Inside NAVBOT

Find out what's in that NavBot, how the cam works and why battling robot competition tests even the best to destruction.

If you remember, NavBots are used inside Heavyweight Y-Pout and Middleweight Why Not to guide them round the battlezone. Weighing 15lb, each NavBot is virtually identical, with a motor from a remote-controlled car and a custom-made gearbox within.

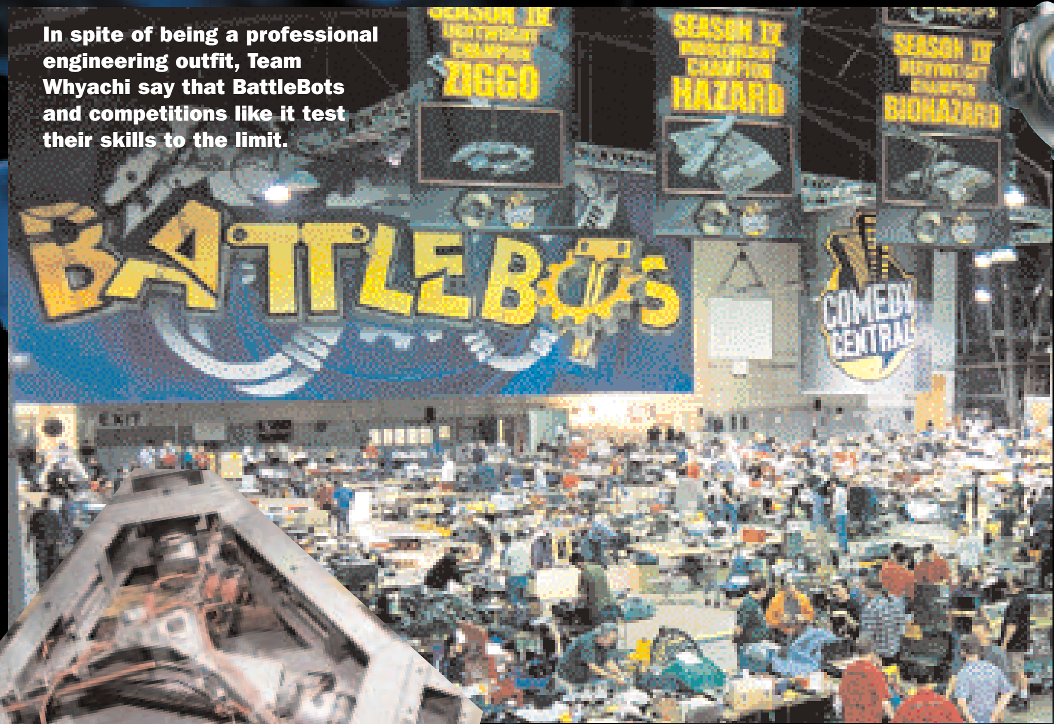
NUDGE, NUDGE

The robots' designer, mechanical engineer, Terry Ewert, has explained how the NavBot turns a cam inside that wobble box and keeps it (the cam) pointing in the right direction: that's what steers the big bot.

According to Terry, the NavBot does only a fraction of the work to actually propel the big robot – every 15 times a second, giving the fast-spinning bot a tiny nudge in the right direction. It's the three wheels spinning the robot at 1000rpm that do the donkey work.

FIXED SPEED

The speed at which the robot 'translates' (moves across the floor) is set by the mechanics of the big robot and wobble box, not the NavBot. Both Y-Pout and Why Not move at about three feet per second tops, and the key things that make them do this are the speed of rotation (1000rpm), and the amount by which each wheel steers out and in per rev (3°). That 3° is pinned down by the amount of 'throw' the cam has (0.25 inch) (see Need to Know). But why not give it more throw and make the robot faster?

