"JOURNAL OF THE CONSTRUCTORS CLUB"

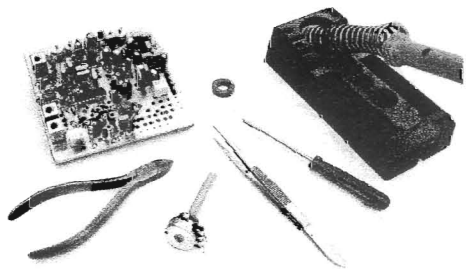
Hot Iron

Spring 2005
Issue 47

Contents

The Walford Electronics website is also at www.walfordelectronics.co.uk

Editorial



The sun is out and streaming into my office so Spring is not far away! I even smelt it in the middle of our local town the other day! It turned out to be the flower market!! At my local Club last week (Yeovil), there was the familiar discussion about a lack of equipment building and a poor entry for the Construction Competition. It was strange because I knew that about 40% of those present either had or continued to build pieces of their own gear - some from kits but many as completely home conceived projects. There is a hesitancy by builders to even display their efforts but others love to see these things - it gives much encouragement to those not quite so adventurous, especially when the build standard is not very high but the 'thing' does actually work! One of our members recently reported that he had just had the best QSO in 40 years - why - because he had just nearly finished building his own rig!! It was a very significant achievement for him. If a construction leader can be found, then Clubs should have no difficulty devising a project that can be built in small stages so it is easy to fund, get going and also keep up the interest. The **Sutton** (see below) suits the bill!

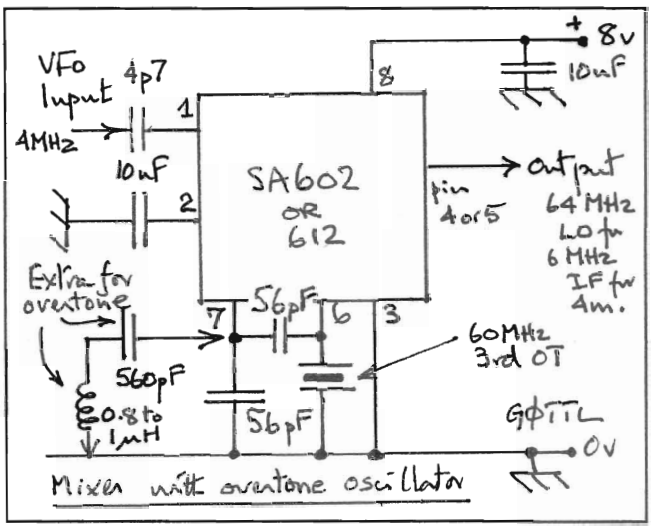
Kit Developments

Many of you will have seen the publicity for the **Brent** in Sprat and Radcom which has kept me busy etching PCBs! Most have been for 80m but several have chosen higher bands with the Mini mix kit. (It can also be used as a receiving converter.) The LO frequency mixing scheme for higher bands is the same as that used in the **Sutton** DC RX - photo later. Reports from my ever helpful band of early builders are encouraging - not too many errors and it does seem to work! It starts life as an 80m rig but with parts for a LO crystal mixing scheme to work (in principle) on any other band but I have limited it to the traditional harmonically related bands (to 10m) for commercial reasons only. The crystal and new RF filters are on a small band card which plugs into the back of the RX so it becomes a switch selectable 80/any band plugged in RX. The band card also contains the 50R low pass filters for an associated transmitter; there being two choices of TX! The **Mallet** is the 1.5W CW transmitter which can also take amplitude modulation with the standard Audio amp kit and a small transformer. The phone alternative is the **Montis** double sideband suppressed carrier 1.5W TX. Both TX's can drive the 10W Linear. Plenty of stages for a Club project! These will appear in PW shortly so I must not fully publicise them yet! Tim G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics– is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

The SA602, it's internal oscillator and overtone crystals.

My current project, in between building Tim's rigs - see below, is the development of a VHF SSB transceiver for 6 and 4 meters, of which space permitting, I hope to describe to you in future editions of Hot Iron. According to Philips, the internal oscillator of the SA602 chip can operate up to a frequency of 200 MHz, which makes it a good choice for simple mixer VFO circuits. Fundamental mode crystals are only readily available up to about 45 MHz. So for a 50 MHz radio you could use a 40 MHz fundamental crystal mixed with a 4 MHz local oscillator. Add this to a 6 MHz IF stage and you are on 6 meters. In order to get on 70 MHz or 4 meters though with the same IF and local oscillator you would need a crystal frequency of 60 MHz. Which means using an overtone type crystal.



Overtone crystals are cut in such a way that they oscillate at an odd harmonic of the actual crystal frequency. So a 60 MHz 3rd overtone crystal is really a 20 MHz component which generates a strong 3rd harmonic at 60 MHz. Normally in a discrete component oscillator you would use a tuned LC circuit to select the required overtone oscillating frequency. With the 602 internal oscillator though it works the other way around. What you have to do is suppress the fundamental oscillation with a tuned circuit, which forces the internal oscillator to run at the overtone frequency. You achieve this by adding a single series capacitor and inductor from pin 7 of the IC down to ground.

