technical topics

by **Pat Hawker**, G3VA*

VK2ABQ TRIBANDERS, REINARTZ SQUARES & MOXON RECTANGLES

BY COINCIDENCE, two articles featuring the same antenna system appeared in the June 2000 issues of *QST* and *Practical Wireless*. Both traced briefly, if sometimes a shade misleadingly, the history of an antenna that originated in the 1970s but has since flowered in several versions: The VK2ABQ Tribander Beam for the 14/21/28MHz bands. This antenna received widespread attention after publication in 'TT' in January 1974, although its first appearance in print had been some two months earlier as a short contribution by Mr F Caton of West Merrylands, New South Wales to the 'Circuit & Design Ideas' feature of *Electronics Australia*, October 1973. It was accompanied by an Editorial Note: "This appears to be a very interesting approach to the never-ending search for the ideal aerial system. Of necessity, the description must be short but there should be sufficient information for readers to duplicate the original."

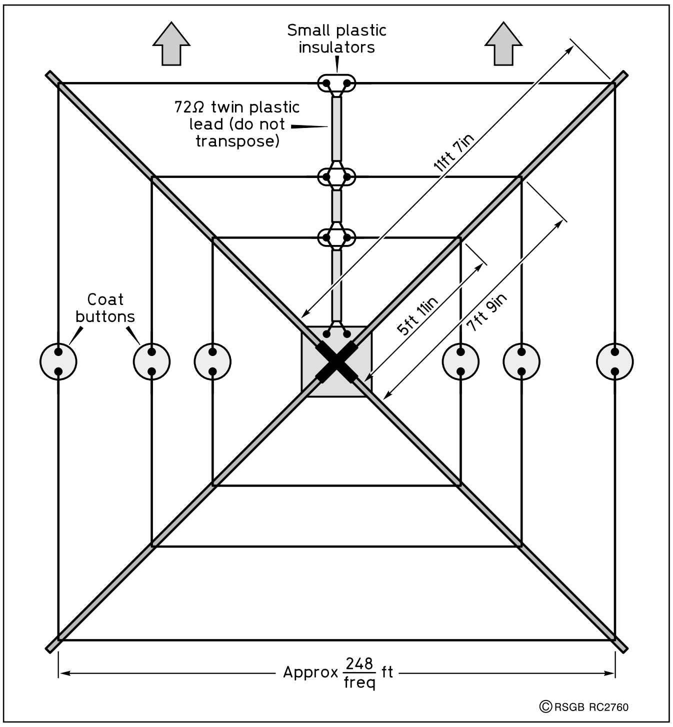

Fig 1: The VK2ABQ tri-band beam for 14/21/28MHz, seen looking down on the array.

Immediately after its publication in *EA*, the late Fred Caton, VK2ABQ, and former G3ONC, sent me an airmail letter containing the clipping and some extra information on construction and adjustment. From these I was able to concoct the item that appeared in 'TT' under the same heading previously used by *EA*. VK2ABQ frankly admitted that he did not know the forward gain, but claimed that it had a back-to-front ratio of 2-4 S points, with substantial gain over a dipole and a low angle of radiation on long haul contacts.

I admitted to having slight qualms about some aspects of the design, not reassured by the extremely scrappy nature of his notes, a characteristic that I came to recognise over the following years when he sent further ideas that never quite equalled his original tri-bander design. Nevertheless, I added: "the general concept seems interesting and a convenient way of constructing a compact tri-bander; so the information is presented as possibly experimental, but well worth investigating, certainly VK2ABQ/G3ONC has had good results." There can be do doubt that Fred was a gifted and determined experimenter in the days before NEC computer design began to dominate the antenna field.

It needs to be stressed that VK2ABQ designed a wire tri-bander that could be fixed or rotated. He made no claim to having developed the basic square-shaped compact element/reflector. As noted below, this compact form of directional antenna can be traced back to 1937, shortly before the recognition of the greater gain that can be achieved by close-spaced arrays – a major development based on the work on MF antennas by Dr George Brown of RCA.

VK2ABQ himself wrote: "After a lot of experimenting, I am now using what I consider to be the simplest and best home brew tri-bander yet. It has no traps or coils and so no losses related to such devices. Also, no mysterious blobs of electronics hanging on the array. Also, mechanically the system is very simple, it has no boom and a 14, 21 and 28MHz version has a turning radius of only 12 feet."

