Technical Topics

PAT HAWKER, G3VA
37 Dovercourt Road, London SE22 8SS

DX, NVIS & LARGE HORIZONTAL LOOPS

THE SEPTEMBER TT noted the good performance that can be achieved with balance-fed large horizontal loop (circular, square, rectangular, triangular [delta]) antennas mounted at a height of some half-wave or more above ground. But it also noted that, if the height was of the order of a quarter-wave or less, optimum radiation, at least on the band where the loop is a full-wave, is skywards, forming a cloud-warming NVIS antenna. See, for example, TT February 2002, Fig 1(c).

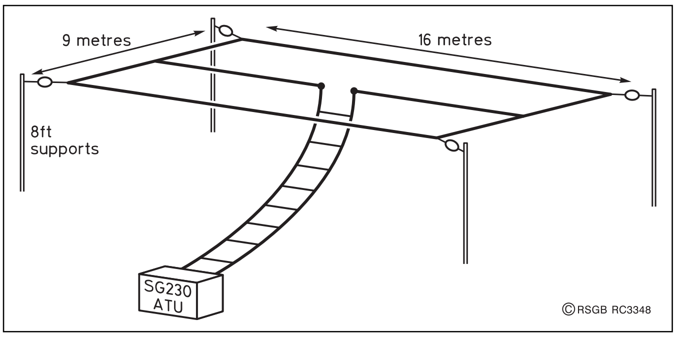

Fig 1: The low (8ft high) large 'loop' antenna with a 50m perimeter and fed by open-wire line across the short sides. Erected by G3HQT for 3.5MHz NVIS operation, it has proved a reasonably-effective DX antenna on the higher HF bands.

But there is still something of a mystery about this conventional finding. Many years ago (TT July 1968 and subsequent editions of *Amateur Radio Techniques),* Peter Pennell, G2PL, a renowned DX operator of that era, reported a happy-accident experience that led me to name his findings the G2PL Special antenna. To quote: Peter Pennell, G2PL, has found a way of using a two-element quad which suggests a new form of easily-built omnidirectional antenna. Normally, his two-element [three-band] quad is up in the air on a tilt-over type mast, but during some gales this was lowered so that the quad was firing directly up into the sky, with the 14MHz reflector-loop touching the ground in places.

Under these conditions, he found the performance of the antenna to be superior to that of a resonated vertical on all three bands (typically S9 from VK on 14MHz, S7 from W6 on 21 and 28MHz). The feeder SWR was little different from that in the vertical position. The particular array has three feeders about 100ft long and terminating in balun toroidal transformers [separately] feeding each of the driven elements. When tilted over, the height of the 28MHz driven element was about 7ft and that of the 14MHz element about 12ft.

Tests at 2PL suggest that the vertical angle of radiation compares with a dipole a half-wave above ground, and he feels that it would be a simple matter to erect such a system using four vertical posts, rather in the manner of the original DDRR hula-hoop antenna. It seems that the resonant loop antenna is being assisted by the reflector on the ground. For *ART* I was able to add: Subsequently, several other amateurs reported effective use of this arrangement. It also became clear that a horizontal full-wave quad loop performs well as a roof-space antenna. The higher radiation resistance and lower Q than an indoor dipole are useful characteristics in this application.

I have never seen a satisfactory explanation of why the 2PL antenna, with each element a full-wave perimeter at a height of about 0.2λ, should exhibit a vertical angle of radiation comparable with a horizontal dipole at a height of 0.5λ. I was reminded of the 2PL Special, first by a letter from Peter Ball, G3HQT, and secondly by an article in *QST,* August 2002 A Horizontal Loop for 80-metre DX by Dr John S Belrose, VE2CV.

G3HQT writes: The item on NVIS antennas in the June TT struck a chord. About a year ago I put up a 50-metre horizontal rectangular loop only 8ft high, with the idea of working short skip on 3.5MHz. A small variation is that I feed it across the short sides as in **Fig 1,** the intention being to make the current in phase in each branch. A short length of open-wire feeder connects to a SG230 auto-ATU nearby. It tunes up on all bands 1.8 to 28MHz.