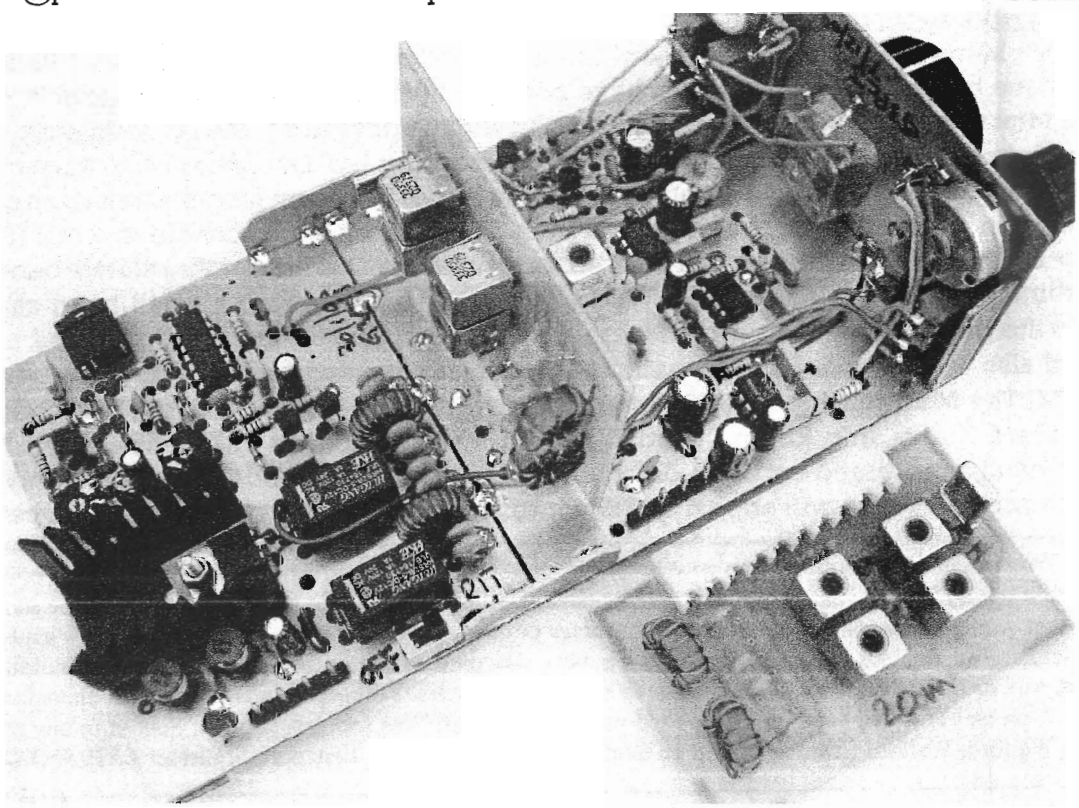
I've done a few tests with overtone crystals I had to hand and it does work well, the highest frequency I've tried so far was 120 MHz using a 5th overtone. I'm waiting now for the 60 MHz components to arrive and then I'll make a proper start on the VHF project. Watch this space!

Vintage components and tuning capacitors.

If I can help with air spaced capacitors for projects, valves or other vintage radio parts do get in touch. Also transistor radio spares or bits to build things with. I need the space! You can email me at richard@pasttimesradio.co.uk or telephone 01302 858468 73 Richard Booth G0TTL

Sutton RX etc

Richard Booth is kindly helping to evaluate the Sutton RX. This is what mine looks like with a band card plugged in etc. This version has the Mallet CW transmitter attached at the rear. The Montis phone DSB TX is the same size as the CW TX. I am testing the prototype Montis right now! G3PCJ



The Joys of Engineering Part 2 - by Eric Godfrey G3GC

When I arrived on the first day at EMI as a lab assistant I was shown up to Room 501, Dr. White's Office, on the top floor adjacent to the lift. Adjoining his office was Room 502 accessible both from his office and from the corridor. Dr White was the leader ("Managers" had not been invented in those days!) of the "Circuits Section" and Room 502 was his main laboratory of about 1000 sq. feet. The offices and labs were constructed from metal/glass partitioning some ten feet high, the lower four feet being metal and the upper six feet were glass , partly frosted for privacy. From the lift, a long corridor led to the end of the building with more labs and a workshop. The "Circuits Section" continued along the left hand side of the corridor and included a special laboratory (looked after by of one of Dr. White's senior engineers) that was constructed as a windowless screened room with the door having metal tongues to complete the screening when closed. There was also a small workshop about twelve by twenty-four feet with two 'resident' mechanics, with drilling machines, lathes, vices, a hand press and a forge, all of which could be used by any of the 5th floor engineers and lab assistants. On the right hand side of the corridor was the "Receiver Section" (Tom Cocking, G2CV was one of the engineers) and the small "Filter Section" led by a mathematician. Going back in the other direction from the lift there were more small laboratories and a large "Dark Room" for viewing television pictures. Beyond this was a large but virtually empty area where the transmitters, by then installed at Alexander Palace, had been situated for the experimental television transmissions from Hayes prior to the opening of Alexander Palace in 1936. The modulated sound and vision carriers, vision 45 Mc/s and sound 41.5 Mc/s, were fed via separate 5" diameter rigid copper feeders, to the aerials on the tower behind the labs. This had vertically polarised omni-directional aerials for both sound and vision with the latter mounted above the former. The tower erected on top of Alexander Palace for the public service was identical with this one at Hayes. I have taken a bit of time to describe this area since it was often the battle ground for "Solder Wars" or shooting with "High Pressure Hose Guns" and many practical jokes.

