Detector Field Test

The Nexus

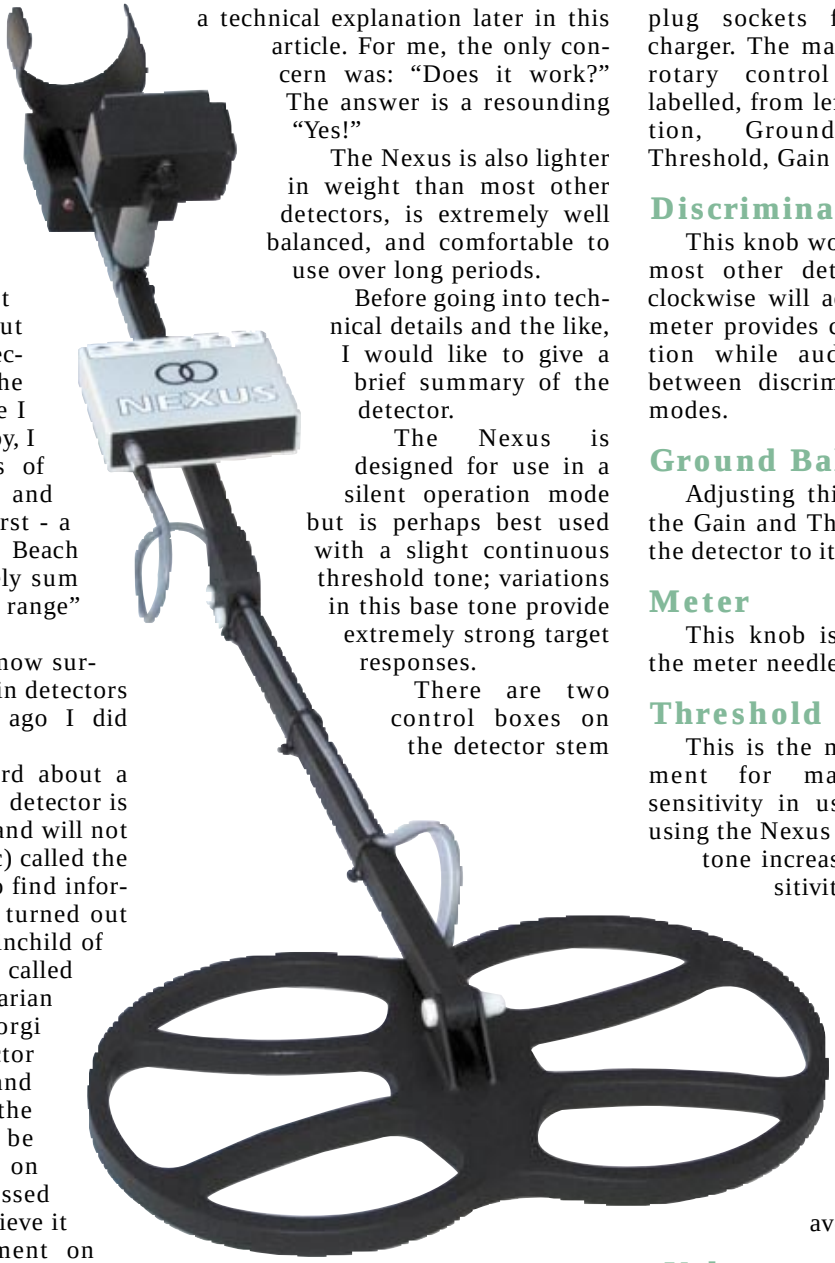
Chris Wren

My name may well be familiar to readers from my books on hammered coins (The Short Cross Coinage, The Voided Long Cross Coinage and The English Long Cross Pennies). Over the years I have also met many detectorists at clubs and rallies throughout England. I have been a detector user since 1970 and in the years that have passed since I started this fascinating hobby, I have used metal detectors of almost every make, model and type imaginable from my first - a "Prospector" made by ML Beach and costing the then princely sum of £12.10s., to "top of the range" models today.

It is very rare that I am now surprised by something "new" in detectors – but some few months ago I did indeed see something new.

