Vintage Radio

By Ian Batty

DKE38 Deutscher Kleinempfänger

Germany's Third Reich produced at least two significant products to appeal to the common people. The first was the Volkswagen or "People's Car" and the second was the Volksempfänger or "People's Radio". This was followed by the smaller, more economical German Small Radio, the DKE38 Deutscher Kleinempfänger which was a 2-valve regenerative set and was manufactured by a number of German firms.

Germany, battered like most of Europe by four years of war ending in 1918, had endured barely a decade of political turmoil when the Great Depression hit the Western world.

The 1930s saw opposing political parties struggle for supremacy from which the National Socialist Party emerged. Leaving the next twenty tragic years to the historians, how was such a takeover of a modern nation possible?

Warning High Voltages!

Note that the circuit has no power transformer so it is potentially lethal to the touch since the circuit can be at the full 230VAC mains voltage. If you are working on it, you must use a 230:230VAC isolation transformer.

Apart from major political rallies, radio was an important tool in this process. Then, as now, stations could be set up at moderate cost and could, with enough power, reach every receiver of an entire country.

With government control of licensing, radio is an ideal medium for spreading ideas and opinions, for good or ill. Joseph Goebbels seems to have recognised this potential early on.

So as part of national reconstruction, ordinary people were offered two important pieces of technology we take for granted today: a car and a radio. And the People's Radio was always intended to serve political ends, at least as much as simply benefiting the population.

Both the VE301 Deutscher Volksempfänger and the DKE38 Deutscher Kleinempfänger were designed by engineer Otto Griessing, at the request of Propaganda Minister, Joseph Goebbels. The larger VE301 was a 3-valve regenerative circuit with a pentode demodulator followed by an output pentode and a full-wave rectifier for the mains power supply.

Cheap as it was, the VE301 cost around two weeks' average wages, so an even cheaper design became attractive and the DKE38 filled the bill at half the price. With a triode-tetrode (in the one envelope) doing all the "signal" work and a rectifier, the Kleinempfänger is even simpler than a set I built as a lad back in the late 1950s.

So let's check out the D(eutsche) K(lein) E(mpfänger) 38, which appeared in 1938. I've two main reasons for this investigation: how good can a radio be with just two active stages, and how can a minimal regenerative set compare with a minimal superheterodyne radio, such as the Astor DLP

I reviewed in the October 2016 issue?

The VE301 and DKE38 both cover the standard broadcast (Medium Wave) band and 145~400kHz of the Long Wave band. Both bands had been used for broadcasting since around 1920, principally for local and national broadcasts.

Some debate continues to this day over the design. Was it just a cheap-and-cheerful mate to the Volkswagen "beetle"? Perhaps the VE301 was deliberately designed to prevent owners from tuning in to politically-undesirable shortwave broadcasters such as the British Broadcasting Corporation.

Regeneration

Early valve amplifiers had been bedevilled by "howling" which was oscillation due to anode-grid feedback. Generally regarded as a curse, the effect was investigated by a young engineer, Edwin Armstrong. He seems to have reasoned that controlled feedback could greatly increase a receiver's gain.

By 1912, Armstrong had developed his regenerative technology to the point where he was able to pick up messages between San Francisco and Honolulu. Remarkably, Armstrong was in New York; well away from the intended transmission path. He also detected transatlantic signals from Ireland, a feat achieved only with difficulty by Marconi's much larger and more complex TRF receivers.