In 1937, solder was not as thin as it is today but was about an eight of an inch in diameter usually with three cores of resin embedded in it (the smallest soldering iron was 60 Watts with a bit about 5/16" in diameter). A piece of this solder about an inch and a half long folded into a "U" shape formed a good missile for a catapult made from strong elastic bands, available from the stationery stores, held between one's thumb and finger. Many a lunch hour was spent avoiding these lead bullets and the layout of the corridors and dark rooms made good hiding places for snipers. Sometimes things went wrong and on one occasion I managed to hit one of four large audio valves (DA100s) in a mobile rack of equipment used to provide a high power signal anywhere in the audio range. (I believe this had been used as the audio test source for modulating the experimental TV transmitter but was now used as a general audio source). The solder penetrated the glass envelope but inexplicably the glass did not shatter. With some difficulty I managed to get the solder out of the valve and so the appearance of the hole in the glass was a mystery, although I suspect that some senior staff had a good idea how it happened but not, I hope, by whom.

A second type of missile launcher was made from brass tube some two feet long (the internal diameter of which was just a little larger than a flat headed 2 BA screw) connected to a rubber hose fed from the high pressure (80 lbs / sq in) air line. A trigger mechanism was made for the hose end of the tube and the 2 BA screw was dropped down the tube to rest against it. On turning on the air and releasing the trigger the screw shot out at high speed and with great force. Wisely only one of these were made as the missiles were highly dangerous being able to penetrate three ply wood at a distance of twenty yards. With only one available it was used for shooting at home brew targets and we became very skilful in its use. So much so, one could come back during the lunch hour only to find one's teacup being used for target practice, usually with terminal results.

Going back to when I first arrived at EMI, I was introduced to all members of Dr. White's section except for a junior engineer who was away in hospital having his "cross eyes" sorted out. They must have been very bad because when he returned he was still a bit cross-eyed. I was also introduced to the two mechanics in the workshop and to the section leaders of the Receiver and Filter Section. Everyone seemed very likeable to me except for the crossed-eyed one with whom I felt ill at ease. In due course I found that he was very self centred, thought a lot of himself and was in fact not like by any of the staff. This made him the target for many practical jokes from anybody on the 5th floor. Next time, I will recall some of these and other jokes that were perpetrated by staff at all levels.

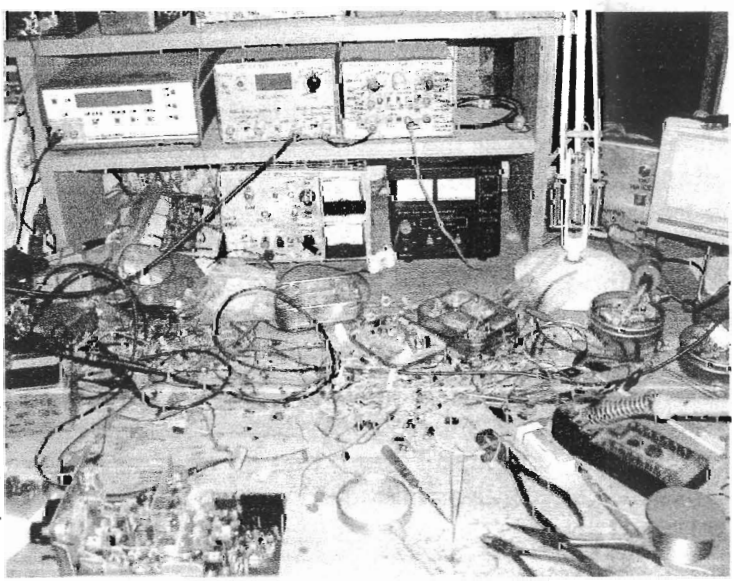
Gear for Home Constructors

Years ago, the first bit of gear that a budding radio enthusiast was encouraged to build was a multi-meter! No one would ever do that nowadays since the yellow commercially made digital multi-meters are so cheap! The old approach did at least have the benefit of teaching you about Ohms Law even if the meter's calibration wasn't too good. Starting with the things to buy:-

