To the average amateur, surplus is synonymous with outdated American military electronic equipment with little thought to the military part or what the equipment was actually used for. The following article concerns surplus of a different origin, how it works, was used, and is used today.

German World War II Communications Receivers

Technical Perfection
From A Nearby Past
Part I

BY DICK W. ROLLEMA*, PA0SE

Radio communication equipment, as used by the allied forces during World War II, is well known among collectors and lovers of wireless equipment from the past.

Communication equipment that was used by the German forces during the war is much less known; that applies not only in the United States, but for Europe as well. This may look remarkable as that same Europe formed one of the main theatres of war. Why was it that so much of the allied equipment was left behind after the German forces capitulated that war surplus shops flourished for many years after, whilst at the same time German equipment has been relatively rare right from the start of the post war period?

Not because these units were manufactured or used in limited quantities. One of the main suppliers of radio equipment, the Telefunken firm, employed some 40,000 workers, spread over 350 different locations, by the end of WW II. How many sets of different categories were made is unknown to the author. But it has been put on record that of one radio used in tanks, the so called “Bogegerät”, some 180,000 units were manufactured.

The reason that so little of the vast German production remained may well be that the allied forces that occupied Germany after it collapsed ordered that all radio equipment that was found was to be demolished. By the end of 1945, and the beginning of 1946 this order was changed in that equipment remaining at that time was not to be destroyed but dismantled. The components that resulted from that action formed the basis for German production of consumer radio equipment, a production that came to a faltering start at that time.

Not only thousands of radio’s ended under the crash hammer, also all drawings and other documents that supported design, development and production of the equipment went the same way so that hardly a trace of it was left. What we know about the background for the wartime production of German radio equipment has been reported orally by some of the leading men who were involved. Please don’t get the idea that the author condemns the decision to destroy all wartime German equipment. It was a completely understandable and justified decision. But it does explain why most of us radio amateurs, both in the USA and outside, are in general rather unfamiliar with the communication equipment that was used “on the other side.” And that is certainly to be regretted as this equipment was of exceptional technical perfection and beauty.

Of course some German WW II radio equipment escaped destruction and part of what remained found its way into the hands of collectors, some of whom specialize in German radio apparatus. By sheer coincidence your scribe came into contact with one of those specializing collectors, Arthur Bauer, PA0AOB, who lives near Amsterdam. Arthur owns a most beautiful collection of German WW II radio equipment. When I met him for the first time in 1977, his collection comprised more than ninety items. By today it must have passed a hundred easily. It is certainly no simple feat to bring together so much of this rare equipment.
Arthur scans the whole of Europe for it and he has his contacts in most of the countries of our part of the world. PAOAOB not only collects the German equipment, he also uses it for his contacts with fellow amateurs.

Photograph 1 shows Arthur, PAOAOB, making a QSO via a powerful German transmitter of WW II vintage. The receiver at the left of the transmitter will be described later in this series. Single sideband does not exist for Arthur, of course. Only c.w. and a.m. and a system of teletyping over radio, invented in the twenties by Dr. Rudolf Hell. The machines that use this system are called "Hellschreiber" ("Schreiber" means "writer" in German). The system is different from RTTY as we know it in that the characters are transmitted in a form of simplified facsimile (FAX). The received characters are printed on a paper tape as they are received as "pictures". The charm of it is that the receiving machine does not decode the characters as in normal teletype. The decoding is done by the operator who interprets the "pictures" on the tape as characters. Interference and or fading on the radio path can never result in a wrong character being printed. The picture of the characters may become blurred or smeared by the interference. But due to the supreme capabilities of the human eye and brain a lot of interference can be accepted before the received characters become unreadable. The price for this immunity against interference is increased bandwidth. The signal is about six times as wide as a radio teletype signal of the same transmission speed in characters per second. This is partly compensated by the fact that the Hell system of teleprinting does not need FSK as modulation mode. Simple on/off keying of a c.w. transmitter gives fine results. So in the end the Hell signal occupies about the same bandwidth as a teletype signal of the same speed.

The Hell system is commercially obsolete. But it has been revived by a group of European amateurs, who possess the machines for it. Photograph 2 again shows Arthur typing on a "Hellschreiber," as they were extensively used by the German forces during WW II. Your scribe is so lucky as to have a "Hellschreiber" on loan from PAOAOB and so he meets Arthur and several other amateurs in Europe every Sunday afternoon on forty meters, using this nostalgic way of communicating. One of the members of the "Hell group" is Hans Evers, DJ6SA/PAAOCX and he described the Hell system of teleprinting in Ham Radio Magazine, December 1979 ("Hellschreiber rediscovered...").

But back to the subject of this series: German WW II communication receivers. In the next section we will describe some general characteristics of German radio equipment. One feature we will discuss in more detail: a quartz crystal intermediate frequency filter with continuously variable bandwidth. This type of filter was used in several receivers of the superheterodyne type. Following it we will discuss two receivers of the tuned radio frequency variety and two superheterodynes.

You are probably surprised that the Germans used t.r.f. sets. But they certainly knew how to make them in superior form. A great advantage of the straight set is that spurious responses are non existent, even in the presence of extremely strong signals as in shipboard use, where several transmitters may be active at the same time receivers are operated. Another advantage from a military point of view is that the t.r.f. set does not use oscillators and so...
the chance of location by the enemy using a direction finder on spurious radiation of the set is negligible. This article could only be prepared thanks to the assistance of PA0AOB. Not only did he make the receivers available for photography, he also gave the author the opportunity of using some of the sets in his own shack for a considerable period of time. The fact that PA0AOB could provide the original technical manuals, or exact replicas of them, was also of great help in the preparation of this article.

**General Characteristics of German Radio Equipment**

The oldest company that manufactured military radio equipment in Germany is undoubtedly Telefunken. During the first World War (1914-1918) this firm supplied radio communication equipment for the German army. Production of military equipment was forbidden in Germany under the Versailles treaty that ended WW I. But when Hitler came to the fore in the early thirties the situation changed drastically. When general conscription was announced in 1935, production of weapons and other war material came into full swing. New communication equipment was to be developed and produced. Again Telefunken was the leading firm. Also Lorenz, a German branch of the American ITT concern, started extensive activities in the field of military radio. In 1937 the German government invited tenders for a new radio for military aircraft. It came as a shock to Telefunken that Lorenz emerged as the winner with their FuG 10 set. This consisted of beautifully made separate receivers and transmitters for different frequencies that were combined to a complete set by mounting them into a frame, again made of cast alloy. The electrical connections between the units consisted of multi-pole connectors on the modules, mating with similar devices on the frame. The whole became an extremely strong combination with almost ideal electrical characteristics and easily accessible on all sides for servicing. The whole assembly slides from the front into a sturdy cabinet that in itself already forms a solid and stable basis.

This battleship-like construction also works out in a negative way; most of the German pieces of radio gear are extremely heavy, no doubt partly due to the fact that aluminum was not used for the boxes and frames. The exact composition of the alloy is unknown to this author, but very likely zinc formed a major component of it. The moving parts such as gears, tuning capacitors and switches are masterpieces of mechanical engineering. Moving a coil turret from one position to another, e.g., is done by a big solid crank and it feels like opening a safe or the door of an expensive oldtime automobile. Regardless how complicated the mechanical devices, they can always be dismantled in a few seconds by loosening one or two screws. That the mechanical linkage can be complicated is evident when one realizes that made it extremely stable, both from a mechanical and an electrical point of view. Inside the box was divided in completely screened compartments that housed the different stages belonging to that unit. The units were combined to a complete set by mounting them into a frame, again made of cast alloy. The electrical connections between the units consisted of multipole connectors on the modules, mating with similar devices on the frame.

