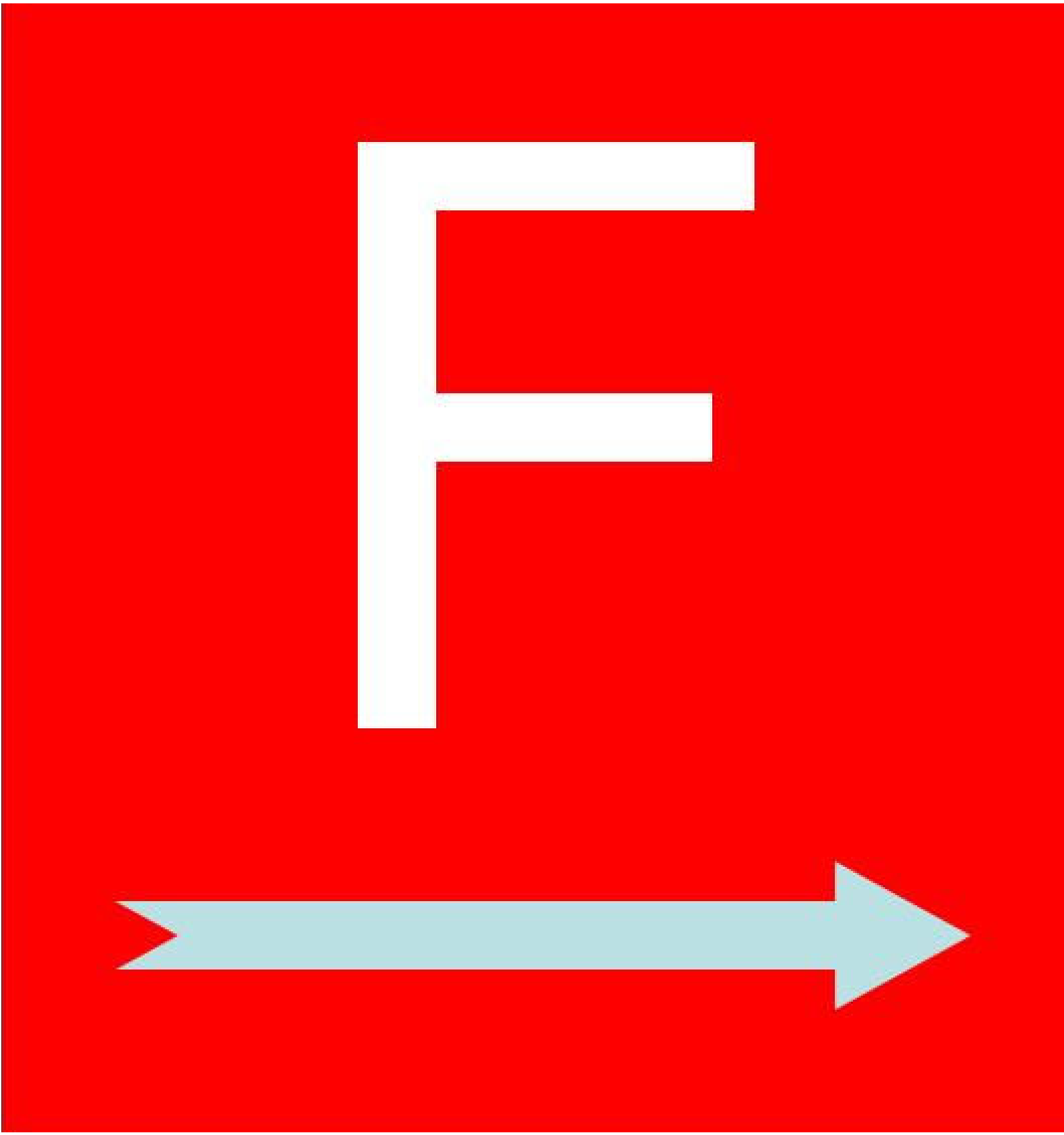
German Field Line Communication equipment of WW 2



Funksammler Publications

Foreword

For a long time, the field of collecting communications equipment was dominated by two sorts of people: Collectors that wanted nice looking equipment to put in their displays and Technical enthusiasts that want to analyse and bring back to life this old equipment. Publications on German Communications equipment have been catering to either the collector or to the technical enthusiasts. Publications for the collectors generally show external shots of good condition equipment without giving much information on the workings of the equipment; Publications for the technical enthusiast contain a fair bit of technical knowledge and do not always respect the originality of the equipment. The best information could often be found in original manuals, but those were hard to find and only accessible to those reading German.

In recent years this community has been joined by re-enactors, people that try the mimic historic battles using historic equipment. They want to show the equipment in the correct setting and if possible demonstrate how it works. Increasingly I hear collectors ask “how do I make this work” and technical enthusiasts ask “what is the right way to display this”.

In this volume I am trying to combine the historic, technical and practical information on German Field Line communications equipment. It shows the equipment from the outside; explains what is on the inside and shows it in typical operational setup. It gives information on how to correctly connect and operate the equipment.

With the information in this volume the collectors should be able to identify the items in their collection and check if they are complete and correct, it can aid the technical enthusiast in figuring out how it works and how it might be repaired while the re-enactor should be able to set up their equipment correctly and give a try operating it.

The subject matter in this volume is limited to what I termed “Field Line Communications equipment”. It shows what could typically be found in a German field army and was used by the fighting troops and their immediate headquarters. I have omitted much of the higher echelon specialised equipment such as Telex equipment and line-of-sight radio beam equipment. I have also omitted Fortress related equipment. Perhaps I will address these in future volumes.

Table of Contents

1. Introduction

In modern warfare communication is an essential part of command and control. From the end of the 19th century, technology started to play an increasingly important role in battlefield communication. By the First World War, extensive use was being made of wire communication and the first –relatively primitive- mobile radio stations came into being.

In the interwar years, Germany was bound by the conditions of the Versailles treaty and was prohibited from developing and producing many types of weapons and military equipment including communications equipment. This did however not stop the German military minds from developing new concepts in war: Blitzkrieg using fast armoured units striking deep behind enemy lines. It was quickly realised that reliable communication would be an essential prerequisite for the persecution of future wars and especially from the early 1930's a fast development of radio and line communication equipment and tactics was commenced.

Whereas wireless communications offer a great flexibility especially suited to the fast moving armies of the Blitzkrieg, it was line communications that were used in preference and wherever the possibility existed. This required equipment and an organisation that could build and move telephone networks at speeds hitherto never imagined. Also the density of communications would be surpassing anything experienced in previous wars.

During the war the communication networks built by the German Armed Forces would reach epic proportions reaching from North Africa to the Polar circle, from the Atlantic coast to the depths of Russia.

A number of variations and accessories were developed so that different functions and roles could be performed by the field telephone equipment. They were not only being used widely by the German Armed Forces, but for many years after the war by some foreign armies and services.

This book gives an overview of the line communication equipment and materials used by the German forces on the mobile battlefield of the second world war. The scope of this book has been limited somewhat, equipment for fixed fortifications and telex type line equipment has not been included.

The aim of the book is to give collectors, re-enactors and those interested in the communication aspects of world war two a relatively detailed account of what the equipment was, what it was used for, how it is constructed and how it was used.

Most chapters have a section on **Development and description** in which the history and working principles are explained. This is followed by a **Construction** section in which key controls and components are identified. Finally an **Operation** section explains how the equipment can be operated.

The book uses a mixture of original German terms and translations; in some cases good English equivalent terms exist, but in many cases the German equipment and their terminology are quite unique. German terms are printed in italics and can be found in a Glossary at the end of the book.

2. Field Telephones

Introduction

The field telephone is the basic and most frequently used piece of communication equipment on the battlefield. Used from the front line to the highest headquarters, it gave military commanders and unprecedented real time control of operations.

Even though the design principles of field telephone equipment were well understood for many years, much of the equipment from before the1930's was expensively produced on a small scale. The rapid developments in public phone network technology with which the field equipment was required to interface had led to a great complexity of equipment. The 1930's saw a major re-think based on the following principles:

- Standarisation: Standardise tactics and designs for all services
- Simplification: Eliminate rarely used functions and create "fool-proof" operation
- Accessorisation: Create accessories so that standard equipment can be used to perform different functions
- Ease of production: Use of materials and techniques that suit mass production
- Portability: Create light weight, small size, robust equipment
- Reliability: Eliminate potential faults and weaknesses due to misoperation and effects of climate and weather
- Speed: Maximise the speed with which telephone reliable communications can be built and changed

The new field telephone unit, telephone switchboard and auxiliary equipment were introduced into service in 1933 and subsequent years would become the mainstay of German field communication. They would remain in production with only minor changes until the end of the war; of the *FF 33* field telephone originally developed by Siemens in 1933, over 1.6 million examples were made by 24 different manufacturers.

FF 33 Field telephone

Development and description

Figure 2: Armee Fernsprecher Alter Art

The development of field telephone equipment started in the late 19th century and by the time of the First World War the basic design features of field telephones were well established with the *ArmeeFernsprecher Alter Art* and the later *FF 16* and *17* models. "*FF*" stands for "*Feld Fernsprecher*" or field telephone. These telephones were locally powered by a battery (this mode of operation was called "OB" or "*Ortsbatterie Betreib*").

Locally powered networks were commonplace during the early years of the telephone but in the beginning of the 20th century, public networks increasingly used central powered systems (the power for the microphones is provided over the phone line from a central power supply. In Germany this was called a "*Zentralbatterie Betrieb*" (ZB) system. For field use however, locally powered telephones remained the norm of many years.

Figure 1: FF 16

Figure 3: FF 26

As public telephone systems developed with a variety of operating principles, additional features were found to be necessary such as an automatic end-pulse when the handset was replaced, ability to connect a dialling disk etc. This resulted in the rather complex *FF 26* model.

When the Nazi's came to power, a rapid expansion of the armed forces was anticipated and so in 1933 the *Feldfernsprecher 33* was developed, essentially a "back to basics" model modernised to suit mass production. The earlier wood was replaced by a rugged moulded bakelite housing.

Figure 4: Early FF 33 phone. Note the plated metal parts

The components of the field telephone (bell, generator, microphone transformer and connections etc.) were placed on a metal frame which could be lifted out of the housing giving easier access for maintenance. Complicated components such as buzzers, end-pulse switches, external battery connections etc. were omitted to keep production and operation as simple as possible.

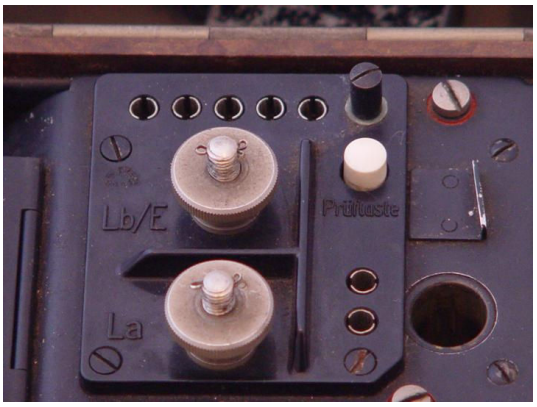


Figure 5: Connection panel

Connections for the handset, headset and the telephone cables were accessible on the top panel of the telephone, with the battery being accessed via a hinged lid connected to the top panel.

The bakelite housing cover could be closed over the top panel to protect the telephone from rain and dirt, a rubber seal on the edge of the lid allowed the lid to be closed on the cables. Two rotating metal covers closed off holes in the side of the housing for the generator handle and the two connection sockets for the interconnection cord. A bracket on opposite sides of the housing allowed a carrying strap to be connected.

Figure 6: Battery

To avoid the battery of an OB system from discharging unnecessarily the battery is normally switched off and will only work when a microphone switch is depressed. To avoid the batteries from short circuiting when two or more OB phones are used in a single circuit, the microphone circuit is not directly connected to the phone line, but via a microphone transformer ("*Sprechspule*").

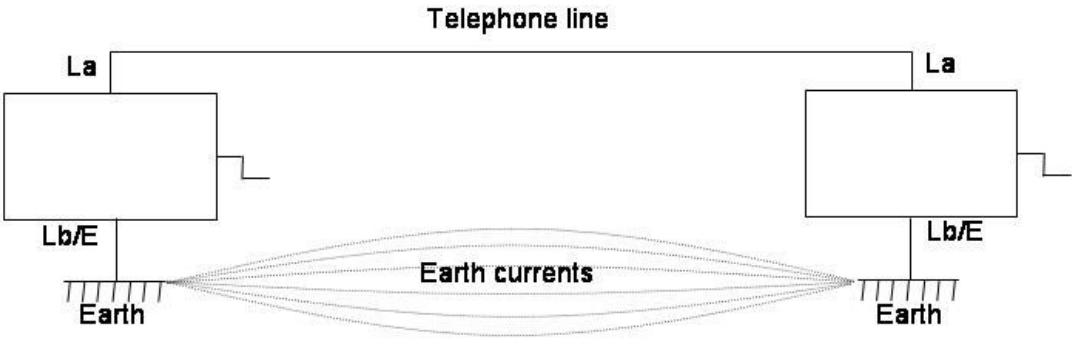


Figure 7: Current flow in a one line system

The FF 33 telephone has two line terminals marked "La" ("*Leitung a"* or line a) and "Lb/E" ("*Leitung b / Erde"* or line b / earth). The German army often used single wire connections with the other terminal connected to earth.
The upside is that a single cable connection only uses half the wire required for a double connection, making it cheaper and easier to build; the downside is that the return current flows through the earth, making it easier to intercept. For this reason telephone connections within 3 km of the front line had to be executed as double cable connections.

Sometimes during 1939 the type of microphone used in the *FF 33* handset was changed. The lower impedance microphone required a different microphone transformer. New *FF 33's* can be recognised by a green stripe on the writing tab on top of the bakelite lid. The new microphones also have a green cross marking. Also around this time the finish of metal part was changed from a lacquered alloy to black painted steel.

Figure 8: New microphone and green

Most existing *FF 33's* were modified to the new standard as very few examples with the old microphone coil and a non green striped writing tab survive.

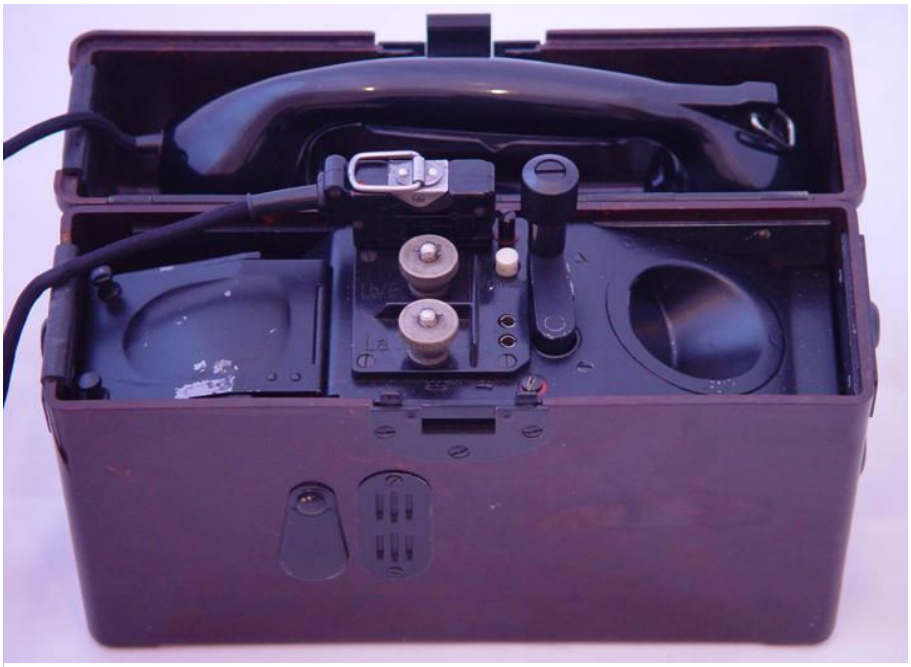


Figure 9: Model 1939 FF33. Note black painted metalwork

Figure 10: Late war 1943 model FF 33. Note changed line connections and the yellow painted metalwork

In 1943 the *FF 33* was slightly modified again to simplify production. The stamped metal frame was lightened by and spot welded rather than riveted. The bracket to hold the crank handle in place when stored was replaced by a simple stamped notch. The inside side covers were omitted. The line terminal contacts were changed to a new type using less metal. Towards the end of the war, "*Dunkelgelb*" (dark yellow) paint was increasingly used to paint metal components.

Figure 11: Kriegsmarine version of the FF 33

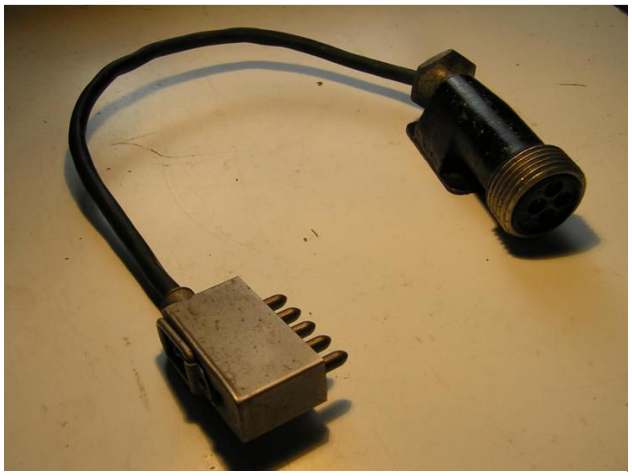


Figure 12: Kriegsmarine headset adapter cable

The *Kriegsmarine* (the German Navy) had use for a special version of the *FF 33* equipped with the Navy four pin headset connection. The Navy headsets were designed for use in high noise environments and would keep the hands free. In these headsets, the Navy four pin socket was placed on the outside of the bakelite housing.

A short adapter cable connected this outside plug to the normal five pin socket inside.

A different microphone transformer was required for use with the navy headsets, to distinguish the navy modified *FF 33*'s they were marked with a yellow stripe on the writing tab.
Some of the *FF 33* Manufacturers are:

1		Ferdinand Schuchhardt, Berliner Fernsprech- und telegraphhenwerk AG	Berlin
2	ber	Friedrich Reiner Telefonfabrik	Muenchen
3		Richard Bosse & Co	Berlin
4		Eumig, Electrizitäts- und Metallwaren Industrie	Wien
5	bxf/eaa	Telefonbau & Normalzeit GmbH	Frankfurt/Main
6	bI	Radio A. Mende & Co	Dresden
7	dej	Siemens & Halske AG	Berlin
8	fsh/fsc	MK, Mikrofona Brueder Knotek	Prag
9		Mix & Genest	Berlin
10		Erka, Rudolf Krueger Telegraphen Bauanstalt	Berlin
11		Hagenuk	Kiel
12		Stöcker & Co.	Leipzig
13		Badische Telefonbau	Renchen
14		Kapsch	
15		Friedrich Merk Telefonbau	München
16		SABA	
17		Süddeutsche Apparate Fabrik GmbH	Nürnberg
18		Heliowatt Werke Elektrizitätswerke AG	Schweidnitz
19		Neufeld & Kuhnke GmbH	Kiel
20		STE Societe des Telephones Ericsson SA	Paris
21			
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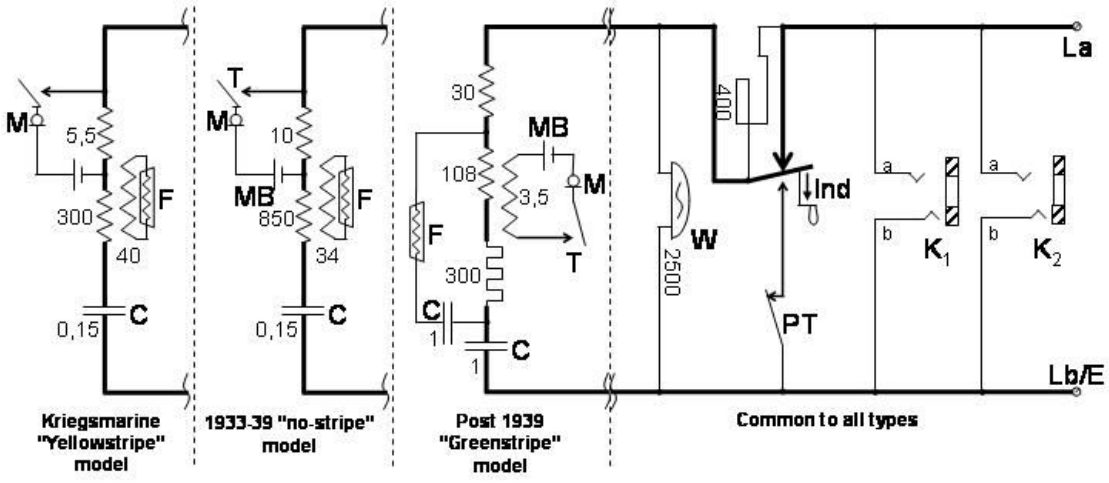


Figure 13: FF 33 Schematics

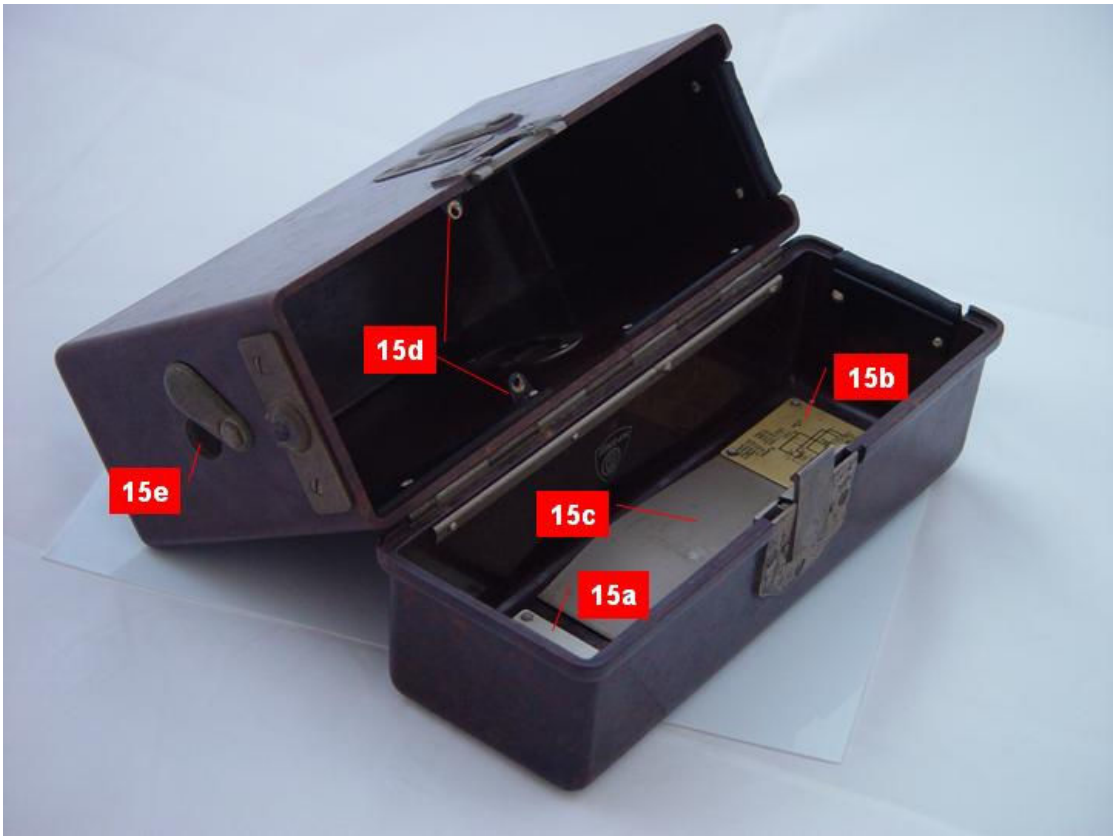
The schematics show the different variations of the *FF 33*. The key difference is in the microphone transformer, whose resistance values are shown. Note how the microphone circuit has moved to the secondary side of the transformer on the "Greenstripe" model.

Construction

Figure 14: FF 33 front view

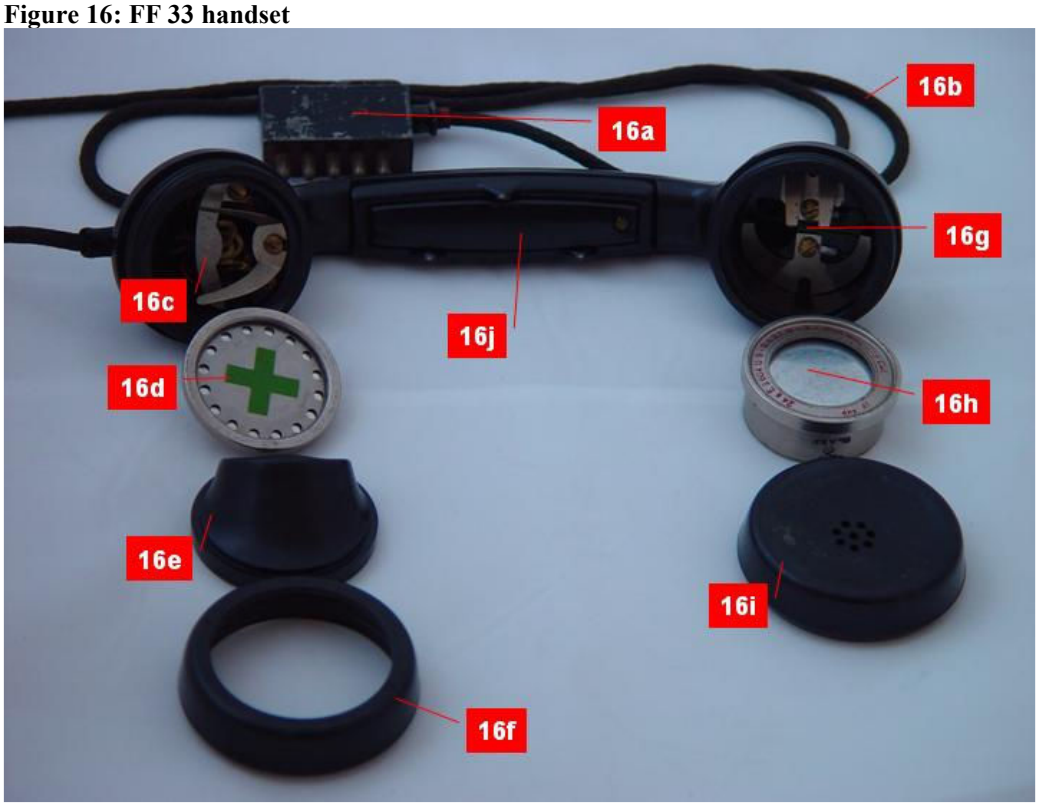
14a Writing tab (details like the station name or the station name on the other end of the line could be written on this tab with pencil)	14b Alphabet tag 14c cable rubbers 14d top lock 14e bottom lock 14f Bell sound passages	14g Interconnection socket cover 14h Carrying strap brackets

Figure 15: FF 33 casing



15a Overview schematic 15b Wiring diagram	15c Handset spring 15d Mounting brackets	15e generator crack hole and cover

Figure 16: FF 33 handset



16a 5-Pin plug
16b Cable
16c Microphone contacts
16d Microphone
16e Microphone cap
16f Microphone cap lock ring
16g Speaker contacts
16h Speaker
16i Speaker cap
16j Microphone switch

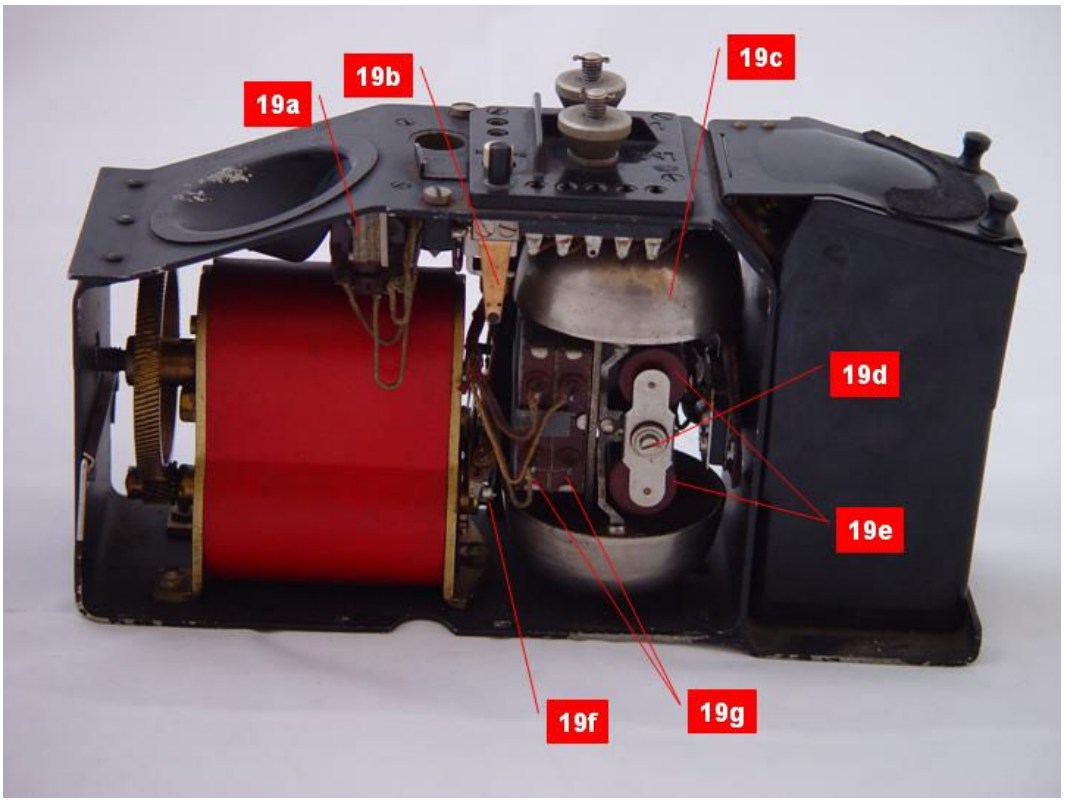
Figure 17: FF 33 telephone unit

17a Battery lid
17b 5-Pin handset socket
17c Handset socket pin
17d Test button
17e Recess for handset
17f Housing locking screws
17g Lb/E connection
17h La connection
17i 2-Pin headset socket
17j Generator crank storage
17k Manufacturer, serial number and date area
17l Battery box
17m Interconnection cable sockets
17n Bell sound passages
17o Removable side panel
17p Side panel locking pin

Figure 18: FF 33 unit internal front view

18a Battery box
18b Battery terminals
18c Battery spring
18d Microphone transformer
18e Interconnection cable sockets
18f Wiring loom
18g Ringtone generator
18h Generator crack connection

Figure 19: FF 33 unit internal back view



19a Microphone transformer
19b Test button contacts
19c Bells (When the top screw is slackened, the bells can be rotated to adjust)
19d Bell yoke
19e Bell coils
19f Generator switch
19g Capacitor blocks (preventing the low frequency ringing current flowing through the speaker coil and the speaker)

Figure 20: FF 33 accessories

20a Carrying strap
20b Connection lug
20c Hook for handset
20d Battery (Element d)
20e Earth pin
20f Earth pin carrying sheath
20g Interconnection cord

Operation

The minimal equipment needed to operate the field telephones are two *FF 33* (or compatible) phones, two wires and two 1.5 V batteries.

- Place the phone on a suitable surface, take the generator handle from its storage and connect it to the generator.

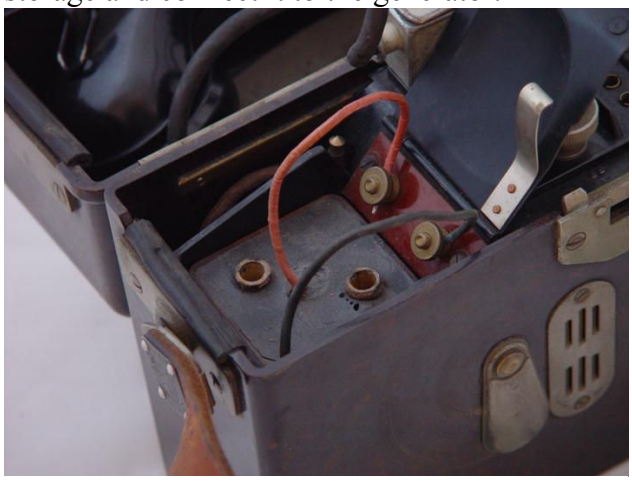


Figure 21: FF 33 Battery connection

- Connect the batteries the battery terminals (polarity is not critical).
- Connect one wire between the “La” connections of both phones and the other between the “Lb/E” connections. The normal mode of transmission by the German Forces was a single wire with return via earth; in

this case the “Lb/E” terminal would be connected to an earth pick on each side.

- Uncoil the handset lead and place all the wires and leads on the rubber strips
- Close the lid and place the handset crosswise on top of the telephone. Alternatively the phone can be hung from a nail or tree branch using the carrying strap. In this case the handset is hung from the hook on the carrying strap.

Figure 22: FF 33 connected and ready to use. Note the generator handle attached through the side and the connected carrying strap. The phone could be hung from the shoulder or a branch and the handset could be hung from the hook visible on the strap.

When the generator handle of one phone is cranked, the bell of the other phone should ring. The bell of the own telephone can be tested by depressing the white test button while turning the crank (a single telephone can also be tested in this way by shorting the La and Lb/E terminals).

When speaking in the handset the microphone switch has to be depressed. The voice should be heard back in the own handset and should be heard through the handset on the other end of the line. Both parties can depress the microphone switch and speak and listen simultaneously as with normal telephones.

Figure 23: Alphabet table and painted warning "*Feind hört mit!*"

When using field telephones it must be assumed that the message can be overheard by the enemy ("***Feind hört mit!***"), so messaging discipline is required by using appropriate codes for names and locations. For weak signals and noisy backgrounds the spelling alphabet printed on the top of the lid can be used to spell out messages.

On ending the telephone call the receiver shall be replaced and the generator should be cranked with three short movements. This "calling-off" procedure is particularly important when connected via telephone switchboards.

The signal will grow weaker as the line connection between telephones gets longer. The maximum range will depend on type of cable and how the connection is built. The following table gives an idea of the ranges achieved between two *FF 33* field telephones.

	Line lying on ground	Line suspended high	Double line
Light field cable	3 – 5 km	10 -20 km	-
Heavy field cable	10 - 12 km	50 - 60 km	30 -40 km
Long range cable without Pupin coils	-	-	40 - 48 km
Long range cable with Pupin coils	-	-	100 - 120 km

Figure 24: Two FF 33's connected by the interconnection cable

FF 33 field telephones can be interconnected via the interconnection sockets on the side to form a makeshift telephone switchboard. Each *FF 33* comes equipped with an interconnection cable that can be placed between two local phones. When so connected, the two separate field telephone lines can communicate. Several field telephones can be interconnected in this way.

SB Zusatz 33 End-Pulse generator

Development and Description

Figure 25: FF 33 with SB Zusatz

One type of telephone network in use at the start of the 20th century was the "*Schlusszeichen Betrieb*" (SB) or End-pulse system. This system was used where it was important that the switchboard connections could be reused for the next caller as soon as the previous call had ended. Apparently not all callers applied the correct manual calling-off procedure at the end of their call so that the switchboard did not get a signal that the call had ended. By using the automatic end-pulse system, this switchboard was always notified as soon as the handset was replaced.

The earlier *FF 26* field telephone had a built-in end-pulse switch but the simplified *FF 33* omitted this functionality. The field telephone could however be used in SB networks using the "*SB Zusatz 33"*.

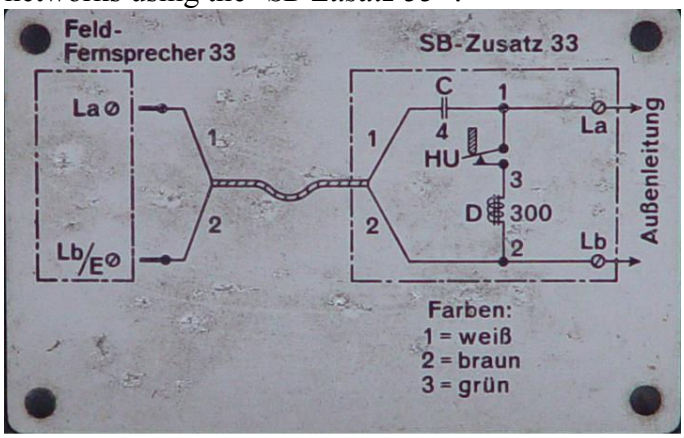
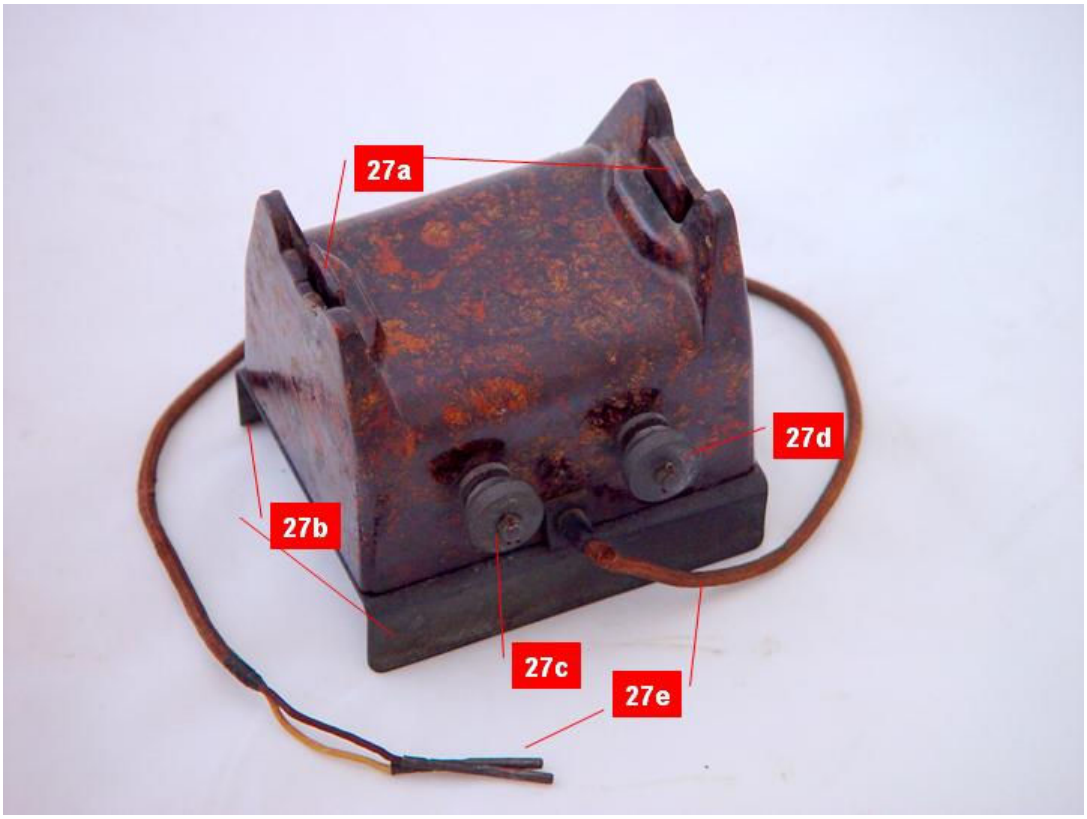


Figure 26: SB Zusatz schematic

The system works by letting a small DC current flow over the telephone line. When this current is interrupted, the "end-pulse" is generated in the telephone switchboard. Apart from a switch, the *SB Zusatz* contains an inductance coil and a capacitor to isolate this DC current from the normal telephone signal.

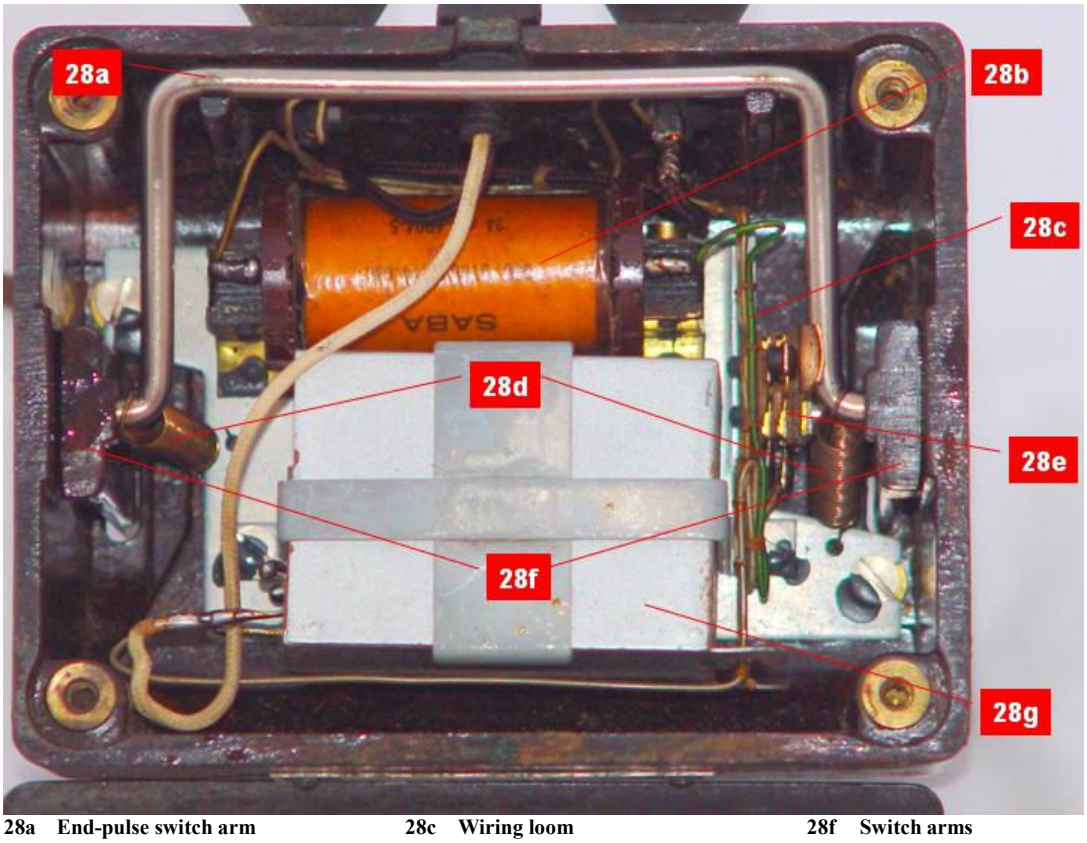
Construction

Figure 27: SB Zusatz exterior



27a	End pulse switch arms	27c	La line terminal	27e	Connection cable to *FF 33*
27b	clamp	27d	Lb line terminal		telephone

Figure 28: SB Zusatz interior



28a	End-pulse switch arm suspension	28c	Wiring loom	28f	Switch arms
		28d	Switch arm return spring	28g	Capacitor
28b	Inductance coil	28e	End-pulse switch contacts		

Operation

End-pulse systems are no longer in use so the unit can not be used in practice. When the SB system was still current, the *SB Zusatz* 33 could be used with a *FF 33* field telephone.

- Connect the two wire connections of the *SB Zusatz* to the line connections of the *FF 33*: white to “La” and brown to “Lb”.
- Connect the telephone line to the “La” and “Lb” terminals on the side of the *SB Zustatz*.
- Close the lid of the field telephone, clamp the *Zusatz* on top of the lid of the

Figure 29: Connecting the SB Zusatz

FF 33 and place the handset on top of the Zusatz.

When a call is received, the *FF 33* will ring as normal. Lift the handset from the *SB Zusatz* and depress the microphone switch to speak. When the call has ended, replace the handset on the *SB Zusatz*. This will automatically break the connection in the switchboard.

When making a call, turn the generator crank and wait until the switchboard operator acknowledges the call. Tell the operator who you wish to speak to and conduct your conversation as usual. When the call has ended, replace the handset on the *SB Zusatz*.

Table phone Tischfernsprecher 38

Development and description

Similar in functionality to the *FF 33* with *SB Zusatz 33* the *Tischfernsprecher 38* was developed as a neater desk version of the field telephone. To minimise the cabling required on the desk itself, a single cable leads to a separate battery/connection box, which can be placed under the desk or hung on the wall.

Figure 30: Tischfernsprecher 38

The *Tischfernsprecher 38* can be used in central and local battery systems, as well as end-pulse networks. In addition, an external bell could be connected to the phone so that important calls could not be missed. These features make it a telephone more suited to higher staff and administration functions bound to offices and barracks, less so as a field telephone.

Figure 31: Tischfernsprecher 38 terminal unit

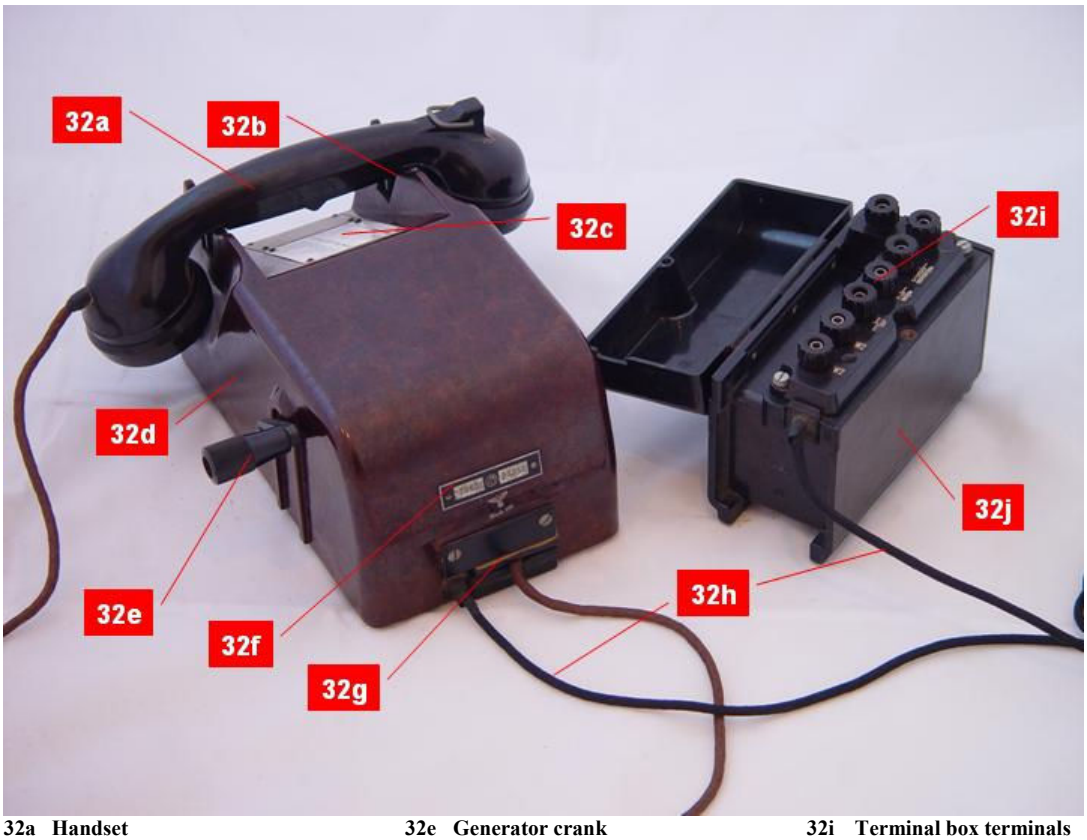
The Terminal unit has the following connections:

MB	Two "*Mikrofon Batterie*" or microphone battery connections
La/OB/SB	"*Leitung a / Orts Batterie / Schlusszeichen Batterie*" or line a / local battery / end pulse battery: This connection was to be used in local battery or end pulse systems, also when the *Tischfernsprecher 38* is connected to another field telephone
La/ZB	"*Leitung a / Zentral Batterie*" or line a / central battery. This connection was to be used for central battery networks
Lb/E	"*Leitung b / Erde*" or line b / earth:
W2	Two "*Wecker 2*" or Bell 2 connections: an external bell could be connected to these terminals.

