Hot Iron

Issue 10 *"Journal of the Constructors Club"* **Winter 1995**

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Editorial

I thought I might have quite a lot of people wanting to win something in the draw which I announced in the last issue of Hot Iron - five of you sent in responses and I would like to thank you all for your most interesting answers. There were hardly any common themes but this in itself is most interesting. It shows that radio amateurs have very broad interests; some wanted only CW rigs while others wanted only SSB. Bands of interest ranged from 160 to 2 metres! Some wanted cases as options and others thought this unimportant. Nearly all claimed to be inexperienced but I think this is modesty! Slightly to my surprise, two respondees implied that Somerset Range kits were the only complete rigs that they had built. I put the names into a hat and was about to ask my wife to pull one out, but by chance one of our neighbouring farmers was here with some splendid locally produced real Cheddar cheese and he seemed to be rather more impartial! **Pat King G4GFY is the winner.** Well done Pat, a two tone oscillator is on the way to you. I was tempted to offer some cheese for a prize!

Tim Walford G3PCJ Editor

Kit Developments

I am pleased to announce that the **Pitney** is now available. It is a simple regenerative tuned radio frequency receiver intended as a first serious radio construction project for **novice** electronic builders. It is able to receive all the normal modes (AM, CW or SSB) used by broadcast and amateur stations in its basic frequency coverage of 1 to 5 MHz. It uses five transistors and a voltage regulator for the varactor diode tuning, without integrated circuits, so is very easy to understand and get working on the strong stations in the medium waveband. It is able to run off 9 or 12 volt supplies and is intended for use with "walkman" type phones. A small modification gives better coverage of the amateur 160 and 80m bands and adds 40m. No test gear is required as there is nothing to set up! It is supplied complete with all hardware and detailed instructions so all the builder needs is tools, a battery, phones and a moderate length of wire for an antenna! It is an excellent project to compliment Novice radio examination courses. See later note. The one off price is £27 plus £1 P&P.

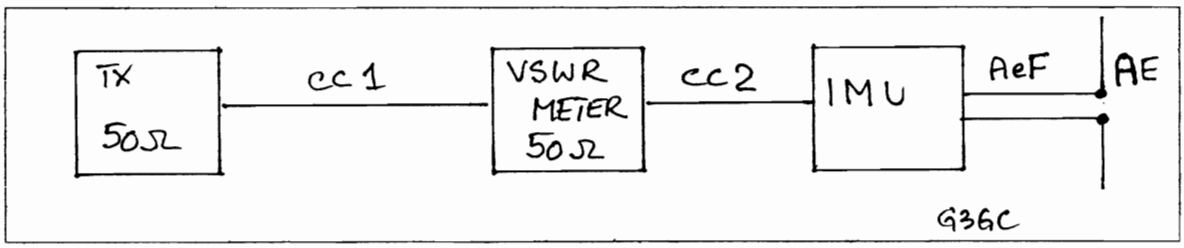
The **Bruton** is also very nearly available, Geoff G4OWH is kindly building a pre-production model now. There is a high confidence in the circuitry as much is common with other rigs; this project also has a smart and comprehensive manual. The Bruton is a superhet phone TCVR that can work on any single band between 20 and 160 metres. Band changes are done by fitting different coil and capacitor packs so once fitted you cannot change easily to another band! CW can be added with either CW kit. This project is not as complex or dense as the Taunton. It also has provision for channelised operation which can also be on groups of frequencies outside the normal amateur bands such as those used by the Air Training Corps. The Manual will be available for £5, the RX will be £58, the TX £25 or £84 for the TCVR with Construction Club membership.

Meanwhile work continues on a two band plug-in card for the Taunton which I hope to try out shortly, a 3 digit counter, a signal generator, and seperate simple DC RX and CW TXs to work with each other and the Pitney. No shortage of projects and your ideas are always very welcome!

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel & Fax 01458 241224 Subscriptions are £5 per year for the UK (£7 overseas) from Sept 1st in each year. Sept 1st 1995.