We will now take a look at the German radio equipment and see whether we can find some characteristics that make it so unique and different from similar gear used by the allied forces. In the first place we observe the tendency to use a minimum number of different types of radio tubes. Most of the receivers used the same type of tube in all stages! This posed some tricky problems for the designers. We will meet an example of this later on. From a logistic and maintenance point of view it is of course a clear advantage to limit the variety of tubes to the absolute minimum. The tubes were especially developed for this military equipment. They were miniature types, certainly gauged by the standards of those days, and very robust. The tubes fitted special sockets that completely enveloped them and in which they had to be inserted top first. Nevertheless, the hope that a few types of tubes for all receivers and transmitters would suffice was not fulfilled; by the end of the war some 100 different types could be found on the lists of military tubes.

Another feature of German radio receivers and transmitters is that the designers certainly were generous as to the total number of parts used, especially if by doing so potential sources of trouble could be avoided. One finds, e.g., decoupling devices and screening liberally applied in all stages of a receiver or transmitter. Another feature is that even the simplest piece of equipment has the possibility of having its proper operation checked by the user. A built-in voltmeter with selector switch to measure voltages at different parts of the circuit is the minimum always found. Sometimes quite elaborate built-in operational checks can be encountered. Again we will meet an example of this later on in the series.

The most striking characteristic of German equipment is no doubt the mechanical part of it. The traditional chassis, so familiar to radio equipment of the past, was never used as such by the Germans. Instead they filled the space in a cabinet in three dimensions. The circuitry of a radio set was divided in a number of units, "modules" we would call them in our day, that could be easily removed and replaced. Usually such a module took the shape of a completely screened box of cast alloy that made it extremely stable, both from a mechanical and an electrical point of view. Inside the box was divided in completely screened compartments that housed the different stages belonging to that unit. The units were combined to a complete set by mounting them into a frame, again made of cast alloy. The electrical connections between the units consisted of multi-pole connectors on the modules, mating with similar devices on the frame. The whole became an extremely strong combination with almost ideal electrical characteristics and easily accessible on all sides for servicing. The whole assembly slides from the front into a sturdy cabinet that in itself already forms a solid and stable basis.

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that, e.g., variable capacitors or band switches that are ganged are sometimes found in different modules that can be easily taken out of the frame, in spite of the mechanical gears. Nevertheless the mechanisms operate with extreme precision. Examples that demonstrate these principles will be shown when we come to the discussion of the four receivers that will be covered in this article.

The German sense for perfection, that is reflected in even the smallest details like terminals, is also demonstrated in the instruction manuals that come with the sets. These not only provide very complete information for the operational use of the set, but also the maintenance man finds everything he needs to know for performing his job properly.

That the designers certainly had service ability of their products in mind is already clear from a simple visual inspection of a radio set. One finds, e.g., screws that are surrounded by a red ring. These have to be loosened to remove a complete unit (module). If one wants to take a unit farther apart the screws marked with a blue ring have to be removed. It is these details that make it a real joy to dissect a German WW II radio.

As announced in the previous section we will now discuss one feature in more detail: an intermediate frequency crystal filter with continuously variable bandwidth.

Such filters are found in several German communication receivers and they were made for different i.f.'s. The "Kölner" receiver for instance, that we will meet later, has an intermediate frequency of 1 MHz. The bandwidth of the crystal filter working on this i.f. can be varied between 0.2 and 10 kHz!

The circuit diagram of this filter is shown in fig. 1. The filter is positioned between i.f. amplifier tubes. A second filter of the same configuration follows the tube on the right. Upon casual inspection one could easily conclude that this filter is of the familiar type to be found in many popular American communication receivers and introduced in the early thirties by James Lamb in his "Single Signal Superhet." These filters feature a sharply peaked response plus a rejection notch that can be moved up and down in frequency by means of "phasing capacitor" C3. But this conclusion would not be correct. The German filter exhibits a real bandpass response, that is to say a flat passband and symmetrical filter slopes at the transitions between pass and stopbands. How is it possible to realize such a response with just a single quartz crystal resonator?

For explanation we turn to an elementary form of bandpass filter, the so-called "constant-K type," depicted in fig. 2. This filter consists of two parallel tuned circuits connected by a common inductance ZK and loaded by an impedance ZK_0 that has a different value for every frequency in the pass band and stop bands. Because this is almost impossible to realize in practice the filter is used between a source with internal resistance R and also loaded by R. R is taken as the value of ZK_0 at frequency f_0.

In fig. 3 a constant-K bandpass filter is shown that has been designed for a center frequency of 1 MHz and a pass band of 10 kHz wide, just as the filter in the "Kölner" receiver. The component values for L1 and C1 have been taken equal to L1 and C1 in fig. 1 for the "Kölner" filter. Now look at the series resonant circuit L2C2; don't C2 and L2 have "impossible" values? Indeed, especially L2 could never be constructed with a self-inductance of 3.6 henry at 1 MHz. To produce a capacitor of 0.007 pF isn't simple either. But wait, let us take a look at the equivalent electrical circuit of a quartz crystal resonator, as shown in fig. 4. This consists of a series tuned circuit and a parallel capacitor that represents the capacitance of the crystal electrodes. The values for the elements of the equivalent circuit shown in fig. 4 are typical for a 1 MHz crystal. These values are very near to those of the series circuit C2L2 in fig. 3! So it looks like we could replace C2L2 by a suitable quartz crystal and so obtain a bandpass filter at 1 MHz with a 10 kHz wide pass band. But what about the earlier statement that the elements of a constant-K filter were supposed to be without losses? R, of 5 kilo-ohms in fig. 4 certainly looks like a high loss. But be careful with that conclusion; what really matters is the Q of the series tuned circuit. And Q is equal to the reactance of C2 or L2 at 1 MHz, divided by R. And that works out to a Q of 6280. That value is so high that the crystal, acting as the series tuned circuit, can be considered lossless. And how about the losses in the parallel...
tuned circuits L1C1? The coils in these circuits certainly don't have such a high Q that they can be considered to be without losses. But as shown in fig. 3, these circuits have to be loaded by resistors of 113 kilo-ohms, and part of this loading can be provided by the loss of the circuits themselves. Isn't that beautiful? The loaded Q of the parallel tuned circuits has to be equal to the center frequency f_0 of the filter, divided by the width of the pass band. In our case 1000 kHz divide by 10 kHz. So the loaded Q of circuit L1C1 must be 100. with good quality components this can be easily obtained. If the actual Q of the circuits turns out to be higher than 100, extra loading by resistors (or by the output impedance of the preceding tube and the input impedance of the following tube!) can be provided.

So now that we have seen how the single crystal filter can really work as a bandpass filter let us go back to fig. 1, the filter of the "Köln". We see several extra components, as compared to fig. 3. In the first place the crystal is not connected between the upper ends of the parallel tuned circuits, but between taps on the coils. This is done because it would be very difficult, if not impossible, to manufacture a quartz crystal resonator where the parameters of the electrical equivalent circuit have exactly the values required. So in practice the crystal is measured to find out what the actual values of C and L are and then the proper tap on the coil is computed.

