A Wire with Total Recall

Exploring the properties of 'memory wire'

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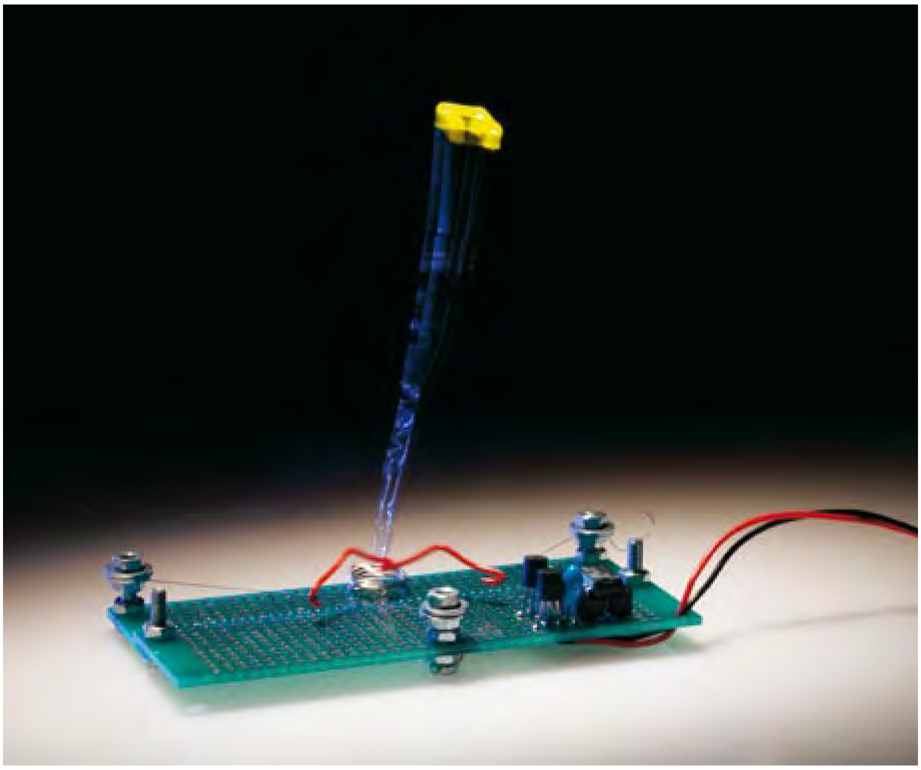

Memory metal is often thought of as 'a solution looking for a problem'. It's an intriguing material; warming it makes it return to its original shape. The application described here is academic in that it doesn't provide a solution to any great problem but instead produces a novel visual effect.

This design should provide some relief for those of you who are irritated by the sight of continually blinking LEDs. This circuit grabs attention by swaying an LED gently back and forth like a tree bending in the wind. The movement could have easily been produced by a servo or electric motor but memory wire has the advantage of moving silently. This type of wire is also known as Nitinol, indicating that it is an alloy of nickel and titanium. The wire can be deformed into any shape which is retained until heat is applied then it returns to its original shape. The original shape is 'programmed' into the wire by heating it to a much higher temperature. A bent wire returns to its original straight shape or a straight wire returns to its original pattern. This looks particularly bizarre if the original shape is something like a paper clip; straighten it out then apply a little heat and watch it fold back up into a paper clip!

Memory wire can also be used to provide mechanical propulsion; in this setup the wire is fixed between two points and then deformed by tensioning the wire. When heat is applied it shrinks back to its original length producing a pulling force between the two points. The wire is available in different diameters and from a number of suppliers [2] [3] [4].

The Mechanics

This design repeatedly swings the LED along a trapezoidal shaped path. The motive force is provided by a 15 cm length of 0.15 mm diameter memory wire. It is necessary to put the wire under sufficient tension so that when heat is applied it shrinks by 4 to 5 % back to its original length. Heating is achieved by passing a current of around 300 mA through the wire.

