Free Roving Machine

A device which will "explore" a room and, by finding and tracing the path of a length of tape laid on the floor, return to a charger at intervals to recharge its batteries

by M. F. Huber, B.Sc.

A number of years ago, Dr. Grey Walter first demonstrated that quite simple machines could mimic the goal-seeking ability of animals. The machine described here will avoid the obstacles in a room and return at intervals to a battery charging point. For safety reasons, the machine charges at a low voltage. The charger consists of a step-down transformer in an insulated box, with sockets in which the probes on the machine engage. The charger is placed against a wall of the room, and a few feet of white tape are laid on the floor from a point midway between the socket holes towards the centre of the room, with the blind end formed into a small loop (Fig. 1).

The machine is driven by two motors, one for each of the rear wheels, so that steering can be obtained by reversing one of the motors. A third, castor wheel, is fitted to the front of the machine.

The front bumper is made from springy piano wire and has two associated contacts. In a head-on collision both contacts are made, but if the machine hits an object with a glancing blow only one contact is made.

The probes at the rear of the machine have to make contact with the charger unit. They are mounted on single turn springs of light piano wire and are arranged so that if one probe is depressed more than the other a contact is broken.

The machine roams the room with the bumper at the front. If the machine strikes an obstacle head-on, pressure on the bumper will cause capacitors C_4 and C_5 (Fig. 2) to charge to 15V. Relays *B* and *C* will be energized by Tr_4 and Tr_5 for unequal periods dependent on the time-constant C_4R_5 and $C_5R_6R_8$. Relays *B* and *C* reverse the motors, and consequently the machine will back away, turn, and proceed in a new direction. If the obstacle is struck a glancing blow, only the motor on the opposite side is reversed and the machine sheers away because only one of the bumper switches make; obstacles which energize *RLC* also energize *RLD*. Relay *D* puts the machine in a "search" mode by lighting LP_1 with contact *RLD*/1. Contact *RLD*/2 holds the relay on.

Lamp LP_1 is situated underneath the machine and its purpose is to illuminate a strip of white tape on the floor as mentioned earlier. The tape is sensed by a pair of phototransistors, which are used to control the motors in such a way that the machine follows the tape. Lamp LP_2 lights at the same time as LP_1 and provides a visual indication that the machine is in the search mode. Potentiometer R_{10} is used to set the brightness of the lamps.

After a number of collisions the machine will eventually cross the white tape. Whichever of the phototransistors (Tr_1 and Tr_2) is over the tape (which is now illuminated by LP_1) it will, by energizing the appropriate relay, cause the motor on the opposite side to reverse. Zener diodes D_7 and D_8 ensure that the relays operate without backlash; diodes D_6 and D_9 prevent overdriving[1]. The machine will thus shunt to and fro over the tape until it has aligned itself along it. It will then follow the tape with the probes at the front. Quite sharp changes in direction are permissible for the tape, since if both phototransistors lose the tape on a corner, the machine merely reverses back onto the tape.

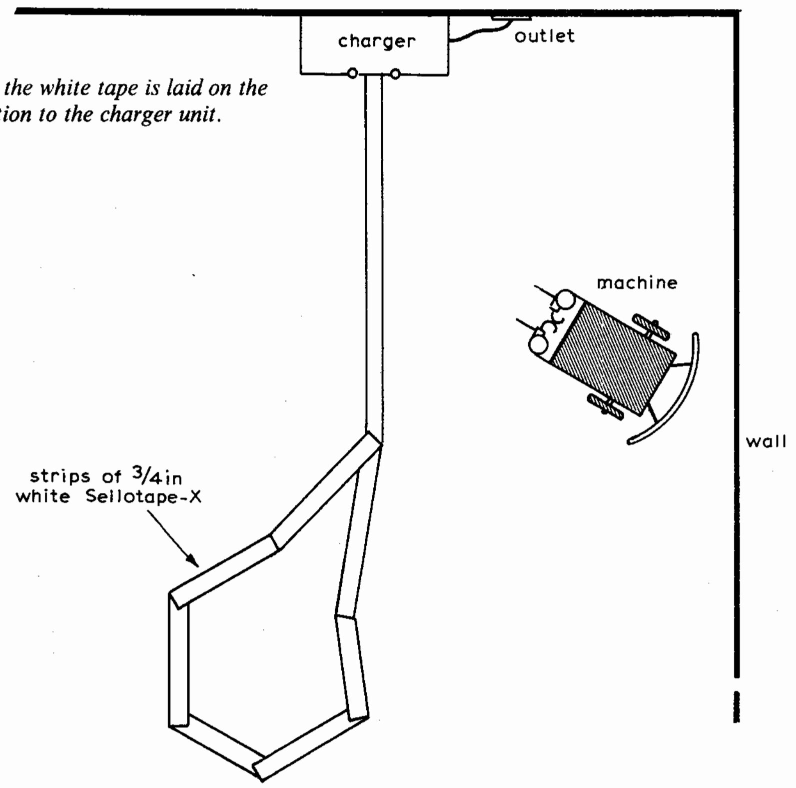

Fig. 1. How the white tape is laid on the floor in relation to the charger unit.

