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EMILY

ROBOT with a One Track Mind
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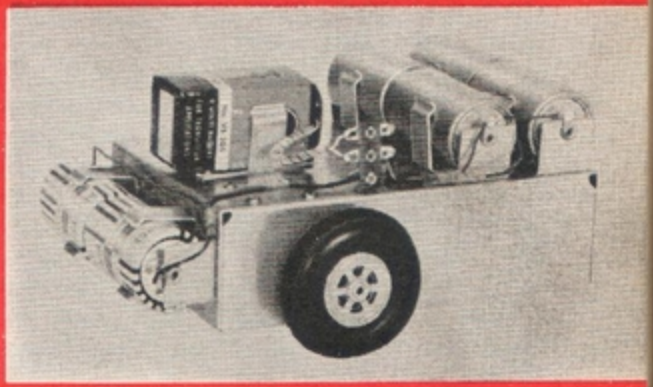


Emily...

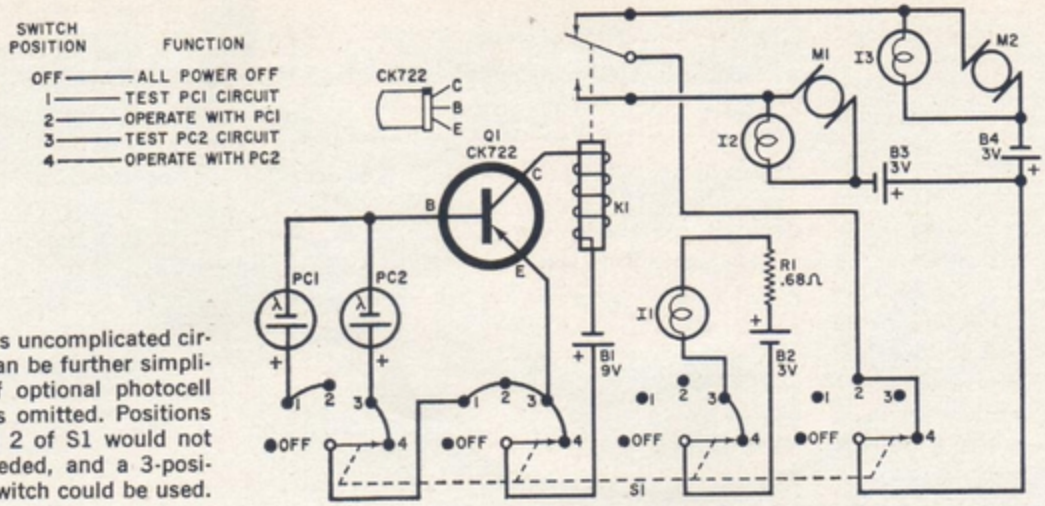
The Robot with a One Track Mind

By BERNARD DICKMAN

THE strange-looking object following the white line is named "Emily." She may look like a dishpan with eyes, but this "Electro-Mechanical Inebriated Ladybug" is actually an electronic robot of the simplest type. Though equipped with only one "sense organ" (a photocell), two "muscles" (a pair of motors), and a very rudimentary "brain" (a transistor and relay), she's capable of some extremely intelligent (if slightly inebriated) behavior.

The ladies of our own species are often *said* to have "one-track minds." In Emily's case, however, this is literally true. Set her down on a white line and she'll doggedly follow it, regardless of how many times it twists and turns. Though her weaving gait suggests that she's a little "under the influence," she always reaches the end. This isn't all Emily can do, though; blink a flashlight beam at her and she'll follow *you* to the ends of the earth.

COVER STORY



Emily's uncomplicated circuit can be further simplified if optional photocell PC1 is omitted. Positions 1 and 2 of S1 would not be needed, and a 3-position switch could be used.

