How to get into robotics without boiling your brain cells or breaking the bank Part 1

Without doubt, every electronics enthusiast has been fascinated with robots and robotics at some time or other. Here's an opportunity to build a robot that starts out as a simple, yet versatile, 'beast' with the capability of considerable expansion. This project is a 'minimum' kit version of the 'Tasman Turtle' robot from Flexible Systems, previously only available in built-up form, developed for publication by co-operation between ETI and Flexible Systems.

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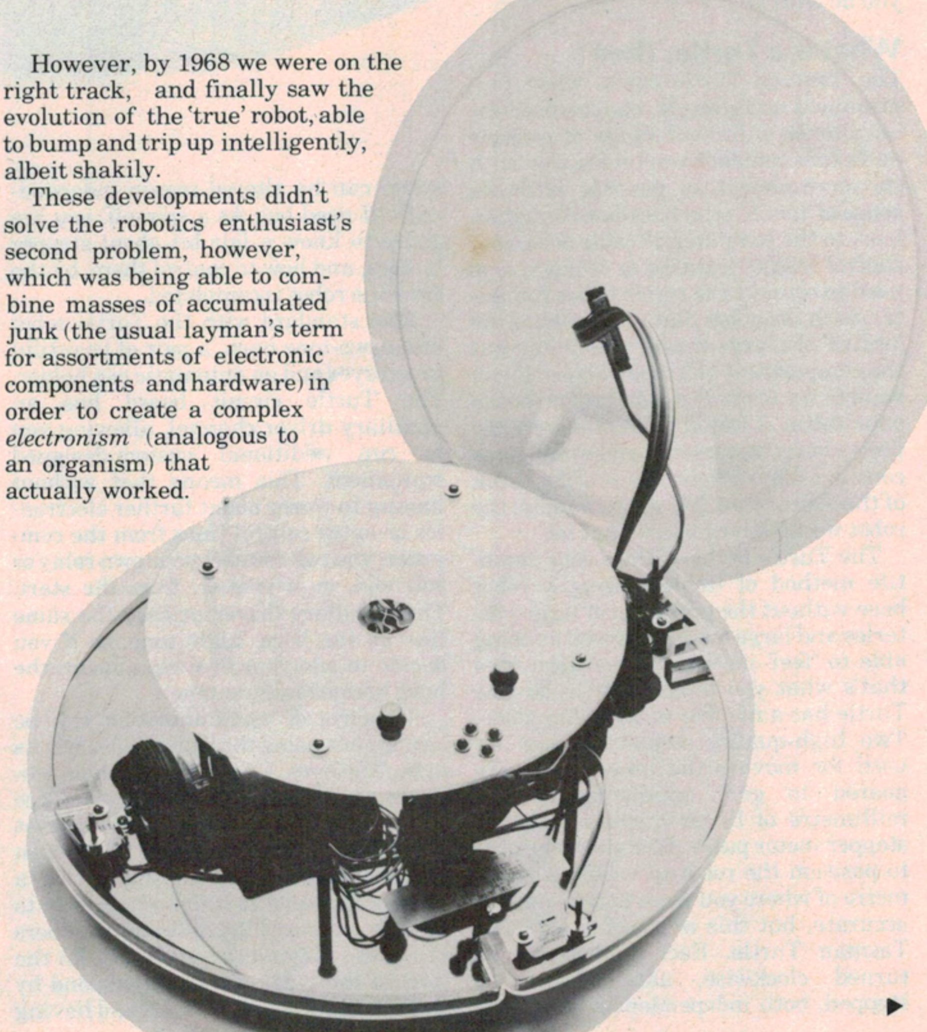
SOME PEOPLE like to watch turtles in glass tanks, others like to build them; this article is for the latter. Until now anyone wanting to participate in the fine art of robotics has had a number of problems to overcome before the opportunity to actually use a robot becomes a reality.

First of all you had to wait till the second half of the 20th century, when the combination of advanced computing and microelectronics finally brought robots to reality. The concept of an intelligent, moving machine, however, is far from that young; mechanical systems (though not intelligent) in the form of moving statues have been around since as long ago as 1500 BC, and in 1917 Karel Capek invented the title for the new form — he meant it to symbolise work, and the word 'robot' actually comes from the Czech *robota,* meaning forced labour.

The real 'day of creation' for 'intelligent' robots came in 1938, however, when Thomas Ross developed a robot mouse. This first robotic device could attempt and solve mazes, and led the way to descendants which still attempt (though not necessarily solve) mazes in appropriately named 'micro mouse' competitions around the world. After this, development seemed to go off down something of a blind alley, with a rather rigid obsession with microtechniques leading to the evolution simply of smaller and smaller mechanical dolls.

However, by 1968 we were on the right track, and finally saw the evolution of the 'true' robot, able to bump and trip up intelligently, albeit shakily.

These developments didn't solve the robotics enthusiast's second problem, however, which was being able to combine masses of accumulated junk (the usual layman's term for assortments of electronic components and hardware) in order to create a complex *electronism* (analogous to an organism) that actually worked.



