By Pat Hawker, G3VA,
37 Dovercourt Road, London SE22 8SS

TT

An 'antenna special' this month, with more of the history of the close-spaced beam unfolding. A more positive look at the much-maligned 'G8PO Special' is provided, and details are given for designing folded dipoles with wire of different diameters. Finally, a new 3.6V H-mode mixer is described, and there is a follow-up on receiving SSB and CW on super-regenerative receivers.

THE UNIDIRECTIONAL [YAGI/BROWN] ARRAY

The roles of Dr George Brown and *Radio* magazine in the development of the close-spaced 'Yagi' unidirectional HF beam ('TT', October and December, 2003) continue to unfold. Dave Gordon-Smith, G3UUR, admits to being an avid wireless historian and vintage gear operator with a modest collection of old magazines, books and literature from earlier days. He writes: "One of my favourite old magazines is *Radio*, and I have a patchy collection of these back to 1932 (they are hard to come by in the UK, and not too easy in the USA). After Walter Van B Roberts' article in the January 1938 issue (see October 'TT'), there was a follow-up general design article by the Editor, W W (Woody) Smith, W6BCX: the 'Practical Design of Close-Spaced Unidirectional Arrays' (June 1938, pp38-41), a photocopy of which is enclosed. The first article by John Kraus, W8JK, on his 'flat-top' (8JK beam) appeared in the March, 1937 issue in which he states his indebtedness to Brown for the idea of the close-spaced anti-phase array and in which he also suggests an array which closely resembles the G8PO antenna [see below]."

G3UUR notes that the 1938 articles on close-spaced parasitic arrays all credit Brown, but in the following years they cite the previous articles and ignore Brown's contribution entirely. An exception is in the RSGB book *HF Antennas for all Locations*, by Les Moxon, G6XN (2nd edition, p23): "Spacings between the elements of additive arrays normally need to be at least λ/2, although a row of elements may be backed by a row of reflectors spaced λ/4 and phase-shifted by 90º… Additive methods were the only ones generally recognised until the appearance of a classic paper by G H Brown in 1937 which demonstrated the practical possibility of gains in excess of 5dB from pairs of closely-spaced elements. One of the sequels was the development of the W8JK array… but, despite its deep roots in the history of amateur radio and the sanctity conferred by long and extensive use, it has to be said that the W8JK antenna has few practical merits. This is because (a) achievement of gain despite close-spacing and antiphase excitation implies large currents with consequent reduction in efficiency and bandwidth and (b) major improvements require only a small modification, in the course of which the W8JK antenna gets deprived (perhaps rather unfairly) of its label. On the other hand, its virtues include extreme simplicity and the ease with which an understanding of its mode of operation can be extended to include all other small beams."

G3UUR, in commenting on how many writers have ignored Brown's contribution, adds: "The same thing appears to have happened with A E Green's contribution to ladder filter design. As far as I can find out he worked for Marconi. Dishal credits him with major contributions to the modern theory of ladder filter design in his early papers, but he gets ignored in his vital paper 'Modern Network Theory Design of Single-Sideband Crystal Ladder Filters' (*Proc IEEE,* September 1965, pp1205-1216). The crucial generalised coupling coefficient equation, that is so important to those of us who design high-order filters from Butterworth to high-ripple Chebyshev, is actually due to Green, not Dishal! There's little justice in this world!"

To return to the evolution of close-spaced antenna arrays, there seems no doubt that Woody Smith's article in the June 1938 issue of *Radio* represented a significant contribution in highlighting the importance of the vertical radiation pattern of the horizontal elements of a driven flat-top or a parasitic array. He suggested that there was already confusion among those attempting to apply the radiation patterns shown in Fig 28 of Brown's paper. These were based on vertical monopole elements.

W6BCX pointed out that, as indicated by Brown, by using a properly-adjusted director or reflector in conjunction with a dipole element, it is possible to increase the forward gain by up to 5dB, and attenuate the power radiated to the rear by as much as 12dB. But, because the director will reduce the effect of the earth upon the VRP of the driven dipole, the radiation from the dipole element will be increased at a lower, more useful [for DX] angle. "For this reason, a dipole of such height above ground that there is but little power radiated at low angles (a quarter wavelength above earth, for example) will often exhibit more than the theoretical 5dB gain when a director is added. If the dipole is far removed from earth, the gain will more nearly approach the theoretical value when a director is added."