1. Tools. Buy a new one whenever you find you havn't got the right one! 18W iron and multi-core solder, long nosed & ordinary pliers, tweezers, selection of screwdrivers (various sizes and types of head), small round and flat files, hand drills, wire side cutters. Highly desirable - solder sucker, junior hacksaw, selection of small nuts and bolts and self-tapping screws, wire strippers, selection of leads with small insulated croc clips, etc.
2. Digital Multi-meter, four and a half digits minimum covering AC and DC volts to say 1000, Ohms to 10M, DC current mA to 10A and maybe AC current. Nice to have frequency and or capacitance but not essential! Alternatively buy an AVO or lesser equivalent if found cheap!
3. Variable Bench DC power supply. Suggest adjustable from 0 to about 20 volts at up to 4 Amps. One can fairly easily make one of these but commercial ones with twin meters are now almost as cheap as buying the parts and they are risk free (almost)!! As cash allows, acquire a fixed 13.8 volt 5A supply for equipment in regular use. Ditto sealed 12 v ex-alarm batteries.
4. Counter. These can be made without too much difficulty but the commercially made ones are now within financial range, especially 10 year old ones seen at rallies. Aim for at least 6 digits, preferably 8, so that MHz frequencies can be measured directly down to Hz. Go for as wide as bandwidth as possible. Often the input impedance is 1M for scope type probes up to 20 MHz and 50R for higher frequencies.
5. Scope! I know they are expensive but you will never regret buying one. For years it was the only piece of commercially made gear that I had. Single trace old 10 MHz scopes can often be picked up at rallies for £10 - 30. A new 30 MHz dual trace one is now about £300 with probes and represents excellent value for money. If you win the lottery, add a spectrum analyser!

Before you have acquired all the above, you should have contemplated building some of the following:-

1. RF power meter. Easy to build - 50R with ranges of say 5W, 0.5W and 50 mW. Calibrate in dB.
2. 50R step attenuators. Very useful with above and again easy to build. Suggest at least two, first unit with switches giving any combination of 1,2, 3, 4, 10 dB (power) and second unit having two switches for 20 and 30 dB power attenuation.
3. Harmonic marker generator. Wide band output with selectable fundamentals of say 50 KHz, 100, 500 KHz and maybe 1 MHz. Easy to make. For cheap receiver frequency calibration.
4. General purpose Audio power amplifier and LS. Say 3 W max output with gain control and maybe a switch controlled pre-amp with overall max voltage gains of x10, x100 and x1000.
5. Two tone audio signal source for setting up SSB TX. Two frequencies within audio range, equal level outputs, adjustable between say 10 mV to 1 volt. Desirable to also have a variable frequency one covering say 50 Hz to 5 KHz.
6. QRP 50R RF resistive matching bridge. Forward and reflected indications.
7. Wide range RF signal generator. Variable output level up to about 10 mW. Frequency range - 100 KHz to 30 MHz.
8. Several 50R in/out fixed gain wideband RF amps, say with power gain of 10 dB and others of 20 dB. At least one with max output of 1 Watt.
9. Selection of 50R twin low pass filters for each of main bands to clean up signals.
10. Diode mixer. 50R in/out at all three ports.



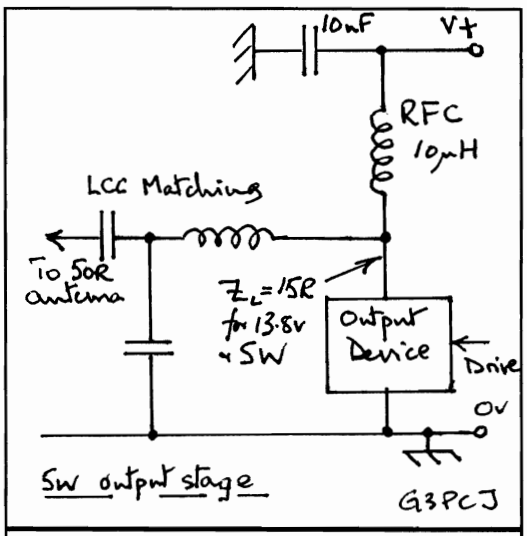
Making that lot should keep you occupied for a while! Don't let it get like my bench right! Tim G3PCJ

Radio Frequency Chokes

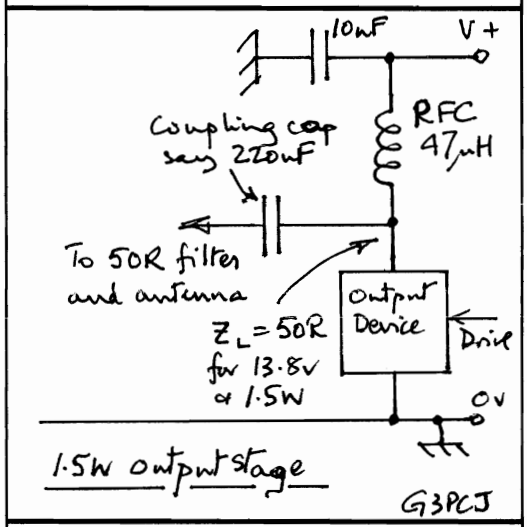
Steve Hartley G0FUW asks about winding RF chokes. That's not something most people do nowadays so it tells you he is a keen constructor! I shall not take it literally though!

