"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Winter 2016 Issue E94

Editorial

A nasty damp grey day here after a wonderful dry Autumn with magnificent leaf colours in all our trees – given the large number of you readers in North America, I can comment that the scene in the North West states (famous to us in Europe for your Fall colours) must have been spectacular if you have had similar conditions. This change in our weather makes me look at the list of inside electronic things that I need to tidy up and progress, of which creating a new 'top of my range' rig has to be pretty near the top of my job sheet!

I have note books filling up with block diagram ideas, circuit scribbles for various potential functional blocks and then the awful estimates of what the resulting rig's might cost be. This price estimation process is fraught with risk but it is noticeable that sale price is a much more important consideration in Europe than it is in North America where 'performance' has a much higher priority. I find the second hand market for black box rigs creates a price zone which it is advisable to not approach when contemplating a top end design! My latest doodles get pretty near this zone when you add in the potential extras of frequency readouts and antenna matching units, after you have given the rig at least 5W output of CW or SSB with AGC and CW receiving filters etc - even on a single band; add in one or two extra bands and it becomes unattractive except to those who wish to build their own gear almost irrespective of cost, and who are then able to say that they have built it on air, with all the pride that gives. I am currently looking at how to utilise my range of RF accessories and filters to make a simpler single band rig into a multi-band one – it is certainly worth exploring more!

Meanwhile, later in this issue you will find diagrams and photos of the first block of the **Weston** project. I have long felt that good projects can be made without an etched/drilled PCB and so I will be describing how to create this receiver over three issues of Hot Iron. This is not an original idea of mine but arose from suggestions of at least two regular contributors to HI – thank you! The intention is to end up (after three issues) with a mid complexity single band superhet RX. I will provide full circuit details which I hope will allow potential builders to also use whatever similar or commonly available parts they can obtain locally. I am also contemplating whether it might be feasible to carry on and make it into a transceiver but at the moment I do not wish to add any complexity to the RX that might make the TX ultimately easier.

Tim G3PCJ

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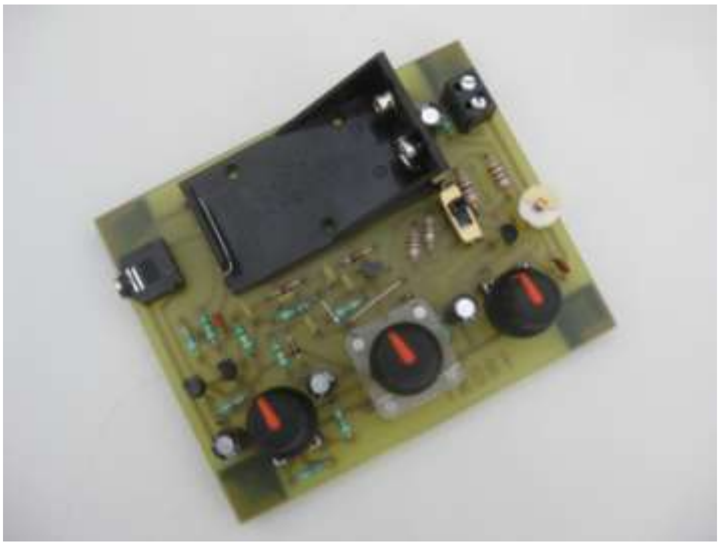
Hot Iron is published by Tim Walford G3PCJ of Walford Electronics Ltd. for members of the Construction Club. It is a quarterly newsletter, distributed by e mail, and is free to those who have asked for it. Just let me know you would like it by e mailing me at electronics@walfords.net

Kit Developments

With articles about the **Halse and Hatch** in Practical Wireless, I have been busy sending out kits for them – so far with surprisingly little comment on how builders are getting on – this is either because all is fine or builders have given up in disgust! I hope & pray it is the former!



The **Rockwell** (right) has been altered in the light of most helpful comments by two particular builders who felt there was room for development of the rig itself and of the instructions. A little bit of head scratching by me on the build sequence, and the addition of a trimmer, now makes it much more adaptable for either general coverage of much of the HF spectrum, or for particular amateur bands. To remind readers, it has two switch selectable bands with two values of the ready wound inductors that can each be wired in series or parallel for coverage between 20m down to the low frequency end of the Medium wave near 750 KHz. The latter gives an early confidence boost to novice builders who can easily receive the AM broadcast stations before attempting the more challenging CW or even SSB reception! Because the Regen stage uses the Colpitts configuration, there is an existing chain of fixed capacitors across which the variable tuning capacitor can be connected so as to reduce the tuning range on a chosen band to make tuning adjustments easier - the extra trimmer sets the mid band frequency.