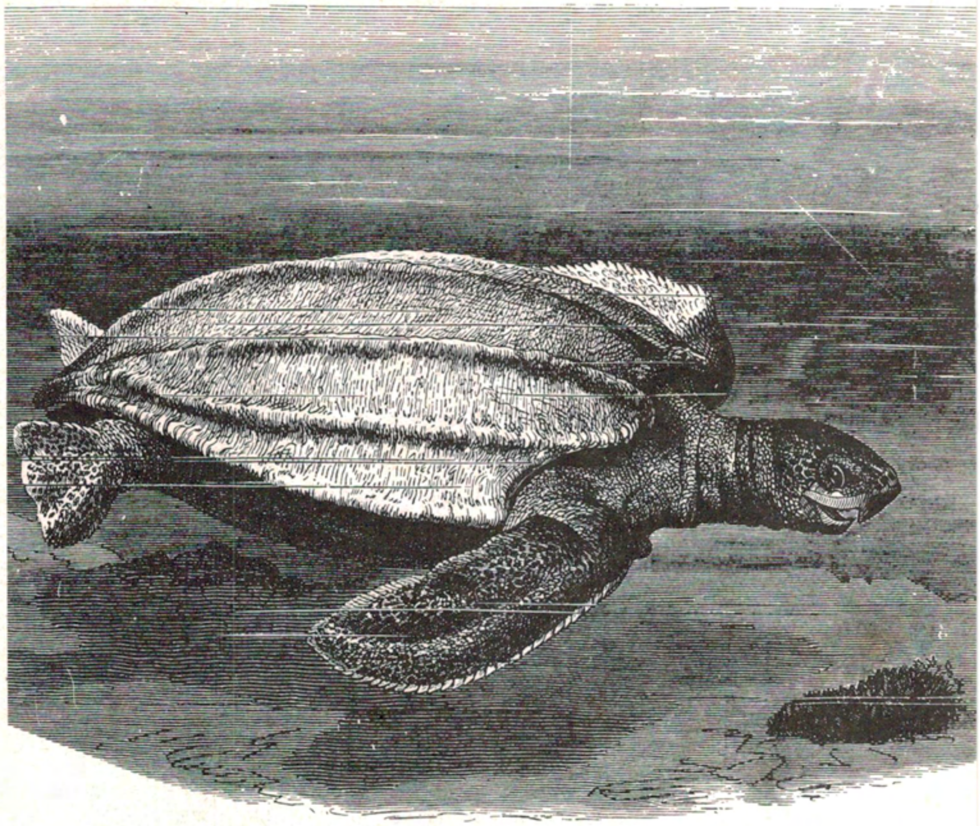
▶

This proved a much harder step for most people than being born at the right time.

Consequently, most people interested in the concept but unable to put it into practice turned to the closely allied area of computing. They learnt to program computers in BASIC or machine code, to play mazes on monitors instead of with robots, and to come close to real robots only in screen simulations. It was a bit of a let-down, but we kept on expanding our make-believe (paper robots?) world with such gadgets as printers or disk drives in the hope of satisfaction.

Now, finally, robotics can become a reality. Someone else has put together the loads of components and hardware for us, and, just like the icing on the cake, has designed it to work from our computer and in the languages we have already learnt to use. Voila! The age of the Turtle is with us.

The evolutionary progress from semi-bright mice to intelligent turtles is quite a step, and who knows what will come next. In the meantime, though, what do you do with it?



What is a Turtle, then?

The Tasman Turtle robot, when programmed accordingly, can be used for an almost unlimited range of projects and experiments. Even interaction with its environment is possible with its sense of 'touch', which feeds information back to the computer. A cable or remote control (radio, infrared or whatever) is used to connect the turtle to the computer, with the effect that the robot has the 'brains' of a large or small computer, but the compactness of a mobile base. If you were to try to put the computer on board your robot, it would have to have some pretty hefty motors in it and would have considerable current drain. Just think of the size of your 5 V power supply; the robot would have to have that too!

The Turtle is therefore a very versatile method of implementing a robot base without the problems of large batteries and large motors. As well as being able to 'feel' its way around (provided that's what you program it to do) the Turtle has a number of other functions. Two high-quality stepper motors are used for moving the base. These are geared to give approximately one millimetre of linear displacement per stepper motor pulse. To actually be able to position the robot to within a millimetre of where you want it is incredibly accurate, but this is possible with the Tasman Turtle. Each motor can be turned clockwise, anticlockwise or stopped, both independently, and their speed can be altered (again independently if need be). As a spin-off, you are going to know a fair bit about stepper motors, and how to control them, by the time the robot is completed.

Also standard with the Turtle robot are a two-tone horn, a pair of beautiful green eyes and an automatic pen holder. The Turtle circuit board has an auxiliary driver channel, allowing you to run additional custom-designed equipment. This means that without having to worry about further electronics or extra control lines from the computer, you can connect your own relay or solenoid, or whatever, from the start. The auxiliary driver utilises the same line as the horn 'high' tone, so if you decide to add your own equipment, the horn becomes single-tone.

All sorts of communication can be carried out using the Turtle's horn or its eyes. The eyes, for example, can be programmed to flash once for yes or twice for no. You could devise a code so that when your program needs information (suppose your turtle is trapped in a maze and wants to know which way to turn to get out) then different numbers of flashes mean different codes. (In the case of the maze you could respond by touching one of the switches and having the turtle move in that direction).

Similarly the horn can be used for communication since it can be pulse-coded (high = on, low = off). Why not try learning Morse code by having the Turtle talk to you in Morse code with its horn? Different sound effects are possible by varying the tone and the timing of the horn control.

The last thing the Turtle has is its automatic pen mechanism, designed to hold any normal thin pen, pencil or felt pen, which can be controlled (up or down) from the computer. The Turtle becomes a ready-made graphics device with the 'pen in toe' and, combined with the accuracy mentioned previously, the computer art capabilities are enormous. Some ideas worth mentioning are to get the Turtle to spell your (or its!) name — try it in script writing. Get it to print questions or statements on paper instead of on the screen. It could leave a path when it follows a maze to give a permanent trace of its movements. What about using it as an xy plotter? Quite complex patterns or designs are simple to generate using the pen facility. I have even had the Turtle 'rattle its brains' by vibrating the solenoid for a startling effect (without the pen in its holder!).

NOTE: 'Tasman Turtle' is a registered trade mark of Flexible Systems.

The next thing to learn is how to actually make the Turtle do all these things. Firstly, though, it is important to contemplate a few aspects of the robot so that you can enjoy all its benefits.