The wire is fixed at either end and in the middle forming an angle of 90 degrees. The shortening and lengthening of these small lengths of wire is barely perceptible so the movement is magnified by the mechanical leverage produced in the LED fixture (see **Figure 1**). Two lengths of insulated wire with hooked ends provide tension to the memory wire from a 1 cm diameter spring made up of four turns of 0.5 mm copper wire mounted on the circuit board. A small steel spring could be substituted to provide the tension.

Each time current passes through one section of the memory wire it contracts and pulls the hook which makes the LED sway. A 10 cm long lever produces around 1 to 2 cm of movement in the LED which can be further increased by lengthening the lever. The complete mechanical structure and electronics are contained on the prototyping board. **Figure 2** is a side view of the assembly and shows the memory wire particularly well.

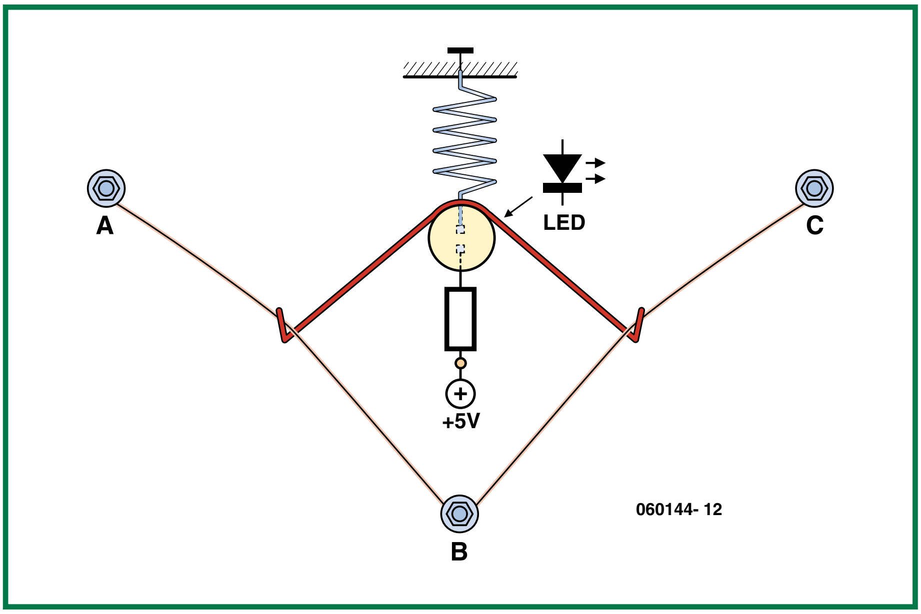

Figure 1. The memory wire is clamped at three points and tensioned from a spring via two hooked wires. The LED is fitted to the top of the spring.

Electronic control

The memory wire used in this application is called Flex-150 [2]; it has a resistance of 50 ohms/m and can carry a maximum of 400 mA. Each 7.5 cm length of wire has a resistance of almost 4 Ohm and should be used with a voltage supply of less than 1.6 V. A single 1.5 V battery or 1.2 V rechargeable battery can be used for test purposes. A microcontroller is used to switch current through the wires so that the LED repeatedly moves along a two-axis path defined by values stored in the software (**Figure 3**).

The switching waveforms have a relatively small 'on to off' ratio so it is possible to switch current through the memory wire directly from the 4 to 6 V supply (four NiMH cells would be a suitable power source). The BC337 transistors can handle up to 1 A and the PWM switching waveforms are arranged so that there is never more than one transistor conducting at any one time. The program causes the LED to sway between four positions.

Source code for the Tiny11 program can be downloaded free of charge from the *Elektor Electronics* website [5]. You can also access additional memory wire information along with some suggestions for further experimentation.