Impedance Matching Units The second of two related noted by Eric Godfrey, G3GC

An impedance matching unit is a device for transforming an impedance of one value to that of another value. The most common use by amateurs is for transforming the impedance at the input to the aerial feeders to the 50 Ohms required by the transmitter. Amateurs, more often that not, quite incorrectly call it an "Aerial Tuning Unit". One thing such a unit does not do is to tune the aerial. G5RV a few years ago commented on this and suggested that it should be called an "Aerial Systems Matching Unit" (ASMU) which is descriptive of its use although I prefer the simpler "Impedance Matching Unit" (IMU) since the impedance being transformed does not necessarily have to be an aerial system. There is no reason why, if you wanted to, you should not match your transmitter to a bowl of goldfish but pity the poor goldfish. Matching units may take on many different forms but the common configuration used by amateurs is the Z-Match so called because it matches the impedances i.e. the "Z". There are a number of commercial forms of this arrangement including the KW E-Zee Match. Such units often also perform the change from a nominal balanced aerial system to the unbalanced coaxial system required by the transmitter.



The above figure is similar to that on my previous article on VSWR meters in Hot Iron 9 but now the 50 Ohm termination has been replaced by an IMU connected to the aerial feeder (AeF) at the far end of which is the aerial (AE). For the moment we will assume the aerial is a full wave dipole cut to resonance with a centre impedance of 700 Ohms resistive and that AeF is a twin 300 Ohm feeder. There will be a VSWR of 2.33:1 on the feeder due to the mismatch of the 700 Ohms to the feeder's 300 Ohm impedance. Let us assume the feeder is an odd number of quarter waves long when it will behave as a quarter wave transformer and its input impedance at the output of the Matching Unit will be 128.6 Ohms (300^2 /700). The VSWR meter will now indicate a VSWR, with respect to 50 Ohms, at the input to CC2 of the combined effects of the aerial, the aerial feeder, the IMU and the cable CC2. Supposing that with some random setting of the IMU, this combination gives a VSWR of 2:1. The Matching unit is now adjusted (some say tuned) to give a VSWR of 1:1 at the input to CC2 with respect to 50 Ohms. This operation has not altered anything on the aerial side of the IMU with the feeder AeF still 300 Ohms and the aerial impedance is still 700 Ohms; it has not been "tuned" as it was already at resonance and therefore there is still a VSWR of 2.33:1 on the twin feeder. Thus it is quite clear that an IMU does not effect the impedance or VSWR of anything beyond itself other than to allow all the power to be transferred to the aerial rather than some power being reflected. What was said in the last article about interconnecting feeders applies when going back from the VSWR meter towards the transmitter.

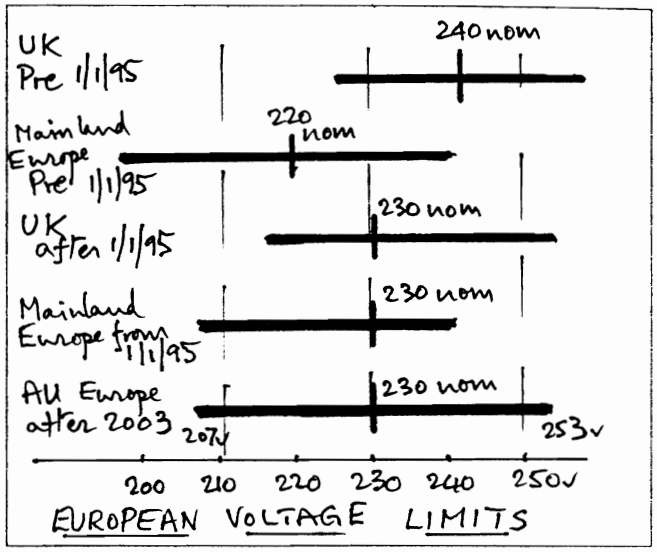
Theoretically it must be possible to get a VSWR of 1:1 with some combination of the values of the IMU components. However in practical units there are limitations on the range of impedances which can be matched due to limited range of the variable components. An external capacity across the input to AeF may help or an additional length of feeder between AeF and the IMU may move the impedance into an area with which the IMU can cope. Both of these have to be "suck it and see" operations since the VSWR itself does not indicate what the actual impedance is. However if you cannot get a VSWR of 1:1 and you are not running out of the range of the controls, then this indicates that there is more than one frequency present in your transmitter output. The most likely cause of this is harmonics and a low pass filter in the transmitter output will usually provide a solution. This effect is often noticed when having set up the IMU with a QRO commercial transmitter and then, on using a simple QRP TX (probably homebrew), the IMU settings have to be changed. The fact is that VSWR is not dependent on power. Summing up, the important points concerning IMUs are:-