PARTS LIST

B1—9-volt battery (RCA VS 305 or equivalent)
B2, B3, B4—3-volt battery; 2 flashlight cells in series (Burgess Type 2 or equivalent)
I1—2.2-volt, prefocused-type flashlight lamp (G.E. Type 222 or equivalent)
I2, I3*—Pilot lamp (G.E. Type 48, or equivalent)*
K1—Sensitive relay; 8000-ohm, 0.7-ma. coil; s.p.d.t. contacts (Sigma 26F-8000-CDS/SIL or equivalent)
M1, M2—Miniature d.c. motor (supplied with gear train kit—see "Hobby-Shop Items" listed below)
PC1, PC2—Selenium photocell (International Rectifier B2M or equivalent)*
Q1—CK722 transistor
R1—0.68-ohm, ½-watt resistor
S1—4-pole, 5-position rotary switch (4-pole, 3-position switch if PC1 is not used—see text)
1—2" x 7" x 5" aluminum chassis (Bud AC-402 or equivalent)
1—1¼" x 2¾" x 2⅝" miniature aluminum chassis (Bud CB-1623 or equivalent)*
1—Socket for I1 (Dialco 505 or equivalent)
3—Battery holders—for B2, B3, and B4 (Keystone 186 or equivalent)
1—Battery holder—for B1 (Keystone 96 or equivalent)
Misc.—Terminal strips, wire, hardware, plastic dishpan, pilot lamp assemblies for I2 and I3 (if used), etc.*
**Optional—see text*

Hobby-Shop Items

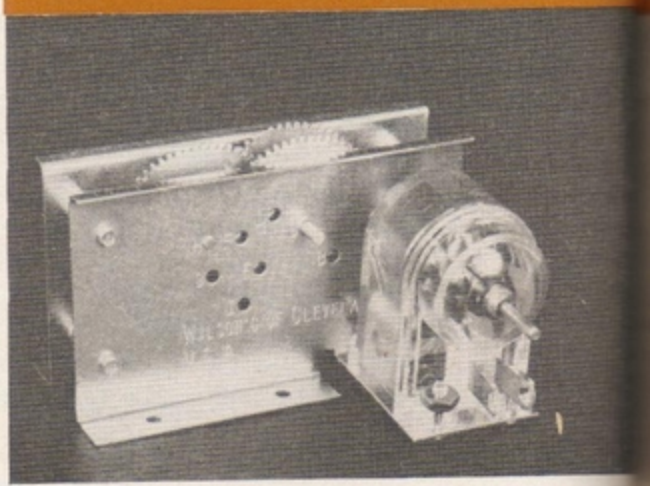
2—Wilson No. 3000 motor and gear train kits —see text
2—2½"-diameter, airplane-type wheels (VECO No. 321 or equivalent)
1—1"-diameter, airplane-type wheel
1—6"-length of stiff wire (diameter to match hub of 1" wheel above)
Misc.—Epoxy-resin glue (Duro E·POX·E or equivalent) or "heatless" solder (Craftsman Metal-Mend or equivalent)

How Emily Works. Emily's uncanny behavior is made possible by a very simple electronic circuit. With switch *S1* in *position 4*, as shown in the schematic diagram, photocell *PC2* is connected to the base circuit of transistor *Q1*. Also, power is fed to the transistor, exciter lamp (*I1*), and motors *M1* and *M2* from batteries *B1*, *B2*, *B3*, and *B4*, respectively.

Exciter lamp *I1*, a 2.2-volt flashlight bulb, is powered from 3-volt battery *B2* and provides illumination for photocell *PC2*. Though resistor *R1* drops the battery voltage a bit, *I1* is still operated slightly in excess of its rating. This is done purposely, since the extra light output is needed to insure positive operation of the photocell.

When *PC2* is illuminated, a small volt-

One of the two motor and gear train units which drive rear wheels. Assembled from kits, these units were set for reduction ratios of 216 to 1.



age is generated which biases *Q1*'s base. This causes the collector-emitter resistance of the transistor to drop to a low value, allowing current to pass from *B1* through *K1*'s coil. The energized coil then pulls down the relay armature.

