Lorenz Short Wave Receiver Lo6K39a
The Ultimate Tuned Radio Frequency Set?

by Dick Rollema, PA0SE

In *German World War II Radio Equipment* (*RB65*) several aspects of the construction of these radios were discussed and illustrated by the FUG10 aircraft radio equipment.

We will now have a look at another example: short wave radio receiver type Lo6K39a, a tuned radio frequency (TRF) set, made by Lorenz.

'Lo' stands for 'Lorenz'; '6' means there are six tuned circuits, 'K' means 'Kurzwellen' (short wave); '39' is the year the set came into operational use and 'a' means that capacitors of standard types were used.

The German forces used quite a lot of TRF sets, though superheterodyne receivers with single-knob tuning (ganged variable capacitors for the input tuned circuits and local oscillator) were known since about 1932. It is sometimes said there was fear that radiation from the local oscillator in a superhet would enable the enemy to locate the set by

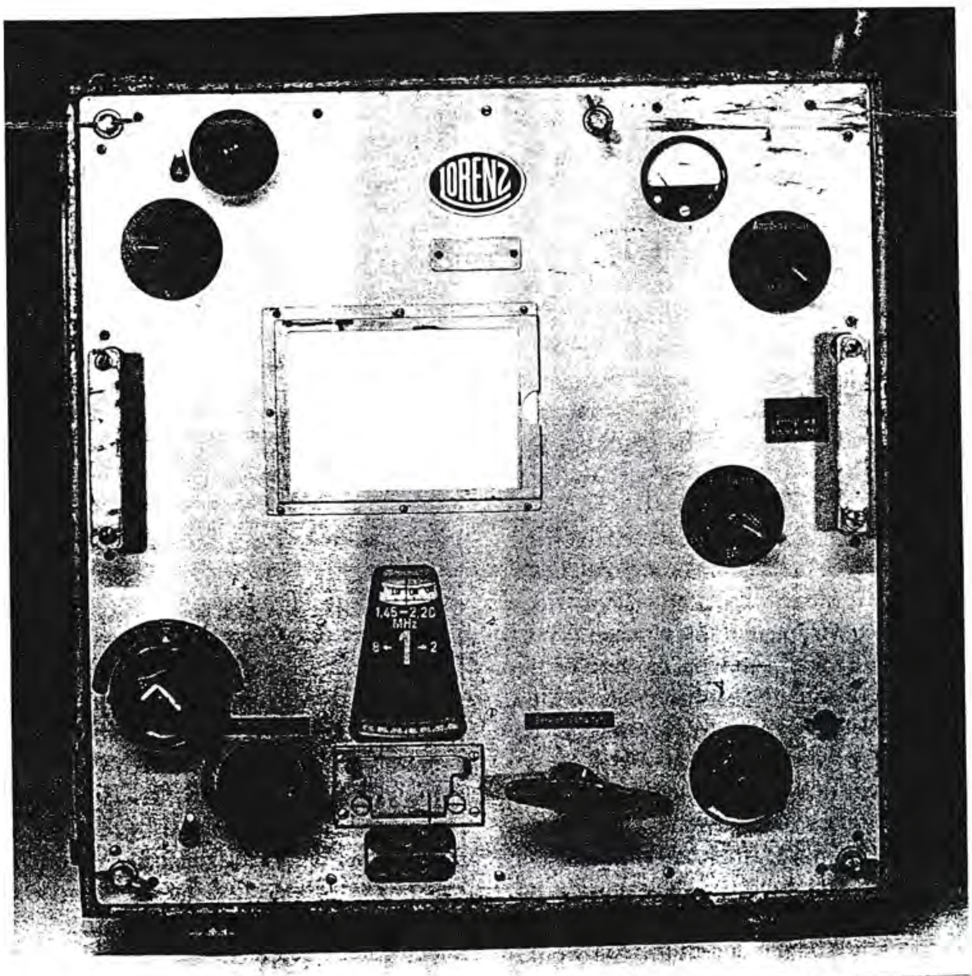


Photo 1 – Lorenz TRF receiver Lo6K39a. The set belongs to the collection of Mr Cas Caspers, PA0CSC, of Veldhoven near Eindhoven direction finders. The German superheterodynes were always very well screened and featured extensive selectivity before the mixer with three or more tuned circuits. It is difficult to imagine how the oscillator signal could reach the antenna via these circuits which are tuned to a frequency that differs from the oscillator frequency by the intermediate frequency.