This Tasman Turtle is probably the first robot for hobbyists designed to be run from a microcomputer, and as such is perhaps much more powerful than anything seen before. It is certainly more versatile. The programming (as will be explained) is extremely easy, so much so that even a complete novice will be able to run the Turtle around long before screen graphics are mastered. The sample programs to be given are in BASIC, but the Turtle can run in any language, even machine code, and a very special language called LOGO has been developed so that the Turtle can be programmed by typing in words like 'forward, back, left, right, pen up, toot 10', etc.

A big feature of the Tasman Turtle is its versatility. Because it is not restricted to ROMs (and therefore to people who can handle ROMs) there is no special equipment or requirements needed to get started. You can make the Turtle do simple things to begin with and then progress as you become better at programming or as you become more familiar with the robot. It is possible to do quite advanced experiments with the Turtle which require no actual changes to the robot. It is all possible because the robot takes on the identity of *your* program. It can be an art robot; be used to devise heuristic programs, study learning techniques, simulate conditioning; it can study the shape of a room and build a memory map or identify objects, detect objects that have changed position, work out the area and perimeter of the room; it could take on promotional work, have fun in shop windows, advertising; demonstrate information theory, process control and many other things I haven't even thought of. Most of all, though, it is *fun* robotics.

While the Tasman Turtle is multivariate by virtue of programmability, it is also a suitable standard base for anyone interested in further electronic add-ons. Most of us have some ideas of what we would have in a robot if we built one, and the Turtle robot becomes a platform for just that.

A wide range of simple and effective projects can be implemented with the Turtle, from line following to speech, and some will be presented in this short series of articles. Many projects meant for other uses will also adapt easily to the Turtle (anemometer, light sensor, load detector, sound operated switch, for example), and I can just see little claws 'snapping' away at anything that crawls! Imagine — a moving, talking, hooting-tooting, snapping Turtle!

Enough day-dreaming, shall we get on with the reality?

PARTS LIST ETI-645

MINIMUM TURTLE — HARDWARE

- 1 x bakelite base, 330 mm dia., cut and drilled
- 2 x front motor mounts (triangular)
- 2 x rear motor mounts (elbows)
- 2 x wheel axle brackets (small elbows)
- 2 x stepper motors
- 2 x small brass gears, 12 mm dia.
- 2 x nylon gears, 40 mm dia.
- 2 x axles (5 x 45 mm)
- 2 x rubber tyred wheels
- 4 x microswitches
- 1 x wooden front foot (hemispherical, drilled)
- 1 x smoke-tinted plastic dome
- 1 x circular 'touch' band
- 1 x clear plastic disc, 230 mm dia., drilled
- 1 x small speaker
- 1 x solenoid
- 1 x pen bracket & clamp assembly
- 4 x red LEDs and bezels
- 2 x green bezel lamps
- 1 x 100R, 1 W resistor
- 1 x 1 m length rainbow cable
- 1 x length of speaker wire
- 1 x 25-pin connector (RS232 type)
- 2 x hex keys (for gear grub screws)
- 4 x 1" x ⅛" Whitworth steel screws
- 4 x ¾" x ⅛" Whitworth steel screws
- 13 x ¼" x ⅛" Whitworth steel screws
- 2 x ½" x ⅛" Whitworth steel screws
- 2 x ⅜" x ⅛" Whitworth steel screws
- 24 x ⅛" Whitworth steel nuts
- 43 x metal washers
- 1 x metal self-tapping screw
- 4 x ½" (12.5 mm) long x ⅛" tapped Whitworth metal spacers
- 2 x ½" (12.5 mm) long tubular spacers
- 2 x 2" (50 mm) long tubular spacers
- 2 x 2½" (63.5 mm) long tubular spacers
- 4 x 3" long x ⅛" Whitworth steel screws

Construction

There are four individual sub-assemblies involved in the 'minimum' Turtle. These are: the base, the small inner disc, the electronic control pc board and the dome. Everything mounts to the base, one way or another. Putting the beast together is simpler than describing it — of that, we can assure you! In this part we will cover the assembly of motor drive and 'touch' systems to the base plus the assembly of the various components that mount on the small inner disc. In the next part (May issue) we will cover the assembly of the electronics and completing the Turtle, plus a power supply and rudimentary controller. Let's go, then!

First step is to sort out and identify all your hardware. A hardware parts list is included here for your guidance. Note that, where possible, measurements have been given in metric and imperial. Generally, Whitworth thread nuts and bolts are employed. You will need some 'five minute' epoxy glue, or similar.

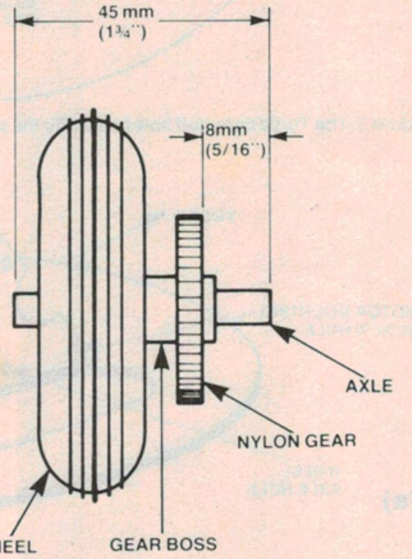


Figure 1. **Wheel assembly. Wheel hub butts against gear boss and the two are glued at this point.**

Wheels

Figure 1 shows the wheel assembly when completed. Place a nylon gear on each axle such that the face opposite the boss is exactly 5/16" (8 mm) from one end. Tighten the grub screw using the appropriate hex key supplied (the larger of the two). Now push a rubber tyred wheel on each axle — you'll find it a firm fit, so that the wheel and gear boss touch. Glue the wheel to the gear boss using epoxy glue or similar. ▶

