ern European countries and in China etc. Some time ago, attention was drawn in *TT* to the rather wide range of manufacturing skills found in RF power valves stemming from China as observed by Bill Orr, W6SAI. Some factories were turning out good quality, close tolerance valves but others less so.

A 'New Products' item in *QST* (November 1994, p104) draws attention to a range of Svetlana Electron Devices power valves including a new, relatively low-cost, 4CX800A ceramic/metal transmitting tetrode which used as a linear amplifier is rated at up to 750W PEP output (a pair giving 1500W PEP) and which is being manufactured at a Svetlana valve factory in St Petersburg, Russia.

The air-cooled 4CX800A is a high-performance valve intended for grounded-grid or grounded-cathode service with a passive (untuned) 50Ω input circuit and capable of good linearity at relatively low anode voltages. The SK1A socket, with built-in screen bypass capacitor, increases the maximum frequency rating to 250MHz.

Interestingly enough, *QST* gives the address for data enquiries etc as George Badger, W6TC, Svetlana Electron Devices Inc, 3000 Alpine road, Portola Valley, CA 94028, USA (tel 415-233-0429). W6TC is well-known in the UK not only for his detailed work on coaxial-cable baluns but also for his many visits to Europe on behalf of Varian-Eimac.

THE T-NETWORK ANTENNA TUNER

THE CLASSIC PI-NETWORK or LC/CL two-component matching networks can be used as the basis of an antenna tuning unit (ATU). These are theoretically capable of matching any transmitter to any antenna impedance (resistive or reactive). However, in practice the matching range is dependent on the component values. For the widest step-up and step-down transformations, the high-voltage variable capacitors need to have low minimum and very large maximum capacitance values - a significant disadvantage these days. The pi-network and the standard LC configurations do however possess the advantage that they not only transform impedance but also form a low-pass filter and so provide additional harmonic and higher-frequency spuriae attenuation: see **Fig 7.**

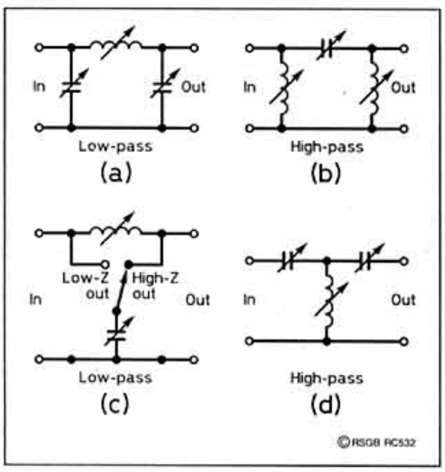

Fig 7: Some basic ATU configurations. (a) Pi-network in conventional 'low-pass' form. (b) Inverse pi-network with components interchanged but providing high-pass filter. (c) Switched LC network providing either step-up or step-down of the impedance with a degree of low-pass filtering. (d) T-network (high-pass).

But modern solid-state transceivers include built-in low-pass filtering tailored to the individual bands, with the result that there is far less requirement for the harmonic attenuation previously provided by the ATU. This has opened the way to much greater use of the T-network which can provide an acceptably wide range of impedance transformations without a requirement for large-value variable capacitors. The disadvantage that they form a high-pass rather than a low-pass filter is no longer regarded as a real disadvantage. Many of the current ATUs on the amateur market now utilise the T-network: see **Fig 7(d).**

Andrew S Griffith, W4ULD, provides a useful article on 'Getting the most out of your T-network antenna tuner' (*QST*, January 1995, pp44-47). He describes "how to adjust this popular tuning circuit so that it transfers maximum power to your antenna without going snap, crackle and pop."

He shows that the T-network of **Fig 8** with variable capacitors with a range of 20-240pF and a roller-coaster inductance variable from 0.1 to 35μH when used with a transmitter designed to feed 50Ω line can match purely resistive loads of about 10Ω to 3000Ω from 1.8 to 21MHz. On 24 and 28MHz the range narrows to about 10 to 1500+ since C_{in} and C_{out} cannot be adjusted to less than 20pF. With reactive loads, the matching range narrows. However, W4ULD points out: "Even with reactance present, very few cases should occur in which the antenna cannot be matched with the proper tuning technique."