The other revised project is the **Mk 6 AMU** shown below. This retains the same fundamental matching bridge and T match circuits as in earlier versions, but now has what I think is an easier form of 'variable inductor' for people to build. (It also fits into padded bags for carriage more easily!) The 'inductor' is changed to a series of switch selected toroids, wired in series with inductors that increase in a binary progression – this gives up to a total of 20 μH in about 0.1 μH increments. In reality, for any particular band, only two or three adjacent inductors are actually required because the T match circuit is so versatile. With both sections of the two PolyVaricon capacitors, the circuit will match loads of about 25 R to 2500R over the range 2 to 30 MHz with either balanced or unbalanced feed line. The switch selectable resistive matching bridge allows a safe tune up irrespective of the actual line impedance. It drives a LED which you extinguish for AMU tuning, but when you bypass the bridge, the LED responds in response to RF output voltage. The design can feed a conventional moving coil meter if desired. Power is limited to about 20W due to the PolyVs and bridge resistors. Out soon. G3PCJ

Crowbars & Light Bulbs - simple protection circuits – Peter Thornton

These circuits are common in Industrial Electronics Maintenance workshops, where electrical and electronic faults have to be found quickly! In amateur radio shacks, these circuits are just as useful, and prevent disaster without blowing fuses. Fig. 1 below shows a crowbar circuit. This is designed to blow the fuse if - for any reason - the power supply delivers a higher voltage than the equipment being powered can tolerate. It has a subtle addition: a tungsten filament lamp in parallel with the fuse provides features not normally associated with common designs.

Initially, if you're powering up for the first time suspect equipment (or you don't trust your power supply regulator), remove the fuse F1. Install an incandescent bulb into the L1 position, of equal rating to the power supply output voltage and of sufficient wattage to power the equipment (21 watt / 12v. car stop lamps are useful). Connect up the equipment, and power up. If any shorts or similar destructive faults exist, the light bulb limits the current available to the load, and stops any disastrous burn-outs. An incandescent filament light bulb has a unique feature: it's cold resistance is ~ 10 times LESS than its "hot" resistance. If the load is fault free, the lamp should (if you've fitted a sufficient wattage lamp) not visibly glow, but if the glass envelope feels slightly warm after a few minutes - the equipment running more or less as per normal. I have various 12v car lamps to hand, 2.2 to 48 watts at a nominal 12v rating (remember you can parallel lamps, and if you use lamp holders, you can simply slot in another lamp if you need to).

Assuming the equipment runs as expected, then the fuse F1 is fitted. The equipment is now powered directly from the power supply, and any failure in the power supply which would result in over-voltage being applied to the equipment is clamped by the zener diode and SCR. The 10K // 100nF eliminate any noise pick-up or brief transients. You can pick and mix the zeners to get the voltage you want, remembering to add the SCR gate-cathode volt drop of ~ 0.7v. A 15v zener gives a trip point of ~15.7v which mimics very closely the maximum charging voltage of an "aged" car battery in summer with no lights, air-con, or heated screens to drop the alternator output - hopefully your equipment designer took this into account!

Lamp L1 now has it's second role: if the voltage rises to the trip point, the fuse blows open, and L1 lights to tell you so. Now L1 shows it's third function: before you use the crowbar again, you should **CHECK IT ALWAYS TRIPS** at the over-voltage you want: but how do you do this without blasting lots of fuses? Easy! Remove F1. Turn the power supply down, connect a dummy load on the output (a 12v / 21 watt light bulb perhaps), and wind the power supply up **SLOWLY** whilst monitoring the output voltage - until the lamp L1 lights. Note that voltage; try a few times to be sure you have the exact voltage at triggering, and you have tested the trip without wasting fuses. Replace F1 and that's that.

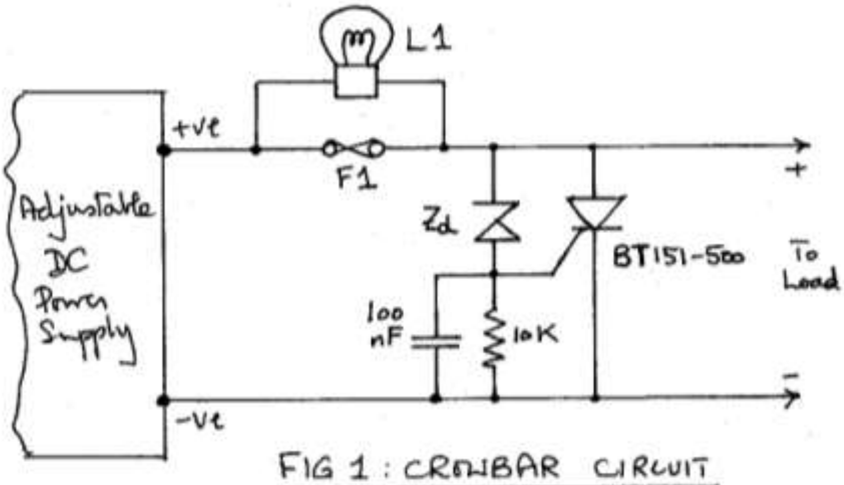


FIG 1 : CROWBAR CIRCUIT

Fig. 2 below is an AC version for mains powered equipment – this circuit has live mains parts that might harm you: you MUST follow the appropriate electrical codes that are applicable in your region for safety, and use due diligence in your construction. Use protective devices as appropriate - you have been warned!

This unit shuts off the output if over-loaded; L1 is a tell-tale lamp - it tells how the mains are supplying the load, the relay is arranged to drop out if the load draws excess current. When feeding a switched-mode power supply, you might need higher wattage lamps than expected at L1 to persuade the switch mode power supply to run - the start-up circuits like to see full mains at switch on in some designs.