As intended, it works well on 3.5MHz as an NVIS antenna but, surprisingly, is a reasonable DX antenna on other bands: for example HK0, ZD7 on 7MHz; VK6, TI, EY, 9G, VU, 6W on 10MHz; LU, A5, V51, HI on 14MHz; ZL, A9, FR, P4, W7 on 18MHz; 3W, V3 on 21MHz; KG4, ZF on 24MHz; and P4 on 28MHz. This with 100W, sometimes in competition with other stations.

If it was serendipity that brought about the G2PL and G3HQT extremely low-height loop antennas, a different route was followed by VE2CV for what amounts to an NEC-4 simulation of an original loop design specifically for 3.5MHz DX (but suitable also for 7 and 10MHz): **Fig 2(a)**. This was inspired by earlier work by Paul Carr, N4PC (*CQ* December 1990), and W Bolt, DJ4VM (*Ham Radio,* August 1969, and see brief mention in G6XN s *HF Antennas for all Locations*), **Fig 2(b)**. The transposed arrangement of Fig 2(a) results in a full-wave loop operating in a W8JK driven-element mode and with a null in the overhead radiation pattern: **Fig 3**.

Although it does not appear that VE2CV has yet validated the design with an actual antenna, it is based on a simulation using W7EL S *EZNEC Pro* version of *NEC-4D.* In his introductory notes, VE2CV stresses that he considers horizontal polarisation is preferred for 3.5MHz DX, particularly at low elevation angles, since horizontally-polarised waves are hardly affected by the finite conductivity of the ground in front of the antennas. The exception is where vertically-polarised antennas are used over very good ground, near the sea shore or over alkaline salt flats.

Nevertheless, VE2CV does not consider that a 3.5MHz horizontal dipole at a practical height to be an ideal antenna for DX. He believes that the radiation pattern should have a null overhead, to minimise NVIS signals from atmospheric noise and interference, and a low-angle lobe to maximize reception/transmission over paths to distant stations. This would require the dipole to be about 40m high. The proposed arrangement uses 40ft supports as normally proposed for the conventional Loop Skywire , as illustrated in the September TT (Fig 1). On 3.5MHz, such antennas are more suited to NVIS than to DX (although even high vertical radiation can prove effective sometimes for grey line (chordal hop) propagation during ionospheric tilt periods).

VE2CV, in his six-page article, provides details of matching network values for the system impedance of the antenna at 3.75, 7.2 and 10.14MHz. Fig 3 shows the vertical and horizontal radiation patterns of the antenna at a height of 40ft. **Fig 4** shows that when a 1λ horizontal loop is used at twice the design frequency (as a 2λ loop) it produces a vertical null.

COMMON FAULTS & CURES

HARRY LEEMING, G3LLL, with many years in the trade behind him, adds to the com-

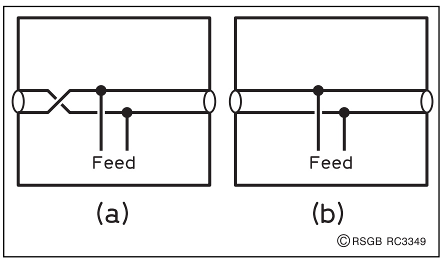

Fig 2: (a) Top view of VE2CV's simulated quad loop with transposed phasing lines, operating in the W8JK mode and producing a vertical null on 3.5MHz. (b) Top view of the 1969 DJ4VM loop. (*QST*, August 2002)

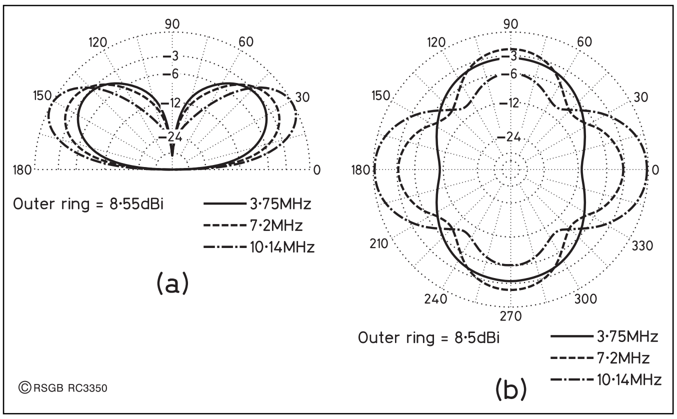

Fig 3: Principal plane elevation (a) and azimuthal (b) patterns for the simulated antenna of Fig 2(b) at a height of 15m over average ground.

ments in the August TT on intermittent and other common faults. He writes:

Intermittent faults: As suggested, these can be very time consuming. I find that often the best approach is a few pokes and prods in likely areas.