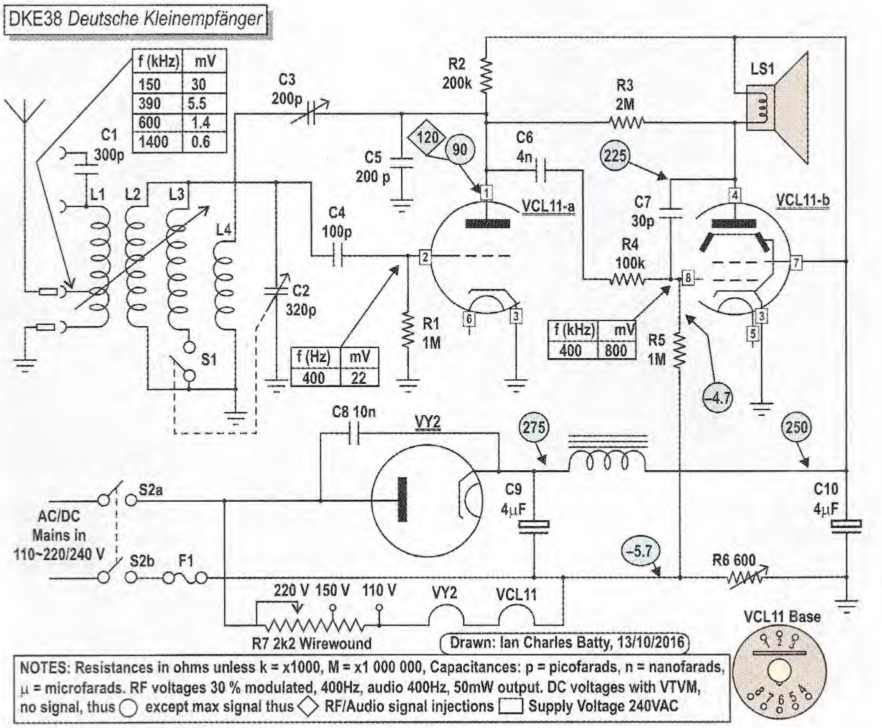
DKE circuit description

Active functions are handled by the VCL11 triode-tetrode. It has an 8-pin base most commonly seen on German metal valves. It uses a 50mA heater and while this seems very low for any heater current, the heater voltage of 90V gives an actual consumption of around 4.5W for both sections.

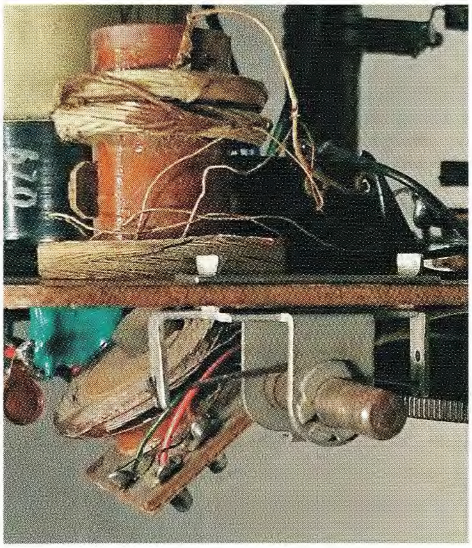
Note that the heaters of the rectifier diode and the triode-tetrode are both in series with a tapped 2.2kΩ wire resistor, R7, which enables the heater current to be correctly set to suit the incoming supply voltage.

The triode is a high-mu type, while the tetrode manages a creditable 4200 microsiemens, considering its low heater power. Note the cathodes of both valve sections are connected to pin 3.

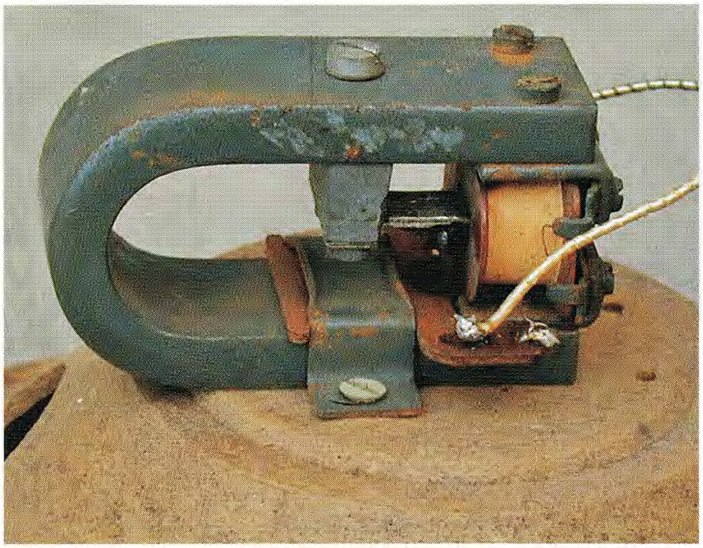
The incoming signal is tuned by L2 (in parallel with L3 on the MW setting) and variable reaction capacitor C2 and then fed to the grid of the triode via



The circuit of the Kleinempfänger DKE38 is unusual for a number of reasons: it is transformerless and therefore the chassis is live; the fuse can be in the Active or Neutral line; the loudspeaker is a moving-iron type with no transformer coupling and the bias for both valves is unconventional. The circuit also has no volume control; this is provided by varying the aerial coupling.