Radiation could just as well be feared for a TRF receiver, which for telegraphy in the A1A mode (keyed carrier) is operated with an oscillating detector. True, the amplitude of the signal is much smaller than of the oscillator signal in a superhet but in the TRF set the input circuits resonate at the frequency of the oscillating detector, so transmission of that signal through these circuits to the antenna is more likely. It has been reported that a German raider during WWII indeed managed to locate merchant ships sailing on their own, not in convoy, by direction finding on the signal radiated by their receivers. Presumably these ships had rather old-fashioned equipment, perhaps with an oscillating detector directly coupled to the antenna.

The German Navy (Kriegsmarine) had another reason to dislike the superheterodyne receiver: its spurious frequency responses (second channel or image frequency and higher order products of the mixing process). On board ship, transmit and receive antennas are close together. Transmitters may be active with reception on other frequencies taking place at the same time, so the risk of spurious responses is a very real one.

The Lo6K39a was not only used on shipboard but was also the main receiver in the land-based stations that were in contact with the German submarines.

General description of Lo6K39a

Lorenz developed the Lo6K39a according to a specification issued by the Kriegsmarine in 1937. The author had access to the technical manual for the set and the first line in that comprehensive booklet neatly summarises what it is. In translation it says something like 'Short wave receiver Lo6K39a is a five valve tuned radio frequency receiver with six ganged tuning circuits. A sixth valve serves for frequency calibration'.

Photo 1 shows the front panel of the receiver. The dimensions are 538mm high, 500mm wide and 320mm deep (21.2 × 19.7 × 12.6in approx.). That is without the shock absorbing feet, on which it was normally mounted for shipboard use. The radio is built like the proverbial battleship and that is reflected in its weight, a solid 65kg (143lb approx.). The radio covers 1.5 – 25MHz in eight sub-bands that cover the following ranges according to the specifications:

Range 1: 1.50 – 2.135MHz
Range 2: 2.135 – 3.05MHz
Range 3: 3.05 – 4.33MHz
Range 4: 4.33 – 6.16MHz
Range 5: 6.16 – 8.74MHz
Range 6: 8.74 – 12.40MHz
Range 7: 12.40 – 17.60MHz
Range 8: 17.60 – 25.00MHz

In practice there is some overlap between ranges. The relatively small frequency segments of each range, together with the 50:1 slow-motion drive makes for very easy tuning, up to the highest frequencies. But it is made even easier by the outer one of the two concentric knobs to the left of the dial window, which varies the tuning of the detector circuit over plus or minus 3kHz around the frequency set by the main tuning control. The inner knob varies the gain of the receiver. The main tuning knob is the left-hand one on the bottom row. The tuned frequency can be read from a separate scale for each sub-band. There is no risk of reading the wrong scale because a window in a mask that rotates with the band selector control displays only the scale to be used. Below it is a logging scale and on top a blank scale on which marks can be entered by pencil through a hole in the glass cover. The mask also clearly shows the frequency range of the selected sub-band and by means of arrows even the direction the selector knob has to be turned for the adjacent sub-bands. Band switching by means of the crank on the right of the middle in the bottom row is very positive and imparts a sturdy feeling, like opening the door of a safe or an expensive old-time motorcar.