Dirty contacts: Controls and switches are largely self-cleaning, provided that they are used regularly. But the never- or very seldom-used switch or control that is tucked behind the back of a rig or, even if at the front, is a common source of trouble.

Relays: A common cause of intermittents. Removing the case and gently poking at the contacts with an insulated tool will usually show if this is the trouble. Be sure to clean them with a cleaner free of lubricant, such as video head cleaner.

Plug-in circuit boards: Another weak link, especially if the socket and contacts on the boards are made from different metals. I find that gold-plated memory and non-gold-plated sockets on computers need cleaning every couple of years.

Crimped connections in plugs: These tend to start becoming troublesome after 20 years or so, and are a common cause of intermittent faults on the FT-707.

Intermittent dry or broken joints: These cannot be blamed on smoking, but often occur where a largish component, such as an audio output or regulator IC, is clamped on to the chassis and soldered to a PCB with resultant movement between the two as the board flexes.

The first five problems are much more likely to occur where the owner of the rig smokes. When I was in business, I reckoned that about a third of my repair income came from undoing the faults caused by cigarette smoke! [See also The Smoker s Legacy (TT , July 2001, p64), in which G8MOB stresses: The moral is to be very careful when buying radios from smokers or those acting for silent key smokers, unless the set is a fully-sealed military unit such as the R210 receiver. Tobacco smoke and electronics just do not mix.]

G3LLL emphasises, from the viewpoint of a service engineer, that often the most difficult aspect of fault-tracing is obtaining the complete story of what has happened from the customer. He writes: At times I have felt that an interrogation room with a bright light would come in handy! One time, a hand-held unit was presented to me claimed as intermittent on transmit . Eventually it transpired that it was in fact intermittent on receive. The owner had presumed that it was not transmitting as at times he could hear nobody coming back to him!

He advises: When presenting a rig for repair, try to give as much detail as possible. If the receiver tends to go dead, is the S meter still registering? Can you hear any hiss from the loudspeaker? Do the pilot lamps go dim when you key the microphone? Can you hear the output on a receiver in the shack? Is the fault on all bands and modes? Do not rely on a third party to pass on the information to the engineer. Write everything down and attach a note to the rig with a day-time telephone number. The more information you give, the quicker the fault will be to fix, and the less you should have to pay.

Finally, G3LLL endorses the use of an elastic band around the handles of a pair of pliers to form an effective third hand as mentioned in the caption to Fig 1 of the August TT as an alternative to the use of wooden or plastic clothes pegs.

LEAD-FREE SOLDER AHEAD?

A MAY 2000 TT item Electronics & the Environment (p55) drew attention, *inter alia*, to the third draft of a European Commission directive on Waste Electrical and Electronic Equipment , which was aimed primarily at reducing the growing mountains of computer junk, but also addressed the use of cadmium, mercury and some other toxic metals, along with lead. The draft at that time scheduled a phasing-out of the use of all these substances, exempting batteries and PCBs, by January 2004.

It was reported by *IEEE Spectrum* that some major companies, including Sony and Matsushita, were planning to eliminated lead solder from domestic products during 2000. Possible alternatives to lead-tin solder were given as tin, copper and silver: It seems likely that tin / copper will be used for wave soldering, with tin / silver / copper used for solder paste. These alloys have higher melting temperatures than the current tin / lead solder alloys (melting point, typically 173 - 220 C according to the percentage of tin). Tin / silver / copper melts about 240 C and tin / copper still higher. The melting point of pure lead of is about 328 C, copper about 1083 C and silver about 961 C. The percentage of tin in the alloy governs the melting point of the solder alloy.