Motors *M1* and *M2*, each of which turns one of Emily's rear wheels, are controlled through the relay's contacts. When the relay coil is not energized, power is fed to *M2;* when it is energized, power is fed to *M1*. The two motors are never powered simultaneously.

Photocell *PC2* and exciter lamp *I1* are mounted on the *M1*, or right, side of the chassis, near the front, as shown in the photos. The lamp, which is of the prefocused type, is pointed down. If it passes over a white surface, light is reflected back into the photocell and motor *M1* is switched on; if the surface is dark, *M1* is shut off and power is fed to *M2*.

When Emily is placed over a white line on a dark floor, the left-rear wheel (driven by *M2*) will rotate. Pivoting on her single front wheel, she will turn toward the right until *I1* passes over the line, reflecting light into *PC2* and activating *K1*. This, of course, switches power from *M2* to *M1*, and Emily will turn toward her left until *I1* is moved away from the white line and power is switched back to *M2*.

The process is then repeated as described above—the net result being that the robot follows a mildly "drunken" course along the line. Indicator lamps *I2* and *I3* (optional), wired in parallel with *M1* and *M2*, respectively, are Emily's "eyes"; they blink on and off as she changes direction.

Position 3 of *S1* is used for test purposes. With the switch set in this position, photocell *PC2*, the transistor, and exciter-lamp circuits are left unchanged —but power for the motors is cut. In this way, the operation of the white-line tracking circuits can be checked without running the motors.

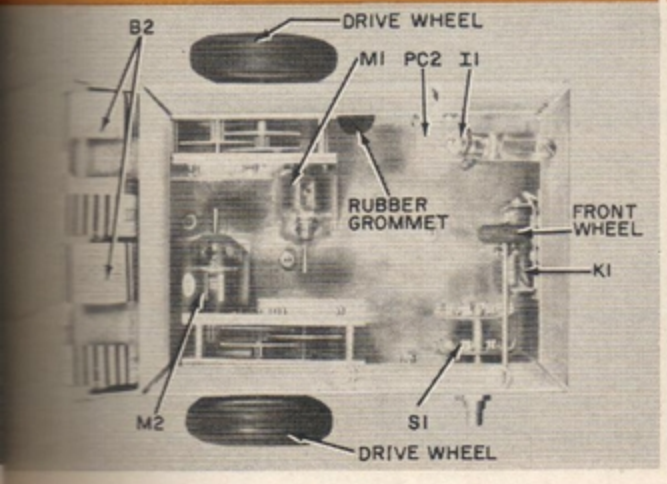
With *S1* in *position 2*, photocell *PC1* is connected to *Q1*'s base circuit in place of *PC2*. This optional photocell is mounted on top of Emily's cover and enables the robot to follow, by means similar to those discussed earlier, a flashlight beam in a darkened room. Power is also fed to the transistor and motor circuits, but exciter lamp *I1*, not needed in this application, is shut off.

Position 1 of *S1* is used for testing the light-beam following circuit. With *S1* in this position, everything is connected as above, except that the motor circuit is shut off. To cut off all of Emily's power, *S1* is placed in the "off" position.

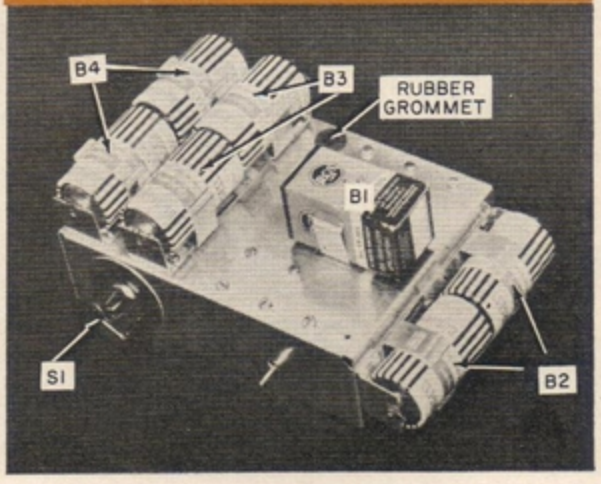
If the light-beam-following feature is not desired, *PC1* is not needed—nor are switch positions 1 and 2. In this case, Emily may be wired to use a 4-pole, 3-position switch.