This shaft (left knob) varies the coupling between the primary and secondary aerial coils to provide the volume control.



This close-up shot shows an example of a typical moving-iron loudspeaker. Note that the driving coil is driven directly from the plate of the tetrode without an output transformer.

100pF capacitor C4. C4 allows grid leak bias to develop across 1MΩ resistor R1; if C4 was not present, the antenna coils would prevent grid leak bias.

The amplified signal appears at the anode and is fed back via adjustable capacitor to C3 to L4 which then couples back to L2 & L3 and of course, then feeds back via C4 to the triode grid.

This means that the grid signal is increased. If you're thinking this would make a good oscillator, you're right. It's got the potential to set up the "howling" oscillation described above. But if we carefully control the amount of positive feedback, it's possible to lift the stage gain from around 40 times to well over 100.

There's a mechanically-variable coupling control for volume acting on the aerial coil's primary. The above photo shows the tuned/reaction windings on the top side of the phenolic chassis, with the "swinging" primary winding and its control mechanism below.

Band-changing occurs when the tuning dial passes the midpoint of its rotation. LW operation uses a single secondary winding. For MW, S1 puts the second winding in parallel to reduce the total circuit inductance, just as resistors in parallel give a total lower value.

The dial is calibrated with 0-100 markings; red for LW, plain for MW. Given that tuning accuracy is affected by the regeneration setting, showing tuning frequency or station markings would not have been practical.

As well as an amplifier, the circuit is a leaky grid demodulator, ie, a diode of sorts. "Grid leak" resistor R1 is commonly 1MΩ or greater. This allows the grid to drift weakly negative. The valve will now rectify any incoming signal; positive-going signal peaks will push it to maximum anode current, negative-going peaks towards cutoff.

The net effect is much greater amplification of the negative signal peaks. The amplified signal is developed across the 2MΩ resistor R3, with filter capacitor C5 partially filtering the RF component in the process of demodulating the audio, which is then fed to the grid of the output tetrode via capacitor C6 and resistor R4.

The output stage's grid bias is developed across R6, a factory adjustment which sets the output stage's anode current. It's a classic back bias arrangement and not, as described in one online article, designed to reduce HT supply hum. The bias is fed to the grid via resistor R5.

Some confusion exists regarding coupling components R3, C7, R4 and C6. Taking C6 first, it's the usual coupling capacitor from the driver to output, in this case from the triode's anode to the tetrode's grid.

R4 would usually be a stopper resistor, placed so that it damps parasitic oscillations in the tetrode. But here, it appears in combination with 30pF capacitor C7.

Ineffective at audio frequencies, C7 provides negative feedback at above-audio frequencies to filter out any of the original RF carrier from the output audio. R4 is needed to prevent C7's feedback affecting the demodulator's RF operation.

R3 provides conventional negative feedback from the output stage's anode back to the demodulator and thus to the output grid.

Moving-iron loudspeaker

The loudspeaker requires special mention. For a start, it is a moving-iron arrangement, with the cone attached to an iron pole-piece instead of a voice coil, as in a conventional dynamic speaker.

Second, it has a very high DC resistance of 2kΩ and an even higher impedance of 17kΩ at 1kHz, which means that this can be driven directly from the tetrode's plate rather than using an output transformer. The plate current flows through the loudspeaker's field coil but it is only 12mA and not likely to cause much additional distortion.

The pressed cardboard "basket" may seem pretty agricultural, but it does not need the steel basket we see used in dynamic speakers (needed to hold the voice coil, magnet and cone in alignment).

The moving-iron type's "motor" contains all parts except for the outer rim of the cone. Since this outer rim does not need precise positioning, the pressed-cardboard basket gives adequate strength and stability while economising on costly steel. Eliminating the output transformer also saved steel and wire; highly necessary in pre-war Germany.

The moving-iron speaker can also use a high-impedance winding that matches directly to the output valve. This eliminates the costly and bulky output transformer needed for

The DKE38 shown with the original moving-iron loudspeaker. Note the vertical tapped resistor which is used to set the filament current in the rectifier and the triode-tetrode. The preset control is R6 which was adjusted by the factory to set the back bias for the tetrode section.

matching to the low voice coil impedances of dynamic speakers.

The lack of a power transformer has already been mentioned. One side of the mains supply is fed through the double-pole switch S2 to the anode of the rectifier diode, VY2.