The knob on the extreme right at the bottom controls detector regeneration. The German designers certainly knew how to make a superb regeneration control. The detector moves smoothly in or out of oscillation without any backlash or fringe howl. The round object at the top left of the front

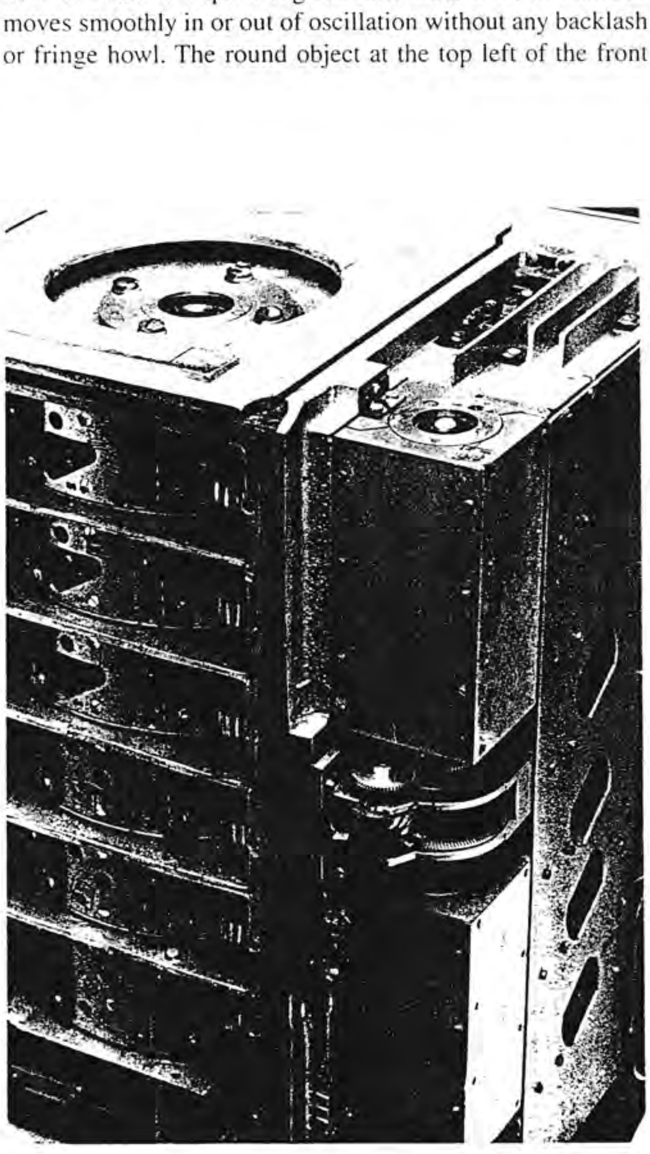


Photo 2 – Removing part of the screening reveals the coil turret panel covers a neon lamp that protects the receiver against high voltages on the antenna, e.g. from a neighbouring transmitter. Immediately below it to the left is a three-position antenna switch whose function will be explained later. Top right is a meter with a yellow and a red pushbutton. Operating the yellow button makes the meter indicate the 12.6V heater voltage; the needle should be in the yellow sector of the meter dial. Depressing the red button makes the meter show the anode DC voltage; the needle should now be in the red sector of the dial. The knob below the meter allows measurement of the anode current of each of the six valves; when currents are normal the needle is in the blue sector of the meter dial. For this the gain control must be at its maximum position and the frequency dial at zero on the logging scale (the reason for this will become clear later).

The meter switch is spring-loaded; when released it automatically returns to the starting position. The knob in the middle on the right operates an audio filter, tuned to 1000Hz and with a bandwidth of 200Hz at –3dB. The pushbutton below right activates a quartz-controlled oscillator for frequency calibration.

Finally below the dial window are outputs for a headphones and an 'Einheitsbetriebsgerät' (Remote control unit).

Circuit description

A simplified circuit diagram is shown in **Fig. 1**. Reference will also be made to **Photographs 2 and 3** that show the back of the receiver when taken out of its cabinet. Some of the screening covers have been removed to show the coil turret and three sections of the variable capacitor.

Inside the receiver a jumper can be set for either a high-impedance (end fed) antenna or a low-impedance one (with coaxial feedline).