When the machine arrives at the charger the probes may enter the holes first time. Slight misalignment of the machine can, however, cause one or both of the probes to strike the charger face instead. The probe contacts are designed to separate immediately if one probe is depressed more than the other, or after a certain equal pressure on both probes is reached. Thus when the holes are missed, LP_1 is extinguished as the probe contacts open. In cases of severe misalignment, which occur when the tape is first acquired very close to the charger, the machine may make a dozen or more stabs at the holes before insertion. Usually though two or three attempts suffice.

When the probes contact the supply, the output from the bridge D_1 to D_4 charges C_1 causing Tr_1 to conduct heavily. Diode D_5 prevents overdriving and, together with R_1 forms a discharge path for C_1. Relay *A* is energized by the current through Tr_1 and is held on via contact *RLA*/1 with the battery charging current, if the batteries are in need of charge. When *RLA*/1 changes over, only a reduced voltage can reach the motor control circuits through the motors. Resistor R_9 is large enough to cause *RLD* to de-energize.

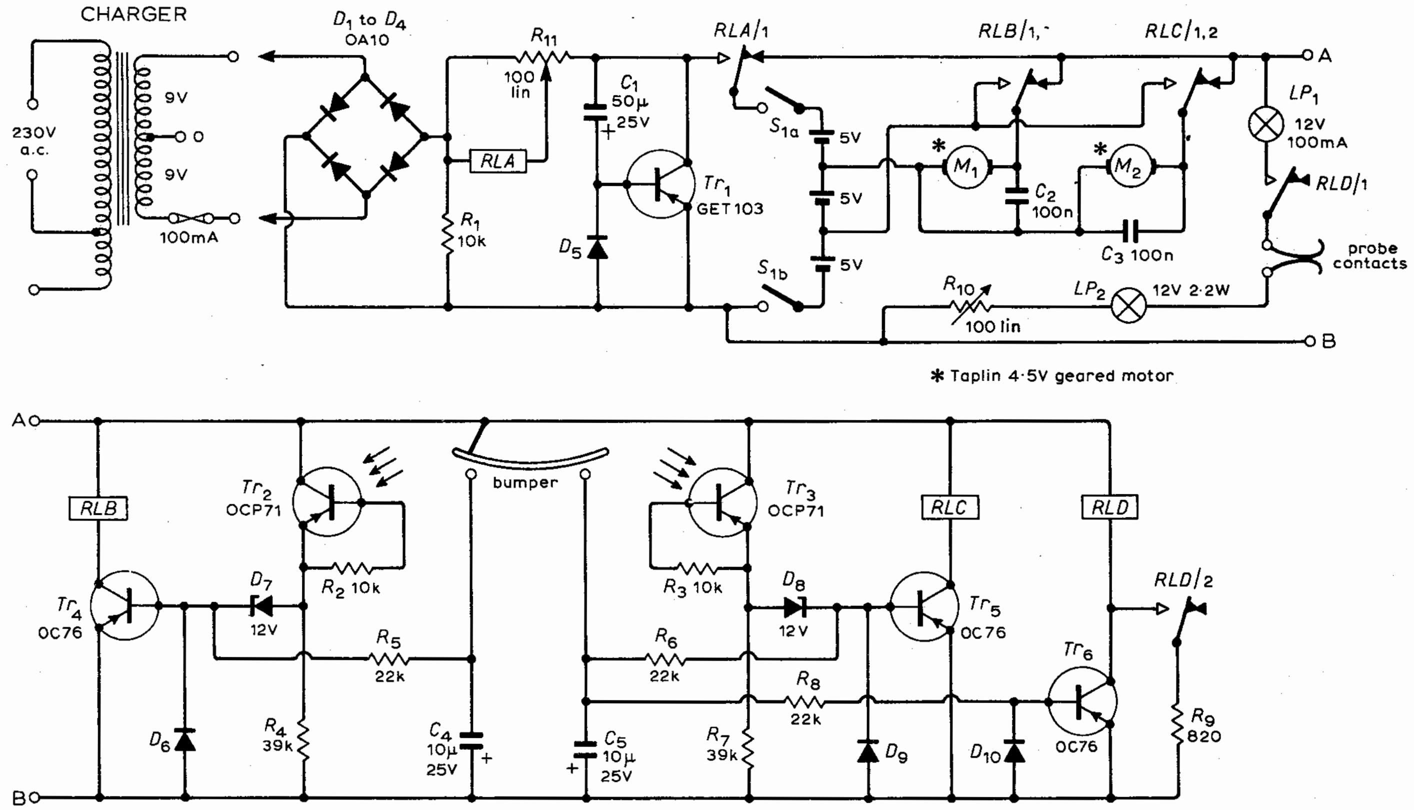

Fig. 2. Circuit diagram of the machine and the separate charger unit.