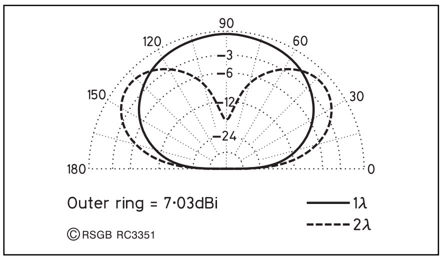

Fig 4: Vertical radiation patterns for 1λ and 2λ loops.

Derek Penrose, G1CWZ, provides an update on the situation in the form of an article in the IEE s *Electronic Technology,* July/August, 2002 (pp46 - 47): Micro-Welding Offers Solution to High Process Temperatures , by Tessa MacGregor. This describes the use of custom-built micro-welding machines for gold-ribbon bonding of PCBs. Such a setup might well be suitable for industrial purposes, but would seem out of the question for DIY construction. What is relevant is the introductory note which states: In 2006, laws are being activated which ban solder containing any lead, and some assembly categories will not tolerate the 260 C temperatures needed for most lead-free solders. Manufacturing industries are now looking for alternative joining methods and micro-welding may provide the solution.

It was noted in the August TT that, for effective soldering of SMT with current lead / tin solder, one needs the bit temperature of the iron to be roughly 100 above melting point (eg about 290 C or a little lower). But it was also stressed that one should never go above 300 C with present solid-state and SMT components. One can see a problem arising! G1CWZ wonders whether we need to stockpile what he calls proper solder! Or will the law ban only the *use* of lead / tin solder but not its *sale*?

Brian Horsfall, G3GKG, adds some further useful points to the soldering lore given in August. He writes:

Regarding filing the tip (and bit-wear generally). If the bit is uncoated copper, a normal 60% tin / 40% lead solder will eat it away quite quickly by dissolving the copper in the molten solder. Multicore *Savbit*, which contains a small percentage of copper, was designed to slow down this effect and did, indeed, give many times the bit life. With an iron-coated bit on the other hand, *Savbit* or similar copper-containing solder will rapidly dissolve away the iron at the tip and lead to pitting and a very much shortened life. The unfortunate corollary is that, using the correct, plain 60 / 40 solder with an iron-coated bit, it is much more difficult to keep the tip nicely tinned, compared with the incorrect use of *Savbit*. You pays your money and takes your choice!

Watch out for apparent bargain prices of solder at rallies usually on a reel with one corner of the label accidently torn off. If you fall for this one (as I once did), you will probably find that it is a 40% tin / 60% lead solder, quite unsuitable for radio work. Although both mixtures start to melt at about the same temperature (183 C), the 60 / 40 eutectic mix is fully liquid by 188 C and the joint solidifies quite quickly as it cools. The 40 / 60 mix is not fully melted until about 235 C and so goes through a gradually-solidifying pudding phase on cooling, during which the slightest movement is guaranteed to produce a dry joint.

MF PERFORMANCE OF THE CFA

THE AUGUST ITEM Poynting Vector Synthesis & the CFL drew the conclusion that there is very little significant radiation from the loops of the CFL and that Poynting Vector synthesis , in the form suggested in the Patents, is based on a fundamental fallacy. But this does not mean that the original CFA structure does not work, if relatively poorly, as an antenna based on conventional theory. What is disputed by the professionals is the uniquely high efficiency that has been claimed ever since 1989 by the inventors of this electrically-short antenna.

There have been several trials and tests of the CFA as an MF broadcast antenna; in none of which has it proved capable of reproducing the performance claimed by the inventors for the original Cairo broadcast crossed-field antenna. Admittedly, much of the criticism has come from simulated studies, with the inventors steadfastly claiming that the CFA is not amenable to *NEC* programs.