Switch 4 in Fig. 1 is the antenna switch mentioned before. Position I is the one normally used for reception. In position II the input of the receiver is earthed. This permits listening to a local transmitter without overloading the receiver. Position III is used to tune a transmitter to the frequency of a station received. First the receiver is tuned to zero beat with that station in position I of the switch. Then the switch is moved to position III. Terminal 'zum Sender' carries a signal at low level from the transmitter, without any output to the transmit antenna (silent tuning). The transmitter is then tuned for zero beat in the receiver. The antenna is followed by a triple tuned bandpass filter and the first RF valve (1. Vorkreis, 2. Vorkreis, 1.HF-Verst.-Stufe). Neon lamp 5 shunts the first tuned circuit. The need for it follows from a German specification for all Kriegsmarine receivers that stated the receiver should be able to withstand a voltage of 200V RMS at the antenna terminal without blocking! The first RF valve is followed by a single tuned filter; the second RF valve (2.HF-Verst.-Stufe), another single tuned filter and the third RF valve (3.HF-Verst.-Stufe).

The gain of the receiver is controlled by potentiometer 30 that varies the screen grid voltage of the first two valves. The

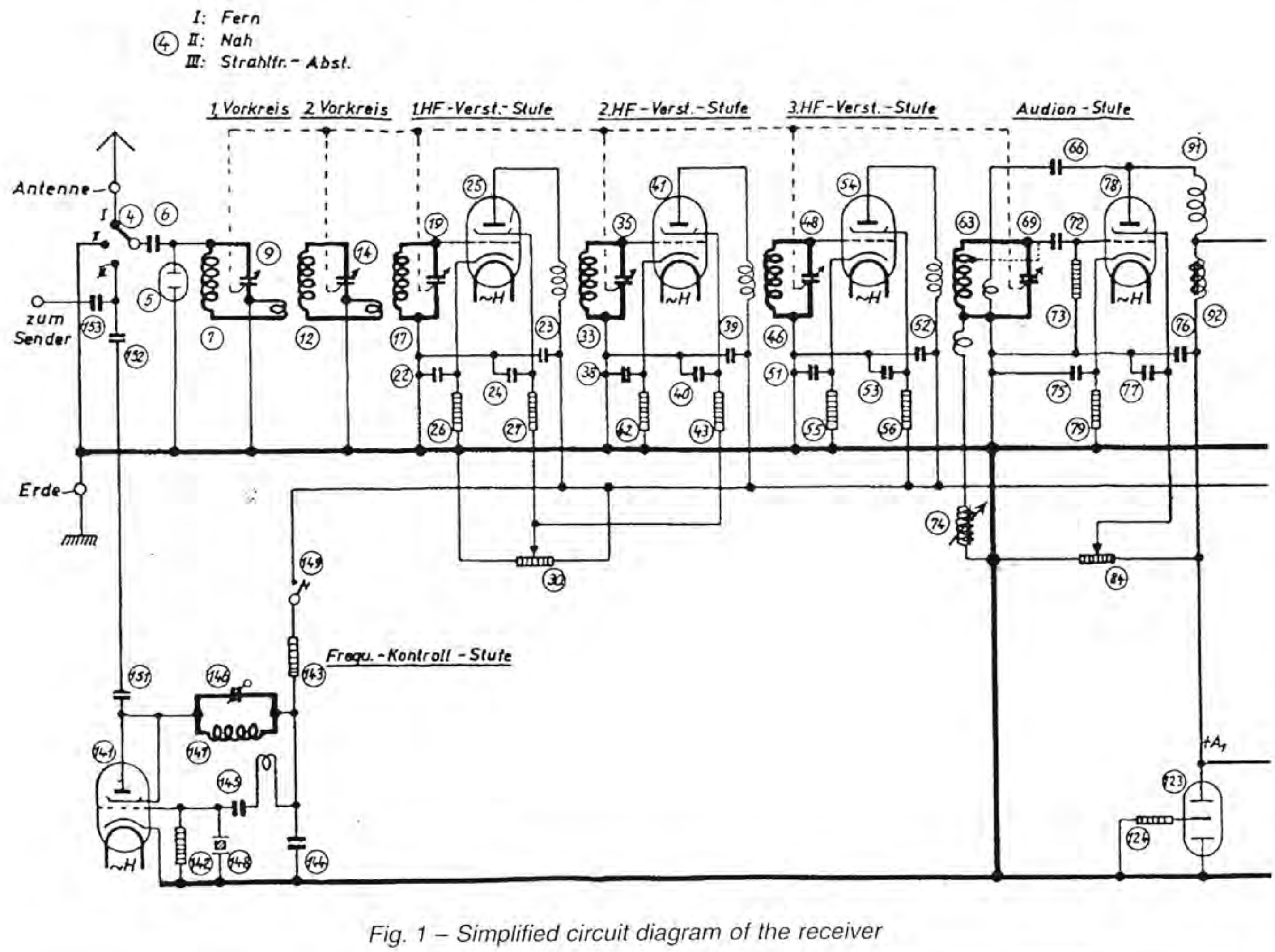
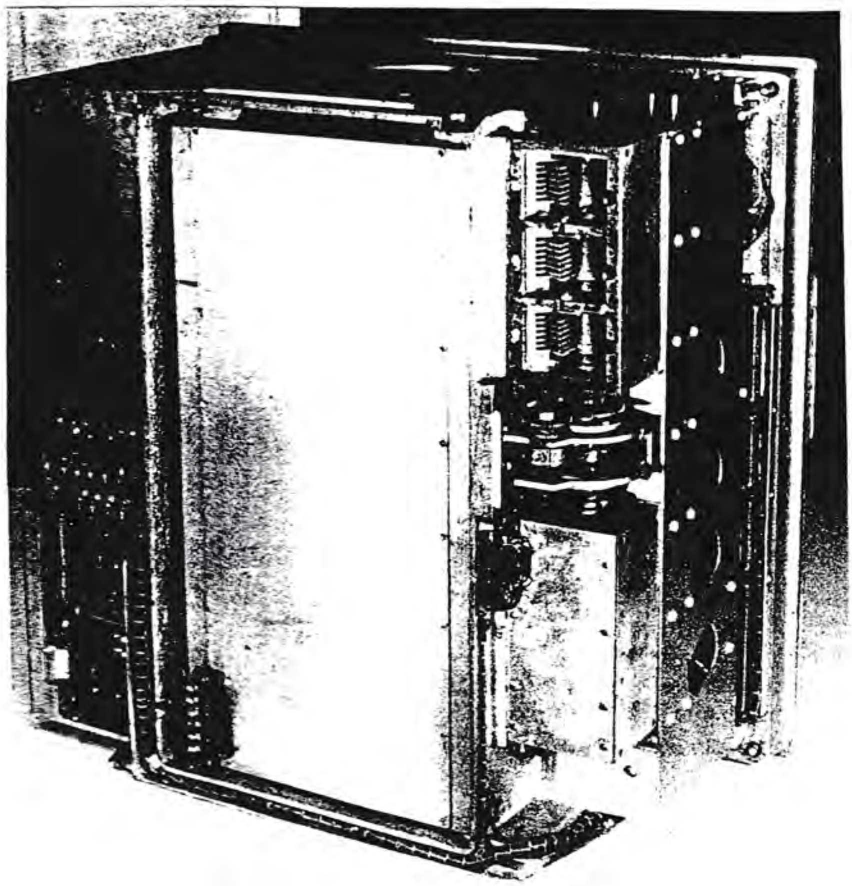
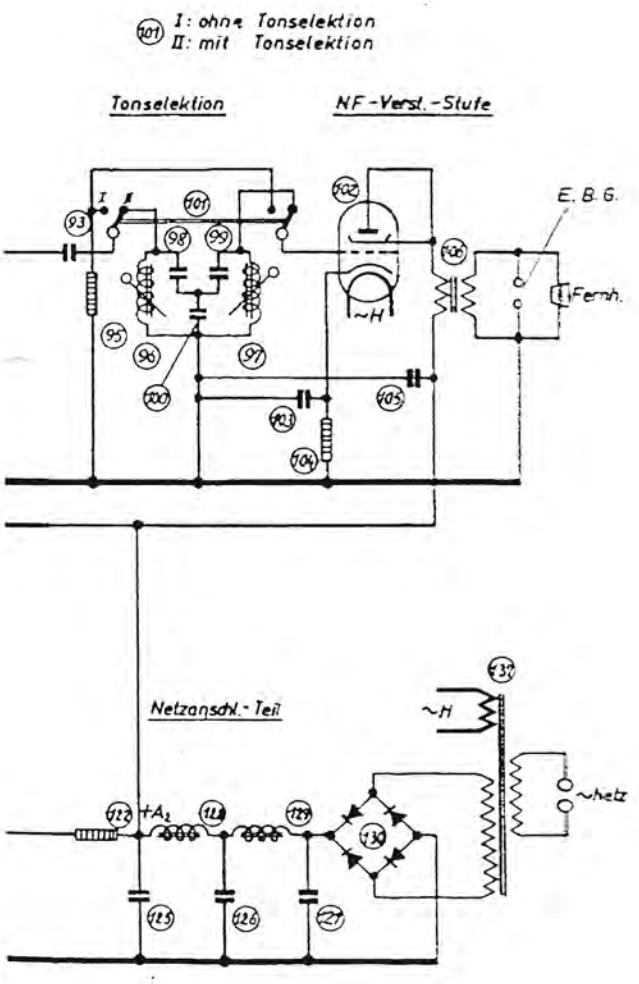


