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The Hallicrafters S20R Sky Champion Communications Receiver

Philip Moss describes an elderly but interesting set from the USA.

I bought this set, **Fig. 1**, from eBay, for £45 in 2012. Seeing at the time yet another ubiquitous DAC 90 was up for £51, I don't think I did too badly. The radio was in OK but not wonderful condition. Probably the many honest caveats the seller put in the description put people off, including that it was probably for 110V, which was true. Much more about the transformer later. He also said the speaker cone was jammed. The pictures, which were in-focus, showed that it was not too bad, but some corrosion was visible and it would turn out that it had probably got into the mains transformer, which he wouldn't have known. I found that out much later. It had clearly had a replacement electrolytic can, but didn't look much interfered with. Well, not quite true… I was lucky, the owner was a long way away, but his wife worked not that far from me so I was able to collect it from her and avoid a delivery charge.

A War-Time Story

Somewhere I have read that there was an important role this model played in World War 2, although it may have been another similar model of Hallicrafters. We were very short of radios at first, and that included sets working into VHF. This set goes up to ~44Mc/s.

The story goes that one day Men from the Ministry (quite which I am not sure) went off to Edgware Rd or Lisle Street in London, saw the set, and promptly requisitioned it.

The set was then flown on an AVRO Anson light bomber, which was also used as a fighter, and incidentally also was used to carry the experimental versions of air-borne air-intercept radar, which enabled night-fighters to find their targets, as implemented in the Bristol Beaufighter, dedicated night-fighter.

The result of this was that as **Prof Lindermann** had suggested, the Germans were using radio beacons for bomber navigation. These were near the frequency of the Crystal Palace TV transmitter, with that service obviously suspended 'for the duration', and with this knowledge we had countermeasures available to mislead the Germans till they 'twigged', and cause them to bomb off-target. Both the UK and Germany had used similar frequencies for their TV services.

Specification

The S20R has four bands, 540kc/s to 1.8Mc/s, 1.7 to 5.75Mc/s, 5.62 to 18.4Mc/s and 17 to 44Mc/s. There is a need to have more bands to comfortably cover these ranges, even with the fine-tuning facility. The set has a tuned RF amplifier stage, a 6SK7 variable-mu pentode, a 6K8 triode-hexode frequency-changer, then two IF amplifiers, both 6SK7, hence a total of three IF transformers, all double-tuned using trimmer capacitors, then a 6SQ7 double-diode triode for detection and AGC detection with the diodes strapped together, and the triode as audio pre-amp, with a 6F6 output valve. It is unclear why AGC is often taken from the same diode as the audio. It saves the whole cost of one small capacitor, and probably a resistor too.

Against doing this is higher audio distortion, a heavier load on the IF transformer and hence lower *Q*. The other way of doing it is that the AGC is taken off the anode of the valve and only loads the primary winding. Also, you cannot have delayed AGC doing it this way. A 6H6 double-diode is used in the noise-limiter circuit, and a 6J5 triode as BFO, finally an 80 directly-heated full-wave rectifier. All valves are octal, and most are metal although my set had glass valves for output and rectifier.

Bandspread is by a small variable capacitor, which is part of the main tuning capacitor, see picture **Fig. 2**, and is on all three sections, not just the local oscillator. The standard version of the set is for 110V mains. Only the export version has a multi-tapped transformer primary. Consumption is 85W. The antenna input is stated as 400Ω, which was not untypical when this set was designed (along with 100, 200 and probably 300Ω!). 50Ω didn't become standard for professional and amateur radio sets until sometime post-War. The set cost $49-50 in 1939. I found two useful websites for this set, which did not come with a circuit or other information:

antiquradio.org/halli10.com

and the manual at

www.one-electron.com

then go to Tech's Filing Cabinet.

First Inspection

On first inspection I noted that the 6F6 had been replaced by a 6V6GT. It is clearly visible in the photo of the chassis top, Fig. 2 again. An apparently melted Octal plug was in the back but actually this was some type of rubber I think, that had hardened and shrunk with age. The socket is for external battery or vibrator pack operation. The mains lead was worn, but as it was rubber-covered cotton, it was fine to try the set, via

Fig. 1: The S20R.
Fig. 2: Top view.
Fig. 3: Bottom view.

a Variac, for 110V. The unused tag on the mains transformer was not the hoped-for 240V tap. All controls were mechanically sound. All the trimmers looked to be done up tight, a bad sign suggesting someone had been at them and didn't know what they were doing. Who would ever think....