An array can, in practice, because of its lower elevated angle of radiation compared with a dipole at equivalent height, provide a performance on DX signals that is better than its total forward power gain. This, as W6BCX indicated in 1938, has often led to confusion in the claims made for antenna gain. There is, in fact, still some confusion between 'radiation efficiency' and 'effectiveness' of antennas over specific paths. The effectiveness of an antenna, either for NVIS or for DX, is highly dependent on its environment. The addition of a director or reflector to a dipole antenna at a modest height can, in effect, change what may be quite a useful antenna for medium distances to a good DX performer.

REVERSIBLE UNIDIRECTIONAL ANTENNAS

The mention by G3UUR of 'The G8PO Special' - a reversible unidirectional antenna based on the W8JK driven 'flat-top' bi-directional beam array (**Fig 1**) - led me to look again at the original article by J E (Ted) Ironmonger, G8PO (*RSGB Bulletin,* November 1947, pp86-88). This design was noted briefly in 'TT' September 1990 in an item 'The 8JK Revisited and the New BRD-Zapper'.

Fig 2 shows the G8PO antenna as given in the original article and as reproduced in the September, 1990 'TT'. The 21MHz unidirectional Zapper (**Fig 3**) stemmed from W9BRD and utilised an end-fed W8JK, fed via a two-wire stub that is gamma-fed from coax and carefully adjusted to provide a 135º phase-difference (the direction could presumably be reversed by transferring the gamma connection to the other feeder, although this was not mentioned by W9BRD).

There have been various centre-fed designs derived from the basic W8JK bi-directional antenna, using driven elements phased so that they provide a unidirectional beam, including the ZL-Special and the HB9CV. Both of these designs have become firmly

Fig 1: Basic single section W8JK flat-top bi-directional antennas. In 1981, Dr Kraus pointed out that the centre-fed arrangement can be used over a continuous frequency range of 3:1. With a typical spacing, S, of about λ/8 on the lowest frequency used, the dipole element lengths can effectively range from less than λ/2 to more than 1.5λ.

Fig 1

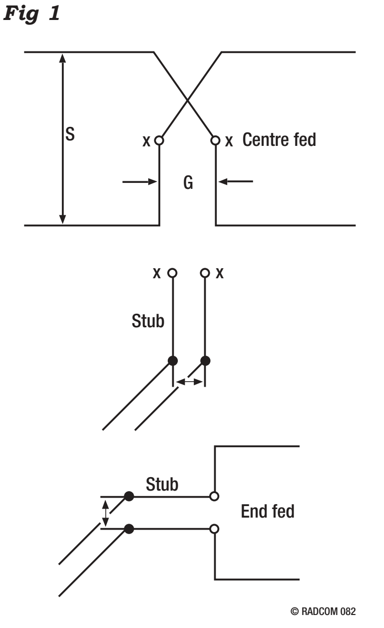


Fig 2: The original 'G8PO Special' reversible unidirectional array, as described in 1947. Direction depends on whether transmitter feed is connected at S1 or S2. The delay line is twisted once to provide the 135° out-of-phase drive. Note that some amateurs experienced difficulties when implementing the antenna as shown, primarily due to high standing waves on the feeders (see text). The claim in the 1947 articles for the very high front-to-back ratio was excessive for a correctly-implemented antenna.