The required value for C2 and L2 of the series tuned circuit changes with the square of the tap ratio on the coils. If for example the taps were made halfway up the coils then the value of C2 would be four times as big and of L2 four times as small as in case of connections to the top of the coils. So by selecting proper taps on the coils the actual crystal can be matched to the filter. In the "Köln" several taps are available, obviously to cater for manufacturing tolerances in the crystals.

Another new element is trimmer capacitor C3. This is a neutralizing capacitor for the parallel capacitance of the crystal and its holder. Once properly set it needs no further adjustment.

You will also note that the anode of the tube feeding the filter is connected to a tap on the coil. That is obviously done to decrease the loading of the input circuit of the filter by the output resistance of the tube. Undoubtedly the designer had selected this tap in such a way that the correct value for the loaded Q of the input circuit is obtained.

The grid of the tube following the filter is also tapped. From a loading point of view this seems unnecessary as the input impedance of a pentode at 1 MHz is very high. But the tube is controlled by the automatic gain control system. And under influence of the a.c. voltage the input capacitance of the tube changes slightly and this could detune the output circuit C1L1 of the filter. Hence the tap. This leaves us with the function of C4 and C5 to explain. They are sections of a two-gang variable capacitor, but a special one; the construction is such that when one section increases in capacitance, the other section decreases by the same amount. Now assume that at a certain position of the capacitor the input and output circuits of the filter have been aligned to the same frequency. The filter then acts as a bandpass filter of 10 kHz wide in our case. Now turn the capacitor, say in such a direction that C4 increases and C5 decreases. This means that the two parallel tuned circuits become detuned from 1 MHz by equal amounts and in opposite directions. Now the whole circuit is no longer a proper bandpass filter. Indeed what remains is a crystal, acting as a series tuned circuit, connected between two impedances. These impedances become lower as they are detuned farther from 1 MHz. The result is a narrowing of the pass band that ultimately approaches the response of the crystal alone, which is a very narrow one. Because the input and output circuit are detuned in opposite directions, the response always remains symmetrical. There you are; a crystal filter where the passband can be smoothly varied between a few hundred cycles and 10 or more kiloHertz by simply rotating a single knob!

In the "Köln" and other receivers as well, two of these filter sections were used in cascade, separated by an i.f. amplifier tube. The sections of the capacitors for varying the bandwidth are in that case combined to a four gang unit.
It is a remarkable fact that this beautiful solution to the problem of obtaining a continuously variable i.f. bandwidth in a receiver seems to have been lost with the disappearance of German WW II communication receivers from the scene. The system has been used in some post war German receivers, e.g. made by Siemens, but the system in general was almost forgotten until about a year ago. Credit goes to Hans Evers, PA0CX/DJ0SA, for having it revived in an article in the Dutch amateur radio magazine *Electron* of July 1979. Hans, for many years, has owned a German receiver in which a crystal filter of the type described is used with excellent results. Triggered by an article in a German magazine on the alignment of such filters, Hans finally found out how the filter really worked. The explanation given above is correct and has been proven by Caspers, PA0CSC, who calculated the response of a filter according to fig. 1 with the values of C1 and L1 of the crystal inserted on an digital computer. The calculated response conforms very closely to the measured one.

It should not be difficult for the homebrewer of today to make a crystal filter according to the old German principle. One only needs to know what the parameters of the equivalent circuit are for a crystal that is to be used in the filter. These can be measured in a set-up shown in fig. 5, thanks to Hans Evers. It is perhaps well to explain that the vernier adjustment is an older technique of which the German Signal Corps, but also at higher army staffs, police and traffic control authorities. It was a popular set, produced in great numbers and one of the few sets that found their way to amateur service in Europe in post-war stations.

### Photo 5- Receiver Torn E b with cabinet removed. Note the bases of the four tubes that disappear completely in their holders. They can be retracted by means of the knob that is part of the molded tube base.

![Diagram](https://via.placeholder.com/150)

**Fig. 5** - The parameters of the equivalent electrical circuit of a quartz crystal resonator can be easily measured in this set-up, due to Hans Evers, PA0CX/DJ0SA.

\[
\begin{align*}
\text{Signal generator} & \quad (V_a) \\
\text{Crystal} & \quad (V_b) \\
\text{VTVM} & \quad (V_b) \\
\end{align*}
\]

\[
L = \frac{Q}{6.28 f} \quad \quad C = \frac{1}{6.28 f t Q}
\]

\[
r = R_4 \left( \frac{V_a - 1}{V_b} \right)
\]

Caspers, PA0CSC, who calculated the response of a filter according to fig. 1 with the values of C1, L1 and the proper loaded Q of the input and output circuits of the filter can be computed with formulas that can be found in for instance the ARRL *Amateur Radio Handbook*. For the variable capacitor with counteracting gangs we could probably use two varicaps on which the control voltage acts in opposite ways.

It is perhaps well to explain that the success of these early crystal filters is for a large part due to the fact that the Germans knew how to produce stable high Q coils, using powdered iron cores and such at a time when in other countries air coils were still used as a rule, with a simple powdered iron tuning slug used on others. Fine coils were not found exclusively in the r.f. and i.f. parts of German receivers. In the variable frequency oscillators of transmitters coils can be found in which silver turns are burned into ceramic coil formers. As a result these oscillators show a remarkable mechanical and electrical stability. According to PA0AOB this technique reduces the temperature coefficient by a factor of 200, as compared to a conventionally wound coil. The same construction techniques were used in the manufacturing process of trimmer and fixed capacitors in tuned circuits.

### Tornister-Empfänger b

We will use the original German designation of the receiver we are going to discuss now. Photograph 4 shows a front view of the set. You see that the set consists of two units above each other. The cabinets—meant to be carried on the back of a soldier—that house the units are called “Tornister” in German. Actually in photograph 4 you see two half “Tornister”, one housing the receiver and the other the power supply. “Empfänger” is the German word for receiver. And the letter “b” in the designation simply indicates which receiver. Mostly the designator was shortened to “Torn E b” and that is what we will use. The Torn E b was created around 1935/36. It was in general use with the German Signal Corps, but also at higher army staffs, police and traffic control authorities. It was a popular set, produced in great numbers and one of the few sets that found their way to amateur service in Europe in post-war stations.

It is a tuned radio frequency (t.r.f.) set with four filament type tubes that were run from a 2 volt battery at 0.2 a. each. So the whole radio consumed about 0.8 a. from the battery. The anode current came from a 90 v. dry battery at a consumption of about 12 ma. It was also possible to generate the a.f. from the 2 volt battery via a vibrator unit and that is what you see in photograph 4.
vibrator unit is on the bottom shelf of the lower cabinet. Still another possibility was to run the whole set from a 12 volt automobile battery, also with a vibrator for the h.t.

The set covers the frequency band 100-6970 kHz in eight ranges. The actual coverage of each subband is as follows:

<table>
<thead>
<tr>
<th>Band</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>97</td>
</tr>
<tr>
<td>2</td>
<td>172</td>
</tr>
<tr>
<td>3</td>
<td>306</td>
</tr>
<tr>
<td>4</td>
<td>541</td>
</tr>
<tr>
<td>5</td>
<td>958</td>
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<tr>
<td>6</td>
<td>1685</td>
</tr>
<tr>
<td>7</td>
<td>2940</td>
</tr>
<tr>
<td>8</td>
<td>4420</td>
</tr>
</tbody>
</table>

Photograph 5 shows the inside of the set and fig. 6 the circuit diagram. This is a reproduction of the original diagram from the technical manual for the radio. The receiver has two r.f. amplifiers, a regenerative detector and an audio output stage, producing sufficient to drive two sets of headphones.

