells.

Most manufacturers recommend that their cells be slowly recharged at a rate equal to one-tenth of the maximum discharge rate. To accommodate a wide variety of cells, rotary switch *S2* offers a choice of 12 values of charging current. The switch grounds the emitter of *Q1* by way of one of 12 fixed resistors (*R3* through *R14*) whose resistance determines the magnitude of the charging current. Table II lists the current values selected by the author and the corresponding resistances of fixed resistors *R3* through *R14*. These resistances were determined experimentally, and are dependent on the zener voltage of *D1* and the dc beta of the Darlington.

Construction. The circuit of the Universal Charger is relatively simple, so point-to-point wiring techniques are recommended. Be sure to observe the polarities of all semiconductors and that of *C1*. Assemble the project in a utility box, mounting *Q1* either on a heat sink attached to the outside of the box or on the box's outer surface itself if it can dissipate the heat generated by *Q1* without the aid of a heat sink. Use an insulating mica washer, shoulder washers, and silicone thermal compound when mounting *Q1*. Be consistent when wiring *S2*, taking care to avoid inadvertent shorts.

Some variation from the values given for *R3* through *R14* will probably be required if the currents listed in Table II are to be obtained. (Of course, you can choose different charging currents to suit your own particular applications.) This variation will be due to the exact dc beta of the Darlington transistor and the zener voltage of the zener diode used.

Although the parts list specifies a particular Darlington and diode, substitutions can be freely made. The zener voltage can be as low as three volts or as high as 12 volts. (A lower zener voltage will allow a greater number of cells to be charged in series than is possible with a higher-voltage diode.) Parameters of the Darlington transistor are not critical, but it is recommended that the device used have a power dissipation equal to or greater than that of the component in the parts list (120 watts).

The best way to determine the values required for fixed resistors *R3* through *R14* is to temporarily ground the emitter of *Q1* through a 1000-ohm potentiometer before connecting any components to the emitter or to *S2*. The potentiometer should be connected to the emitter of

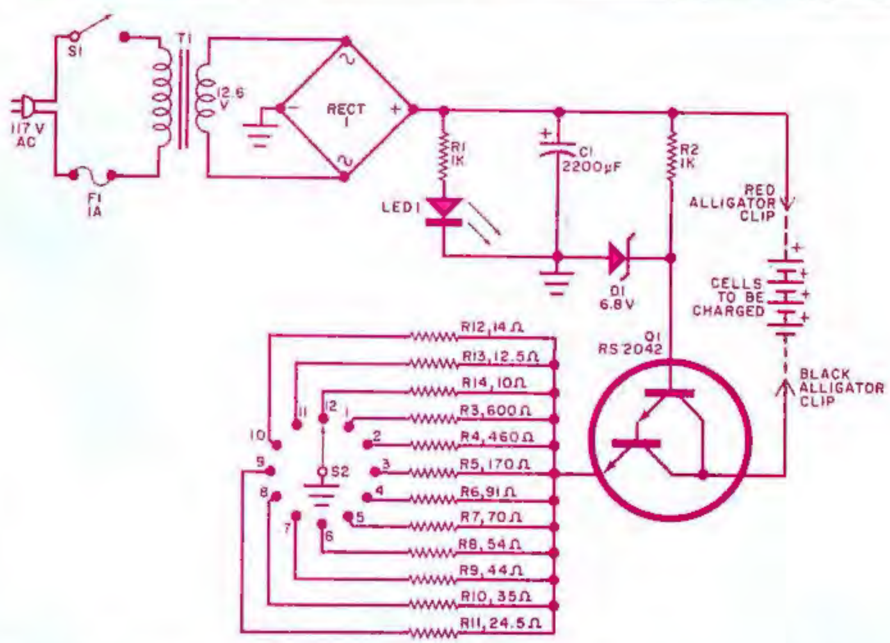

Fig. 1. Schematic shows how zener D1, Darlington Q1, and resistors R3 through R14 form constant-current source which regulates battery charging.

PARTS LIST

C1—2200-µF, 35-volt electrolytic
D1—6.8-volt, 1-watt (or greater) zener diode (see text)
F1—1-ampere fast-blow fuse
LED1—Light-emitting diode
Q1—120-watt (or greater) npn Darlington transistor (Radio Shack RS-2042 276-2042—see text)
The following are ½-watt, 5% tolerance fixed resistors unless otherwise noted. Also, see text with reference to *R3* through *R14*.
R1, R2—1000 ohms
R3—600 ohms
R4—460 ohms
R5—170 ohms
R6—91 ohms
R7—70 ohms
R8—54 ohms
R9—44 ohms
R10—35 ohms
R11—24.5 ohms, 1 watt
R12—14 ohms, 2 watts
R13—12.5 ohms, 2 watts
R14—10 ohms, 3 watts
RECT1—1.4-ampere, 50-PIV modular bridge rectifier
S1—Spst toggle switch
S2—1-pole, 12-position rotary switch
T1—12.6-volt, 1.2-ampere stepdown transformer
Misc.—Suitable enclosure, terminal strips, color-coded alligator clips, knob for *S2*, heat sink, mica washer, shoulder washers, silicone thermal compound, hook-up wire, line cord, strain relief, fuseholder, machine hardware, solder, etc.