Fig 2

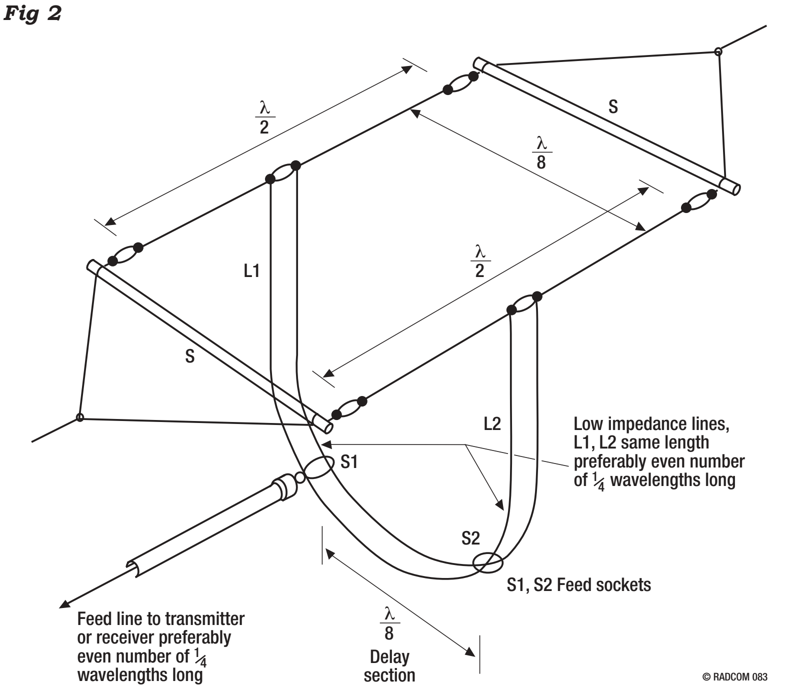
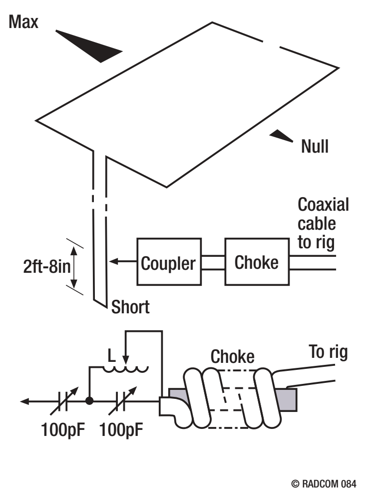


Fig 3: How W9BRD converted a 21MHz end-fed W8JK array into his BRD-Zapper.

Fig 3



established. I began to wonder why the November 1947 G8PO with its facility of reversing the beam direction by simply plugging the transmitter output into one of two feed sockets, spaced to provide a 'delay line', seems to have virtually disappeared from the scene, although in 1947 it attracted considerable attention.

I found that my 'look-back' in 1990 had suffered from a common shortcoming in such 'research'. I had missed the follow-up letters in subsequent issues, including those from G2HDU (December 1947), G3JR and VK2NO (both August 1948). Some were critical on theoretical grounds or practical experience, some constructive (for example, VK2NO advocated folded-dipole elements). More importantly, I had also missed a second article 'Reflections on the G8PO Aerial', by Ted Ironmonger who, at the time, was in Australia as VK3WU (*RSGB Bulletin,* August 1949, pp38-48). This acknowledged the difficulties that some users had experienced in attempting to duplicate the results achieved with the antenna of Fig 2. G8PO recognised that problems arose because the phase delay on a transmission line changes appreciably when there is a significant SWR, almost inevitable with the impedance of close-spaced dipole elements being a poor match for low-impedance twin-wire feeders.. He introduced a reversible 28MHz two-section array with a Bazooka matching section.

But, by then, the 'G8PO Special' had gained a reputation for inconsistent performance; the results claimed in the original article were difficult to achieve, particularly the high front-to-back ratio. However, there can be no doubt that the basic principles are sound and capable, if implemented with an understanding of the problems, of providing a useful reversible-beam antenna.

A detailed discussion and some practical hints are given on reversible driven-element antennas in the section 'Two-Element Driven Arrays' (Chapter 3, 'Close-Spaced Beams', pp75-78 of the *first* (1982) and pp90-93 of the *second* edition of *HF Antennas for all Locations*, by L A Moxon, G6XN. **Figs 4** and **5** are reproduced from G6XN's book but, for a full understanding of the pros and possible cons of such reversible unidirectional designs, it would be advisable to read all the relevant sections of this valuable (if at times not easy to read) book.

I7SWX's 3.6V 2T H-MODE MIXER/LVDS SQUARER

'TT', April 2003, pp82/83 featured a two-transformer version of G3SBI's H-mode mixer developed by Gian Moda, I7SWX/F5VGU. While this remains a valid design, Gian points out that there is now a new production by several manufacturers of fast bus switches, basically similar to the 5V FST3125, but focused on 3.5V types. He notes that going down in supply voltage has the potential disadvantage that it takes the mixer application into an area where the high level signals to be handled may come near the limit levels of the switch, ie 3V p-p. On the other hand, the lower voltage types provide better switching characteristics than the earlier 5V types (although some recent production of these show improved characteristics). Faster (ie shorter) switching times permit the use of higher local oscillator drive frequencies, hence higher IF and signal input frequencies are possible with lower attenuation.