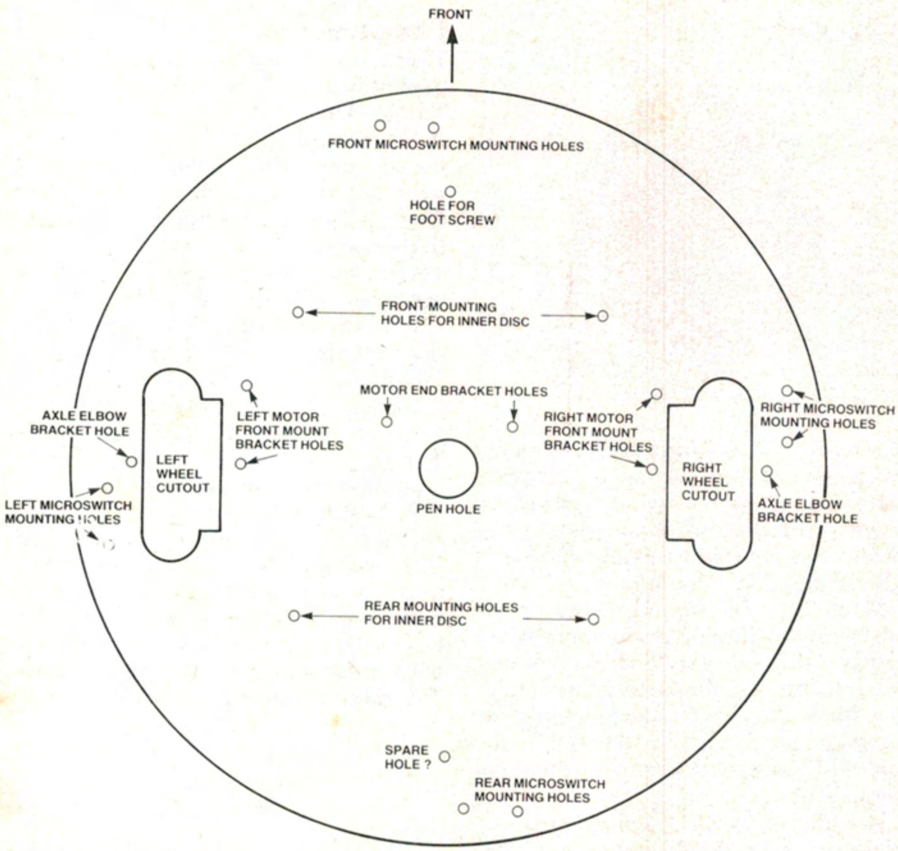


Figure 2. **The Turtle base and how to identify the various holes.**

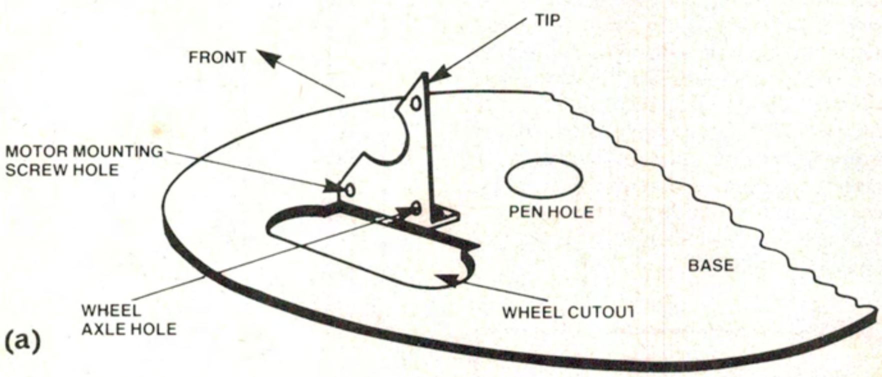
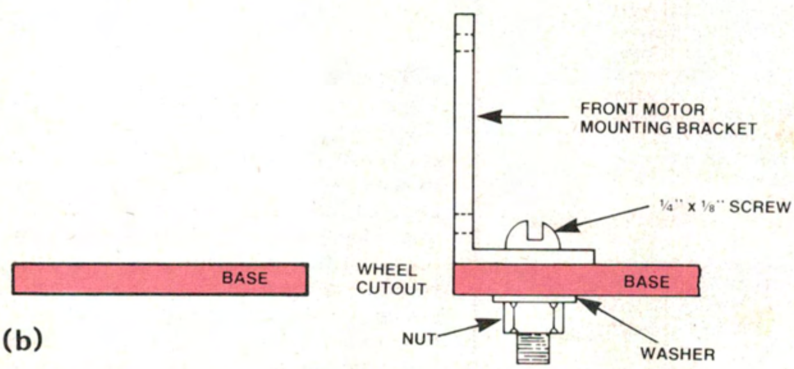
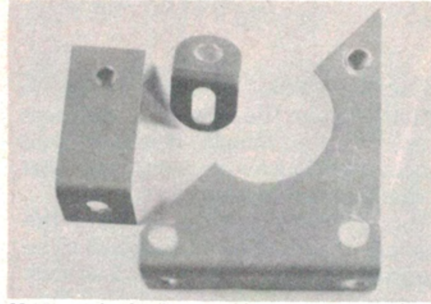


Figure 3. **(a) Mounting the left hand front motor bracket to the base. (b) Position the bracket such that the edge is flush, or as near as possible, with the edge of the wheel cutout. The right hand bracket mounts in a similar way.**





Motor and wheel assembly mounting brackets. From left to right: rear motor elbow bracket, small elbow wheel axle bracket and the front motor mounting bracket. You'll have a pair of each.

Base

Take the bakelite base and identify the top — you should find a 'Made in Tasmania' sticker on the top side. If not, turn it so that the holes correspond with Figure 2. Identify the two front motor mount brackets.