A check with a DMM showed no leakage to chassis from the mains and a sensible value HT to chassis. It also showed an open circuit mains switch but I am used to that. It usually isn't true, and the application of mains blows away the oxidation and the set comes on. True in this case. The internal cables were all cotton-covered rubber, but looked fine, and the grommets were all perished.

Some resistors were checked and found in good order, some spectacularly close to their marked value. None were 5%, almost all 20% tolerance. I clearly hadn't checked any in the AGC though, as I found out later.

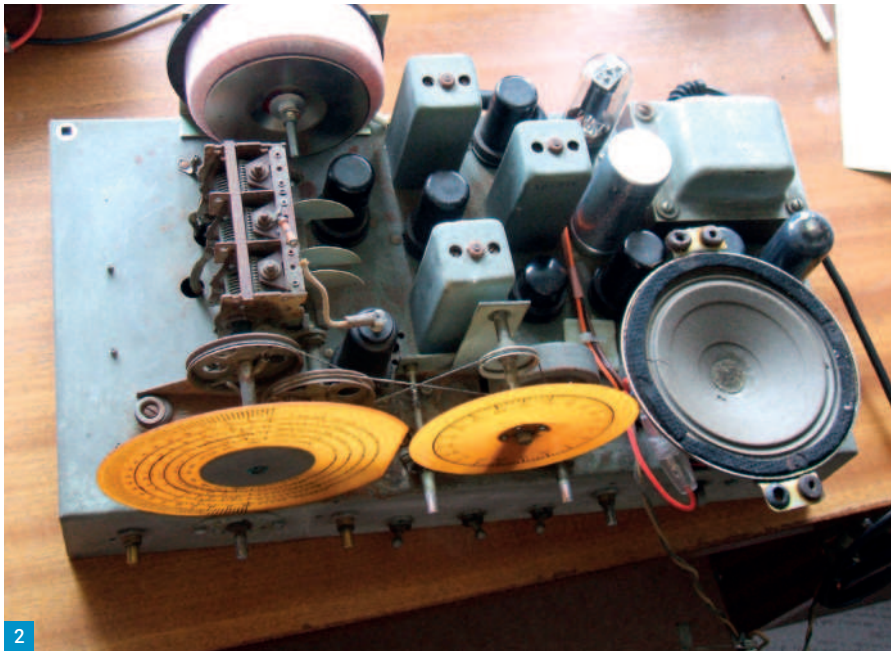
Access

The bottom, **Fig. 3**, allows easy access, perhaps too easy, to the trimmers for the RF circuits. The coils are all air-cored and wax-impregnated, as they should be, and as the set had been damp, a very good thing too. For most purposes the top of the chassis has easy access through the lid in the top but things I did required the cabinet to be taken off. Also, the front-panel, which was a bit fiddly. I needed to repair some of the lettering. I couldn't get the correct font for the Hallicrafters name, and my work with Letraset wasn't entirely straight, but it looks fine if you don't look too closely and is much better than unreadable legends to the controls.

First Try

So, time to try it. An antenna was attached to the screw terminal, the main connector being an N-type, which I avoid. The input is balanced, but there is a shorting-bar, which was already in place for unbalanced antennas. Mine is a random length inverted-L. Very little in the speaker so I used headphones. Very quiet, but plenty of signals.

At this point I will say that I had to do a lot to this set, and the article would be too long if I listed it all, so this is an abbreviated version. The wavechange switch operated reliably, there was more power as I could hear chatter from the output transformer, and it turned out that the break contacts on the phones jack were dirty/intermittent.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The Repairs