Subsequent reports from several UK amateurs who checked out the VK2ABQ soon confirmed that it fulfilled a useful role for amateurs still seeking a simple tri-bander as a low-cost alternative to commercial rotary beams using tubular elements. The design is simpler to construct and to erect than a typical condensed-quad array, although the forward gain is likely to be rather less.

Care is needed in adjustment for optimum performance. Variations in dimension were suggested for example by G3FRB and these are shown in **Fig 1**, although G3FRB stressed that a GDO should always be used to check for resonance. This is a relatively high-Q design, making for critical dimensions. Tuning for resonance and low SWR is facilitated if it is easy to raise and lower the antenna. Although reports were received of satisfactory performance when a VK2ABQ-type antenna was erected as a fixed beam in a roof space, this is not really advisable for any high-Q antenna - as it will be affected by nearby metal objects, etc.

The power gain of a VK2ABQ will be less than can be achieved with a well-designed close-spaced 2-element Yagi array or the Moxon Rectangle discussed below, but it remains valid to claim that the VK2ABQ deserves attention as one of the few mechanically simple tri-band designs suitable for home construction with a minimum of tools. The first publication in book form was in my *Amateur Radio Techniques* (5th edition 1974, subsequently in the 6th and 7th editions, all now out-of-print). It has also appeared in several other RSGB books on antennas, most notably *HF Antennas for all Locations* (see below).

The same January 1974 'TT' in which the VK2ABQ appeared included a short report on an RSGB London lecture by Les Moxon, G6XN. I wrote: "A full house, but why [even then] so few younger members?… A right royal evening of myth destruction and constructive hints. Looking through my notes I find such nuggets as: What's so important about front/back ratio if the beam has side lobes: tune for maximum gain… 14MHz folded dipoles work very nicely on 21MHz (the trick is to use resonant feeders)... There is no optimum height for horizontally-polarized aerials – get as much height as you possibly can (even if this means using a two-element rather than a three-element Yagi)… Unless a low SWR has been achieved after great care, this usually indicates *poor* performance… Interaction between different aerials is important (and for the amateur who has everything, including two different beams, he can get an extra 3dB gain without difficulty)… Loops are not single-band resonators… Trees have a great effect on vertically-polarized aerials…There is no limit to the possible errors when aerials are compared on the basis of ground-wave measurements."

G6XN is a long-time professional scientist/engineer and his book *HF Antennas for All Locations* (published by RSGB, first edition 1982, second edition 1993) although not always easy reading, remains one of the very best antenna books for the radio amateur!