The lamp L1 is in series with the live line of the incoming mains, and limits the current as in the crowbar circuit. In series with the lamp is a normally open relay contact, the relay coil being fed from the load side of L1. S1 bridges RLA/1 normally open contact: to start feeding the load, momentarily press S1: full line volts are fed to the load via L1. If the load doesn't take excess current RLA will latch in and power be fed continuously to the load. RLA coil should be rated at the line voltage of your supply, and must be an "AC" type of relay with a contact voltage and current rating suitable for the heaviest load likely to be encountered.

The relay forms an under-voltage trip latch: if the output voltage falls below the relay drop-out value, then RLA/1 contact opens, isolating the load. Why should the output voltage fall? Excess current, and the non-linear characteristic of L1, drops the voltage across RLA coil! With this circuit, over-current does not mean smoke: L1 limits the current and then RL1/A isolates the load. For those "awkward" loads - like high voltage power supplies that need to charge up empty smoothing capacitor banks - S1 can be judiciously kept engaged, the relay will pulse, L1 flash, and s-l-o-w-l-y fill up the load capacitance until the load is up and running and RLA locks in – but be careful in case something else nasty is going on! Any faults in the load that only appear when the voltage has risen to near maximum - like electrolytics that go "short" at near full applied voltage - will not cause blown fuses, and RLA safely drops out.

A selection of mains light bulbs, 15 to 150 watts prove useful: if the load won't start up, even after several relay pulses, try a higher wattage lamp. The unit can be conveniently built in a conduit knock-out box, with a short (fused) mains lead feeding the power, and a surface mount socket fitted to simply plug in the (now protected) load.

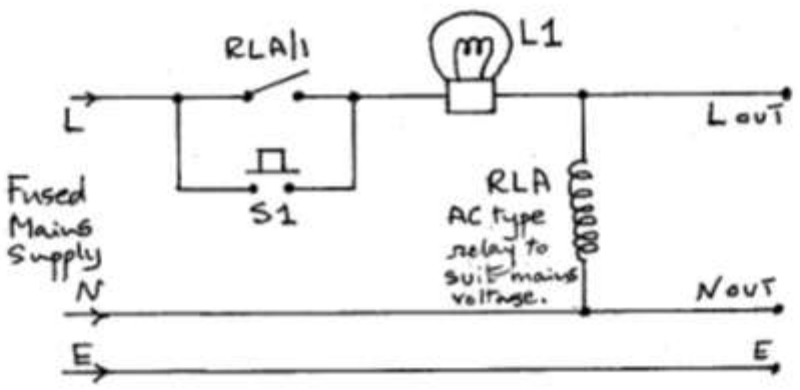
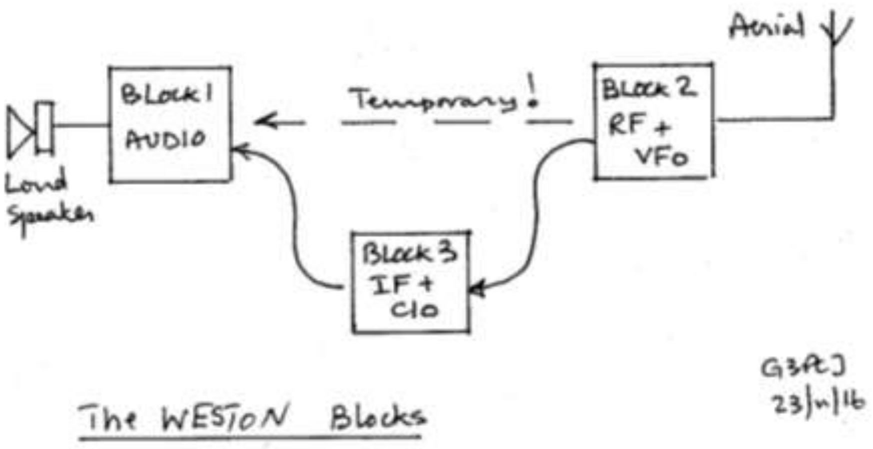