At the Millennium Conference on Antennas and Propagation in Davos, Switzerland, April 2000, Dr John Belrose, VE2CV, presented a paper The Crossed-Field Antenna Analysed by Simulation and Experiment that concluded: The inventors claim that their CFA, in spite of its small electrical size, is a broad-band efficient radiator due to its ability to couple very effectively to the propagation medium and to minimise wasteful near-field reactive power. Our study shows that the CFA is a very inefficient radiator. The near field is very strong. And, the very large reactive powers which circulate between the two feed points causes problems with the transmitter (an apparent mismatched load) with the matching and phasing networks, and results in power loss. There is (in the author s experience) an unbelievably wide divergence between the results of our study and the performance claimed for the MF broadcast CFA antenna system in operational use in Egypt. Thus the excellent operational performance claimed by the inventors of the CFA is an enigma.

A detailed study of a variety of electrical-short MF antennas is reported in a long (22-page) paper Short Medium-Frequency AM Antennas , by the Brazilian professional broadcast engineer (and radio amateur) Valentine Trainotti (*IEEE Trans on Broadcasting,* September 2001, pp263-284).

This is introduced with the comment: Vertical antennas with heights less than $\lambda/8$ for broadcast service have not been very well studied because of poor interest in radiators of low efficiency.

The paper analyses from a theoretical and practical viewpoint a wide variety of short monopoles, short dipoles and short folded monopoles as well as the crossed-field antenna (CFA). Types analysed include: top-loaded monopole; umbrella-loaded monopole; cylindrical monopole; top-loaded cylindrical monopole; series-fed monopole skirt-loaded; folded monopole, short dipole and the CFA. For optimum performance all the antennas require a virtually-perfect ground plane.

Of the CFA, he writes: This antenna is nothing new and its behaviour is similar to a short monopole of the same height. It has a short cylindrical monopole structure as a radiating system, called the E plate, and a metallic plate (called the D plate) under it and parallel to the ground plane with, lately, in order to increase its radiation performance and facilitate its tuning, a top hat. In the paper he points out that there are no magical effects in the CFA radiation behaviour, because this is similar to a short monopole as measurements indicate. He insists that the assumptions made by the inventors as to how it works seem completely wrong . Among the many points made in this paper is that it was determined by calculations and measurements that top-loaded and umbrella-loaded antennas of less than $\lambda/8$ in height can give a performance not too far below those of a quarter-wave monopole when an almost perfect ground-plane is used. **Fig 5** shows the original barrel-shaped CFA, as disclosed in 1989.

I must apologise for some confusion and shortcomings in respect of the patent numbers for the CFL antenna given in the August TT , both in the text and in the caption to Fig 3. The correct number for the CFL is US 6,025,813 as given in the text but GB 9,718,311 refers to the first Application filed in the UK. This was later revised and not finally accepted as Patent GB 2,330,695 until 26 June 2002. There are some differences in the claims made in the UK and USA patents, but the descriptions and illustrations are similar. It is interesting to note that the inventors claim that the CFL radiates vertically-polarised signals as would radiation from the outer braid of a vertical feeder! The numbers given in the caption are those for the original CFA patents: US 5,155,495 and GB 2,215,524.

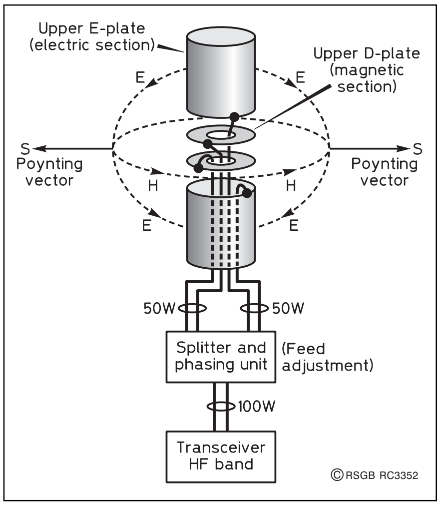

Fig 5: The original 'barrel-shaped' crossed-field antenna (CFA) as disclosed in 1989.

METERING & TUNING AT HIGH VOLTAGES

DEREK BUNDEY, FIEE, G3JQQ, adds usefully to the March TT item Metering High-Power Valve Amplifiers , contributed by G3GKG. He writes: I seem to recall that past wisdom was to ensure that the risky zero adjustment screw and front cover was covered by perspex, not difficult to do, but use appropriate screws rather than Araldite. I assume the use of old-fashioned full-size UK meters rather than the modern small Japanese-style meters. Most of the older black variety will withstand medium-EHT but, if nervous, a larger fixing hole can be used with a plastic ring spacer. Rear grub screws can be covered with tape.