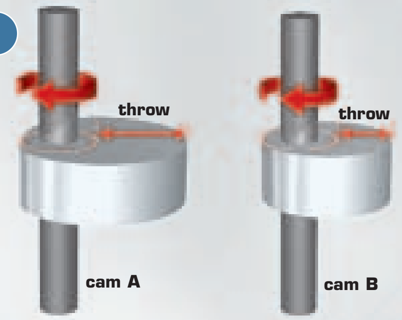


In spite of being a professional engineering outfit, Team Whyachi say that BattleBots and competitions like it test their skills to the limit.

Often it is the cam that rotates, but in both Why Not (*above*) and Y-Pout the robot spins while the cam stays still.

Need To Know

Cams can be various shapes but all work by using off-centre (eccentric) rotation to produce straight-line motion. The amount of movement is called the 'throw' of the cam. Here A has more throw than B.



Such is their conviction in the power of 'spin bots' that Team Whyachi aim to enter one for each weight category! © 2002 BattleBots Inc (Daniel Longmire)

For one thing, more speed means more stress on the wobble box and and the wheel assemblies. But there's something else...

FULL STEAM AHEAD

Unlike most other fighting robots, here the robot is the weapon: locomotion and weapon are one.

"To be an effective weapon, we want the robot to spin at top speed for the whole of the bout," says Terry. "But that means the robot is always translating at top speed. Tactically speaking, a faster machine mightn't be a smarter one to drive."

DRAWING A PICTURE

So how does the NavBot work? Terry: "It has two wheels locked together on a 'live' axle. This resists the torque [turning force] applied by the steering cam linkage [the wobble box]. In line with this live axle is a gearbox and a motor – which is also free to turn with the wheels."

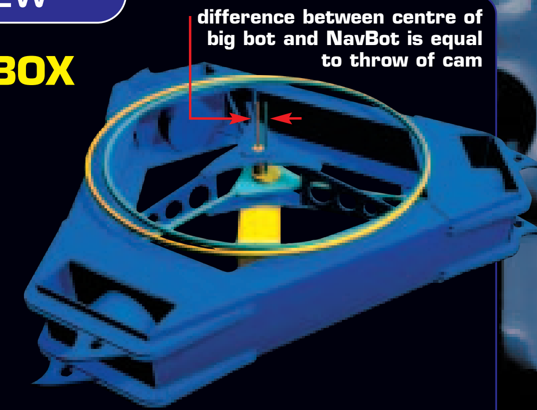
Whoah. This is getting tough!

Fortunately, Terry helps by doing a little sketch in our notebook (see NavBot artwork).

Inside View

WOBBLE BOX

THINK OF IT THIS WAY...
To visualize how that wobble box shakes those steering rods look at the centre of the big (spinning) robot, and the point where the rods meet. You'll see they're slightly apart; they each spin in slightly different circles. It's that eccentricity (equal to the throw of the cam) that causes the rods to shake.



LIVE AXLE

When the big robot is following the NavBot's pointer, both the NavBot's wheels are locked together and roll with the big bot. To change direction, the right wheel (as we're looking at it), is driven forward or backward to turn the NavBot (and pointer and cam) to a new position.

SLOW BUT STRONG

Okay. So we've got a motor that's able to turn one wheel (quite slowly but with a big force) relative to the other. It might turn it in the same direction (so that it's going slightly faster than the other wheel), or in the opposite direction (so it's going slower). But the net result is to turn the NavBot (and cam), making the steering rods move in and out at a new spot (relative to the arena floor).

MORE WORM POWER

Terry says that although the NavBot can be spun quite quickly through 180°, the big bot itself won't follow straight away. (It'll take quite a few revs to come round the full 180°.) During this time, the big bot is trying to turn the NavBot back again. So the NavBot has to resist.

"The gearbox has a worm gear as part of the train, so after the motor stops, the wheels are locked back together," says Terry.

To understand this, you need to appreciate one of the special characteristics of a worm gear. (You might remember one being to pack a fairly high gear ratio into a tight space – which we saw used on Hypno Disc way back in Issue 8.)