There are three tuned circuits of which the variable tuning capacitors are ganged. We also find three sets of eight coils, one set for each subband. The coils with their associated fixed and trimmer capacitors are housed in a coil turret that can be clearly seen in photograph 5. This picture shows several of the features that we mentioned in the previous section. The coil turret is of cast alloy and contains completely screened compartments for each coil. The contacts are supported on cylindrical ceramic bars. The three gang tuning capacitor is also completely screened. You see the shaft bearing on the backside of the capacitor at the lower left. You also notice the bases of the four tubes. The two r.f.s and the detector tube are at the left, the a.f. tube at the right. The tubes disappear completely in the tube holders. They can be withdrawn by means of the circular knobs that are part of the molded tube base. The two r.f. stages and the detector stage are also completely screened. The extensive screening and decoupling leads to an extremely stable set with no trace of undesired feedback between stages.

Let us again take a look at the front (photograph 4). The big knob at the lower center controls the coil turret. Immediately above it the selected subband number is shown in a little window. Left and right of center you see windows that display a table; this gives the frequency that corresponds to the reading of the fine tuning dial that revolves with the tuning capacitor, seen at the right. The table lists

Fig. 6- Circuit diagram of the tuned radio frequency receiver Torn E b, as it appears in the instruction manual for the set.
the frequency in increments of 5 dial divisions. But for a finer reading we can extrapolate between these increments; in a fourth window, immediately above the one that shows the subband number, we read how many kiloHertz correspond to one dial division. For subband 1 this is 0.8 kHz, as you may be able to read from the photograph.

The knob called “Rückkoppl” at top right controls the regeneration of the detector stage, number 55 in the circuit diagram. Any of you who have used a t.r.f. set know that the joy or misery you derive from it is determined in a major part by the action of the regeneration control. The set should slide smoothly into oscillation, without thumb or backlash, that is to say the detector should start and stop oscillation at the same position of the control. These desirable features are dependent upon a number of factors in the circuit, as any of you oldtimers can testify. But the German designers of t.r.f. sets certainly knew the secret of making a fine regeneration control. The one on the Torn E b, or any German t.r.f. set for that matter, is a pure joy to use. Fine control is assisted even more by a slow motion drive on the regeneration capacitor!

The knob with the crank turns the tuning capacitor via a 1:19 slow motion drive. This operates with great precision and with a smooth feel. Nevertheless it was at this point that the author had some criticism on the receiver; at the high end of the frequency band covered by the set near 7 MHz, one revolution of the tuning control changes the frequency by some 200 kHz and this is too much for easy tuning of s.s.b. signals. This criticism is quite unfair, of course, as at the time the receiver was developed s.s.b. was unknown, at least for military applications. Still I found a way of fine tuning the set; as with most t.r.f. sets at high frequencies the regeneration control pulled the receiver tuning somewhat and this could be used as fine control.

The control marked “Lautst” is the gain control. It varies the screen-grid voltage of both r.f. amplifier tubes. This works very well and avoids the possibility of overloading the detector. Top center we find the antenna trimmer with screwdriver adjustment. It is marked 20 in the circuit diagram.

For telegraphy an audio filter, tuned at 900 Hz, can be brought into the circuit by means of the switch “Tonsieb.” The filter consists of a parallel tuned circuit with coil 62 and capacitor 63. It is very effective on c.w.

Top left on the front panel we find a voltmeter. It reads the filament voltage. Not only is the meter calibrated so that the proper voltage of 2 v. can be read, the correct voltage reading is also indicated by a red marker! By pushing the button on the meter front the instrument reads the h.t., that should be 90 v. and the correct value is again indicated by a colored marker on the meter face, this time in blue.

Finally we find on the front panel an on/off switch that controls the filament current, a plug for the power cable and sockets for two sets of headphones. And of course two big and easy to use terminals for antenna and ground.

As I already mentioned, Arthur, PA0AOB, gave me the opportunity to use the radio for considerable time in my own shack. Although the design is now over forty years old, the set still performs remarkably. As to be expected the receiver is at its best on c.w. Especially on the 500 kHz marine band it leaves nothing to be desired. But also on the long wave and medium wave broadcast band many more stations were copied than on a modern run of the mill superhet. Quality of the audio is rather limited, but then the set was certainly not meant for music. Selectivity is excellent. In fact on the long and medium wave bands the regeneration control should not be advanced too far, otherwise serious top cut is experienced.

Also on the short wave bands c.w. is received very well. S.s.b. can be resolved too, but tuning gets a bit tricky there, as already mentioned. Cross- and intermodulation forms no problem. Even in Europe’s extremely crowded forty meter band, with its many intruding strong broadcast stations, amateur c.w. signals can be easily copied at night, a test that many modern superhets fail. The forty meter band is not within the range of the set according to the official specs, as it does not tune beyond 6970 kHz. Nevertheless, in practice some 30 or 40 kHz of the 7 MHz amateur band is in fact covered.

One is struck by the quiet operation of this t.r.f. set. The input noise is just noticeable on a quiet band. And the background level is steady, no doubt caused by the fact that there is no a.g.c. As was well-known Dutch radio expert stated before WW II: “automatic gain control moves the fading from the signal to the background.”

The set is rather small, 36.5 cm wide, 24.5 cm high and 22 cm deep. This is for the receiver alone. Together with the battery and accessories “Tornister” height is 46 cm. But the weight of the complete unit is surprising, 24 kg (52.9 lbs).

(To Be Continued)
In Part II of this expanded series we take up the Lo 6 K 39a receiver. Many of the receivers that have survived the war and time are still seeing service by amateurs throughout the world.

**German World War II Communications Receivers**

**Technical Perfection From A Nearby Past**

**Part II**

*BY DICK ROLLEMA*, PA0SE

In Part I of this series, we saw some of the ingenious thinking that went into the design and construction of German equipment used during WW II. We pick up where we left off last time with a discussion of the Lo 6 K 39a short wave receiver. The pictures attest to the fabled methodicism of German craftsmanship, and one can only surmise that the accompanying manuals told of the number of people required to either lift or move some of this equipment. Some of it looks like it should have crane hooks welded to the cabinets.

**Short Wave Receiver**

Lo 6 K 39a

The receiver that we are going to discuss now must be the ultimate in tuned radio frequency receiver design. But before we start to describe it we will first explain the type designation, just as we did for the Torn E b in the previous section. “Lo” stands for “Lorenz”, the firm that designed and built the set. Lorenz was the German branch of the American ITT concern. The figure “6” means there are six tuned circuits. The “K” means “Kurzwellen,” German for short wave. The set came into operational use in 1939, hence “39” in the type number. And the “a,” finally, means that capacitors of standard types were used.

The Lo 6 K 39a was used by the German Navy during WW II. Photograph 6 gives you a first impression of this receiver. It cannot be called small, as the Torn E b, with its dimensions of 53.8 cm high, 50 cm wide and 32 cm deep. That is without the shock absorbing feet, on which it was normally fitted for shipborne use. Again, it is built like the proverbial battleship - it was meant for the Navy - and that reflects in its weight, a solid 65 kg (143 lbs). Arthur Bauer, PA0AOB, the owner of the set in the photograph, kindly gave it to me on loan for a practical evaluation and I had to enlist the help of my neighbor, a contractor with bulging muscles, to help carrying the monster up two flights of stairs to my shack in the attic.