Now find out which is for the left hand motor and which is for the right. Taking the left hand bracket, mount it as shown in Figure 3a. Ensure that the bracket is flush with the edge of the wheel cutout (or nearly so), as in Figure 3b. The right hand bracket is mounted in a similar fashion.

Now you can mount the wheels. Locate the wheel axle hole in the left hand motor bracket — see Figure 3a. Take one wheel assembly. The nylon gear goes toward the motor mount bracket. Slip that end of the axle in the appropriate hole in the bracket (Figure 4a), slip a small elbow wheel axle bracket on the other end of the axle and secure it as shown in Figure 4b. Note that the slotted hole in the small elbow axle bracket is on the base and the bolt passes through it. Now mount the other wheel in a similar fashion.

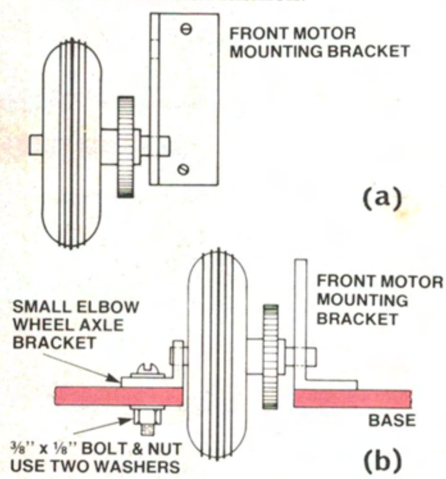


Figure 4. **Mounting the wheel assembly to the left hand front motor bracket. (a) Insert the nylon gear end of the axle in the appropriate hole in the front motor bracket (view looking down). (b) Support the other end of the axle with the small axle elbow bracket and temporarily bolt it in place. The right hand wheel assembly mounts in a similar way.**

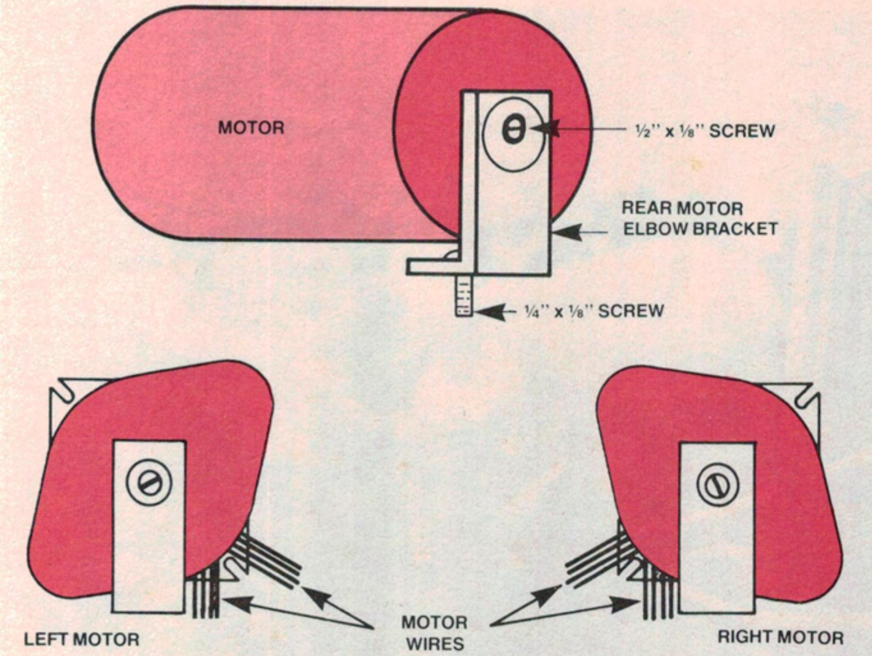


Figure 5. **How the rear motor mount bracket is fixed to each motor. Note the different positions for the left and right motors.**