It would also turn out that someone, when 'repairing' the HT section and replacing the electrolytic, had managed to mis-wire it so that all the set's current went through the output transformer's primary. As though that wasn't enough, they also failed to solder a wire at the output valve's holder, so the set was running on the screen grid's current, not the anode, hence very low output intermittently. The speaker cone was gently freed, and as it was torn with the cone being very brittle, it was repaired using single layers of Engineers' Tissue (known by the uneducated as loo-rolls), stuck with Bostic or similar and built up both sides of the cone, a method I have used successfully before. Next, I applied diluted Bostick to reinforce the cone's roll-edge, but without making it stiff. I then applied Wood Hardener, a liquid for converting soft, rotten wood into a hard inert substance that can then be painted. It is for work on houses generally, but stiffened the cone well. I have had to use quite a lot on my house's windows. It is made by Tetrion and Bonda, stinks and is highly flammable, be warned. I was glad to have saved the speaker because finding a small energised replacement would have been hard. Obviously, I could have used a normal one, and a smoothing resistor and/or choke, but I preferred to leave the original if possible, which it was.

The volume control was open circuit at the earthy end so had little effect, but the track was fine, and washing with isopropanol cured it. The set had initially hummed badly, and I found the replacement reservoir capacitor was itself dead so replaced it.

The output valve grid was at +7V, although measuring the resistance of the coupling capacitor showed it open circuit at a meter maximum of 33MΩ. This was a long time ago. I have learnt not to rely on resistance measurements at low voltage, as they mislead. One give-away is if a small value capacitor slowly creeps up on measurement, or measures differently if measured the other way round (obviously I am not talking about electrolytics here). Some think they are batteries and have a voltage of their own, and in a sense they are. Clearly there is a chemical reaction going on, remembering that paper has a natural tendency to self-destruct, going acid, and this in the presence of metal. I now almost always change paper capacitors, even high-grade metal-encased and military ones, automatically in high-resistance circuits. The grid-leak resistor had crept up from 500 to 680kΩ, and while I would not automatically change out-of-tolerance resistors, actually for the output valve it is important because with age valves tend to suffer leaks, which drive the grid positive, and hence draw too much current. In passing, I noted a neat feature. The valve type was stamped three times around the rim of its base, and then filled in with white paint. I had not seen that before. I occasionally see numbers written or stamped onto the chassis adjacent to the holder. I wonder how often someone got the wrong holder and the stage had to be stripped down and rebuilt with the correct one?

I found the noise-limiter to be hopeless. It immediately introduced terrible distortion. Again, I tested the resistance of the two capacitors used, and they were both >30MΩ,

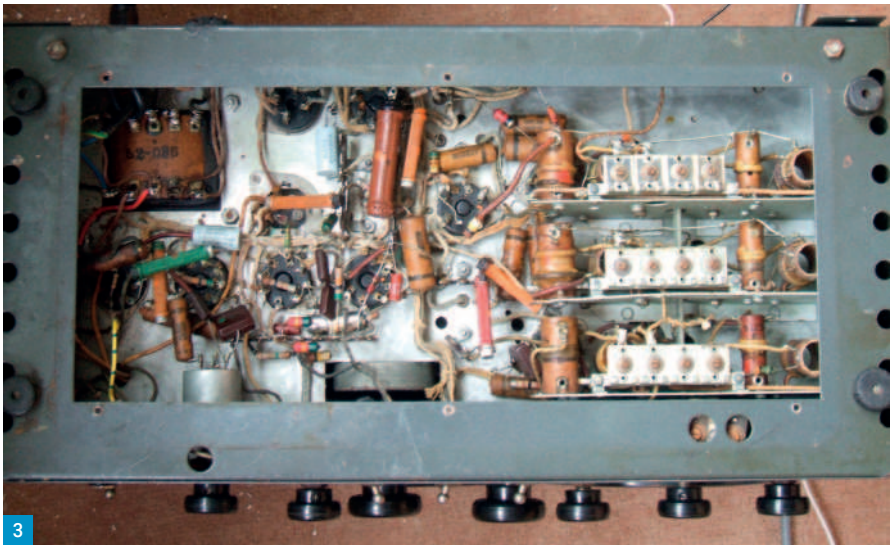
though one only one way. As previously stated, they can think themselves to be batteries, this one a 0.8V one. The resistors were close enough to be fine. On replacing, the distortion had gone, and finding a suitably (impulse) noisy signal, demonstrated the circuit did work. The AVC, or AGC as we call it these days, switch didn't work due to oxidation, so was always on. I will rarely if ever want it off anyway, but would like it working. Strangely, after operating it many times, it appeared to make no difference but worked the next day. I couldn't get to it to use a contact cleaner on it.