Fig. 1 – Simplified circuit diagram of the receiver

Photo 3 – One of the screening boxes has been opened to show three sections of the six-gang tuning capacitor. Between the boxes can be seen the potentiometer that keeps the gain constant when tuning over a frequency sub-band. The pot is driven from the shaft of the variable capacitor





third RF valve feeds the signal to the tuned circuit of the leaky grid detector valve (Audion-Stufe).

The impedance at resonance of a parallel tuned circuit is higher when the circuit is tuned to the high end of its tuning range (minimum capacitance) than at the low end. This affects the gain of the valve that precedes the circuit. That gain is the product of the mutual conductance (slope) of the valve and the impedance of the tuned circuit. The net result is that the stage gain increases when the circuit is tuned from low to high within a sub-band. As there are three RF valves, each with a tuned circuit following, the effect is aggravated and it would be necessary to adjust the gain control continuously when tuning to keep the gain and signal handling capability the same.

To counter this, the Lorenz engineers used a clever trick. In photos 2 and 3 a potentiometer can be seen between the two screening boxes at the right housing the variable capacitor. This pot is coupled to the shaft of the tuning gang by means of a set of gears, so it rotates with it. The pot controls the screen-grid voltage of the third RF valve in such a way that the voltage becomes lower when the set is tuned towards higher frequencies, so keeping the gain constant. (The potentiometer is not shown in the simplified diagram of Fig. 1.)

The detector features the already mentioned smooth regeneration control through varying its screen-grid voltage by potentiometer 84.

Already mentioned is the fine tuning control that varies the tuning over ±3kHz around the frequency set by the main control. The simple solution of a small variable capacitor in parallel with the main capacitor, as can be found in some