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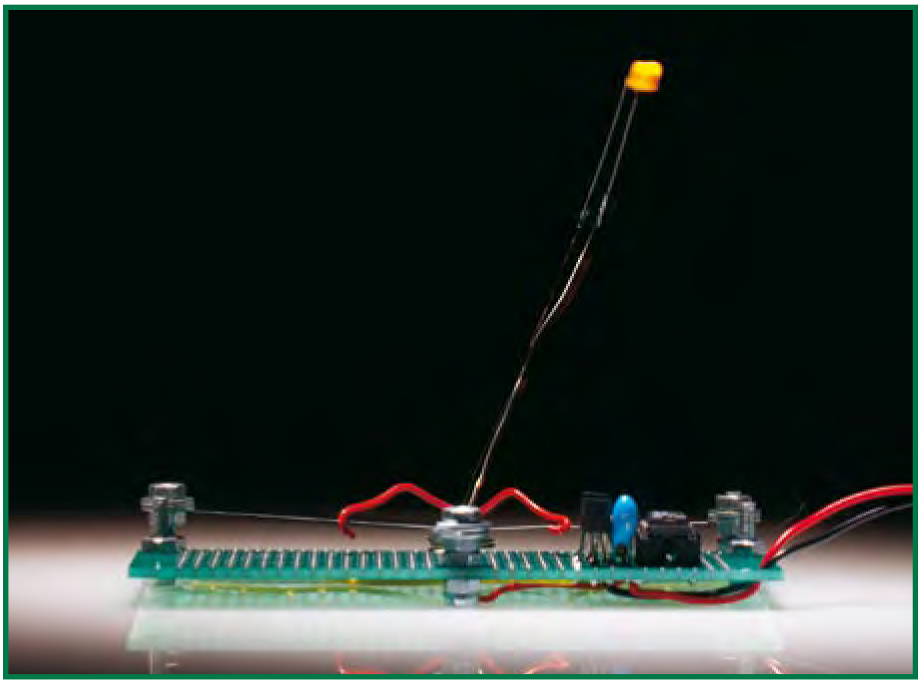

Figure 2. A side view of the assembly shows the memory wire fixing. Current through the memory wire causes it to pull the LED in that direction.

Web links

[1] www.stiquito.com

[2] www.mikromodellbau.de

[3] www.robotstore.com

[4] www.memory-metalle.de

[5] www.elektor.com (month of publication)

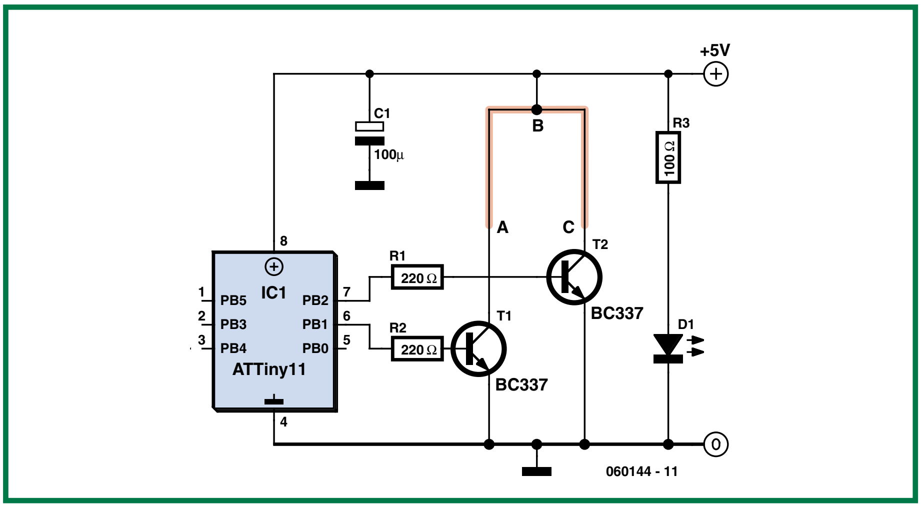

Figure 3. Current through the wires is switched by a microcontroller, this ensures consistent, repeatable LED movement.