The first thing is to calculate the inductance that ought to be provided! This is not as hard as you might imagine since rules of thumb are often used. The first point is that the impedance of the choke at the lowest operating frequency should several times the other 'controlled' circuit impedances. The second rule is that if there is any doubt, increase the inductance several times!! Let me try to explain the first point by using an example where I went wrong!

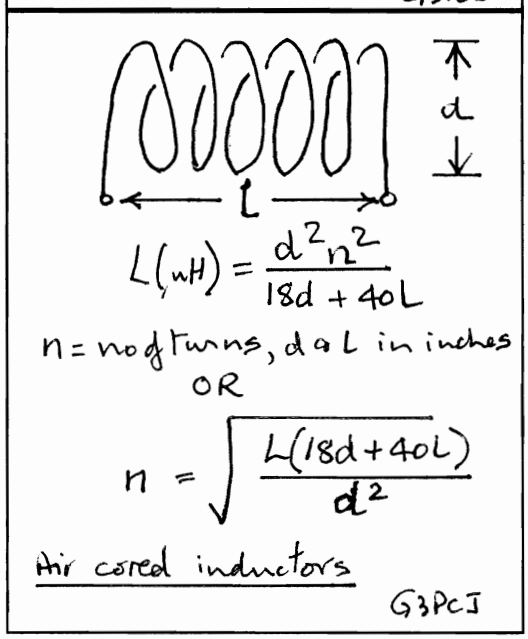
For many years I have used the circuit on the right for 5 Watt RF output stages. The three unlabelled LCC parts are a resonant impedance transformation network between the impedance at the device drain/collector and the 50R antenna - they are not relevant to this discussion. The choke (labeled RFC) is there to provide the DC supply and its impedance in parallel should not materially reduce the other circuit impedances at that point - in this case the drain or collector load impedance to get the wanted output. Lets consider the 80m case when wanting 5 Watts from a rig using a 13.8 volt supply. The peak (SSB) or maximum power on CW (the desired 5W) will be the peak voltage squared divided by twice the load impedance. (Standard power in a resistor theory. Note *NOT* RMS voltage hence the $2R_L$!) Allowing for the transistor, the peak RF voltage will actually be a bit under the supply voltage, say 12.25 v. Turn this formula around and the drain load works out to be 15 Ohms, so the choke impedance should be several times this - say x4 = 60R on 80m. Using the inductive impedance formula, this needs a choke of a 2.7 micro-henries. For that reason I used a 10 /uH choke for many years, which also allows for use on 160m.



Imagine my dismay when a new design of 1.5 W rig would not give full output on 160m using the somewhat simpler output circuit in the middle box. I eventually went back to the theory and realised my mistake! As before, the drain load impedance is roughly supply volts squared divided by twice the desired output = 12.5 squared over 2x1.5 = 52 Ohms. (This is why simple rigs, directly connected to the antenna, are often rated at 1.5W!) 10 /uH is only 113R on 160m - not enough! When changed to 47 /uH all was well!



Steve, wishing to wind his own, will have to use more theory! They can be air wound like the traditional valve output choke and split into several sections to avoid unwanted resonances. Note that a valve output stage operates at much higher load impedances anyway due to the higher supply voltage, so that the value of the choke becomes very much greater. The total number of turns for the desired inductance would be calculated from the formula right and perhaps increased by 10 - 20% to allow for a 'sectionalised' format.