FIG 2: LIGHT BULB PROTECTION

The Weston Receiver

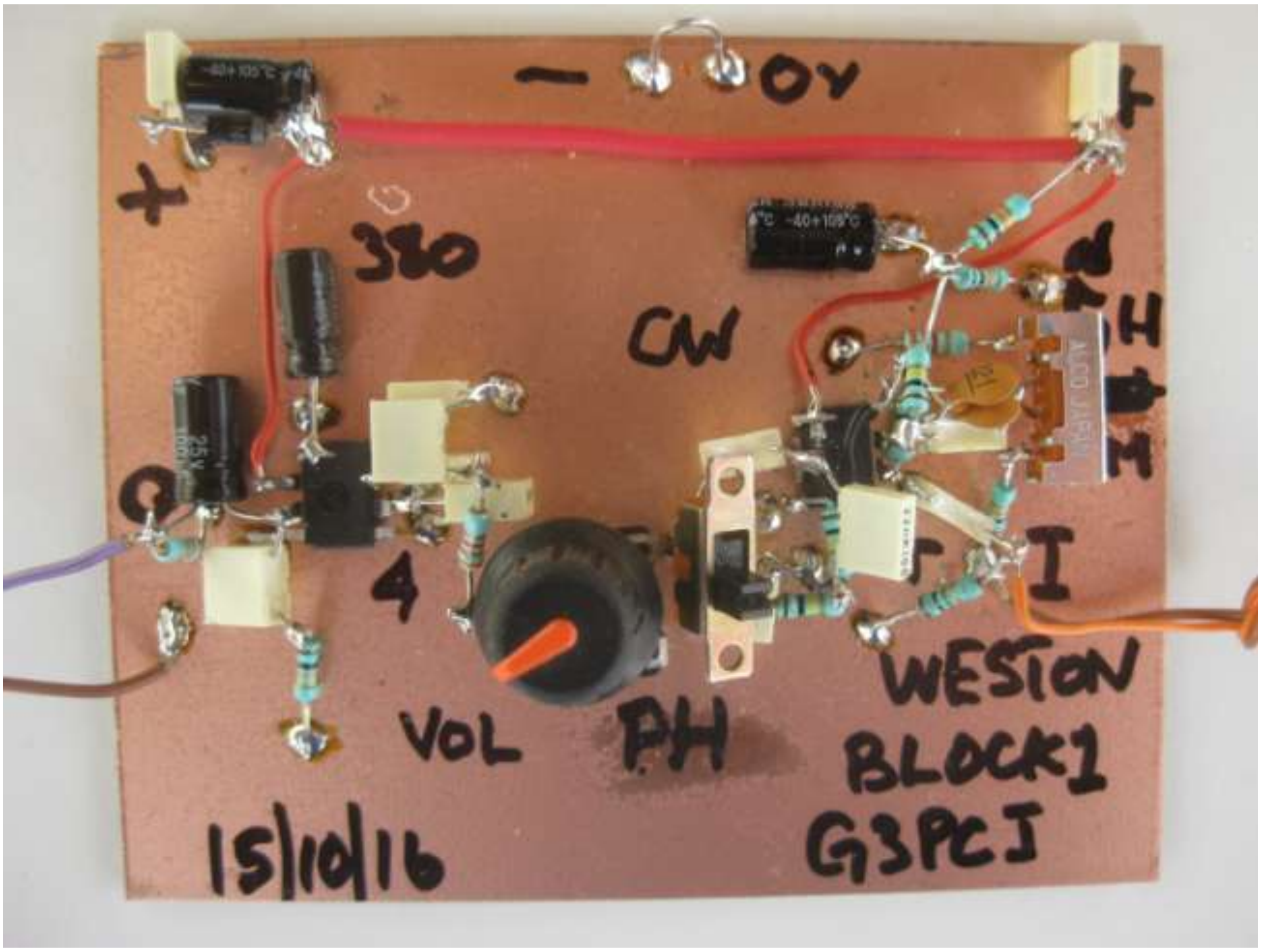
The ***concept*** of this rig is an easily built superhet receiver, for any band in the 20 – 80m group initially. I envisage three main Blocks which I will describe in this and the next two Hot Irons. I am NOT providing kits of parts and it does not depend upon an etched printed circuit board - you can do you own if you wish, or use ready made strip boards with lots of holes, but I have never been keen on them! Dead bug construction is an easy alternative as explained below! The general arrangement is shown in the diagram below. Block 1 is the audio stages, Block 2 will add RF filters, mixer and VFO so that it can become a direct conversion RX temporally! Block 3 will then add an IF strip, mixer and carrier insertion oscillator; the whole will then become a single band superhet after the VFO has been altered for the IF offset.



Dead Bug Construction!

A word first on this method of building circuits! It is excellent for RF work because of the continuous sheet copper ground plane and the short leads (if desired) for components which minimises stray capacitance. The technique has all earthy parts soldered direct to the ground plane wherever the layout suggests it is best or convenient! It also permits easy alterations when needed. With a little practice it becomes quite easy to do! I tend to start from the circuit diagram laid out for the best signal flow – in this case from right to left – and sometimes sketch out a physical layout for the main components - the ICs, TOKO inductors and other larger mechanical parts like tuning capacitors etc. If you are going to add controls and or input/output sockets, it is often best to do their physical arrangement first - you can easily solder smaller pieces of the sheet material to the front edge (with suitable braces) for a control panel with any sockets that you want. Not every Block will need a 'control panel' and you might choose to use smaller preset type controls mounted directly to their associated parts, as I did for Block 1. I find it best to then mount the ICs; upside down with the pin numbers written in the corners. Assuming you are using dual in line ICs, the earthy pins are first bent out sideways just beyond the plane of their body, so that these earthy pins lie down against the copper ground plane for easy soldering. The supply pin(s) is then decoupled with a 10 nF disc directly between that pin and the ground plane so that the IC is now also well anchored. Often it is best to next put in the supply components with a supply line to the various stages running along the top edge of the copper sheet where it will not be in the way of other parts. Any supply resistors run from this edge wire to the IC supply pin with its decoupling capacitor. A wire link can be used instead where there is not supply dropping resistor. The input circuitry can then be attached as convenient with any extra joints between components up in the air away from the ground plane or other junction points. If there are at least three leads (ideally spaced at 120 degree intervals!), then these joints will be pretty rigid in space!