He provides detailed tuning procedures for both roller-coaster tuners and tapped-inductor tuners but warns that while power loss in a T-network is often less than 0.3dB "it may be considerably higher. For a given impedance transformation, minimum loss occurs when C_{out} is as high as possible when a match has been achieved. The loss in a T-network with the component values shown in Fig 8 can approach 2dB when matching load impedances lower than 20Ω at 1.8, 3.5 and 7MHz. Under these conditions, component heating and/or arcing may occur, and the tuner's power-handling capability may have to be derated. With the proper tuning techniques, however, an acceptable impedance transformation - as indicated by a 1:1 SWR - should be obtainable under most circumstances. Tips include:

- To achieve the highest possible efficiency at a given impedance transformation, tune the network with the highest output capacitance that allows a match.
- When matching loads of less than 25Ω on 3.5 and 1.8MHz, you may have to reduce output power to reduce tuner heating or to keep it from arcing.

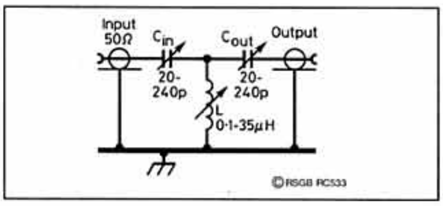

Fig 8: The T-network ATU as described by W4UMD.

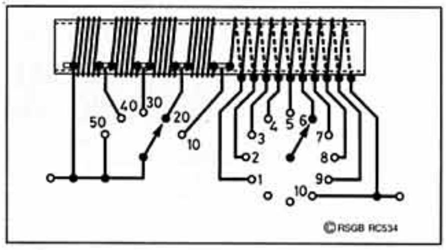

Fig 9: A variable-inductance ATU coil described by Hector Cole, G3OHK in *TT* (May 1989) using two switches and just 14 taps to permit selection of from one to 50 turns of a 50-turn coil and which can be quickly reset to any number of turns previously found suitable without the turns counters required for roller coaster coils.

- When operating high power, do not feed short (less than 0.3λ) loaded dipoles with a feed-line that is a multiple of 0.50λ (electrical) long. Such antennas may have feedpoint impedances of 5 to 9Ω, and the tuner will see this very low load impedance.
- When operating high power, do not operate a 1.8MHz dipole on 3.5MHz or a 3.5MHz dipole on 7MHz with a coax feed-line that is an odd multiple of 0.25λ (electrical) long. The antenna's high feedpoint impedance will be transformed to 1.5 to 2Ω at the tuner. To add insult to injury, the feed-line loss will be excessive - over 6dB and so wasting 75% of the transmitter's output power as heat.

The tuning procedure recommended by W4ULD for roller-inductor tuners is given below, but it is advisable to practice with low power into a dummy load fed via a length of coaxial cable, preferably with a variable capacitor of about 100pF in series with the centre conductor of the coax at the dummy antenna and to provide practice at matching reactive loads.

1. Set C_{out} at maximum capacitance and leave it there.
2. Set C_{in} to about half scale.
3. Adjust roller inductor for an SWR dip (this may be barely noticeable).
4. Slightly increase or decrease C_{n} and readjust the inductor for a dip.
5a. If the SWR is lower than it was in (3), slightly vary C_{in} in the same direction as in (4).
5b. If the SWR is higher than before, adjust C_{in} in the opposite direction to (4). Alternatively, inch C_{in} in the step (4) direction and redip the SWR with the inductor until an SWR of 1:1 is obtained.
6. When you have almost reached the match point, the SWR may start to go up as C_{in} is adjusted, but make the change anyway and redip with the inductance.
7. Continue to adjust C_{in} in the same direction until adjusting the inductor produces a higher SWR than before. Inch the capacitor back to the previous setting.
8. If you cannot obtain a 1:1 SWR reduce C_{out} and repeat the process, beginning at step (2). If you cannot acceptably minimise the SWR at some setting of C_{out}, the antenna impedance is out of range of the tuner.