In October 2004, I heard about a detector for inland use (this detector is not designed for beach use and will not operate well on wet sand etc) called the "Nexus". It was not easy to find information to start with and it turned out that the Nexus was the brainchild of Georgi (he is happy to be called George) Chaushev, a Bulgarian electronics engineer. Georgi had developed a metal detector that seemed very different and it caught my attention for the great depths claimed to be achievable. I took a gamble on it and have been so impressed with the potential that I believe it to be a serious improvement on almost every detector available today.

The Nexus is entirely hand built and the standard of finish and construction is exceptional. Georgi is a perfectionist and this shows in the care and attention he pays to all aspects of his detector. On first seeing the Nexus, the thing that immediately grabs your attention though is the unique "figure of eight" coil configuration. I am no electronics engineer so Georgi provides a technical explanation later in this article. For me, the only concern was: "Does it work?" The answer is a resounding "Yes!"



The Nexus is also lighter in weight than most other detectors, is extremely well balanced, and comfortable to use over long periods.

Before going into technical details and the like, I would like to give a brief summary of the detector.

The Nexus is designed for use in a silent operation mode but is perhaps best used with a slight continuous threshold tone; variations in this base tone provide extremely strong target responses.

There are two control boxes on the detector stem (plus a meter). One is mounted in front of the meter, and the other underneath the arm cup at the end of the shaft (this holds the 10 AA batteries, accessible by removing four cross-head screws and the back-plate). The meter-housing box is mounted on the end of the handle. The battery box has a simple switch to turn the detector on and off, plus jack-plug sockets for headphones and charger. The main control box has six rotary control knobs. These are labelled, from left to right: Discrimination, Ground Balance, Meter, Threshold, Gain and Volume.

Discrimination

This knob works in reverse order to most other detectors (ie turning it clockwise will accept more iron). The meter provides continuous discrimination while audio can be switched between discrimination and all-metal modes.

Ground Balance

Adjusting this in conjunction with the Gain and Threshold knobs will set the detector to its optimum for the site.

Meter

This knob is rotated to centralise the meter needle.

Threshold

This is the most important adjustment for maximum depth and sensitivity in use. I have found that using the Nexus with a slight threshold tone increases the depth and sensitivity achievable.

Gain

This is the level of sensitivity setting. Usually, the higher the setting, the better the depth - but on some sites it may be necessary to reduce this setting to avoid some false signals.

Volume

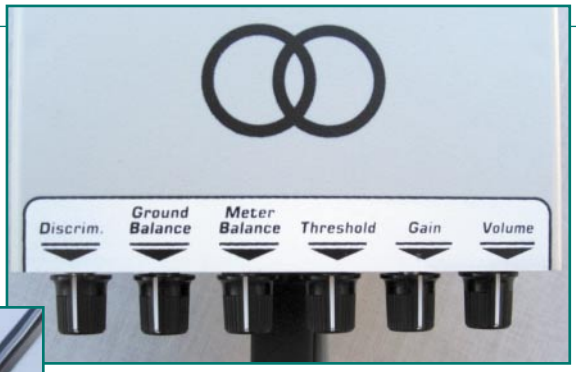
This adjusts the volume. The Nexus must be used with headphones as it has no internal loudspeaker.

All-Metal/Discrimination Mode Switch

This switch is located under the meter, and toggles the detector between All-Metal and Discrimination audio modes.

Meter Sensitivity

This knob - located at the rear underside of the meter housing - is used to adjust the degree of sensitivity with which the meter reacts to targets. It should be set so that the needle swings quite gently.



There are three standard coil sizes available at present: 4in, 6in, and 9in. However, the sizes given here are the diameters of a single element of each figure of eight coil; the 9in coil is thus actually 16.5in long and 9in wide. The purchaser can choose which one he wants supplied with the detector and the other two are then available as accessories.

As with all detectors, the basic principle is that you select the coil according to the targets that you are most interested in finding. No single coil will ever perform to the best possible level across the full spectrum of sites, finds and depths. Although all three coils do perform well on all targets, there are some advantages in choosing a particular coil for a specific application. In general terms, the smaller the coil the better the overall performance on the smaller targets. If your primary detecting interest consisted in finding tiny coins, then the 4in coil would be best. The 6in coil would perhaps be a good compromise between the extremes, and the 9in coil gives the best results on the large, deep targets. All of the coils, however, when tested against other leading detectors fitted with much larger coils, seem to perform exceptionally well.