I7SWX writes: "Having collected some 3.3V FST3125 devices, I have assembled a 3.6V I7SWX two-transformer H-Mode Mixer. There is not a lot of difference between the 5V version (powered up to 6.8V) and the 3.5V one, except that some resistor values are changed: **Fig 6.** If you wonder why I used a 3.6V supply rather than 3.3V, the answer is that 3.3V IC regulators are much more expensive than the classic 78L05, 78L06 or LM317. With these inexpensive devices, it is quite simple to provide a 3.6V supply, as shown. A possible 3.3V PSU is shown in **Fig 7.**

"The main and most important part of the 3.6V mixer is the LVDS (low voltage differential signalling) squarer. The new LVDS components are of two types: 'drivers' and 'receivers'. Most are for 3.3V applications, although a few are for 5V use. The 3.3V types have a higher speed than the 5V ones, around 200 to 300MHz against 75 to 150MHz. These components are normally used for high-speed digital communication over balanced line and correspond to the ANSI TIA/EIA-644 standard. There are three types of LVDS line receiver IC: single, dual and quad. There are also types with mixtures of drivers and receivers.

"Some dual- and quad-receiver ICs could prove very interesting as they have a single or dual Enable control.

This function could be used to inhibit the receiver mixer(s) – two or three 'receivers' at a time) applying the 'noise blanking' system suggested by Bill Carver, W7AAZ for the Triad super HF receiver (see *Experimental Methods in RF Design*, by Wes Hayward, W7ZOI, *et al,* ARRL, 2003 pp6.48/49). The noise-blanking signal needs to be generated and controlled by an external noise receiver and would make a very interesting and important noise blanking system. These LVDS SMD ICs have low power dissipation and are simple to use. The balanced input signal should be about ±100mV, while the output is a TTL/LVTTL logic level.

"Why use an LVDS squarer instead of the 74AC86 as used in earlier H-Mode mixers? The 74AC86 is still usable with the 3.6V version but, when used with a local oscillator exceeding 40MHz, its symmetry and phasing degrade very rapidly, particularly if not using balance adjustment.

"The LVDS squarer shown in Fig 6 derives from an idea of Harold Johnson, W4ZCD, mentioned to me by Bill Carver, W7AAZ. Apparently, W4ZCD began experimenting with these LVDS components with the object of finding an adjustable solution for balancing the output waveforms and phasing to 180° over a wide bandwidth. Because of other priorities, W4ZCD did not go ahead but I was triggered by his idea. I tried various arrangements to implement a squarer that would give the maximum output waveforms and phase balancing over a wide band to improve the drive to the H-Mode mixer, lower the attenuation and reduce the second harmonic output of the LO. The squarer shown was the simplest tested and probably the one that performed best."

I7SWX has provided extensive information on this mixer and squarer, including additional basic information, detailed measurements of attenuation, list of suitable LVDS devices, a power supply using a low-voltage LM317L regulator, waveforms etc. He also points out that anyone wishing to experiment with this LVDS H-mode mixture can purchase the PCB from Stefan Petrov, LZ1OV. Two PCBs for 5 Euros, three for $10. For additional information e-mail: i7swx@yahoo.com and stefanp@yahoo.com For more information on the I7SWX two-transformer and G3SBI three-transformer H-Mode mixers see 'TT', April 2003, October 1993, July, August and September, 1998.

FOLDED DIPOLE FEED IMPEDANCES TO ORDER

In the 'TT' item last October on the contribution of George Brown (see above), I referred to a letter I received in 1979 from Walter Roberts, W3CHO/W2CHO/K4EA that included a mention of an article he had written on folded dipoles. To quote: "Another of my antenna articles 'Input Impedance of a Folded Dipole' (*RCA Review*, June 1942), will tell you more than you probably want to know about the subject."

This intrigued me and I tried on various occasions at various libraries to trace the June 1942 issue of *RCA Review*, but always met with the response that there was no such issue. The librarians insisted that the publication of this journal was suspended during the years that the USA was engaged in WWII. It was only recently that I discovered by accident that K4EA had made a typing error in his letter: the issue concerned was June 1947!