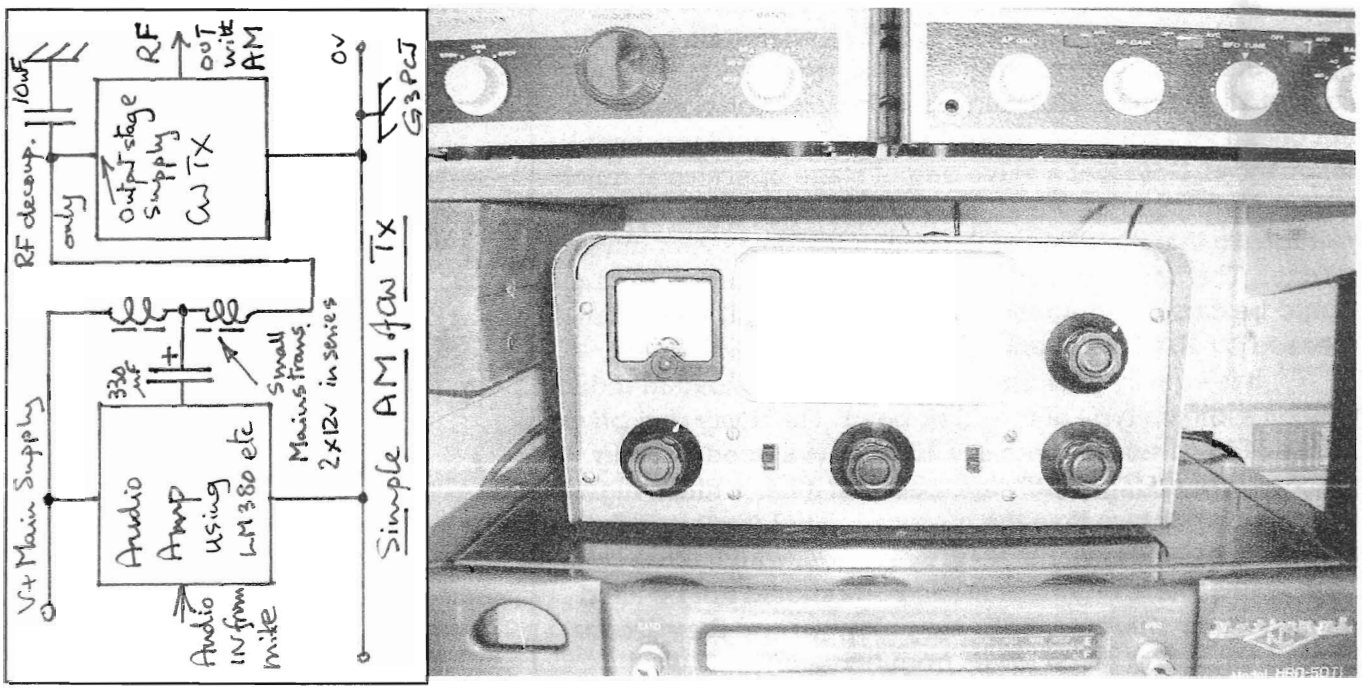
It is equally permissible to use a ferrite loaded inductor - on a known type of toroid or bead. The dusty dull black *ferrite* FT50-61 toroids with say 10 turns is a good starting point for low voltage QRP rigs, because it has a much higher inductance per turn than the coloured T50-2 (red) *powdered iron* toroids. Unknown black/grey toroids, which often come from mains filters or switch mode PSUs should not be used because their characteristics are unknown and they are intended for use on much lower frequencies. Tim G3PCJ

Amplitude Modulation

Recently there has been a revival in interest in amplitude modulation (AM) for a variety of reasons - I guess improved speech quality compared to 'Donald Duck' SSB, doing something 'different' and, perhaps more importantly for readers of Hot Iron, its enables phone communication without too many complications! The two main disadvantages are a strong steady carrier, which is potentially annoying to other band users, and spectrum inefficiency because both sidebands are transmitted simultaneously. The transmitter has also to dissipate a higher level of wasted power for a given RF output. These reasons have caused AM to be almost unused now for high power amateur use. (Interestingly, AM is still used for commercial broadcasting but not for all that much longer if you believe commercial broadcast receiver designers!) Its historic attraction was easy 'detection', so that a receiver could be made with not much more than a diode and high gain audio amplifier; but the serious drawback was lack of selectivity! The pioneers used multiple RF amplifier stages to improve selectivity and sensitivity but these were complicated and often unstable! This was not properly overcome until the superhet was devised. (An interesting sideline was the regenerative TRF RX but this was too temperamental for unskilled operators!)

I have recently been trying to add a phone capability to the Sutton range of DC rigs so considered AM. The main alternative of phasing SSB is just too complicated for most kit builders. There is also now fresh AM activity on the extended 40m band and more action by enthusiasts on 160m using historic gear. Adding AM to a CW transmitter is fairly easy (see later) but reception was a worry! Not wishing to depart too far from the conventional direct conversion receiver with its good selectivity, I reckoned that a stable DC rig should be able to read AM. If the RX's stability is good enough to read phone single sideband (either sideband without the carrier), it should be equally good when both sidebands are there! What of the carrier? As this has a constant level and is on the same frequency as the RX's LO, it will not demodulate (in the DC rig's product detector) into an audible signal. AM is often thought to be tricky to copy but I suspect this has more to do with a poor transmitter - perhaps one that has some unwanted frequency modulation as well as the desired amplitude modulation. So Andy Howgate, using a Sutton RX, and his friend Roger G3VKM with a KW One Sixty TX (6W carrier with plate and screen modulation) very kindly set up a test. They operated on 1.952 MHz and Andy was able to easily copy Roger even when the rigs drifted slightly apart in frequency. Roger's KW160 is shown below.

AM is most easily applied to a CW transmitter by modulating the output stage supply voltage with the audio signal. Full modulation requires a swing between 0 volts and twice normal volts. The audio power required is half the RF carrier power. When a semiconductor audio power amp is used, whose output DC level is half the supply voltage, then a 2:1 step up is required. A conventional modulation transformer is terribly expensive but a small mains transformer will suffice! The circuit below shows how AM is applied to the Mallet CW TX using the Audio Amp kit. G3PCJ



Transformers!