Anyone who has ever used an Arado 120 metal detector will find operating and using the Nexus very similar in general terms. Apart from achieving much greater levels of depth and sensitivity, the Nexus has the added advantage of full audio discrimination. Those detectorists who are used to some of the silent running motion machines available today (and who habitually detect in discrimination mode rather than in all-metal) may find the Nexus strange at first.

As with any detector, becoming familiar with its method of operation and settings is essential to get the maximum level of performance possible. However, even beginners should quickly reach depths beyond the capability of their existing detectors. I have used the Nexus over a period of a few months now and am becoming increasingly confident of correctly interpreting the signals and in picking up the faintest of targets. I am finding that, with practice, I am able to differentiate between signals given by different metals and shapes of target – the target responses from the Nexus to lead and aluminium foil in particular are readily distinguishable from other metals.

A slower sweep speed than might be used with a silent search motion unit is advisable if you want to consistently pick up the smallest, faintest signals. Pinpointing is simply by X-ing over the target and is generally reliable (although, as with most detectors, targets in the ground that are at an angle to the coil may give a slightly offset pinpoint position). A hand-held mini probe is a very useful accessory, as well as a digging tool capable of going down to a depth of over 2ft!

For general searching, I would use the 6in coil. I would change over to the 4in coil if I had particular reason to think that there were small coins to be found (such as hammered fractions, Saxon *sceats*, Celtic quarter staters, small Roman, etc), or to the 9in coil if I were hunting for Bronze Age implements or other larger targets. I would also prefer the 9in coil if searching old pastures or other undisturbed ground, where finds tend to be deeper and larger.

In Air Bench Test

The table lists the depths for each of the test targets, in all-metal mode. The Nexus was fitted with a new set of batteries and was set up to achieve maximum possible depth performance levels and the depth was measured for the minimum discernible signal. Each item was tested in all-metal and then in discrimination mode. It was noted that there was no significant depth reduction when using discrimination mode (the discrimination level was set to reject the iron nail, also shown in the photograph). The depths are given in inches, to the nearest half inch. All of the test items used are dug artefacts and coins of various periods, metals and sizes that might be commonly found anywhere in the UK. I tried to select things I consider to be both "easy" and "hard" to find.

I personally checked each signal. It was noticeable that Georgi was able to consistently pick out a clear signal from the Nexus at slightly greater depths than myself (usually about half an inch to an inch deeper). My figures are given in the Table as being more representative of what a new user might achieve. Each signal was accepted as being at the greatest depth when the limit at

coil fitted / Test Target	Nexus 9in coil	Nexus 6in coil	Nexus 4in coil
Bronze Age socketed axe	32in	23.5in	22in
Durotriges base silver stater	17.5	13.5	12
Celtic fibula	7.5	6	6.5
Small Roman Bronze Coin	7.5	6	6.5
Carausius antonianus	18	14.5	13
Vespasian denarius	17	13	12.5
Vespasian sesterius	23	18	16
Roman bronze ring	21	16	15
Roman silver ring	18	14	12
Saxon silver sceat	11	9	8.5
Saxon Gold Tremissis	16	12	11
bronze strap end	16.5	13.5	12
Round Hammered Farthing	12	9.5	8.5
Edward I silver penny	15	12	11
Elizabeth I silver 6d	19.5	15.5	14
Nuremburg bronze jeton	16	14	12
large bronze strapend buckle	24	20	17
silver ring	20	15.5	13
lead seal matrix	19.5	15	14
lead spindle whorl	21	16.5	15.5
1869 bronze farthing	18	14	13
1707 silver sixpence	18	14	13
1921 bronze penny	23	18	16
1889 silver crown	24	17.5	15
silver fork	25	17.5	15
4-hole brass trouser button	16	13	12
.303 brass cartridge case	20	16	15

which a clear and unambiguous positive signal. Obviously there must be an element of subjectivity in any test of this type. What one user would accept as being a "clear" signal may not satisfy another. When looking at the results of any bench air test, it should be obvious that results "in the ground" will be less impressive. However, what can be said with certainty is that, if a detector is unable to detect something in air at a certain depth, then it will not do so in soil. If anyone wishes to put their own detector up against the Nexus, I will be delighted to accept the challenge – in the presence of any interested witnesses!