The telephone unit itself consists of a bakelite base plate on which all components are mounted. On the back side connection terminals to the battery/connection box, handset and optional headphone are placed together so that all leads can be neatly led outside through a rubber seal. The bakelite top lid pivots open and is locked closed with two spring loaded hooks.

Construction

Figure 32: Tischfernsprecher 38 overview

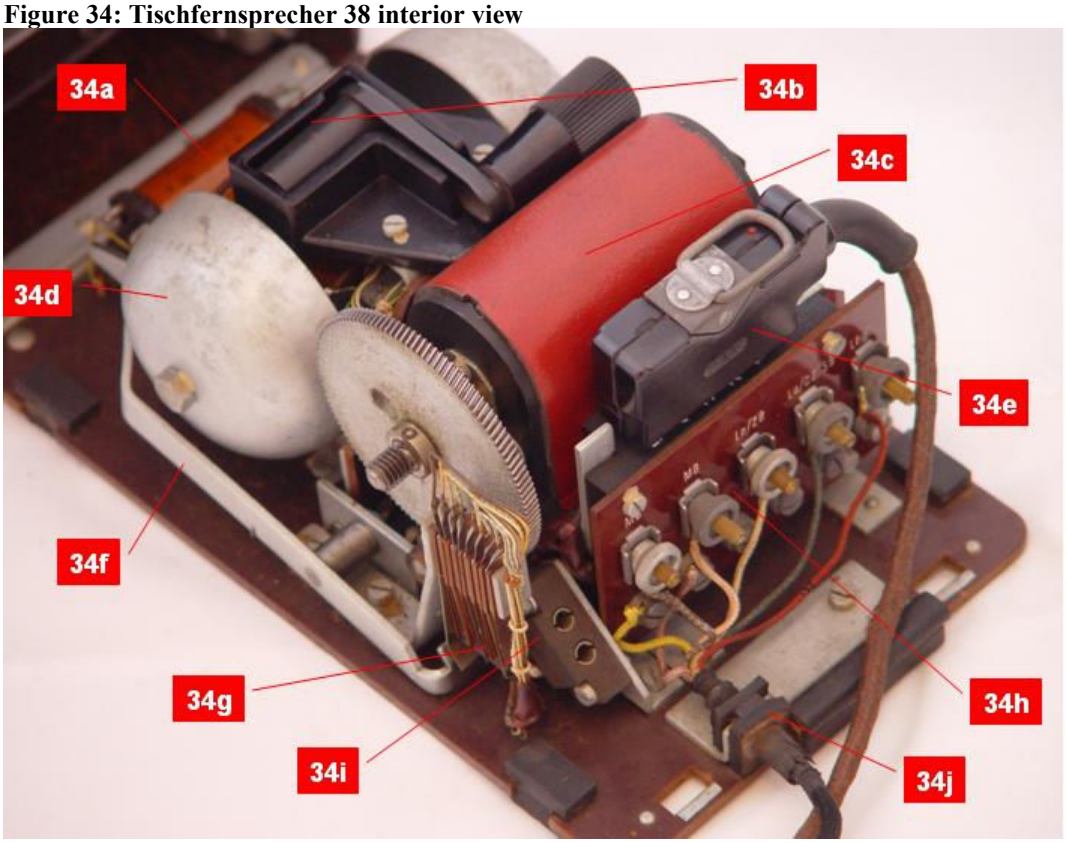


32a Handset
32b End pulse switch
32c Alphabet tag
32d Bakelite housing
32e Generator crank
32f Manufacturer plate
32g Rubber cable transit
32h Connection cable
32i Terminal box terminals
32j Terminal box battery compartment

Figure 33: Tischfernsprecher 38 underside

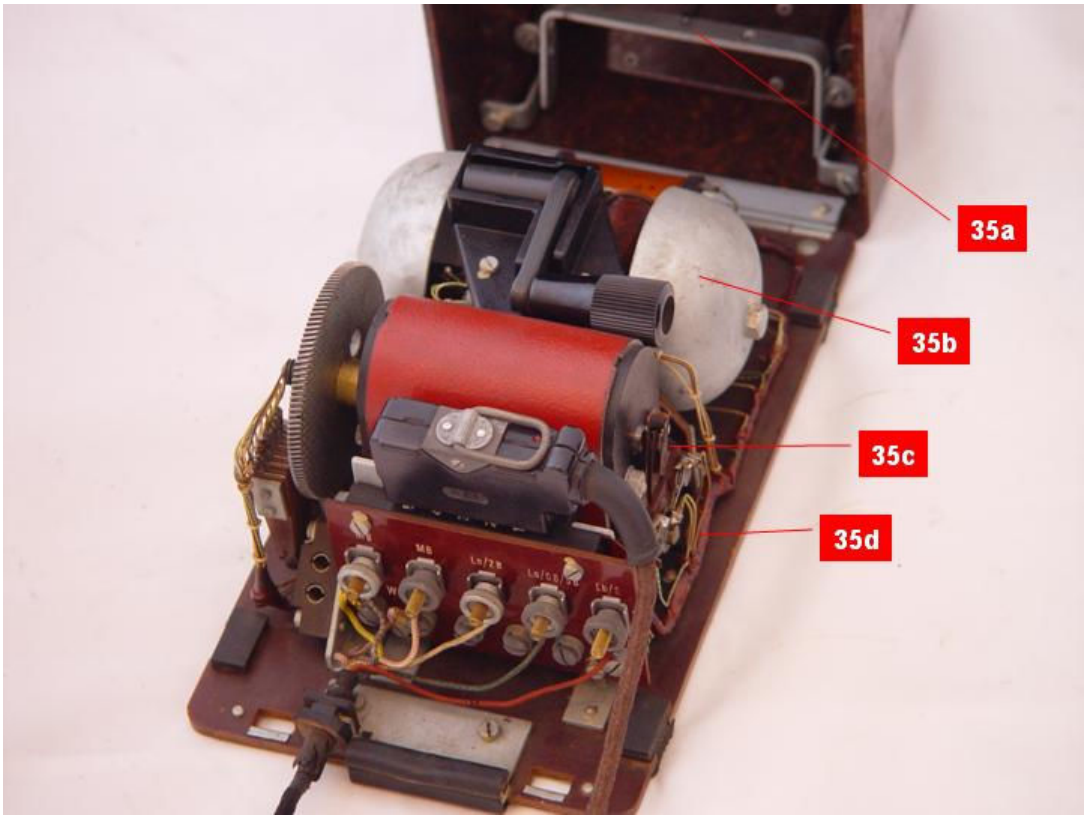
33a Housing swivel
33b Rubber feet
33c Bottom plate
33d Schematic
33e Housing Locks

Figure 34: Tischfernsprecher 38 interior view



34a Microphone coil
34b Storage recess for generator crank handle
34c Ring tone generator
34d Bell assembly
34e Handset connection plug
34f End pulse switch lever
34g End pulse switch contacts
34h Connection cable termination panel
34i Headset connection socket
34j Connection cable transit

Figure 35: Tischfernsprecher 38 interior view



35a End pulse switch suspension in top cover
35b Bell assembly
35c Generator switch
35d Wiring loom

Operation

- Open the *Tischfernsprecher 38,* plug in the handset, remove the generator handle from its storage recess and closing the unit again, taking care that the cables pass through the rubber seal.
- Place the handset on the telephone unit and connect the generator handle.
- Open the battery compartment of the battery/connection box and connect a 1.5 V battery to the “MB” terminals.
- Close the battery compartment and connect the telephone line to the required terminals. For connection with another *Tischfernsprecher 38* or and *FF 33* use the “La/OB/SB” and “Lb/E” terminals.
- Connect an extra bell if required to the “W2” connections.
- Place the battery/connection box in a convenient place and the telephone unit on the desk with the Alphabet and writing tabs facing the user.

Operation is identical to a normal *FF 33* field telephone so crank the generator handle to call the other end of the line and depress the microphone switch in the handset while talking.

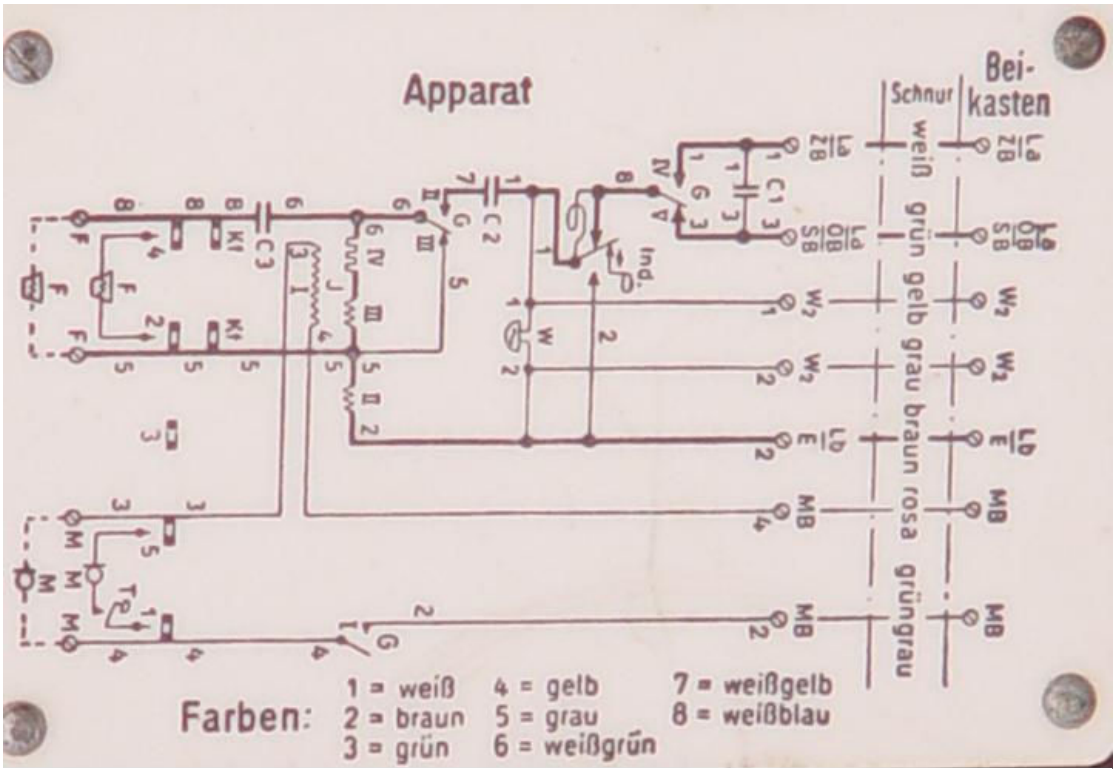


Figure 36: Tischfernsprecher 38 schematic

Amtsanschiesser 33

Development and description

As explained in the previous section, the *FF 33* was a “no frills” piece of equipment, which consequently did not have any provisions for connection to public telephone networks. To enable this functionality, a separate unit was developed, the *Amtsanschliesser 33*.

Figure 37: Amtsanschliesser 33

The *Amtsanschliesser 33* could be used as an independent telephone unit, or could be connected between a field telephone line and the public network. It contained an end-pulse switch and a dialling disc, allowing connection to most public networks then in use.

With a housing made of sturdy bakelite, a dialling disk set at a comfortable angle, a “hook” to place the handset on top and connections on the backside the unit is shaped like a classic desk telephone.

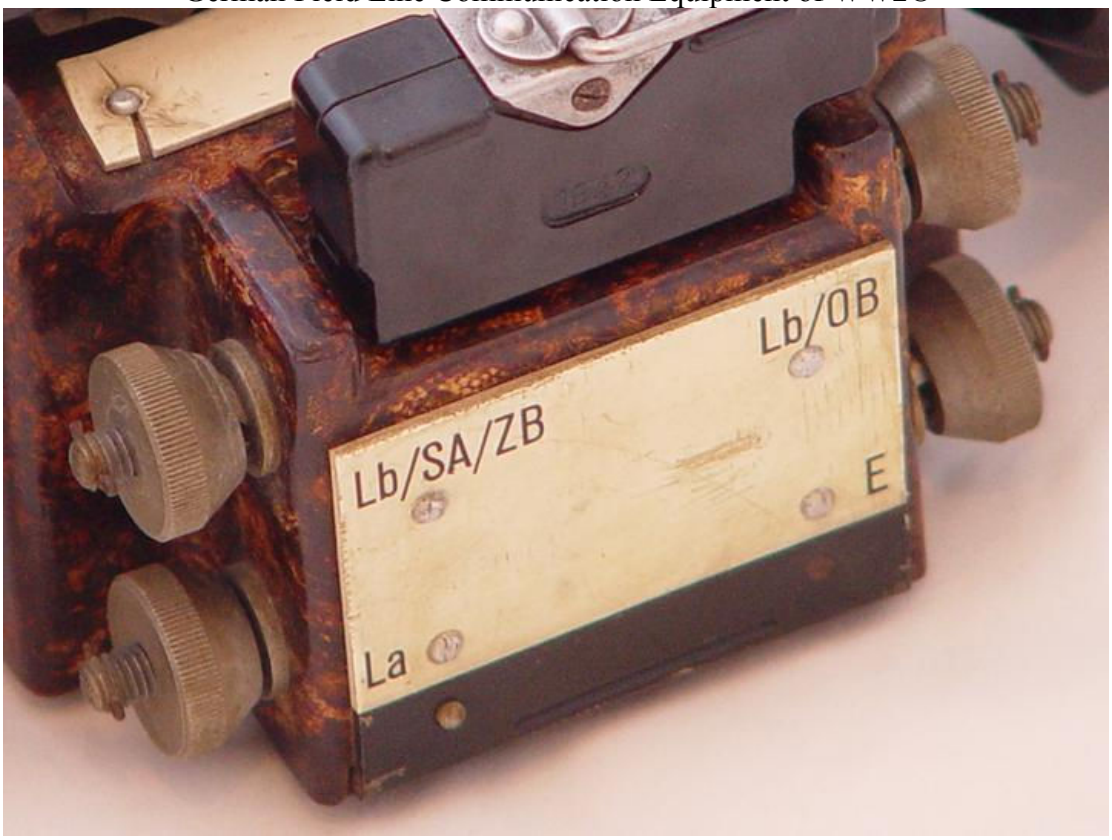


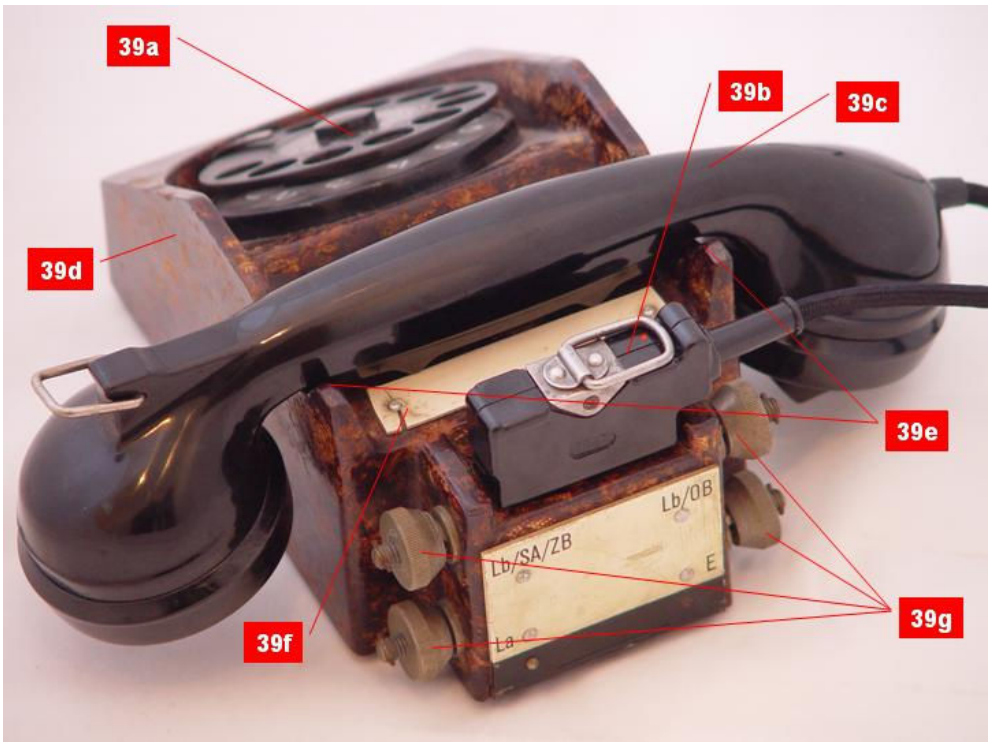
Figure 38: Amtsanschliesser connections

The *Ambstanschiesser 33* has four line connection terminals:

La	*Leitung a* or line a: This connects to the terminal of the automatic public network that carries the positive voltage
E	*Erde* or earth: This terminal was only used when a connection to a "Earthed System" network was made. In the 1930's this system was already rare and being phased out.
Lb/OB	*Leitung b / Ortsbatterie* or Line b / Local battery: This terminal was only used when connecting to a "SB" (*Schlusszeichen Batterie*) network. This type of network would automatically free up the connection in the switchboard when the end-pulse switch was depressed. This type of network is no longer in use.
Lb/SA/ZB	*Leitung b / Selbsanschlussbetrieb* / Zentral Battery or Line b / Self connecting network / central battery: This connects to the negative terminal of the automatic public network.

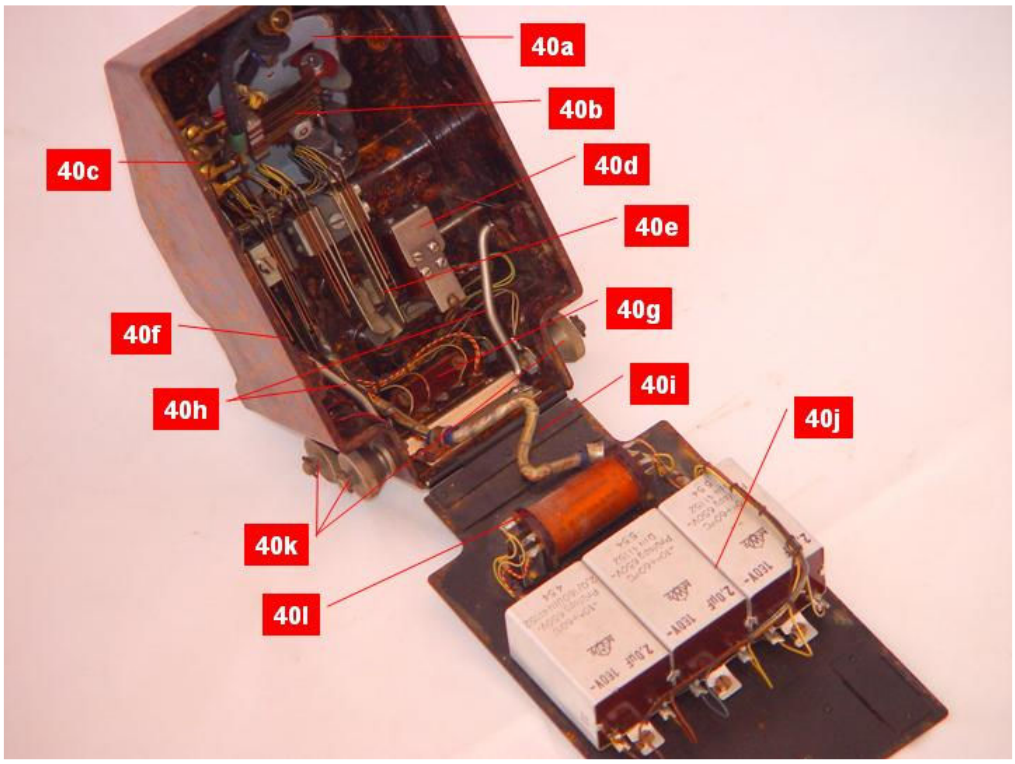
Construction

Figure 39: Amtsanschliesser external view



39a Dialling disk
39b Handset plug
39c Handset
39d Bakelite housing
39e End-pulse switches
39f Writing tab
39g Line connections

Figure 40: Amtsanschliesser internal view



40a Dialling disk unit
40b Dialling disk pulse contacts
40c Dialling disk connection strip
40d Buzzer
40e Contacts for inductor and interconnection cord jacks
40f End-pulse contacts
40g Handset connection strip
40h End-pulse switch suspension
40i Wiring loom
40j Capacitor blocks
40k Line connection screws
40l 15l Microphone transformer

Operation

If your public phone network supports “pulse dialling”, the *Amtsanschliesser* should work as a normal phone. Most modern networks however use “tone dialling” so a pulse to tone converter might be required.

Figure 41: Amtsanschliesser 44 ready for use. Note instruction leaflet in front

- Connect the “La” and “Lb/SA/ZB” terminal to the public phone line.
- Connect a handset from a field telephone to the *Ambstanschliesser* and place the handset on top of the unit.

To make a call, lift the handset and dial the required number using the dialling disk. Depress the microphone switch in the handset while speaking. When the handset is replaced on top of the unit the connection will be broken. The *Ambstanschliesser* is now also ready to receive calls. When a call is received the buzzer will make a rattling sound. When the handset is lifted, connection will be made.

When the *Ambstanschliesser* is to be used to interface between a field and public line:

- Place a FF 33 field telephone next to the *Ambstanschliesser*.
- Establish the field connection as described in the Field Telephone section.
- Unplug the handset from the field telephone and plug this into the *Amtsanschliesser*.
- Plug the interconnection cord (*Vermittlungsschnur*) into the one of the jacks on the side of the *FF 33* field telephone.

Figure 42: Amtsanschliesser connected to FF 33

When a call is received from the public line operate the *Amtsanschliesser* as described above. Establish connection over the field telephone line. When both connections are established, place the other end of the interconnection cord into the jack on top of the *Amtsanschliesser*. The person on the far end of the field telephone line can now talk via the public network.

When the call is ended, the person on the far end of the line turns the generator crank which will cause the buzzer in the *Amtsanschliesser* to rattle. Disconnect the interconnection cord and replace the handset on top of the *Amtsanschliesser*. The placement of the interconnection cord jack on top of the *Amtsanschliesser* is such, that the handset can not be replace accidentally when the connection is in use.

When a call is received from the field telephone network the procedure is similar but the order in which the connections are made is reversed.

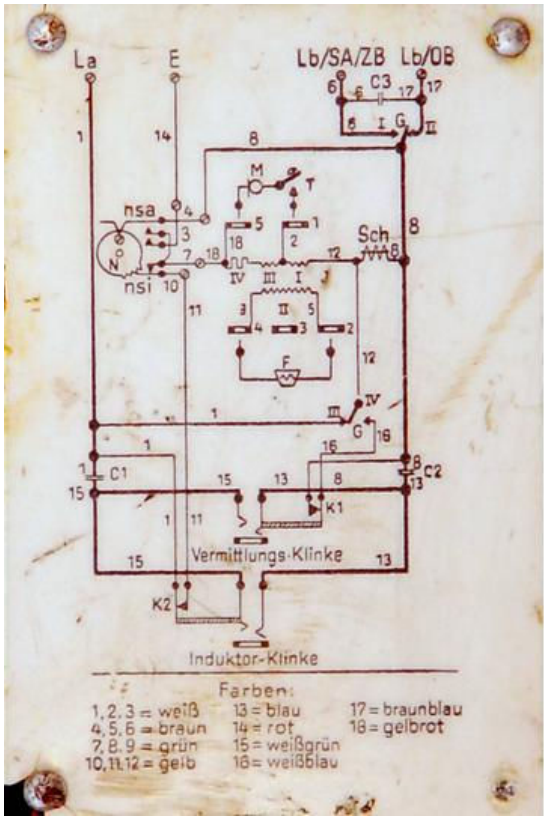


Figure 43: Amtsanschliesser schematic

OB Fernsprecher 43

Development and Description

Figure 44: OB Fernspecher 43

As the war was dragging on and the situation of the German industry was deteriorating, the production of field telephones was simplified. Not only were some simplifications to the *FF 33* made, but it was also concluded that a large proportion of field telephones were used in fixed positions where demands on weather protection, portability and connectivity were minimal

In 1943, a cheap and basic telephone was developed aimed at inside use at fixed positions. Weather protection, carrying facilities and the interconnection cable jacks were omitted and the metal frame was replaced by a simple pertinax plate on which all components and connections were mounted. The handset cable was connected direction to the phone, dispensing with the five pin plug. This telephone became known as the "*OB Fernsprecher 43 fuer ortfesten Betrieb*" (local battery phone 43 for fixed station use). Other than the changes described above, standard *FF 33* components were used.

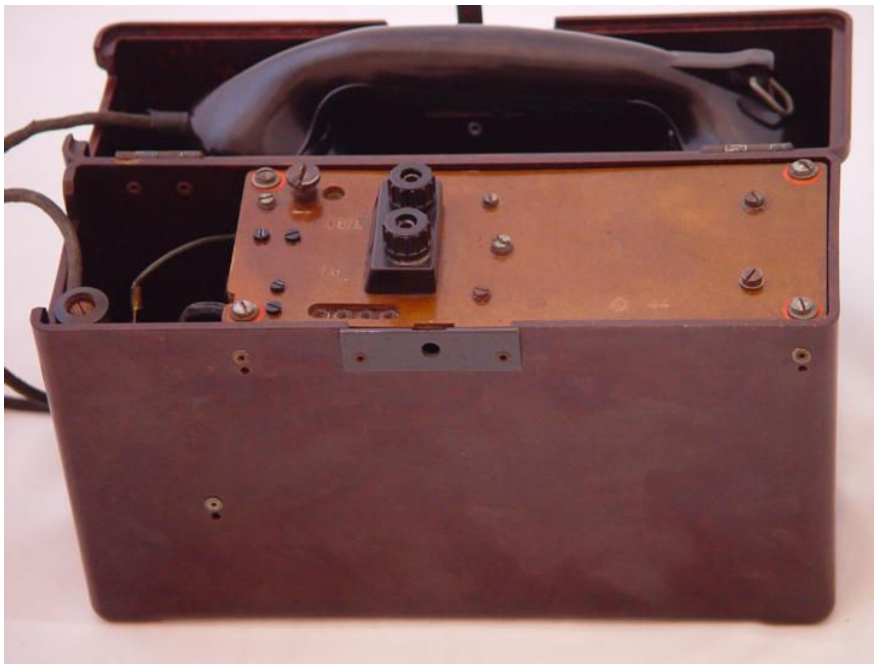
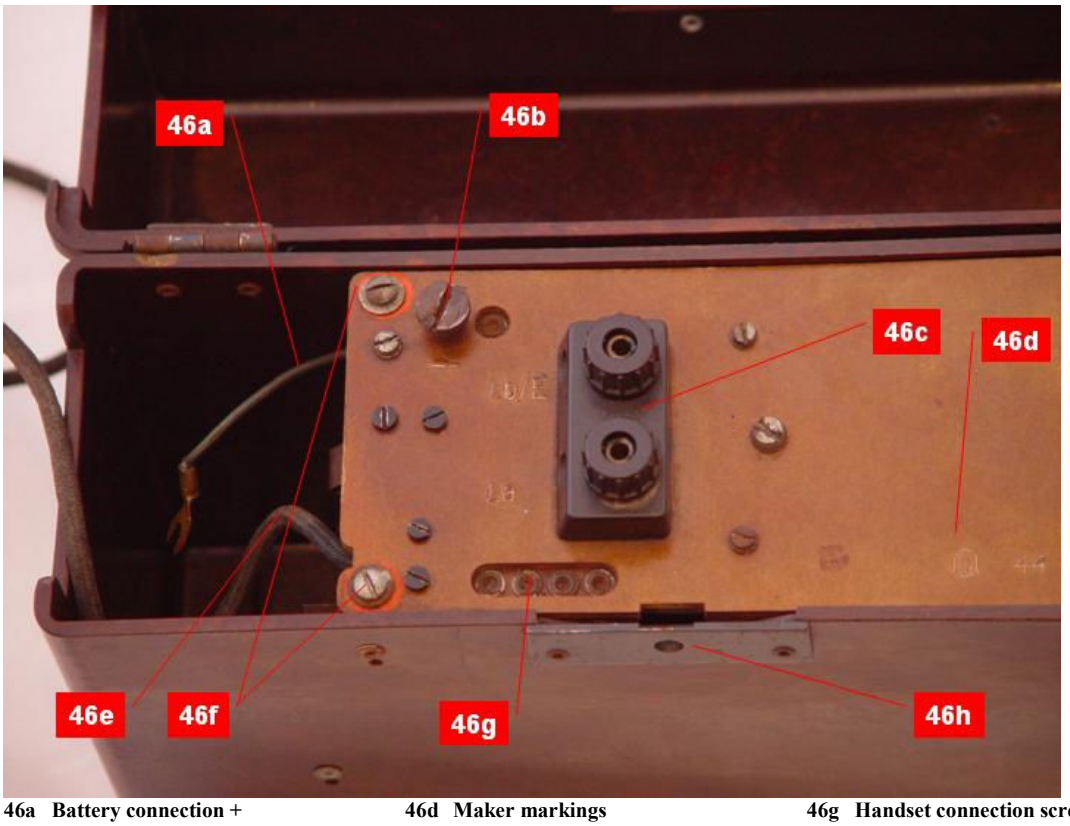


Figure 45: OB Fernsprecher 43 opened up

The *OB Fernsprecher 43* can be recognised by the red tag in place of the *FF 33* Alphabet plate and its Spartan exterior lacking all metal components of the *FF 33*

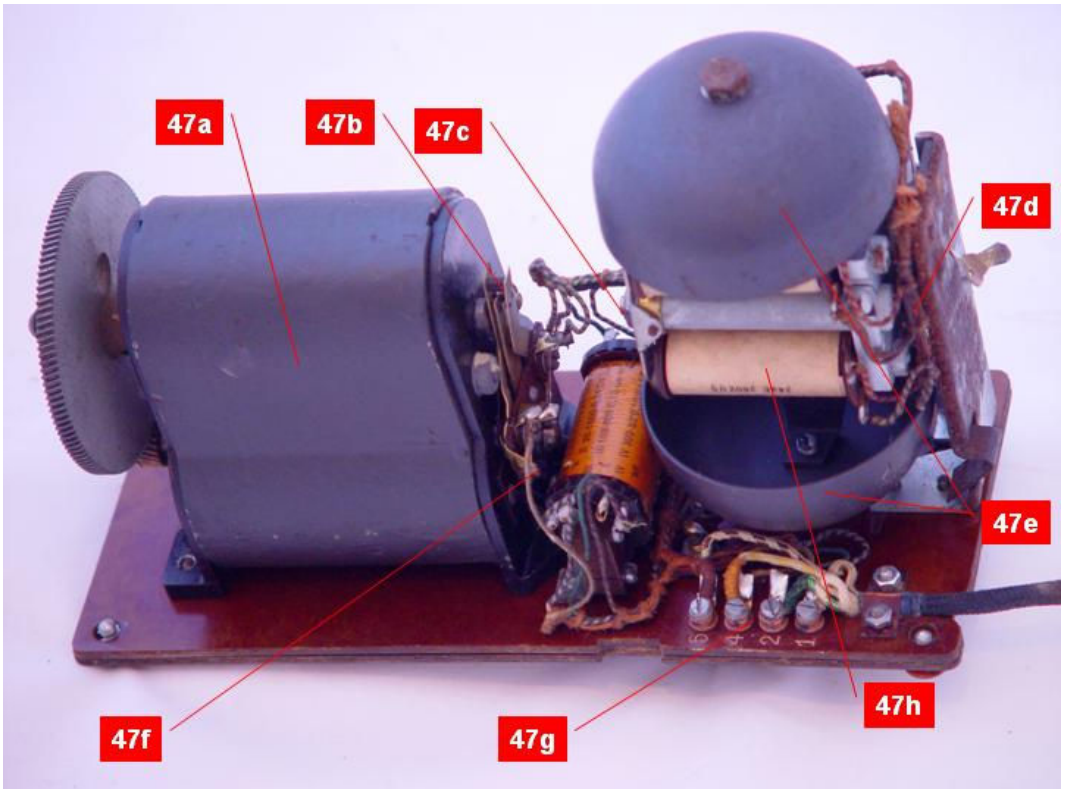
Construction

Figure 46: OB 43 top panel



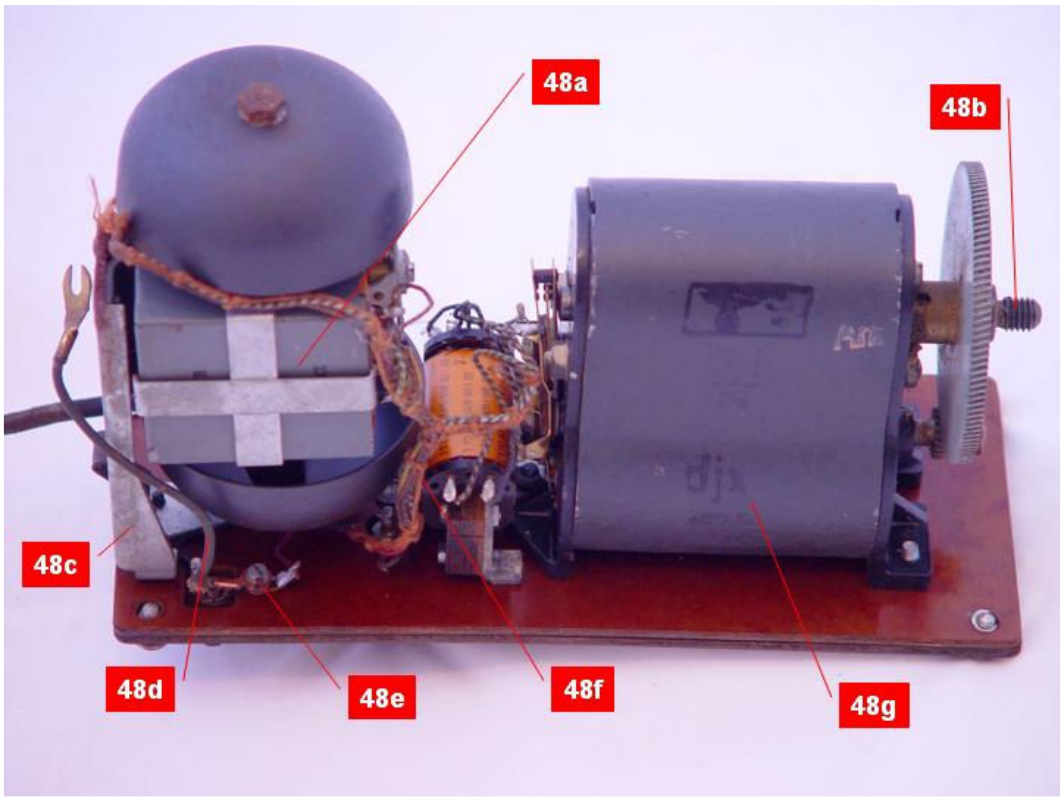
46a Battery connection +
46b Battery connection -
46c Line connections
46d Maker markings
46e Handset cable
46f Top panel locking screws
46g Handset connection screws
46h Bottom lock

Figure 47: OB 43 internal view



47a Ring tone generator
47b Generator switch contacts
47c Bell yoke
47d Wiring loom
47e Ringtone generator
47f Microphone transformer
47g Handset connection
47h Bell coils

Figure 48: OB 43 Internal view



48a Capacitor block
48b Generator crank connection
48c Mounting frame for bell assembly
48d Battery connection +
48e Battery connection -
48f Wiring loom
48g Maker marking on generator

Operation

Operating the *OB Fernspecher 43* is exactly as the FF 33 field telephone.

Figure 49: OB Fernsprecher 43 ready for use

Erdsprech Gerät

Develoment and Description

One disadvantage of field telephone connections is the cable can easily be damaged by artillery fire. This was a common occurrence in forward areas, requiring a dangerous trip by a repair crew to find and repair the break in the cable. Until repaired, no connection could be made with normal field telephones.

Figure 50: Erdsprechgerät

From the telephone interception experience in the First World War, it was learned that telephone conversations could be picked up amplifying the currents flowing through the earth. The same principle can be used to bridge breaks in telephone lines. Instead of amplifying the received signal (as is used in interception equipment), the *Erdsprechgerät* boosts the telephone signal into the telephone wire by a factor 200, creating enough signal to bridge a gap of up to 5 meters in the telephone cable. Alternatively, the *Erdsprechgerät* could be used on long lines or lines with a high attenuation, where normal *FF 33* telephones could no longer work.

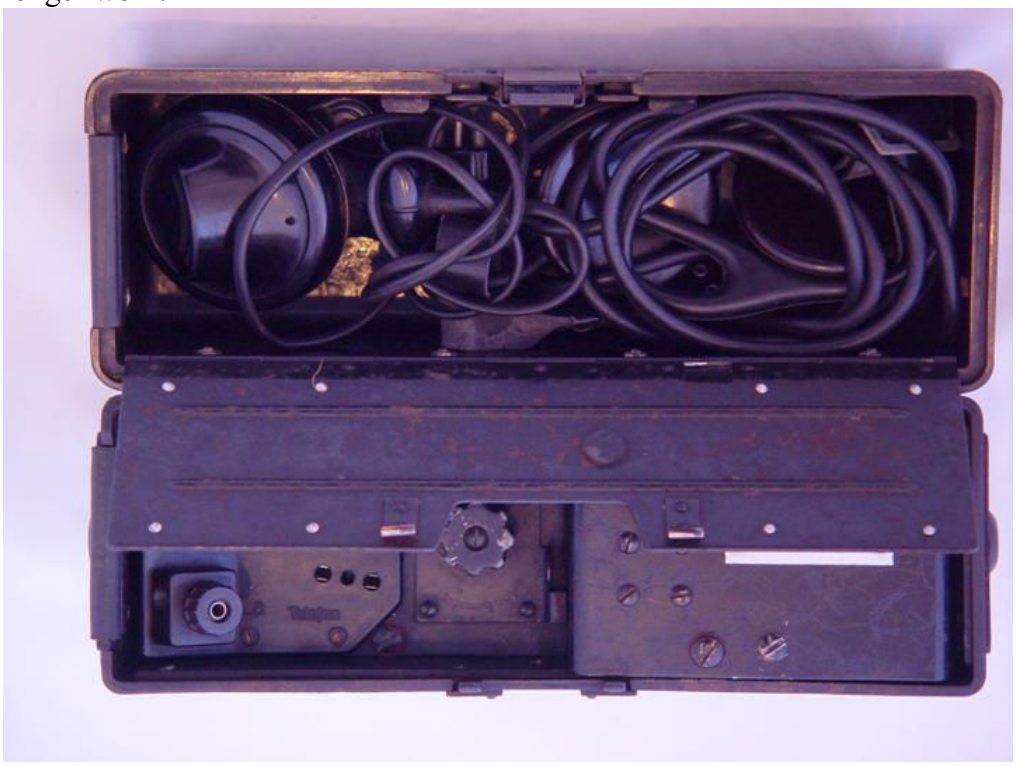


Figure 51: Erdsprechgerät storage in lid for headset and microphone

Instead of a battery to power the microphone, the *Erdsprechgerät* uses a DC generator to generate about 14 Volts microphone voltage which is fed to a powerful microphone. The speech signal of high amplitude is injected into the broken line via a matching transformer. On the other side, a sensitive headset is used to receive the signals. The matching transformer with three settings can be used to optimise the signal

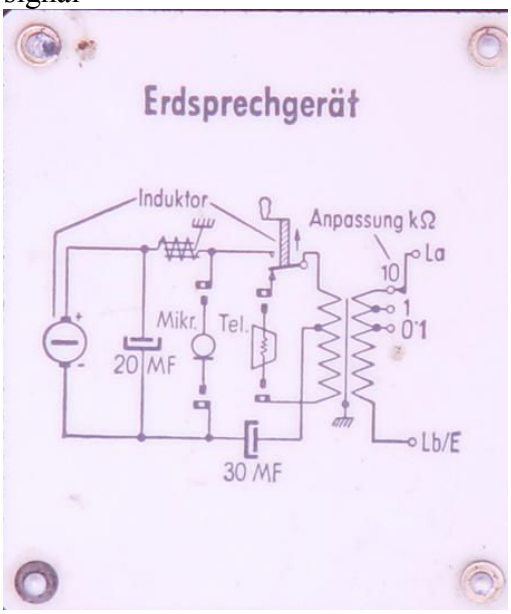


Figure 52: Erdsprechgerät schematic

To distinguish the *Erdsprechgerät* from a normal *FF 33* the side of the unit and the writing tab are clearly marked "*Erdsprechgerät*" and on early versions, a white band is painted on the housing.

The control panel was different from the normal field telephone with connection jacks for the cable (marked "La" and "Lb/E" as with the *FF 33*), connection jacks for microphone and headset and a matching switch. Instead of a handset, a separate microphone and headset were used, which could be stored in the lid of the housing. The *Ersprechgerät* dös not have a ringing generator nor bell, requiring different operation practices than normal field telephones. With the *Erdsprechgereat*, the generator handle has to be turned continuously during operation. One disadvantage of the *Erdsprechgerät* is that it can relatively easily be overheard by the enemy, so "***Feind hört mit!***".

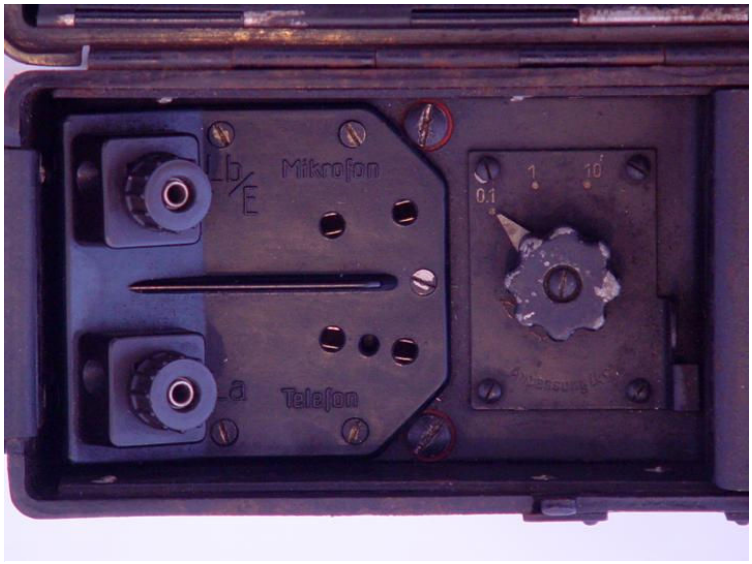
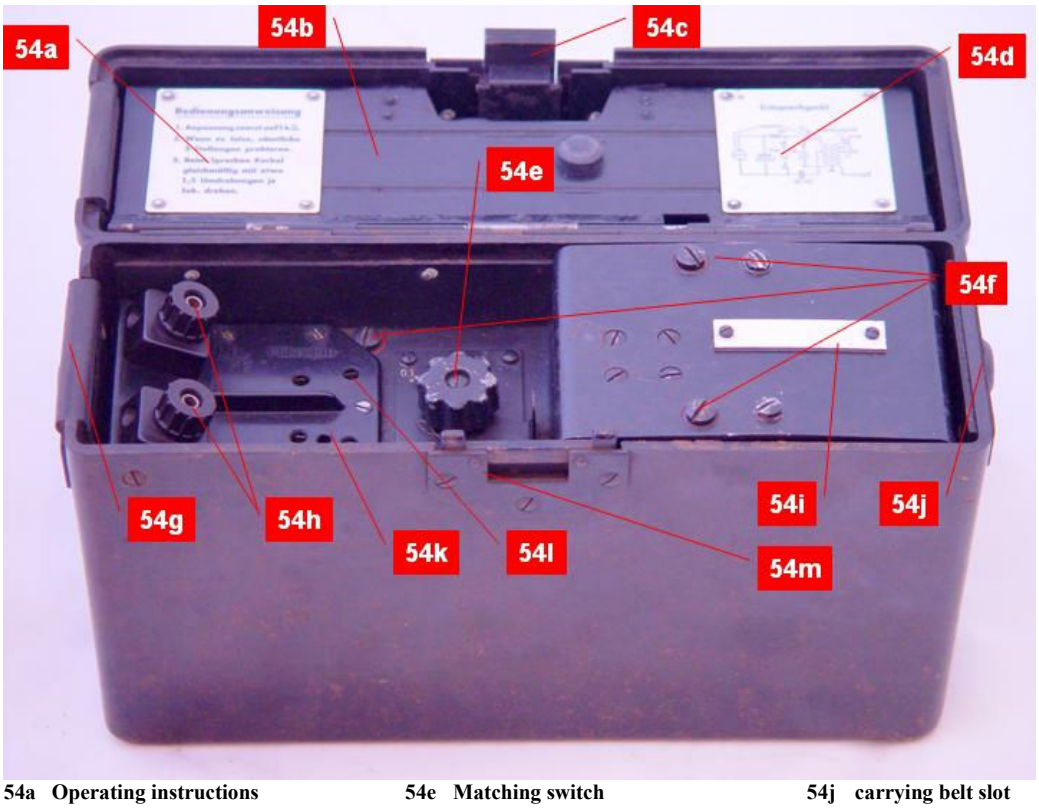


Figure 53: Erdsprechgerät control panel

An earth pin and a 20 m length of single core telephone cable complete the *Ersprechgerät* set.