This discovery came from reading

Fig 4

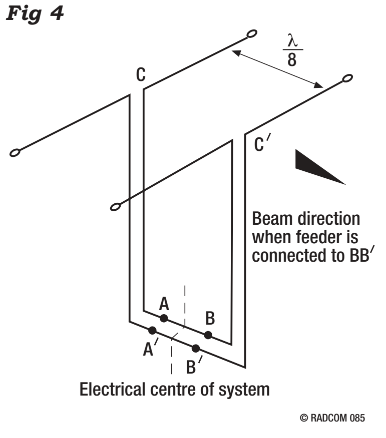


Fig 5

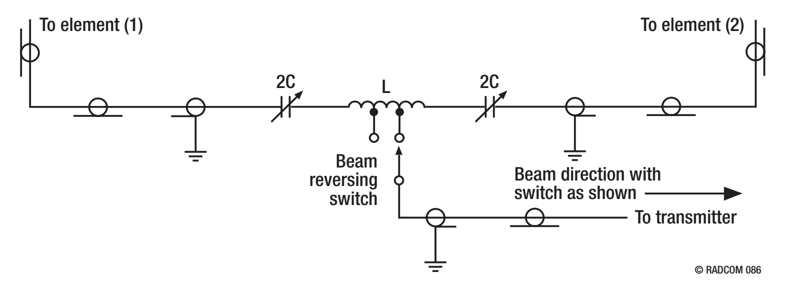


Fig 6

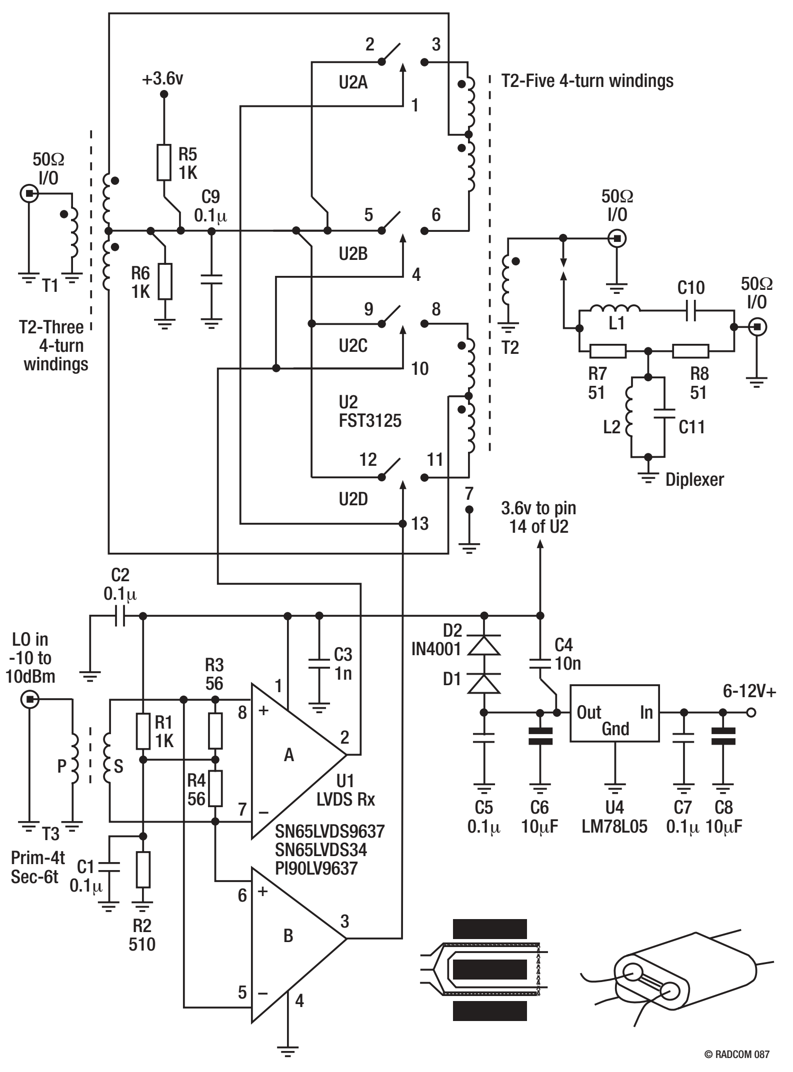


Fig 4: G6XN describes this two-element reversible array with resonant (or mismatched) feeders. If the elements are resonant, the length CABC must be an even number of half-wave-lengths. AB can be regarded as the phasing line, but is much less than λ/8 if open-wire lines are used. Note that the feeders are crossed over as for the W8JK antenna.