The output from the cathode feeds a standard pi filter, with two 4μF capacitors, C9 & C10, together with an iron-cored choke. R6, between the negative terminals of the two capacitors, develops the back bias for the grid of the output tetrode, as mentioned above. C8, across the diode, is there to reduce rectifier buzz.

Appearance and controls

The DKE38 has a very spartan Bakelite cabinet with simple controls: the left-hand knob, volume, adjusts the coupling between the aerial coil primary and its tuned windings.

The central tuning control tunes either the Long Wave or Broadcast bands, with the change-over occurring at the middle of its 360° travel. The right-hand "regeneration" control adjusts feedback from the triode's anode to a regeneration winding on the aerial coil assembly.

The set is constructed on a fibre composite chassis with point-to-point wiring. It's pretty much a double-sided breadboard radio. My set's mains cord anchoring consisted of one mains wire doubling through a hole in the chassis – not even close to safe.

The top view of the chassis (on the last page) shows the 8-pin VCL11 socket at top left, above the aerial coil. The VY2 rectifier socket is towards the right, above the filter choke with the two main filter capacitors at the right-hand edge. The tuning capacitor occupies the lower centre.

Original parts are easily spotted: any large enough to be branded bore the Reichsadler "Imperial Eagle" symbol. The underside view shows the aerial coil at lower right, with the large tuning knob in the centre. Minor components are wired point-to-point under the fibre/composite chassis.

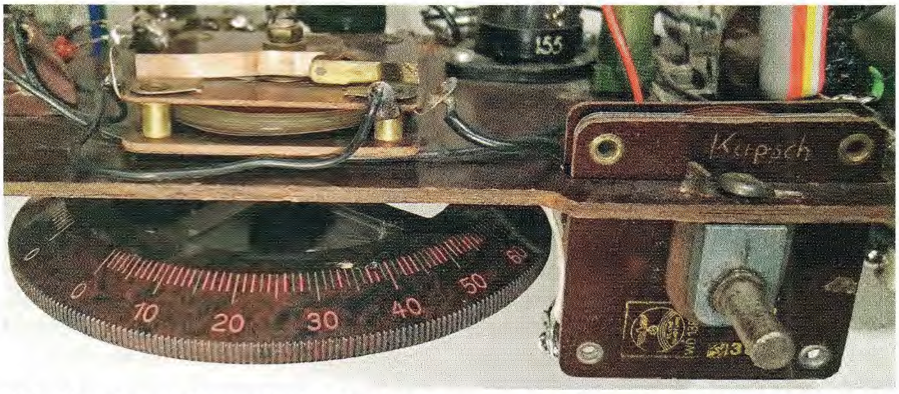
The aerial coil primary offers two tappings for different lengths of aerial wire, with a third connection via 300pF capacitor C1. The adjustable regeneration and tuning capacitors both use plastic dielectrics.

This makes them compact but also easier and cheaper to manufacture than air-spaced versions which must be made to high precision to preserve plate spacing. There's a bonus for the tuning capacitor – it can rotate through a full 360°, allowing the set to change bands (as noted below) simply by turning the knob past the end of the current band.