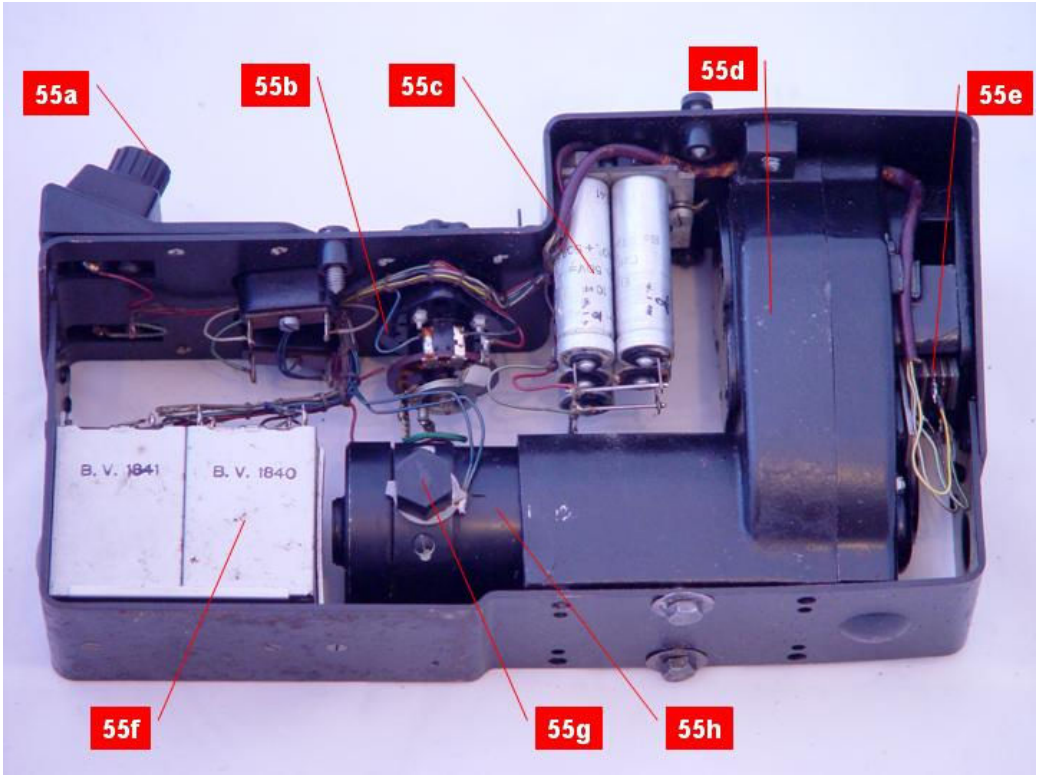
Construction

Figure 54: Erdsprechgerät top view



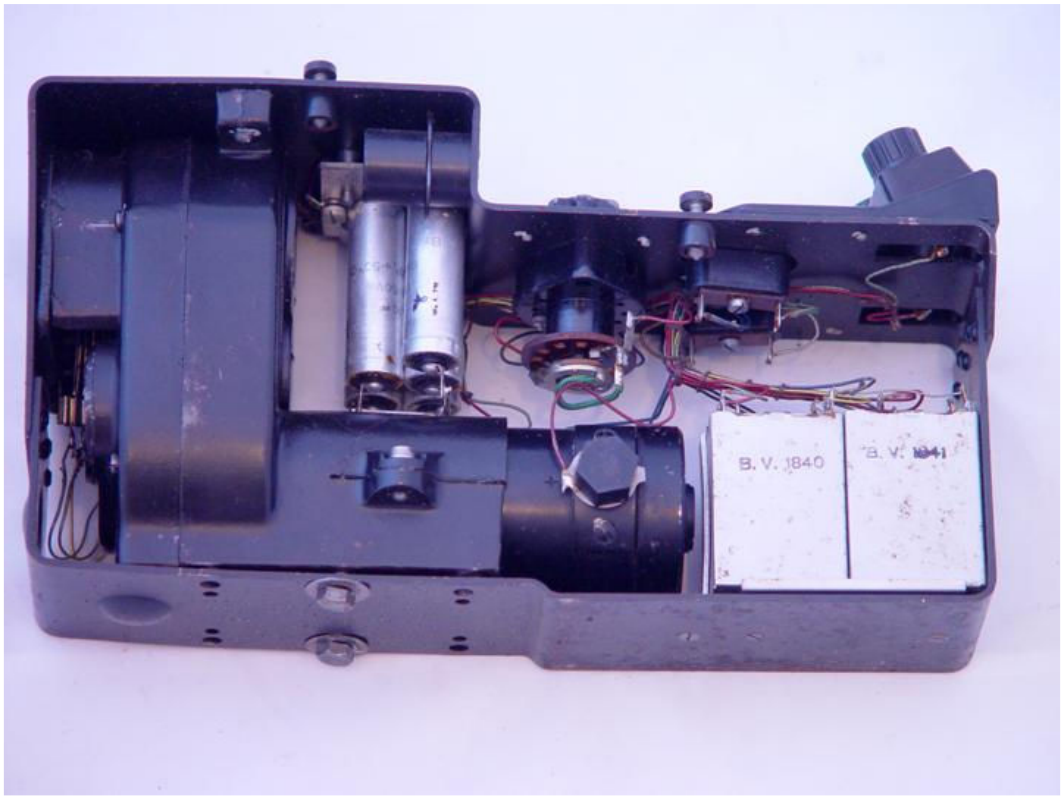
54a Operating instructions	54e Matching switch	54j carrying belt slot
54b Lid to Headset storage compartment	54f Lock screws	54k Headset connection
54c Upper lock	54g Cable transit rubber	54l Microphone connection
54d Schematic	54h Line connection terminals	54m Bottom lock
	54i Small writing tab	

Figure 55: Erdsprechgerät inside view



55a Line connection terminals	55d Generator gearbox	55g Generator brush cap
55b Matching switch contacts	55e Generator contacts	55h Generator
55c Capacitors	55f Matching transformer	

Figure 56: Erdsprechgerät internal view



see view 1 for components

Figure 57: Erdsprechgerät headset and microphone

57a Headset plug
57b Microphone plug
57c Microphone
57d Headset headband
57e Headset "Dfh.g"
57f Headset adjustable chinstrap

Operation

To create a connection, two *Erdsprechgeräte* complete with headsets and microphones, two earth pins and 2 lengths of 20 meter single core telephone wire are required. It is assumed that a standard field telephone connection with a single wire and earth pins is already in existence and that the wire has been broken with both ends lying in or on the ground with a gap of up to 5 meters. If a broken two-wire telephone connection has to be bridged, the two wires are connected in parallel to the *Erdsprechgerät*.

Figure 58: Erdsprechgerät with generator crank, headset and microphone connected

- Place the earth pin about 10 meters from the *Erdsprechgerät* and connect to the "Lb/E" connection of the *Erdsprechgerät* using a suitable length of single core cable. If the operating position is surrounded by barbed wire, make sure the earth pin is placed about 10 meters outside the barbed wire enclosure.
- Prepare another short length of wire to connect the "La" terminal of the *Ersprechgerät* to the telephone wires. About 20 cm of the cable insulation is stripped, so that it can quickly be connected to the terminals of the telephone line or lines.
- Connect the generator handle to the generator though the hole in the side of the casing.

When the normal telephone connection is broken due to the effects of enemy artillery fire, immediately switch over to the *Erdspechgerät* connection:

- Connect the prepared "La" wire to the telephone wire; in case of a two-wire connection, connect the prepared "La" wire to both telephone wires in parallel.

To operate the *Erdsprechgerät*, two men are usually required: one to turn the generator and another to speak and listen and take notes. The unit can be operated by a single person in emergencies, with one hand used to crank the generator and the other to hold the microphone to the mouth.

Figure 59: Erdsprechgerät operating instructions

To speak, turn the generator with a constant 1 – 1.5 turns per second. The microphone is to be held no more than 2 cm away from the mouth.

To listen, the headset is to be worn by the operator. Release the generator crank (this allows the generator switch contact to switch on the headset). Initially set the matching switch to the "1" position. Once a signal is received, the alternative positions should be tried to find the position which gives the loudest reception.

Only one station can speak at the time while the other should be listening, so the two stations will have to agree operating practices beforehand, for example that station A always calls station B first. Since it is also not possible to "ring" the other station, fixed operating times should be agreed.

After the normal telephone line is interrupted and the *Erdsprechgerät* is connected, station A will start calling station B by turning the handle 1 -1.5 times per second and for example calls: "Here station A, here station A, station B please come in, over, over….". After this station A will listen for a reply. If no reply is received after two minutes, the matching switch is to be tried on another setting and the calling procedure repeated.

Figure 60: Erdsprechgerät ready for use

After station B has received the call, it will start turning the generator crank and will for example reply: "Here station B, here station B, I read you bad/good/load and clear. Best reception is at position 1 or 10, do you read station A? Over, over…."

When the connection has been established, normal conversation can resume. Because the signal is less secure than even normal telephone connections, secure communication protocol should be used by using codenames etc. "***Feind hört mit!***".

3. Field Telegraph equipment

Introduction

Telegraphy is essentially a digital form of communication where letters and numbers are replaced by a sequence of code. This code can be transmitted by switching a DC current on/off or can be modulated so that a tone is switched on/off or changed in pitch.

An example of telegraph code is Morse code, in which each letter is replaced by a sequence of short and long pulses (dots and dashes). Another example is the 5-bit Baudot telex code, where each letter is represented by a sequence of ones and zeros, for example 01011 representing the letter "J".

This chapter primarily discusses equipment that could be encountered in the "Field", i.e. could be encountered by front-line troops, Baudot-type telex equipment will not be considered. This specialised equipment which was generally too bulky and fragile for field use could primarily be found at headquarters and message centres.

DC Wire Telegraph

Development and Description

Due to the proximity of the trenches of the First World War, the security of telephone lines were easily undermined. Especially single wire connections, where the return current flows through the earth are susceptible to eavesdropping. But even two-wire connections can induce stray currents in the earth, which could be picked up by increasingly sensitive monitoring equipment. In 1915, the then Captain A.C. Fuller invented a telegraph device using DC current. Because DC current does not induce stray currents in the earth, it was impossible to intercept the signal, even on single line connections it is virtually impossible to tap into the earth currents. The Fullerphone, as the device became known, can be used simultaneously with a telephone on the same line over distances far exceeding that of normal telephone connections. During experiments, communication distances exceeding 1000 Km were found to be possible.

Figure 61: British Fullerphone Mk IV

Figure 62: DC wire telegraph

Although DC telegraphy was widely used by the British and Commonwealth armies, little is known about its use by the German army. The German device is not strictly a Fullerphone and has no name or type reference, not even a description or manual of the device is known, so it will simply be called the "DC wire telegraph".

The working principle of the DC wire telegraph is based on switching-on and –off of a DC current through the connection between the two stations. This current needs to be detected and transformed into an audible signal. The Fullerphones use an electromechanical buzzer to chop the line current flowing directly through a set of headphones; the German device uses an electronic oscillating circuit with a *RV2,4T3L* Tetrode valve to tone in the headphones. The line current is used to change the voltage on the screen grid of the Tetrode, influencing the waveform of the oscillator.

A Morse key is used to switch a 9 V battery voltage on and off. When depressed, the oscillator will generate a tone in a set of headphones of the sending unit and the current will start flowing through the telephone line to the receiving unit causing the oscillator at the receiving end to generate a tone as well.

Figure 63: DC wire teleraph, opened lid showing the stored Morse key and headphones

The unit uses two 4.5 Volt *Ba4,5KZT5* batteries (the same as used in the Enigma machine).

The unit is built in the same bakelite casing as the standard field telephone and can be distinguished by red markings on the writing tabs and a red band around the casing. A small Morse key and a set of headphones complete the set.

The DC wire telegraph has four wire terminals

Figure 64: DC wire telegraph connection panel

Ltg	La	"*Leitung a*" or Line a of the telephone connection
	Lb/E	"*Leitung b / Erde*" or Line b / Earth of the telephone connection
Feldfspr.	La	"*Leitung a*" or Line a connecting to La terminal of the FF 33
	Lb/E	"*Leitung b / Erde*" or Line b / Earth connecting to the "Lb/E" terminal of the FF 33

The advantage of the DC wire telegraph is its security. A drawback is that the operation requires two trained operators who should be able to read and write Morse code.

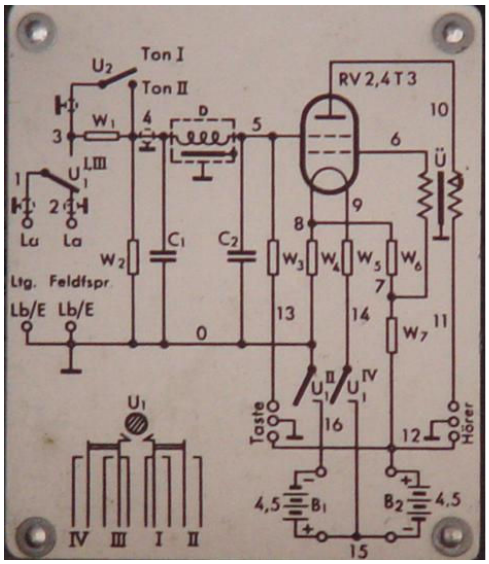
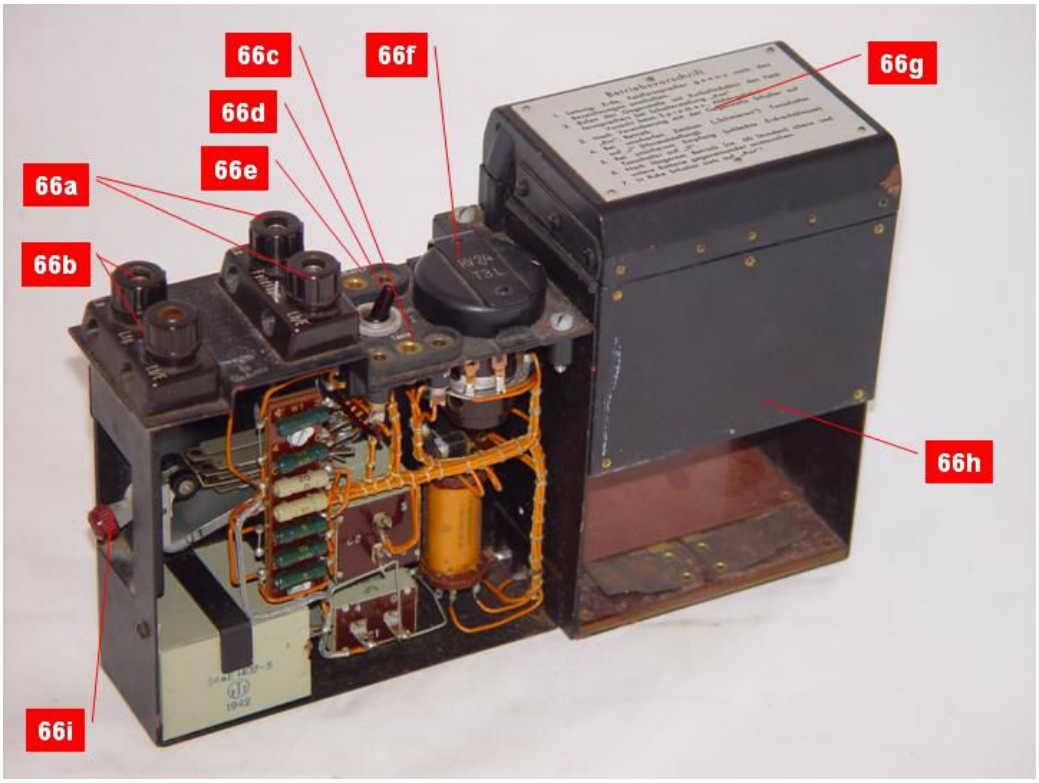


Figure 65: DC wire telegraph schematic

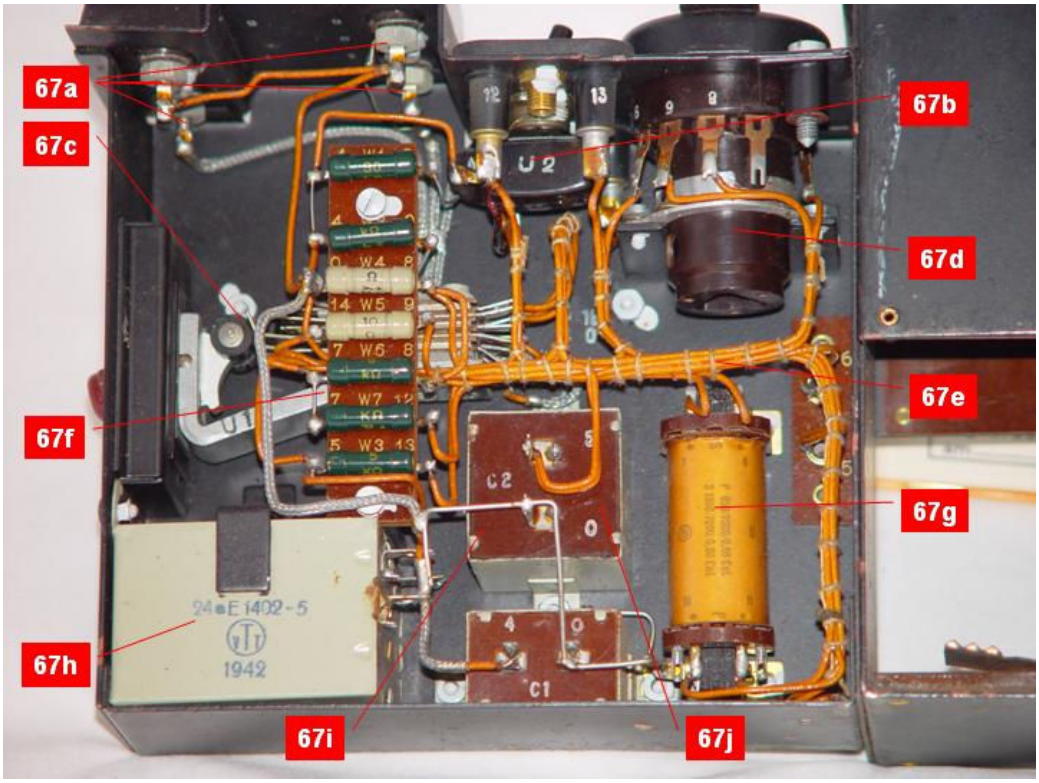
Construction

Figure 66: DC wire telegraph



66a Connection to FF33
66b Line connections
66c Headphone connection
66d Switch for pitch control
66e Morse key connection
66f Radio valve housing
66g Battery compartment lid with operating instructions
66h Battery compartment
66i On-off switch

Figure 67: DC wire telegraph internal view



67a Connections to outgoing line and field telephone
67b Pitch control switch
67c On-off switch
67d Radio valve housing
67e Wiring loom
67f circuit board with resistors
67g Output transformer
67h Filter Inductance coil
67i Filter Capacitor block
67j Wiring loom

Operation

To set up a DC wire telegraph connection, two DC wire telegraphs and two *FF 33* field telephones are required.

- On each end, connect the telephone wires to the "*Ltg La*" and "*Ltg Lb/E*" terminals; connect the "*Feldfspr La*" and "*Feldfspre Lb/E*" terminals to the corresponding terminals of the *FF 33* field telephone.
- Remove the Morse key and headphones from their storage compartments and connect the Morse key to the "*Taste*" terminal; the headphones to the "*Kopfhörer*" terminal.
- Ensure that the power switch is on "*Aus*" (Off).
- Open the battery lid and insert two *B 4,5KZT5* batteries on top of each other, the first one with the battery contacts pointing down, the second with the battery contacts upwards. Close the battery lid. The installation is now ready for use.

To establish contact, use the *FF 33* field telephone to call the other party by turning the generator crank. Establish voice contact. Beware that the voice communication is not secure: "***Feind hört mit!***" Once contact has been established, switch the DC wire telegraph on by moving the switch to the "*Ein*" position.

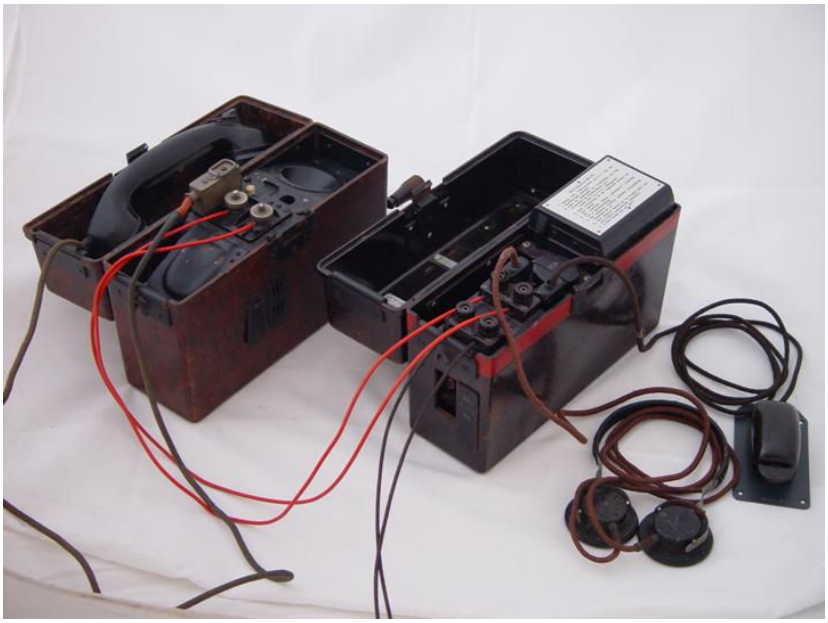


Figure 68: DC wire telegraph set up with FF 33

Figure 69: B4,5KZT5 battery

Set the tone switch in the "*Ton I*" position ("*Ton 1*" is the default switch position). To send message, use the Morse key to key the message. Morse code in a clear tone will be heard in the headphones of the sending station. Only one station can send while the other listens.

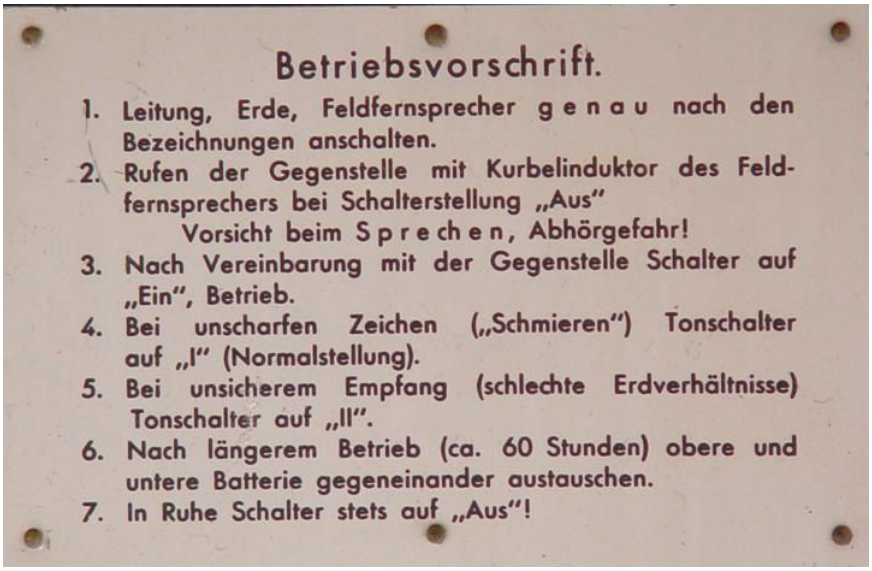


Figure 70: DC wire telegraph operating instructions

At the receiving station the tone will also be heard. If the tone is unclear ("smudged") the tone switch should be set to the "*Ton I*" position. When the signal drops away (due to bad connection or earth leakage), switch the tone switch to the "*Ton II*" position.

When the connection is finished, always switch off the DC wire telegraph to the "*Aus*" position to avoid the batteries from draining. After 60 hours of operation, switchboard the top and bottom batteries. In the off position, the *FF 33* field

Figure 71: DC wire telegraph ready to use

telephones can be operated as normal.

Feld Fernschreiber

Development and Description

In 1929, Dr. Ing. Rudolf Hell applied for a patent for "a device for electric transmission of written characters". Rather than using a Morse- or digital Baudot code to encode the letters, Hell represented each letter (or actually symbol) in a 7 by 7 grid, basically scanning the symbol column by column and transmitting it as a series of shorter and longer pulses.

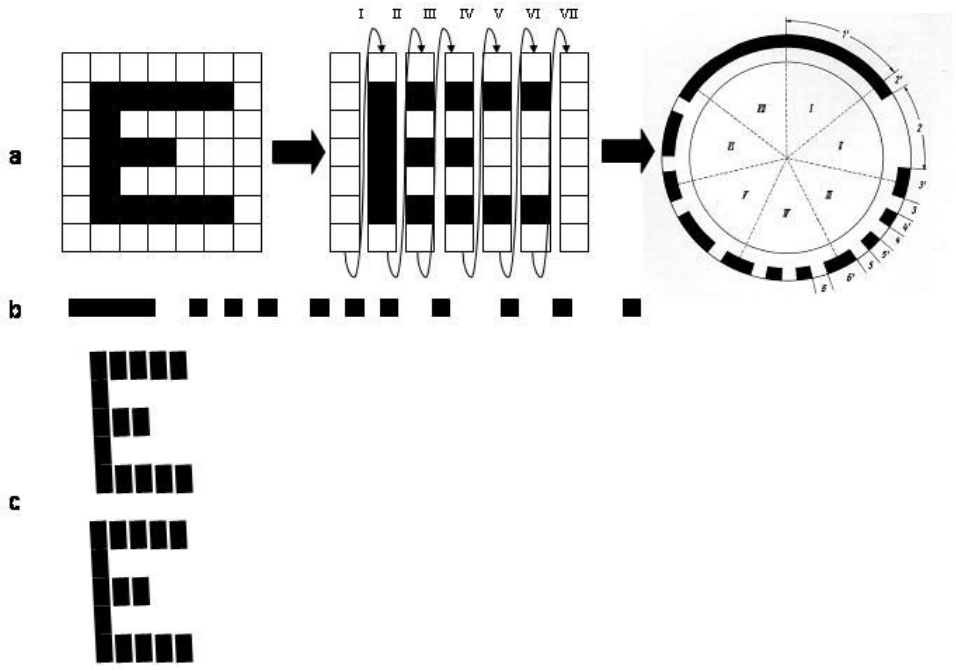


Figure 72: Principles of the Hell code

For example:
a) Shows how the letter "E" is placed in the 7 x 7 grid, how the coding sequence is formed and how "E" is represented on the coding cylinder
b) Shows the pulse sequence for the letter "E" which can be transmitted.
c) Shows how the letter is received and printed onto a paper strip

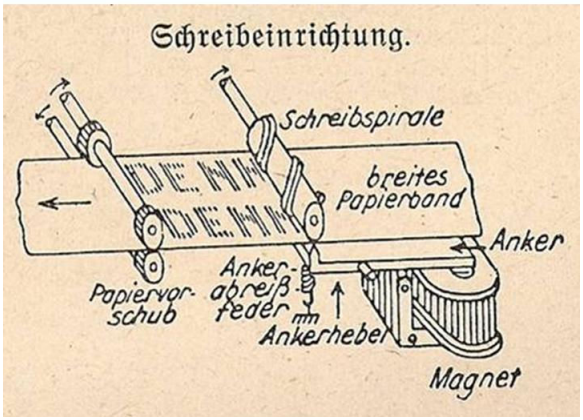


Figure 73: Printing unit principles

In 1932 Hell demonstrated a second key feature of the *Feldfernschreiber*: a helical worm wheel printing system which allowed the symbols to be printed on a strip of paper. In this system a worm wheel is wetted with ink and is turning just above a 15 mm wide paper strip which is moving at a right angle under the wheel at one seventh of the speed of the worm wheel. A strip under the paper pushes the paper upwards against the worm wheel in time with the pulses of the transmission. Each time that the paper and worm wheel touch, ink will be transferred onto the paper. For example the long pulse of the letter "E" will thus result in a vertical stripe, followed by three short

stripes next to it etc. (due to the constant movement of the paper the letter will appear slightly slanted). In fact the helix winds around the worm wheel twice, resulting in two simultaneous contact points which causes the letter to be printed twice, one above the other.

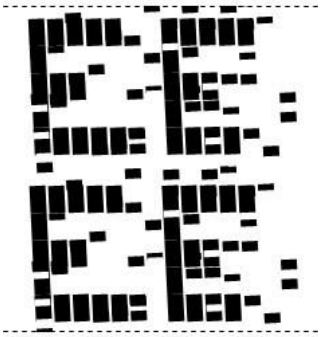


Figure 74: Interference

There are two major advantages to the Hell system. First of all, it is very robust against interference. Interference causes the symbols to become smeared or fuzzy. Since the human brain is very good at pattern recognition, most people will still recognise the fuzzy characters, especially when placed in the context of a word. This clever use of this human capability allowed the Hell system to function with bad signal to noise ratios.

The second advantage of the Hell system in that transmitter and handset do not have to be synchronised. If a symbol starts printing late in relation to the position of the worm wheel, the letter will "run off" the bottom of the paper strip but at the same time it will appear again at the top. Because of the double printing of each symbol, there will always be a complete symbol printed on the paper. Speed differences between the transmitter and handset will result in the text to slant upwards or downwards. The operator can quite simply adjust the engine speed to make the text run horizontal again.

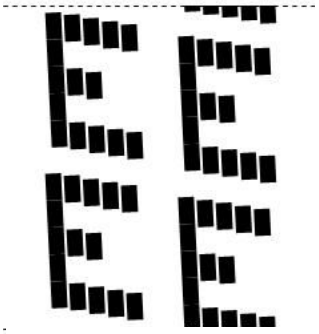


Figure 75: Loss of synchronisation

Figure 76: Siemens-Hell-Feldfernschreiber

When the design of the system was optimised by Dr. Ing Rudolf Hell, the Siemens firm prepared the system of mass production with the *Siemens-Hell-Feldfernschreiber* developed in 1933 with the first machines entering military service in 1935.

The *Feldfernschreiber* is consists of five main parts:

1. Code generator with keyboard
2. Printing system
3. Motor system
4. Base unit with gear system, paper storage and paper drive mechanism
5. Amplifier

The code generator consists of a coding cylinder, where each symbol is represented by areas of conducting and insulating material. The cylinder rotates with a speed of 2.5 revolutions per second, allowing a communication speed of 2.5 symbols per second.
An interlocking mechanism allows a single key on the keyboard to be depressed in synchronisation with the turning cylinder. When a key is depressed, the related contact will be pressed against the rotating cylinder resulting in the electrical pulse sequence of the selected symbol.

Figure 77: Keyboard and code generator

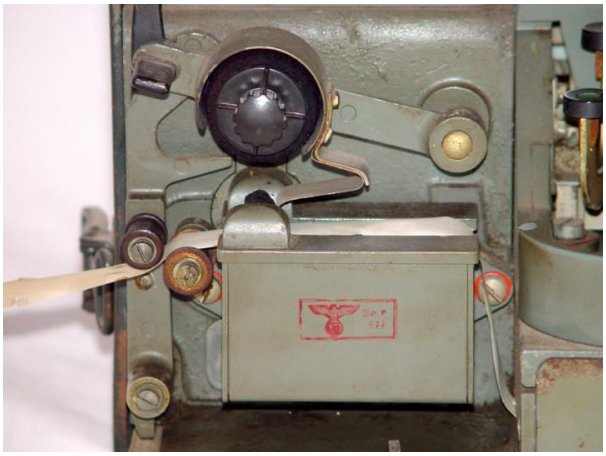


Figure 78: Printing unit

The printing system consists of a worm wheel which is wetted by an ink roll. A paper strip is passed between this worm wheel and a contact strip underneath. The contact strip is pushed upwards by an electrom agnet in time with the pulses, pushing the paper against the worm wheel and printing the symbol as described before.


Figure 79: Motor unit

The Motor system consists of a 12 V DC electromotor which is turning at a constant 3600 revolutions per minute. An electromechanical governor ensures that the motor speed can be tuned slightly so that two machines can be synchronised. The motor also drives a generator supplying 150 V to the amplifier. To allow the governor to work, the “natural” speed of the motor is designed to be much higher than 3600 rpm, so it constantly needs to be braked to run at the correct speed. The motor contains

an extra field winding, the “regulator field” to bring it down to the correct speed. When the speed rises, the governor contact will close and the regulator field will be powered. This will cause the motor to decelerate quickly until the governor contact opens, causing the motor to speed up again. To avoid the governor contacts to wear quickly, an electronic regulator valve is used to drive the regulator field.

The motor drives the code generator, the printing system and the paper supply via a gear system so that they are always perfectly synchronised on a single machine: The writing on the transmitting machine itself will always be perfectly horizontal on the paper strip.

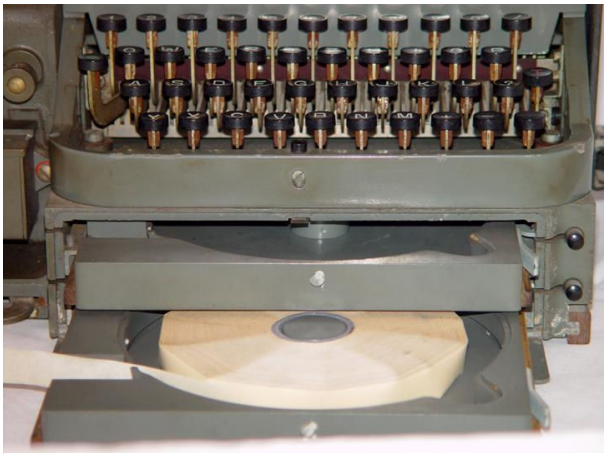


Figure 80: Keyboard unit with paper drawers

Paper rolls are kept in two paper drawers situated under the keyboard. The 15 mm wide paper strip passes through a slit to the printing system where the paper is fed with a constant speed between the worm wheel and contact strip.

Figure 81: Amplifier unit

The Amplifier unit contains a 900 Hz oscillator, an amplifier, a rectifier and a regulator for the motor speed control. The Figure below shows the *Feldfernschreiber* connected to a wireless receiver and how the principle signals are amplified and rectified to drive the electromagnet in the printing system.

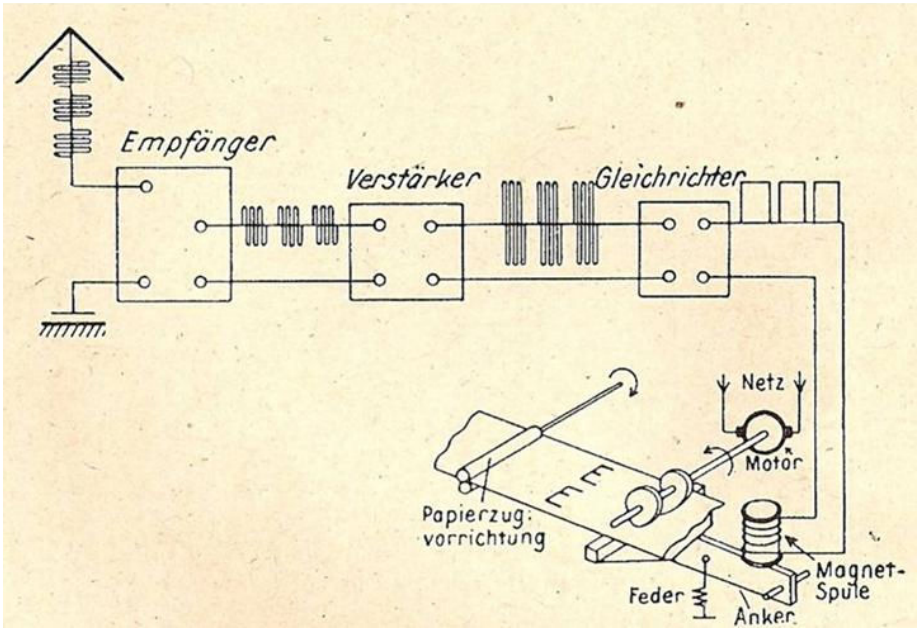


Figure 82: Operating principles of the amplifier (connected to a radio receiver)

In the schematic in figure 57, "G" is the coding cylinder, the 900 Hz signal is modulated by the symbol pulses and send to a phone line via a transformer. At the same time the signal is fed (via an adjustable gain control called "*Verstärkung*" and another transformer) to the first stage of the amplifier. The output of this amplifier is fed to another transformer which allows the signal to be monitored via a headset ("*mithören*"). The signal is then rectified (filtering out the 900 Hz tone) so that just the symbol pulses are fed to the second stage amplifier, which in turn drives the electromagnet of the contact strip in the printing system (14).

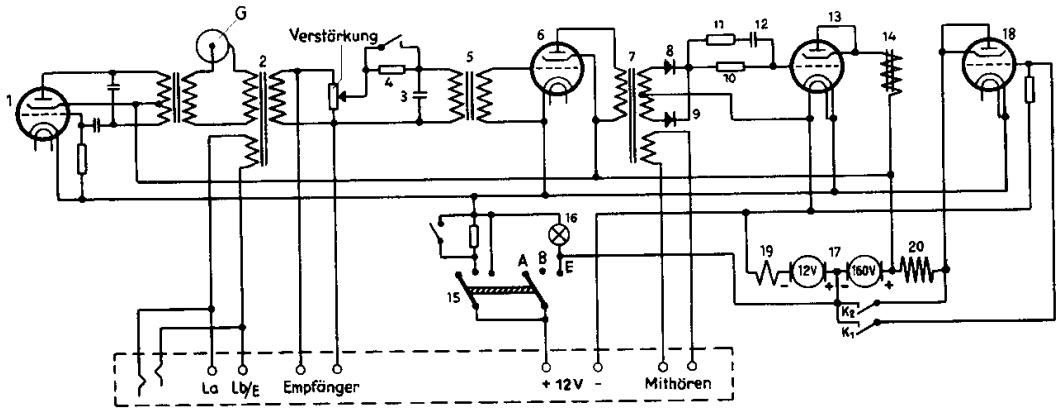


Figure 83: Feldfernschreiber circuit diagram

Mechanically the *Feldfernschreiber* contains two main units in one box:

1) The Keyboard unit comprising the code generator, printing system, motor, gearbox and paper supply:

Figure 84: Keyboard unit

The keyboard unit can be pulled out of the box by about 8 cm to allow easy access to the keyboard, printing unit and speed control. Two paper trays are placed under the keyboard, normally hidden from view behind a lid. Left of the keyboard is the printing unit which is screwed against the gear housing with two screws. The motor is placed on top of the gearbox housing. The governor can be controlled by turning to top end of the motor unit, a graded scale allows for precise adjustment.

2) The Amplifier unit which unites all electronics, controls and terminals:

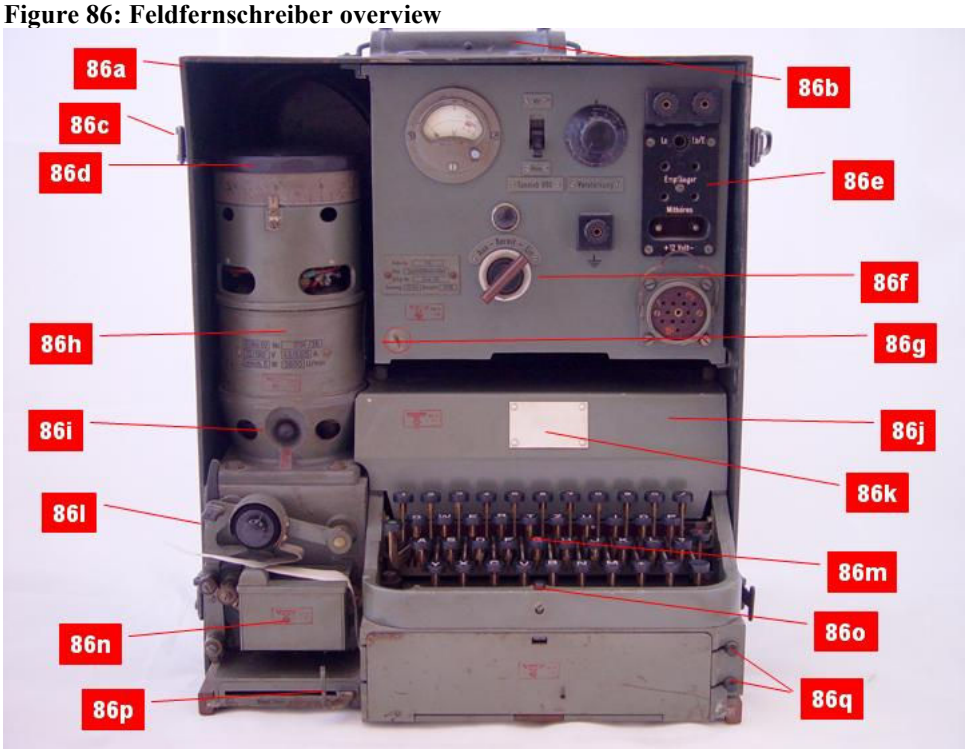
Figure 85: amplifier unit

- More or less centrally placed on the front panel has the main operating switch ("*Aus / Bereit / Ein*" or Off / Standby / On) with a control light placed over it.
- Top left sits a voltage instrument to check the 12 V supply voltage and the 150 V anode voltage for the amplifier.
- Next to the instrument is a "*Tonsieb 900*" or 900 Hz filter switch ("*Mit / Ohne*" or With / Without) which allows for filtering of the amplifier input signal.
- Next to the filter switch is the "*Verstärkung*" or amplification control knob which allows the signal strength going into the amplifier to be controlled.
- Top right of the control panel sits a bakelite termination panel. Two telephone line terminals ("La" and "Lb/E" as with a *FF 33* field telephone"), a jack for a telephone interconnection cord, a two-pin jack for a "*Empfänger*" or radio handset, a two-pin jack marked "*Mithören*" (headphone connection) and finally the two–pin male power supply jack marked " + 12 Volt –".
- Bottom right sits a round 12 Pin jack, which allows for the connection of accessories such as a transmitter keying unit or a calling unit.

One locking screw holds the amplifier unit in place, undoing this allows the unit to be pulled out of the box for access to the electronic valves.

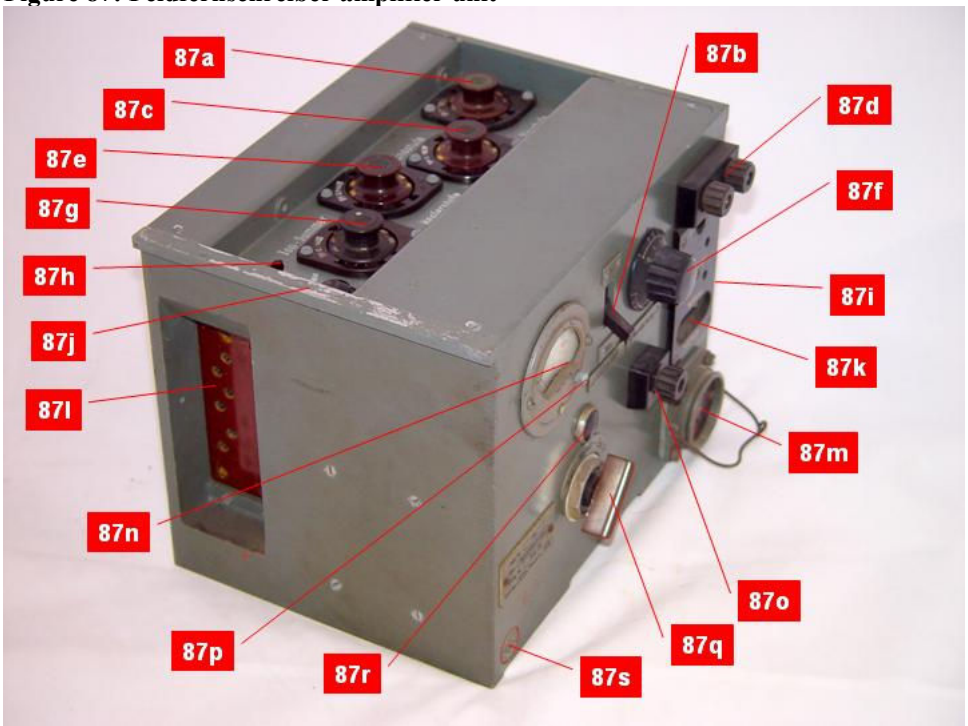
Construction

Figure 86: Feldfernschreiber overview



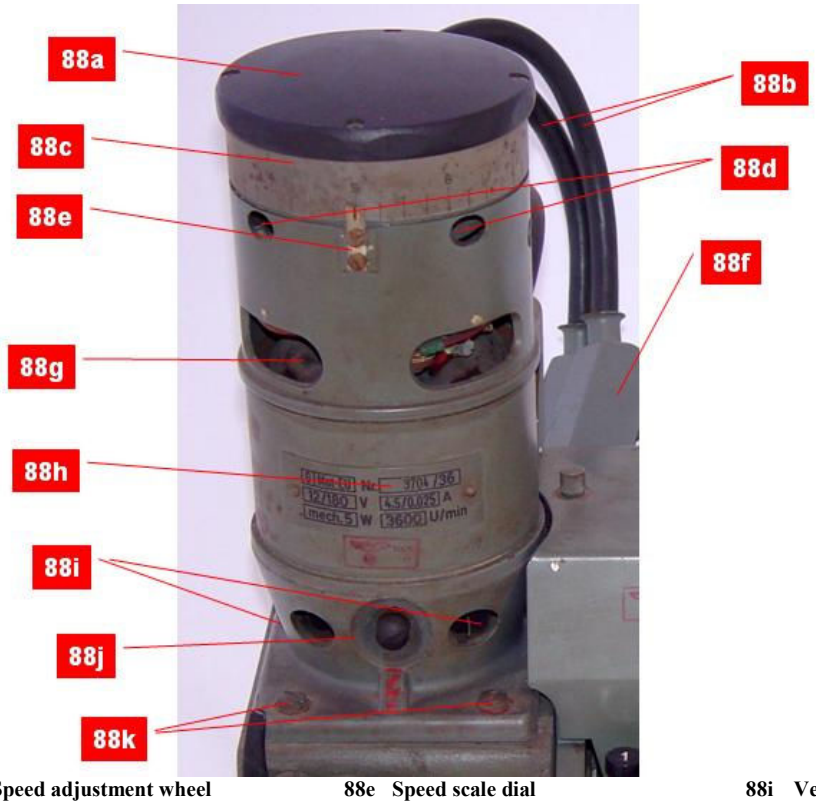
86a Outer casing
86b Carrying handle
86c Locking handle for lid
86d Speed adjustment
86e Electrical connection panel
86f Main switch
86g Amplifier unit lock screw
86h Motor unit
86i HV brush cover
86j Coding unit cover
86k Writing tab
86l Ink roll lock mechanism
86m Keyboard
86n Printing unit
86o Paper compartment release
86p Keyboard unit slide lock
86q Paper drawer release button

Figure 87: Feldfernschreiber amplifier unit



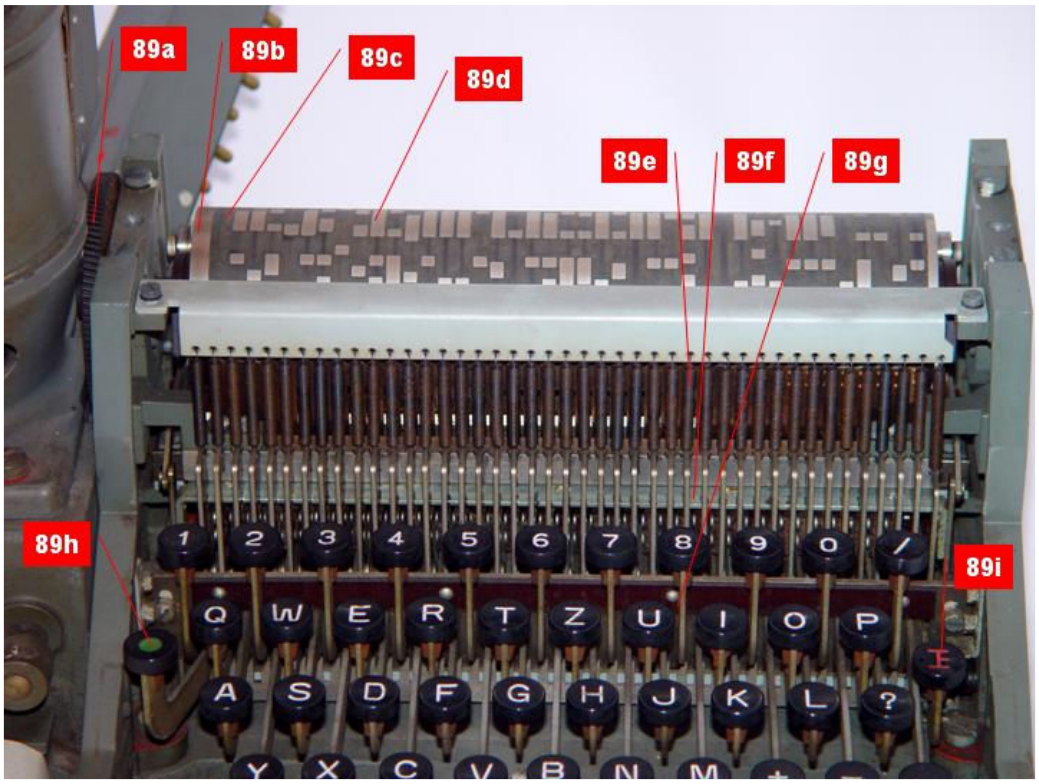
87a First stage amplifier tube
87b Filter switch
87c Second stage amplifier tube
87d Line connection terminals
87e Motor speed regulator tube
87f Amplification control
87g Oscillator tube
87h Power supply filter switch
87i Electrical connection plate
87j Fuse
87k Power supply socket
87l Keyboard unit connections
87m Auxiliary equipment socket
87n Volt meter
87o Earth connection
87p HV test button
87q Main switch
87r Standby light
87s Locking screw

Figure 88: Feldfernschreiber motor unit



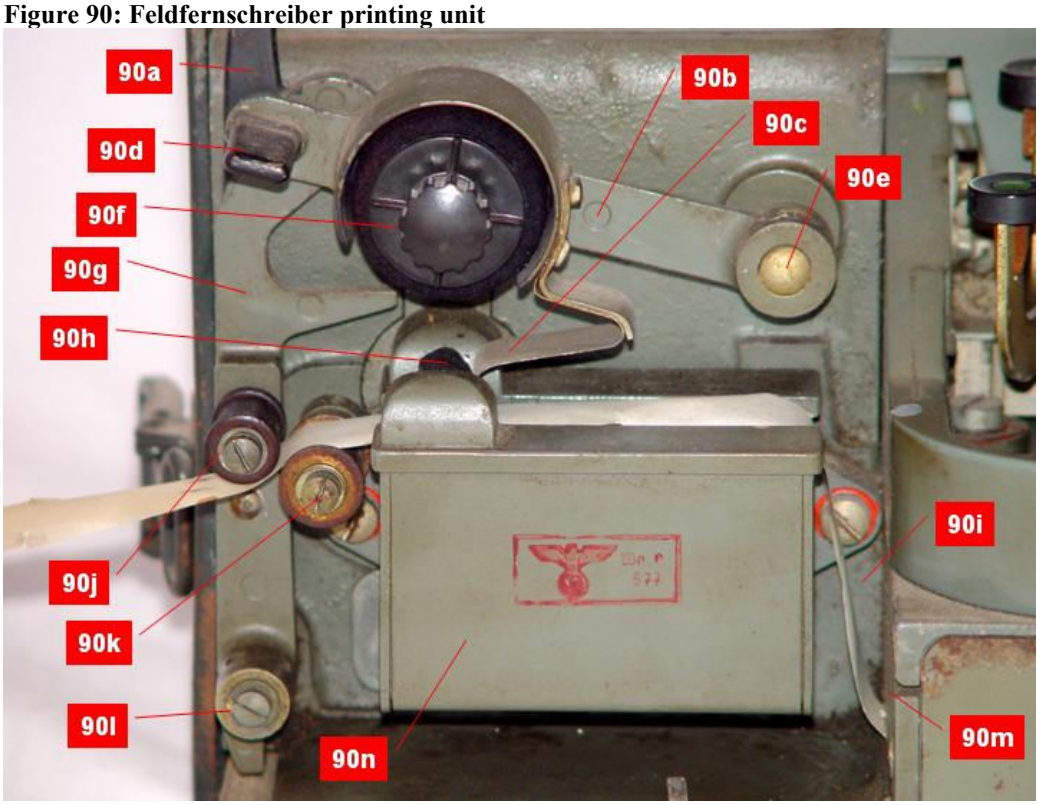
88a Speed adjustment wheel
88b Connection cables
88c Speed scale
88d Ventilation holes
88e Speed scale dial
88f Connection plugs
88g Access to LV brushes
88h Date plate
88i Ventilation holes
88j HV brush lock screw
88k Motor unit mounting screws

Figure 89: Feldfernschreiber keyobard and coding unit



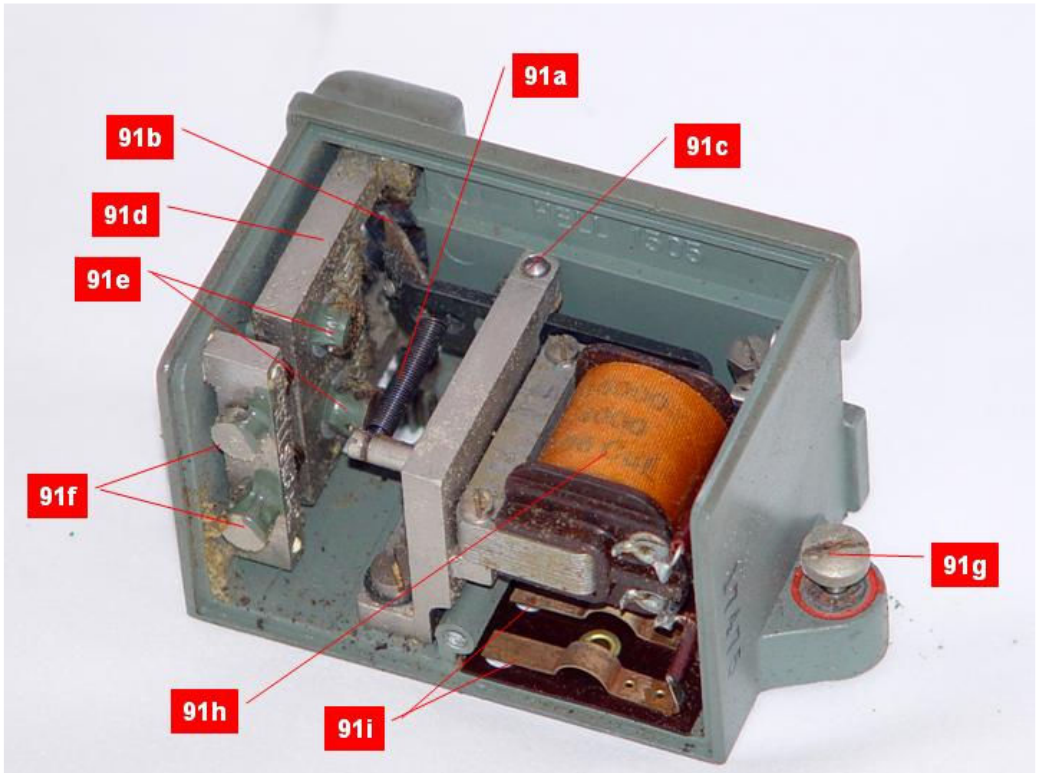
89a Code wheel driving gear
89b Code wheel mass contact
89c Isolated area
89d Conducting area
89e Key return spring
89f Contact and locking mechanism
89g Key
89h Morse key (green dot)
89i Pause key

Figure 90: Feldfernschreiber printing unit



90a Locking fork handle	**90f Ink role**	**90l Locking fork connection**
90b Ink role suspension arm	**90g Locking fork**	**90m Paper feed slot**
90c Paper tensioning spring	**90h Worm wheel**	**90n Print unit housing**
90d Suspension arm handle	**90i Paper feed**	
90e Ink role suspension arm connection	**90j Paper idle wheel**	
	90k Paper driving wheel	

Figure 91: Feldfernschreiber printing unit internal view



91a Contact strip spring	**91e Worm wheel side adjustment**	**91h Electromagnet coil**
91b Contact strip		**91i Electric contacts**
91c Contact strip pivot	**91f Worm wheel height adjust.**	
91d Worm wheel mounting	**91g Fastening screw**	

Operation

To set up a *Feldfernshreiber* link, two *Feldfernschreiber*, two 12 V batteries or power supplies and a telephone link are required. As with the *FF 33*, a two wire connection or a single wire connection with Earth return can be used.