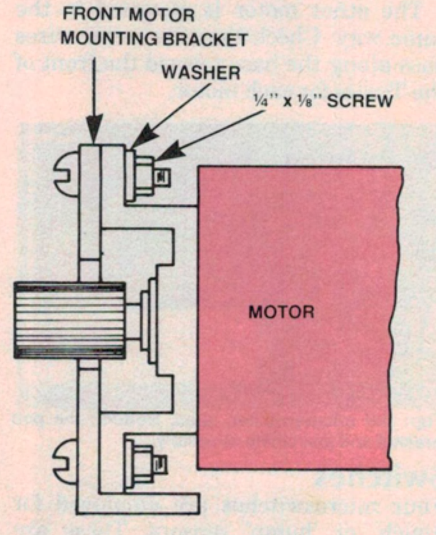


Figure 7. **Securing the front face of the motor to the mounting bracket.**

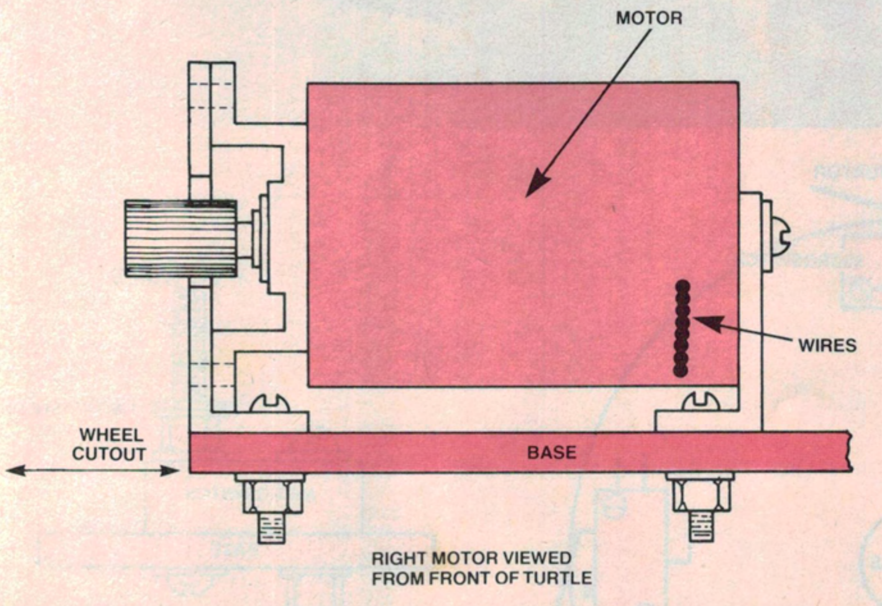
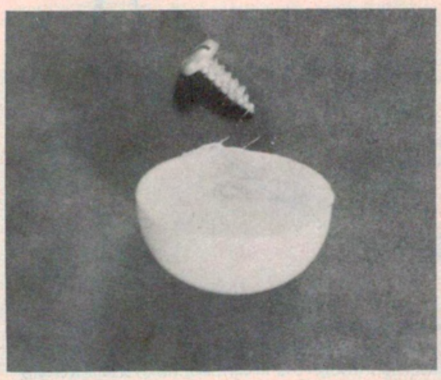


Figure 6. **Mounting the motor. Secure the end bracket screw first.**

The front 'foot' comes next. This is a small hemisphere of wood with a hole drilled in the bottom. Locate the mounting hole for it — see Figure 2 — and secure it to the underside of the base with the self tapping screw provided. Take care not to tighten it too much or your might split it.



The wooden front 'foot' and its mounting screw.

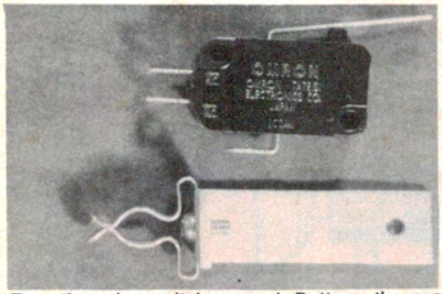
Motors

Take the two stepper motors and the two small (12 mm dia.) brass gears. These should be placed on each motor shaft so that the grub screw is furthest from the motor. Mount each gear flush with the end of the motor shaft and tighten the grub screws with the hex key provided. (These require the smaller hex key). Now take the rear motor elbow brackets. Place a ⅛" x ¼" screw in the hole in the small end of the bracket — this is used to secure the end of the motor to the base. Remove the existing end screws in each motor. Secure each bracket to the motor, as per Figure 5, with a ½" x ⅛" screw. Use a washer under each screw head. Note that these brackets are mounted differently on each motor. The motor that will drive the left hand wheel has the wires passing to the right at the bottom of the rear bracket, while the right hand wheel motor has the wires passing to the left of the rear bracket, at the bottom. This means that, when the motors are mounted to the base, the wires pass towards the front of the Turtle.

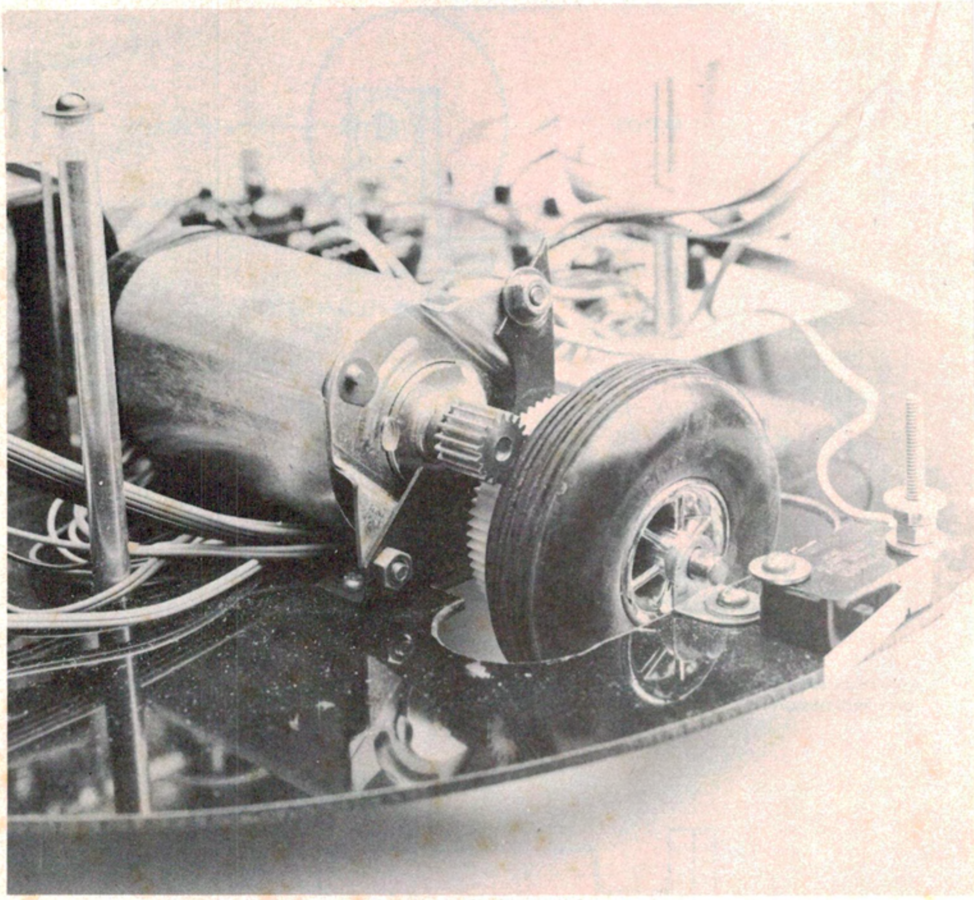
Take one motor and place the screw hanging from the end bracket through the appropriate hole in the base (see Figure 2), so that the shaft end of the motor butts against the front mounting bracket as per Figure 6. Loosely secure the end bracket with a nut and washer. The brass gear will mesh with the nylon gear and set the wheel assembly in position. Now you can tighten the screw holding the wheel axle elbow, after positioning the elbow so that it is flush with the wheel hub.