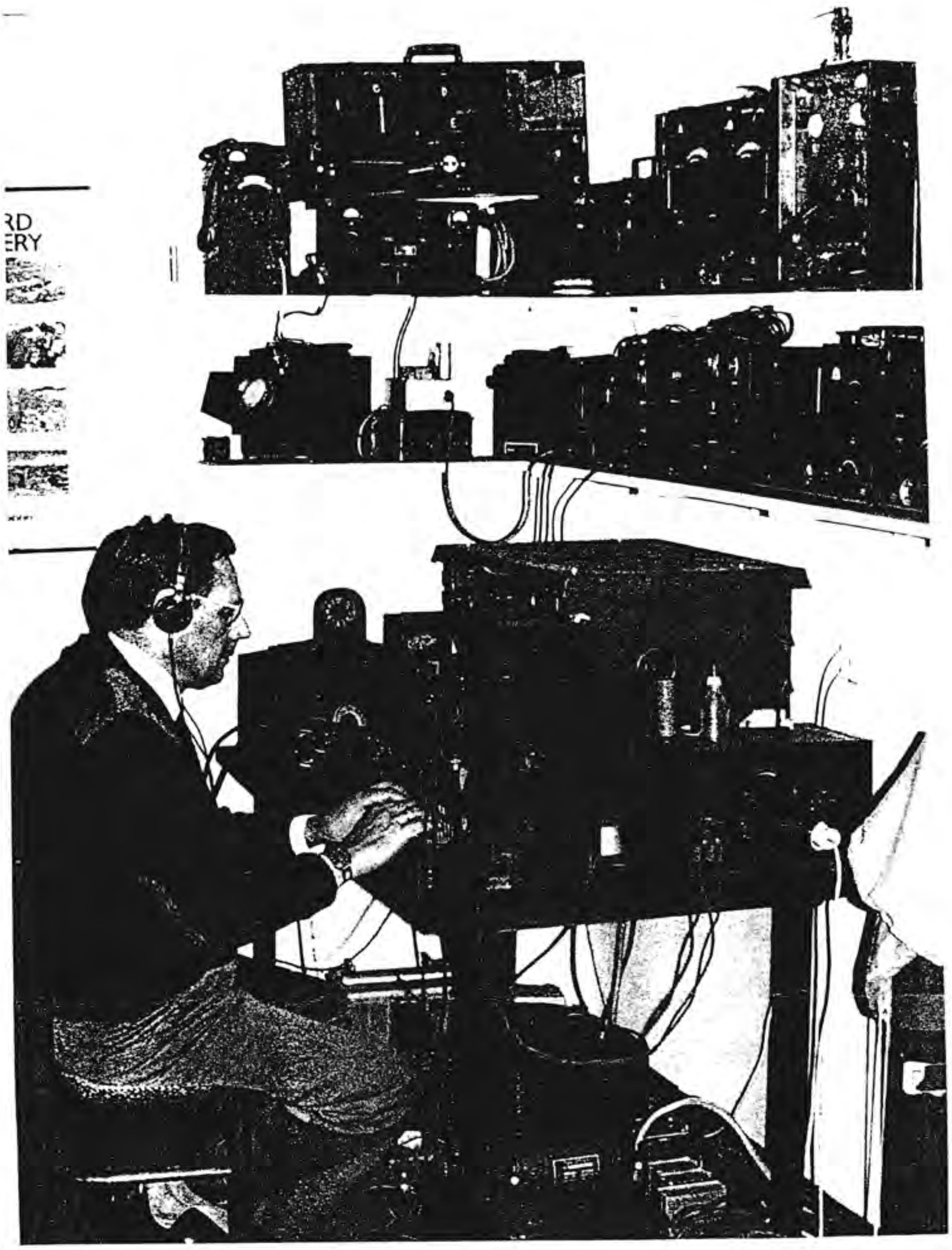


Photo 4 – Owner of the TRF set described is Mr Cas Caspers, PA0CSC, seen here typing on a German WWII Hellschreiber. At the left on the table is a Telefunken superheterodyne receiver type E52, also known as 'Köln', that will be the subject of a future article in RB

receivers for bandspread, could not be used because the frequency variation by the fine tuning control would be much higher when the main capacitor is at its minimum value than at its maximum capacitance. Instead a coil is used, the inductance of which is varied by moving a powdered iron core in or out; number 74 in Fig. 1. This coil is connected to the detector circuit via another coil per sub-band which is selected such that the desired frequency range of ±3kHz for the fine tuning control is achieved for each sub-band.

The coils are housed in a turret with six compartments, each of which contains eight coil sets, one for each sub-band. Before the turret rotates the contact fingers on it are lifted. When it has reached its new position the contact fingers are lowered again. A separate set of contacts interrupts the anode voltage for the RF stages and also the headphones are short circuited to avoid unpleasant crashing sounds when changing bands.

The detector is followed by an audio filter (Tonselektion) with two circuits tuned to 1000Hz that can be switched on by means of switch 101. The last stage (NF-Verst.-Stufe) is an audio amplifier that feeds the headphones and/or the 'Einheitsbetriebsgerät' (E.B.G.). That was a remote control unit that could be placed on, for example, the bridge of the ship. There was also a version for land-based use.

At the bottom left in Fig. 1 is the calibration oscillator. Its frequency is determined by quartz crystal 148 on 100kHz. With antenna switch 4 in position III and pushbutton 149 depressed a signal is heard at every 100kHz division of the frequency scales. If necessary a correction can be made by a screwdriver adjustment.