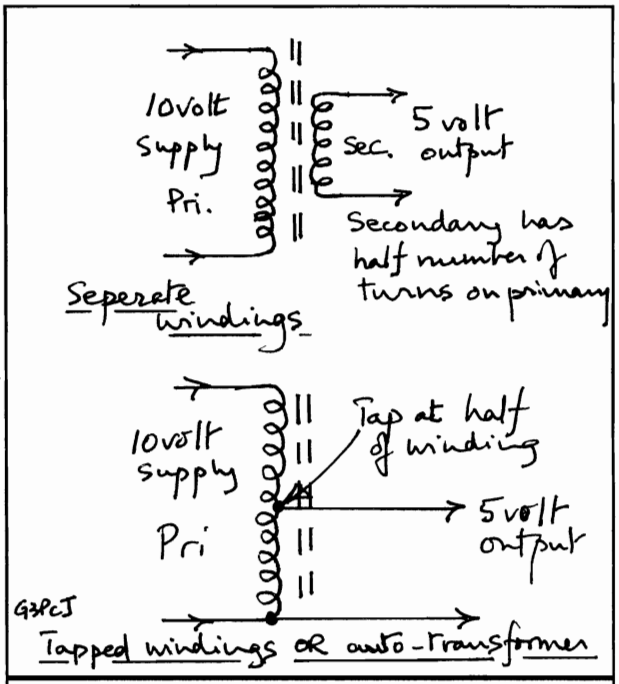
For this type of discussion, the theory applies equally well to power transformers as it does to RF transformers. They are really quite easy things to understand and are a most valuable circuit element! In the general case, there are separate input and output windings as shown right. Tapped windings are also often used for economy and may transform the input voltage either up or down.

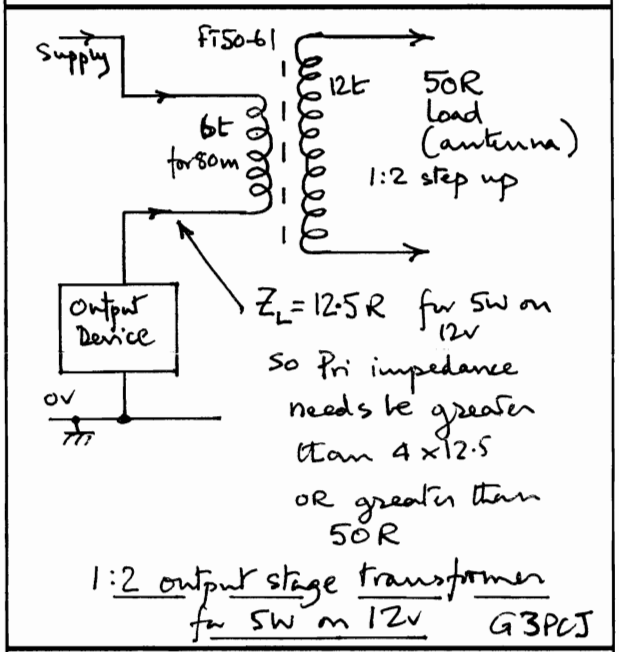
The key parameter of a transformer is the turns ratio between the windings. This is the number of turns on the secondary divided by the number used for the primary. So a transformer with a 1:2 turns ratio would have twice as many secondary turns as primary. This means that its output voltage will be double that of the input because the increase is directly related to the turns ratio. So if your transformer is using say a 10 volt supply and you need 40 out, then you need four times as many turns on the secondary as on the primary. If you want only 5 out for the 10 volt supply then you need only half the primary turns put on for the secondary. Very easy! You don't even need a calculator.

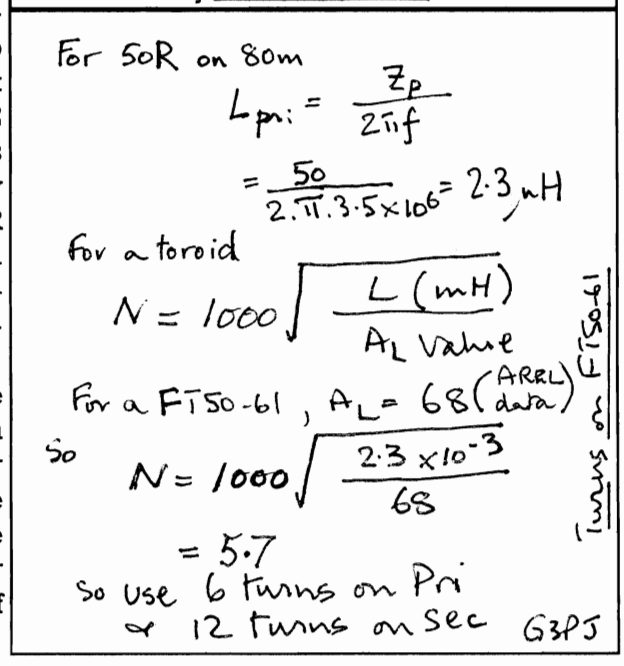
In principle they can be used either way round (swapping input and output) but do this with caution if it is operating near its maximum power level. (See later.) The next point to consider is how many actual turns should be put on the primary, and hence on the secondary when multiplied by the turns ratio. As a guide, the impedance of the primary winding as a plain inductor should be several times the circuit impedance. A figure of four times is often used for RF work. (For 50 Hz mains transformers it is more complicated. For low voltages it is much easier to accurately measure the voltage output of a few turns and add turns as required by threading around the core.)