1) The IMU does not tune the aerial.
2) The VSWR on the feeder connecting IMU to aerial remains unchanged with adjustment of the IMU.
3) If you cannot obtain a 1:1 VSWR, without running out of control range, then your TX has an impure output which is probably due to harmonics.
4) VSWR is not dependent on power levels.

I hope that these notes will have helped to clarify some of the often misunderstood aspects of VSWR measurement and adjustment. Eric Godfrey G3GC

Mains Voltage Harmonisation

An interesting diagram has recently been brought to my attention showing how the main electricity supply voltages are scheduled to "change" over the next few years in Europe. Interestingly, the change which occurred on Jan 1st last was a non-event since in the UK our supply was already compliant with that required from 1995 and no actual change had to be made! The change was that of name only. The difference is that equipment should eventually be able to take the much lower limits implied with a nominal 230 volts which can legally go down to 207 volts (and up to the present 253 volts!). I guess that at some stage after 2003, the actual nominal voltage in the UK will be changed to 230 volts instead of just being called 230 volts! I am not sure what this does for conventional incandescent light bulbs! G3PCJ



100 Watt HF MOSFET Amplifier

Builders of the Tiny Tim and the Taunton may not be aware of a RadCom construction article by G0MRF (Feb/Mar 1993) which described a 100 Watt HF MOSFET amplifier suitable for use with low power exciters. After several months of lost QSOs on 80m, about a year ago I decided to tackle the construction of an amplifier to assist my Tiny Tim.

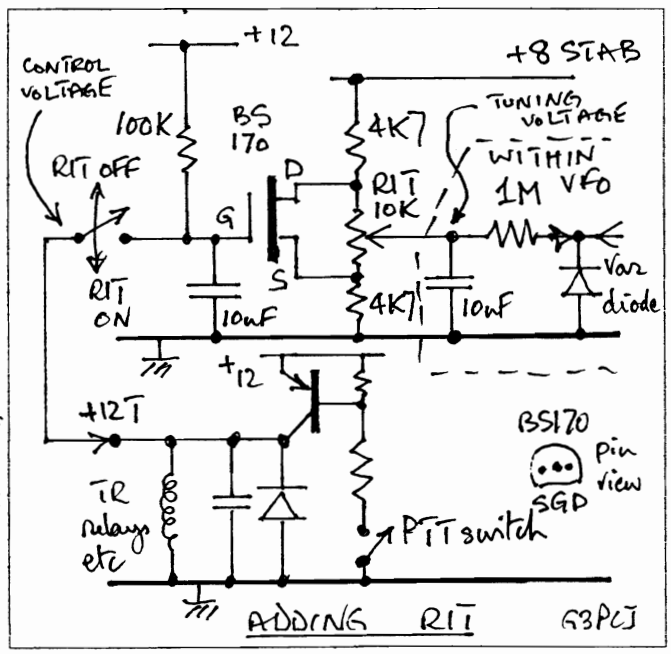
I have found the G0MRF design to be ideal. At the time I constructed the amp, a reasonably priced kit was available. The extra's required were a case and most difficult (for me) to source, a 48-50 volt 5 Amp peak supply. The design is capable of 100 W RF output 1.8 to 14 Mhz with less up to 21 MHz. The feature was well written and easily understood. My amplifier has now been in almost daily use on 80m and although my power supply (unstabilised) is low on volts, I find that I can work around Europe and I've even had a couple of contacts with W/VE. Not bad for a Tiny Tim!