Figure 92: Feldfernschreiber ready for use

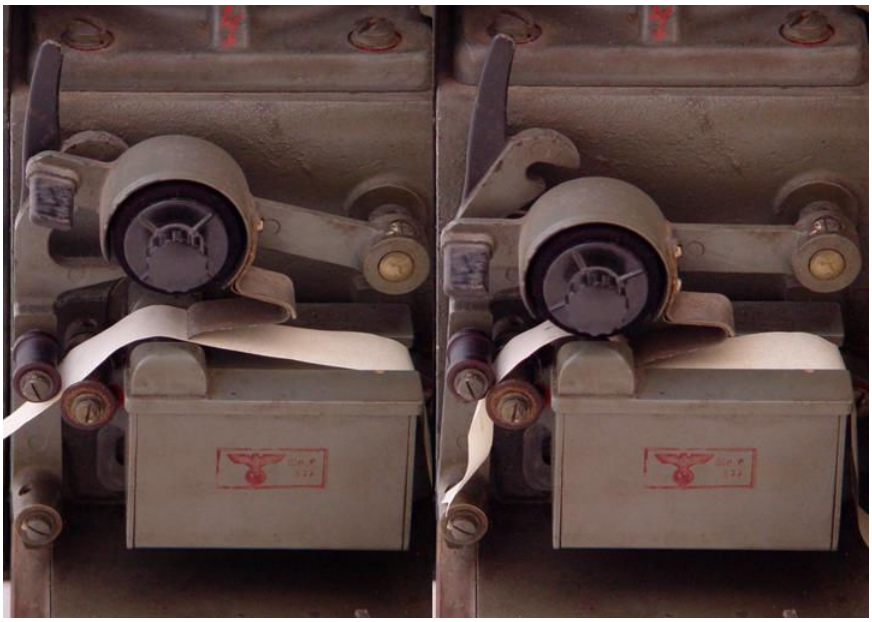
The *Feldfernschreiber* can also be operated over a radio link. In this case a keying unit, or a transmitter prepared to work with the *Feldfernschreiber* must be employed such as the *15 W.S.E.b* or the *AS 59*. In this chapter however, only operation over a telephone line will be described in this section.

- Set up the *Feldferschreiber* by opening the case and set up the keyboard unit by pulling the keyboard sliding lock lever to the left and pulling out the keyboard.
- Connect the 12 V supply to the *"+ 12 Volt –*" socket on the amplifier unit.
- Connect the telephone wires to the "La" or "Lb/E" terminals as with a normal *FF 33* field telephone. The unit can also be connected to an existing field telephone net by connecting the *FF 33* and *Feldfernschreiber* with a telephone interconnection cable.
- Apply some water to the ink roll or if necessary apply new ink.
- Check the paper supply and lead the paper strip through to the printing unit, underneath the worm wheel and between the driving wheels.
- Ensure that the ink role locking fork is placed in the up position.
- Plug a headset into the "*Mithören*" jack.
- Place the "*Tonsieb 900*" switch in the "*Ohne*" position.
- Place the main switch on "*Bereit*" or Standby, you are now ready to operate the *Feldfernschreiber* link.

The *Feldfernschreiber* does not have a calling facility so the two stations will have to agree operating practices beforehand, for example that station A always calls station B first and fixed operating times should be agreed. If the equipment is used on an existing field telephone connection, contact can be made with the *FF 33* field telephones first after which a switch is made to *Feldfernschreiber* operation.

Figure 93: Feldfernschreiber plugged into an existing field telephone line

If station A wants to establish connection, it switches on the *Feldfernschreiber* by moving the main switch to the "*Ein*" (On) position. The motor will now start turning. Press the Pause key (with a red "E" symbol). This key will stay locked down and the machine will automatically keep sending the pause symbol.



Station B will also switch on the machine at the allotted time and will be listening for the Pause key signal with the headset. When the signal is received, station B will start printing by moving the ink role locking fork in the down position.

Figure 94: Ink roll in standby (l) and printing (r) position

The paper strip will start moving through the printing unit and the pause symbol should appear. The Operator of station B will now adjust the speed control (by turning the top adjustment ring of the motor) so that the symbols are printed horizontally on the paper. He will now adjust the "*Verstärkung*" control on the amplifier so that the clearest contrast of the printed symbols is established.

Figure 95: Properly synchronized (top), fast (middle) and slow (bottom) reception

After a few minutes of sending the Pause symbol, station A will open the communication by for example sending "Station B Station B from Station A KKKKK" (K is the telegraph code for "over". During sending the stations can choose not to print the outgoing message by lifting the print role fork in the up position. Station B will replay "Station A Station A reception good, KKKKK". This will allow station A to adjust the "*Verstärkung*" control to maximise the contrast of the printing (speed should not have to be adjusted since station B has already synchronised the two stations). Now the messages can be switchboard between the two stations. The communication can be ended by sending "SKSKSK". The machines can now be returned to the standby position "*Bereit*" with the ink role locking fork in the up position.

If required, the paper strips with the message can now be glued to a message form and handed to the recipient of the message.

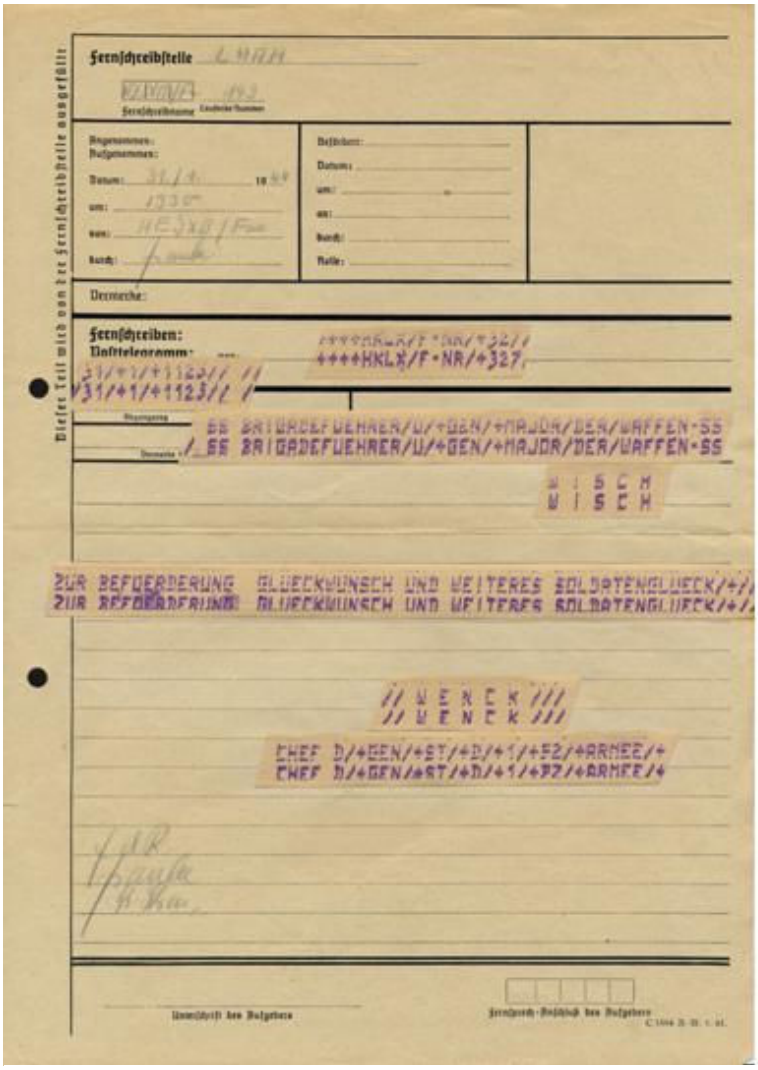


Figure 96: Feldfernschreiber message

4. Field Telephone switchboards

Introduction

Field telephones were not just used for point to point communication; extensive networks were built allowing commanders to reach the frontline positions of all units under their control.

A key element to link telephones into networks is the telephone switchboard, a unit that allows a particular line to be connected with all other lines in the network. The German Armed Forces developed equipment that could link from two to hundreds of lines and could link field telephone networks into existing public telephone networks.

Telephone switchboard unit Vermittlungskästchen

Development and description

Figure 97: Complete Vermittlungskästchen

The exact date of its development is unknown, but since the manufacturing dates of inspected switchboard units mostly fall in the late 1930's, it is not unreasonable to assume that it was developed in the early 1930's together with the new generation of field telephone equipment.

The *Vermittlungskästchen* is a basic single unit containing all components required to service a single field telephone connection. The *Vermittlungskästchen* consists of two parts: a wooden box containing a "Kellogg[1]" switch, all connection terminals and an interconnection cord and secondly a indicator relay housed in a black metal case. The indicator relay plugs into the top of the wooden box.

By itself a *Vermittlungskästchen* is not very useful, but when two to ten units are connected side by side a telephone switchboard of flexible size can be created. It operates on a "single interconnection cord" principle, where each telephone line has its own interconnection cord.

Figure 98: Small exchange using Vermittlungskästchen

[1] Milo G. Kellogg held several senior positions in U.S. telephone operating and manufacturing companies in the late 19th century. In 1897 he set up his own manufacturing firm, Kellogg Switchboard & Supply Company. He held more than 150 patents, and he had invented and patented the Divided Multiple telephone switchboard. His name is often misspelled as "Kellog" in the German Armed Forces literature,

A single *Vermittlungskästchen* could be carried in a leather pouch on the belt.

Figure 99: Vermittlungskästchen in carrying pouch

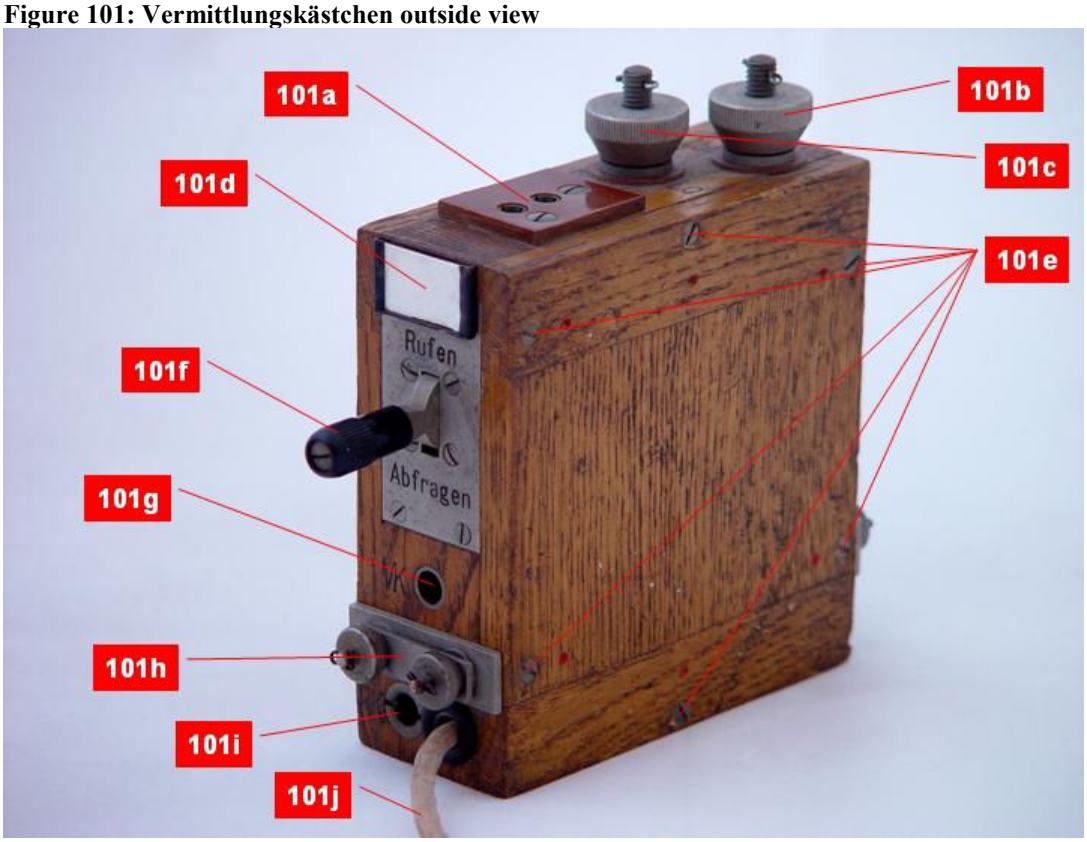
They were also supplied in a box of five units. Mounted on top of the box, the units form a neat five-line telephone switchboard.

Figure 100: Five Vermittlungskätschen in box forming a five line exchange

Photographs of the *Vermittlungskästchen* in action are relatively rare. It is assumed that the small 10-line field switchboard was issued and used in preference for most field use.

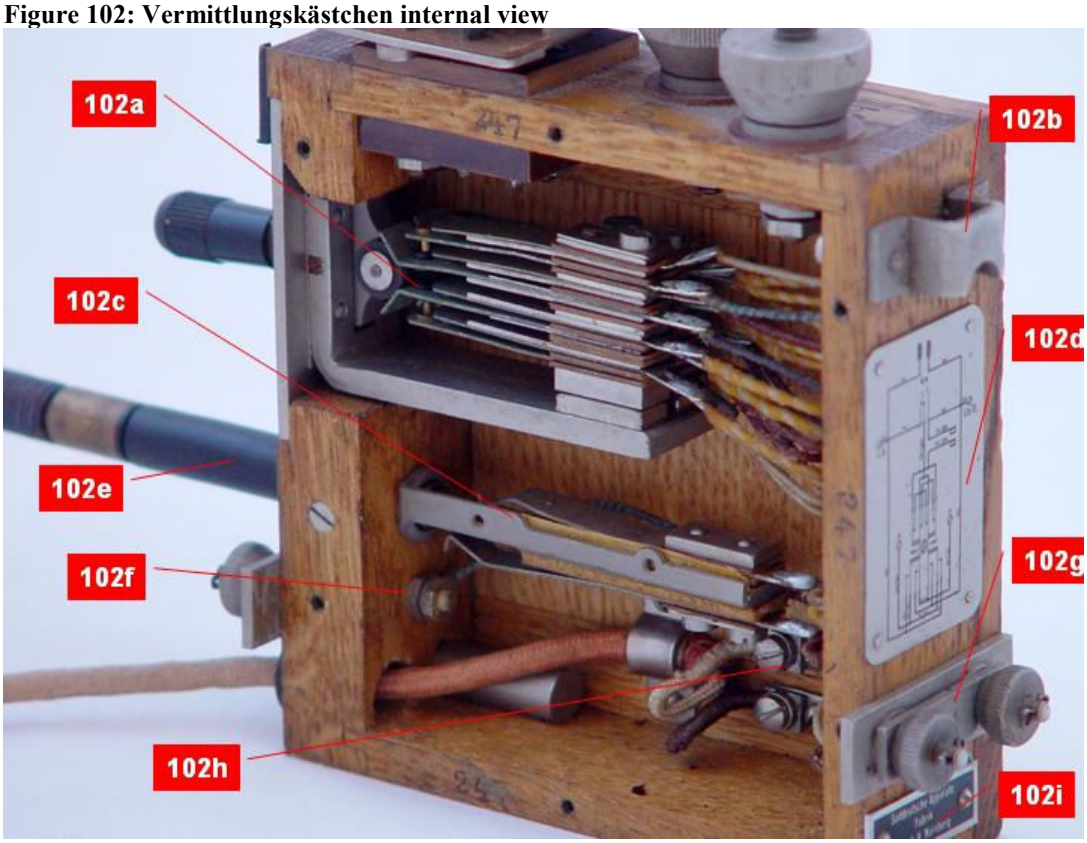
Construction

Figure 101: Vermittlungskästchen outside view



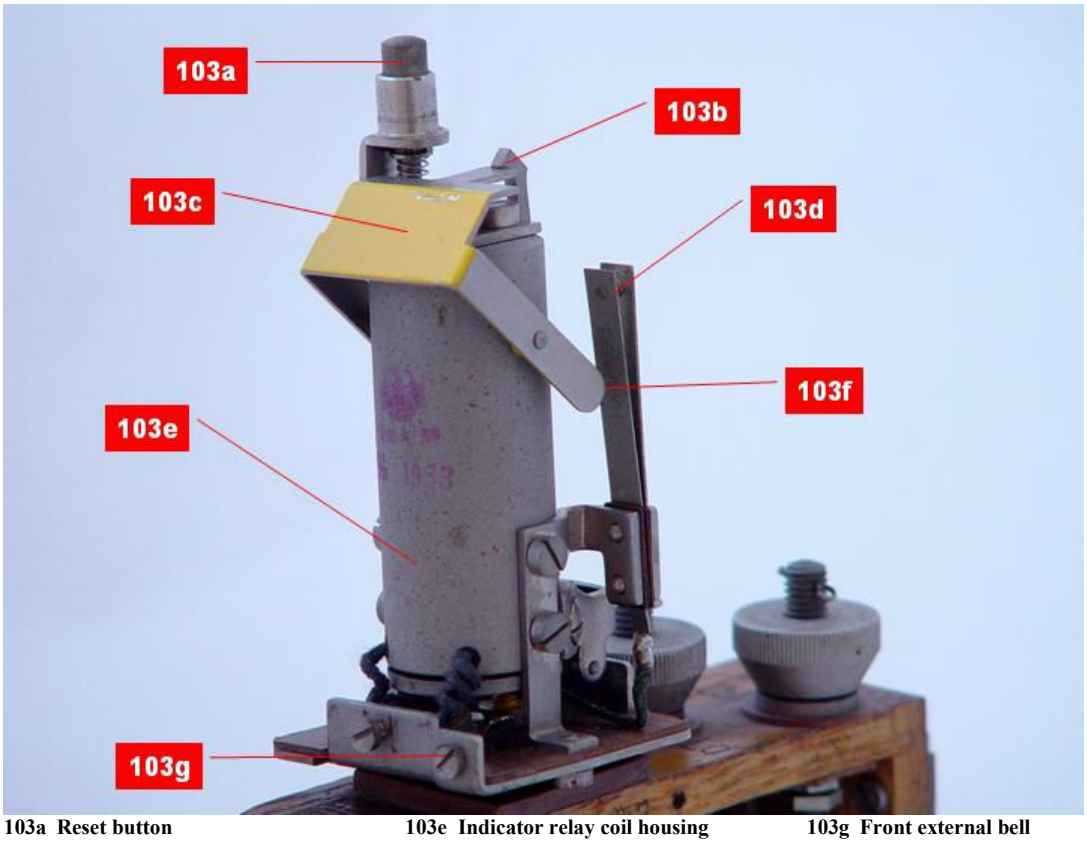
101a Indicator relay socket
101b Lb/E connection terminal
101c La connection terminal
101d Writing tab
101e Screws to open housing
101f Kellogg switch
101g Interconnection cable socket
101h Front interconnection strip
101i Interconnection plug storage
101j Interconnection cable

Figure 102: Vermittlungskästchen internal view



102a Kellogg switch contacts
102b Suspension lug
102c Interconnection socket contacts
102d Schematic
102e Interconnection plug
102f Front interconnection strip contact
102g Rear interconnection strip
102h Interconnection cable connection
102i Maker label

Figure 103: Vermittlungskästchen indicator relay internal view



103a Reset button
103b Indicator relay yoke hook
103c Indicator flap
103d External bell contact
103e Indicator relay coil housing
103f Lever to operate external bell contact
103g Front external bell connection

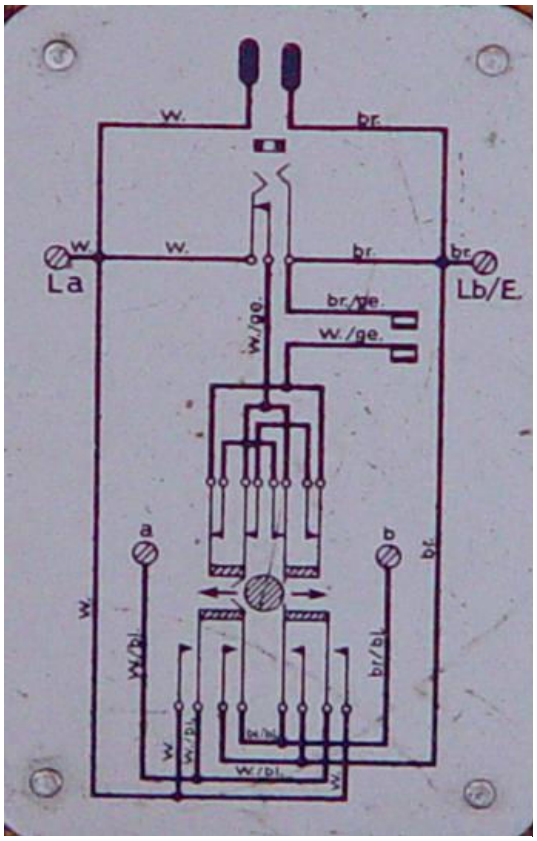


Figure 104: Vermittlungskästchen schematic

Operation

To build an switchboard using the *Vermittlungskästchen*, two to ten units are required plus a *FF 33* field telephone.

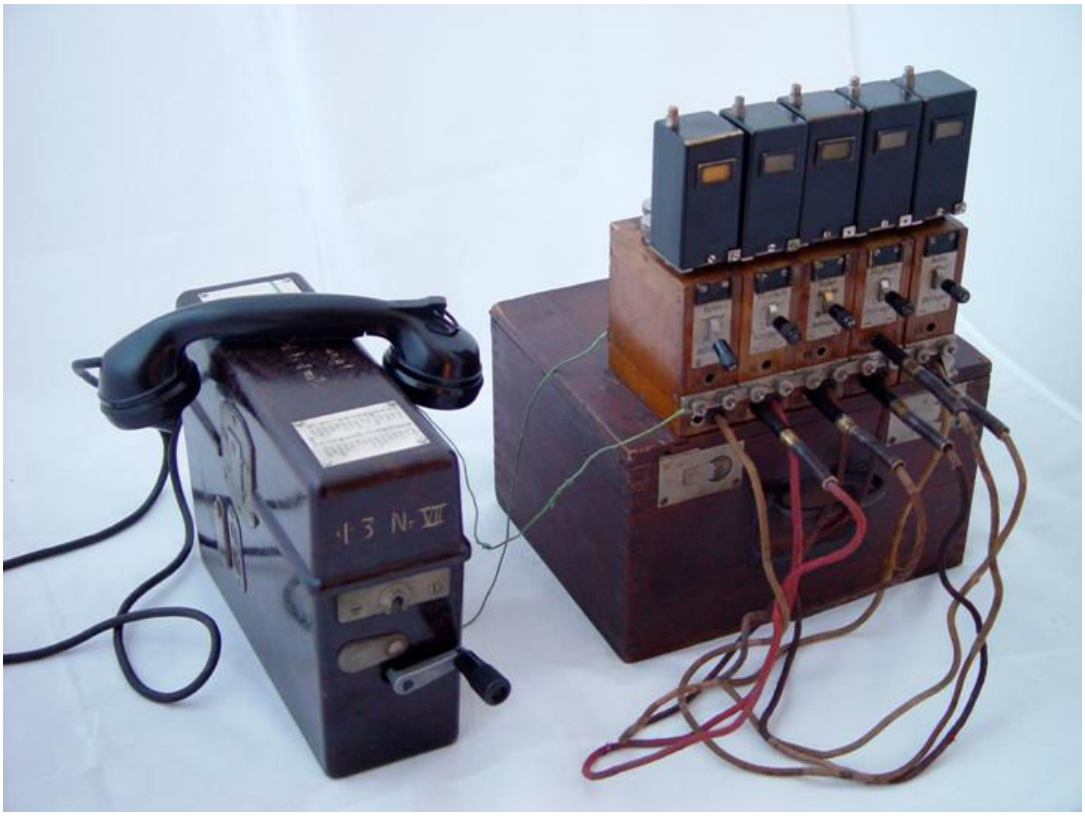


Figure 105: Small exchange ready for use

- Place the *Vermittlungskästchen* next to each other and interconnect them using the front and rear interconnection strips.
- Place the Indicator relays on top of each *Vermittlugnskästchen*. (If required an external bell or light can be used by connecting the front and back switch contact of the indicator relays to a battery and bell circuit).
- Reset all the indicator relays.
- Connect the telephone lines to the “La” and “Lb/E” contacts as with a normal field telephone.
- Place the interconnection cable plugs into their storage sockets.
- The names or codes for the individual telephone lines can be written on the writing tabs.
- Set up the *FF 33* field telephone next to the switchboard and connect the phone’s “La” and “Lb/E” terminals to the front and rear interconnection strips of the nearest *Vermittlungskästchen*.

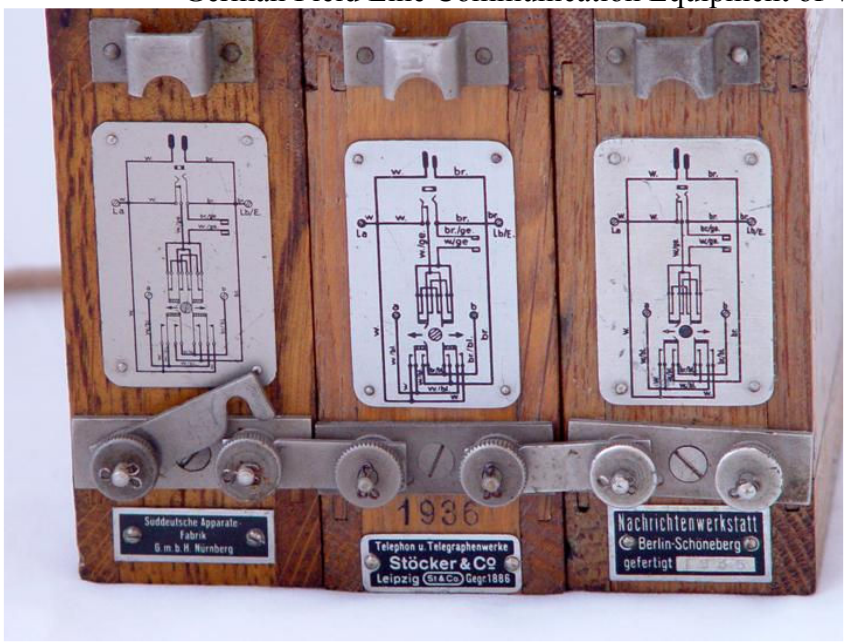


Figure 106: Strips interconnecting the Vermittlungskästchen

Figure 108: Kellogg switch to the "Abfragen" position

Figure 107: Yellow flag to indicate incoming call

If an incoming call is received, the indicator relay will drop, a yellow flag will appear behind the window of the indicator relay. Move the Kellogg switch to the "*Abfragen*" position, the operator can now speak to the caller (while depressing the microphone switch in the field telephone handset as usual). When the caller has indicated to which other line he wishes to be connected, depress the Kellogg switch of the requested unit to the "*Rufen*" position and turn the generator handle of the *FF 33*. This will ring the bells of both the telephone on the far end and at the switchboard. Connect the interconnection cable of the incoming unit to the "*Vk*" socket of the outgoing unit to establish the connection. Reset the indicator relay and return the incoming Kellogg switch to the middle position.

Figure 109: Interconnection cable plugged into the "Vk" socket

At the end of the call, one of the two users has to turn the generator handle of their telephone, this will drop the indicator relay flag of the incoming *Vermittlungskästchen*. The operator now removes the interconnection cable plug from the "*Vk*" socket of the outgoing unit and replaces it in its storage socket. Reset the indicator relay to prepare the switchboard for the next call.

10 line switchboard OB 17

During the First World War a number of different field switchboards were used by the German army. The "*Klappenschrank OB 05*" (OB = *OrtsBatterie* = local battery) was available in 3, 5, 10 and 20 line versions which were meant to be replaced in 1918 by the "*Feldklappenschrank OB 17 zu 10 Leitungen*". The end of hostilities prevented the OB 17 to be used operationally during the First World War but the type remained in production during the interwar years until it was replaced by the new type10-line switchboard in 1933. The type remained in production until at least 1937.

Figure 110: OB 17 exchange in transport configuration

The name "*Klappenschrank*" or indicator flap cabinet refers to the way the incoming calls are shown. When the ringing signal comes in, a relay is powered that releases a small indicator flap. When the flap is down, the line number becomes visible allowing the operator to take action.

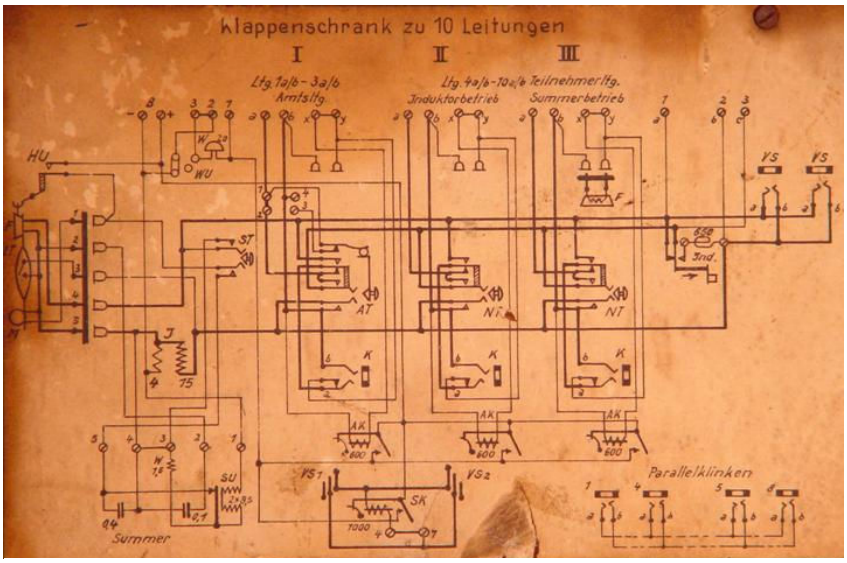


Figure 111: OB 17 Schematic

The *OB 17* used a two-cord interconnection system. In this system the incoming and outgoing lines are connected using a pair of interconnection cables. A total of 8 interconnection cables was available on the *OB 17*, meaning it could make 4

connections at the same time. Each cable pair is connected to a separate indicator flag, allowing the end of the call to be signalled to the switchboard. So the *OB 17* has 10 indicator flaps for the incoming lines plus an additional four (red marked) flaps for the end-of-call signalling.

Figure 112: OB 17 with the top connection panel exposed

The *OB 17* has an internal ring tone generator as well as a buzzer. The buzzer could be used in situations where the ring tone might cause problems, for example where the telephone was in hearing distance of enemy positions. In this case, the telephone could be called by using the buzzer, which would cause a loud noise in the handset of the telephone. The *OB 17* is also equipped with a DC alarm bell. When one of the indicator flap relays drops, an auxiliary contact will be closed which will cause the bell to ring. A headset can be connected directly to the *OB 17* and it has its own microphone transformer. An external battery (*Ortsbatterie*) is required to operate the microphone, buzzer and DC alarm bell. Normally a 4.8 Volt battery could be used.

The first three incoming lines could be adapted for connection to a "ZB" (*Zentralbatterie Betrieb* or central battery operation) or "SB" (*Schlusszeichen Betrieb*) network. A number of levers would have to be reset and jumpers would have to be replaced with capacitors or inductions to avoid shorting out the "ZB" battery.

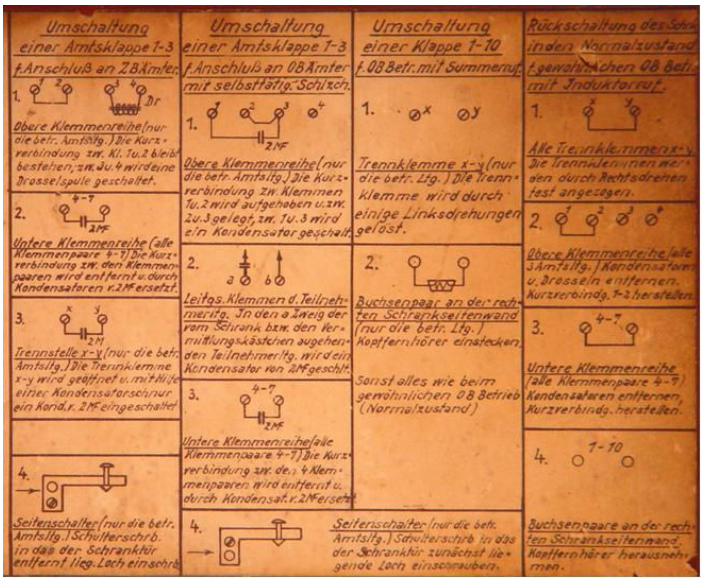
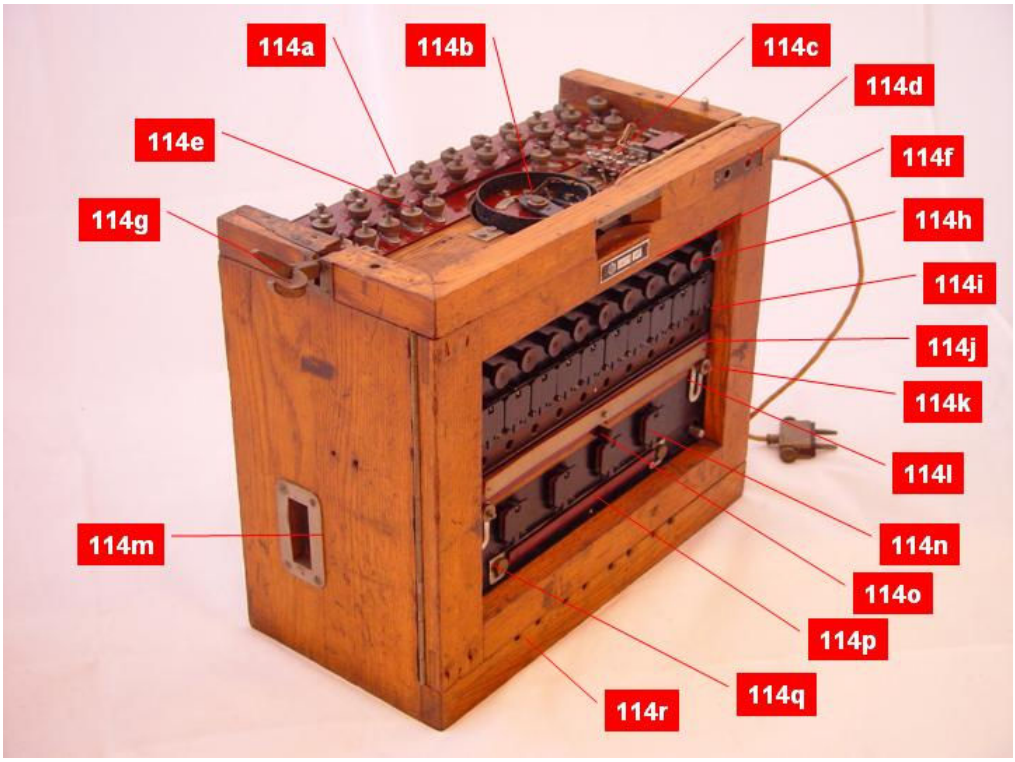


Figure 113: OB 17 jumper configuration for connection to different public networks

All four lines could be connected to a common "conference" connection so that more than two phones could be connected to a single call.

Construction

Figure 114: OB 17 overview

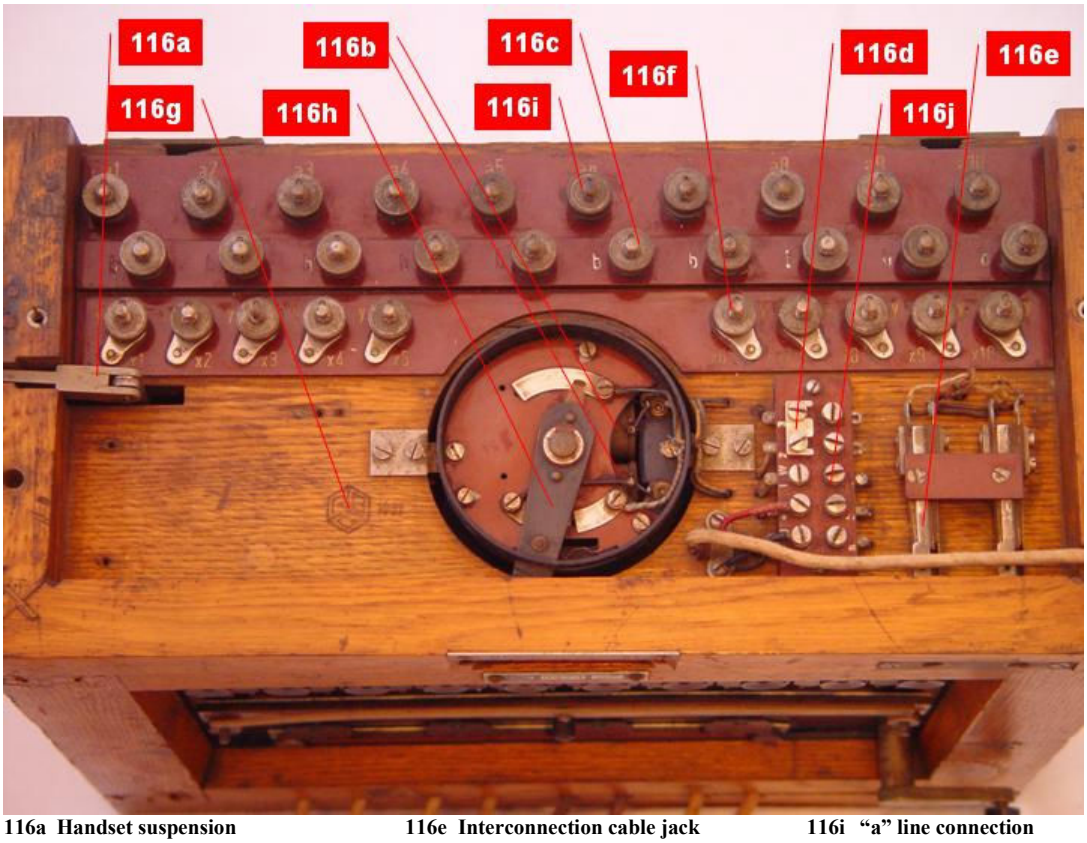


114a Line connection terminals	114g Handset hook	114m Handset socket
114b Bell coil selector	114h Connection button	114n End of call signal flap
114c Battery connection panel	114i Signal flap	114o Buzzer button
114d Interconnection cable jacks	114j Interconnection socket	114p Signal flap locking bar
114e Buzzer selection jumpers	114k Locking bar fastener	114q Locking bar fastener
114f Maker tag	114l Signal flap locking bar	114r Interconnection cable holes

Figure 115: OB 17 overview

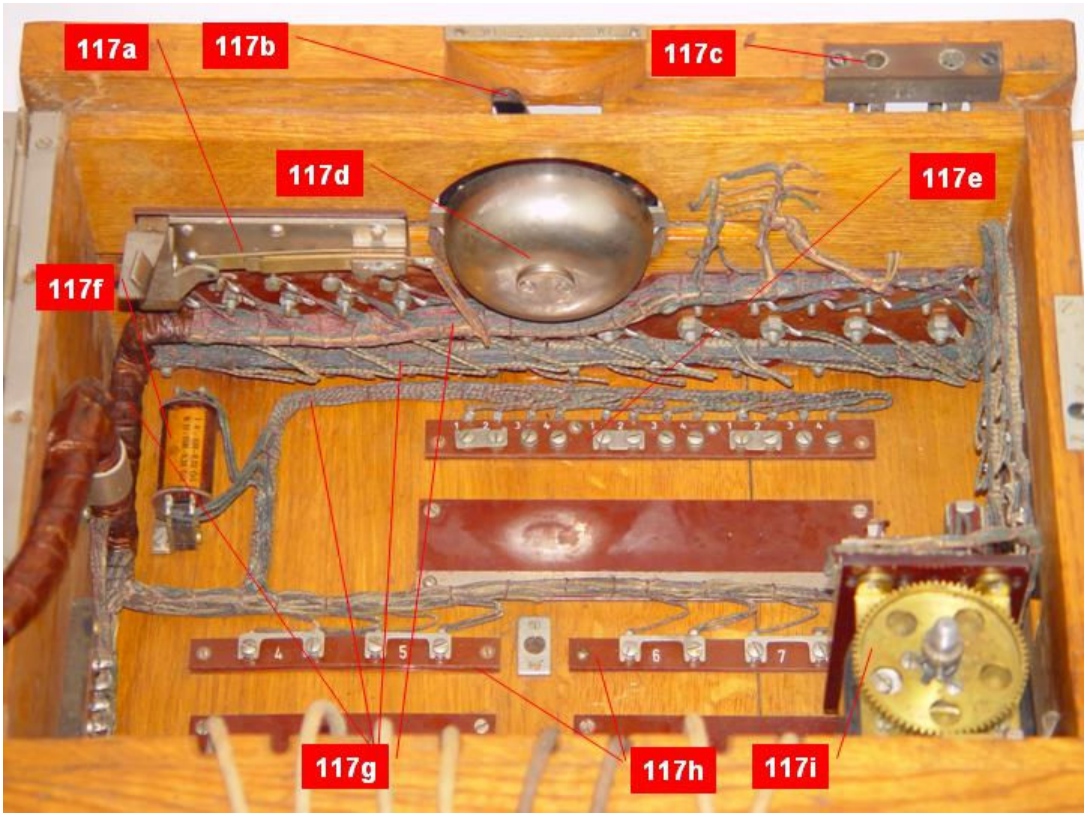
115a Bell sound passages	115f Line number strip	115l Generator crank
115b Conference call sockets	115g Fallen signal flaps	115m External battery
115c Top panel locking screws	115h Headset plug	115n Interconnection cables
115d Bell coil selector	115i Red cable pair flag	115o Headset
115e Headset sockets for buzzer operation	115j Falled signal flap	115p Battery connector
	115k Buzzer button	

Figure 116: OB 17 top view



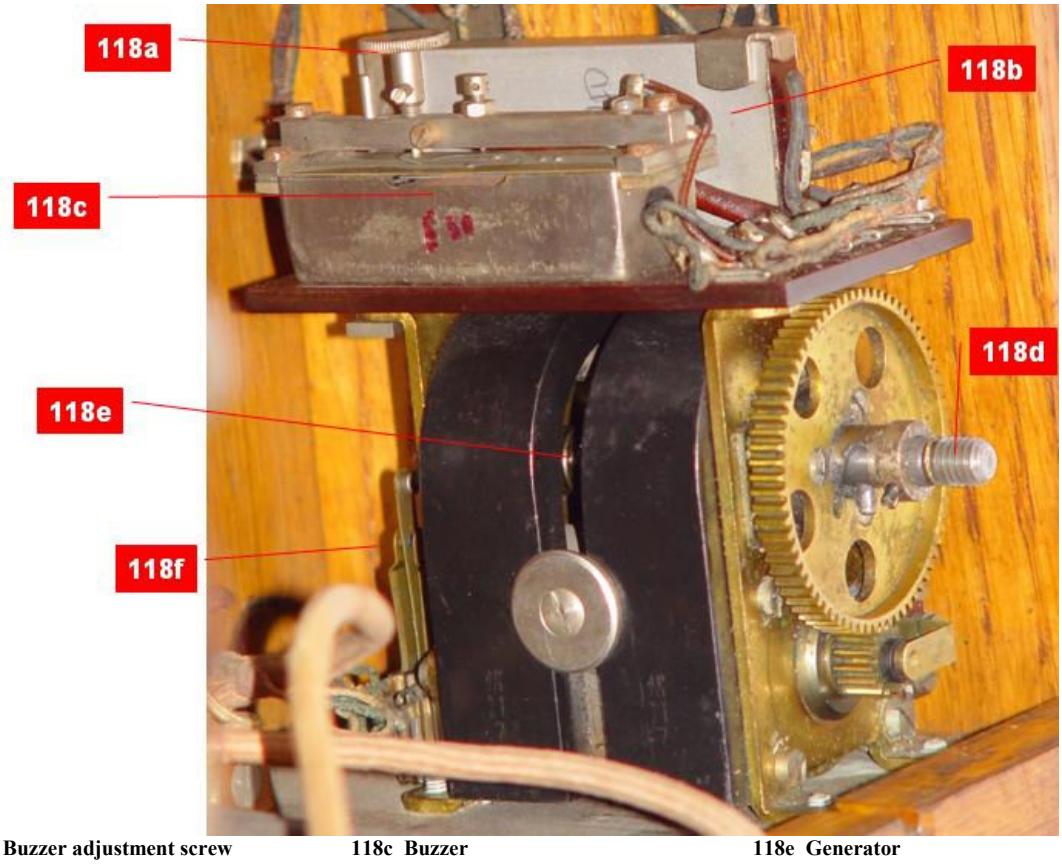
116a Handset suspension
116b Bell coils
116c "b" line connection
116d Bell battery jumper
116e Interconnection cable jack
116f buzzer operation jumper
116g Maker mark
116h Bell coil switch
116i "a" line connection
116j Battery connection panel

Figure 117: OB 17 internal view



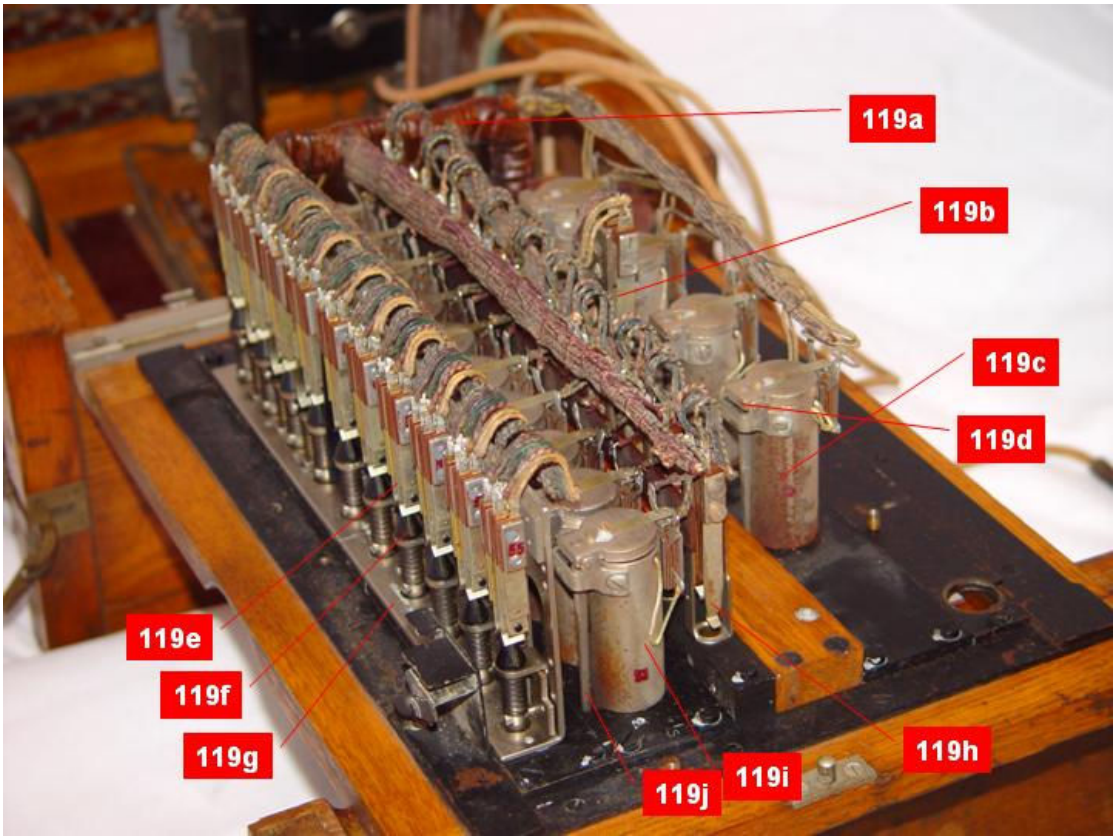
117a Handset suspension mechanism
117b Bell coil selector
117c Interconnection cable sockets
117d Bell
117e Jumper connection board
117f Microphone transformer
117g Wiring looms
117h Jumper connection boards
117i Generator buzzer unit

Figure 118: OB 17 Generator buzzer unit



118a Buzzer adjustment screw
118b Buzzer capacitor
118c Buzzer
118d Generator crank spindle
118e Generator
118f Generator switch contacts

Figure 119: OB 17 inside front panel view



119a Wiring loom
119b Buzzer button contacts
119c End of call indicator relay
119d Indicator relay yoke
119e Interconnection button
119f Interconnection button contacts
119g Interconnection button interlock bar
119h Interconnection cable socket contacts
119i Line indicator relay
119j Indicator relay yoke

Operation

The "*Feldklappenschrank OB 17 zu 10 Leitungen*" is a self contained unit only requiring a headset and an external battery to operate, so no additional field telephone is required. In this section it is assumed that the switchboard will be used for 10 local battery field telephone connections and that all jumpers and settings are set accordingly.