Here, it's the fact that a worm gear (unlike a spur gear) can be driven in one direction only, that's being exploited. The motor can turn the wheel, but if the big bot tries to use the wheel to turn the motor (which it would have to to turn the NavBot), it can't! But there's one mystery remaining...

NASCAR-style uniforms add an air of professionalism in the pits.

Y-Pout took only five weeks to design and three weeks to build (Why-Not was built at the same time)!

MOVING THE MOVER

The power supply to the motor is inside the NavBot but does not turn with the motor. So how do you connect something that's spinning to something that isn't?

Terry: "There's a slip-ring set-up." Brushes on the outside of the motor contacting with a split ring on the motor itself, supplying a 36V DC current to drive it.

THE DOWNSIDE

Not only is this bot conceptually amazing, it is (like all Team Whyachi's machines) superbly built. It's hard to imagine it could have a down-side. But such is the extreme challenge of BattleBots, there always is. We've met one already – the machine moves at one speed – there's no halfway house. But there's a more fundamental problem...

"Take Why Not, for example: we've got the highest horsepower to bot ratio in the world: 116lb of bot, with three Magmotors, run over voltage, to give 27 horsepower. It hits as hard as Superheavyweight Son of Whyachi. The spinning force at the periphery is something like 360gs. It's really pushing the limits. When we hit something, we fly off like an ice hockey puck," Terry explains.

In other words: these robots punish not only their opponents but themselves too.

Some of that peripheral weight is due to the batteries stored there, and so far it's those batteries being knocked loose that has incapacitated both machines. As is often the case, the robot's strength is ultimately its own weakness. That's why Terry admits that designing and building fighting robots is a far greater challenge than the machines he makes for a living!

REX'S ROBOT CHALLENGE

I'm building a simple electronic circuit to indicate battery charge levels (such as on Cassius Junior). Here I'll show you how I use my PC to start making a board on which to build it.

Electronics is a specialised subject and the theory can be hard to grasp. But you don't need to understand the theory to make a circuit that works! You just need to follow the circuit diagram – a plan showing you the components and where to put them.

This tried and tested circuit has one chip (LM3914N – which you've met already), three resistors, one variable resistor and a capacitor – simple! (Don't worry about what these components do or how to identify them at this stage.)

PHOTO-ETCHING PCBS

To mount the components, I'm making my own version of a printed circuit board (PCB). It connects components by way of neat, narrow tracks of copper. The process I'm going to use to make it is called photo-etching.

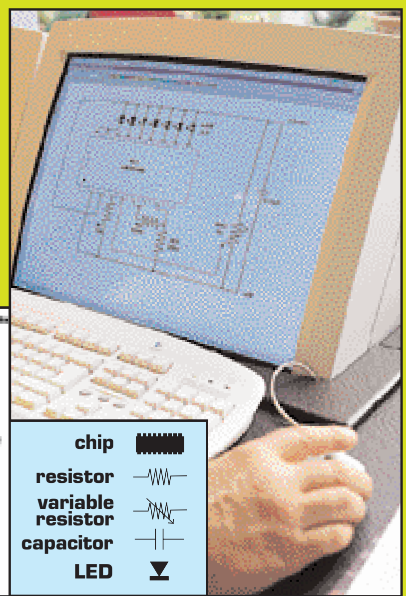
Photo-etching is a process that uses hazardous chemicals, and it should not be done by children. It should only be attempted by adults with extreme care and regard for safety. (I will show an alternative method of mounting the components.)