I got the original technical manual with the set and the first line in that comprehensive booklet nicely summarizes what it is. In translation it says something like “The short wave receiver Lo 6 K 39a is a five tube tuned radio frequency receiver with six ganged tuning circuits. A sixth tube serves for frequency checking.” The radio covers 1.5-25MHz in eight subbands that cover the following ranges according to the specifications:

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

In practice there is some overlap between ranges. As you see the subbands cover relatively narrow frequency ranges and that, together with the 1:50 slow motion drive on the tuning capacitor makes for very easy tuning, up to the highest frequencies. But more about that later.

The circuit diagram is shown in fig. 7 in simplified form, as presented in the manual. As you see the input is protected by a neon tube. This already indicates that the radio was designed for operation near transmitters, a situation encountered on board naval ships. The lamp is alight.

There are not less than six tuned circuits! Of these the first three precede the first r.f. tube in the form of a triple tuned bandpass filter. This was no doubt another protection of the input.

*Say You Saw It In CQ*
directly calibrated in frequency for joining subbands. In the photograph with separate windows for each band can be read because of a circular mask danger that the wrong frequency scale each of the eight subbands. There is no with the coil turret the shaft is vertical. The gear train in between. The unit can be sturdy feeling, like the exclusive auto crank is very positive and imparts a switching action by means of this crank at the bottom of the front panel through a set of gears. The band switching action by means of this crank is very positive and imparts a sturdy feeling, like the exclusive automobile door we mentioned in an earlier section of this article. The six sections of the tuning capacitor are divided over two screening boxes, with part of the gear train in between. The unit can be seen at the right in photograph 7. As with the coil turret the shaft is vertical.

The dial on the tuning capacitor is directly calibrated in frequency for each of the eight subbands. There is no danger that the wrong frequency scale can be read because of a circular mask with separate windows for each band which rotates with the coil turret thereby allowing only the frequency scale of the selected subband to be read. In photograph 6 this is the middle one of the three windows in the black mask. The mask also clearly indicates the frequency range and the subband number and even in which direction the crank must be rotated to reach the adjoining subbands. In the photograph subband 5 (5.97 - 9.00 MHz) has been selected. Subband 4 can be reached by turning counter clockwise and number 6 by turning clockwise. Another example of German perfection!

The lower window displays a logging scale and the top window has no glass, which makes it possible to enter pencil marks on the dial.

We already mentioned that tuning is made easy through the slow motion drive and the relatively narrow subbands. But it is made even easier by means of a fine tuning control that varies the tuning of the detector circuit (which determines the tuned frequency on c.w. and s.s.b. with an oscillating detector) plus or minus 3 kHz around that makes the operation of this German WW II communication receiver such a pleasure. 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 capacity) than at the low end. This affects the gain of the tube that precedes the circuit. That gain is the product of the mutual conductance of the tube and the impedance of the tuned circuit.

The detector features the already familiar smooth regeneration control by varying its screen grid voltage. The net result is that the stage gain increases when the circuit is tuned from low to high within a subband. As there are three r.f. tubes, each with a tuned circuit following, the effect is aggravated and we would have to adjust the gain control continuously when tuning to keep the gain and signal handling capability of the set the same. Indeed, this would have been a problem were it not for the ingenuity of the designers of the Lo 6 K 39a, who found a clever remedy. If you take a good look at photograph 7 again you will notice a potentiometer at the right between the boxes containing the tuning capacitor. This potentiometer is coupled to the shaft of the tuning gang by means of a set of gears, so it rotates with it. This pot controls the screen grid voltage of the third r.f. tube (not shown in the simplified diagram of fig. 7) in such a way that the voltage becomes lower when the set is tuned towards higher frequencies, so decreasing the gain. This compensation is so effective that the user does not notice any obvious change in receiver sensitivity when tuning within a subband. Neat eh?

The detector drives the a.f. final stage via...
Photo 7 - This view from the back of tuned radio frequency receiver Lo6K39 shows the coil turret with six compartments, each of which houses eight coils, one for each frequency range. The two boxes at the right contain the sections of the six-gang variable tuning capacitor. Between the box a pot can be seen that is driven from the gears for the tuning capacitor. The pot varies the screen grid voltage of one of the tubes, in order to keep receiver gain constant when tuning over a frequency range.

an audio filter tuned to 1000 Hz with a 3 dB bandwidth of 200 Hz. Because this is a double tuned bandpass filter its slopes are steeper than for the one in the Torn E b receiver.

The sixth tube is used in a crystal calibrator on 100 kHz. All tubes are of the same type, an especially designed tube for military applications, a miniature pentode with the type number RV 12 P 2000. This universally used tube has an indirectly heated cathode that takes 0.075 amps at 12.6 volt heater current. The tube goes top first into a holder that completely envelopes it. In order to retract it a special tool is screwed into its base. Otherwise the bottom of the tube is flush with the panel that carries the holder. A photograph of the RV 12 P 2000 appears later in this article.

As you see in fig. 7 the receiver has a built-in power supply with a double smoothing section. The supply voltage for the detector stage is stabilized by a neon tube.

The Lo 6 K 39a is a sophisticated radio in every respect. This reflects

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CIRCLE 63 ON READER SERVICE CARD
In the provision for metering the different stages, top right in photograph 6 we find the test instrument that features not one, as in the Torn E, but two pushbuttons. By pushing the yellow button we read the heater voltage and the meter pointer should indicate within a yellow sector on the meter face. The anode voltage can be checked by operating the red pushbutton and the meter should read within a red segment on the meter face. But it doesn't end there. We can also check the anode currents of the six tubes. As a preparation to this the controls for gain and regeneration should be turned fully clockwise and the tuning control on "O" (the tuning control effects the screen grid voltage of tube number three, as we saw). Under and to the right of the meter we find a six position switch marked "Anodenstrom" (anode current). It is normally held in an off-position by means of a spring. When we move the switch against the spring into position "I" the meter reads the anode current of tube number 1. If the tube is in normal condition the meter pointer is within a blue sector on the meter dial. The same happens for tube 2 with the switch in position "II". And so on for all six tubes. Speaking of perfection...

As could be expected the electrical specification of the receiver is very complete, be it that in the days of WW II some of the electrical characteristics were specified differently from nowadays.

Output is stated as the voltage over a pair of headphones with 5000 ohm impedance at 800 Hz. The receiver noise should produce between 0.2 and 3.0 v, with the gain control at maximum and the detector just in oscillation for maximum sensitivity for c.w. With maximum 0.3 v. receiver noise 2 microvolt input for A1 (c.w.) and 4 microvolt for A2 (m.c.w.) should produce 1 v. output at optimum position of the regeneration control. According to tests made by the author a signal of 0.4-0.8 microvolt generator emf behind 50 ohm internal generator resistance produces a readable c.w. signal.

You probably wonder what sort of selectivity can be expected from a t.r.f. set with six tuned circuits. The specs state the selectivity as follows that at ±0.85% detuning a 10^6 times increase of signal is required to restore the response from a 2 microvolt signal at 4.62 MHz (signal generator modulated with 400 Hz at 30% modulation depth, mode A2, regeneration control set just before oscillation). We would say that 0.85% detuning causes 60 dB attenuation, which certainly is not bad. There are many more interesting points in the specs but we will leave it at that.