Figure 120: OB 17 front panel opened up to reveal the interior

- Place the switchboard on a sturdy surface and open the front panel.
- Take the interconnection cables out of their storage sockets and lead the cables through the recesses under the front panel.
- Remove the generator crank from the storage position.
- Close the front panel and connect the generator crank to the generator.
- Remove the top lid, take out the battery lead and connect is to the battery.
- Connect the telephone lines (up to 10) between the "a1" .. "a2" and "b1" .. "b10" terminals.
- Fold out the handset hook,
- Plug in the handset in the socket on the left side and hang the handset on the hook.
- Check that all the "x" and "y" screws are tight.
- Replace the top lid.
- Unscrew the indicator flap locking bars and slide them downwards. Some indicator flaps may fall during unlocking; push them back up until held in the closed position. You are now ready to operate the switchboard.

Figure 121: OB 17 exchange ready to go

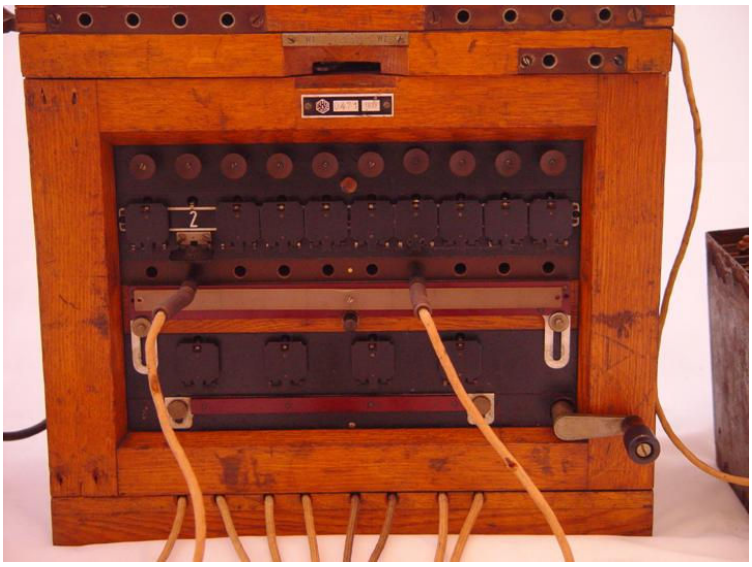


Figure 122: Incoming call on line 2

When an incoming call is received (say on line 1), the indicator flap of line 1 will drop, at the same time the alarm bell will ring. Take the handset off the hook, depress the line connection button for line 1, you can now speak with line 1 (while depressing the microphone switch on the handset as usual). Let us assume that line 1 wishes to speak to line 4. Press the interconnection button for line 4 (automatically putting line 1 on hold by releasing line connection button 1) and turn the generator crank, ringing the bell on line 4. When line 4 answers, notify the recipient that you have a call from line 1 for him, and plug the first two interconnection cables in the interconnection sockets for line 1 and line 4. Replace the handset on the hook (automatically releasing line connection button 4). Line 1 and line 4 are now interconnected and the switchboard is ready to receive the next call.

When the call is ended, one of the participants will crank the generator. This will cause the first interconnection cable signal flap to drop and reveal a red field. At the same time the alarm bell will ring. Disconnect the two interconnection cables from lines 1 and 4 and reset the flap. The first set of interconnection cables is now available again for a new connection.

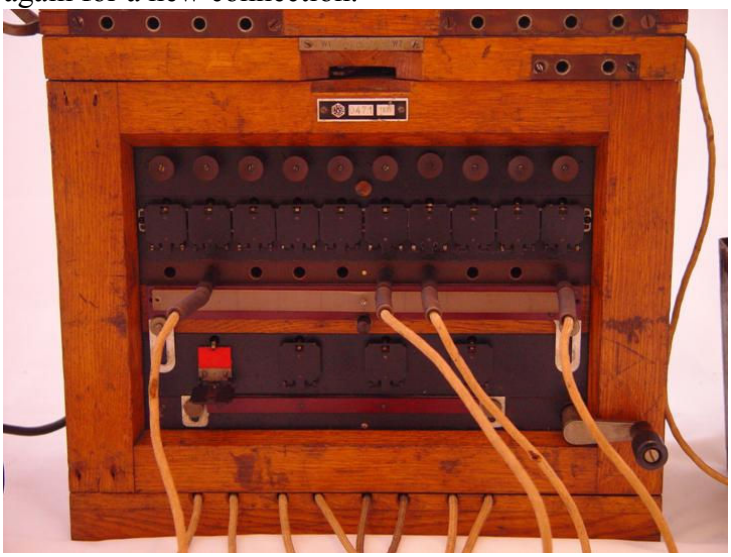


Figure 123: End of call signal for the first cable pair connection lines 2 and 6

The switchboard operator can listen in on a connection by unhooking the handset and pressing the interconnection button for one of the lines connected (for example if he suspects that they have forgotten to give the end signal).

If more than two lines need to be connected in a conference call, the process is similar to above, but now the second cable of each interconnection cable pair is plugged into the conference sockets in the top lid. So if for example lines 1, 4 and 10 need to be in a conference, the first interconnection pair is plugged between line 1 and the first conference socket, The second pair between line 4 and the second conference socket and the third pair between line 10 and another conference socket. In this way, a maximum of four lines can be connected to one conference (five if the switchboard operator also participates). At the end of the conference, one party turns the generator crank, this will cause all the connected interconnection cable signal flaps to fall simultaneously and the switchboard can be reset.

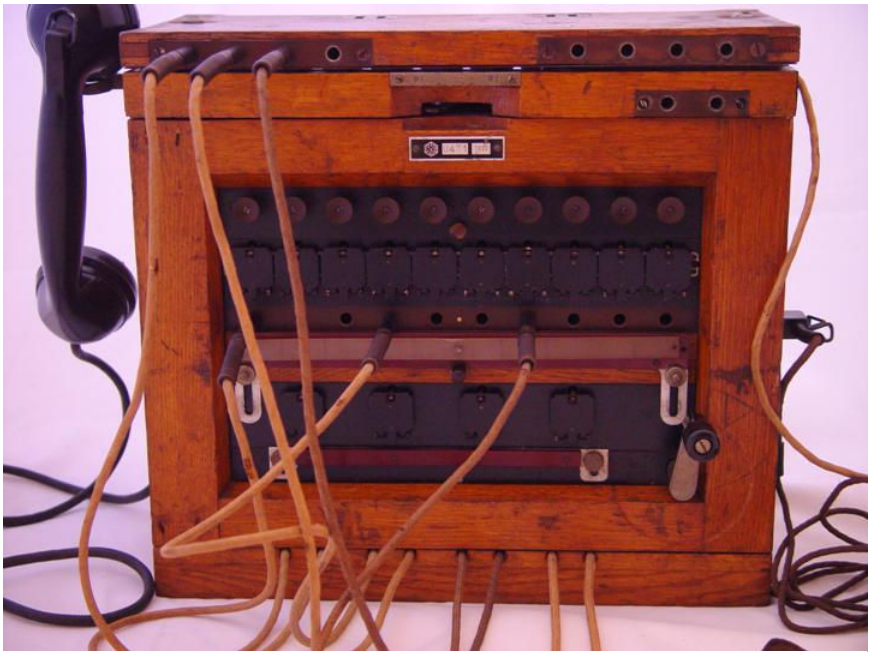


Figure 124: Lines 1, 4 and 7 connected to a conference call

Kleiner Klappenschrank zu 10 Leitungen 10 line switchboard

Development and Description

As can be learned from the previous section, the construction and operation of the "*Feldklappenschrank OB 17 zu 10 Leitungen*" was relatively complex. The redesign of equipment in 1933 had the aim to simplify and the new 10 line field switchboard would be as simple as possible, omitting buzzers, alarm bells, built-in telephone and provisions to connect to public networks. These functions would have to be taken up by external accessories where necessary. At the same time the unit was redesigned for "single interconnection cord" operation, negating the need for separate interconnection cable indicator flaps. Instead of eight cables, the unit now has 10 interconnection cables, one for each line. The basic design with a falling indicator flap, interconnection button and interconnection cable socket for each of the ten lines remained unchanged.

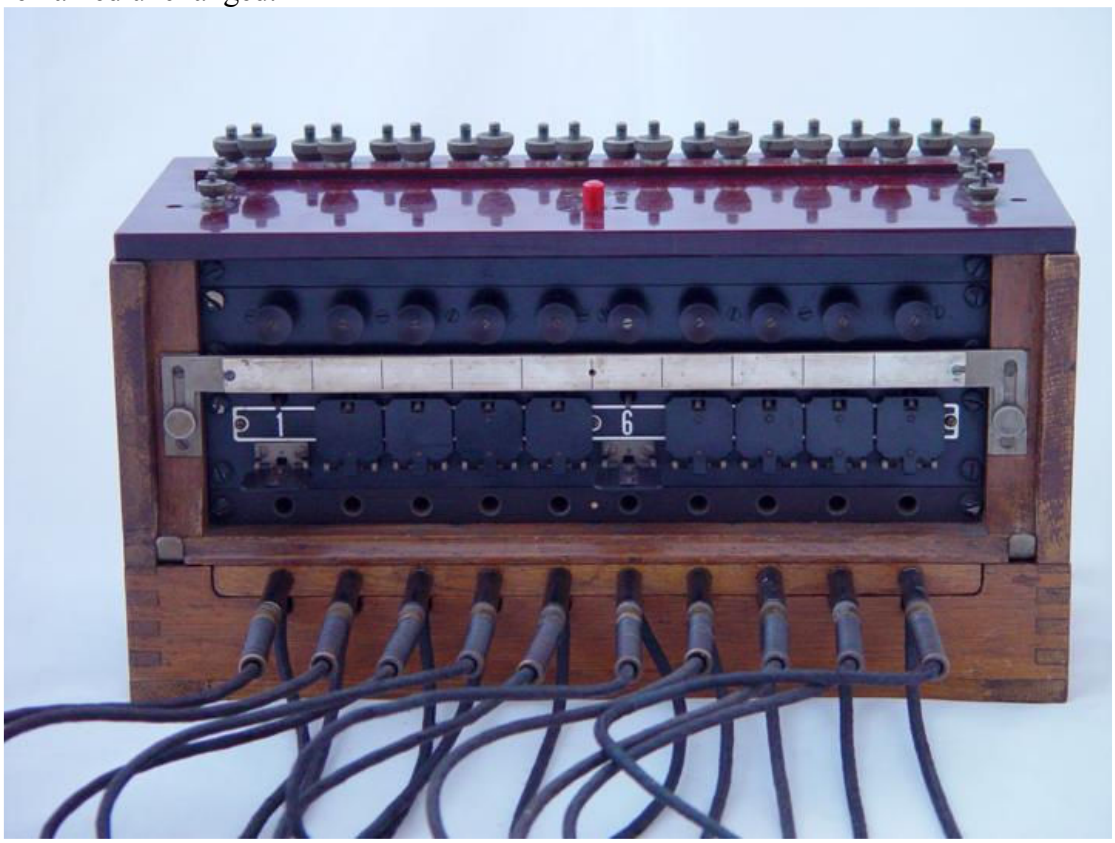


Figure 125: 10 line exchange overview

To operate the new "*Kleiner Klappenschrank zu 10 Leitungen*", an external *FF 33* field telephone would have to be connected. If connections to public networks were required, an "*Amtszusatz*" or public network connection unit would be required.

The redesign resulted in a unit roughly half the size and weight of the old *OB 17* model. The unit did not require any presetting of jumpers or interconnections, making it far simpler to operate. A metal lid protecting the top and the use of the standard *FF 33* carrying strap allowed the switchboard to be carried in the field and protects it from the weather.

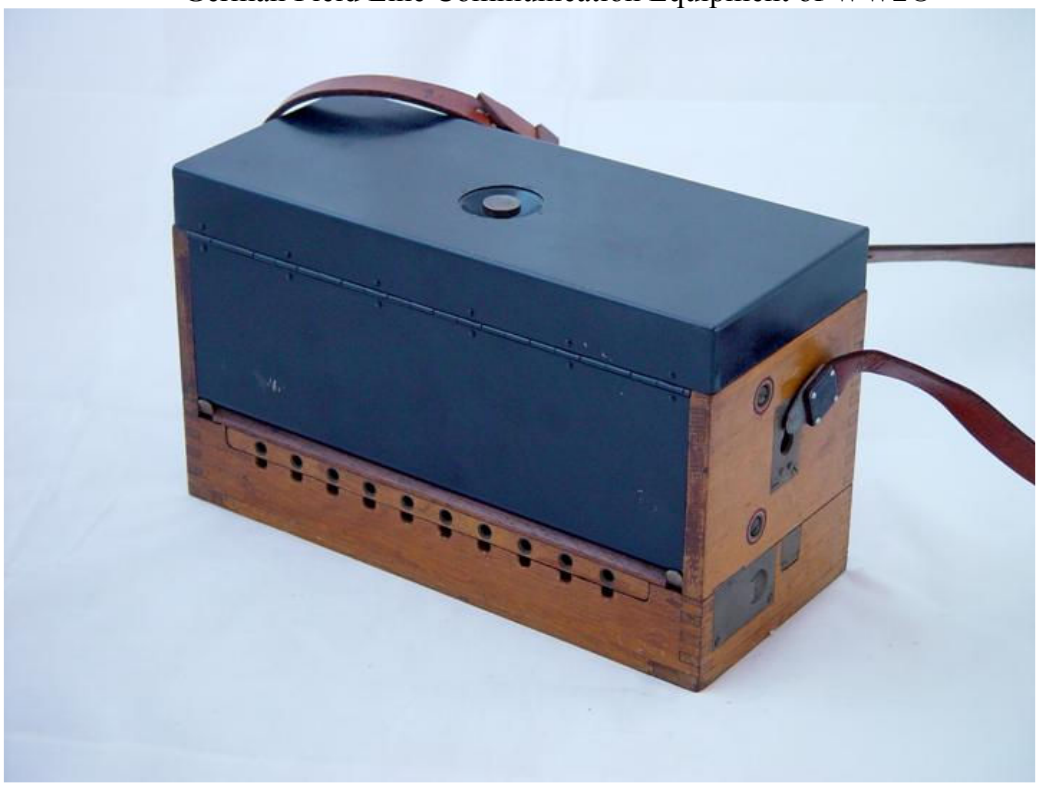


Figure 126: 10 line exchange in transport configuration

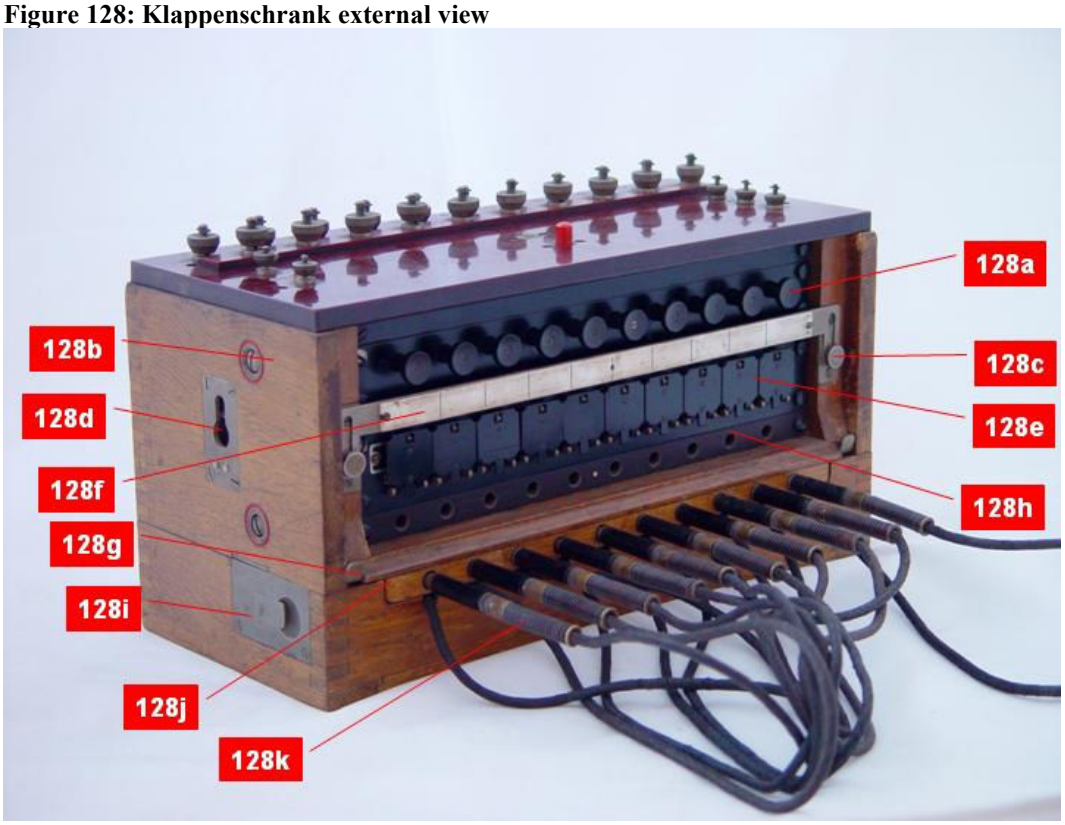
Two locks on the side allow the unit to be opened, giving access to the interconnection cable storage compartment. Also in this compartment is a 30 pole plug socket, which can connect the switchboard to a remote line terminal unit, negating the need to connect the lines directly to the switchboard.

Figure 127: Remote line connection panel

Normally the incoming telephone lines are connected to the terminals on the top panel. Apart from line connections, the top panel has two terminals to connect a *FF 33* field telephone and three terminals to connect an external alarm battery and alarm bell. These are all the connections that the operator will have to deal with.

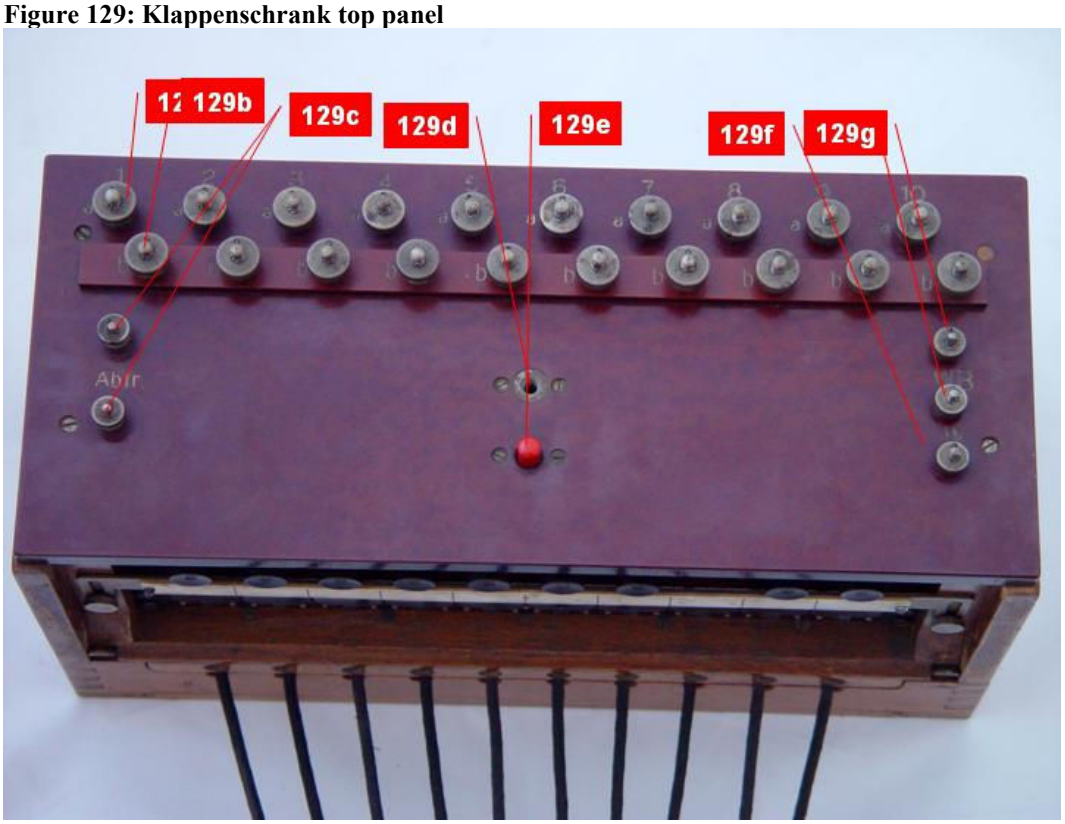
Construction

Figure 128: Klappenschrank external view



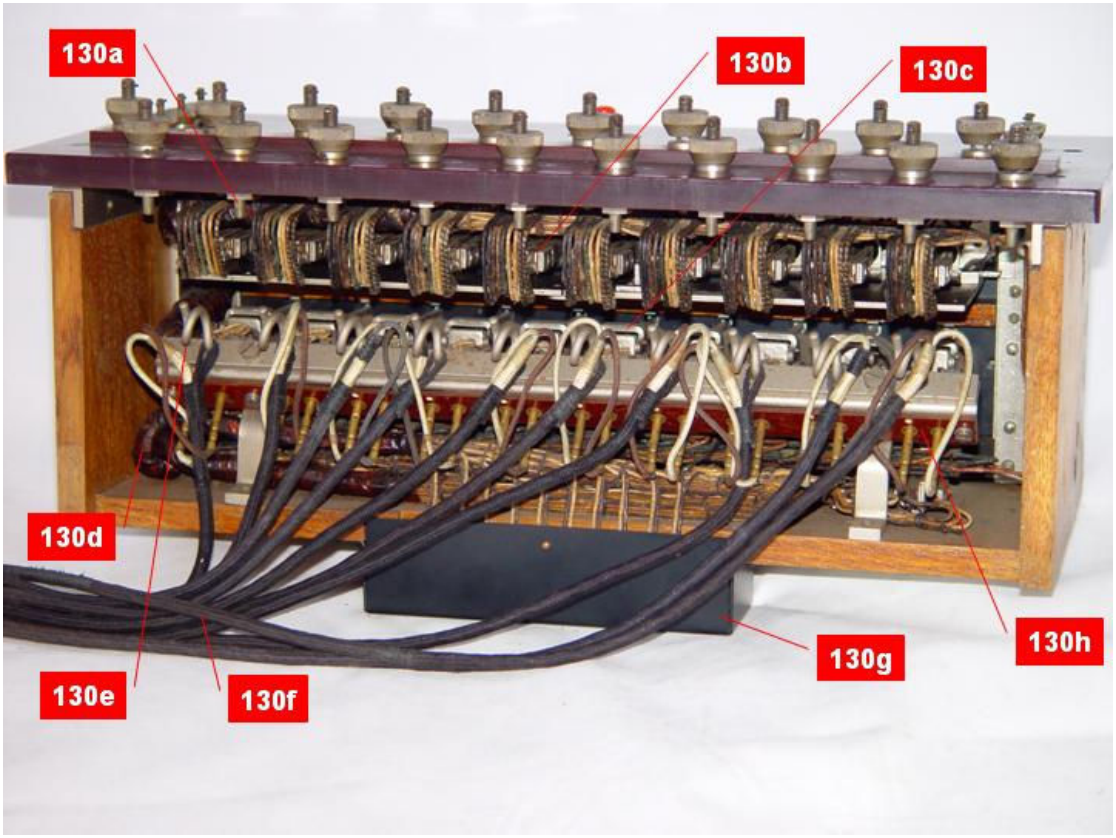
128a Connection button
128b Interior fastening screw
128c Signal flap locking bar screw
128d Carrying strap slot
128e Signal flap
128f Signal flap locking bar with writing tab
128g Lug for metal cover
128h Interconnection cable socket
128i Storage compartment lock
128j Interconnection cable storage
128k Interconnection cable jack

Figure 129: Klappenschrank top panel



129a "a" line terminal
129b "b" line terminal
129c Connections for field telephone
129d Screw hole for metal cover
129e Connection button reset
129f External alarm bell battery connection
129g External alarm bell connection

Figure 130: Klappenschrank interior view



130a Line terminal connection
130b Interconnection button contacts
130c Signal relay
130d Wiring loom
130e Interconnection cable hook
130f Interconnection cables
130g Socket for remote cable connector
130h Connection strip for interconnection cables

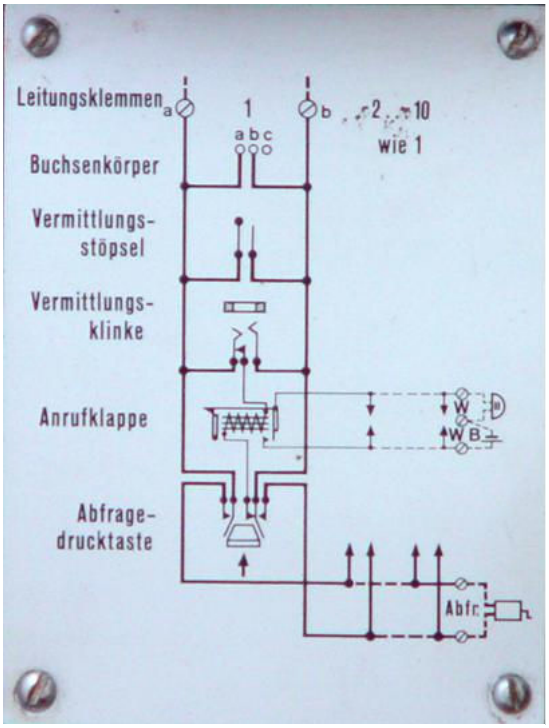


Figure 131: Klappenschrank schematic of a single field

Operation

To set up an switchboard using a "*Kleiner Klappenschrank zu 10 Leitungen*" requires the switchboard unit and a *FF 33* field telephone. If connection to a public telephone network is required, the "*Amtszusatz fuer den kleinen Klappenschrank zu 10 Leitungen (33)*" is required.

Figure 132: Klappenschrank cable storage compartment

- To set up the switchboard, place the "*Kleiner Klappenschrank zu 10 Leitungen*" on a suitable surface.
- Remove the metal lid.
- Place a *FF 33* field telephone next to the unit and connect the two "*Abfr.*" Terminals to the "La" and "Lb/E" terminals of the *FF 33*.
- Connect the incoming lines to the "a" and "b" terminals.
- The codes or names for the incoming lines can be written on the writing tab on the signal flap locking bar.
- Unlock the locking bar by sliding it upwards and locking it in place with the two locking screws.
- 

Figure 133: Klappenschrank ready for operation

t
hat may have fallen during this operation. The switchboard is now ready for operation.

When an incoming call is received the signal flap of the relevant line will drop, revealing the number of the line behind the flap. Press the connection button for the relevant line and speak to the caller via the handset of the *FF 33* field telephone (remembering to depress the microphone switch in the handset while talking). When the caller has indicated which line he wants to speak to, press the connection button for that line and turn the generator handle of the field telephone. When the call is answered, place the interconnection cord of the caller into the interconnection plug socket of the outgoing line. Return the signal flap of the caller in the up position and press the red connection release button on top. The call is now connected.

Figure 134: Klappenschrank incoming call on line 4, connected to line 8

At the end of the call, one of the callers will turn the generator rank, resulting in the signal flap of the incoming line to drop. The operator can now remove the interconnection cord of that line and replace it in its storage socket. Close the signal flap to reset the switchboard for the next call.

Conference calls can be made by repeating the connection process: the interconnection cable of caller 1 is plugged into the interconnection plug socket of caller 2; the interconnection cable of caller 2 is plugged into the socket of caller 3 etc. In theory, all ten lines can be connected to a single conference.

Amtszusatz fuer den Kleinen Klappenschrank zu 10 Leitungen

Development and Description

As discussed in the previous section, the "*Kleiner Klappenschrank zu 10 Leitungen*"

Figure 135: Amtszusatz front view

was a simplified design, without any provisions for connection to public telephone networks. To enable this function, the "*Amtszusatz fuer den Kleinen Klappenschrank zu 10 Leitungen*" was developed. The "*Ambstzusatz*" allowed connection to "ZB" ("*Zentralbatterie Betrieb*" or central battery), "SB" ("*Schlusszeichen Betrieb*" or end-pulse battery) and "*Wahlbetrieb*" or automatic dialling networks.
The unit was designed to be placed on the left hand side of the "*Kleiner Klappenschrank zu 10 Leitungen*" and has identical height. Two strips connect the *Ambstzusatz* to the "Abfr." Terminals of the 10 line switchboard. If required, a second *Amtszusatz* can be connected to the left of the first, this will just allow the rightmost interconnection cord of the switchboard to reach.

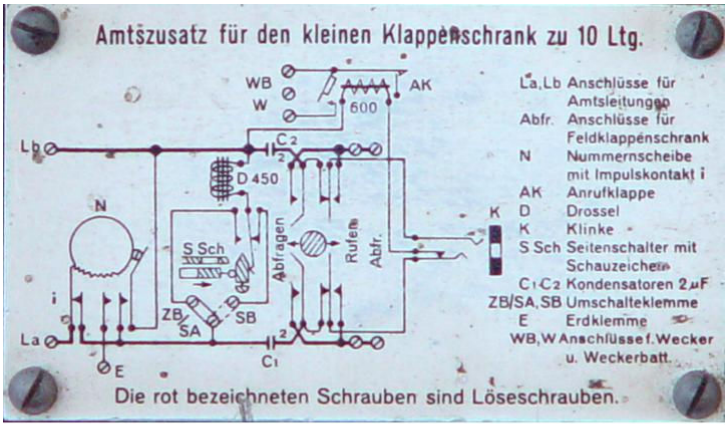


Figure 136: Amtszusatz schematic

The front panel has a dialling disk, a single signal flap to indicate incoming calls, a socket for the interconnection cable, a Kellogg switch and a "*Trennen*-" or end-pulse-button.

The top panel contains all the connection terminals:

La	"*Leitung a*" or line a connection to the public network
Lb	"*Leitung b*" or line b connection to the public network
E	"*Erde*" or earth Terminal
W	"*Wecker*" or external alarm bell connection
WB	"*Wecker Batterie*" or external alarm bell battery connection
SB	"*Schlusszeichen Bebrieb*" or End-pulse operation jumper terminal. The jumper can be set either to the "SB" or to the "ZB/SA" jumper terminal.
ZB/SA	"*Zentralbatterie Betrieb / SelbstAnschlussbetrieb*" or Central battery / Automatic dialling network jumper terminal.
Abfr.	"*Abfragen*" or enquiry terminals

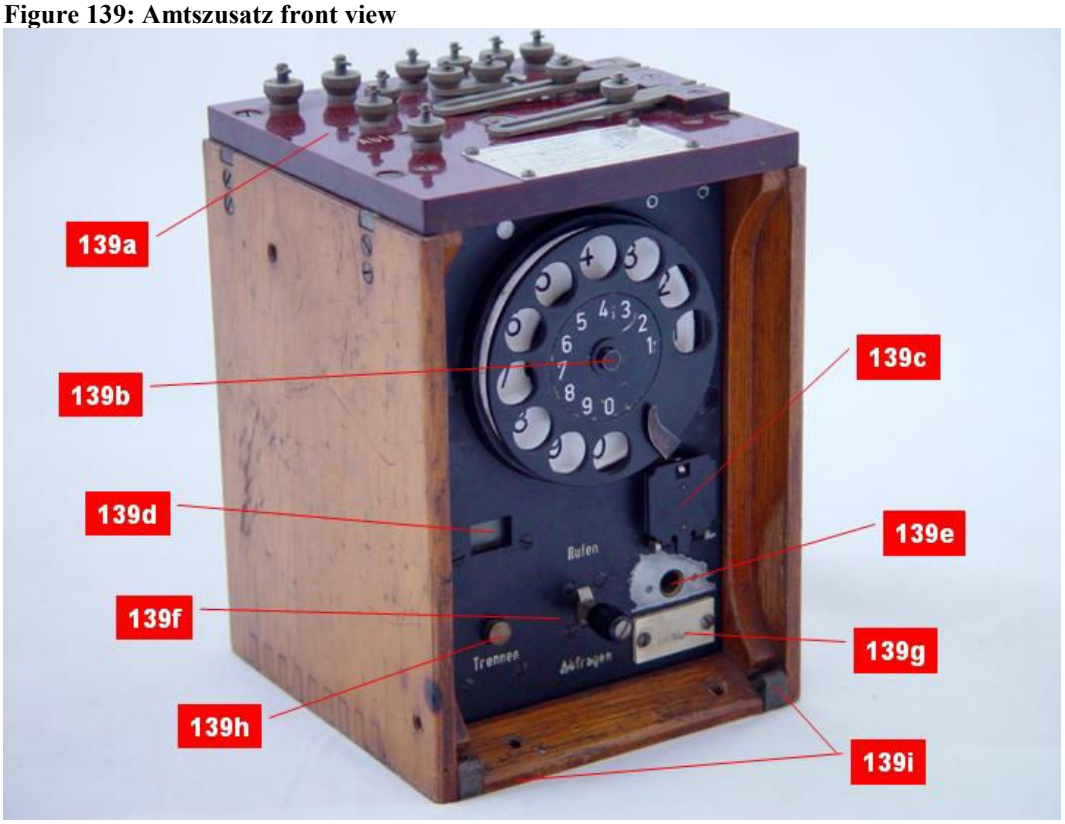
Figure 137: Amtszusatz connection panel

A metal cover can be placed over the unit protecting it from rain and a handle is provided on the back of the unit for carrying.

Figure 138: Amtszusatz with cover

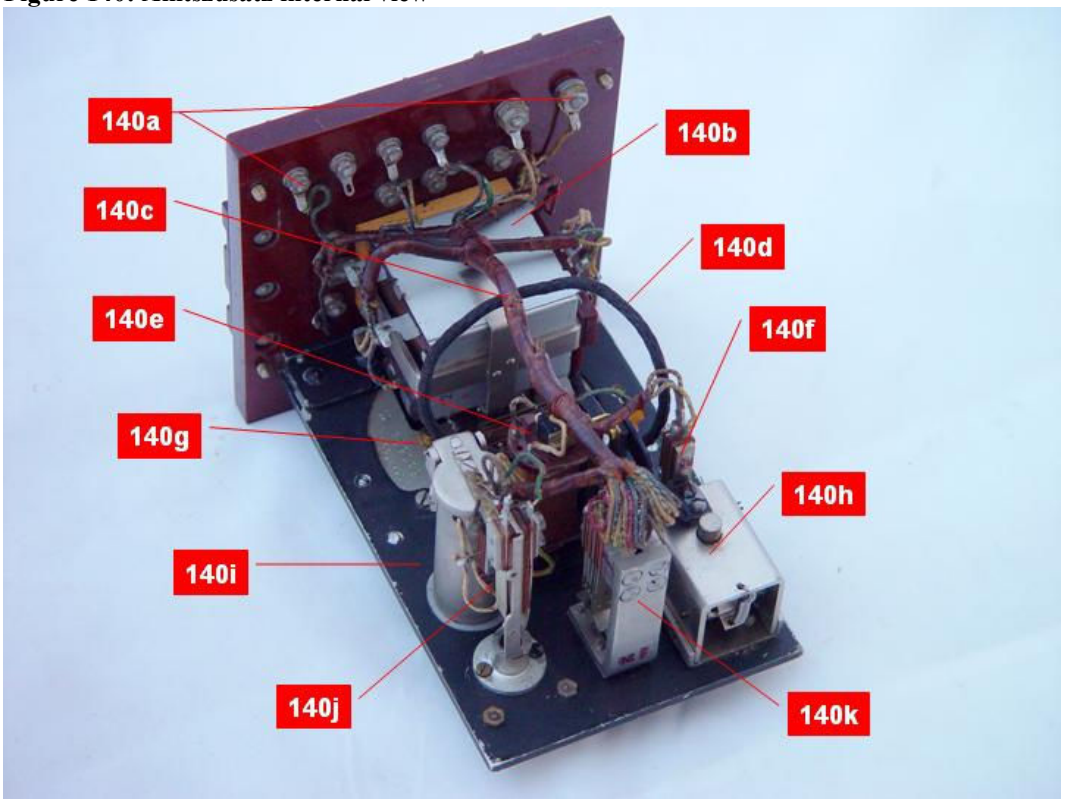
Construction

Figure 139: Amtszusatz front view



139a Connection panel
139b Dialling disk
139c Signal flap
139d End pulse indicator window
139e Interconnection cable socket
139f Kellogg switch
139g Writing tab
139h End pulse button
139i Lugs for metal cover

Figure 140: Amtszusatz internal view



140a Top panel connections
140b Capacitor blocks
140c Wiring loom
140d Dialling disk connection cable
140e End pulse self inductance coil
140f End pulse switch contacts
140g Dialling disk mechanism
140h End pulse interlock mechanism
140i Indicator relay
140j Interconnection cable socket contacts
140k Kellogg switch contacts

Operation

If your public phone network supports “pulse dialling”, you should be able to use the *Amtszusatz* on the network. Most modern networks use “tone dialling” so a pulse to tone converter might be required.

Figure 141: Amtszusatz jumper connections to the Klappenschrank

- Set up the “*Kleiner Klappenschrank zu 10 Leitungen*” as described in the previous section but do not connect the *FF 33* field telephone to the “*Abfr.*” terminals.
- Remove the lid and set up the “*Ambstzusatz fuer den kleinen Klappenschrank zu 10 Leitugen*” on the left side of the switchboard.
- Connect the two “*Abfr.*” interconnection strips between the switchboard and the *Amtszusatz*.
- Connect the “La” and “Lb/E” terminals of the *FF 33* field telephone to the “*Abfr.*” terminals on the left side of the *Ambstzusatz*.
- Connect the public network connection wires to the “La” and “Lb” terminals of the *Ambstzusatz*.
- Ensure that the “SB” – “ZB/SA” jumper is placed in the “ZB/SA” position.
- Depress the end-pulse button and reset the Kellogg switch to the middle position.
- Ensure that the signal flap is closed. You are now ready to operate the *Amtszusatz*.

When an incoming call from the public network is received, the indicator flap will fall, revealing a red field. Depress the Kellogg switch to the “*Abfragen*” position, this will allow the operator to talk to the caller (as usual depressing the microphone switch in the handset of the field telephone). At the same time, the end-pulse button will reset activating the end-pulse circuit. Enquire which line the caller wants to be connected to. Reset the Kellogg switch to the central position and call the outgoing line as

described in the previous section. Connect the interconnection cord of the outgoing line to the interconnection cord socket of the *Ambstzusatz*. Press the red disconnection button on top of the switchboard, the two lines are now connected.

When an outgoing call is requested by a field net participant, enquire as to the number to be called and put the caller on hold. Place the Kellogg switch of the *Amtszusatz* in the "*Abfragen*" position (the dialling tone should now be heard in the field telephone) and dial the requested number using the dialling disk. When the phone is answered, notify the recipient that he has a call from the field and place the interconnection cord of the caller into the interconnection cable socket of the *Amtszusatz*. Place the Kellogg switch in the middle position; the two lines are now connected.

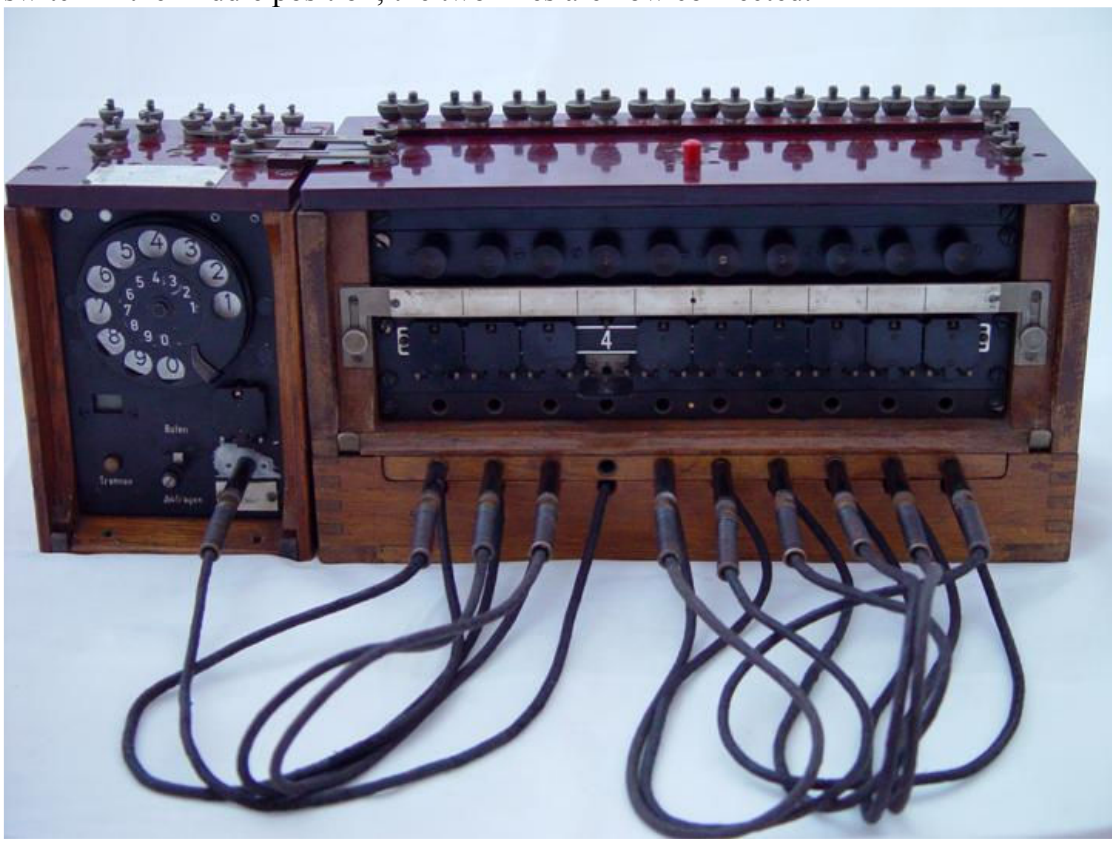


Figure 142: Line 4 of the Klappenschrank connected to an external line

When the call is finished, the field net participant has to crank the field telephone generator to indicate the end of the call. This will result in the relevant indicator flap on the switchboard to drop and reveal the line number. Disconnect the interconnection cable and replace it into its storage socket. Depress the "*Trennen*" button on the *Amtszusatz* to generate the end-pulse to disconnect from the public network. The unit is now ready to receive the next call. Failure to press the "*Trennen*" button will be equivalent to leaving the phone off the hook; any public caller to the switchboard will get an engaged signal.