Then add the output parts in the same manner. If required, you can usually add resistors of 1 M or higher as a sort of stand-off insulator – this approach is good in the higher frequency part of the project where circuit impedances tend to be much lower than 1 M, but be more careful in audio stages where impedances are often high – if the circuit already has 1 M resistors, its is best to avoid any extra 1M stand-offs in that part of it! Some photos follow of my Block 1 but yours does not have to be exactly the same. I am afraid that my photographic skills and kit are not really up to showing the detail properly. Try it & see how you get on – nothing is lost if you have to re-arrange the layout as long as you can still solder the components together!

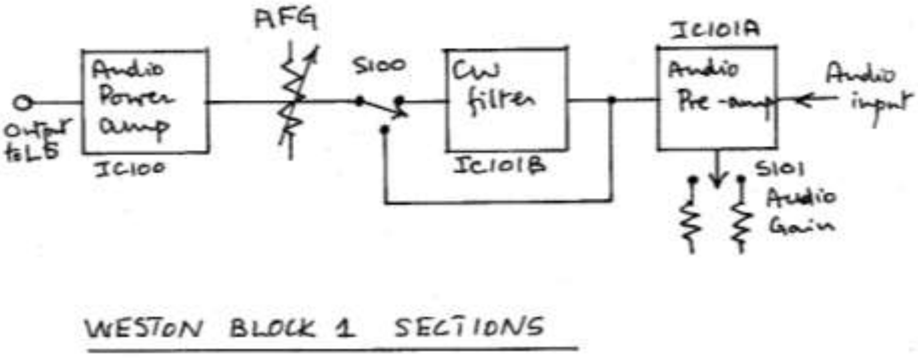


Above – Dead bug technique - Block 1

Left – Output stage IC100 close up

Block 1

These are the audio stages with parts numbered up from 100. The audio sections are shown alongside with the circuit on the next page. It has a gain adjustable op-amp voltage amplifier, with selectable audio filter for CW, followed by the AF gain control and the audio power amplifier. Given that physically, the RX is likely to have its output on the left for right handed tuning, the circuits etc have a signal flow of right to left for easy transfer to the physical realisation. Physically, I have made mine by 'dead bug' construction on a copper clad fibre glass sheet that acts as ground plane and an easy form of 0 volt line!



As we progress, I hope to be able to suggest alternative parts for the semiconductor devices so builders can use whatever they can acquire or have to hand. The audio power stage needs to be able to drive modern 4R speakers so they can also easily also drive the higher impedance 32R type of phones; I prefer the LM380 which has a fixed voltage gain of x50 to the alternative LM386. Either the 8 pin or 14 pin 380s can be used. They can take a supply up to 22 volts! This part of the circuit has provision for muting and the feed in of CW sidetone when transmitting if wanted. The preferred AF gain control would have a logarithmic type of control law but a linear one is perfectly usable; the value can be whatever is to hand in range of 1K to 10K. It is preceded by a fundamentally high input impedance op-amp voltage amplifier, with a centre off switch in the feedback network that allows the gain to be set to x1, x33 or x100. You could use other resistor values for a x10 position but I was trying to minimise the number of different values in each block! The suggested op-amps are the low noise type with FET inputs to minimise any output voltage offset effects; the TL072 has two op-amps in one IC but you could use two of the single TL071s, or even omit one if you do not want the CW filter. Bipolar input op-amps like the 741 are not ideal (due to their finite input current) but might work if desperate! Without the two input capacitors C120/121, the input impedance is about 100K which is suitable for many general purposes like the simple receiver below. (R113 is an anchor with no effect due to its high value; C120 & 121 are needed for Block 2 to reduce its output audio bandwidth.) The second op-amp stage is a humped low pass Sallen and Key filter, designed as a CW filter whose response rolls off sharply above about 1 KHz; it has a slight peak at nominally at 723 Hz. Again, a low noise FET input type op-amp is preferred. The supply range can be up to 30 volts! In several cases, two components are suggested to avoid another value. The parts list is:-

Resistors	1R R101; 3K3 R100,102,111; 10K R107,108,112; 100K R104,105,109; 1M R113 AFG Pot R103 – 1K to 10K – desirable have log law with knob!
Capacitors	220 pF disc C111,116,117; 22 nF Polyester C100,106,107,108,112,114,119,120,121 ; 470 nF Polyester C103,105,109,110,118; 10 /uF 25v electro C104 ; 100 /uF 25v electro C101,102,115
Semicons	1N4007 D100; IC100 LM380-8; IC101 TL072
Hardware	Copper clad fibreglass board – min about 80 x 100 mm; S100 1P 2W switch; S101 1P 3W centre off switch; wire and solder as required etc