The practical evaluation in the author's shack fully confirmed what...
would be expected from the specs. The set had been inactive for many years. Owner PaATAOB did not realign the receiver before it was handed to the author. The only thing Arthur 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 100 kHz crystal in the calibrator was spot on. Tuning is as easy as can be, even sideband on 21 MHz, thanks to the fine-tuning control. As with the simpler Torn E b, the set is beautifully quiet. As to be expected the set is at its best on c.w.

The author remembers that at the test equipment department of the electronics firm, where he was employed some 15 years ago, a Lo 6 K 39a was used to check the purity of the output from a signal generator under test.

(To Be Continued)
Part III now takes up with a 1938 design for a superheterodyne receiver. The Kw E a as you will see from the photos is a marvel of mechanical engineering. While PAØSE regales us with the theoretical aspects of the design, one can only imagine how that was transformed into the mechanical beauty we see unfold. Still, the thought of lugging 77 pounds of hardware around leaves a lot to be desired. -K2EEK

Short Wave Superhet Kw E a

The first of the two superheterodyne receivers we are going to discuss is the Kw E a (Kw = "Kurzwellen" = short wave, E = "Empfanger" = receiver, a is serial indicator). This radio was designed by Telefunken and it became operational in 1938.

Photograph 8 gives you a first impression of what it looks like. Photograph 9 shows the receiver out of its cabinet and photograph 10 a rear view.

The dimensions of the radio are 69.2 cm wide, 27.4 cm high and 34.6 cm deep. It weighs 38 kg (77 lbs). Not directly a set to take on holidays.

The total frequency span of 1 to 10 MHz is covered in five ranges, as follows: 980-1610 kHz; 1560-2550 kHz; 2470-4060 kHz; 3940-6395 kHz and 6205-10000 kHz. Again the subbands are kept relatively narrow which improves the ease of tuning and the frequency read-out.

Looking at photograph 8 you notice several by now familiar features. Left of the dial the band-selector control above ("Grob" = coarse) and main tuning control with crank ("Fein" = fine) below. The dial features the rotating mask we already met on the previous receiver with a slot that displays only the frequency scale in use. The mask also shows the limits of the selected range and the frequency increment that corresponds to one dial division, 10 kHz on range III, as seen in the photograph. The receiver uses the same filament type tube in all 11 stages. It is the type RV 2 P 800 pentode we also encountered in the Torn E b. The radio consumes 1.6 a. at 2 v. for the filaments and 15-20 ma. at 90 v. anode current. The bottoms of the tubes with extraction knob can clearly be seen in photographs 9 and 10.

The simplified diagram in the instruction manual is too complicated to reproduce here. Therefore we present a block schematic diagram as fig. 8.

The mixer is preceded by two r.f. amplifier stages. There are five tuned r.f. circuits that are ganged to the oscillator tuning circuit. The user has the option to use a single or a double tuned circuit between the antenna and the first r.f. tube. Normally one circuit is used. But the manual says that when interference is experienced from a very strong near-by transmitter the second circuit between antenna and first r.f. tube should be brought into operation. The switch for this is the top one of the two controls at the right on the front panel.

The lower one of these controls is an antenna attenuator. Not a resistive one but a variable series capacitor between antenna and input circuit. To avoid detuning of this circuit a second section of the capacitor adds just as much capacitance in parallel with the tuned circuit as the series capacitor detracts. In other words the input attenuator is a differential capacitor. It is called "Ankopplung" (= coupling) on the front panel. There is also a series trimmer in the antenna that compensates for different antenna capacitances. It is set once and for all for a particular antenna and therefore has screwdriver adjustment (top right just
The six sets of coils that have to be switched for the five frequency ranges are mounted in a coil turret. This one is of particular beauty. Photograph 11 shows the turret, taken out of the receiver, which is a simple operation. The turret is moved from one position to the next by means of a Maltese cross mechanism that can just be seen at the extreme left of the turret. But before the turret starts to rotate the contact fingers are lifted from their partners on the turret by means of a camshaft that can be observed in photograph 11 in front of the turret. When the turret has come to rest in the new position, the contact fingers are lowered onto the turret again. The fingers make a slight wiping movement when pushed onto the ring shaped contacts on the turret, thereby removing possible dirt deposits.

The receiver uses the relatively low intermediate frequency of 250.9 kHz. But because five tuned circuits are used ahead of the mixer the image response is sufficiently suppressed (on the order of 80 dB).

The oscillator is of the tuned anode circuit variety. A coil in the grid circuit is inductively coupled to it. A second coil, coupled to the anode circuit of the oscillator is in series with the coil that forms the r.f. tuned circuit connected to the grid of the mixer tube. In this way the oscillator signal is injected into the mixer.

There are three i.f. amplifier tubes. They are preceded by double tuned i.f. transformers on 250.9 kHz.

The receiver offers the selection of seven different bandwidths, of which four are meant for telephone, the fifth, sixth, seventh and eighth are for c.w. only. The bandwidth in positions seven and eight is identical, but in the eighth position the b.f.o. is switched to the other side of the passband. The bandwidth selector control can be seen in photograph 11 directly under the meter.

The principle of the bandwidth variation is indicated in fig. 8 in simplified form. In positions 1–5 the bandwidth of the i.f. amplifier is changed by varying the coupling between the tuned circuits of the i.f. transformers. By going from position 1 to 5 the coupling capacitors between the tuned circuits are made smaller and smaller. This would also shift the center frequency of the passband slightly. But this is compensated for by adding extra capacity in parallel with the tuned circuits as the coupling capacitors become less. Also the damping resistors in parallel with the tuned circuits are increased in value as the bandwidth narrows. In position 5 no extra damping is used. In positions 6–8 of the bandwidth control the i.f. bandwidth remains the same but the a.f. bandwidth is reduced. This is done by a tuned circuit that resonates at 900 Hz between the detector and the a.f. final amplifier. In position 6 it is brought into the circuit but the response is broadened by means of a parallel resistor. In positions 7 and 8 the resistor is removed and the bandwidth is at its narrowest.

The b.f.o. is crystal controlled and works at a fixed frequency of 250 kHz, thereby generating a beat note of 900 Hz with the 250.9 kHz i.f. signal. The b.f.o. can be brought into operation by means of a separate switch. It is directly under the bandwidth selector switch. If in position seven interference is experienced the operator can go to position eight. The b.f.o. is now changed from 250.0 to 251.8 kHz, again generating a beat note of 900 Hz but now
Photo 9- Receiver Kw E a taken out of its cabinet.

Photo 10- Short wave receiver Kw E a as seen from the rear. The two neon lamps at the right protect the input circuits against high voltages when the set is operated near a transmitter.
using lower sideband reception instead of higher sideband in positions six and seven. The b.f.o. has a separate crystal at 251.8 kHz for this.

The detector is of the leaky grid type. Both i.f. and b.f.o. signals are introduced on the control grid of the RV 2 P 800 pentode tube that is used throughout the receiver. The detector tube is coupled to the final a.f. tube by means of the tuned circuit at 900 kHz that we already mentioned. In positions 1-5 of the bandwidth control it is replaced by a RC-type coupling.