20 line switchboard

Development and Description

To bridge the gap between the smaller 10-line and larger 60+ line switchboards, in 1940 the "*Klappenschrank zu 20 Leitungen*" or 20-line switchboard was introduced. Weighing in at about 40 Kg, the switchboard is a heavy sturdily built unit. The unit is fully encased, offering excellent protection during transport with even the interconnection cables being protected within the casing. Like the small 10-line switchboard, the unit could be set up and connected quickly. The unit also contains its own alarm bell, alarm bell generator, buzzer and handset connection, so no external *FF 33* field telephone is required for operation.

Figure 143: Klappenschrank zu 20 Leitungen

An enlargement unit could be placed on top of the "*Klappenschrank zu 20 Leitungen*", containing additional line connections and two public network connection fields, complete with dialling disks.

The "*Klappenschrank zu 20 Leitungen*", like the *OB 17*, uses a two-cord interconnection system. Ten interconnection cord pairs are provided. When not in use, the interconnection cords automatically roll into the interconnection cable enclosure which forms the bottom section of the unit, preventing snagging and damage. Ten Kellogg switches are connected to the interconnection cords, this means that the operator can only speak to a incoming line once one of the interconnection cords is plugged into the relevant field (in the previously discussed switchboards, each incoming field had its own dedicated Kellogg switch or interconnection button).

On the left and side of the front panel are three 5-pin connection sockets for handsets, or headsets with breast microphones when hands-free operation is required. On the top left of the panel is a provision to hang the handset

On the right of the front panel is an enclosed battery compartment, which houses the local battery ("*OrtsBatterie*") and the alarm bell battery ("*WeckerBatterie*"). A switch on the front panel allows the alarm bell to be switched off for silent operation.

The front panel contains four centre sections. The top section houses the conference parallel sockets, which allows several lines to be connected to the same call. The two middle sections contain the 20 incoming line fields, each with a signal flap and an interconnection cable socket. The bottom section contains the ten interconnection cable flaps, one for each cable pair.

If the internal buzzer could not be operated, a alarm bell generator was provided, the crank handle can be found on the right bottom side of the interconnection cable enclosure.

Figure 144: Enlargement unit placed on top of the exchange

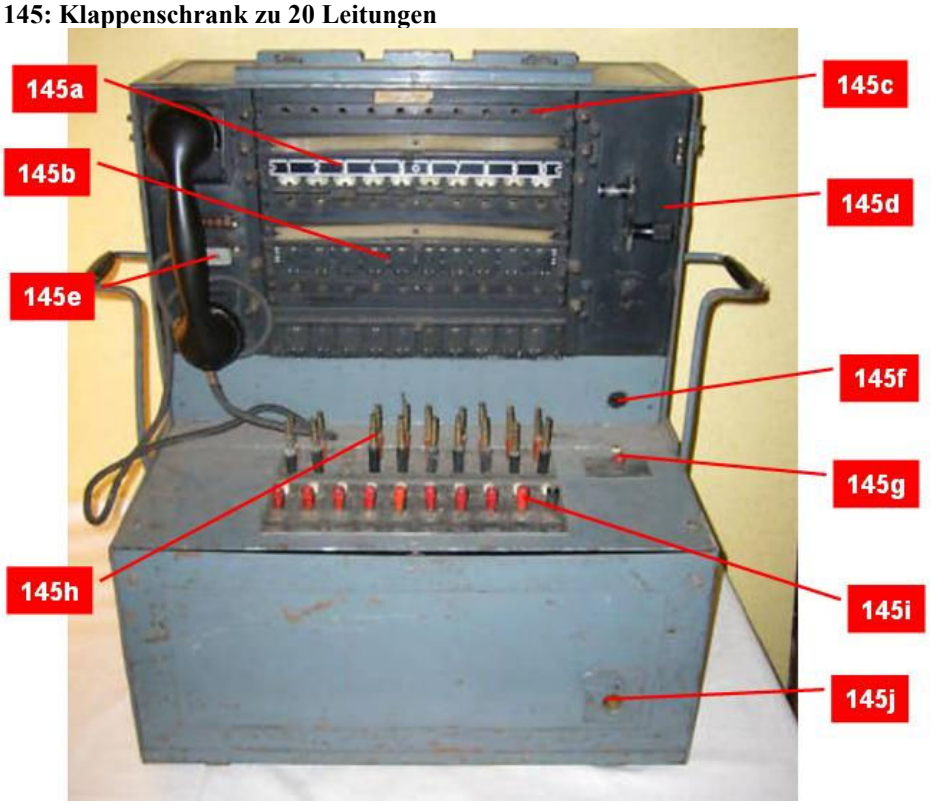
The enlargement unit sits on top of the switchboard. On the left and right side it contains two fields for interconnection to public networks. Each field has a writing tab, dialling disk, signal flap with Kellogg switch and interconnection cable socket, similar to the "*Amtszusatz fuer den Kleinen Klappenschrank zu 10 Leitungen*". The centre section contains the incoming line fields, either an additional 30 lines, or 10 additional fields and a 9 by 10 "Scribner[2]" parallel connection field, which allows four complete 20-line units plus enlargement units to be coupled as a single, 120 line switchboard.

Due to the weight and size, it is likely that it was designed to be a vehicle mounted mobile switchboard.

[2] C.E. Scribner was a Western Electric Manufacturing Company engineer credited with many patents and inventions, amongst others the telephone "jack". Building large telephone switchboards posed specific challenges, at some point the length of the interconnection cables limits the number of lines it can reach. This problem was solved by connecting each subscriber to multiple sockets along the switchboard. The original solution was patented by Firman and later refined by Scribner. In this solution, each "workstation" of the switchboard has a parallel socket matrix, allowing an operator of a particular workstation to place outgoing calls to the lines of all other workstations.

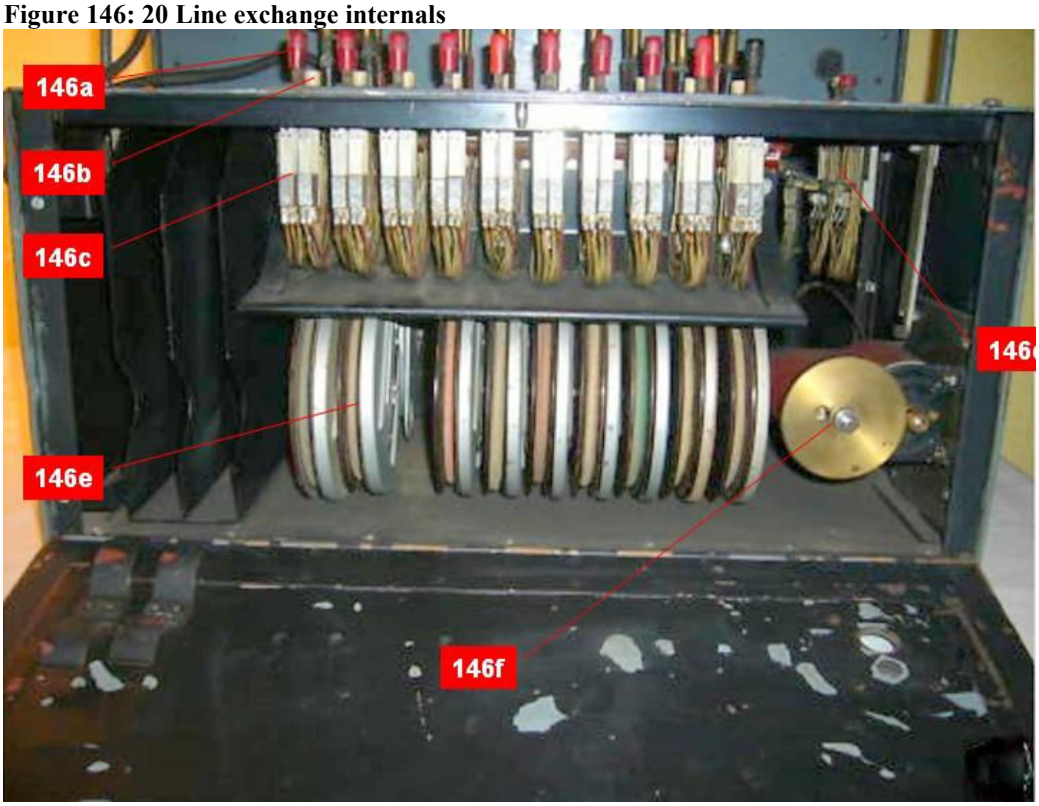
Construction

Figure 145: Klappenschrank zu 20 Leitungen



145a Upper 10 lines with signal flaps and interconnection plug sockets
145b Lower10 lines with signal flaps and interconnection plug sockets
145c Conference call sockets
145d Alarm bell battery compartment
145e Handset
145f Signal indicator
145g Switches for ring tone generation and parallel operation
145h Interconnection cable jacks
145i Kellog switches and call-back buttons
145j Generator crank

Figure 146: 20 Line exchange internals



146a Kellogg switch
146b Call back button
146c Call back button contacts
146d Parallel operation and ring tone switch contacts
146e Spring loaded cable reels
146f Generator

Figure 147: 20 Line exchange back connection panel

147a 30 pole sockets for remote connection of lines

147b 30 pole sockets for parallel operation

147c Direct line connection terminals

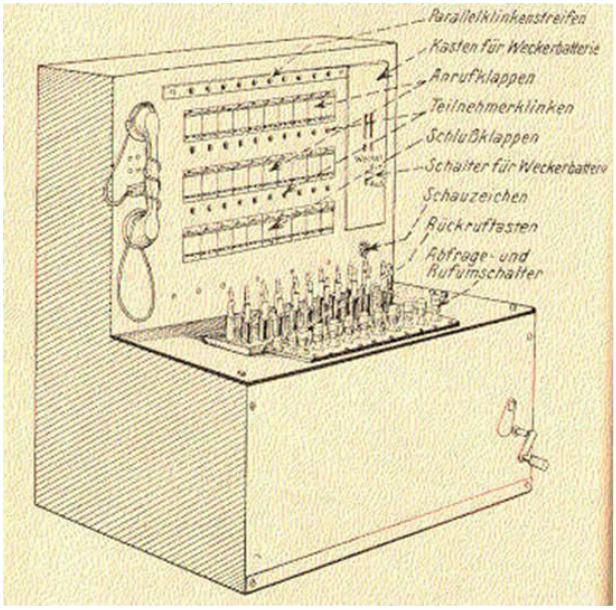


Figure 148: Handbook illustration

Operation

- Place the "*Klappenschrank zu 20 Leitungen*" on a suitable surface.
- Remove the front panel. Remove the back cover and connect the incoming field telephone lines.
- Unlock the signal flap locking bar and lock in the up position. Close any signal flaps that have dropped during this operation.
- Open the battery panel and connect the battery.
- If the enlargement panel is used, place this on top of the switchboard and connect the incoming lines to the connection terminals on the back.
- Set the alarm bell switch to the desired operation ("*Aus*" for silent operation). You are now ready to operate the switchboard.

When an incoming call is received, the signal flap of the incoming line will drop. At the same time, the alarm bell will ring (if switched on) or the alarm indicator with flash. Place the first red interconnection cable into the socket of the incoming line and place the Kellogg switch in the "*Abfr.*" position. Take the handset from the hook; you can now speak to the incoming caller (while depressing the microphone switch on the handset as usual). When the caller has given the outgoing line he wishes to speak to, place the first black interconnection cable into the socket of the outgoing line. Hold the Kellogg switch in the "*Rufen*" position and crank the generator handle. When the outgoing line answers, place the Kellogg switch in the neutral position and close the signal flap of the incoming line. The connection is now established and the switchboard is ready to take the next call. Up to 10 calls can be connected like this at the same time.

Figure 149: Klappenschrank zu 20 Leitungen in action

To end the call, one of the participants has the crank the generator handle, this will cause the signal flap of the relevant cable pair (bottom row of signal flaps) to fall. At the same time the alarm bell will ring or the alarm indicator will flash. Disconnect the interconnection cables from both the incoming and outgoing line and let them retract into the bottom panel. The interconnection is now ready for re-use.

The key difference with the switchboards described earlier in the chapter is that not every individual line has it's own Kellogg switch or interconnection button. Before the operator can speak to an incoming line, one of the interconnection cables has to be plugged into the required socket. If all ten interconnection cable pairs are in use, it will not be possible to respond to an incoming call.

When the enlargement unit is placed on top, calls can be made to more lines and to external lines. The operation of the external line fields is identical to that of the "*Ambstzusatz*" described before.

Grosse Feldklappenschrank (1937)

Development and Description

Figure 150: Grosse Feldklappenschrank

The development of the large field switchboard goes back to 1916, when the imperial army introduced the "*Grosse Feldklappenschrank 16*". Conceived as a modular system, the large field switchboard was not designed for a particular number of lines, but could be configured as required. The design was slightly updated in 1937, after which it was simply known as "*Grosse Feldklappenschrank*". Units from the 1916 and 1937 versions remained interchangeable.

The main modules of the "*Grosse Feldklappenschrank*" are:
a) Collapsible metal table frame
b) Base unit a ("*Untersatz a*"), containing the interconnection cable pairs and switches
c) Base unit b ("*Untersatz b*"), forming a writing surface
d) Line connection unit for 10 lines, containing 10 signal flaps and interconnection cable sockets
e) Line connection unit for 50 lines, containing 50 signal flaps and interconnection cable sockets
f) "Scribner" parallel connection unit for 40, 100 or 150 lines.
g) Public network connection unit ("*Ambstszusatz*"), containing three public line connection field complete with dialling disks
h) Conference call connection strips with 10 interconnection cable sockets

Figure 151: From top to bottom: Conference call unit, Amtszusatz, 2 x 10-line connection units, Base unit a

The units were interconnected with 30-pole plugs and cables. The outgoing telephone lines were not connected to the units directly, but a remote terminal block was used connected by a 30-pole cable interconnection cable.

Figure 152: Doppelpolwechselschalter

A number of accessories could also be used such as an external alarm bell and the ring tone generator, usually containing two buzzer circuits (*Doppelpolwechselschalter*).

The modular construction of the large switchboard meant that it was easily transportable and highly flexible. A typical set up would consist of both base units placed side by side on the table frame. Three 10 line connection units and a conference call unit would be stacked on top of base unit a and two 10 line connection units and the Public network connection unit would be stacked on top of base unit b. This would give the switchboard a total of 50 field telephone lines and 3 public network connections. If more field telephone lines were required, the three line connection units could be replaced with a single 50-line unit, in this way 70 field telephone lines could be serviced.

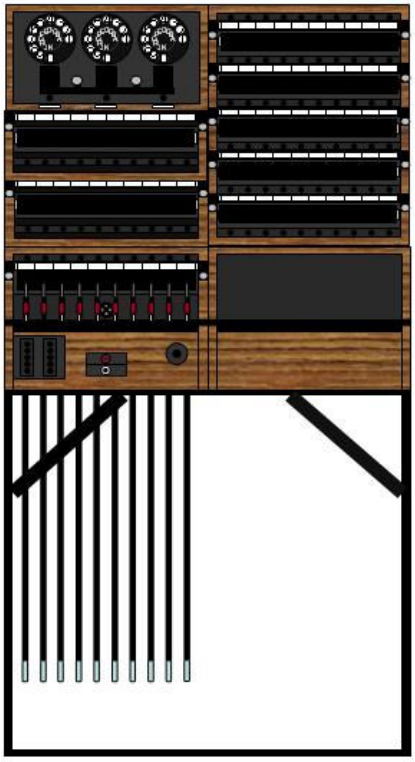


Figure 153: Configuration with 70 lines + 3 public network connections

For larger switchboards, several switchboards could be placed next to each other and interconnected by using “Scribner” parallel connection units. For example, the units on the base unit b could be replaced with a 150 line parallel connection unit. In this way, a total of six complete 30 line switchboards could be linked together for a total of 180 lines. By sharing the “Scribner” connection units both left and right of each operating station and using 50 line connection units, a total of 7 complete 50 line switchboards could be linked into a single 350 line switchboard.

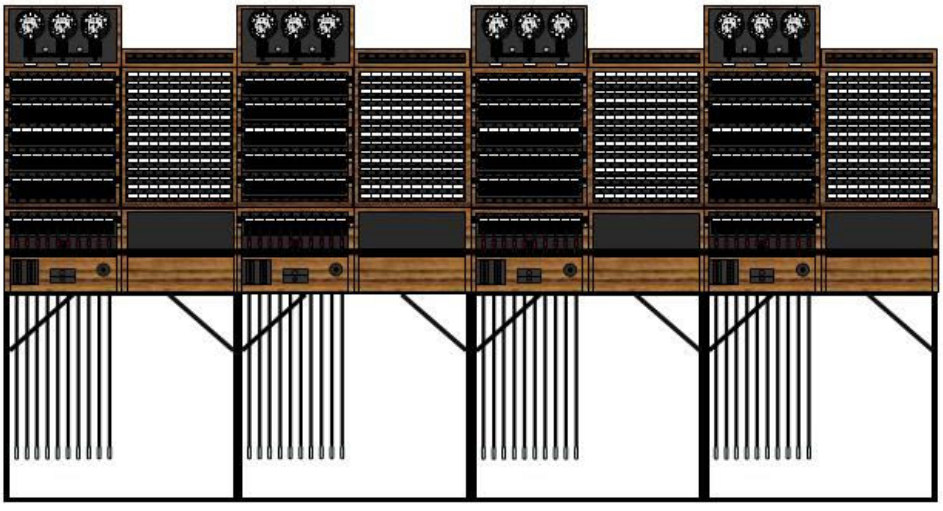


Figure 154: Large exchange (200 lines + 12 public connections) using 50-line units and 150-line Scribner units

For larger switchboards, an "*Überwachungsschrank*" or monitoring panel could be added, allowing a supervisor to monitor the operation and perform fault finding.

The metal frame has a height of 72.5 cm, the height of the base units are 11.5 cm to the line panel and 23.5 cm total height. The "working surface" is therefore a comfortable 84 cm off the ground.

The module standard width and depth are 32 x 18 cm while the standard line connection unit for 10 lines is 11 cm high. The *Ambstzusatz* unit is 17 cm high while the conference call connection unit is only 6 cm high. The height of the 50-line unit and the 100-line "Scribner" unit is 39 cm. By combining the units, stacks of the same height can be constructed. For example 3 x 10-line units plus a conference call unit or 2 x 10-line unit plus the *Amtszusatz*. The total height of the switchboard including the frame is typically 135 cm.

Figure 155: (r) Supervisor base unit and measuring unit on top

Most units have an alignment ridge on the bottom and a corresponding slot on the top of the unit. Each stack of units could be fixed together with a locking pin running top to bottom through all units. The conference call unit is clearly designed to be the top unit, as the top lid has to be opened to gain access to the locking pin holes.

The "*Grosse Feldklappenschrank*" uses a two-cord interconnection system. A total of ten interconnection cord pairs are provided in base unit a. When not in use, the interconnection cords are suspended under the base unit, weighed down by cable weights. Ten Kellogg switches are connected to the interconnection cords; this means that the operator can only speak to an incoming line once one of the interconnection cords is plugged into the relevant field. To avoid confusion, the cable pairs are alternatively coloured white, green and red.

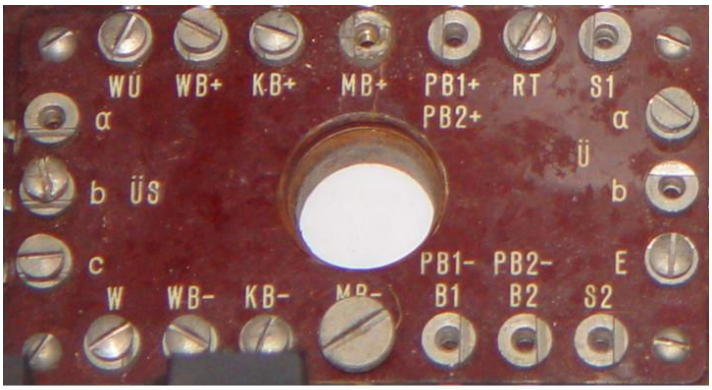


Figure 156: Base unit a connection panel (see table for explanation)

The lid of the bottom section of the base units can be lifted, giving access to various connection strips. Accessories like external batteries, alarm bells, buzzer unit are connected to these strips in the base unit.

WU	Wecker Untersatz	Connects to the stacking pin contacts in both base units and to the external alarm bell.
W	Wecker	
WB+	Wecker Batterie +	Connects the alarm bell battery
WB-	Wecker Batterie -	
KB+	Kontroll Batterie +	Connects control battery
KB-	Kontroll Batterie -	
MB+	Mikrofon Batterie +	Connects the microphone battery
MB-	Mikrofon Batterie -	
PB1+ PB2+	Polwechselschalter Batterie 1&2 +	Connects the ringtone generator batteries
PB1- B1	Polwechsel Batterie 1 – Batterie 1	
PB2- B2	Polwechsel Batterie 2 – Battery 2	
RT	Ruf Taste	Connects to the activation contact of the ringtone generator
S1	Signal 1	Ringtone signals for the ringtone generator
S2	Signal 2	
Ü a	Überwachung a	Connects to the monitoring panel.
Ü b	Überwaching b	
ÜS a	Überwachungs Schrank a	
ÜS b	Überwachungs Schrank b	
ÜS c	Überwachungs Schrank c	
E	Erde	Earth connection

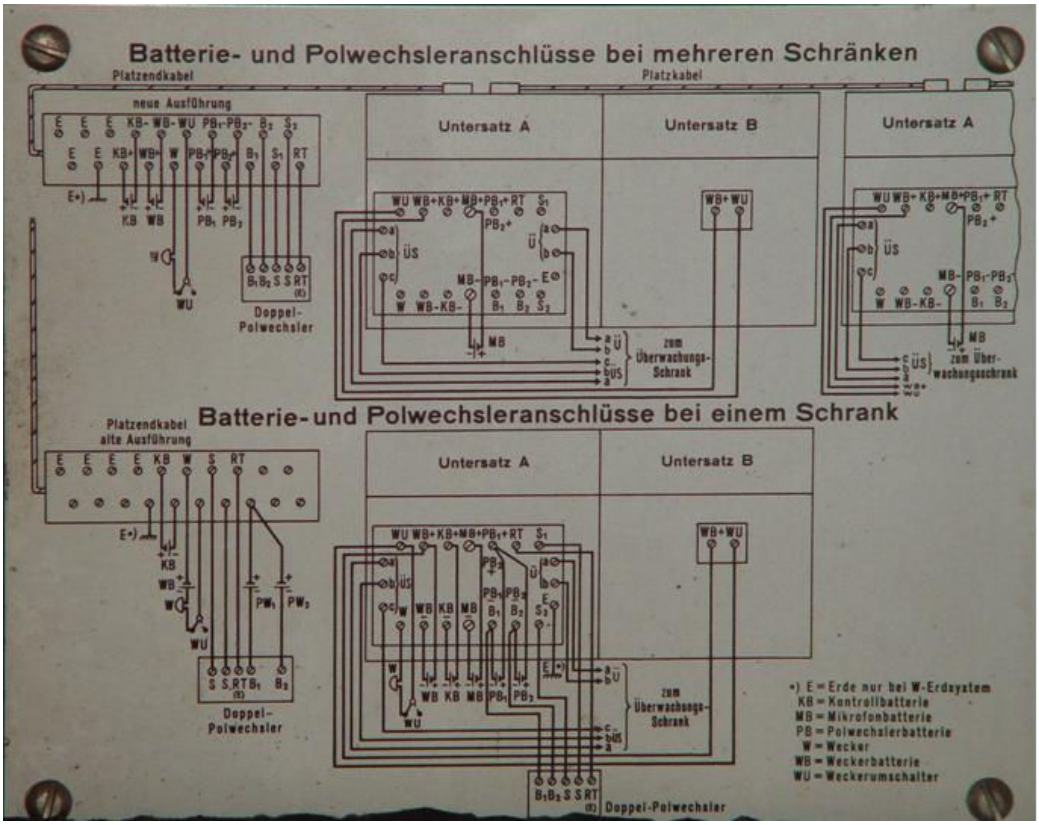
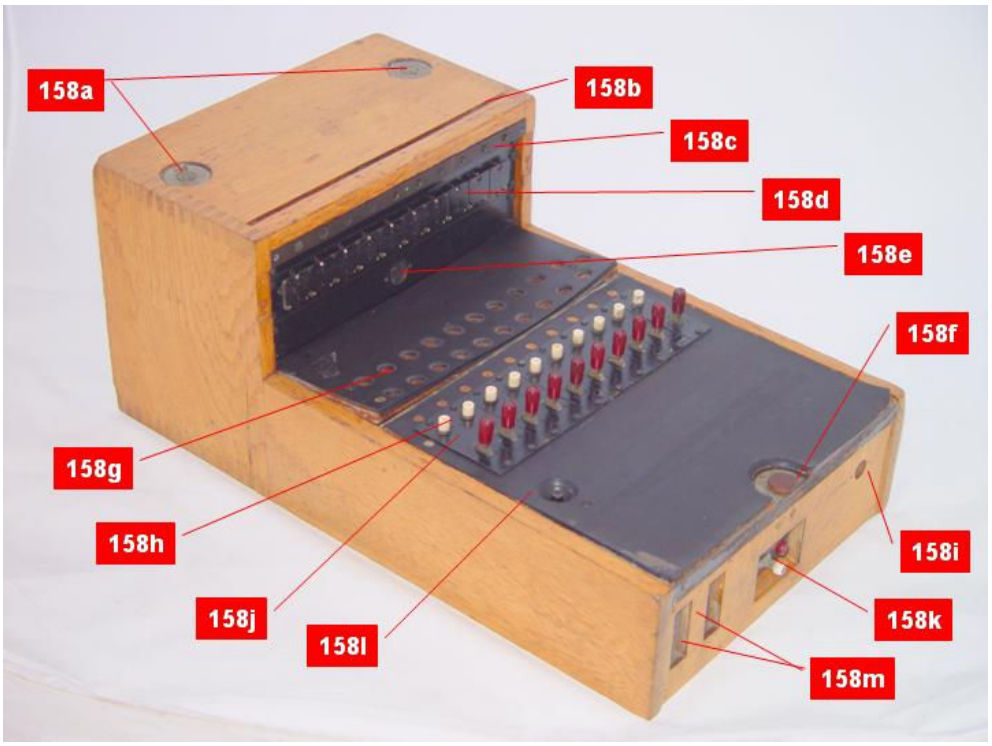


Figure 157: Connections for single or multiple switchboards.

Two five-pin plugs on the front of base unit a allow connection of handset and/or headset. Typically a busy switchboard would require the use of a headset and breast microphone, keeping the hands of the operator free. The base unit b surface could be used as a writing surface to keep logs.

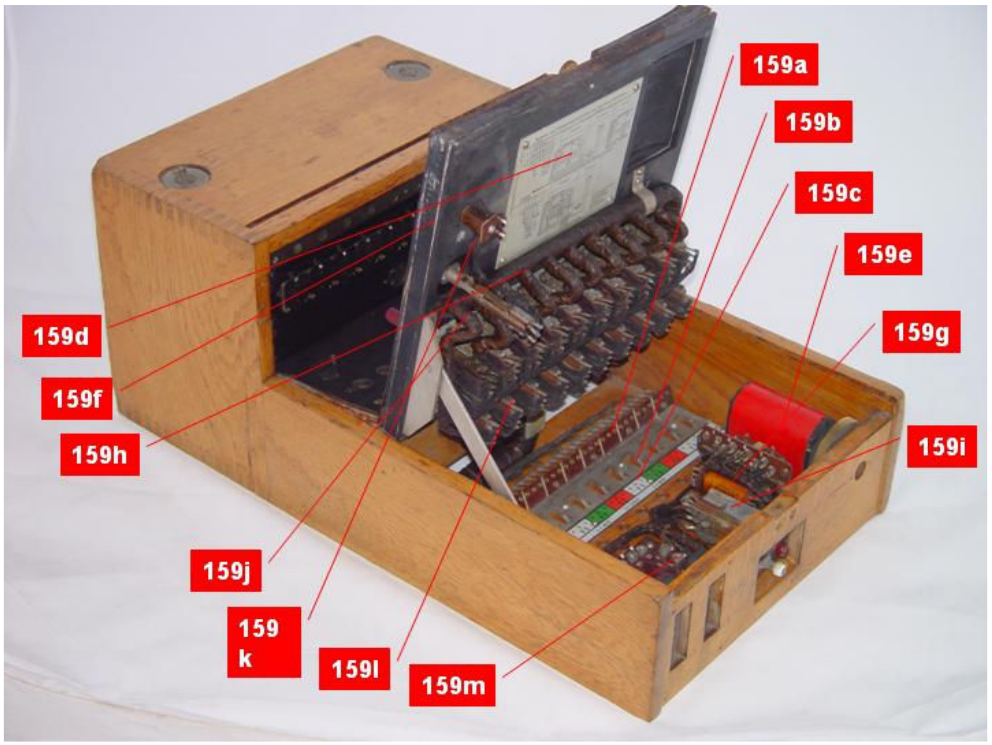
Construction

Figure 158: Base unit a overview



158a Stacking pin sockets
158b Alignment groove
158c Monitoring plug sockets
158d Signal flaps for cable pairs
158e Alarm indicator
158f Locking screw
158g Passages for interconnection cables
158h Callback buttons
158i Generator crank hole
158j Kellogg switches
158k External alarm bell and parallel connection switches
158l End pulse button
158m Sockets for hand- or headsets

Figure 159: Base unit a front compartment

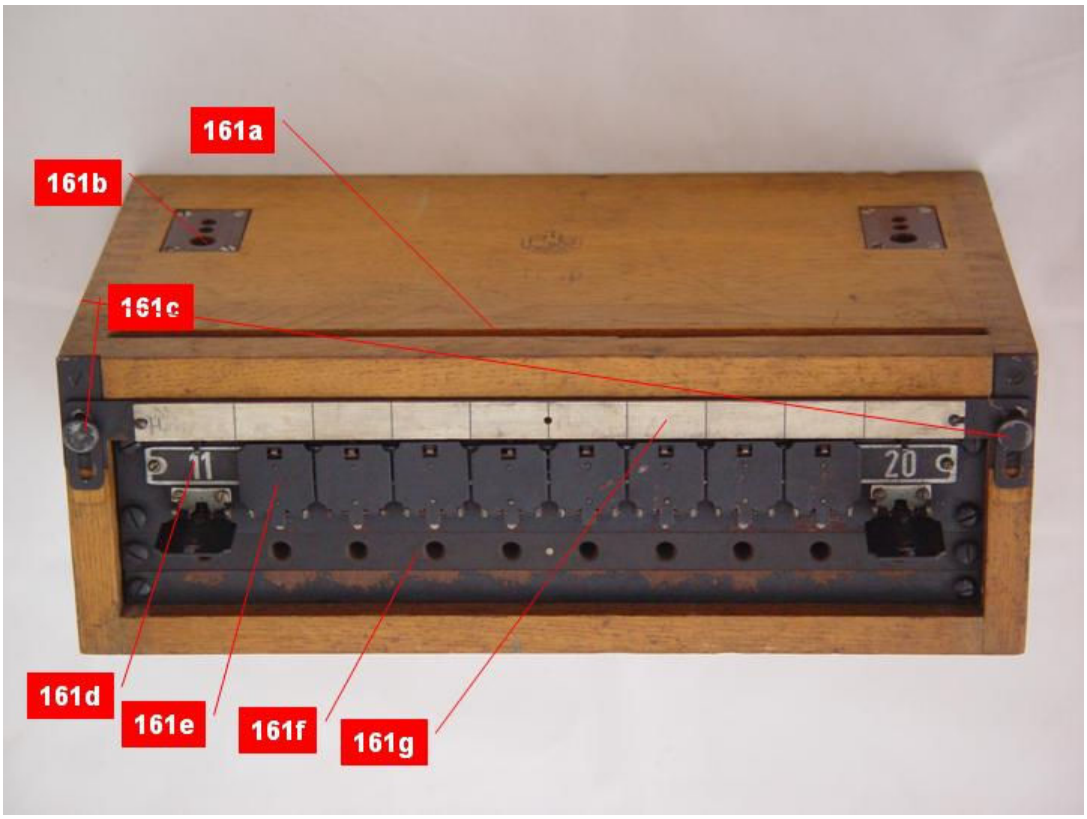


159a Front interconnection cable connection strip
159b Hooks for interconnection calbes
159c Connection instructions
159d Schematic
159e Ringtone generator
159f End pulse coil
159g Microphone coil
159h End pulse switch contacts
159i Front switch contacts
159j Wiring loom
159k Kellogg switch contacts
159l Callback button contacts
159m Connection panel

Figure 160: Base unit a back compartment

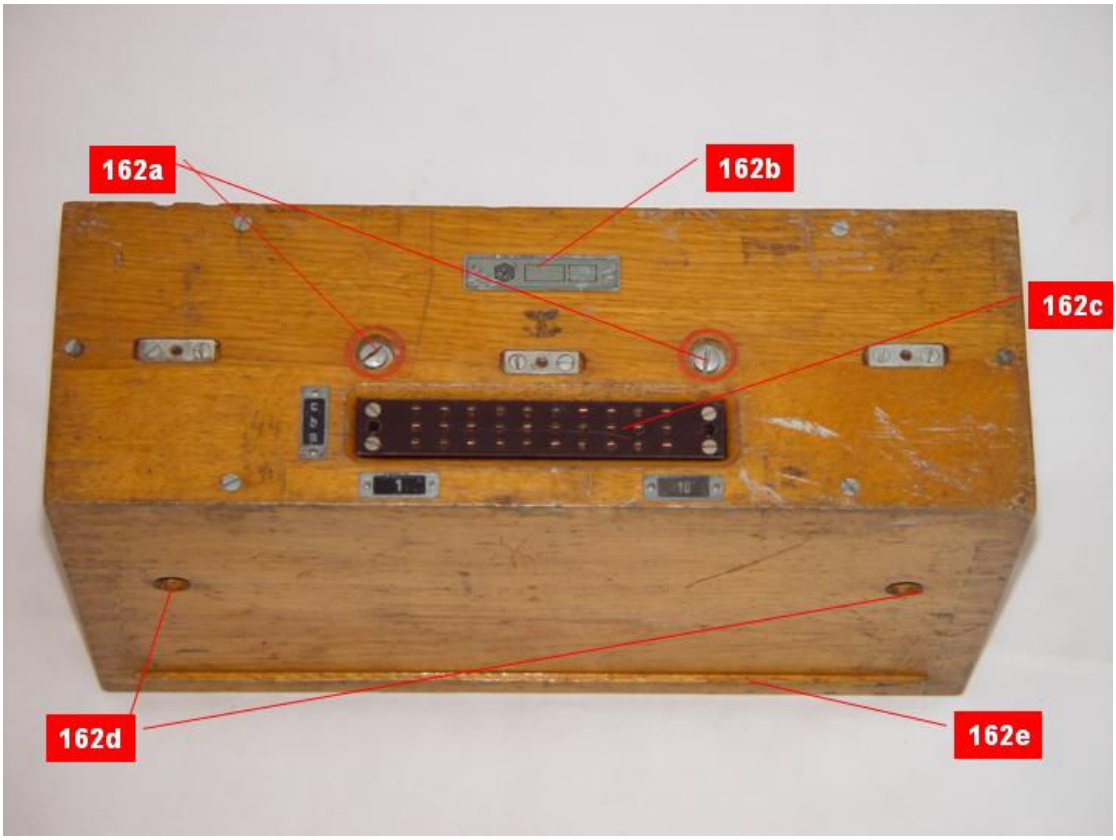
160a 30-pole interconnection socket
160b Alarm indicator coil
160c Signal relays for cable pairs
160d Wiring loom
160e Coils
160f Capacitor block
160g Rear interconnection cable connection strip
160h Tool storage

Figure 161: 10 line connection unit front view



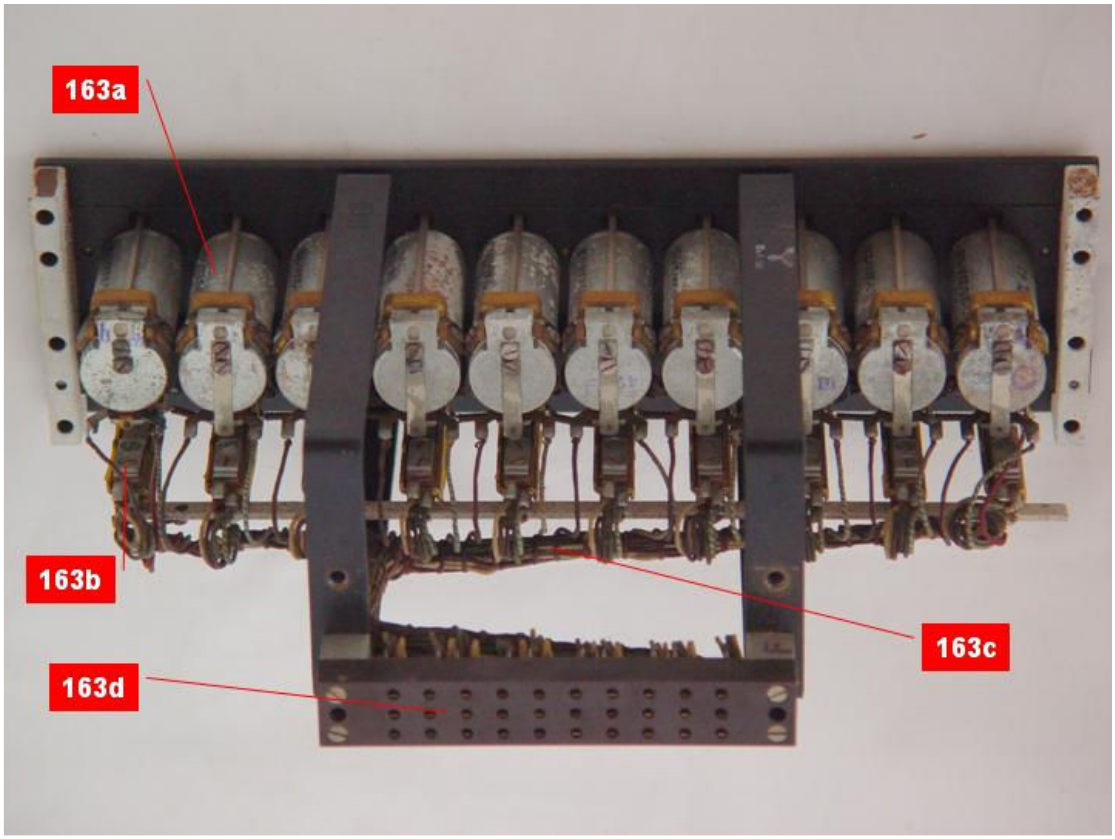
161a Alignment groove
161b Holes an contacts for stacking pin
161c Locking bar screws
161d Line Number strip
161e Signal flap
161f Interconnection cable socket
161g Locking bar with writing tab

Figure 162: 10 line connection unit back view



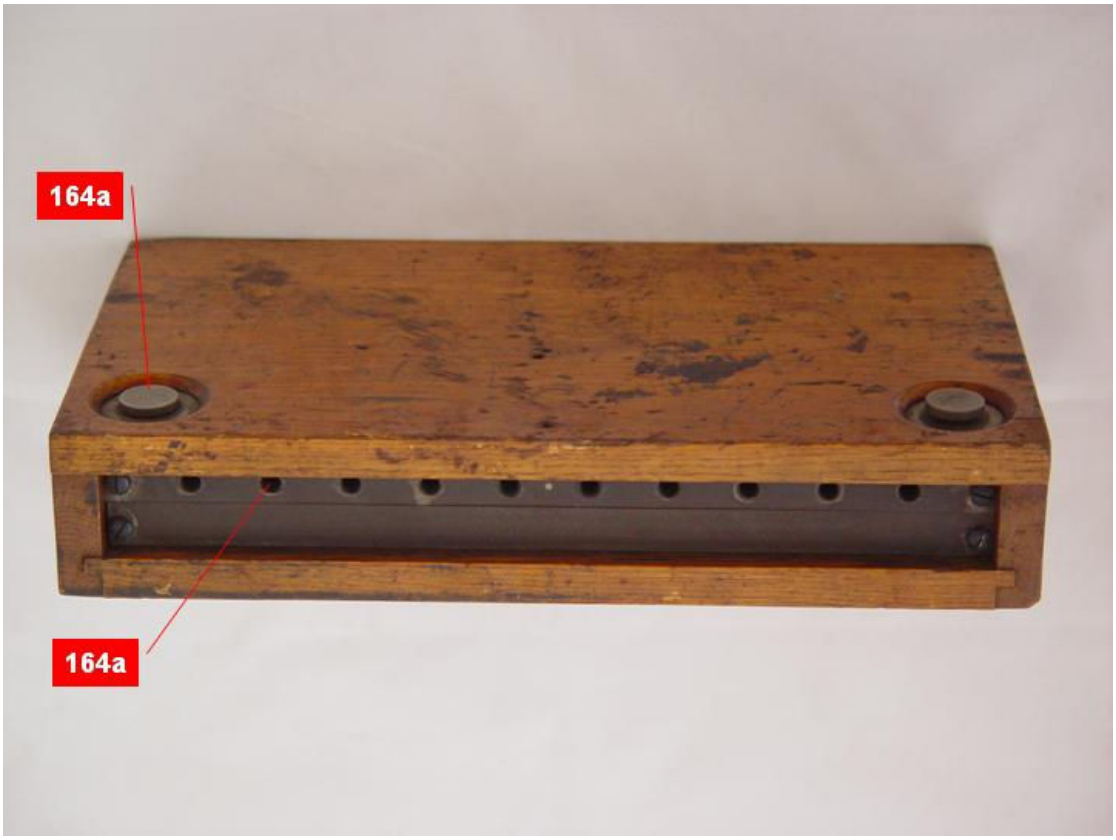
162a Housing locking screws
162b Maker/date tag
162c 30-pole interconnection socket
162d Holes for stacking pins
162e alignment ridge

Figure 163: 10 line connection unit internal view



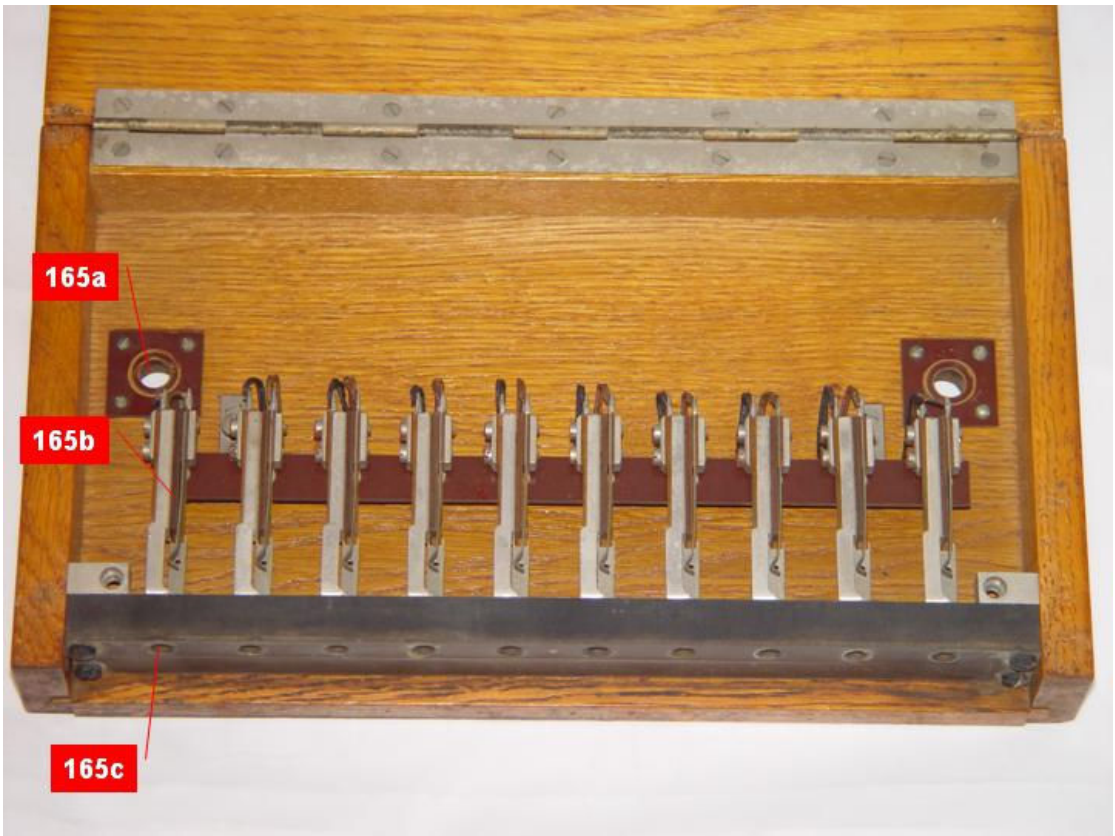
163a Signal relay
163b Interconnection cable socket contacts
163c Wiring loom
163d 30-pole connection socket

Figure 164: Conference call unit front view



164a Top lid locking screws **164b Interconnection cable sockets**

Figure 165: Conference call unit internals



165a Hole for stacking pin **165b Interconnection cable socket contacts** **165c Interconnection cable socket**

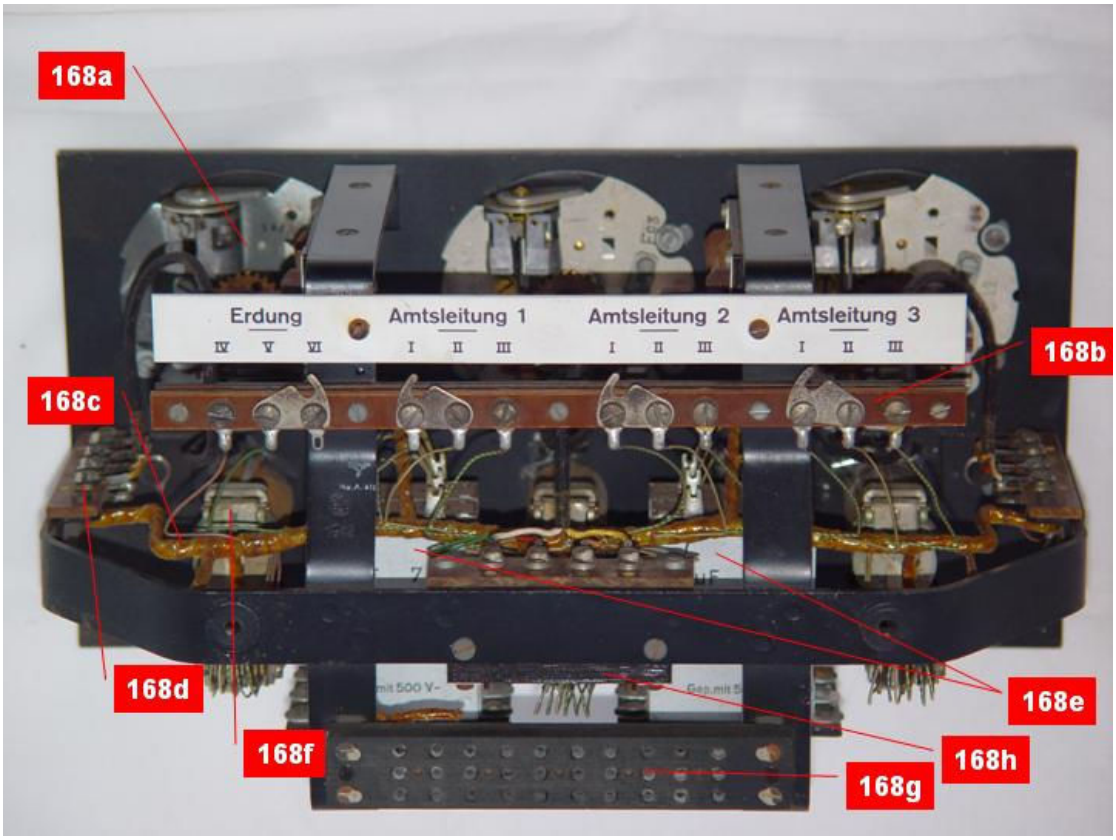
Figure 166: Amtszusatz front view

166a Stacking pin holes
166b Alignment groove
166c Dialling disk
166d Signal flap
166e Locking bar screw
166f Locking bar
166g Connection cable socket
166h Writing tab