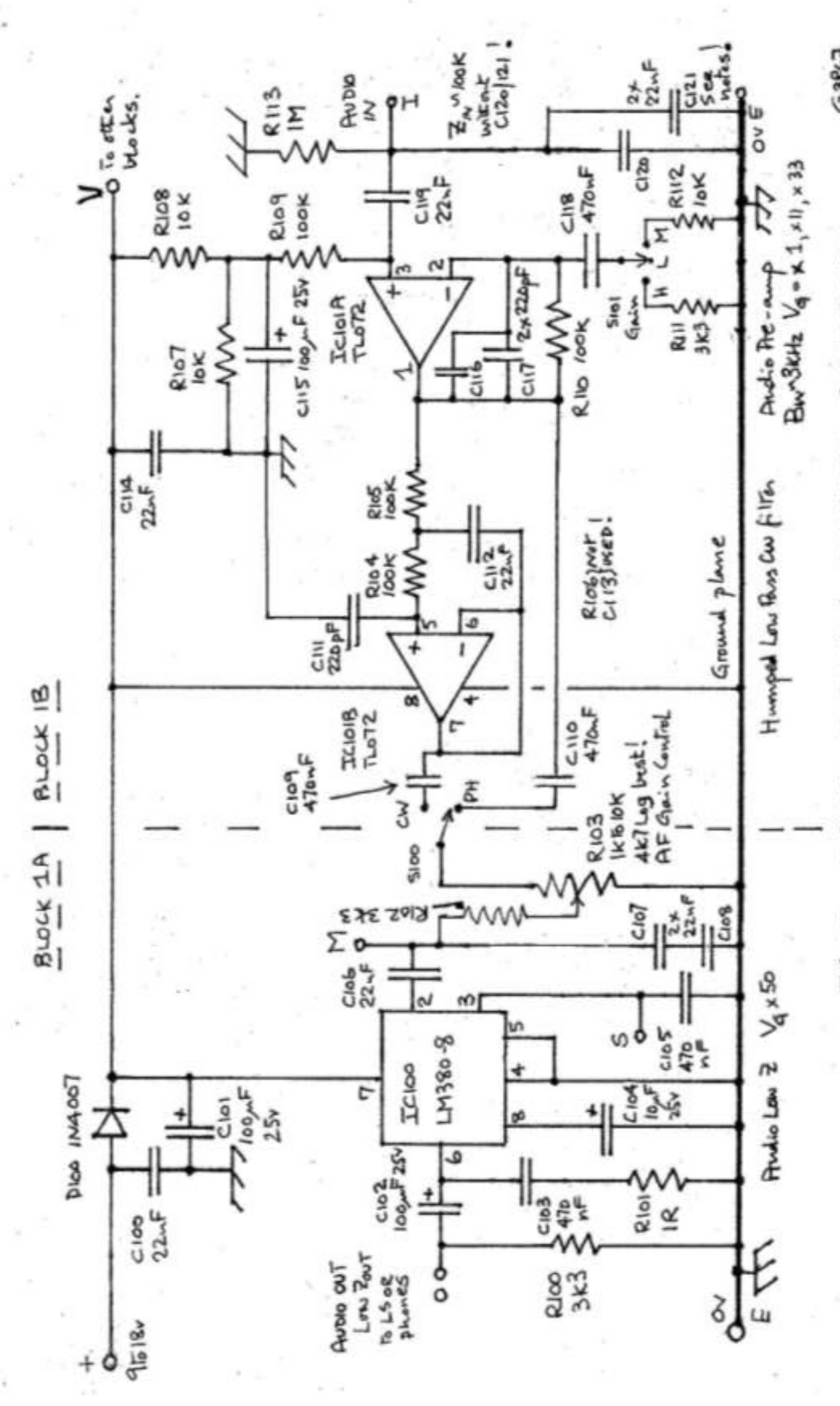


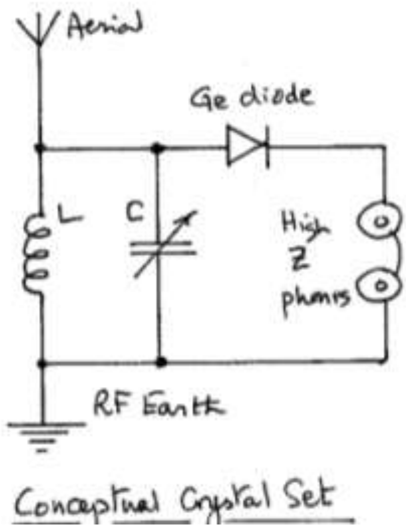
FIG 100 – CIRCUIT OF BLOCK 1 OF WESTON – AUDIO STAGES

Testing Weston Block 1

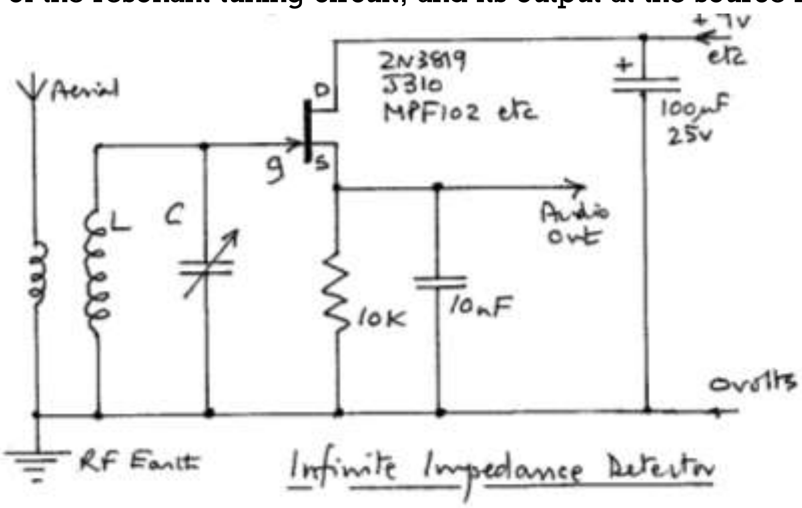
You can test the two sections separately after each is built. Power up the output stage and the DC voltage on chip output pin 6 should be close to half the supply voltage. If that is right, connect you loud speaker or phones and then perform the 'screw-driver hum test'; apply your finger to the shaft of a metallic screwdriver and dab it cautiously on the input pins – listen carefully and you might hear hum picked up by your body from nearby mains wiring, or possibly slight clicks as you make contact. Next power up the op-amps and check the DC output pin (1 & 7) voltages – again they should be half the supply voltage and you can repeat the screw driver hum test on their input but beware, the noises might be somewhat louder so be prepared for that! If you select the CW filter, the hum is likely to sound as though it is coming from a long large diameter pipe! A high gain audio amplifier like this is quite a useful item to have on your work bench for all sorts of monitoring jobs, or even as a speech amplifier for a transmitter. But what you really need to test it, is a crystal set to make it into a receiver - see below!