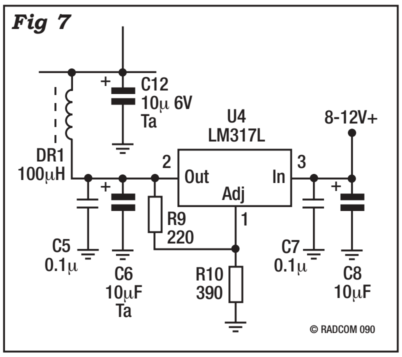
Fig 5: G6XN's suggested phasing network for two-element beams. Coaxial outers are bonded together. Elements of close-space arrays must be antiphase connected, so that if the inner or the coaxial feeder goes to the right-hand side of one element, it goes to the left of the other. For details see HF Antennas for all Locations.

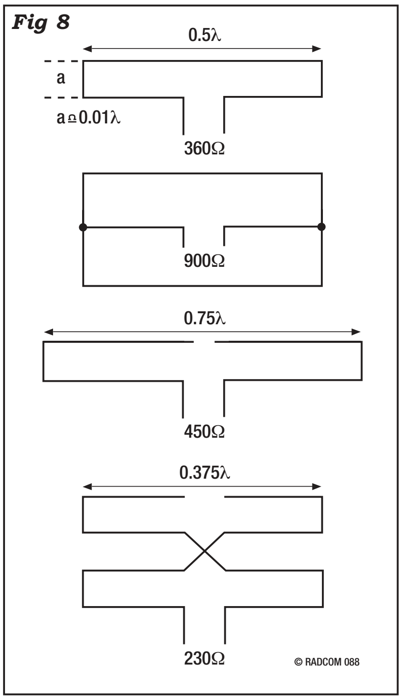
Fig 6: 3.6V two-transformer H-Mode Mixer with LVDS squarer as developed by I7SWX.

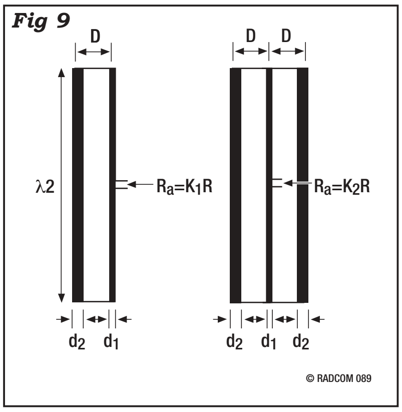
Fig 7: PSU using the higher-cost LM317L.

Fig 8: Basic folded-dipole element impedances using conductors of the same diameter as originally described by Dr Kraus, W8JK.

Fig 9: Walter Roberts, K4EA, showed how the impedances could be multiplied by a factor, k, when conductors are of different diameters. Calculations were simplified by 'Ham' Clark, G6OT, and he developed an Abac to eliminate the arithmetic. It should be noted that the impedance multiplier, k, depends not only on the ratio of the diameters of the two conductors but also on the spacings of the two wires.







an old, but still useful, article 'Folded Dipoles with Equal and Unequal Elements', by H A M Clark, G6OT (*RSGB Bulletin,* October 1947, pp62-64, 75), sub-headed 'Here at last is a method of finding the effective resistance [feed impedance] of a folded dipole in which the wires are not all of the same diameter. An easy-to-use Abac is given which saves all the arithmetic'. G6OT was a senior engineer with EMI, a company that had close contact with RCA. Incidentally, he was responsible for the design of the audio side of the 1936 Alexandra Palace 405-line television system – and post-war was the chief technical engineer at the famous Abbey Road recording studios.

In the '*Bull*', G6OT wrote: "So far, only aerials with one or more wires of the same diameter have been discussed, and it is seen that the resistance can be multiplied by 4, 9 or 16, by the use of two, three or four wires. [Some examples of folded dipoles using conductors of similar diameter, as originally announced by Dr Kraus, W8JK, are shown in **Fig 8 –** *G3VA*]. These are rather large steps and it may be that it is required to multiply the resistance by some intermediate factor, say 6 or 12, in order to effect a match in a particular case. It has been known for some time that this can be done by using wires or rods of unequal diameter in the same loop. Up till now, however, it has been common practice to employ hit-and-miss methods to obtain these intermediate values.