Clearly, in operational circumstances and when the correct settings of the ATU have not previously been determined, it will be helpful to fellow operators to use a 'quiet tuning'

QUIET-TUNING FOR 100W TRANSCEIVERS

FRITS GEERLIGS, PA0FRI, uses the arrangement shown in **Fig 10** to permit the adjustment of an ATU without radiating more than a tiny fraction of the transceiver output. This does not give a direct SWR reading but makes it easy for zero tune-up of the ATU without radiating more than about 50mW. With the silicon diode in parallel with the meter, the usual sensitivity-control potentiometer can be omitted. The only critical component is the 50Ω non-inductive (dummy load) resistor formed from two 100Ω, 25W resistors in parallel. For further information on quiet tuning see 'Simple quiet tuning and matching of antennas' by Professor Mike Underhill, G3LHZ, *RadCom*, May 1981, pp420-422.

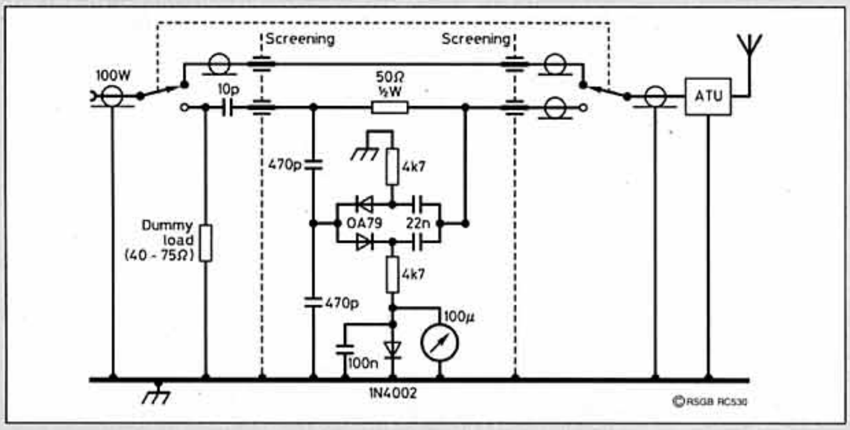

Fig 10: PA0FRI's quiet-tuning unit for use with 100W transceivers. Note that the OA79 diode is a germanium type (the germanium-type 1N34 is suitable.

device such as that described by PA0FRI or the article by G3LHZ in *RadCom*, May 1981, pp420-422. **Fig 9** shows a useful substitute for a high-cost roller-coaster.

A point emerging from W4ULD's article is the significant power loss (even with a 1:1 SWR) that can be incurred with ATUs when the component values are restricted, often detected by heating of the coil. It has been noted before in *TT* that, particularly on the lower frequency bands where very low feedline impedances may be presented to the ATU, more than half the transmitter output power (3dB) may easily be lost in an otherwise efficient ATU, usually the result of insufficient maximum capacitances.

CHEQUERBOARD CONSTRUCTION JIG

COLIN WALKER, G3VTS, reiterates the view often expressed in *TT* that for one-off construction of prototypes or operational circuits the home-etched PCB offers few advantages and several disadvantages.

He writes: "Many amateurs often have the need to construct simple items quickly for use in the shack but cannot be bothered to design and etch a PCB particularly if the components to be used come from the junk box.

"Perforated (Veroboard) board or 'dead bug' techniques are suitable but if you have odd pieces of single or double-sided board available it is much easier to cut the surface in chequerboard fashion to a size that suits the project.

"In this connection, a simple jig to cut through the copper or piece of PCB quickly and accurately is a useful tool. Such a jig is shown in **Fig 11(a).** No dimensions are given for the jig as it can be made to suit particular requirements and the material available. I used chipboard and aluminium for the saw guides.

"When complete, the jig is held in a vice and after marking the board with a pencil to show where to cut, it becomes a simple operation to cut through the copper with a fine tooth hacksaw and then clean up with 'Scotchbrite' to remove any burrs and clean the board ready for soldering: see **Fig 11(b).** The board can be easily held by hand and the guides at each side hold the hacksaw-blade square. With care it is possible to cut close enough to solder the pins of an IC onto adjacent lands but I find it easier to cut larger lands and only solder the four corner pins down, then use short wires or components for the remaining pins. With double-sided board, small holes can be drilled through to ground pads as necessary."