Demonstrations of the Nexus in the field can be arranged by contacting us (Chris 01227 369583 or Georgi 01442 219803) and we hope to be attending several rallies through the coming season. The basic retail price for a Nexus supplied with one coil will be £1,200 and this compares favourably with the better quality mass-produced detectors available today. Additional coils will be available at a retail price of £240 each. Georgi is in discussion with a retailer to arrange for a distribution agreement for the Nexus. For the present, the detector is being made to order (about four to six weeks).

For the technical details of the detector, at this point in the article I will hand over to Georgi Chaushev.

Technical Matters

The Nexus is an Induction Balance (IB) detector, as are many popular units today. Many detector users believe the most important part of a detector to be the control box. It is vital to remember that between the target in the ground and the control box there is the truly essential piece of equipment – the coil! The electronic circuits in the control box can only analyse the signals received from the coil. The only way any signal can be processed (by amplification, filtering, analysis and so on) is if the coil is good enough to pick it up in the first place. If the coil is not capable of picking up a signal, no amount of electronic gimmickry in the control box can help you. The most important part of any detector must therefore be the coil. So, what makes a good coil? An Induction Balance search coil transmits and receives an electro-magnetic signal on a set frequency, by using two separate wired coils - one for transmitting and the other to receive signals - that are "balanced" until a minimum possible offset voltage is achieved in the receiving coil.

There are two basic conditions for Induction Balance. These are where the receiving coil is tuned in electro-magnetic resonance to the transmitting coil or where the receiving coil is not so tuned. Most popular metal detectors utilise coil assemblies that are *not* in resonance. A coil assembly that *is* tuned in full electro-magnetic resonance has a dramatic (up to tenfold) suppression effect on the external interference signals that might be received (such as from power lines and other electrical equipment). Therefore, special filters for interference suppression are not needed which is an advantage for achieving better performance. Another significant advantage of such tuned coil assemblies is that the reliability of the discrimination achieved can be much higher - possibly up to 95% when compared with un-tuned coils (which may achieve an average 60% reliability).

A further factor is that a metal detector using a tuned coil requires less amplification of the received signal (by a factor of about ten) which leads to much greater signal stability from the circuits - and less current drain (longer battery life) - this greatly reduces the "chatter" or instability often experienced in the sound of the signals heard. Coils tuned in resonance can, however, experience problems if there is any rapid thermal change, as they are more sensitive to any changes (temporary or otherwise) in shape. Therefore care must be taken to use materials that are physically strong and do not expand or contract with temperature changes.

The theoretically ideal Induction Balance metal detector coil would have zero offset voltage within the receiving coil and absolute mechanical stability. In practice, this is just about impossible to achieve - although with time and care, you can get close to this.

In mass production, the best that can usually be hoped for is to adjust coils within a value range (a manufacturing tolerance) as the time required to manually adjust each coil to achieve as near to perfection as is possible would take too long and cost too much. So, why is zero offset voltage in the receiving coil so important? If the offset voltage is too great, then after being amplified by the electronic circuits, this will lead to considerable loss of sensitivity to target signals, reduced depths at which targets may be detected, lower reliability of discrimination and less gain than would be possible to use in the electronic circuits. Gain is the term used to describe the electronic amplification of any signal. The sensitivity of the search coil unit is vital and is completely dependent on the electro-mechanical properties of the coil assembly. It is necessary for the coil to remain in the original designed and constructed shape at all times in all conditions, to give no - or as little possible - change in the offset voltage while in use. Changes in the shape of the coil may occur through expansion or contraction from thermal changes (weather conditions) or from physical stress (bending, impact, etc). Although these changes may seem small, they will have a relatively large, negative effect on the performance of the entire metal detector. The most common failure of coil performance is due to heat distortion from use in hot and variable weather conditions. A detector may be very good in average weather but its performance will often deteriorate as the temperature rises!

The Nexus coils are tuned in full electro-magnetic resonance. They have been designed and built to counteract any thermal changes in use (they have been tested up to 70 degrees C), to ensure the necessary dimensional stability. Each coil assembly is also adjusted by hand to achieve as near to the minimum offset voltage as is possible. The coils are wound by hand and are embedded in a hand-made casing, built from high strength and low thermal expansion fibreglass material.