Modern alternative to the crystal set!

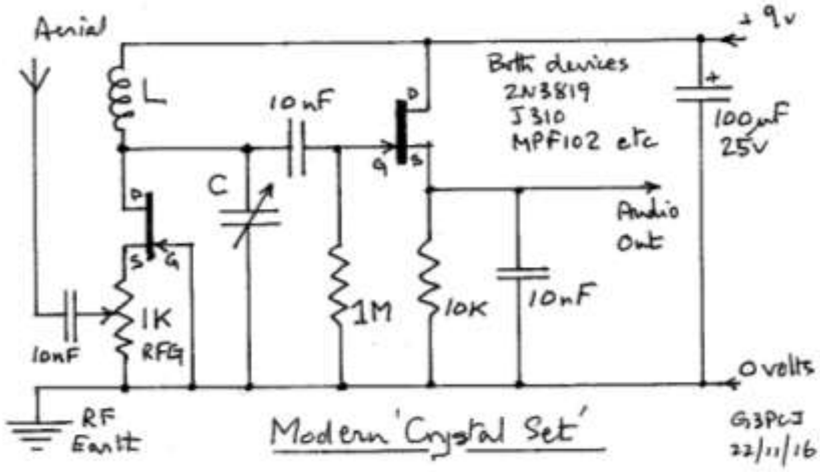
Years ago, building a crystal set for the AM broadcast stations was easy; you needed a germanium diode (or a galena crystal and cats whisker!), an inductor and variable tuning capacitor (see right) and not much else apart from the expensive high impedance phones and a large aerial! But nowadays high Z phones and germanium diodes are almost unobtainable, even if you have the L and C tuning parts. Silicon diodes like the 1N4148 can be used but you will need to apply a small forward voltage to overcome their 0.65v diode drop, otherwise you won't hear anything! Another challenge for very simple tuned circuits is how to preserve their selectivity. Loading of them by either the aerial or of the phones/detector can wreck selectivity easily! If it feeds modern 32R phones, the load impedance on the tuned circuit will be so low that there will be no tuning unless it is tapped right down the inductor which will then make it completely deaf again!

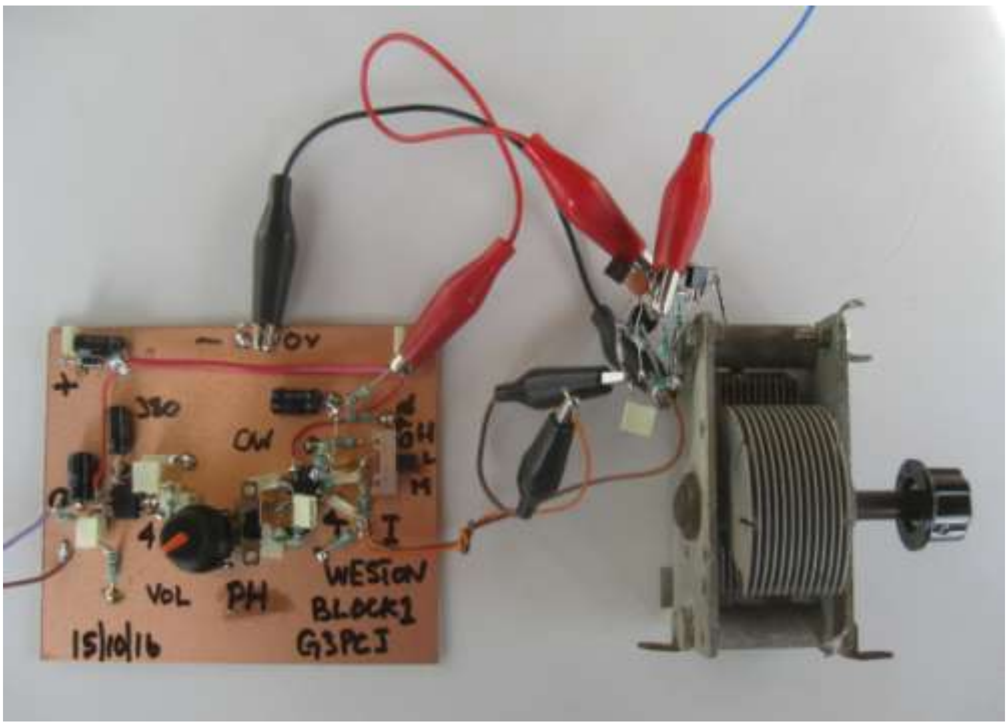


Sadly, I am afraid the answer is to use some modern semiconductor device(s) and a battery. A sensitive detector, which rectifies the incoming amplitude modulated RF voltage without loading the tuned circuit, is needed – a good solution is the 'infinite impedance detector' which uses a Junction Field Effect Transistor (JFET) acting like a perfect diode - this can be connected directly across the tuned circuit because its gate input impedance is way higher than that of the resonant tuning circuit, and its output at the source has a CR combination that passes just the desired audio at a moderate impedance; this can be fed directly into the high impedance audio input of the Weston's block 1 (without C120/121). The resulting crystal set type of receiver is shown alongside. This version still needs a tuning inductor with a separate primary winding for the aerial – but see over!