I am sure that anyone requiring details can find someone with appropriate RadComs or contact G0MRF direct. Pat King G4GFY

Comment from G3PCJ! I am pleasantly surprised that Tiny Tim's receiver was good enough for the real DX. At some time in the future, I hope to revisit my design of QRP Booster linear amplifier so that a single design using four IRF510 FETs will work over the 2 to 30 MHz on a nominal 12 volt supply producing 20 to 25 Watts. Having got them up to 30 Mhz during development of the Taunton transmitter, I am quite hopeful.

Adding RIT to a varactor tuned rig

Simpler rigs such as Tiny Tim and the Bruton, not having Receiver Incremental Tuning , can easily have it added. Often a switch/transmit operated relay is used to "disconnect" the RIT control when the small ofsetting tuning voltage is not required. In this circuit, a low power MOSFET is used instead of the relay and the control remains connected but inactive by placing a short across it. When shorted, the voltage at the RIT control slider is half that of the stabilised tuning supply irrespective of control position and is thus the same as the mid-position value. The actual DC RIT voltage is applied through a 1 MOhm resistor which must be decoupled at the VFO. The MOSFET is switched off only when the control voltage is near 0 volts with the switch closed. Using a control voltage which is high at 12 volts during transmit gives RIT; using a control voltage which is at 12 volts during receive will give Transmitter Incremental Tuning. G3PCJ



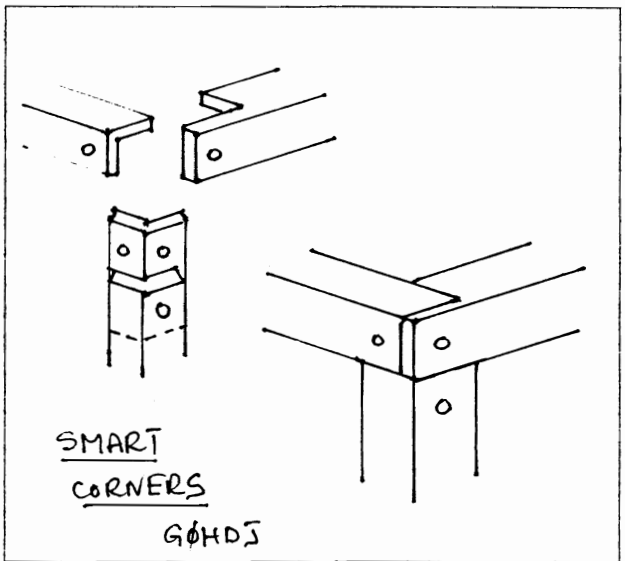
Bespoke Boxes

Building your own equipment often causes the constructor a problem to find a suitable box. "Standard" boxes from the usual suppliers are never the right size or don't have removable panels, etc. (Murphy's 4th Law of inappropriate dimensions!) The answer is to make your own. Bending aluminium to make a tidy box is an art form and a skilled task even with proper folding bars but without them almost impossible. For the "kitchen tablist" the following is offered as a suggestion and any size or shape is possible with the minimum amount of cutting and filing. Angle/corner pieces of aluminium can be cut and joined as shown. (Use counter sunk-head nuts and bolts about 6 BA or metric equivalent plus a drop of Rapid Araldite). Panels can then be fixed permanently with pop rivets or nuts and bolts. Sheet metal can be fixed with self tapping screws allowing the panels to be removed for access etc.

Additional sections of angle (equal or unequal sides) can then be added to provide the supports for the PCB or whatever. If single or double sided PCB is used for the panels, then brass corner pieces (if you don't mind the expense) can be cut and tack soldered to each other and/or to the boards. Screws are then used for the removable panels.

A variety of sizes (equal sides or unequal sides) of aluminium corner pieces and brass corner pieces are available in 1 metre lengths from B & Q (£2.10 for aluminium and £3.29 for brass or thereabouts). Aluminium stockist and scrap metal merchants (Yellow Pages) may have some off-cuts but they may take a bit of finding. The diagram shows how to make a corner.