Figure 167: Amtszusatz rear view

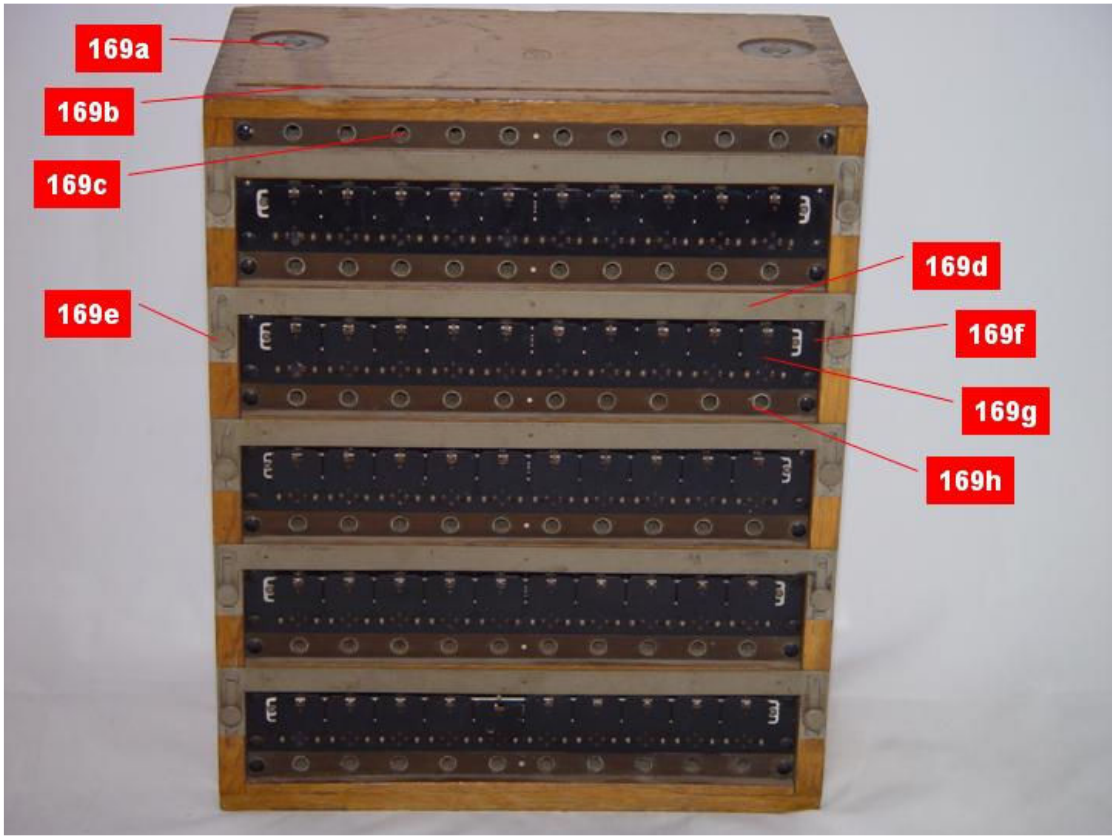
167a Earth jumper
167b Jumper numbering
167c Public network type jumper
167d Jumper setting instructions
167e 30-pole plug socket
167f Schematic

Figure 168: Amtszusatz internal view



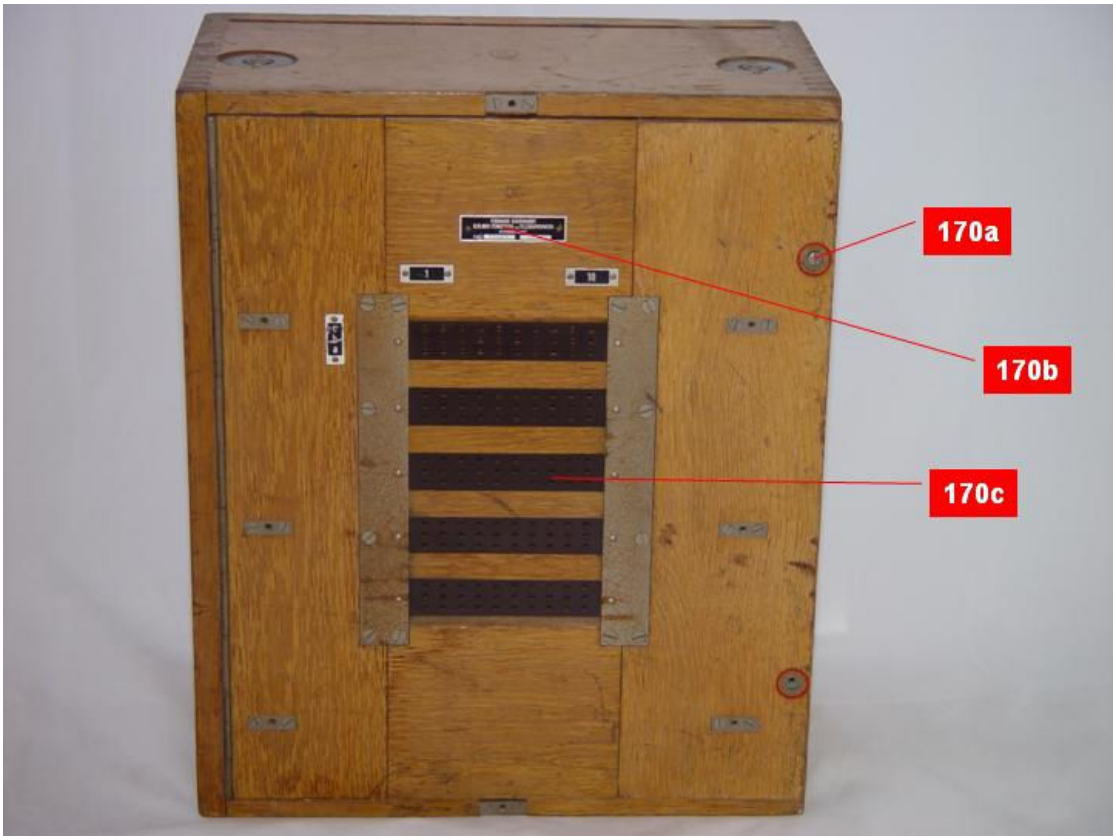
168a Dialling mechanism
168b Jumper strip
168c Wiring loom
168d Dialling disk connector
168e Capacitor blocks
168f Signal relay
168g 30-pole connection socket
168h End pulse self induction

Figure 169: 50 line interconnection unit front view



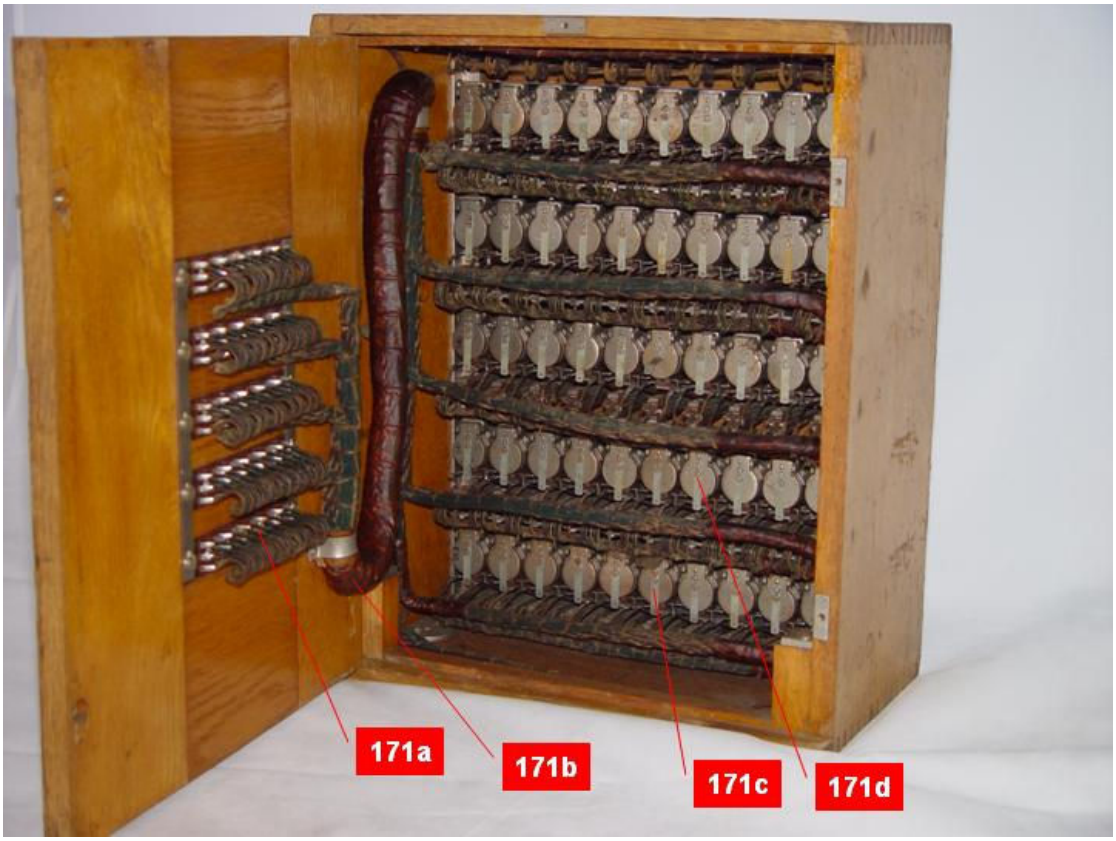
169a Stacking pin connector
169b Alignment groove
169c Conference call sockets
169d Locking bar
169e Locking bar screws
169f Numbering strip
169g Signal flap
169h Interconnection cable socket

Figure 170: 50 line interconnection unit rear view



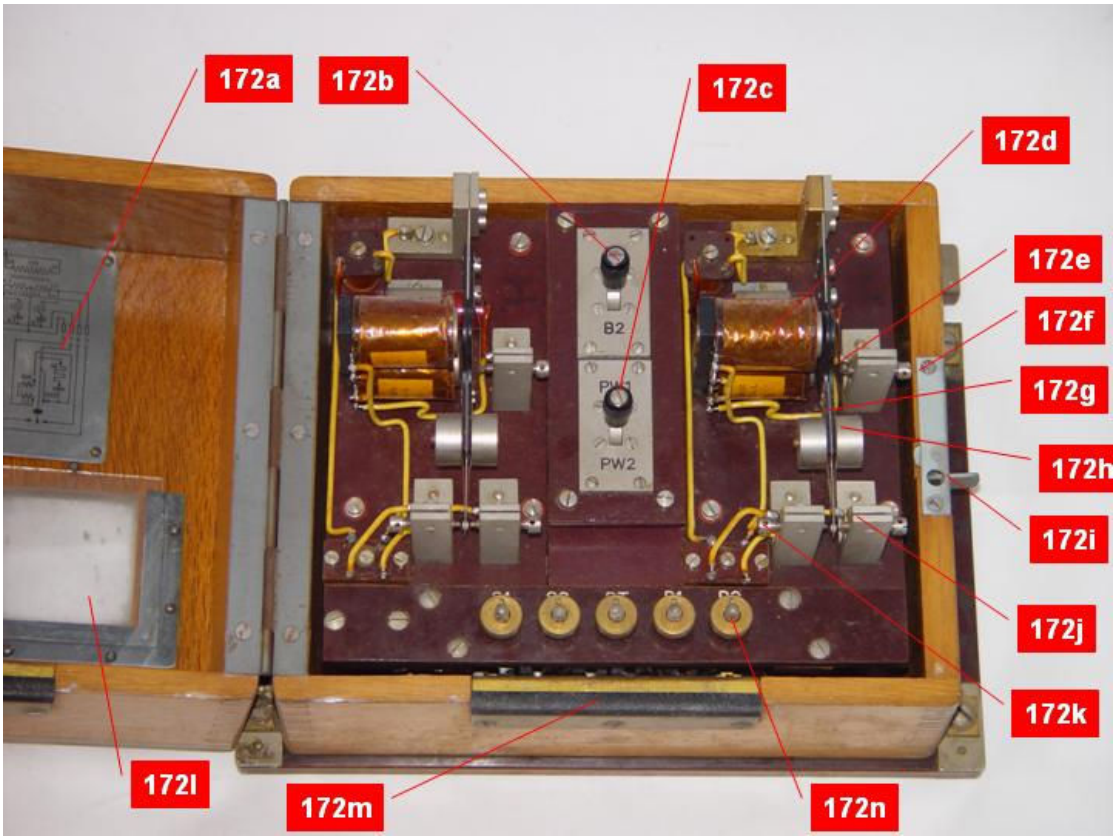
170a Rear panel locking screw **170b Maker/date tag** **170c 30-pole socket**

Figure 171: 50 line interconnection unit internal view



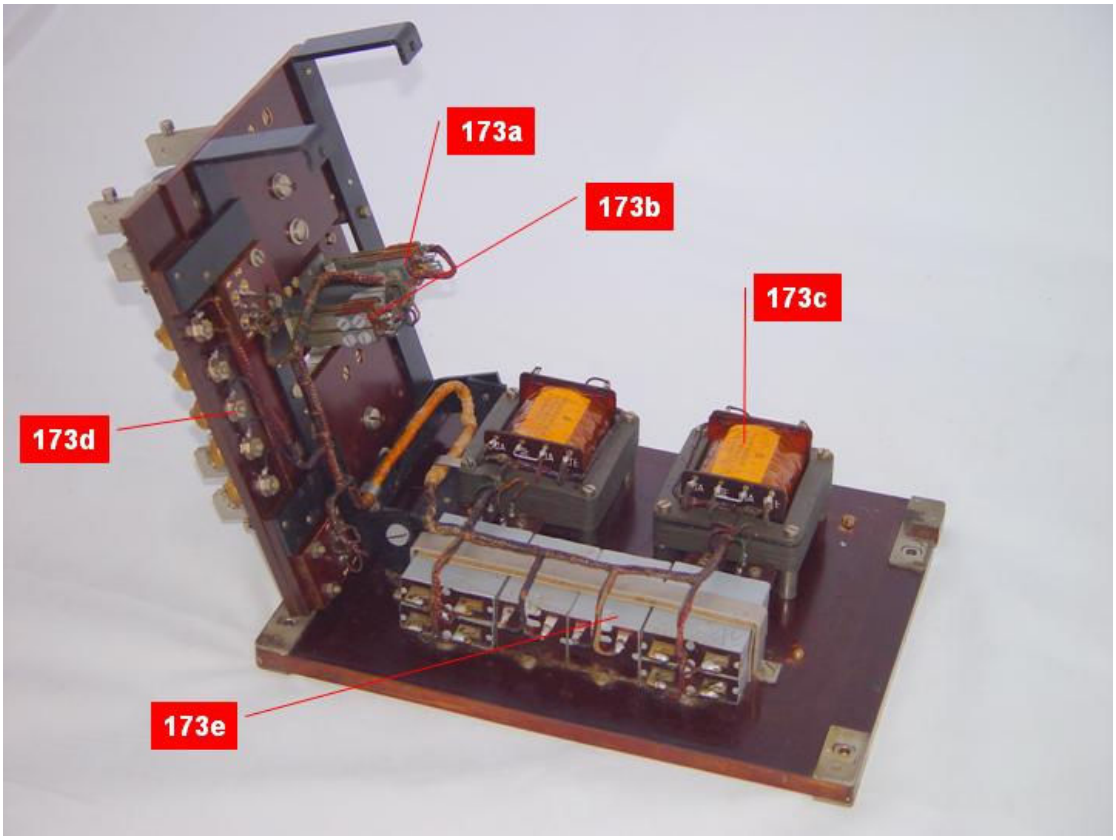
171a 30-pole connections
171b Wiring loom
171c Interconnection socket contacts
171d Signal relay

Figure 172: Doppelpolwechselschalter top view



172a Schematic	172f Generator contact adjustment	172j Generator output contact
172b Battery selection switch	172g Swing arm	172k Output contact adjustment
172c Generator selection switch	172h Swing arm weight	172l Window
172d Generator coil	172i Casing lock	172m Rubber cable transit
172e Generator contact		172n External connections

Figure 173 Doppelpolwechselschalter internal view



173a Battery selector contacts	173c Output transformers	173e Capacitor blocks
173b Generator selector contacts	173d External connections	

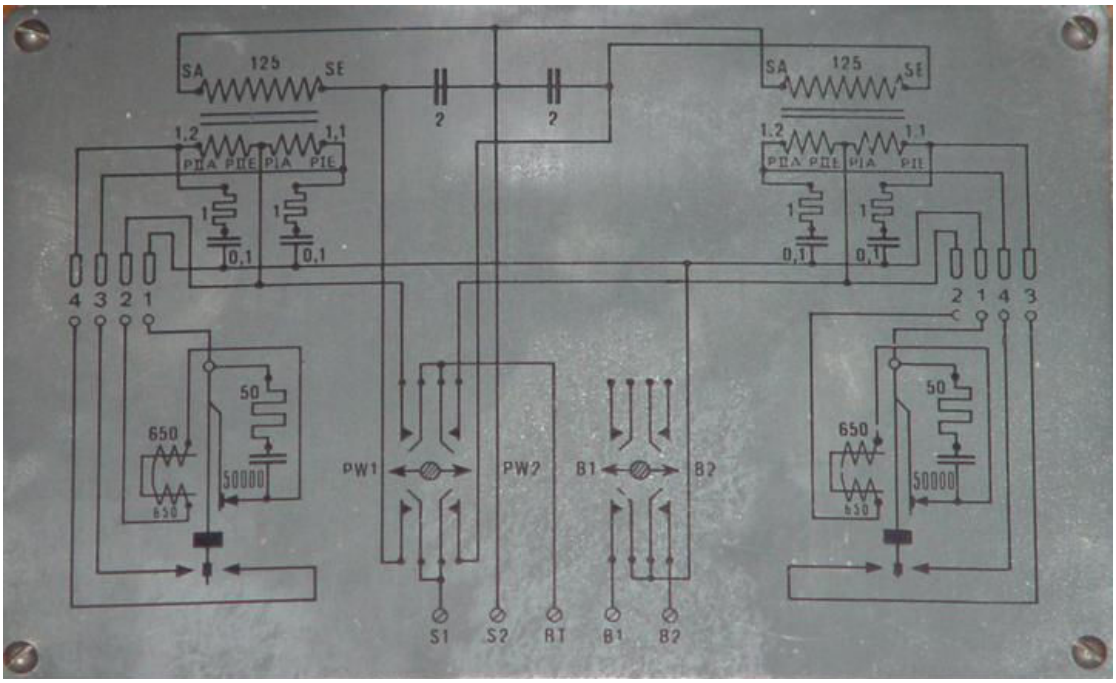


Figure 174: Doppelpolwechselschalter schematic

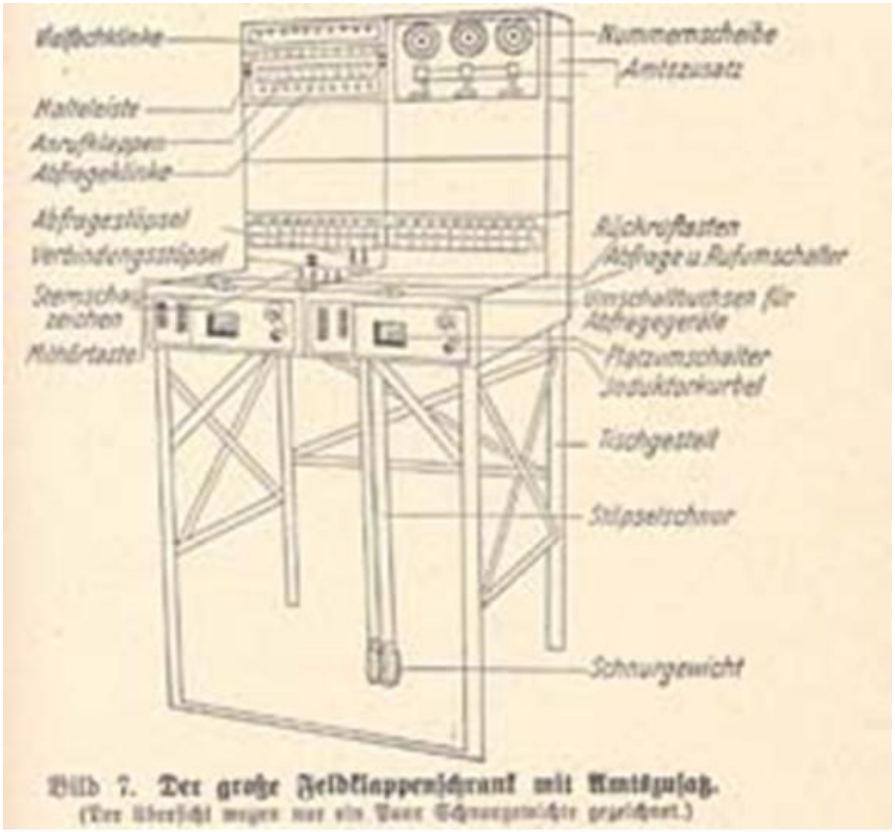


Figure 175: Grosse Feldklappenschrank description from instruction booklet

Operation

The *Grosse Feldklappenschrank* could be used in many configurations; in this section a single 50-line set-up is assumed. This setup consists of:

a. Table frame
b. Base unit a
c. 10 interconnection cable pairs
d. Cable weights
e. Base unit b
f. 10-line unit 1-10
g. 10-line unit 11-20
h. 10-line unit 21-30
i. 10-line unit 31-40
j. 10-line unit 41-50
k. Conference call unit
l. 3-line *Amtszusatz*
m. Doppelpolwechselschalter
n. External Alarm Bell
o. Line connection units
p. 30-pole interconnection cables
q. Stacking pins
r. Battery

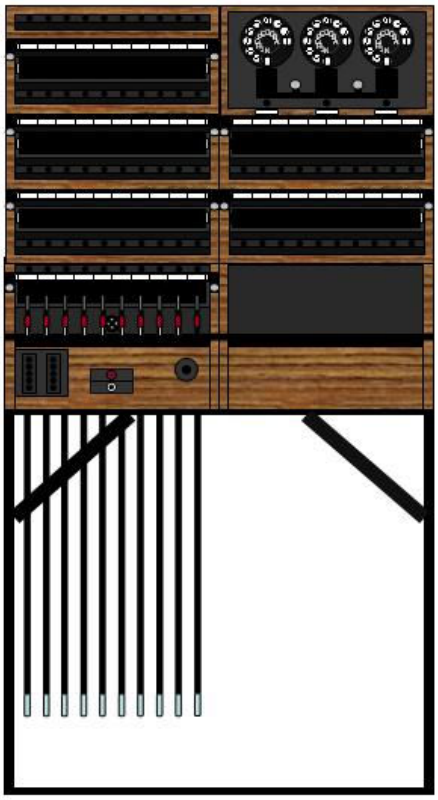


Figure 176: Feldklappenschrank 50 line configuration

To set up the *Grosse Feldklappenschrank*:

- Erect the table frame, ensure all locking screws are tight
- Place base unit a on the left of the table frame
- Place base unit b on the right on the table frame.
- Connect the interconnection cables to base unit a, each cable held taught by a cable weight. Ensure that the cables are not crossed in any way and run freely.
- Connect the Alarm bell contacts in base unit b to the connection panel in base unit a.
- Connect the microphone battery and the battery for the *Polwechselschalter* to the connection panel in base unit a.
- Connect the *Doppelpolwechselschalter* and the external alarm bell to the connection panel in base unit a.
- Set both control switches on the front panel to the central position.
- Stack the 10-line units 1-10, 11-20, 21-30 and the conference call unit on top of base unit a.
- Open the lid of the conference call unit and place the stacking pins through the units and screw them tight onto the base unit a.
- Stack the 10-line units 31-40, 41-50 and the 3-line *Amtszusatz* on top of base unit b.
- Place the stacking pins through the units and screw them tight onto base unit b.
- Place the five line connection units at the place where you want to collect the incoming field lines (usually outside the building or shelter where the switchboard is placed).

- Connect the line connection units to their respective line units using the 30-pole cables.
- Connect the incoming field lines to the line connection units.
- Connect up to three public telephone lines to the *Amtszusatz*.
- Plug in the operator headset and connect the generator crank handle to the generator.
- Unlock all the signal flaps by moving the locking bars and mark up line information on the writing strips and tabs. Close any flaps that fall during this operation. You are now ready to operate the *Grosse Feldklappenschrank*.

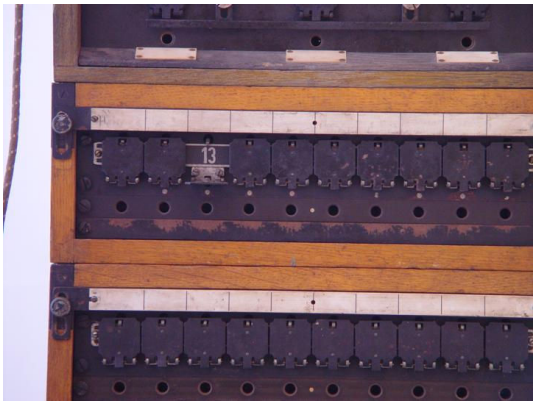


Figure 178: Signal flap indicating incoming call

Move the Kellogg switch backwards in the "*Abfragen*" position. Now the operator can speak to the incoming line. When the caller has indicated which outgoing line is required, place the first front interconnection cable into the outgoing field and move the Kellogg switch forward to the "*Rufen*" position.

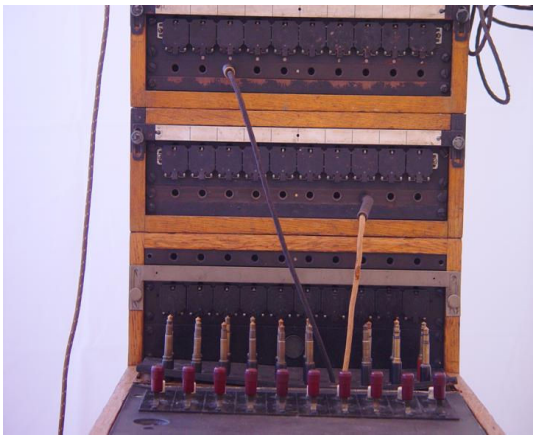


Figure 179: Incoming and outgoing lines connected

When an incoming call is received, the signal flap of the relevant line will drop. At the same time the alarm indicator on the front panel will flash and the external alarm bell will ring. Place the first rear interconnection cable into the incoming field; this will automatically reset the signal flap to the closed position.

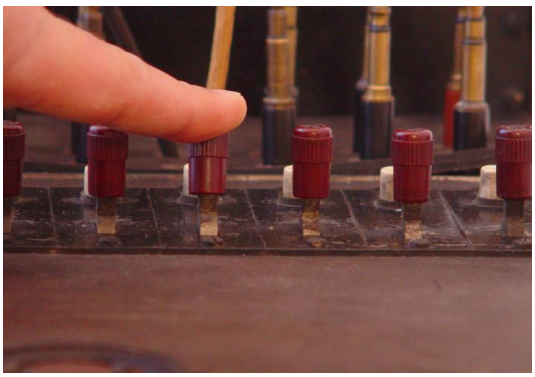


Figure 177: Operating the Kellogg switch to speak to the incoming caller and to ring the requested line

This will activate the "*Doppelpolwechselschalter*" and will cause the alarm bell to ring at the outgoing line. When the outgoing line answers, place the Kellogg switch in the middle position, the incoming and outgoing lines are now connected.

If the incoming line has to be called back, this can be done by pushing the white button behind the Kellogg switch. This will activate the *Doppelpolwechselschalter* and the alarm bell will ring of the phone of the incoming line.

Up to ten connections can be made simultaneously this way. If several callers have to connect to the same call, one of two conference socket strips can be used, one in the base unit a and one at the top of the left stack. In this way two separate conference calls can be made simultaneously.

If a connection to a public line has to be made, call the required number on one of the three dialling disks and place the interconnection cable into the corresponding socket of the *Amtszusatz*. The end-pulse is automatically generated when the interconnection plug is pulled from the socket.

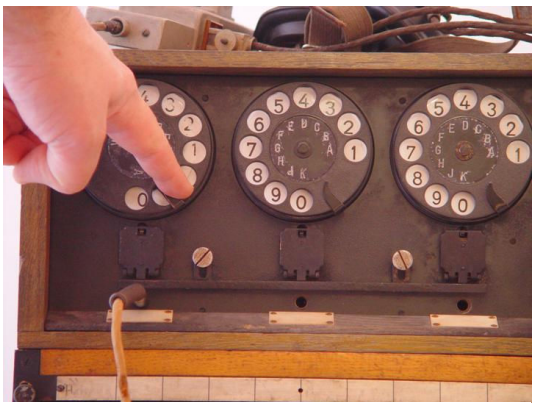


Figure 180: Calling an outside line

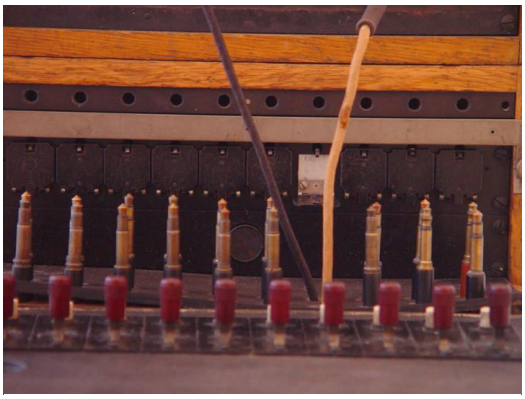


Figure 181: Connection indicator flap indicates that the call has ended and that the cable pair can be removed

At the end of the call, one of the participants has to crank the generator of his field telephone. This will case the signal flap of the occupied interconnection cable pair to drop (the field behind the signal flap as well as the corresponding cable pair are coloured white, green or red for easy identification). At the same time the alarm indicator will flash and the external alarm bell will ring. Remove the interconnection cables and reset the signal flaps. The cable pair is now available for the next connection.

After prolonged use, the battery polarity of the "*Polwechselschalter*" should be reversed (this will undo some of the wear on the contacts). This can be done by changing the switch in the "*Doppelpolwechselschalter*" from "B1" to "B2" or vice versa. If the generator is staring to falter, change over to the second "*Polwechselschalter*" in the unit by moving the switch from "PW1" to "PW2" or vice versa. Adjust the contacts of the failing generator if required. If both generator circuits fail, the generator can be used for manually generating the alarm signal. The red control switch on the front of base unit a has to be flicked to the right to operate the generator. The Kellogg switch has to be pushed forward while cranking the generator

5. Field Cables and laying equipment

Introduction

Command and control depends on secure and reliable communications, so as soon as possible the wire connection between headquarters and units would be established. In Germany itself extensive fixed networks were built up prior to the hostilities but when the fast moving Blitzkrieg broke out, entirely new field networks had to be built in record tempo.

In the build up to war, Germany allocated a significant amount of raw materials to the manufacture of Field cable so at the early stages of the war, the communication troops were relatively well placed to deal with the demands. During the Russian campaign however, the vast distances caused serious challenges. For example wooden poles to build long distance lines were in short supply and insufficient transport was available to ship the huge amount of materials required.

The telephone networks would originate from hubs on Germany's borders and the main trunk lines would follow the thrust lines of major battle formations such as army groups. Connections would branch off to minor formations down to the level of front line units. When higher headquarters advanced the trunk lines were extended and all the branches had to be dismantled and build-up again at the new positions.

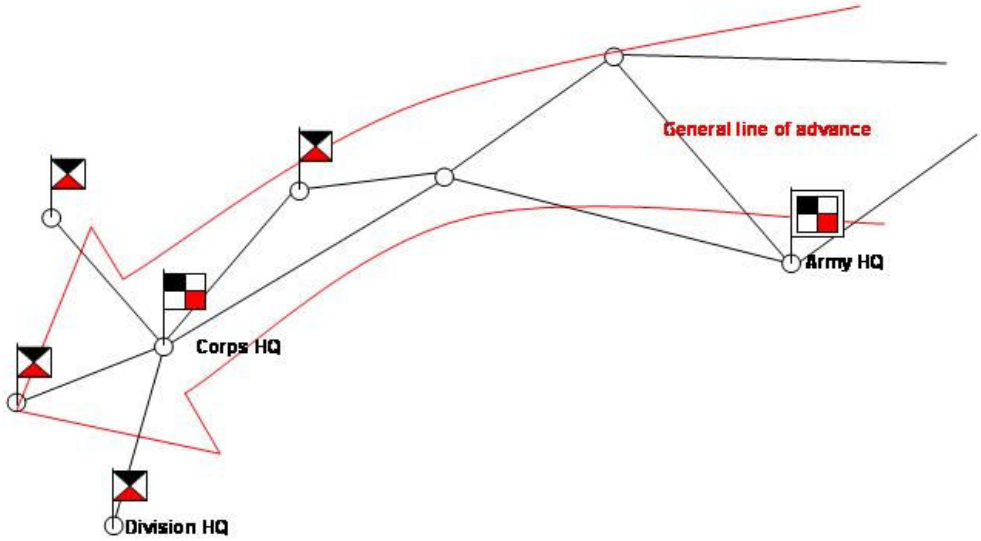


Figure 182: Higher formation networks, usually using existing civil lines or heavy long distance field calbe (FFK) along the main axis of advance

Wherever possible, existing public telephone networks would be used for these trunk lines but often these were destroyed during the enemy retreat. In this case lines were provisionally built using "*Schweres Feldfernkabel*" or Heavy Field Long Distance Cable. As quickly as possible, the Signal troops would then work to restore the public networks or build new overhead telephone lines so that the "Schweres Feldfernkabel" could be reused during mobile operations.

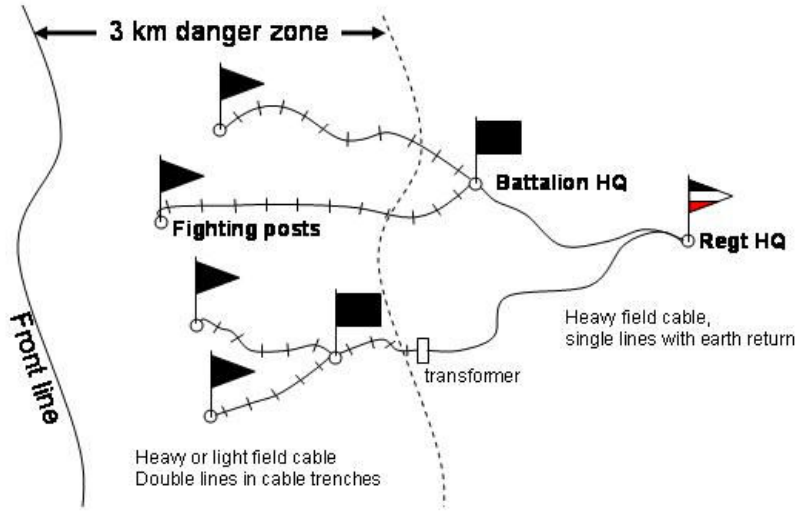


Figure 183: Forward branches using light or heavy field cable. Within 3 Km of the frontline, low-built double cable lines were the norm (hashed lines).

Typically in the Divisional area, single core heavy field cable would be used, usually with earth connections used for the return current. Along roads and where suspension points were available, the cables would be suspended at 3.3 meters above ground ("*Hochbau*"). Away from roads, near villages and on stretches under enemy observation, the lines would typically be laid low ("*Tiefbau*").

To minimise the risk of interception, double cables were prescribed within 3 km of the front line, preferably suspended in cable trenches or on other low suspension points. It was forbidden to lay double field cables directly on the ground or suspend it in tree tops.

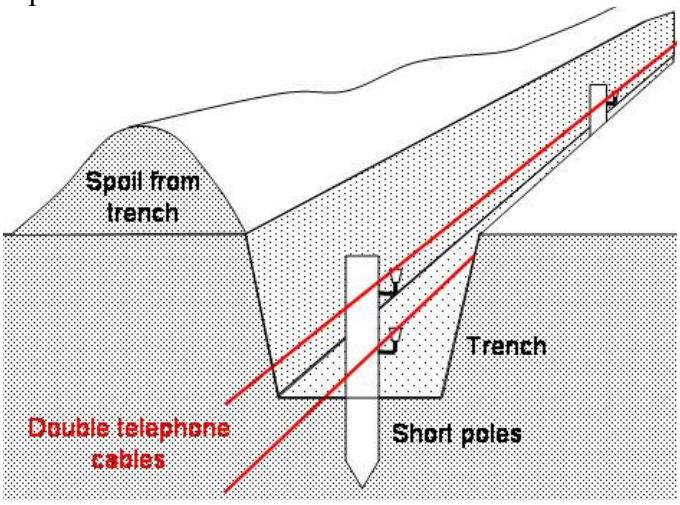


Figure 184: "Tiefbau" of double cables in a cable trench near frontline positions

When time or enemy action did not permit the building of such secure lines between fighting units, single core light or heavy field cable could be used, but the "*Feind hört mit*!" parole had to be adhered to.

The Germans also produced special cable for crossing rivers and water bodies ("*Flusskabel*") but this would only have been used in short lengths.

For permanent suspended telephone lines ("*Freileitungen*"), the Germans used any suitable wire they could get hold of, typically un-insulated copper, bronze or steel wire 1.5 to 5 mm diameter.

Forward connections would primarily be built by "*Leichten Fernsprechtrupps*" Light Telephone Troops or "*Fernsprechanslchusstrupps*" Telephone Connection troops.

- A Light Telephone Troop consisted of 1 leader and 4 men and a vehicle. They were responsible for building the main lines backwards and sideways from the forward positions. They were equipped with both light and heavy field cable.

- A Telephone Connection troop consisted of 1 leader and 3 men. They were on foot and responsible for building lines to and between forward positions. They were equipped with light field cable only.

Figure 185: A light telephone troop engaged in "Geschlossene Bau" of a telephone line

The complete equipment of a "*Fernsprechanschlusstrupp*" consisted of the three signal backpacks, 2 *FF 33* field telephones, 2 signal pouches, 2 "*Vermittlungskästchen*" (switchboard units) and 2 earth pins.

Two men were usually required to build a single line. The first would be responsible for unrolling and tensioning the wire, the second would be equipped with a "*Drahtgabel*" or cable fork to hang the cable over branches etc. The Leader would usually accompany these two men to reconnoiter the route and indicate where the line was to be built. The third man in the troop would stay at the point of origin to test the line once established. For double lines, this procedure had to be performed twice. When cables were place and suspended at the same time, the Germans called it a closed construction or "*Geschlossene Bau*".

When under time pressure, it was not always possible to properly suspend the wire while building. In this case the wire would simply be put on the ground to establish connection as quickly as possible and a second troop would follow to suspend and affix the cables. This was called split construction or "*Getrennter Bau*".

Within the Regiments, the "*Mittlere Fernsprechtrupps*" Medium Telephone Troops would be responsible for building connections between Regimental HQ and higher headquarters and to the neighboring regimental HQ. Because the majority of these lines were in rearward areas, single line connections would normally be built. It was also widely used by divisional and higher level communication troops for medium distance connections. The Medium Telephone troops would primarily use Heavy Field cable.

The building of a Heavy Field Cable took a minimum of 3 men. The first carried a spool of Heavy Field Cable on the "*Rückentrage*" carrying frame. The second was responsible for tensioning the line while the third used the cable fork to hang the wire over branches etc. The Troop leader would reconnoiter the route and indicate where the line was to be built.

At 17 Kg per spool only one spool could be carried per person; special cable carts were developed to carry multiple spools over longer distances.

In many cases the Heavy field cable was laid alongside roads, in which case the cable was unspooled from vehicle mounted frames. For longer lines racks filled with multiple spools could be mounted on the back of trucks.

Typical building times for Field Cable (either light or heavy) are given as:

- Closed construction: 20 - 40 min / km
- Split construction: 12 - 20 min / km
- From horseback: 5 - 25 min / km
- From vehicle: 5 – 25 min / km
- Double line: 30 -60 min / km

For dismantling the following typical times were used:

- Dismantling: 15 -30 min / km
- Dismantling using horse or vehicle: 5 -20 min / km

In the corps and higher headquarter areas the building of the lines was the responsibility of the communication troops attached from the *Nachrichten* regiments to these higher headquarters. The *Feldfernkabel* would typically be built by "*Schwere Fernspechtruppen*" or heavy telephone troops. These vehicle mounted troops would typically build About 2 km of FFK cable connection per hour, mainly along roads following the main axis of advance.

Light Field Cable

Light Field Cable or "*Leichtes Feldkabel*" consists of a 0.8 mm solid copper conductor with double layered cloth insulation. Later in the war the copper was partly replaced by steel strands and towards the end of the war plastic insulation was used. It came on small collapsible drums in lengths of 500 metres weighing 2-3 Kg each.

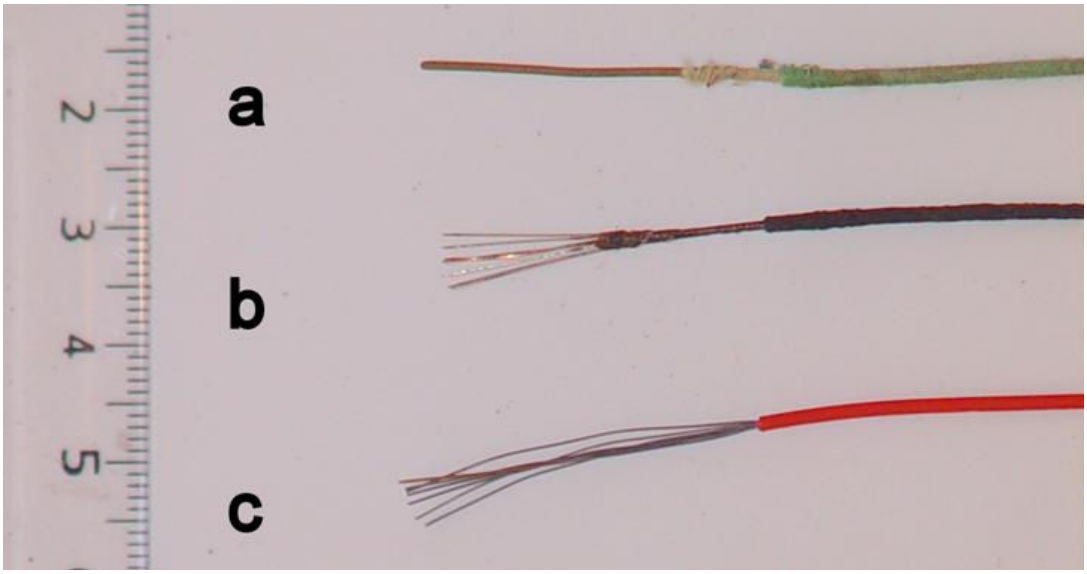


Figure 186: Leichtes Feldkabel

186a Pre-war, solid copper conductor, cloth insulation, waxed green cloth outer layer
186b Mid-war, 6 steel strands + 1 copper strand, cloth insulation, rubberized cloth outer layer
186c Late-war, 6 steel strands + 1 copper strand, red plastic insulation

Each regiment was issued with 8 Km of Light field Cable for use in forward positions. The drums of 17.5 cm diameter and 5 cm width were usually carried in the so called "signals backpack" and could be slid onto a handle ("*Abspuler*") for easy unrolling. Since light field cable was predominantly used in forward areas it would be required to build double lines.

When simply placed on the ground, the range of the Light Field Cable would 3 to 5 km. By suspending the wires in the air by using trees, existing telephone poles and fences etc. this range could be extended to 20 km. The maximum span (for example to cross roads or rivers) would be 20-25 meters.

Figure 187: Cable reels with winder and dispenser

Heavy Field Cable

Heavy Field Cable or "*Schweres Feldkabel*" consists of a 2 mm twisted copper conductor with rubber/cloth insulation. Late in the war aluminium/steel conductors and plastic insulation were used.

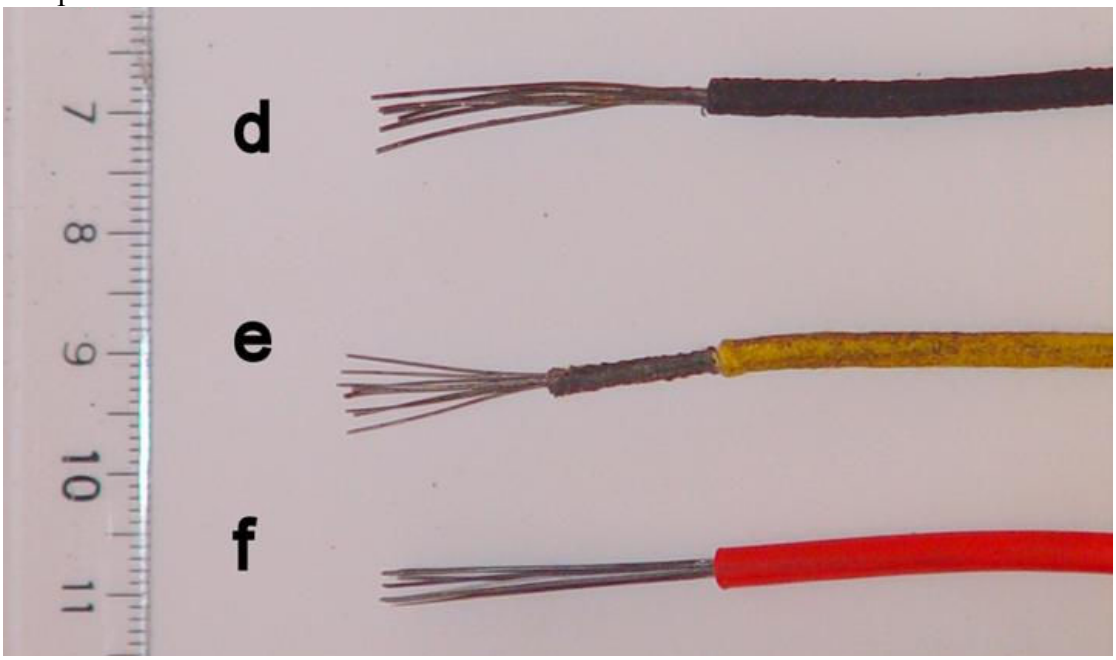


Figure 188: Schweres Feldkabel

188d Mid-war, 5 steel strands + 2 copper strands, rubber insulation, rubberized cloth outer layer
188e Mid-war, 5 steel strands + 2 copper strands, cloth insulation, waxed yellow cloth outer layer
188f Late-war, 8 steel strands +1 aluminium strand, red plastic insulation

Heavy field cable came on steel or wooden drums in lengths of 1000 metres weighing 17 Kg each.

Figure 189: Various drums of heavy field cable.

On one end of the drum, a gear wheel was mounted on the axle. This gear wheel allowed connection to the spooling mechanism of the "Rueckentrage". On the other end of the drum, an exterior groove and connection screw were used to terminate the inner end of the cable. It was forbidden to cut heavy field cable, at the end of the line, the telephone had to be directly connected to the drum without cutting the cable.

Figure 190: End of the cable connected to the drum

Each regiment was issued with 14 Km of Heavy field Cable for use in backward areas. A number of specialized carrying frames and devices were developed so that the heavy cable could be dispensed on foot, horseback or by vehicles.