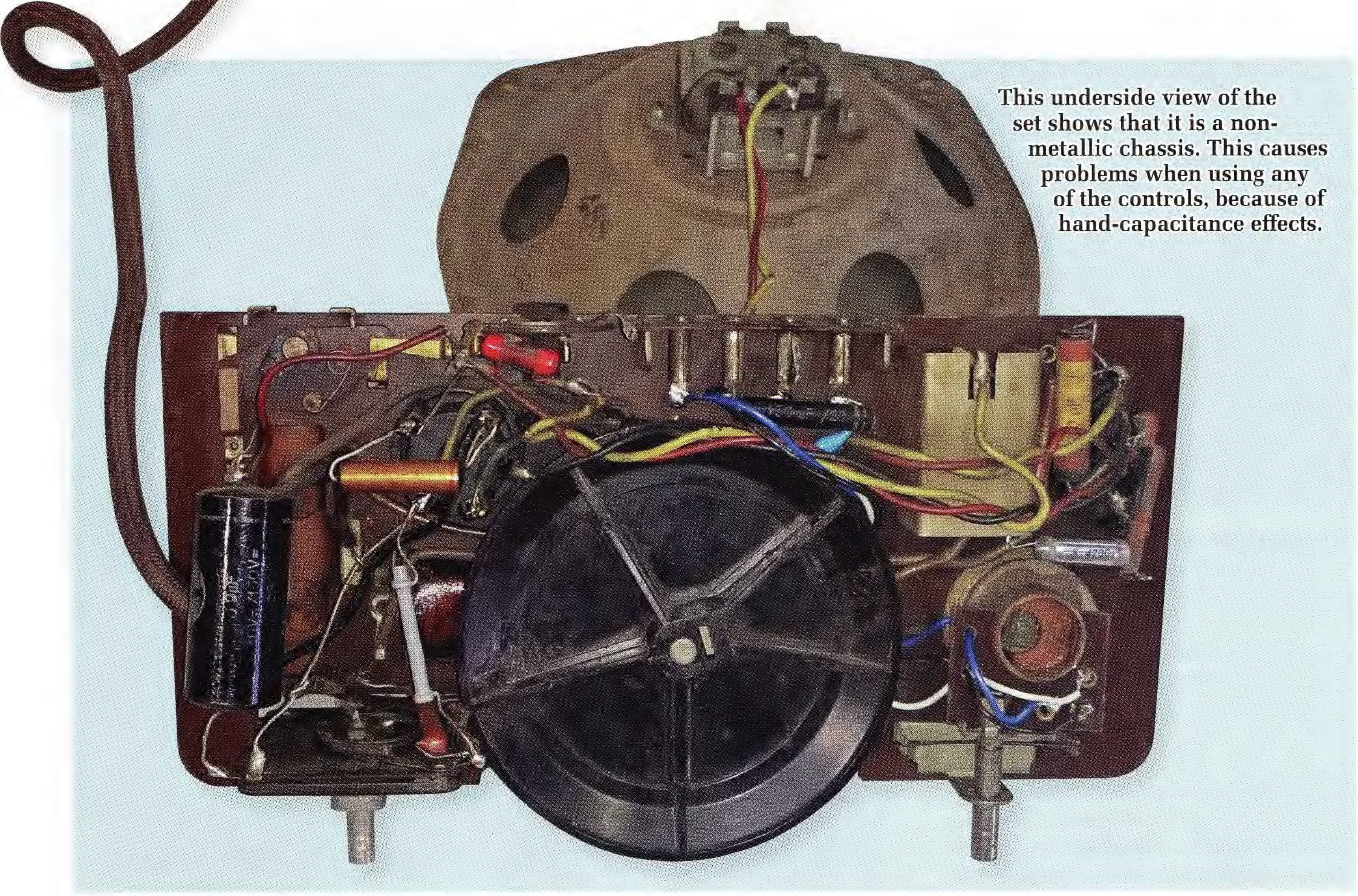
The picture directly below shows the "flat" solid-dielectric tuning capacitor on top of the chassis, with its tuning knob below. The band-change contacts are just visible on top of the tuning capacitor. The vertically mounted reaction capacitor is on the right-hand side with its tuning shaft pointing forward to pass through the front of the case.

Making it work

As purchased, the physical condition



This shot shows the tuning knob which covers the LW and MW bands. The knob on the right is the regeneration control.



This underside view of the set shows that it is a non-metallic chassis. This causes problems when using any of the controls, because of hand-capacitance effects.

of the set was good, although the chassis was understandably dirty and dusty. A brush had little effect, so I turned to one of those microfibre kitchen scourers. Used dry, it cleaned off all the dust and left a light polish on the fibre composite chassis.

The Bakelite cabinet was shiny with no noticeable blemishes, it had the original knobs, and the Reichsadler emblem was undamaged. You'll find some examples where that emblem has been defaced, presumably due to its association with the Nazi Party. A second set, bought while this article was in preparation, was defaced. However, I used it for some internal photos as it's pretty well original.

Electrically, the review set had been restored "to some extent". Many components had been changed and the original moving-iron speaker had been replaced by an oddball dynamic speaker of some 300Ω impedance and a 3600Ω series resistor. Not surprisingly, I couldn't get a peep out of it. A junkbox 240~30V transformer gave a pretty good match for the substitute speaker and I was able to get some operation.