Putting Emily Together. Begin by assembling the two Wilson No. 3000 motor and gear train kits which will supply the robot's motive power. Following the in-

View of robot's underside with all major components installed. Terminals of K1 should be prewired, since they are difficult to reach once relay is in place.



Batteries which power the motors, exciter lamp, and transistor circuit dominate top view. Battery leads are run through the rubber grommet.



structions supplied with the kits, set up each unit for a reduction ratio of 216 to 1.

These kits are available in most hobby shops; but you can also get them by mail (write Wilson's of Cleveland, 6502 N.W. 16th St., P.O. Box 8995, Fort Lauderdale, Fla., enclosing $4.00 for each kit). You'll find that more gears are included than you will need, but it's more economical to purchase the kits than to buy the required components individually.

With the power units assembled, the main construction job can begin. Parts placement is not critical, except where specified, but the photographs should be followed as closely as possible.

Mount the power units under the chassis as shown. Each one should be positioned so that its output shaft passes through the chassis lip at a point about 2″ from the *B2* end of the chassis. Use sheet-metal screws wherever there isn't enough clearance to install a nut for a machine screw.

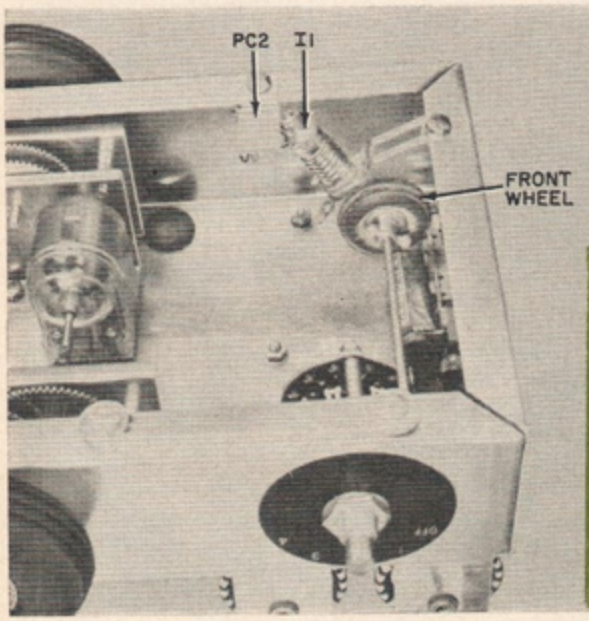
Relay *K1* is installed under the chassis on the end opposite *B2*. Place it far enough from switch *S1* so you won't have difficulty wiring the switch terminals. The terminals of the relay itself are difficult to reach once the unit is fastened in place, so solder leads of the proper length to each one before installation.

The bracket for *I1*'s holder is fastened to the lip of the *K1* end of the chassis and positioned 1″ from the corner as shown. Before installing *I1* in the holder, wrap the bulb with tape so that only its tip is left unmasked. Then, with *I1* in place, bend the bracket down so that the tip of *I1* projects only about $\frac{3}{16}$″ out from the chassis. Photocell *PC2*, its right-angled mounting bracket carefully bent out straight, is also fastened to the chassis lip and placed so that it centers on, and almost touches, *I2*.