The front face of the motor can now be attached to the mounting bracket using ¼" x ⅛" screws. A single washer is placed behind the motor face, as shown in Figure 7. Adjust the meshing of the gears by slightly moving the motor so that the gears mesh well without bending. Finally, tighten all the mounting nuts. ▶

The other motor is mounted in the same way. Check that the motor wires pass along the base toward the front of the Turtle for each motor.

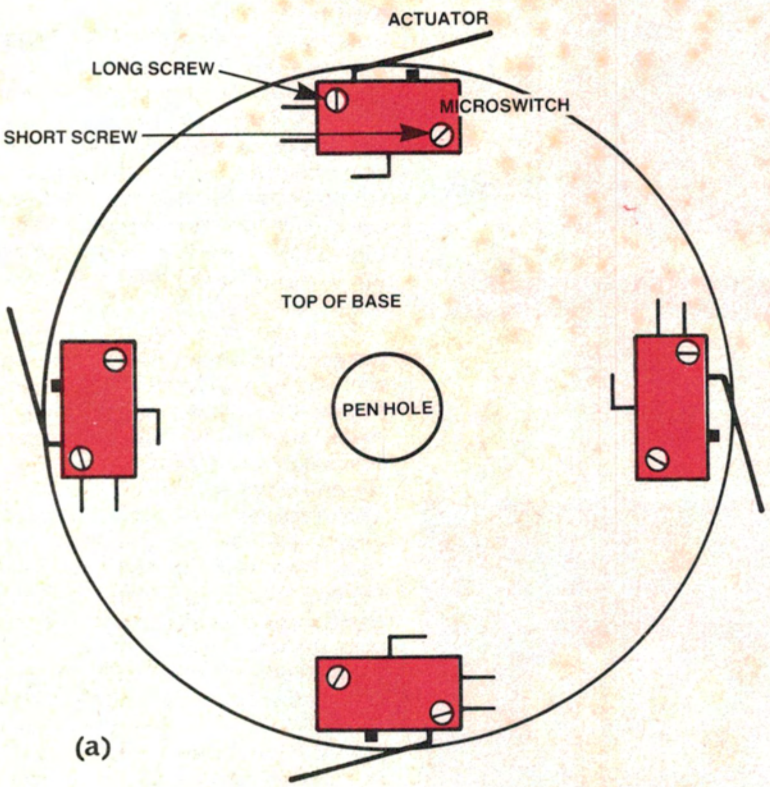


Top: the microswitches used. Bottom: the pen bracket and pen clamp assembly.



Switches

Four microswitches are employed for 'touch' or 'bump' sensors. These are located at 90° intervals around the perimeter of the base. Figure 8a shows their location and orientation. Note that they mount on the top side of the base and the actuators point *clockwise* around the base. Each microswitch is secured by one ¾" x ⅛" screw and one 1" x ⅛" screw. The shorter screw passes down through the switch while the longer passes up through the base, as shown in Figure 8b, the latter also being used to secure the dome.



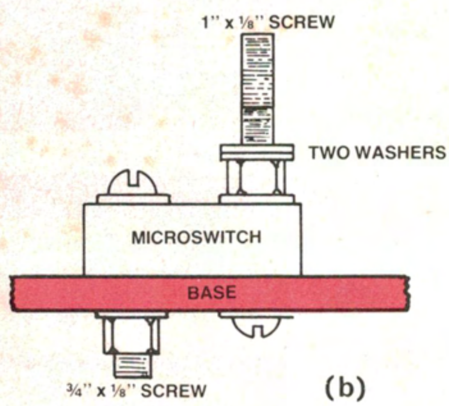
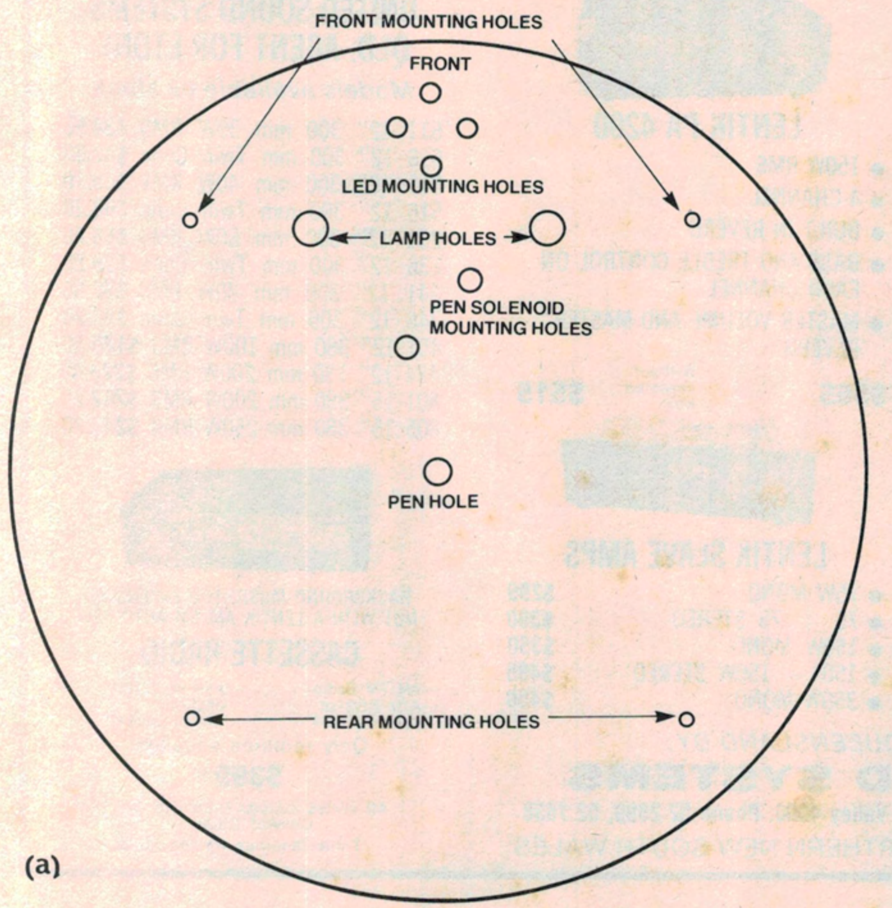