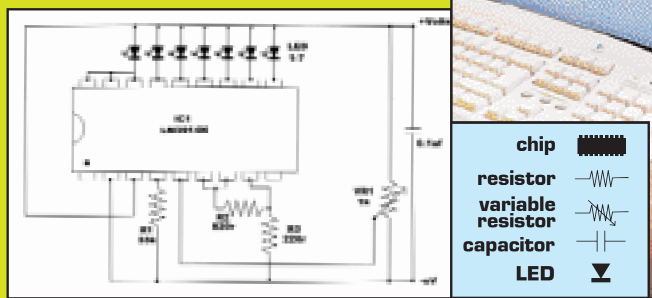
The reason I want to show you this method is because it can open your eyes to the kind of professional results that can be achieved even with limited resources at home or school.

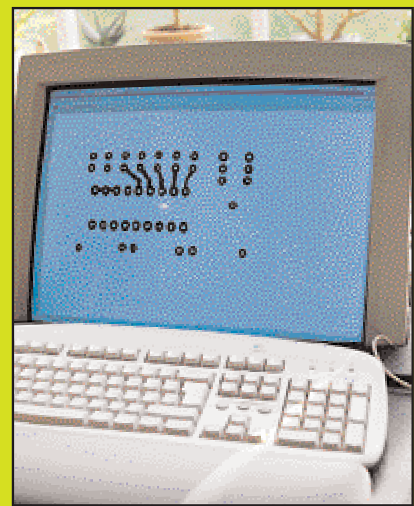
THE ARTWORK

The circuit is made on a piece of copper-clad board that has been pre-coated with a layer of photo-resist. To make the narrow copper tracks, I'll need to etch (dissolve away) the copper from the places where I don't want it, and to protect the areas where I do. This is done by protecting the photo-resist coating in some areas, and for this I need to make a mask – an artwork of the tracks printed on acetate.

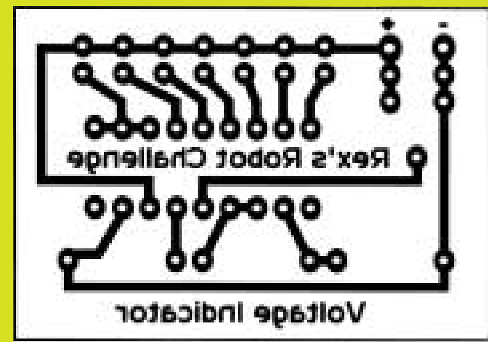
The circuit diagram was provided by my friend Mike Cutter (with whom I work on BBC TV's Brum car). I use it as the basis for making an acetate artwork mask.



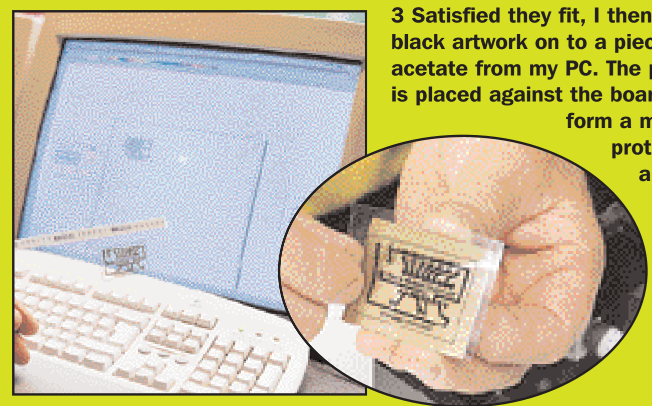




1 I use a simple PC drawing package to draw the circles where I'm going to drill holes in the board for the component's legs. Spacing is based on a 0.1 inch grid. The tracks are 1mm wide, the circles 2mm diameter and the holes 1mm.



2 When I've completed the drawing (here knocked back in grey) I check the components will fit (shown coloured). Note that any writing is reversed (the acetate will be turned over).



3 Satisfied they fit, I then print the black artwork on to a piece of acetate from my PC. The printed side is placed against the board and will form a mask to protect some areas of the photo-resist on the copper-clad board in the next stage.

Coming Next: Ronin – the tracked one, and more from Rex's Robot Challenge.