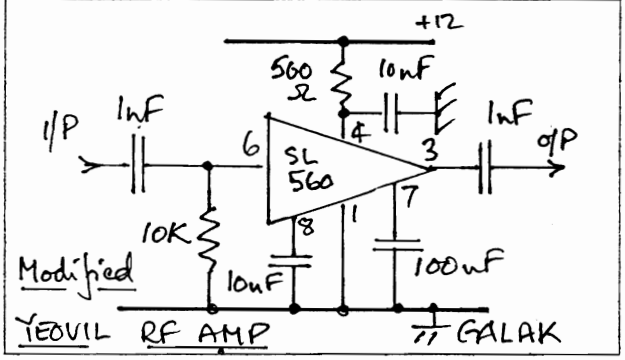
Craig Douglas G0HDJ



Update on RF amp for Yeovil RX

Reg Proctor G4LAK failed to get his IF amp for the Yeovil working and reverted to a RF amp; he tried the circuit in the Spring 1994 Hot Iron but that did not work satisfactorily either so he altered it to that shown on the right. This has made a marked improvement on 20m with some benefit also on 80m.

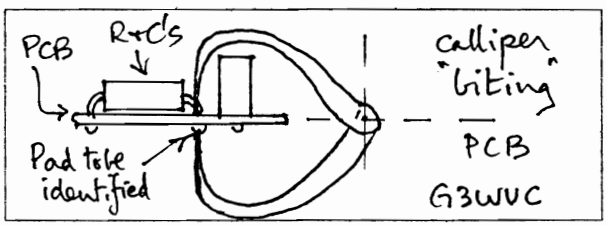
(Reg is now tackling a Taunton and we hope for a satisfactory report in due course! - G3PCJ)



Finding parts locations on PCBs

Nick Collis-Bird recently returned his Taunton to me for a "tweak", (all it needed was removal of a misplaced solder blob), but he had done something to it which was far more interesting! To assist with finding the parts locations, he had lightly scribed a one centimetre grid onto the ground plane side to match up with the grid references given in the construction sequence which are counted off in centimetres. While not being any help on rigs already started, it is an excellent idea for those PCBs about to be loaded which have instructions with grid locations. I have put this suggestion in my text for the Bruton - thank you Nick.

Tony Measures G3WUC has some help for those trying to identify the correct pads on the underside when trying to desolder and remove some component. He finds that a calliper biting on the board right close to the component on the topside will remove all ambiguity about the underside pad as long as the calliper hinge is in the plane of the PCB - see diagram.



Waterproofing

Joseph Bell G3DII thoroughly recommends Finnigan's Waxoyl for sealing and water repelling in all sorts of cable junctions and antenna connectors. It can be used on wood, metal and plastic and protection can be built up with several layers. It does not crack and is presumably flexible. It is made by the same firm that makes the range of Hammerite paint.

Decoupling, ground planes and ground bounce!

This has nothing to do with earthquakes! Some builders may have noticed that my kits seem to have rather more 10 nF disc ceramic decoupling capacitors than may really be necessary. They are there as an insurance policy because trying to eliminate unwanted feedback due to poor bypassing is very tricky for most people with limited test equipment. It is far safer to add these extra capacitors which cost about 4 pence each on all points that might be prone to pick up of unwanted signals than to attempt a phone call cure of some disgruntled customer's marginal rig. However it is important to use suitable capacitors connected to a really low impedance point. Most types of capacitor have a limited frequency range over which they perform best - quite often this will not be as large as the full operating range of the rig. When this occurs you must fit something else in parallel on the same point. In extreme cases you may find that the designer has specified something along the lines of a 10 microfarad electrolytic for LF, parralled by say a 100 nF polyester and 10 nF disc ceramic for HF. This combination will have a low impedance over a much wider range than any one in isolation provided the ground point is rock solid. Sometimes a tantalum capacitor is used instead of the electrolytic and polyester but they are more costly.