Another consideration is the change in impedance levels through the transformer. This aspect varies with the square of the turns ratio. Thus a 1:2 step up transformer actually quadruples the impedance at the output. Consider a 5W output stage running on 12 volts with a load impedance of 12.5R which needs transforming to the 50R antenna line. The primary winding impedance should be at least 4x12.5R = 50R (by coincidence!) which needs 2.3 uH on 80m and hence min 6 turns on an FT50-61 (see right). The secondary has to have double this. In this case the transformer primary can also act as the supply choke.

Maximum power handling calculations are much harder to do and are related to the saturation characteristics of the core material. Half inch diameter rings like the FT50-61 are fine for 5 Watts of RF. Use more side by side for higher levels. At 50 Hz, the core will be gapped iron laminations where max power will be related to the central limb's size. Figures of around 25W per square inch are a guide! Tim G3PCJ







Snippets and Correspondence!

David Buddery G3OEP questions how the Lancaster bomber in which Blumlein died while doing early radar experiments, could have crashed due a single engine failure. According the detailed crash report recently declassified & recounted in his biography, the sequence of events was that a loose tappet adjusting lock-nut on one inlet valve of the Merlin, allowed the tappet clearance to become excessive leading to higher than normal temperatures and eventually valve stem failure; this led to a very severe inlet manifold fire which the engine bay extinguisher could not control, and which eventually melted the main spars of the wing causing it to snap & aircraft to fall out of the sky.
Godfrey Manning G4GLM has kindly offered to help out with requests for elderly (mostly) germanium semiconductors. He has quite a supply but is always keen for re-supplies if old gear is no longer required. Contact him first at cgmm@thersgb.net
Chris Rees G3TUX comments that there IS a case for using a twin lever paddle key even if you do not 'squeeze' or use it Iambically! He argues that the arm of a single lever has to travel much further than is the case for a twin one (theoretically x2) which can lead to poor sending such as 3 becoming SM. This is even more apparent when operators use semi-automatic ('bug') keys where the gap on the dash contact has to be quite wide to ensure sufficient vibration of the pendulum arm! (There speaks the man who sold keys - including a twin lever one to Gerald Stancey G3MCK! Tim)
Spinach powers battery! A recent research note reports on a new solar powered battery developed using spinach laced with special salts and silver electrodes! No output figures per tonne of plant material are given but it does report 12% solar efficiency which is quite high compared to solar PV panels. Its not quite the time yet to plant your garden with nothing else in case the 50 Hz fails!

The 21st Yeovil QRP Convention

This will take place on April 10th 2005 at the Digby Hall, Sherborne, Dorset as in recent years. Doors open at 1000/1030 and there will be talks, radio traders, bring and buy stalls, eats and drinks etc etc. The talks will be on HF DX Propagation (G3MYM), HF Telcoms - Poldhu to Telstar (G4KHU), and What's my frequency (G4JBH). Full details and help with accommodation if required can be obtained from George Davis G3ICO george@mudford.fsnet.co.uk Do make yourself known to me if coming down. If you contemplate purchasing a kit, advance warning is sensible in case I am overwhelmed by unexpected orders! See below for distant travellers.

The Somerset Supper!

To have a little bit of fun, that well know firm of kit suppliers will be holding a ***Supper*** the night before the QRP Convention, ie the evening of April 9th. It will be held in a Sherborne hostelry yet to established, for locals and those staying overnight. To make it slightly more interesting I plan a small display of an item from each diner's home built radio equipment! (Please also bring a QSL card or label.) This will qualify you for a *free* place at the supper table! You buy your own drinks. I do plan to a take a photo or two for publicity purposes but this will not intrude into this ***social*** event where all (including XYLs) will be very welcome. A minimum of formality! Places by advance booking **only** by Mar 28th so please get in touch soonest via walfor@globalnet.co.uk letting me know numbers or special dietary needs. Hope to see it and you! Tim G3PCJ

Finally I must apologise for getting this Issue out a little late - my excuse is that we went to Spain to get a little Spring sunshine. Not a bit of it! We left after the aircraft has been de-iced and arrived in steady cold rain. It got worse - with more snow, rain and serious wind! We did have two good days though and found a few Spring flowers in the mountains. Returned to ice again and a power cut that had put the heating out of sync with real time!

Another reason for publication delay is having to think too hard about suitable topics to include! I do need your suggestions, comments, questions and articles *please - just anything will help!* I reckon I can tidy up most rough material (although you might not think so)! Tim G3PCJ