I also noticed a 200pF capacitor connected between the Earth connection on the aerial socket bar and the "low" side of the mains. I'm guessing this was to capitalise on mains earthing and eliminate the need for a separate earth wire. Be aware that, if such a capacitor fails (or even becomes leaky), you've got a 50-50 chance of putting your aerial system at lethal 230VAC mains potential.

Even so, the set still didn't work as well as I expected, so I popped in a spare VCL11 I'd bought some time ago. Then it was time to take it for a test drive. All measurements were made with an isolating transformer and a 220VAC supply, as I didn't want to stress this rare set with the full mains voltage.

So how did it go? For a set made some 80 years ago, with just two active elements; pretty well. But if you're expecting "superhet convenience", you'd be disappointed.

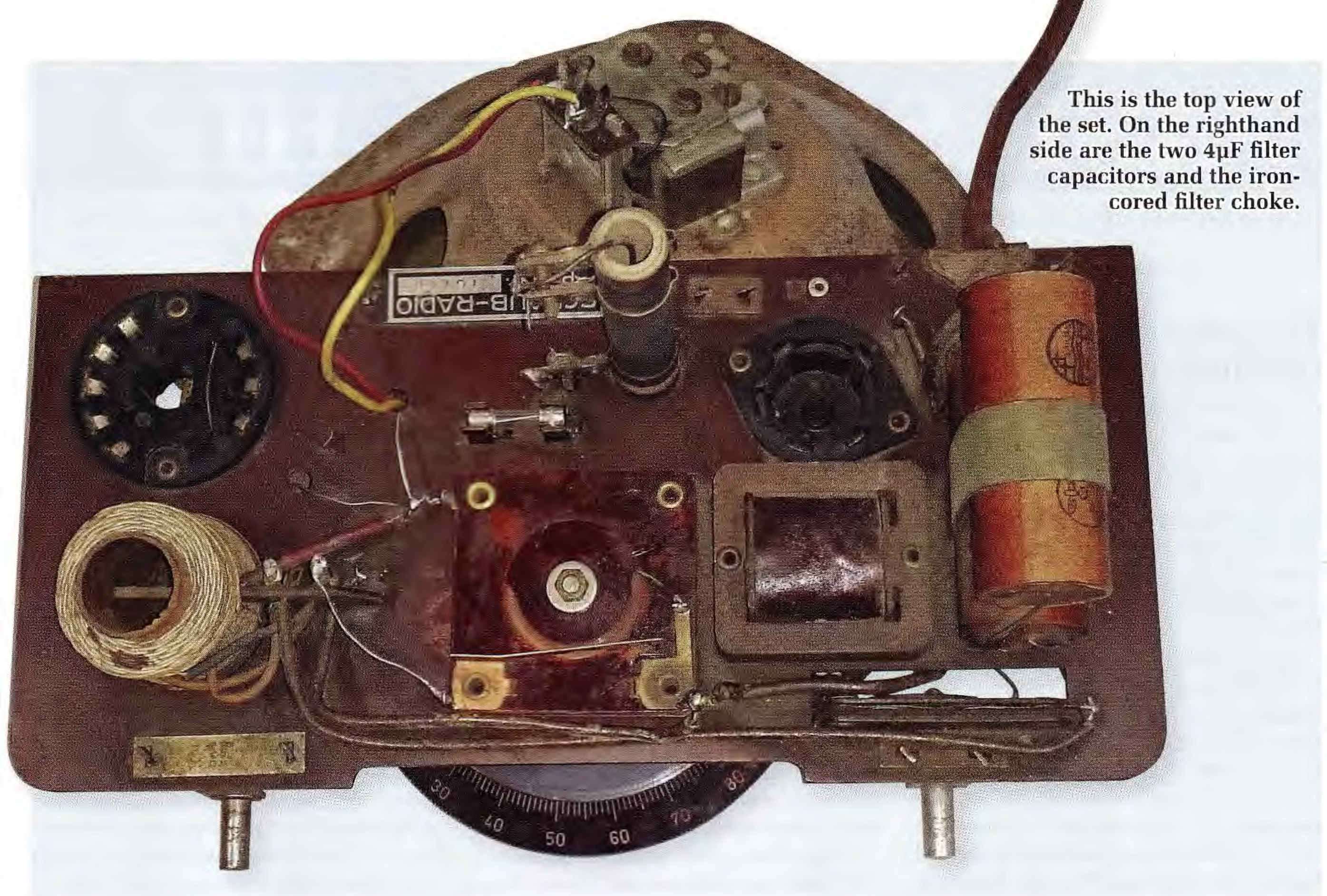
At maximum sensitivity, the Kleinempfänger suffers from hand capacitance effects when tuning or adjusting it – the Bakelite case and chassis simply can't provide the levels of grounding and shielding we take for granted with a metal chassis. This set also demands careful adjustment for optimal performance.