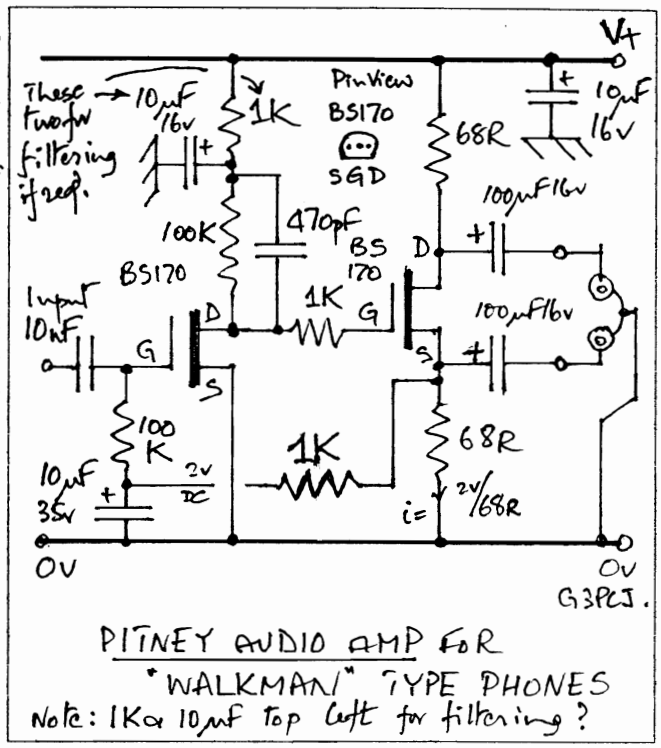
Surprisingly the ground planes that I use on all my transmitter designs are not as "solid" as one would expect. A 5 Watt transmitter operating with an output stage drain impedance of 12.5 Ohms has a peak current of just under an amp so it does not take much impedance to generate a few millivolts. If these millivolts get in the wrong place they can cause all sorts of problems including unwanted oscillation. Using ground planes is the best that one can do cheaply but it still means that you must lay out the functional blocks so that the high currents do not flow in sensitive areas. This is why the classic layout of a transmitter is a straight line with a steady progression giving maximum separation between the sensitive low power stages and the high current output. It is notoriously difficult to make sensible measurements of signals in ground systems but it is not unusual to observe 100 mVolts across a ground plane. These observations emphasise that all high current signals should have their return lead taken to an earth point as close as possible to the device or circuit (matching network) generating the current and not necessarily to the point of the PCB nearest the antenna connector!

Ground bounce is another effect which is more often observed in digital systems where a whole bus (8 or more signals) all change in the same direction very quickly. The sum of the currents discharging the capacity of several bus signal lines flows through the driving IC's earth pin and its internal thin wires connecting to the actual die. To a heavy current signal edge, with sub-nanosecond fall times, these leads look like inductors. It can lead to the 0 volt point on the die actually departing by large fractions of a volt from the earth plane directly underneath the chip! This eats into the noise immunity of the digital signal and may eventually lead to the signal being misread at the receiving gate. It is extremely difficult to replicate and makes fault finding awful! Similarily, rising edges can significantly reduce the supply voltage on the die. Decoupling must be at the chip!

Here are some examples of earthing problems; I remember an early Yeovil that was showing signs of RF instability. It transpired that RF was getting back from the output lowpass filters into the low level TX stage via a heavily decoupled relay control signal. The decoupling was not effective because there was no series impedance to form an attenuator with the lowish impedance of the decoupling capacitors; the answer was to reroute the signal with a longer lead giving added series RF impedance and taking the unwanted output RF current in this lead away from the sensitive low level stage. Owners of Cokers may have noted that the key down frequency alters slightly as you adjust the antenna matching unit. This rig has a VFO operating at the transmit frequency and only separated by about 75 mm from the TX output stage. There is a very small amount of TX current flowing in the ground plane in the VFO area and when this alters, as the AMU is adjusted, it changes the effective value of the VFO resonator components. This is what is actually happening when a rig "chirps". I had intended that the Coker work up to 20m but chirp gets worse with increasing frequency; and the VFO was shifting 8 KHz on 20m which was obviously no good! This is why the rig is only available for 160 and 80m where the actual shift is insignificant. When connecting measuring instruments, you must be sure that the return or earth lead is sensibly located. Generally a probe's earth lead is best connected to 0 volts as near as possible to the point being measured (unless you are investigating ground plane signals!). You also must consider what effect the capacitance of the measuring system will have on the circuit under test. If you are investigating an oscillator, it is hopeless connecting it to a counter with an ordinary screened lead such as miniature coax. That has a capacity of at least tens of pF per foot which will pull it way off frequency. You must use scope type divide by ten probes which have a capacity of about 2 to 3 pF max.! Admittedly they attenuate the signal by a factor of ten but usually this is not important as the sensitivity of the test instrument can be increased to compensate. Avoid coax test leads at all times! Tim Walford G3PCJ