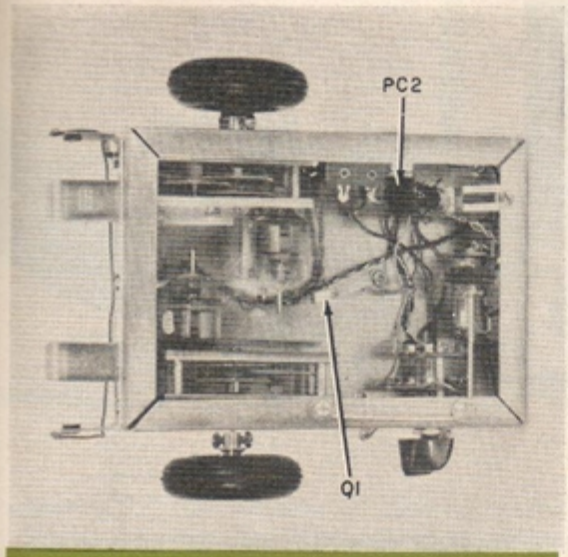
The leads of transistor *Q1* are soldered to a 3-lug terminal strip fastened under one of the mounting nuts for *B3*'s holder. Dropping resistor *R1* (not visible in the photographs) is mounted on a 2-lug terminal strip which is located under *PC2* and fastened to another of the mounting nuts for *B3's* holder. Other terminal strips found to be necessary as you proceed with the wiring can be installed as you go along.

Holders for batteries *B1, B2, B3,* and *B4* are mounted as shown in the photos and need no special comment. The leads from these batteries, and from the pilot lights and photocell (if used) on Emily's cover, pass to the underside of the chassis through a $\frac{3}{8}$″ rubber grommet placed as shown.

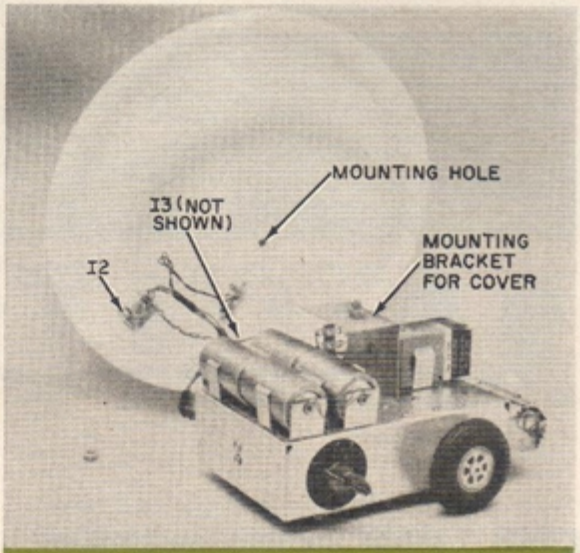
This all but completes the mechanical work on the chassis except for the installation of the wheels. The small front wheel is mounted on a length of steel wire, the diameter of which matches its hub. As can be seen in the close-up photograph of this assembly, the wire is bent



Mounting of PC2, I1, and front wheel can be seen clearly at left. Terminal strip for resistor R1 will be fastened under nut directly below I1. Rear wheels with setscrew pulleys glued on are shown below, as is spare shaft used for centering the hubs. Either epoxy resin or "heatless" solder can be used for gluing.



This under-the-chassis view shows the completed wiring. A 3-lug terminal strip is mount for Q1; connections to PC2 are made via a 2-lug strip.



Completed robot with dish-pan cover in background. All the components and wiring associated with the cover are optional (see text).

at a right angle and fastened at two points on the chassis lip with screws and washers.

The driving wheels are mounted on the gearbox output shafts by means of set-screw pulleys (one is supplied with each Wilson kit). These pulleys must be glued to the wheels; either epoxy-resin glue or "heatless" auto body solder will work well (see Parts List).

The hubs of the wheels used in the model were larger in diameter than the 3/32" pulley hubs. In order to center the pulley hubs on the wheel hubs properly, spare 3/32" shafts from the kits were slipped through the latter. In each case the diameter of the shaft, where it passed through the wheel, was built up with masking tape to match the diameter of the hub. The pulley was then slipped over the protruding end of the shaft and glued in place. When the glue dried, the spare shafts were removed and the wheels mounted on the gearbox shafts.