**37 Dovercourt Road, London SE22 8SS.*

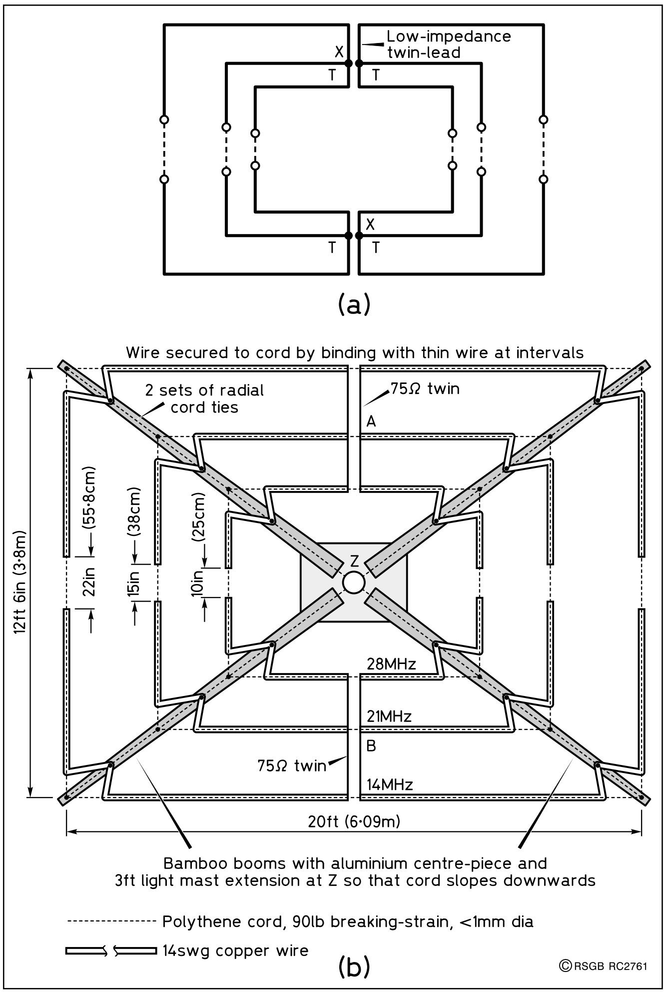

Fig 2: (a) G6XN showed how greater gain could be obtained from a VK2ABQ tri-bander by the use of elements forming a rectangle rather than a square. (b) Implementation of G6XN's rectangular tri-bander without increasing the turning radius.

These memories have been provoked by the two June 2000 articles concerned with the later version of the VK2ABQ elongated into a rectangle. This takes advantage of the extra gain possible with closer spacing of the driven element and the reflector. It was developed by Les Moxon, G6XN, and described in his book: **Fig 2**. It has later been modified and simplified by L B Cebik, W4RNL, who calls his version the 'Moxon Rectangle'. W4RNL's design appeared first in the article 'Modelling and Understanding Small Beams: Part 2, VK2ABQ Squares and the Modified Moxon Rectangle', *Communications Quarterly* (Spring 1995, pp55-70) and has been followed by a number of articles in the UK, USA and Australia. Recent examples include: 'Antenna Workshop: The Moxon Rectangle Revisited', by Peter Dodd, G3LDO (*Practical Wireless*, June 2000, pp 42-43) and 'Having a Field Day with the Moxon Rectangle' by L B Cebik, W4RNL in *QST*, June 2000, pp38-42.

Fig 3 and **Table 1**, from W4RNL's *QST* article, provide an outline of a Moxon Rectangle with the dimensions in feet applying to No.14 AWG bare-wire antennas for the HF bands. However, it should be noted that C, the spacing between the two sections, is fairly critical for optimum performance and it would be advisable to refer to his article for detailed information, including radiation patterns, etc. His article includes expected forward gain figures for various heights above ground, and also includes the outline of a direction-switching Moxon Rectangle by changing the feedpoint from one section to the other and using transmission-line stub loading to lengthen the reflector element electrically. It seems a useful addition to this growing family of directional wire antennas.

No claim was ever made in 'TT' that the basic idea of folding a driven element and a reflector element into a square with sides equal to a one-quarter wavelength was novel to the VK2ABQ design. Indeed, such a mono-band configuration had been illustrated in G6CJ's 'Aerials' chapter in the first two editions of the RSGB's *Amateur Radio Handbook*, published in 1938 and 1939, and rightly attributed to John L Reinartz, W1QP. It stemmed from his classic article: 'Concentrated Directional Antennas for Transmission and Reception – Rotatable loops and antenna-reflector systems of reduced dimensions' (*QST*, October 1937, pp27-29). **Fig 4**, reproduced from my much-battered copy of a pre-war *Amateur Radio Handbook* shows the first four of nine illustrations of compact directional antennas, three of them directly attributable to John Reinhartz's 1937 article.

John Reinhartz, who held the professional experimental call W1XAM as well as his amateur call W1QP, had earlier attracted world attention when in the April 1925 issue of *QST* he presented his theory of ionized layers to account for the skip distances experienced on "short waves". Previously, in November 1923, he was one of the main participants in the first transatlantic contacts between ARRL and Leon Deloy, F8AB, on about 100 metres. In 1924, his pioneering 14MHz signals were heard in California, the first time this feat had ever been accomplished.

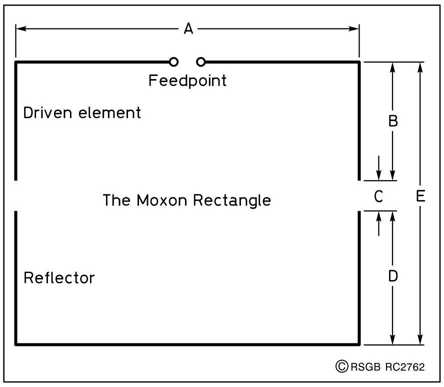

Fig 3: W4RNI's outline of a Moxon Rectangle with various dimensions labelled as in Table 1.

