Poor man's metal detector

By Thomas Scarborough (South Africa)

Imagine a pleasant stroll on the beach with your trusty old metal detector, when suddenly it gives off a loud tone. After digging for a few minutes you stumble upon a ceramic pot filled to the rim with antique coins and jewellery... Eternal fame and great wealth lie ahead of you (after the government has taken its fair share...)! Admittedly, these strokes of good fortune do no happen very often, but it's still the dream of any treasure hunter. Bu then, once or twice a year there's a short article in the paper about some lucky guy who finds a medieval or Roman treasure on a field or in his back yard. Are you the next one?

One thing all commercial metal detectors have in common is their price within the range of 'extremely high' to 'unaffordable'. Even kitted versions that need to be assembled at home are not really cheap, and often result in large amounts of stress during the construction.

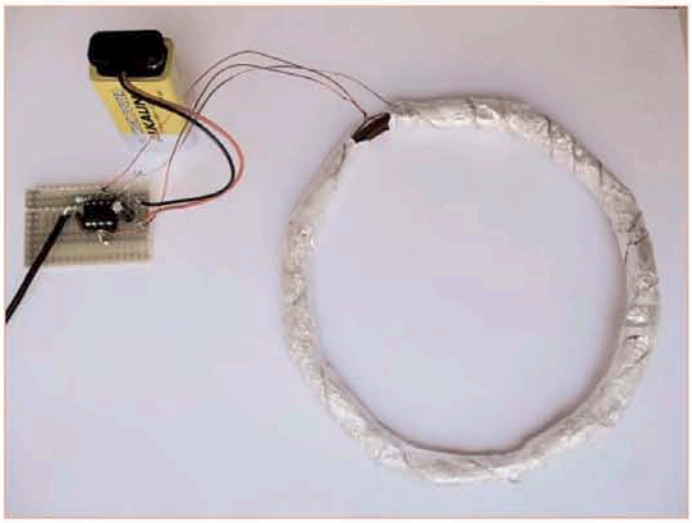
This situation was a big pain for the author. After some serious use of both the grey and white matter inside his skull, the following circuit took shape in his workshop: a cheap and extremely simple metal detector!

The circuit of the poor man's metal detector is built around one of the most trusted and familiar ICs in the world of electronics: the good old 555. Two resistors, two capacitors and a few pieces of 0.3 mm diameter enamelled copper wire complete the whole. Apart from that, you'll also need a portable AM radio, which should lie somewhere in the junk box of any electronics enthusiast. If not, find one at the next car boor sale in your area.

The IC is used as an inverter in this particular circuit, which feeds back the voltage on pins 6 (threshold) and 7 (discharge) through the search head coil L1 to the trigger input on pin 2. Due to the reactance (resistance for alternating current) of the inductor and the inevitable delay in the IC, the circuit will start to oscillate with a frequency close to 80 kHz, resulting in a square wave with this frequency on pin 3 of the IC.

Now, a reasonably high frequency square wave isn't very useful... yet. We found the following solution for that. Coil L2 is connected to the output of the 555, so it starts working as a transmitting antenna with a very small power output. If we place the transmitting antenna close to the antenna of the AM radio receiver, we'll hear a 'whistling' tone on countless places within the range of the receiver. This is a beat frequency which comes about when one of the harmonics of our 80 kHz square wave (a square wave contains loads of harmonics) is close to the frequency to which the receiver is tuned.

The workings of our circuit as a metal detector are now easily understandable. Assume for a moment that you have tuned the receiver in such a way, that the beat frequency has just disappeared. Normally, you won't hear a thing from the loudspeaker or headphone. But when L1 is placed in the vicinity of a piece of metal, the self-inductance (and therefore also the reactance) of the coil changes.