According to the manual the set should normally be used with manual gain control. This varies the screen grid voltage of the first and third i.f. amplifier tubes. But in case of fading automatic gain control can be used. There is a separate i.f. amplifier for the a.g.c. It receives the same i.f. signal as the leaky grid detector and it feeds two diodes in a voltage doubling rectifying circuit for the a.g.c. voltage. This is fed to the second r.f. amplifier and the second i.f. tube. The manual gain control is inoperative when the a.g.c. is switched on and replaced by an a.f. control that is on the same shaft as the manual i.f. gain control. But the i.f. gain can still be controlled manually when using a.g.c. by means of a separate potentiometer that has the same function as the manual gain control for use without a.g.c. but is only operative in the a.g.c. position. The manual says it should only be used in case of very strong interference.

The combined i.f./a.f. gain control can be seen to the left of the left handle that is used to pull the receiver out of its cabinet. The separate i.f. gain control that only works in case of a.g.c. is to the left of the right handle in photograph 8.

The last item of the Kw E a we will discuss is the metering facility. It is like the one on the Lo 6 K 39 a. The meter is at the top left of the front panel and to the left of it you will notice a switch with 13 positions. In the first position the filament voltage is read and in the

**Fig 8- Block schematic diagram of short wave superheterodyne receiver Kw E a.**
second the anode voltage. The voltages should be within a red or blue sector on the meter face for the two voltages. The remaining 11 switch positions are for metering the anode currents of the 11 tubes in the receiver. A black mark on the meter dial indicates the minimum reading for a serviceable tube.

The frequency dial also carries red markers for frequency checking. The calibration signal for this comes from the 250 kHz crystal in the b.f.o. Harmonics of the b.f.o. signal can be fed to the input of the receiver. For this a pushbutton must be operated that can only be reached when the set is out of its cabinet. In case the dial reading is not ok this can be corrected by rotating green encircled adjustment screws on the coil turret.

It is remarkable that the manual for the set does not contain performance specifications. I have not yet had an opportunity to test the receiver in my own shack. But this is going to happen in the future and I am quite convinced that the radio will come up to my high expectations.

(To Be Continued)
At last, for all those who have written asking for the next installment, we have the last of our four-part series on German WW II communications equipment.

**German World War II Communications Receivers**

**Technical Perfection From A Nearby Past**

**Part IV**

BY DICK ROLLEMA*, PA0SE

Part IV concludes the series with a discussion of the E 52a Köln receiver. This receiver is unique in that it uses a modular construction technique and an early form of printed circuit. The frequency readout system is a projection technique reminiscent of early TV sets. At 94 pounds, this too would be a little heavy to tote on your shoulder while strolling down the street.

—K2EEK

**Short Wave Receiver E 52 "Köln"**

Some of the communication equipment and related pieces of gear, like radar, were called after well known German towns. The E 52 is an example of this, because “Köln” is the name of a famous German town, in English speaking countries known as Cologne. We will use both E 52 and Köln when referring to the receiver we are going to discuss now.

There can be no doubt that the E 52 is the ultimate of German receiver design of WW II days. It is another Telefunken design and became available around 1943. The instruction manual that PA0AOB put to my disposal for writing this article carries the date August 1943. The book says the E 52 was meant for short wave communications in the army and for governmental organizations.

You get a first impression from it by looking at photograph 12. The two hinging lids that are lifted to show some of the gadgets under them are normally closed, of course. You probably notice the clean layout of the front panel and the functional shape of the controls. And that was done in the days that “ergonomics” was an unknown word.

The dimensions of the radio are 24.1 cm high, 44.6 cm wide and 36.9 cm deep. Its mass is a massive 42.8 kg (94 lbs.). The set can be run from 110-230 v.a.c, from which 60-96 watts are consumed, or from a 12 v. battery. A vibrator power supply is built in. There are five frequency ranges, as follows:

- Range I: 1.5-3 MHz, white scale on the dial
- Range II: 3-6 MHz, red scale
- Range III: 6-10 MHz, yellow scale
- Range IV: 10-17.6 MHz, blue scale
- Range V: 17.6-25 MHz, green scale

The ranges are selected by the oblong control to the left of the indication “Frequenzeinstellung” (frequency adjustment). The frequency the radio is tuned to can be read from the semicircular dial. To avoid reading the wrong scale the frequency ranges are tabulated to the left of the dial and the table also shows the color of the scale to be read.

A dial like this only provides limited capability to read the exact frequency. Obviously the engineers who were responsible for the design of the E 52 didn’t think this good enough and they added a projection system to display the frequency with great resolution. To achieve this the shaft of the tuning capacitor carries a glass disc on which the calibration for each frequency range has been deposited by photographic means, like on a microfilm. A small lamp illuminates the disc from behind and the frequency the radio is tuned to is projected by means of a lens system onto a ground glass screen that you see above the semicircular dial in photograph 12. As only the figures that belong to the selected frequency range are displayed the reading is unambiguous. In this ingenious way a “dial” is achieved with an effective length of several meters. The glass discs were individually calibrated for each receiver! A spare disc is included as standard.

If the lamp fails the projection system can no longer be used. No problem; the designers already provided a built-in spare lamp and it can be brought into operation by turning the slotted screw you see below the ground glass screen. These lamps are rather unusual as the filament is off...
centered from the middle of the bulb. This makes it almost impossible to obtain one nowadays. But a determined collector is not to be deterred by such a simple fact. An Austrian collector of German WW II equipment gave an order to a factory to manufacture a couple of hundred of these special light bulbs. And so he and his fellow collectors can go ahead for many years to come with their Kölns. At what price we will not mention. . . .

The E 52 was made in several models. The one you see in the photographs is in the possession of PA0AOB and is the most sophisticated model, designated E 52 a. This variety has the possibility to preselect four different frequencies that can subsequently be recalled by motor drive of both frequency range selector and fine tuning.

The frequencies are indicated by different symbols you see on the table to the right of the dial. The frequencies that are preselected are entered in this table by pencil. The frequency actually selected is displayed by its symbol in the little circular window above the table.

The motor driven system operates marvelously. PA0AOB gave me a striking demonstration of it. He tuned an s.s.b. station in on one of the amateur bands. This was "stored" as one of the preselected frequencies. He then started the selector mechanism upon which the motors rotated the range selector through all five ranges. The same happened with the tuning capacitor. When finally the stored "channel" reappeared the s.s.b. station could be read without any retuning! And that for a design from a time when s.s.b. was unheard of for mobile communications.

The receiver has been so designed that one type of tube can be used in all stages. The tube is the miniature pentode RV12P2000 we encountered before in the Lo 6 K 39 a and ten of them are used in all. Only the rectifier tubes in the power supply are of a different type. All tubes can be reached by lifting the two lids at the front top of the receiver. This is shown in more detail in photograph 13, and there you see how PA0AOB's hand has just retracted one of the tubes by means of a special tool that is screwed into the bottom of the tube. In photograph 12 some of the tubes have this grip fitted and some do not. You also notice that the tubes disappear completely in their holders.

The set is constructed completely in modular form as we would call it nowadays. This is shown in photograph 14, where one of the modules has been set apart. All connections are made with plugs and sockets as can be clearly seen in the photograph.

The connections between the modules are made through a "motherboard" in modern terminology that can be seen at the left of the assembly in photograph 14. Some of the wiring on this motherboard closely resembles printed circuit wiring. It was not made in the way we know it now but it certainly used a similar technique. Nothing new under the sun!

The coil turret we met in the three previous sets is not used in the E 52; probably it was too difficult to split it over different modules. Instead band-switches are employed. The switch decks can be found in different modules and the same goes for the sec-

Fig. 9- This block schematic diagram shows the line-up of the "Köln," a short wave superheterodyne receiver with the factory designation E 52.