The Reinhartz antenna loops and squares attracted worldwide interest, particularly the double loop system for VHF operation. The basic elements were included in *Amateur Radio Handbook* as three items in a nine-part (A) to (K) diagram as the (a), (b) and (c) items of Fig 4. I have no idea whether VK2ABQ/G3ONC ever saw this material, but certainly he never claimed that he originated the basic square element configuration. It is for his simple tribander design that, rightly, he should be remembered.

Presented alongside Reinhartz's article was a description by Burton Simpson, W8CPO, of "A Square 'Signal Squirter' for 14MHz", based on a suggestion from W1QP. This was a hefty mono-band affair using *copper* tubing with quarter-wave sides to the square in the form shown in **Fig 4(c)**, with many wooden and brass struts. This elaborate approach was soon to be overtaken by the flood of two-element, close-spaced Yagi designs that followed the presentation by Walter Van Roberts, W3CHO of 'The Compact Uni-directional Array' (*Radio*, January 1938 pp19-23, 173). W3CHO's is believed to be the first amateur radio Yagi design to take advantage of a portion of Dr Brown's classic paper in *Proc IRE*, January 1937. Until then, reflectors had always been placed at least a quarter-wave behind the driven element. Another pioneer of close-spaced arrays was W8XK although, in his antenna, both elements are driven.

Freq (MHz)	A	B	C	D	E
3.6	99.98	15.47	2.16	18.33	36.96
7.09	50.69	7.82	1.15	9.35	18.32
14.175	25.30	3.87	0.62	4.70	9.19
21.225	16.88	2.56	0.44	3.14	6.14
28.3	12.65	1.90	0.35	2.36	4.61

Source: W4RNL in *QST*.

Table 1: Dimensions of Wire Moxon Rectangles for 3.5-28MHz with reference to Fig 3. Dimensions are in feet and apply to No 14 AWG bare-wire antennas.

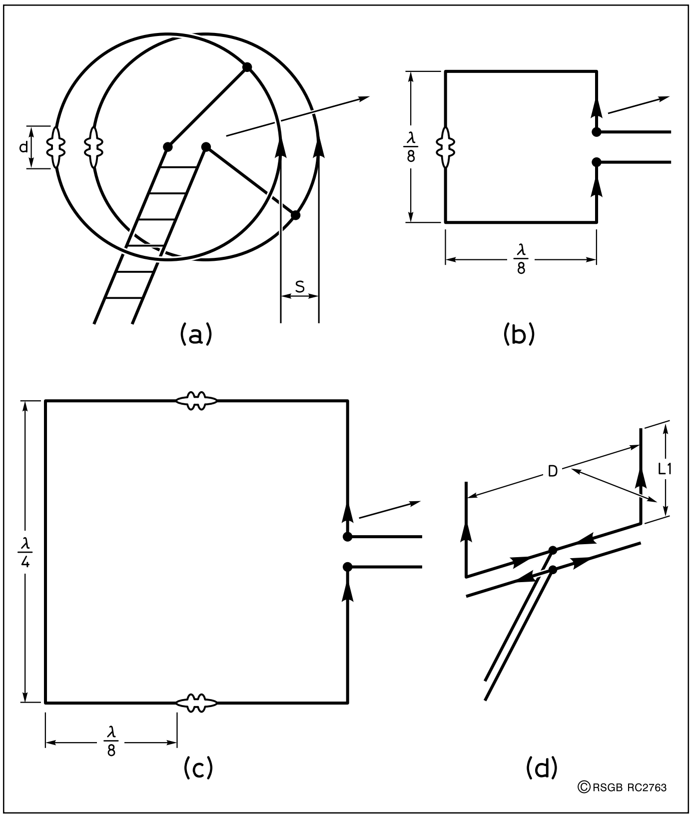

Fig 4: Part of a collection of compact directional antennas as presented in the pre-war editions of the RSGB's *Amateur Radio Handbook.* (a), (b) and (c) were derived from the classic 1937 *QST* article by John Reinhartz.