Concerning the question discussed by G3GKG of tuning tetrode valves by monitoring the screen-grid current, this was covered extensively by the late Bill Orr, W6SAI, in Understanding Tetrode Screen Current published in an Eimac *Newsletter*, circa 1961. Another *Newsletter* reviews the suitability of various valve types to circuit configuration and covers heavy control-grid current for the 4CX series in inappropriate circuits.

G3JQQ adds that his set up is similar to that used by G3GKG, but based upon a modified STC V-bomber transmitter unit, the RAF T4188, mentioned in TT some years ago. It uses two 4CX250 ceramic valves, strict AB1, 1500V (no-load) EHT, 350V screen voltage, tuned by variometer and output loading capacitor, and an input pi-network with preset capacitor. With 20W input, it provides at least 250W output. As driver, a Yaesu FT-1000MP is used at low power: There is no ALC, but a small amount of compression set by monitoring output with an oscilloscope. It covers all bands from 3.5 to 28MHz. The unit is compact and sits under the desk, but it has a large, separate power supply unit. The input is untuned passive-grid with 200Ω loading using a 4:1 setup balun. The input VSWR becomes increasingly reactive at the high-frequency end by the FT-1000MP ATU. The previous driver was an FT-102 that could be matched manually. The amplifier has been in use for nearly 20 years.

Anyone else out there with a T4188? Be assured that a little effort will produce a good linear amplifier!

CERAMIC FILTER AS 455kHz BFO

JOHN BEECH, G8SEQ, was interested to see the notes from LA8AK (TT . July 2002) on his experiments in using 5, 6 and 10 MHz ceramic IF filters as variable frequency elements in VFOs. It reminded him that he had proposed a roughly similar arrangement for use at 455kHz and 10.7MHz some14 years ago. He writes: I remember trying to get this type of filter to oscillate since, at the time, ceramic resonators were relatively expensive and I had a box full of filters which I had bought cheaply .

His results were published originally in *SPRAT* issue 54, spring 1988, and a later version (including the use of ceramic resonators) appeared in TT November 1993 (see *TTS 1990-94*, p240). In this he reported *inter alia*: Finding myself without a suitable ceramic resonator, I experimented with ceramic CMF filters types CMF24550 (455kHz) and also a 10.7MHz ceramic filter type CFS: **Fig 6(a)**. He found that, provided he connected pin 2 (normally grounded when the device is used as an IF filter) as a centre tap in a Hartley / Colpitts configuration, it oscillated. With the 455kHz filter, the output frequency tends towards the bottom edge of the filter passband (ie about 450kHz). With the 10.7MHz filter, oscillation was at the top end of the passband, ie about 10.87MHz.

He added: Using the 4550 as an oscillator in conjunction with a 4550 IF filter, upper sideband can be effectively demodulated: **Fig 6(b)** . At the time, he thought about pulling the oscillator frequency, though never got round to attempting this. Now, more than a decade later, he is thinking of finding time to re-investigate this type of oscillator.

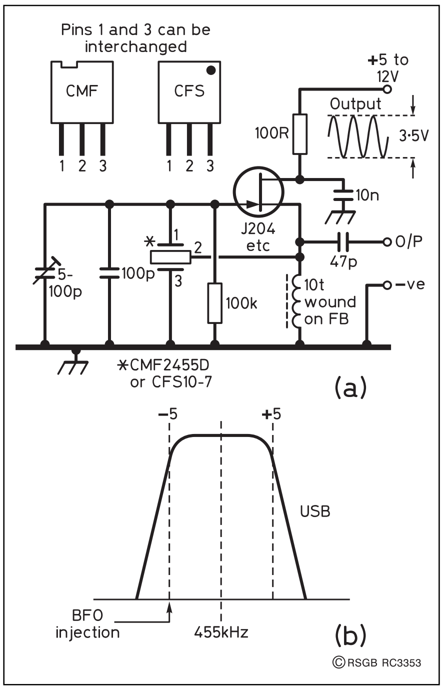

Fig 6: BFO oscillator using a ceramic 455kHz IF filter, as described by G8SEQ in 1988.