TABLE I

Manufacturer's Type Number	Battery Size	Recommended Maximum Charge Rate (mA)
CH1.2/D	D	120
N3500D, GC3	D	350
CD10	D	400
CH1.2/C	C	120
GC2	C	150
N1650C	C	165
CD4	AA	22.5
N450AA	AA	45
CH500, GC1	AA	50
N88	8.4-V transistor	9
CD100	8.4-V transistor	15

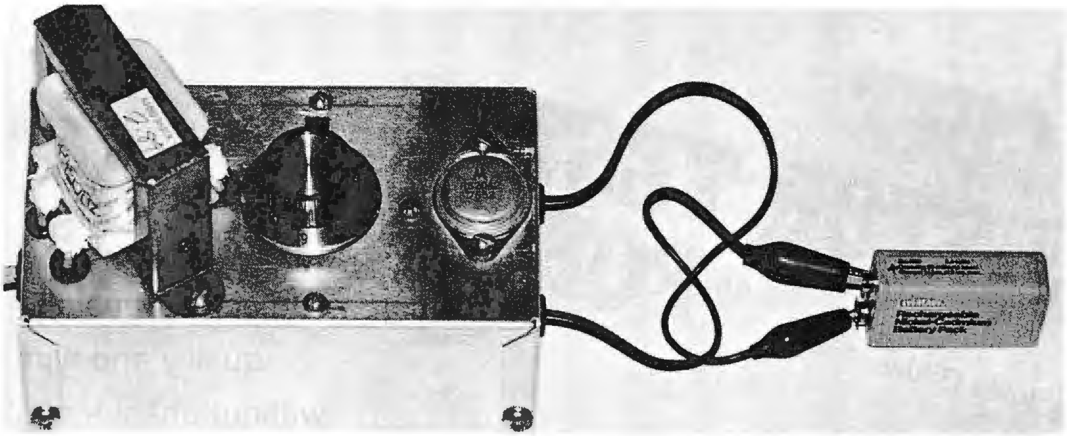

Photo of author's prototype shows components mounted on top of enclosure with clip leads used to connect battery to charger.

Q1 and to ground via leads terminated with alligator clips. Adjust the potentiometer for maximum resistance between the emitter of *Q1* and ground.

Next, connect a milliammeter between the collector of *Q1* (negative meter terminal) and the positive side of *C1* (positive meter terminal). Adjust the potentiometer so that the milliammeter indicates the lowest charging current desired. Then remove the potentiometer from the circuit and measure its resistance with an ohmmeter. Make a notation of the milliammeter and ohmmeter readings.

Insert the potentiometer back into the circuit and adjust it for the second desired (next largest) charging current. As before, disconnect the potentiometer, measure its resistance, and make a notation of the two meter readings. Repeat this procedure ten times until a total of 12 charging currents and resistance values have been determined. The required power rating for each resistor can be calculated using the familiar expression $P = I^2R$, where I^2 is the square of the charging current in amperes (pay close attention to decimal points!) and R is the measured potentiometer resistance in ohms.

Once the required resistance values have been determined, you can connect appropriate fixed resistors between the emitter of *Q1* and the lugs of *S2*. It's very possible that you will not be able to find resistors with the exact values that are needed. If you don't want to synthesize the required resistances by series or parallel (or both) combinations of standard resistor values, you can use trimmer potentiometers in place of fixed resistors. Be sure to choose trimmer potentiometers with adequate heat dissipation ratings if this approach is taken. A very definite advantage of using trimmers is that charge rates can be easily changed at some future time to accommodate newly acquired cells calling for charging currents different from those of the batteries presently on hand.

Interconnection between the charger and depleted cells is largely a matter of personal preference. The schematic suggests the use of color-coded alligator clips. This is perhaps the most convenient method when battery packs are to be charged. There are many other ways to do this, however. For example, the charger output points can be color-coded binding posts or banana jacks. If standard-package (AA, C, D, etc.) cells are to be recharged, suitable battery holders which connect the cells in series can be soldered to leads terminated with color-coded banana plugs. These plugs can then be inserted in the corresponding jacks when cells of that type are to be charged.

Use. After the batteries have been connected to the charger and *S2* placed in the appropriate position, apply line power by closing *S1*. The cells will now receive charging current. Most manufacturers recommend that NiCd cells be charged at one-tenth the maximum discharge rate for 14 hours. This is so because 40 percent more energy must be put into the cell than can be taken out. Similar recommendations are often made for Gel-Cell batteries. Once fully charged, some cells can withstand further application of charging current at the same rate and can be left connected to the charger indefinitely. Others must be disconnected from the charger circuit after they have been fully charged.

In any event, follow the manufacturer's instructions with respect to charging current and duration of charge. The flexibility inherent in the Universal Charger makes it certain that the project can be used with practically any battery that an electronics hobbyist would have occasion to use. Charging currents up to the rating of the power transformer can be obtained without overheating *Q1* because the transistor can dissipate 120 watts of heat. Also, a short circuit at the charger output will not damage the project because the transistor limits the short-circuit current to the value selected by switch *S2*. ◇

TABLE II

Position of S2	Selected Resistance	Charging Current (mA)
1	R3, 600 ohms	9
2	R4, 460 ohms	12.5
3	R5, 170 ohms	28
4	R6, 91 ohms	50
5	R7, 70 ohms	64
6	R8, 54 ohms	80
7	R9, 44 ohms	90
8	R10, 35 ohms	118
9	R11, 24.5 ohms	167
10	R12, 14 ohms	350
11	R13, 12.5 ohms	400
12	R14, 10 ohms	550