The next saga was the AVC. The volts at the diode were very high. They dropped off very fast after the series 2MΩ resistor, which had drifted to 3.6, but replacing it was hardly likely to be the issue, and wasn't. The two decoupling capacitors were replaced: 0.02 and 0.05μF, which greatly reduced the AVC volts, as the voltage was now being passed along better, but it was still a big difference. The RF amplifier, which should have been a 6SK7 and was a 6AB7, had a leaky grid. I thought I had 6SK7s, but it turned out no, after I risked life and limb lifting down a big box of valves. Fortunately, at the Museum (British Vintage Wireless & Television Museum, Dulwich, URL below), I picked up a valve for about 10p in rusty condition, but it worked fine, so that was dealt with.

bvwtm.org.uk

The Great Disaster, the Mains Transformer

It can be seen in the photo of the receiver top, Fig. 2, that at the back there is a bracket with a toroid on. That was the conversion from 110 to 240V. I used a transformer I had changed when doing a repair. The secondary had suffered damage, and I had stripped it off, leaving the primary, which as is often the case was in two equal parts for parallel connection for 110V, or series for our mains. By connecting the mains across the two windings with the set across one end and the joint, it makes a conversion transformer. I made a nice, neat job of that, so great shame then that suddenly the original transformer went bang, with an insulation failure between primary and HT secondary. So, I had to replace the transformer with something suitable from my considerable stock, and my conversion efforts were a waste of effort. As previously stated, I knew the set had suffered damp, and although dry when I got it, I suspect the damage had been done. Mains transformer failure is uncommon in my experience.



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Miscellaneous items were cleaning the heavy knobs, made by Hallicrafters, with their name embossed on the rear. I soaked them for a day in hot detergent water, then used a toothbrush to clean both them and the tuning scales. They are better but the material has gone distinctly yellow with age, no cure to that.

My suspicion about the trimmers being got at proved right. On applying a signal generator, all the signals tuned high so the local oscillator was running low, and sensitivity varied from quite good to poor. Aligning the IFs first, some made a lot of difference, all needed adjusting. I got about 40dB improvement in sensitivity, 100 times in linear voltage terms, so a great deal. As to the RF sections and local oscillator, I had two slightly different versions of the circuit, ambiguous alignment instruction about how to set the fine-tune, and a set with a trimmer from oscillator anode to ground, not shown on either circuit, but a fixed capacitor of illegible value on one. Further, the trimmer was not the type to need the mounting holes in the chassis, but I was sure the soldering was original, and anyway it was jammed solid. Not a great situation. Suffice it to say that after a lot of fiddling about, I did get the front-end aligned, and the sensitivity was generally good, as shown in **Table 1**.

The signal used was from a 50Ω generator, 40% modulated. The range of input levels used reflects the quite large range of SNR (signal <plus noise> to noise ratio) encountered. The figures are not as good as they could be if the set aligned properly, but with the exception of that at 17Mc/s, are pretty good. As per instruction I had a 390Ω resistor in series with the antenna input.

Conclusions

It should be noted that without bad storage and incompetent attention, it would have needed little attention, just a handful of capacitors changing.

The set is of a fairly conventional design, built on a solid chassis with generally solid components. The scale is fairly cramped as is so often the case. It needs a fifth band but that is expensive. The amateur bands are highlighted but some are only a few millimetres long.

I suggest it wasn't the best set for amateur use, even with bandspread signals were very close, and that was with a random-wire antenna and at sunspot minimum. I think it may have fallen between two stools – too expensive because of all it offers for the lower end of the market, but lacking the greater ease of use of say an HRO or AR88 at the more expensive end. A nice set though.

The SX20 was much the same, but with push-pull output and a bass boost switch. Did they anticipate the Ghetto Blaster?

Band	Trim freq	SNR	Padder freq	SNR
1	1400kc/s	11dB @ 5μV	600kc/s	16dB @ 5μV
2	4Mc/s	10dB @ 1μV	2Mc/s	14dB @ 1μV
3	14Mc/s	15dB @ 10μV	7Mc/s	10dB @ 1μV
4	34Mc/s	18dB @ 10μV	1 Mc/s	10dB @ 50μV

Table 1: Measured parameters