GALLIUM NITRIDE THE FUTURE?

EXPERIMENTAL TRANSISTORS based on gallium nitride are claimed to withstand heat and to be capable of handling frequencies and power levels well beyond what is possible with silicon, gallium arsenide, silicon carbide or essentially any other type of semiconductor yet fabricated. A six-page article The Toughest Transistor Yet , by Lester F Eastman (Cornell University) and Umesh K Mishra (University of California at Santa Barbara), appears in *IEEE Spectrum*, May 2002, pp28-33. The authors state that GaN transistors could double or triple the efficiency of cellular base-station amplifiers, enabling base stations, freed from fans and correction circuitry, to be shrunk to the size of a smallish dormitory refrigerator, something that would fit on a utility pole.

They stress that those same characteristics of speed, high power handling, and heat resistance would also suit the transistors for countless other uses. The fly in the ointment is that no inexpensive substrate material for gallium nitride exists, although silicon carbide is a fairly good match. Unfortunately, at present, a 50mm wafer of gallium nitride on silicon carbide, which might yield a couple of thousand transistors, can cost in excess of $10,000, far more than prepared silicon wafers in much larger sizes. Experimental GaN devices have proved capable of sustaining power densities above 10W/mm of gate width (compared to less than 1W/mm for gallium arsenide), while amplifying signals at 10GHz. Researchers tested a GaN transistor at a sizzling ambient temperature of 300 C, and found that it still had a gain of about 100, whereas silicon transistors stop working at about 140 C.

If wafer prices can be brought down, there would appear to be a dazzling future for GaN devices in radio communications.

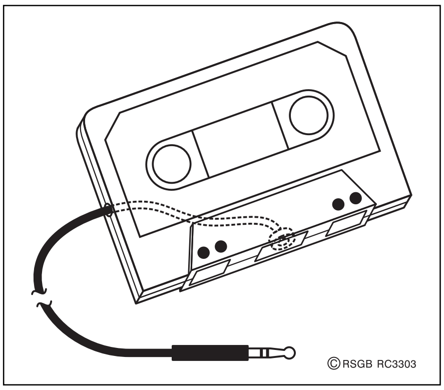

Fig 7: ZS6BFI's method of using a discarded tape cassette and earpiece to feed the audio output from a handheld transceiver into a car audio system. (Source: *Radio-ZS*)

HANDHELD TO CAR AUDIO

BURRIDGE EMMELL, ZS6BFL, has described in *Radio-ZS* (January / February 2002) a simple means of Connecting a Hand-held Transceiver to a Car Audio System . He had found that the output level of his HT did not suit his hearing when competing with car noise. Adapting a system used in some drive-in cinemas, he found a way of using a dismantled tape cassette to feed the audio from a headphone socket into the car audio system: **Fig 7**. He writes: All that is needed is an old cassette case with everything removed and a cheap portable-radio ear-piece. Dismantle the ear-piece and keep the coil. Throw away all the metal bits, possibly keeping the magnet for other use. Install the lead and the coil remembering to keep the coil a fraction away from the pickup head. The lead, where it exits the cassette, must not interfere with the operation of the tape mechanism, If necessary, first test it on a portable tape recorder. On the other end of the lead, connect a plug that suits your HT. Mine is working on a Kenwood AT-22 and Icom R2 and does the job for me.

Remember the warnings of the potential danger of speaking into a handheld unit while driving. But listening through the car audio system seems acceptable.

HERE & THERE

IN CONNECTION with the June TT item on the early Eddystone product detector fitted to the WWII Model 400, in which I suggested that this 130-2200kHz receiver may have been used for the RAF air / sea rescue service, Dave Rumens, G4BOO, comments: I believe these receivers were used by the Communication Branch of the Home Office between 1942 and 1952 when they operated their wide-area-coverage emergency services communications on MF. Further investigation has shown that the RAF launches were fitted with the T1154N / R1155N combination, a second R1155 (type A, B or F) for the navigator (with DF loop) and also the TR1143 and TR1133 for sea / air communications. ♦