The above tuning inductor needs either a separate primary, or taps on the secondary so that the aerial, which might exhibit low impedance at the frequency of interest (or high capacity), does not load the tuned circuit and so destroy its Q and selectivity. Tapped inductors are not that hard to make but there is a transistor alternative! A second JFET RF amplifier stage is easily added and will preserve the high Q and selectivity. The simplest scheme is to use another JFET in the common gate configuration, with the aerial feeding into its source, and the LC tuned circuit as the drain load. Because the supply rail is heavily decoupled, it is at 0 volts in an RF sense so that any RF developed across the drain load inductor, can also appear at the input of the following infinite impedance detector provided it is AC coupled. A final wrinkle is to use the JFET source resistor as an RF gain control because sometimes a little less RF gain may avoid broadcast station interference (BCI): because this is feeding our high gain Block 1 audio amplifier (again without C120/121) we don't need to worry about a low RF input signal level – either intentionally to avoid BCI, or because the aerial is a bit short! The resulting circuit above can be built in ugly fashion in the air or on the frame of the air variable like mine below! Luckily there are still plenty of Amplitude Modulated broadcast stations in the European Medium Wave band at about 1 MHz so any combination of variable capacitor and inductor that resonates near 1 MHz will be fine. I happened to have a 500 pF variable to hand, which with a ready made 100 /uH bead inductor, serves well; you can alternatively pile wind about 50 turns of thin enamelled wire close together on a section of 40 mm plastic waste pipe for an alternative inductor.





Never throw away old burnt out mains transformers because their higher voltage windings are a source of such thin enamelled wire, and the secondary wire might be suitable for winding the amateur band RF filter toroids of a later Weston block!

Snippets

Higher power Linear Dan White has recently been experimenting to obtain more power out of one of my standard Linear RF amp kits that are intended to produce 10W (on 13.8v) with about 1.5W of drive up to about 15 MHz. His plan was to drive it with a Rimpton AM TX coupled to a Rockwell RX on 160m. The main changes were to alter the MOSFETs to IRF520s and the output transformer to 3+3:12 turns; he also beefed up some of the interconnections and gave the bias circuit a little thermal feedback from the much enlarged heatsinks. Bench testing produced over 50W on 160m dropping to 35W on 20m, both with near 10W of drive. More on this later I hope!

Gluing toroids It is happens occasionally that toroids get broken in transit as they can be brittle; one recent builder thought he would try 'super-gluing' the two T50-2 halves back together again as he was reluctant to wait for a replacement. The application was in a transmitter low pass harmonic filter and it worked perfectly. If it had been the inductor of a VFO, I think I would only do that as a temporary fix because I suspect it will alter their temp coefficient of inductance – either up or down might wreck the VFO's stability.

Russian Circuits One of our contributors has put together a compendium of over 100 circuits by Viktor Polyakov and others, for a whole mass of different applications. The Russians have proved to be very inventive over the years and some of these are fascinating. If you would like to receive the pdf file, send your request to the Equipment Engineering Co at equieng@hush.com

DSB/SSB bandwidth Mont Pierce inquires about the bandwidth differences between these two methods of phone transmission. Double sideband modulated RF, as it leaves the transmitter, does occupy double the bandwidth ie about 7 KHz and its nominal frequency is in the middle of this 7 KHz segment; single sideband occupies 3.5 KHz with the nominal frequency (where the carrier would have been) on one side of that section – the side depending on whether it is upper or lower sideband. (DSB is seldom offered in black box rigs, but the carrier can be either suppressed or actually present depending on the type of modulator - if the rig is producing conventional amplitude modulation, then the carrier is present with both sidebands and it occupies 7 KHz. I have used 3.5 KHz here as a typical audio bandwidth for these examples, but it can be down to nearer 2 KHz.) At the receiving station, a simple product detector will produce a 'valid/good' output if either or both sidebands were transmitted provided the receiver's local oscillator is set to where the carrier would have been if had it been transmitted; however if the receiver has narrow filtering ahead of this detector, and that filter is set to remove the wrong sideband then no signal is heard when tying to hear SSB. If it was actually SSB then the frequency is actually clear because nothing was transmitted and that channel (or gap in frequency) could be used by another TX/RX pair, but if it was Double sideband, then there would actually be a signal there if you changed to the other sideband.

That's enough from me. Happy Christmas and a prosperous and healthy New Year! Don't forget to let me have any contributions for Hot Iron! It would be lovely to have some pictures of your Weston projects for the next Hot Iron! Tim Walford G3PCJ