I measured the sensitivity first. Using the standard dummy antenna between my signal generator and the set, for 50mW output, the LW band needed 25mV at 145kHz, and 3.5mV at 400kHz. For the MW band, it was 1.4mV at 600kHz and 600μV at 1400kHz. Removing the dummy antenna improved the 150kHz sensitivity to 600μV, implying that actual performance will depend on aerial wire length.

As expected, bandwidth varied with the degree of regeneration. For the LW band at 145kHz, it was only a few hundred Hertz at full regeneration and ±800Hz with a 10dB reduction. At its top end (400kHz), full regeneration gave a bandwidth of ±800Hz, with a 10dB reduction giving ±1200Hz.

For the MW band, full regeneration 480kHz bandwidth was under ±200Hz (really!) and ±500Hz at reduced regeneration. At 1630kHz it was ±3900Hz and ±7900Hz respectively.

These figures reinforce the general problem with Tuned Radio Frequency sets of all kinds: bandwidth varies drastically with tuning and regeneration simply exaggerates the effect. At the low end of the MW band, just at the point of oscillation,



This is the top view of the set. On the righthand side are the two 4μF filter capacitors and the iron-cored filter choke.

radio broadcasts sound like they're coming down a drainpipe.

What if we eliminate regeneration? Disconnecting it completely demanded some 270mV of input at 600kHz for 50mW out. Remembering that optimal adjustment gave 50mW out for only 1.4mV in, this implies a "regeneration gain" of up to 200 times; as much as an extra (very good) RF amplifier. It's evidence of Armstrong's revolutionary improvement to receivers in those long-ago "pre-superhet" days.

What about responses to signal strength? Output rises from zero signal to a certain level (depending on aerial coupling and regeneration), then flat-lines. For a 50mW output setting, I could increase the input by some 50dB and get no significant rise in output power.

What's happening here is that, as signal rectification increases grid bias, anode current and thus stage gain both fall off as the input signal increases. In circuit, there's a marked rise in the triode's anode voltage with rising signal strength.

Audio performance will depend partly on the speaker (for a moving-armature type) or on the output transformer for a dynamic speaker. Using a representative output transformer, the low-frequency –3dB point was 130Hz. High-frequency response varied greatly, as the RF bandwidth figures indicate. High-frequency response is markedly reduced at maximum regeneration.

Maximum audio output varied frustratingly with aerial coupling, tuning and regeneration. The best was some 140mW but a more reliable clipping figure of 100mW gave some 10% THD (Total Harmonic Distortion).

While 100mW is much less than the customary valve mantel with a 6V6 output stage, it's comparable to many transistor mantels such as the Astor M5.

At 50mW output, THD was around 5%, about 7% at 10mW output. Direct audio injection gave a maximum output of some 500mW with visible distortion. In practice, it reaches 10% THD at around 200mW.

Is it as good as the Astor DLP? The answer has to be no. The DKE38 is not as sensitive, its audio response varies widely, it has lower audio output and is much harder to get the best results from. The DKE38 makes the case for the combination of superhet circuitry and ganged tuning capacitors.

Would I buy another one? During this project, I did. It came at a good price but with one drawback. Otherwise pretty original (including the speaker), it had its Reichsadler symbol defaced, as noted above. You can expect to pay upwards of $1,000 for an all-original, working DKE38.

All told, the Kleinempfänger DKE38 is a remarkable piece of minimalist engineering, and one of the last regenerative sets made in large numbers and offered for sale to the general public.

Further reading

Ernst Erb's Radiomuseum has an extensive collection of circuit, photos and German-language operating manuals. Go to the home page and enter DKE38 into the search bar:

www.radiomuseum.org/

There's an extensive article on Phil's Old Radios:

http://antiqueradio.org/KleinempfaengerDKE38.htm

I've focused on the DKE38's technology in this article. For a reminder of its actual political environment, with examples of propaganda posters, try Phil's Old Radios on the VE301:

http://antiqueradio.org/VolksempfaengerVE301dyn.htm SC