"In the June 1947 *RCA Review,* W Van B Roberts has developed a formula for calculating the multiplying factor when unequal diameters are used: **Fig 9**. This is information which the author believes has been wanted by the amateur for some time. The mathematically-minded are recommended to refer to the original article but, for the sake of those who merely wish to apply the results, the formula is given here with acknowledgement to the author and an original Abac will be given by means of which the resistance of any practical arrangement can be obtained without any arithmetic..."

Walter Roberts originally and then 'Ham' Clark provided information on two-wire and three-wire folded elements using wires of different diameters. Subsequently, a simplification of G6OT's original Abac, but covering only two wires, has appeared in all editions of the RSGB *Radio Communication Handbook*. The text note states: "Ratios of transformation other than four or nine can be obtained by using different conductor diameters for the elements of the radiator. When this is done, the spacing between the conductors is important and can be varied to alter the transformation ratio. The relative sizes and spacings can be determined with the aid of the nomogram in Fig 12.55 [Sixth Edition], These variations of the basic folded dipole do not lend themselves readily to multiband operation."

SSB & CW ON SUPER-REGENS

In the recent 'TT' item 'Super-Regenerative Detectors' (January 2004, pp 42-45), I rashly stated: "Super-regeneration will detect AM and wideband FM signals but, in its usual form, is unsuitable for CW and NBFM reception and has broad selectivity. *There seems no way in which it could handle SSB."* The item, however, included a claim by N1TEV, that use of a clean sine-wave quenching oscillator greatly increases selectivity and allows detection of NBFM.

André Jamet, F9HX, whose detailed description of a 10GHz super-regenerative receiver described in *VHF Communications* 1/1997, was noted briefly in 'TT', May 1997, has also contributed articles on super-regeneration in French and American magazines including: 'La Superréaction à 144, 432 et 1296 et ... 10GHz' (*Ondes Courtes Informations,* 6/7, 1996); 'Un Récepteur 10GHz à Superréaction' *(Ondes Courtes Informations 10/11/12 1996);* 'SHF Super-Regenerative Reception' (*QEX,* January/February 2001).

F9HX points out that he has already asserted that SSB and CW signals can be detected on any regenerative or super-regenerative receiver by a heterodyne effect from a signal generator. The frequency of the insertion signal has to be carefully adjusted in order to obtain a zero beat for SSB or the audio signal required to listen to CW. The reception stability is due only to that of the generator."

Old timers may recall that this form of signal-frequency carrier insertion was quite popular in the early days of SSB, permitting reception on receivers not fitted with a BFO or not sufficiently stable. I recall using a 3.5MHz VFO to provide carrier insertion on 3.5, 7,and 14MHz etc since a relatively weak but stable harmonic signal resulted in excellent demodulation of SSB.

F9HX also points out, in connection with the January notes relating to the waveshape effect on the performance of super-regeneration, that "It's obvious from professional studies that the frequency (or rather the *dv/dt*) of the quenching wave is directly related to the selectivity of the system. These professional studies include two 1948 articles in *Electronics:* 'Super-Regeneration Theory', by W E Bradley of the Philco Corporation, and 'Super-Regeneration Devices', by A Hazeltine and B D Loughlin.

Finally, F9HX draws attention to possibly the only book devoted entirely to this topic: *Super-Regenerative Receivers*, by J R Whitehead (Cambridge University Press, 1950). This book has been mentioned several times in 'TT', as I recall many years ago finding a copy in the Patents Office Library (now part of the British Library) and have also noted that Brian Bower, G3COJ, reported a few years ago that the copy in the BBC Library seemed, undeservedly, to have attracted very few borrowers other than himself! The book stemmed from a detailed wartime study by Whitehead at TRE in connection with the development of more reliable super-regeneration for IFF (identification friend or foe) equipment.

F9HX hopes that his comments will help to fill out and complete the outline of super-regenerative reception history!

HERE & THERE

Apologies for an error in Fig 1 of the January 2004 'TT'. There should have been a 100k (half-watt) resistor between the HT+ line and the anode of the second triode-section of the 6SC7 of the Polish clandestine-radio set. ◆