Why are Nexus coils built in a "figure-of-eight" shape, when just about every other metal detector is provided with circular or elliptical coils as

Various artefacts used for the "in air" bench test.

standard? The coil for each detector is built for the sole purpose of locating metal targets. Unfortunately, most metal targets are below the surface of the soil and the soil itself causes a similar type of signal to all of the metal targets. It is obviously desirable to cancel out unwanted signals from the soil to the maximum possible degree in all cases, while still allowing detection of desired targets. This process is usually called "ground balancing" and detectors are set up (automatically or manually) to ignore any signals below a preset fixed or variable base value. On highly mineralised ground, the base value required to "cancel out" the ground signal will be much higher than on soil with a low mineral content. This is why substantial reductions in sensitivity and depth capability may be experienced on "bad" sites. The rigmarole you have to go through to ground balance a detector to any given site is what sets the base soil rejection value. On very mineralised sites, "hot rocks" will still give a response signal as they are above the base value - discrimination settings (fixed or variable) introduce further levels of rejected signals. The signals caused by the soil also become stronger as the electromagnetic centres of the transmitting and receiving coils are positioned closer together.

From a mechanical point of view, there are three basic types of Induction Balance search coil systems:-

1. Concentric - when the receiving and transmitting coils are positioned about a common electro-magnetic centre

2. Overlapping - when the receiving and transmitting coils are positioned with a degree of overlap between them (figure-of-eight, double-D, etc)

3. Twin Coil - when the receiving and transmitting coils are completely physically separated.

In equal conditions, with coils of the same base diameter and operating frequency, the concentric type has the highest sensitivity of all to unwanted signals caused by the soil and has a limited depth capability (for desired metal targets), relative to the diameter of the coil. Also, it has low discrimination capability for targets having complex shapes. This format is the most difficult of the three for which to achieve near zero offset voltage.

The overlapping coil has considerably lower sensitivity to unwanted soil signals, compared with concentric coils and much greater capability for discrimination of targets of complex shape. It is also the most sensitive form for detection of very small targets. This format readily achieves near zero offset voltage for figure-of-eight shape but for double-D coils, this is much more difficult. The twin coil has the lowest sensitivity to soil but also has the lowest efficiency and no sensitivity to small targets. This format is the easiest to approach zero for offset voltage.

It is a simple fact that a coil loop having a circular shape will achieve maximum electro-magnetic efficiency. For this reason, a system of circular coils achieves the optimum electromagnetic performance. The Nexus therefore utilises a "figure-of-eight" overlapping-circles coil format that provides the highest overall efficiency and performance for Induction Balance. It combines maximum sensitivity to small targets, maximum depth attainable and maximum reliability of discrimination, combined with minimum ground effect. So why are there no figure-of-eight coils made for metal detectors until now? This is simply because they are much more difficult and more expensive to manufacture. It should be remembered that the metal detecting hobby is a niche market with a relatively small customer base and there is a limit on the price most people will pay. The figure-of-eight format is perhaps best suited to being hand built in relatively small numbers.

The final consideration for coils is the frequency to which they are tuned. Metal detectors are radio-transmitting devices that are governed by the Wireless Telegraphy Acts. (When I first started detecting, users were required to have a Pipe Finder Licence. It cost 15 shillings and was valid for five years! CW).

Today, metal detectors for hobby use are exempted from licensing, provided that they operate within a limited frequency range and that they conform to the maximum power output requirements. This is so that they will cause minimum interference to other electronic equipment. The Nexus coils operate on a frequency range of 6-7.5kHz (each coil is tuned on a slightly different frequency within this range to reduce possible interference between different detectors). In general, coils operating at the lower end of the spectrum (typically at about 7kHz, often called VLF - Very Low Frequency) achieve greater depths of detection and are more effective in cancelling ground signals. The signal generated is also more stable.

Coils at the upper end of the range (usually about 18kHz) are more sensitive to tiny targets but they are much less able to cancel ground effect or to distinguish between a signal from the ground and a desired target. Coils in the middle range (typically at about 11kHz) tend to suffer from the disadvantages of both of the low and high frequency characteristics. Some detectors are claimed as being multi-frequency and this simply means that the processor within the detector selects a particular frequency most suitable for ground conditions on that site. Simultaneous multiple frequency operation at one time is not possible. Any detector can only operate on a single frequency at any single time. TH