Audio Amplifier for phones

When designing the Pitney's audio stages, I was keen to avoid using integrated circuits so as to make the rig more understandable; unfortunately this makes driving a loud speaker impractical. Luckily modern "walkman" type phones are cheap (£3 upwards) and have a higher nominal impedance of around 30 Ohms for each earpiece which is much easier if a transformer is to be avoided. It makes a class A output stage possible but since the phones are usually sold as stereo types, I had to think of driving both earpieces separately. This suggested a phase splitter arrangement running at high current to drive each earpiece. Its yet another application for the BS170 low power MOSFET where its maximum dissipation of around 200 mW is the overriding consideration - this limits either its standing current, and hence audio output for the 30 Ohm load, or the overall supply voltage. Using a MOSFET does not require high current drive so the preceding stage can have a high impedance load to give gain. Since the output stage can look like a capacitively loaded source follower, a gate stopper resistor is necessary to prevent output stage oscillation. Interestingly, by grounding the output connected to the source, the gain of the other output is much increased as it becomes a common source amplifier. Even when driving both earpieces connected in parallel to the drain output, there is a gain increase by grounding the source output. The input stage can also be a BS170 in a common source configuration to provide most of the gain. The DC conditions in the two stages are easily controlled with a DC feedback loop which is dependent on the BS170 needing about 2 volts positive between gate and source to turn it on. The input impedance is about 100K and provides a voltage gain of about 50 into stereo phones across both outputs or about 200 if connected with both earpieces in parallel on the drain output with the other output grounded. Supply voltage is 9 to 15 volts. The maximum output is more than enough for phones and it will drive a 15R speaker but don't expect to be deafened! G3PCJ



Dates for your diaries!

Firstly, the **Somerset Homebrew Contest**, which is taking place on **March 30/31st 1996**. It is a multiband QRP contest being organised by the G - QRP Club and is open to all operators using homebrew equipment with sponsorship provided by Walford Electronics. Full details are in the Autumn 95 Sprat; first prize is a Taunton receiver for the band of the entrant's choice. All fully completed entries will go into a draw for a second prize which is a high performance Variable CW filter - this can be used with Somerset Range kits or on its own following some other brand of receiver.

The other date to note is that of the 1996 **Yeovil ARC's twelfth QRP Convention** on **May 19th**; it is being held at a new location in the Digby Hall in Sherborne which is a few miles East of Yeovil and is easy to find. There will also be an informal programme of events on the Saturday afternoon of the 18th with a dinner in the evening which is open to all. Activities for spouses are being planned so that those coming from afar can make it into an overnight break. Full details and assistance with bookings can be obtained from Peter Burridge on 01935 813054.

The **Construction Challenge**, at the QRP Convention, is to build a 80m antenna and receiver within a cube of 0.5 metre side. No more than 12 components are to be used and it has to operate without any DC power source, relying solely on electromagnetic radiation. The winner is the receiver producing the highest DC voltage into a 10 KOhm load when excited by a test transmitter putting 1 Watt CW into a short vertical antenna about 12 metres from the RX under test. Full details from Mike Smith on 01963 250594 in the evenings.

Finally, best wishes for Christmas and the New Year, and please do keep up your contributions for this journal - thank you. Tim Walford G3PCJ