When a valve is changed the new one may have a slightly different input capacitance that would upset the frequency calibration or the tracking between the circuits. To counter this, every tuned circuit that has a valve following not only has the normal trimmer capacitor for alignment but also a second small one. When a valve has been replaced this trimmer is used for realignment on the highest frequency sub-band and all is well again.

A final remark on the power supply. The manual states that after some 1000 hours of use the anode voltage may become too low due to increasing internal resistance with time of the selenium rectifiers. It is then permitted only once to select a higher voltage tap on the secondary winding of the power supply transformer.

The receiver exemplifies several of the features described in *RB65*. For instance instead of a chassis a die-cast frame of a special alloy is used. Also the application of the same type of valve in all stages: universal pentode RV12P2000, a picture of which can be seen in *RB65* on page 8. The valve goes upside down into the valve holder that completely surrounds it. In photo 3 the bottoms of four of the valves can be seen through the holes in the panel on the right.

The coils have small dimensions but a high Q thanks to the use of powdered iron cores, developed by Hans Vogt.

Lorenz also made a TRF receiver that covered 75 – 1500kHz: type Lo6L39 ('L' for long wave). It looks exactly like the Lo6K39a and is electrically the same as well, apart from the different frequency range.

Specification of the Lo6K39a

As can be expected from a radio of this high standard the electrical specification is very complete, although in the days before WWII some of the electrical characteristics were specified in a different way from today.

Output is stated as the voltage over a pair of headphones with 5000 ohms impedance at 800Hz. The receiver noise should produce between 0.2V and 3.0V, with gain control at maximum and the detector just in oscillation for maximum sensitivity for CW. With maximum 0.2V receiver noise 2 microvolts input for A1A (CW) and 4 microvolts for A2A (MCW) should produce 1V output at the optimum position of the regeneration control. According to tests made by the author, a signal of 0.4 – 0.8 microvolt EMF from a generator of 50 ohms internal resistance produces a readable CW signal.

One probably wonders what sort of selectivity can be expected from a TRF set with six tuned circuits. The specs state selectivity as follows: at ±0.85% detuning a 103 times increase of signal is required to restore the response from a 2 microvolt signal at 4.62MHz (signal generator modulated with 400Hz at 30% modulation depth, mode A2A, regeneration control set just before onset of oscillation). We would say now that 0.85% detuning causes 60dB attenuation, which is certainly not bad.

Earlier we mentioned the fear of radiation from the local oscillator in a superheterodyne or the oscillating detector of a TRF set. Lo6K39a is also a good design in this respect; Lorenz states that the voltage at the antenna terminal is at maximum 10 microvolts on 20MHz.

There are many more interesting points in the specs but we will leave it at that.

Lo6K39a in use

Several years ago collector Arthur Bauer, PA0AOB, kindly gave the author a set on loan for evaluation and the help of his neighbour, a building contractor with bulging muscles, had to be enlisted to carry the monster (65kg!) up two flights of stairs to the shack in the attic. Operating the set fully confirmed what could be expected from the specification. The set had not been active for many years. Arthur did not realign the receiver before it was handed to the author. The only thing he did was to clean the moving contacts of the coil turret and capacitor gang with contact spray. Nevertheless the frequency calibration was found to be remarkably correct. The 100kHz crystal in the calibrator was spot on.

Tuning was as easy as can be, even single sideband on 21MHz, thanks to the fine-tuning control. As with most TRF sets the set is beautifully quiet. The receiver is at its best on CW. Again no trace of inter- or cross-modulation was found, not even during night hours in the crowded 40-metre band. And not a single spurious signal or birdie was observed, quite normal for a TRF set of course, but it is a reassuring feeling to know that when a signal is heard one can be sure it is a real one on the frequency the radio is tuned to.

The author remembers that at the test equipment department of the electronics firm where he was once employed, a Lo6K39a was used to check the purity of the output from a signal generator under test.

Acknowledgement

The author is grateful to Messrs Cas Caspers, PA0CSC (**Photo 4**) and Arthur Bauer, PA0AOB. PA0CSC made his Lo6K39a available for photography and also loaned the technical manual to the author. Both PA0AOB and PA0CSC provided extra information, not found in the manual, and they also checked the manuscript. ***RB***