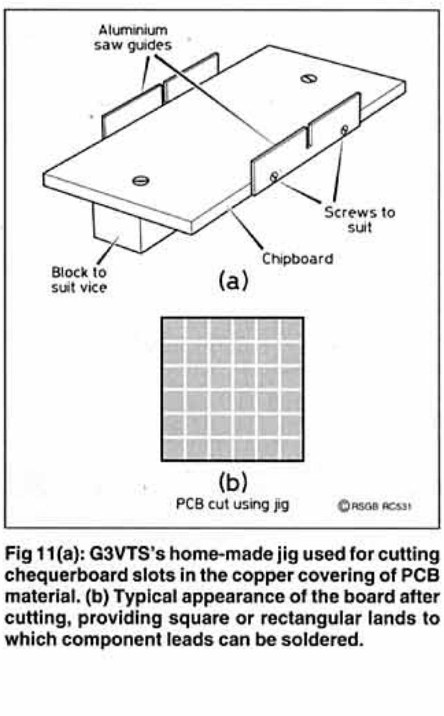

Fig 11(a): G3VTS's home-made jig used for cutting chequerboard slots in the copper covering of PCB material. (b) Typical appearance of the board after cutting, providing square or rectangular lands to which component leads can be soldered.

RF SWITCHING & TUNING DIODES

TT FEBRUARY 1993 REPORTED briefly an important article by Dr Ulrich Rohde, KA2WEU/DJ2LR, which was published simultaneously in English and German (*QST* and *CQ-DL*, November 1992) on "Recent advances in shortwave receiver design". He subsequently published a series of three articles (*QST* May, June and July 1994) on "Key components of modern receiver design" and a recent follow-up "Key components of modern receiver design: a second look" (*QST*, December 1994). In these articles he stressed that for receivers intended to have a very wide dynamic range, the intermodulation distortion that arises from the use of unsuitable RF switching and tuning diodes imposes an important limitation. He has recommended the use (or substitution) of such special-purpose RF diodes as the Hewlett-Packard HP5082-3081 PIN diodes.

Dr Rohde's articles encouraged Tom Thomson, W0IVJ, to investigate how bad in practice are the more distortion-prone switching diodes and how good are those designed for low distortion ('Exploring intermodulation distortion in RF switching and tuning diodes', *QST*, December 1994). He carried out laboratory tests on four types of diodes: The IN4153 generic PN switching diode; the Motorola MPN 3700 PIN diode intended for RF switching; the BAT-17 Siemens PIN switching diode; and the low-cost 1N4007 which is a generic 1kV-PIV rectifier diode with a PIN structure but not intended for RF switching.

He has tabulated results in terms of diode switch insertion loss (dB) at 10MHz with 0, 5, 10 and 20mA bias currents; and similarly the second- and third-order intercept points (IP2, IP3 and dBm). He draws the following conclusions: "RF-specified PIN diodes are the devices of choice for low-distortion switching at HF and above, for bandpass filter selection and IC switching in a narrow-band pre-selector. Although the presence of a PIN structure in the 1N4007 makes it seem attractive as a low-cost alternative to RF-specified PIN diodes, its insertion-loss performance when unbiased and reverse-biased - and its IMD performance when unbiased - is demonstratively inferior to RF-specified PIN diodes.

He adds: "The manually switched and tuned front-end filters of the 1960s and 1970s had much to offer in terms of second-order IMD, but we need not retrogress to those techniques to achieve improved IP2 and IP3 performance today. More attention paid to front-end filtering in general can produce the improvement we need."

Dr Rohde in commenting on W0IVJ's finding, notes that many amateurs had reported difficulty in obtaining HP5082-3081 diodes. He recognises that even with the Motorola MPN3700 with a US price of less than £1, replacing all 20-plus filter-switching diodes can be expensive. Nevertheless he recommends changing all the diodes between the antenna and the first mixer, which includes the diodes on both sides of the bandpass filters of a transceiver but not the transmit/receive switching diodes which typically are already high-quality PIN types. He also adds some notes on Japanese switching diodes which might be used "to replace the 'bad' diodes seen in the past". ♦