Lamp 1 is extinguished and *RLB* and *RLC* de-energize. The motor control circuits can now draw only a negligible discharge current. The motors are disconnected since contacts *A*, *B* and *C* have changed over and the machine will thus remain at the outlet until charging is complete. This period will vary from a few seconds to many hours.

When the battery charging current falls below a certain level set by R_{11}, *RLA* de-energizes. The lamp is no longer lit so the machine ignores the tape and moves off to explore the room.

Control R_{10} is set for optimum tracking along the tape. The setting will depend on the degree of contrast between the tape and the floor; the machine will function properly only on dark or green floors. Control R_{11} is set so that the machine emerges from the charger when the battery reaches between 15.5 and 16V.

Component notes

The individual constructor will no doubt modify the design to suit the components he has available. All the transistors in the prototype were general purpose germanium types. The transformer was type MT98 with a 9–0–9V 80mA secondary but practically any transformer which will supply around 18V will suffice. The expensive items are the rechargable DEAC L-type cells. Three 9.6V 225mA were used split in half and connected in series/parallel to give 15V. The motors can be either Taplin 4.5V geared motors or Meccano No. 11057 or any similar geared motors. The relays need not be exactly as mentioned below but if relays of significantly different characteristics are employed it may be necessary to alter other component values: *RLA*, 100Ω, s.p.c.o. (sensitive radio control type); *RLB*, *C*, *D*, 340Ω, 2 p.c.o. (Clare minature).

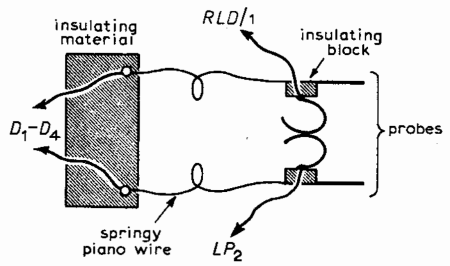

Fig. 3. Construction of the probes at the rear of the machine.

Reference

1. T. D. Towers, "Relay-semiconductor Control Circuits", *Wireless World*, May 1968, pp. 126–9.

Corrections

We regret the transposition of some captions in the article *"Some Early Radio Receivers"* in our November issue. On p.512 the captions at the foot of col.1 and top of col.2 were transposed as were those for the Ultra and Marconiphone speakers on p.513.

In Fig.2 in Mr Oldfield's *letter* on p.521 of the November issue the "greater than" sign after + V_{out} *should be "less than"*.

The table accompanying the *loudspeaker enclosure survey* in the November issue omitted details of those models for which information had not been received from manufacturers; the table below gives data on eight more enclosures. In the article, the ordinate on the Mordaunt-Short MS235 free-field response curve should have been marked in 10dB and not 5dB steps, with the 5dB marking being 0dB. In the third column of page 557 the equation for inductor values of Fig.8(a) should read $L = Z/(2\sqrt{2}.\pi f)$.

Model	Power rating (W)	Size (in)	Impedance (Ω)	Drive units	Finish	Price £	P. Tax
B. & W. Electronics, Meadow Road, Worthing, Sussex BN11 2RX							
DM70	25-100	32⅜×26⅞×15⅜	8	2*	Walnut or satin white	159.50	—
DM2	25-60	25½×14×13¾	8	3	Teak, walnut, rosewood or satin white	69.99	Inc. tax
DM4	10-30	21×10×10	8	3	Teak, walnut, rosewood or satin white	49.66	Inc. tax
DM1	up to 15	16½×9×8	8	3	Teak, walnut, rosewood or satin white	37.39	Inc. tax
D5	10-25	18×9×7	8	2	Teak, walnut or satin white	29.74	Inc. tax
*Including electrostatic unit							
Spendor Audio Systems Ltd, Kings Mill Lane, South Nutfield, Redhill, Surrey RH1 5NF							
BC1	40	25×11¾×12	8	3	Teak or white*	77	Inc. tax
BC11	50	25×11¾×12	8	3	Teak or white*	85.75	Inc. tax
*Walnut and rosewood extra. Trolleys available: black and white £8.50, satin-chrome £10.90.							
Goodmans: data on new enclosure							
Goodwood	60	30×14¼×10¾	4-8	3	Teak or walnut*	55	—
*White extra							