Fig. 10- This simplified diagram shows the essentials of the detector stage in the E 52 receiver.
The frequency the receiver is tuned to is projected on the ground glass screen at the top. The opened hinging lids disclose the tubes and the metering facilities. Note also the clean layout of the front panel and the functionally shaped controls.

The mixer is preceded by two radio frequency amplifying stages and five tuned circuits. The sixth section of the six-gang variable tuning capacitor tunes the local oscillator. As in most German receivers the input is protected by a neon bulb. Link coupling is used in the double tuned bandpass filters preceding the first and second r.f. amplifiers. The oscillator signal is inductively coupled into the cathode circuit of the mixer tube. The intermediate frequency is 1 MHz and that, together with the five tuned circuits in the r.f. part, provides excellent suppression of the image response. It is specified as at least 1:50000, which works out as 94 dB. Further details are given in the following table:

<table>
<thead>
<tr>
<th>Attenuation</th>
<th>Detuning at bandwidth</th>
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<tr>
<td></td>
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<td>3 dB</td>
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<td>1 kHz</td>
<td>2 kHz</td>
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</table>

Not bad for an almost forty year old design, don't you think? No wonder that Arthur, PA0AOB, uses his Köln as the main station receiver and that he is entirely happy with its performance, even with the QRM and strong signals of today.

The detector tube, a pentode, as you may recall, proves detection of the signal, voltage for the automatic gain control and audio amplification as well. We'll come back to that in a moment. The b.f.o. is continuously variable. But when the b.f.o. control is moved into one of its end positions a quartz crystal is switched into the circuit and the b.f.o. is then crystal controlled at a frequency of 1000.9 kHz, thereby causing a beat note of 900 Hz with the 1000 kHz i.f.
Photo 13- PA0AOB's hand has just pulled one of the tubes out of its socket. The tube is a pentode type RV12P2000 and it is used in all ten stages of the receiver.

Photo 14- The E 52 receiver is constructed from easily interchangeable modules. The module at the right has just been removed. All modules plug into a motherboard that carries the intermodule wiring. Some of this wiring is in the form of a kind of early printed circuit!
The amplified signal appears over R5 and via blocking capacitor C8 the a.f. signal reaches the triode at a.f. The amplified signal appears at the suppressor grid as the result of rectification of the i.f. signal is used for automatic gain control. But the control must be delayed. That means that the control voltage should only be applied to the tubes when the input signal at the receiver exceeds a certain level. To achieve this the negative voltage at the suppressor grid is fed to the anode of the tube via R3. The anode functions as a second diode, together with the cathode. Via R4 and decoupling capacitor C7 the control voltage is fed to the controlled stages: the two r.f. amplifiers and the three i.f. amplifiers. How is the delay action obtained? The anode of the detector tube at first cannot become negative because a positive current is flowing towards it via R7, a resistor of 6 meg-ohms that is connected at the right to a voltage divider over the h.t. As long as this current exceeds the “negative” current through R3 the anode is held slightly positive and the “diode” conducts. At a certain moment the suppressor grid becomes so negative that the diode (anode) current becomes zero and when the negative voltage increases further the anode and the a.g.c. line go negative and control starts.

There is one more interesting aspect around the detector. The b.f.o. signal is also fed to the suppressor grid via C4. This has an unwanted effect that the b.f.o. becomes rather strongly coupled to the last i.f. amplifier. This means that b.f.o. voltage can find its way back into the i.f. amplifier whilst on the other end i.f. signal can get into the b.f.o. circuit and could tend to synchronize the b.f.o. frequency when strong. To avoid these effects a bridge circuit is formed that includes the center tapped coil L and capacitors C3, C4 and C5. The latter is a trimmer capacitor and by proper adjustment the bridge is balanced and a very effective decoupling of final i.f. tube and b.f.o. has been achieved.

The gain control consists of two potentiometers on one shaft. On positions “A1 ungeregelt” and “A3 ungere­gelt” of the mode control selector (A1 with a.g.c. and A3 without a.g.c.) one pot controls the screen grid voltage of the two r.f. tubes and the first and second i.f. tube and the second pot the audio gain. In positions “A1 gere­gelt” and “A3 geregelt” (A1 with a.g.c. and A3 with a.g.c.) of the mode selector, only the audio gain control is active and the screen grid voltage remains fixed.

The automatic gain control voltage of the receiver is also made available on a socket. This is used in case of diversity reception using more than one receiver. In this case the a.g.c. of all receivers is paralleled and so the receiver with the highest input signal automatically dominates in the output signal.

Although the power supply part of the E 52 features several interesting aspects we will not go into detail here. Instead we end the discussion of this fine set by looking at some of the built-in checking facilities. By opening the two lids at the front the by now familiar test meter is disclosed, as can be clearly seen in photographs 12 and 13. The instrument carries two pushbuttons for checking the heater and anode voltage of the tubes. The correct readings are indicated by a red resp. blue sector on the meter face. The pushbuttons carry the same colors. The cathode current of the ten tubes in the receiver can also be individually measured. For this purpose there is a pushbutton adjacent to each tube. It is also possible to check the a.f. output level. This is done on set noise checking the heater and anode voltage of the tubes. The correct readings are indicated by a red resp. blue sector on the meter face. The pushbuttons carry the same colors. The cathode current of the ten tubes in the receiver can also be individually measured. For this purpose there is a pushbutton adjacent to each tube. It is also possible to check the a.f. output level. This is done on set noise checking the heater and anode voltage of the tubes. The correct readings are indicated by a red resp. blue sector on the meter face. The pushbuttons carry the same colors. The cathode current of the ten tubes in the receiver can also be individually measured. For this purpose there is a pushbutton adjacent to each tube.

But there is an even more ingenious test possible that provides an overall...
check on the proper performance of the receiver. For this test the pushbutton for measuring the output level is depressed so the meter indicates the noise level at the output. The bandwidth control is now rotated so that the bandwidth is decreased. The output noise decreases as well and the bandwidth is adjusted such that the meter reads the right edge of a black segment on the meter face. Now a second pushbutton is depressed together with the one for output level. This button shortcircuits the input circuit of the receiver. So the noise that is generated in this input circuit is removed from the grid of the first tube. The meter reading should now decrease to the left edge of the black segment. If this is not the case the radio is not in optimum condition and the tubes should be checked. If these seem to be ok then the receiver must be turned into the repair shop.

Finally there is a pushbutton for checking the frequency calibration. This uses harmonics of the quartz crystal in the b.f.o. on 1000.9 kHz. A special circuit is provided that equalizes the signal strength of these harmonics over the whole frequency range of the set. In each of the five ranges a single check point is indicated on the projection dial in red. When the radio is tuned to zero beat on the proper harmonic the reading on the dial should not deviate more than a specific amount from the red mark. The acceptable deviation varies from less than 2 kHz in range I to less than 15 kHz in range V.

And with this we end the discussion of the E 52.

Conclusion

The author imagines that some readers might like to know more about the four receivers we have described or about German WW II radio equipment in general. For instance, where these sets can be found (not easy!). Your scribe is not a collector himself and he is therefore not in a position to answer these questions properly. The only thing he did was to describe the radios for which the material was kindly provided by Arthur, PA0AOB. The author has therefore agreed with PA0AOB that any letters should be addressed to him, because Arthur is the expert in these matters. His full name and address is as follows:

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