The design for the robot's cover can be as fanciful and imaginative as you wish to make it. The cover used here was made out of a yellow plastic dishpan about 12¾" in diameter and 4" high. A 1¼" x 2¾" x 2⅝" miniature aluminum chassis, its two short ends bolted to Emily and the dishpan, respectively, serves as the mounting bracket.

Photocell *PC1* and the pilot lamp assemblies for *I1* and *I2* are mounted on the cover. A terminal strip installed under *PC1*'s mounting nut connects the short leads of the photocell to the longer ones required to reach the chassis. The photocell and the two pilot lamps, as explained earlier, are optional.

Emily's wiring is not at all critical. All connections are made in normal point-to-point fashion, and no special attention need be paid to lead dress. Just be sure to use a heat sink when soldering *Q1*'s leads and to observe carefully the polarity of battery *B1*—otherwise, the transistor might be damaged.

Testing and Operation. Install batteries *B1, B2, B3,* and *B4* and, if *PC1* is used, set switch *S1* at position 1. Shine a flashlight on photocell *PC1* and check to see that relay *K1* pulls in. When you block the light beam with your hand, the relay should return to its normal position.

With *PC1* illuminated, turn *S1* to position 2. This should start motor *M1* and illuminate *I2*. Be sure that the rotation of the wheel is in the proper direction (clockwise when viewed from the side). If the rotation is wrong, reverse either the motor leads or the polarity of battery *B3*.

Next, shield *PC1* from the light. This should switch power from *M1* and *I2* to

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Emily . . . the Robot

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M2 and *I3*. If the rotation of *M2*'s wheel is not *counter*clockwise when viewed from the side, reverse the connections to *M2* or the polarity of battery *B4*.

Now turn *S1* to position 3. This will stop the motor, turn on exciter lamp *I1*, and switch photocell *PC2 to Q1*'s base circuit in place of *PC1*. Position a white card in front of *I1* so that the beam is reflected back into *PC2* and check to see that *K1* pulls in. Then cover the photocell with your thumb; the relay should return to its normal position.

Finally, move *S1* to position 4 and repeat the tests outlined above. With the photocell illuminated, motor *M1* should turn and *I2* should light. When the photocell is covered, power should be switched from *M1* and *I2* to *M2* and *I3*.

If Emily passes these preliminary tests, you're ready to try her out. Use ¾″ masking tape, or some similar light-colored material, to lay out a patch on the floor (pick out as dark a floor as possible which is not too shiny). The path may curve in as many directions as you wish, but a turn that is too sharp can make Emily "lose her way." A little experimentation will soon show you just how sharp a turn she can take.

Center Emily directly over the path and set *S1* to position 4. The robot should travel to the right until she "finds" the path, then follow it to the end. When the end is reached, she'll turn in circles until you shut her off or place her on the path again.

If Emily doesn't work properly at this point, chances are one of two things is wrong. Either motor *M1* is running all the time (*PC2* receiving too much illumination) or motor *M2* is continually running (*PC2* receiving too little illumination).

Should the problem be too much illumination, *PC2* is probably picking up a reflection of *I1*'s beam from the floor. You can make the photocell less sensitive by masking off part of it with black tape (experiment to determine the best area to mask). This tape can be removed when battery *B2* becomes so weak that *I1* no

longer gives quite enough illumination to operate the relay, and replaced when a new battery is installed.

On the other hand, if *PC2* is not receiving enough light when it passes over the tape, you may have to make an adjustment in the position of *I1*. Place Emily on a table with the exciter lamp-photocell assembly close to the edge. Lay a white card under the assembly and turn *S1* to position 3. If the beam of *I1* doesn't reflect back into the photocell, bend *I1*'s bracket one way or the other until it does.

Emily can also be used on a white, or light-colored, floor with a dark path. In this case, though, you'll have to start her to the right, instead of the left, of the line.

To make her follow a light beam, turn *S1* to position 2. Then, standing in front of the robot, aim a flashlight (at a shallow angle) to the left of *PC1*. Emily will travel to her right until she reaches the beam, then follow it as if it were a white line.