HERE & THERE

THE PREFACE to Robert C Dixon's 'Radio Receiver Design' (Marcel Dekker Inc, NY, 1998, viii + 474pp, ISBN 0-8247-0161-5) includes some apt remarks on current trends: "Today's receivers typically employ the same architecture that has been employed in receivers for many years. That is, today's receivers are still superheterodyne in structure, but they employ very different components from receivers of just a few years ago. Even the most common components – resistors – are different, in that at present one-eighth-watt resistors are commonly used, while half-watt resistors were the standard ten or more years ago. Integrated circuits, employing silicon and gallium arsenide, are achieving higher-performance in smaller packages, with less current consumption. Technology has made the difference, and will continue to do so, even as receivers become implemented using more digital structures… For as long as I can remember, engineers have had a dream of being able to digitize at the output of an antenna and process the digital result with a computer, thereby doing away with all those 'troublesome' analogue circuits and components. That dream is rapidly becoming reality, but not without certain drawbacks. The greatest advantage of digital processes is flexibility, not simplicity or even elegance, and many of the things done with digital processing are done with simple iteration of brute force techniques. However, if the end result is a better filter (for example) and it can be implemented in less space, by a microprocessor in its 'spare' time, then it must be used, and will always win out in the end. This shift is already occurring."

DAVID Macey, G6STD/M5AFA, recently successfully scaled down for use on 144MHz the 14MHz Clemens match design shown in various editions of the RSGB's *Radio Communication Handbook*. He finds this works well both as a 3-element and as a 5-element antenna. He wonders why the Clemens match seldom appears in other recent books on antennas for radio amateurs. I wonder if any reader can point me in the direction of the original publication, presumably by a Mr Clemens? It seems to have appeared in the mid-1950s.

NEW LOW-IMD MIXER

THE DISCONTINUANCE of the SL6440 IC mixer which provided a reasonably-acceptable dynamic range (much greater than the NE604) left something of a gap (partly filled by the Motorola MC1496) when building high-performance receivers/converters etc. Chris Trask in *Electronics World,* September 2000, pp680-685, presents detailed information on a new series-shunt feedback active mixer that is claimed to offer clear advantages over both the common Gilbert Cell active mixer and diode-ring mixers. An editorial note states: "With lower local-oscillator power requirements, low distortion and higher saturable output power, this new mixer is highly suitable for low-power, high-performance communications systems. Yet it's possible to implement the design on the kitchen table!" The *EW* article attracted my attention and was also noticed by Michael O'Beirne, G8MOB.

Chris Trask writes: "Mixers are essential building blocks of radio communication systems, being used for modulation, demodulation, and signal frequency conversion. Among the various forms have been transconductance multiplication – dual gate FETs, pentagrid and heptode vacuum tubes, etc – diode and switching FET rings, and the transistor tree – also known as the Gilbert Cell. An inherent undesirable property of mixers has been – and continues to be – intermodulation distortion (IMD) caused by two adjacent signals interacting. This interaction creates spurious signals that can interfere with adjacent smaller signals… Overcoming this unwanted characteristic is no small task. Traditionally, the efforts at improving IMD have included using Class III diode ring and switching FET ring mixers that generally require local oscillator signal levels of +17dBm or more, an unsuitable solution for field-portable equipment where power consumption is an important parameter."

He provides a comparison of the performance achievable with various high-performance mixers: **Table 2**. However, he does not appear to be aware of the H-mode mixers developed by Colin Horrabin, G3SBI, which have been featured in a number of 'TT' columns (and in the RSGB's *Radio Communication Handbook* (6th and 7th editions) and also in *Communications Quarterly*). The H-mode mixer, for example using the FST3125 array ('TT', September 1998) can have an IP_3 performance of the order of +45dBm with an insertion loss of 4.6dB, significantly better than the 2nd generation Trask mixer. Nevertheless, the new mixer appears to offer useful characteristics for operation from batteries, etc.

The *EW* article provides detailed design information on this class of series-shunt feedback active mixers, both the 1st generation mixer and the improved 2nd generation arrangement in which an additional Mini-Circuits hybrid transformer replaces a number of the resistors in the original circuit. The 2nd

Type	Gain	Input intermod Intercept point (IP_3)	Compression Point (1dB)
Mini-Circuits SBL-1	-5dB	+19.0dBm	-4.5dBm
Typical Gilbert-cell mixer	-1.5dB	+17.5dBm	+4.5dBm
Trask 1st generation mixer	-7.0dB	+21.5dBm	+5.5dBm
Trask 2nd generation mixer	-3.0dB	+29.5dBm	+10.5dBm

Source: *Electronics World*. Note this table does not include G3SBI's H-mode mixer configuration that can achieve an IP_3 of the order of +45dBm (see text).

Table 2. Measured performance of low-IMD mixer configurations.