Figure 8. **Locating and mounting the microswitches for the 'touch' or 'bump' sensor ring. (a) Orient the actuators clockwise around the base. (b) The 1" long screw is passed up from under the base through the outermost mounting hole. The ¾" screw passes downwards through the innermost hole. Use washers under each screw head and nut.**

Inner disc

The clear plastic 230 mm diameter disc is used to mount four LEDs, two lamps and the pen solenoid. Take the disc and orient it as per Figure 9a. Note which holes are used to mount particular components. We can start with the four LEDs. You should have four bezels for them; insert them in the holes and push



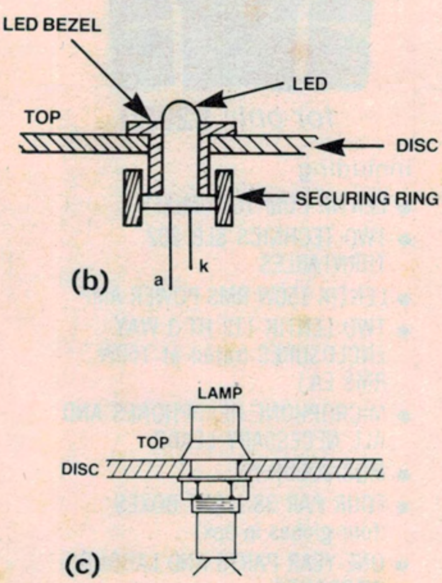


Figure 9. **The inner plastic disc. (a) How to identify the various holes. (b) How to mount the LEDs and lamps.**

a LED into each one from beneath. They should snap in. Then push the securing ring over the bezel from beneath (see Figure 9b). Cut the LED leads so that they're about 12 mm (½") long — keep the longer (anode) leads slightly longer for later identification.

Now mount the two green bezel lamps. The bezels go on the top of the disc. These lamps are secured with a large hex nut and a spring washer on the bottom side of the disc.

Pen solenoid

The pen solenoid mounts on the underside of the inner disc, in the way shown in Figure 10. Note that a washer is placed between the solenoid base and the disc for each of the two mounting screws (¼" x ⅛"). Make sure you orient it correctly as the speaker mounts on the solenoid frame later and it must face the front of the Turtle.

See that the plunger of the solenoid has its keyway toward the front. The pen holder bracket and arm are already assembled and you can screw this assembly onto the solenoid plunger now. The pen solenoid is tightened later on after the pen centring is adjusted.

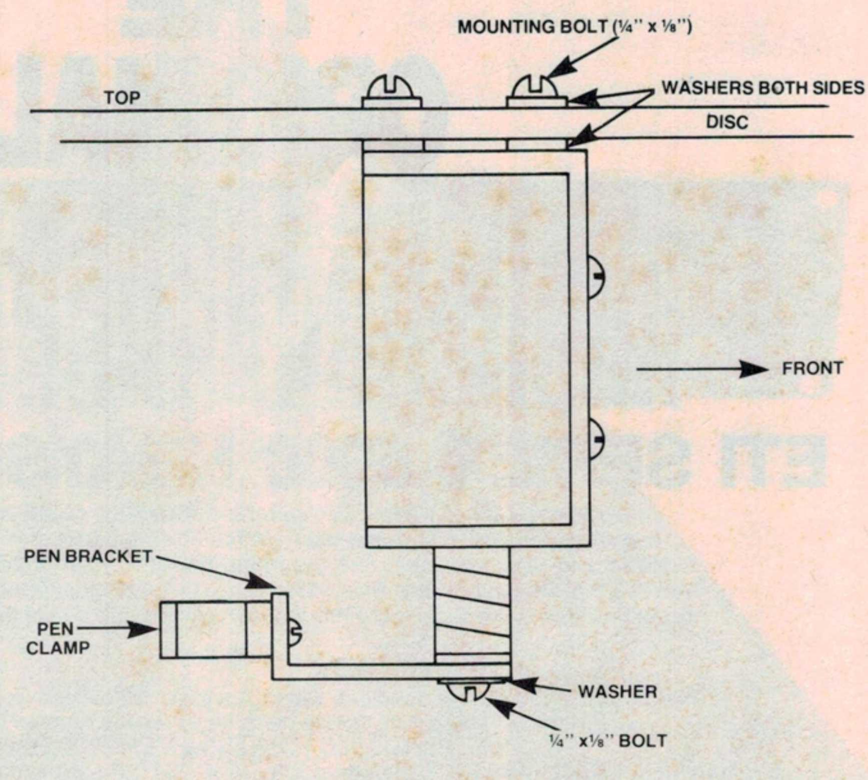


Figure 10. **Mounting the pen solenoid.**

Speaker

Solder the 100 ohm, 1 W resistor to one of the terminals on the speaker after cutting each of the resistor leads to about 12 mm long ●

(. . . to be continued)