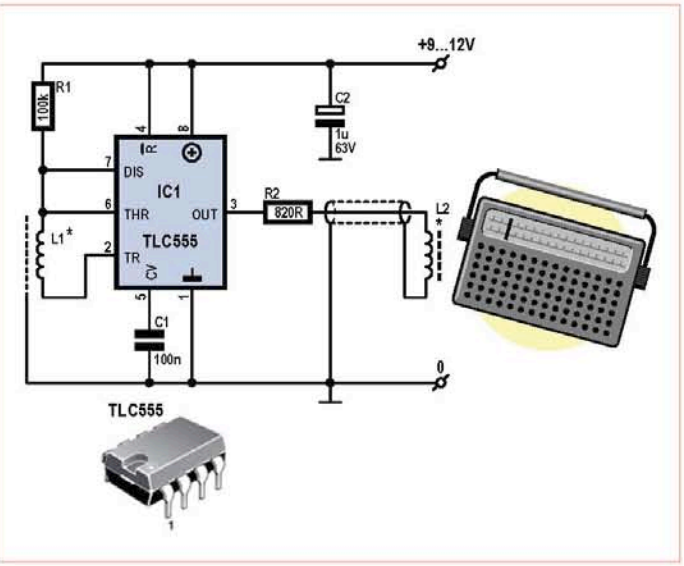
This means that the frequency of the oscillator also changes, causing the AM receiver to pick up a beat frequency again. That could be your pot of gold...

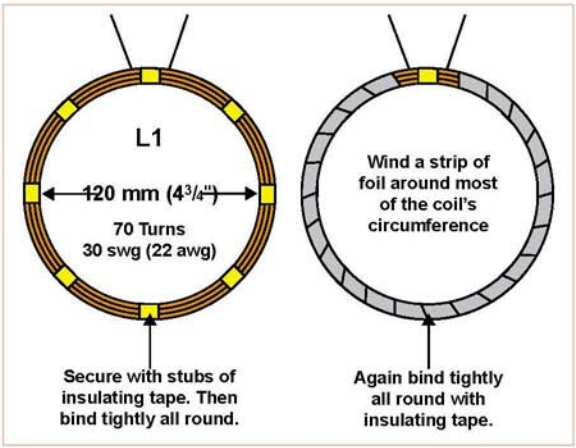
Practical issues

The circuit is built up in a no time at all on a piece of prototyping board (see picture). The biggest job is probably winding the coils, i.e. the search head coil L1 and the transmitting coil L2, but this isn't a complicated task.

You'll need a piece of PVC or cardboard tube with an outer diameter of approximately 120 mm (it doesn't matter if it's a bit more or less) to wind the search head coil L1 on. Neatly wind between 50 and 70 coils of 0.3 mm enamelled copper wire on the tube and carefully shove the coil off its former. Secure the coils with four of five pieces of tape. Finally wrap the whole thing in a layer of insulation tape or something similar.

The searching coil needs a 'Faraday protection', which is formed by a layer of aluminium foil. Keep in mind that a gap of about 10 mm wide needs to remain open. Do not cover the full circumference of the coil with foil. The protection needs to be connected to ground. This can be achieved by winding a piece of bare wire tightly around the foil and covering the whole with yet another layer of insulation tape. Nothing can really go wrong using the picture of our proto-





type and the construction drawing.
The connection wires of L1 are sensitive to disturbances and need to be kept as short as possible. We recommend fitting the PCB with the electronics on it as close as possible to the search coil.
The transmitter coil, L2, is made from 80 coils of the same copper wire around a short ferrite rod. This coil needs to be connected to the rest of the circuit through a piece of protected coaxial cable, as shown in the photo. Again, the protection needs to be connected to ground. As already noted, the antenna needs to be placed very close to the antenna of the AM radio. If the signal still is too weak, R2 can be lowered to 680 Ω or even 560 Ω.
The best power supply for the circuit is a set of batteries supplying between 9 and 12 V. Because the TLC version of the 555 is used, the power consumption remains modest at around 10 mA so the batteries can be used for a long time.
Although this is a very rudimentary design (so don't quit your daytime job to search for treasures just yet!), the sensitivity is quite okay. Through air, a coin with a diameter of about 1 inch (25 mm) can be detected at a distance of 10 cm or more!

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