When simply placed on the ground, the range of the Heavy Field Cable would 10 to 12 km. By suspending the wires in the air by using trees, existing telephone poles and fences etc. this range could be extended to 60 km. The maximum span (for example to cross roads or rivers) would be 150 meters.

To terminate the wire, strip 3 cm off the insulation. Separate the copper (or later aluminium) strand from the steel strands and wind the copper strand tightly around the steel strands. Cut off the excess length of the steel strands.

Figure 191: Wire termination

Heavy Long Distance Field Cable

Figure 192: A Luftwaffe soldier connecting a Pupin coil to a heavy long distance field cable

Heavy Long Distance Field Cable or "*Schweres Feldfernkabel*" (FFK) consisted of two double twisted cable pairs in heavy rubber insulation. Each cable end was fitted with a large, four pin connector.

So called "Pupin[3]" coils could be placed between these connectors. The use of Pupin coils would significantly increase the range of the Heavy Field Long Distance Cable.

The FFK cable came on reels with 250 meters cable each weighing 65 Kg. Too heavy to be man carried, it had to be transported and laid using a special cable cart or from vehicles. For example ,a version of the Sd.Kfz 2 "*Kettenkrad*" was adapted for carrying and laying FFK cable. About 2 km of FFK cable connection could be built per hour.

Figure 193: Heavy long distance field cable

192g 19-strand copper conductors, 2-layer black/natural colour rubber insulation (reversed on second cable pair);Two cable pairs twisted around a rubber core, 2-layer rubber outer insulation.

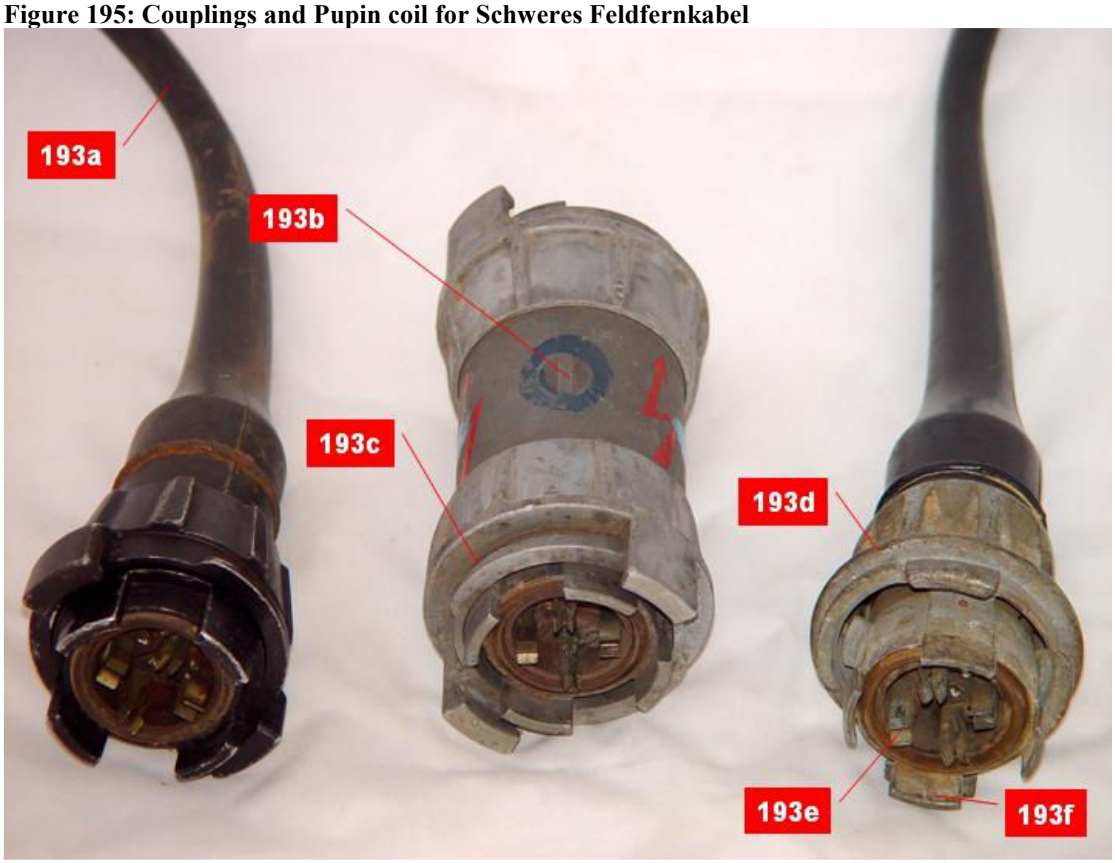
Cable could be laid on the ground, or be suspended using special cable hooks.

Without Pupin coils, distances of 40-48 Km could be achieved, with coils 100 -120 km.

Figure 194: Cable hooks

[3] Michael Pupin was a Serbian immigrant to the US w[illegible] transmission lines based on the theory by Oliver Heaviside. Even though the solution proposed by Pupin was not practical, a patent battle ensued between Pupin's submission and that of George Campbell of AT&T who is normally credited with inventing the loading coil. In German literature however, Pupin's name has become synonymous with the transmission line loading coil.

Figure 195: Couplings and Pupin coil for Schweres Feldfernkabel



193a Schweres Feldfernkabel
193b Allingnment mark on
193c Locking groove
193d Locking ring
193e Cable contacts
193f Allignment collar

Figure 196: Several reels of Schweres Feldfernkabel at a termination point

Signal Pouch

The "*Nachrichten Tasche*" or Signal pouch was used by the telephone operators and carried tools and supplies to connect and repair wire, make simple adjustments to equipment and operate the telephone.

Figure 197: "Nachrichtentasche" and contents

The Signal pouch contained the following items:

a) 1 small message pad
b) 1 roll of paper labels (to mark lines)
c) (1 each) black pencil, blue pencil, red pencil
d) 1 folding cable knife
e) 1 screwdriver
f) 1 set of combination pliers
g) 1 roll of electrical tape
h) 1 table of contents for the Signal Pouch

Cable glove

Leather cable gloves were issued to protect the hands when handling telephone wires. Two types are known, a mitt type and a flap type which has a loop for two fingers and a strap to fasten around the wrist. By squeezing the hand close the flap will fold around the cable.

Figure 198: Cable handling gloves

Cable laying pole

The "*Drahtgabel*" or cable fork was used to guide and suspend telephone lines when building or dismantling. A set of hooks and loops at the tip of the pole allowed the operator to grab, lift, pull and guide the wire into position or to move branches of trees. By twisting the pole, the wire could be release from the loops.

Figure 199: Cable fork

Two types are known, a four meter pole, breaking down in two parts was mainly carrying on vehicles and cable carts. The other type was three meters long, breaking down into three parts which could be strapped to the side of the "*Fernsprechtornister*" by troops on foot.

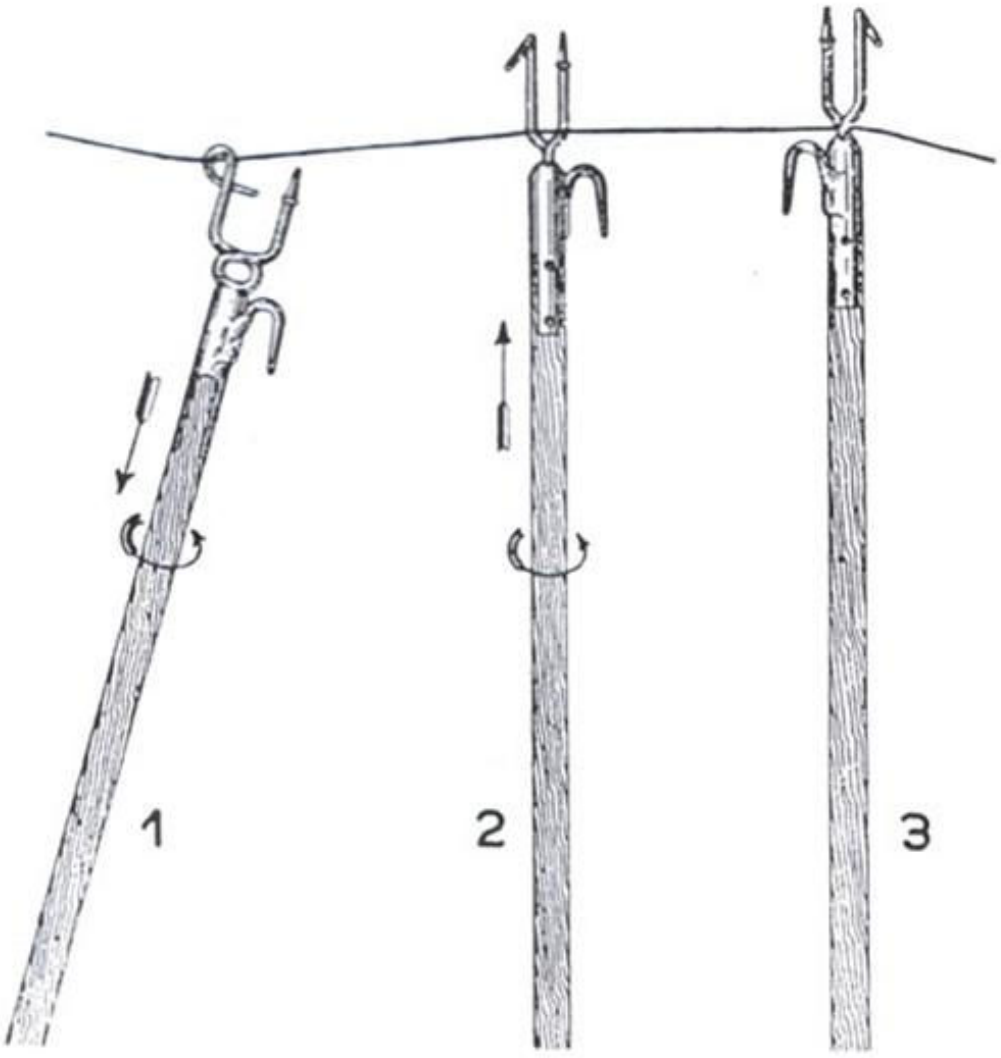


Figure 200: Instructions for use of the cable fork

Climbing belt and irons

To enable the troops to climb in to telephone poles, either to suspend field cables or to tap into existing wires, climbing irons belt were used.

The climbing irons strap to the boots and have large curved hooks that fit around the pole. Two types of climbing irons are known, one for smaller diameter poles, the other for larger diameters. The main difference is in the hook arrangement.

The Climbing belt consisted of a broad leather waist belt with a leather or rope loop that could be slung around the pole.

Figure 201: Climbing gear in use

Figure 202: Climbing irons for small poles

Figure 203: Climbing belt

Fernsprechtornister

The backpacks or "*Fernsprechtornister*" used by the Telephone Connection Troop were numbered 1, 2 and 3; each man in the troop had a differently numbered backpack.

Figure 204: Fernsprechtornister nr 2

The contents of backpacks 1 and 3 were identical:

a) 1 battery (spare)
b) 3 reels with 500 m light field cable
c) 1 crank for cable reel
d) 1 headphone
e) 1 spool earthing wire, 1 spool waxed wire
f) 2 cable placement rods
g) 1 "fork" for cable placement rod
h) 1 insert for cable placement fork
i) 1 cable dispenser ("*Abspuler*")
j) 1 battery tester in pouch
k) 1 cable glove
l) 1 Microphone in tin
m) 1 Zeltbahn
n) 1 tin of wire connectors

Figure 205: Fernsprechtornister interior

The "2" backpack had a slightly different content with the following changes:
2 reels with 500 m light field cable

o) 1 empty reel, collapsed
p) 1 cable winder with crank ("*Aufspuler*")

Figure 206: Fernsprechtornister contents

59a Headphone in pouch
59b Carrying strap
59c Wire reels
59d Field telephone battery
59e Battery tester in pouch
59f crank for cable winder
59g Cable winder "Aufspueler"
59h Spare reel, collapsted
59i Cable glove
59j spools for earthing wire
59k Cable dispenser "Abspuler"
59l Spare microphone in tin

Rückentrage

The *Rückentrage*, or back carrying frame was used to carry, spool out or spool in the Heavy Field Cable. Two versions were made, a collapsible model and a full model with a spooling facility. The collapsible model was lighter and was easier to store, for example in vehicles. Wartime documentation also mentions that it could be worn on horseback. The collapsible model is primarily suitable for carrying cable drums and dispensing cable while the full model in addition can be used to spool up cable neatly onto the drums.

Figure 207: Collapsible carrying frame, folded

Two clips fit neatly around the axle of the cable drum and are kept closed by spring loaded locking lugs. On the left side of the frame is a drum brake with a leather sling, this allowed the user to keep the cable under tension while reeling it out which prevents it from coiling and snagging. Two leather shoulder straps are hooked into hooks on the bottom of the frame and a chest strap allows the carrying frame to be securely fitted.

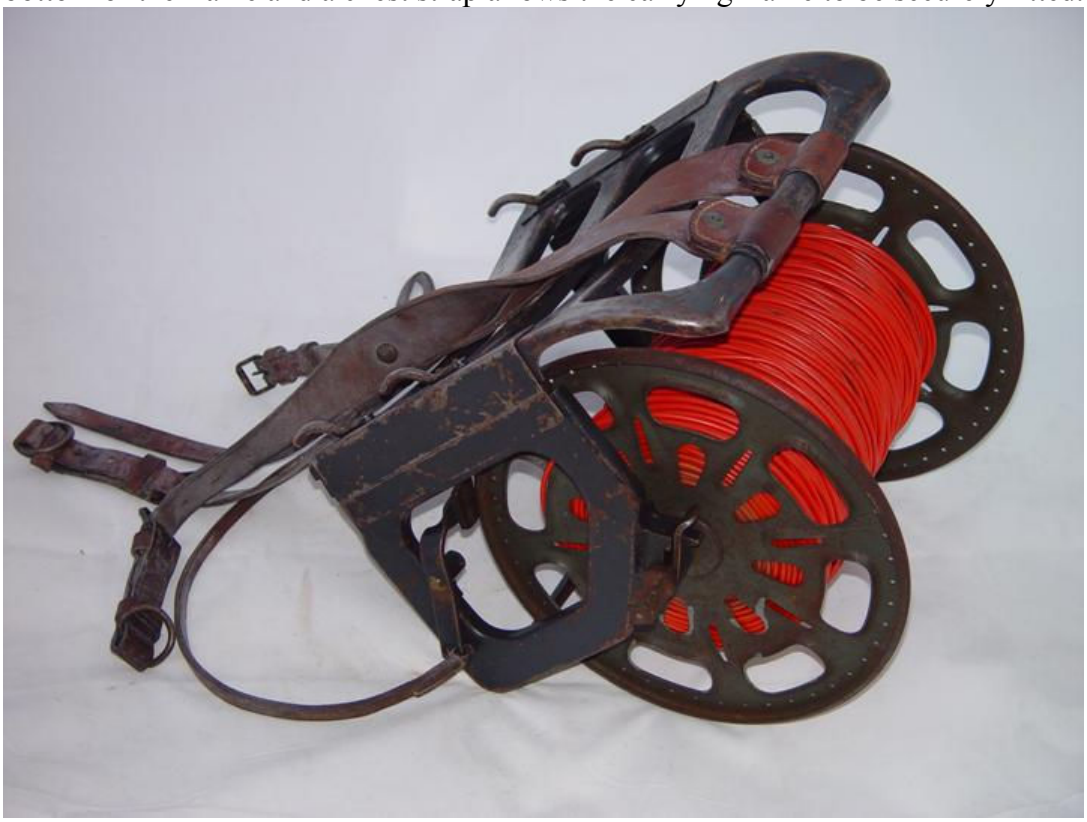


Figure 208: Collapsible model Rückentrage complete with cable drum

On the full model, only the bottom part of the frame could be folded for storage. On the inside of this bottom part was a leather lumbar support, while on the outside a leather pouch to store the winding handle, cable guide and chain was fitted. The frame was fitted with two additional clips to take up the spooling axle. The drum brake mechanism was fitted on the right side of the frame.

Figure 209: Full version Rückentrage. Note the holes in the end of the frame

The spooling facility consists of a cable guide, running from side to side on a grooved axle. The groove on the axle runs in both directions; a following cam in the cable guide automatically follows the groove and turns direction at each end of the groove.
A small loop of bicycle chain is fitted around gears on the cable drum and spooling axle. The gearing of the spooling axle is such that the cable will be neatly and evenly spool up onto the drum thereby maximizing the length of cable fitting on the drum.

Figure 210: Cable guide on spooling axle

A crank could be fitted on the end of the wire drum or on the end of the spooling axle. When dispensing cable the crank, chain and cable guide could be removed and stored in the leather pouch.

Two holes at the rear of the frame allowed the *Rückentrage* to be securely mounted to a frame, for example on the cable cart or on vehicles.

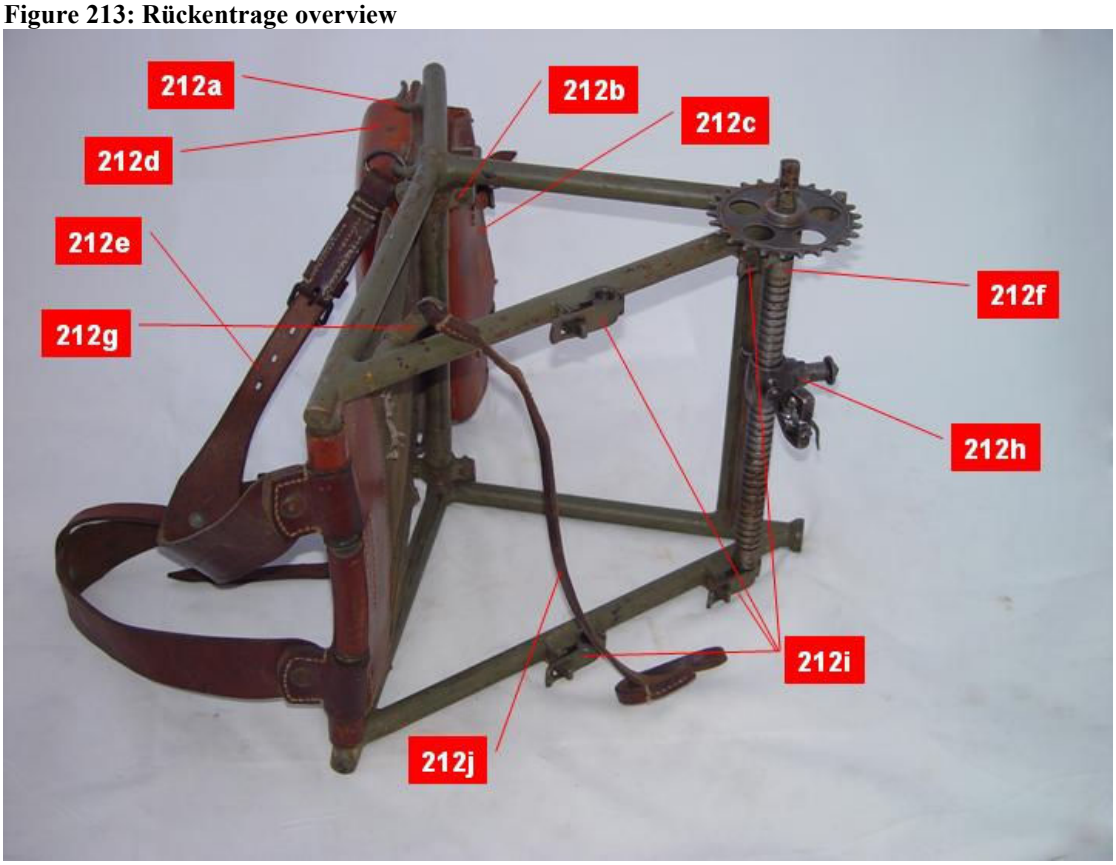
Figure 211: Rückentrage being worn on the chest. Note that the cable guide and chain are not fitted and cable gloves on the right hands

The *Rückentrage* could be worn both on the back and on the front. It was worn in the front for spooling or when the cable had to be tensioned.

The troops called the carrying frame the "*Strippenzieher*" (wordplay on "pulling strings").

Figure 212: Close up of the drum brake

Figure 213: Rückentrage overview



212a Strap hooks
212b Bottom frame connection
212c Leather storage pouch
212d Lumbar support cushion
212e Shoulder straps
212f Spooling axle
212g Drum brake
212h Cable guide
212i Locking clips
212j Brake straps

Cable cart

At 17 Kg, a full drum of "*Schweres Feldkabel*" is already a heavy load to carry over long distances, even when using a *Rückentrage*. Especially when more than one reel needed to be carried, a cable cart proved more practical. The cable cart could carry a *Rückentrage* with drum, two spare cable drums plus several sets of cable forks.

Figure 214: Cable cart with Rückentrage mounted on top. Note how pins engage the holes in the Rueckentrage

Figure 215: Cable cart overview

The pull handle and wheels could easily be dismantled, allowing the cable cart to be stored in a vehicle or to be carried in parts over inaccessible ground.

Drums of *Schweres Feldfernkabel* were too bulky to be man carried, so a handcart had to be used if access by vehicles was not possible. The handcart for *Schweres Feldfernkabel* consisted of an "H" shaped frame that would take a drum of cable between the runners. Wheels on the outside of the runners were slightly larger than the drum diameter allowing the drum to free rotate above the ground. A brake handle was fitted to one of the handlebars to control the drum rotation if necessary.

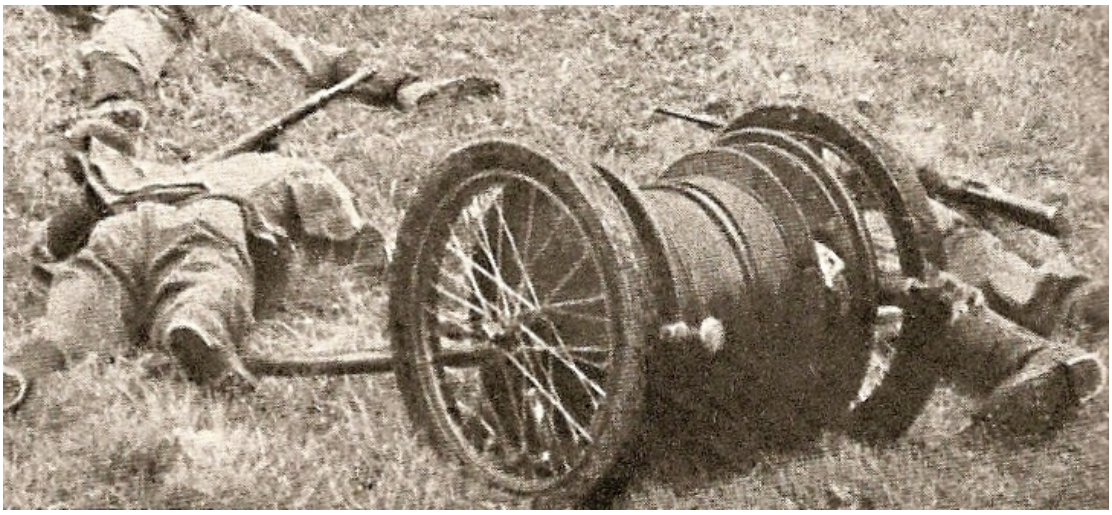


Figure 216: Schweres Feldfernkabel kart

Where possible however, *Schweres Feldfernkabel* would be built using vehicles.

Figure 217: *Schweres Feldfernkabel* being built. Note the cable cart on the right of the truck

6. Miscellaneous Telephone Equipment

Introduction

A number of functions have to be performed by specialist equipment, these functions include:

- Fault finding and dealing with interference
- Connecting different types of networks
- Multiple use of telephone lines
- Extending the range of telephone lines
- Interception of enemy telephone communication

Even though fault finding was a daily activity of front line troops, most other functions were executed by specialised communication troops.

A wide variety of equipment was developed and used, a sample of which is presented in this chapter.

Markers and flags

The location of the telephone station was often indicated by a red flag with s large letter “F” and an arrow on it. Further away from the station, wooden arrows, also with the letter “F” on it would indicate the direction where the telephone could be found.

Figure 218: "F" flag pointing at a telephone station. Note the arrow indicator underneath.

Figure 219: Wooden arrows pointing at a Telephone station

Elementprüfer battery tester

One of the most common test to be performed was a check of the batteries or "*Feldelement*". Most field telephone equipment operated in "Ortsbatterie Betrieb" (OB) or local battery mode, so most equipment had a 1.5 Volt battery fitted. The Elementprüfer was used to check this voltage.

Figure 220: Elementprüfer in pouch

A rotating switch on the back allowed the user to select measurement of 1, 2 or 3 elements in series. The *Elementprüfer* was fitted with a measuring probe on the bottom of the housing with the other measuring probe connected by a short length of cable. This layout made it ideal to test the battery while situation in the equipment. The instrument probe was pushed against the – pole or connection screw while the cable probe was pushed against the + pole and instrument would indicate the voltage of the cell. By pressing a small button on the housing, a resistor was switched parallel to the indicator, allowing the battery to be tested under load.

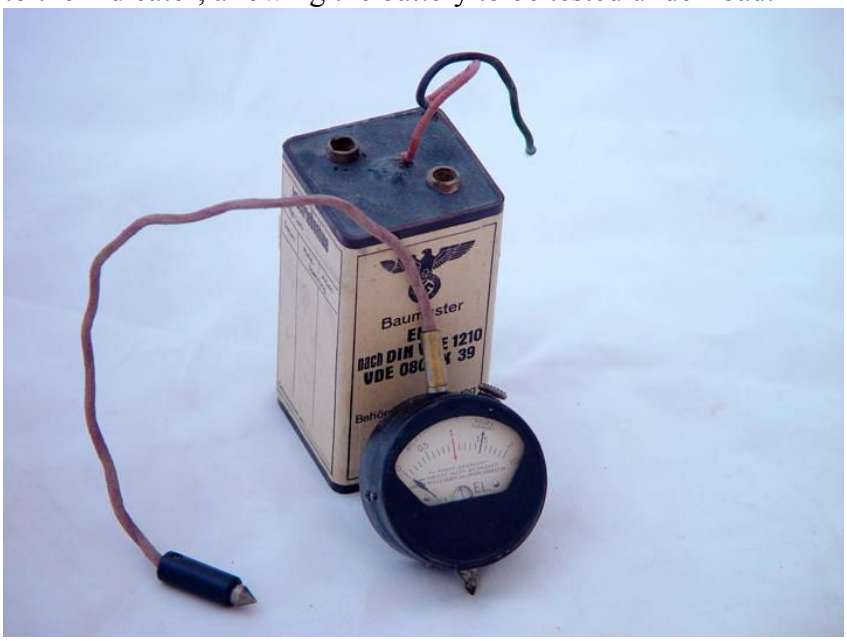


Figure 221: Elementpruefer testing a Feldelement

Feldmesskästchen field tester

For basic fault finding of telephone equipment and lines, the *Feldmesskästchen* was useful tool. The tester could measure voltage and resistance. For resistance testing, the field tester held a 4.5 Volt battery in the bottom compartment. An instruction shield in the lid describes how the instrument can be used to test batteries, measure resistance and test telephone lines. Build in a sturdy wooden box with metal bottom and top protection, the instrument was clearly designed with rough field handling in mind.

Figure 222: Feldmesskaestchen

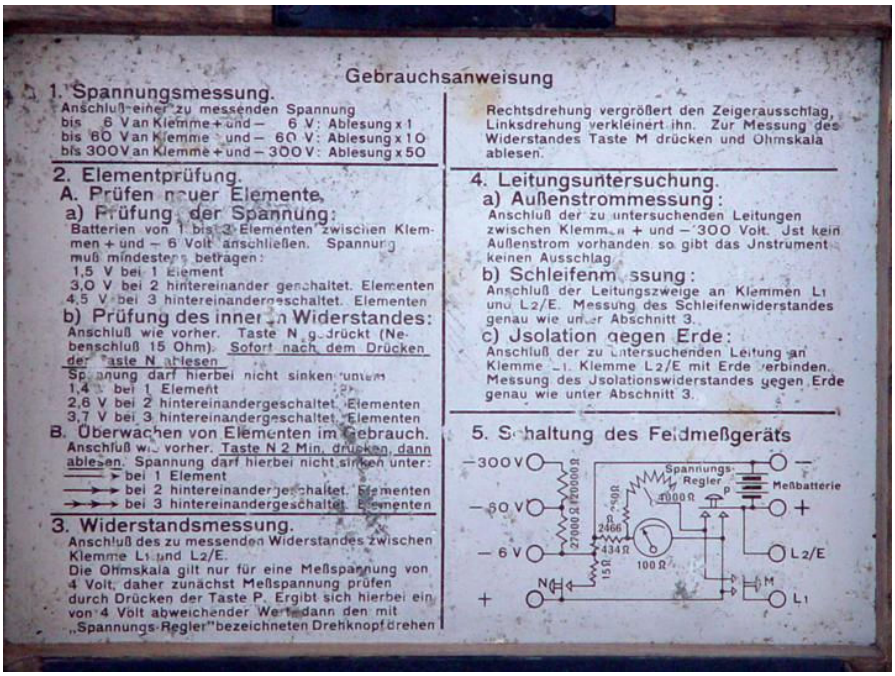


Figure 223: User instructions

Übertrager Telephone Transformer

Development and Description

The section on cable describes that both single and double wire connections could be used, sometimes in a single line. The transfer from single to double cable connection requires an insulation transformer. This transformer was called the "*Übertrager*" or telephone transformer. It consisted of a wooden box with external connections containing a heavy ring-core transformer. Both primary and secondary windings are executed in two halves with mid point connections. In this way the transformer can act both as an insulation transformer and as a Balance-Unbalance transformer. The dimensions of the transformer are chosen quite large to allow the strong bell currents to be passed through without distortion.

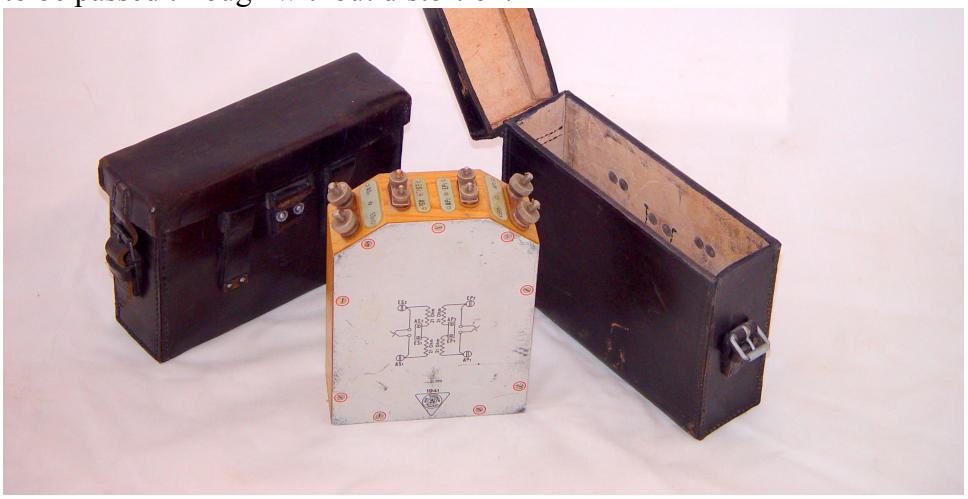


Figure 224: *Übertrager* with leather carrying case

On the top of the *Übertrager* are four large and four small screw connectors. Instead of the large screw connectors, two sockets for interconnection cables, placed on the side of the unit, can be used. The smaller connectors have jumpers fitted. When not in use the *Übertrager* was stored in a leather carrying case.

EP2	Eingang Primär 2	Primary input 1
AP1	Ausgang Primär 1	Primary output 1
AP2	Ausgang Primär 2	Primary output 2
EP1	Eingang Primär 1	Primary input 1
AS1	Ausgang Secondär 1	Secondary output 1
ES2	Eingang Secondär 2	Secondary input 2
ES1	Eingang Secondär 1	Secondary input 1
AS2	Ausgang Secondär 2	Seocndary output 2

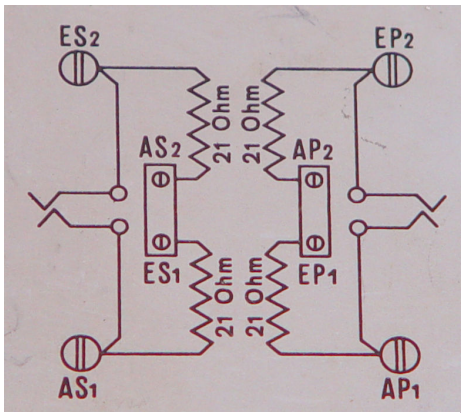


Figure 225: Übertrager schematic

A number of different circuits could be made using the *Übertrager*. As mentioned a one-wire to two-wire transfer could be made:

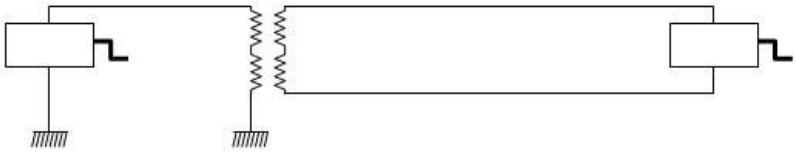


Figure 226: One-wire to two-wire transfer

The *Übertrager* also allowed an additional connection to be made over a two-wire line. In this case the signal from phones "A" will flow as differential mode current through the two wires while the signal from phones "B" will flow as common mode current through the two wires and return via earth. In the properly balanced line, users "A" and "B" can not hear each other. "B" could also be used for telex.

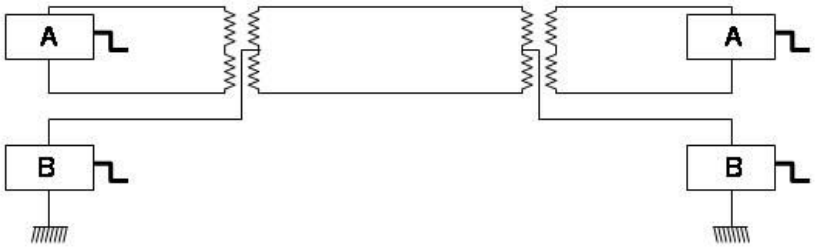


Figure 227: Double use of a two-wire connection

In order to explain this circuit, the currents through the transformer a shown. The differential mode current (Blue) is the only current that creates a magnetic field in the core and is seen at the secondary side of the transformer. The magnetic fields created in the core by the common mode current are in opposite directions and equal each other out. The common mode current (Red) has to flow out via the mid point tab of the transformer.

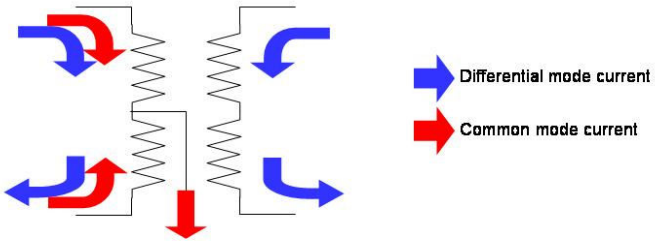


Figure 228: Currents through the Übertrager

The same trick can be repeated for four-wire *Schweres Feldfernkabel*:

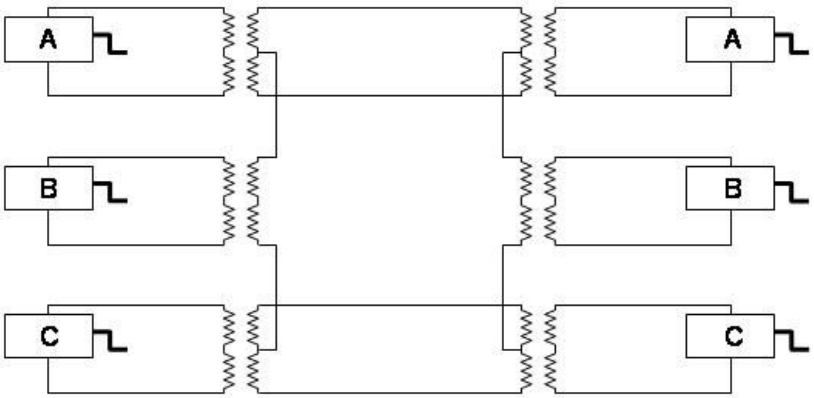
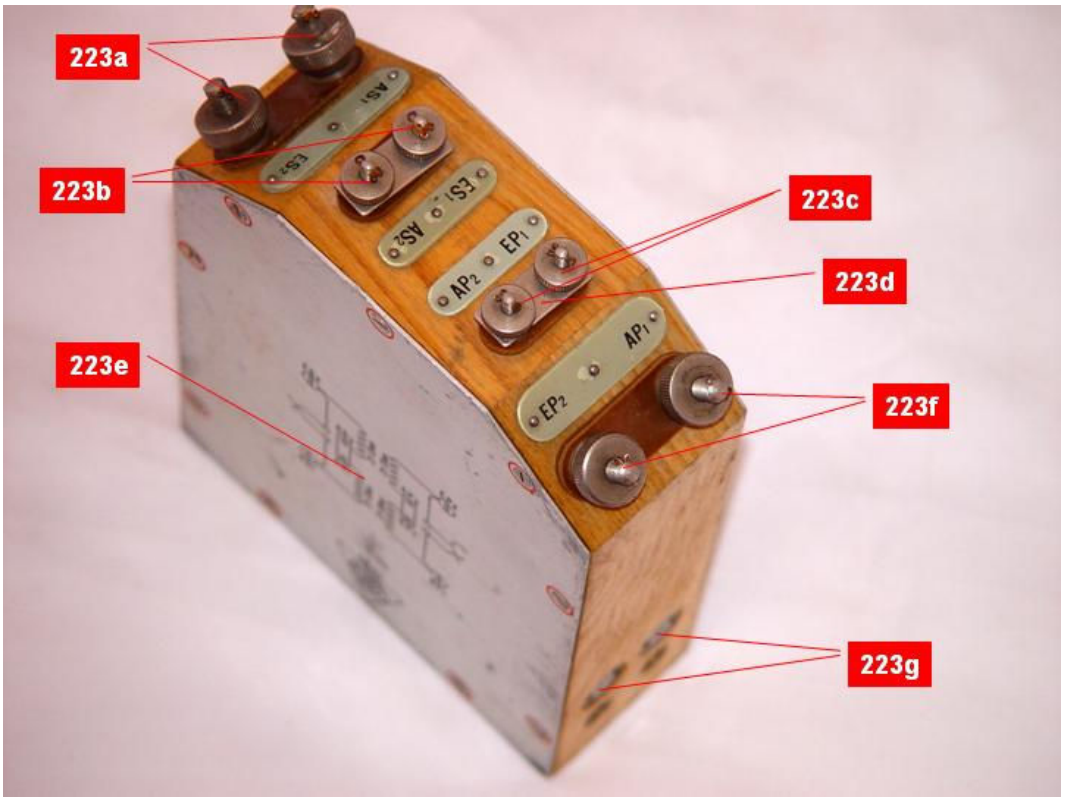


Figure 229: Triple use of a four-wire connection

In this way, for example two phone lines and a telex connection could be established using a single *Schweres Feldfernkabel*.

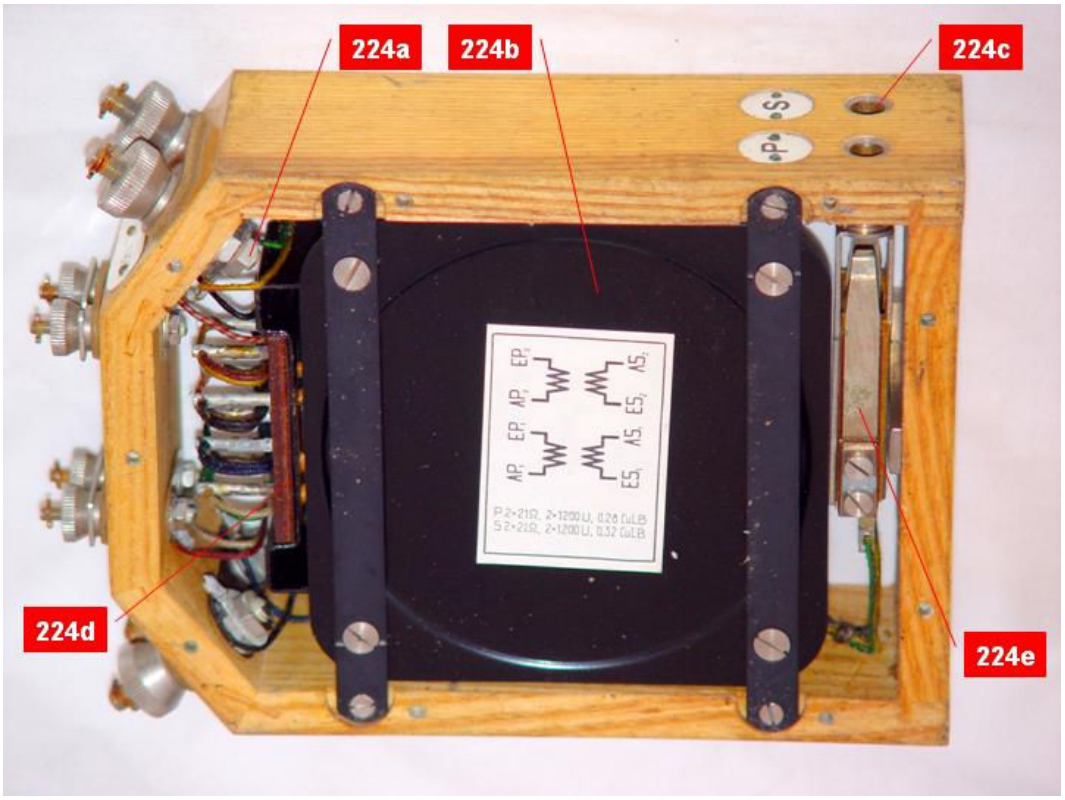
Construction

Figure 230: Übertrager outside view



223a Secondary winding connection screws
223b Secondary mid point connection screws
223c Primary mid point connection screws
223d Mid point Jumper
223e Primary winding connection screws
223f Interconnection cable sockets

Figure 231: Übertrager inside view



224a Internal connection points
224b Transformer housing
224c Interconnection cable sockets
224d Transformer connection board
224e Interconnection socket contacts

Operation

There are many different ways to use the *Übertrager*, so first it needs to be established what exactly has to be achieved. The most common uses are:

1) Transfer from two-wire to one-wire line
2) Solving imbalance caused by leakage in a two-wire line
3) Crossing an area of high common mode interference (eg near high voltage lines)
4) Creation of two channels on a two-wire line
5) Creation of three-channels on a four wire line

Once the use has been established, the appropriate connections can be developed. For example to achieve 1) Transfer from two-wire to one-wire line:

- Place the *Übertrager* so that it is protected from rain and dirt at the transfer point between the two- and one-wire connections
- Ensure both jumpers of the mid point tabs are closed
- Connect the single wire line to connection AP1
- Connect the earth pin to connection to EP2
- Connect the first wire from the two-wire connection to AS1
- Connect the second wire form the two-wire connection to ES2

In some cases the interconnection cable can be used to connect the *Übertrager* directly to a FF 33 field telephone. For example to achieve 2) Solving imbalance caused by leakage in a two-wire line, on each end of the line -:

- Place an *Übertrager* near the field telephone
- Place the interconnection cord into the socket of the FF 33 and in the "P" interconnection cable socket of the *Übertrager*
- Connect the wires from the two-wire connection to the AS1 and ES2 terminals

Figure 232: Übertrager connected directly to a FF 33 field telephone

Field Amplifiers

Several types of amplifiers were developed to increase the range of phone lines. The "*Feldverstärker a"* was two wire version, allowing the amplification of two way communication on a single telephone connection.

Feldverstärker a

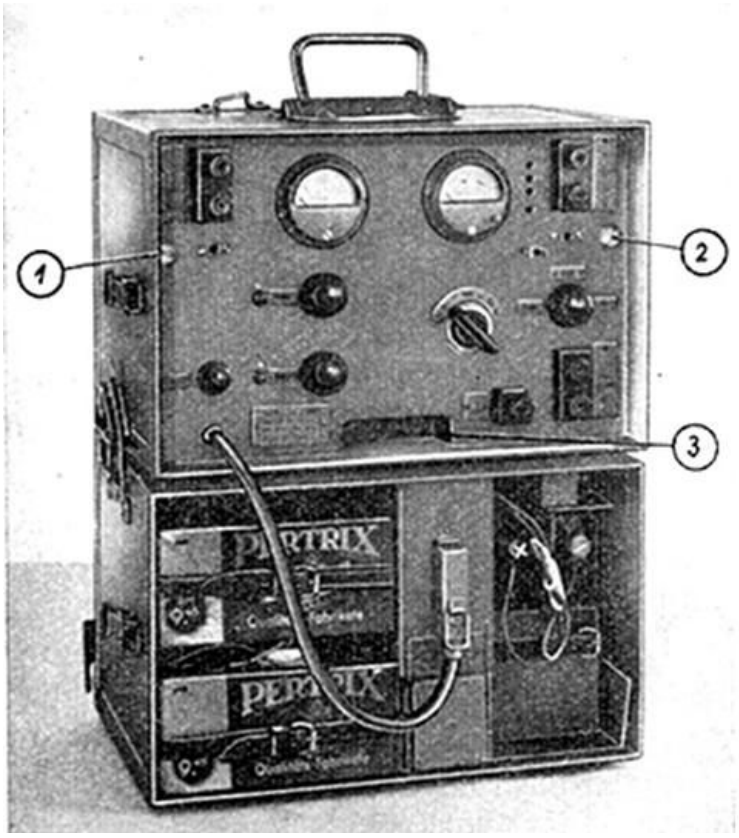


Figure 233: Feldverstaerker a with battery case

The "*Feldverstärker a"* was a two wire field telephone amplifier. It consisted of an equipment box and a battery box that were mounted on top of each other. Two separate amplification circuits either provided amplification from left to right and from right to left. Input/Output transformers on both ends prevented signals to be fed back.

Ringtone detection circuits activate a polar relay which temporarily switches off the relevant amplifier and engages a ring tone generator.

The controls included a main switch, sensitivity controls for the direction switch and filter controls.
Test buttons and an instrument allow the ringtone detection circuit to be tested and adjusted for proper operation. Another instrument is provided for testing the battery voltages.

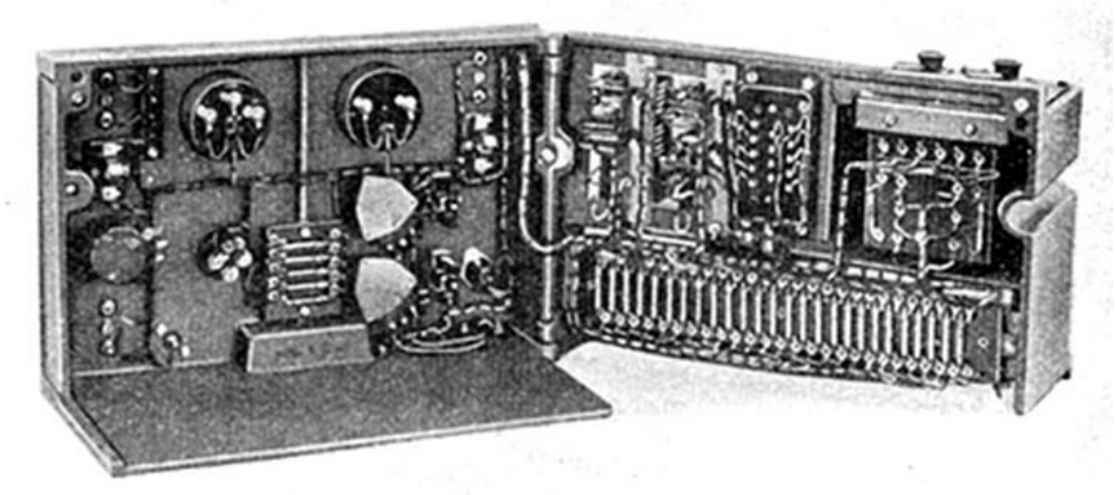


Figure 234: Feldverstaerker a internals

The amplifier could be removed from its casing by loosening screws 1 and 2 and pulling it out using handle 3. The unit could be swivelled open to provide access to the components.

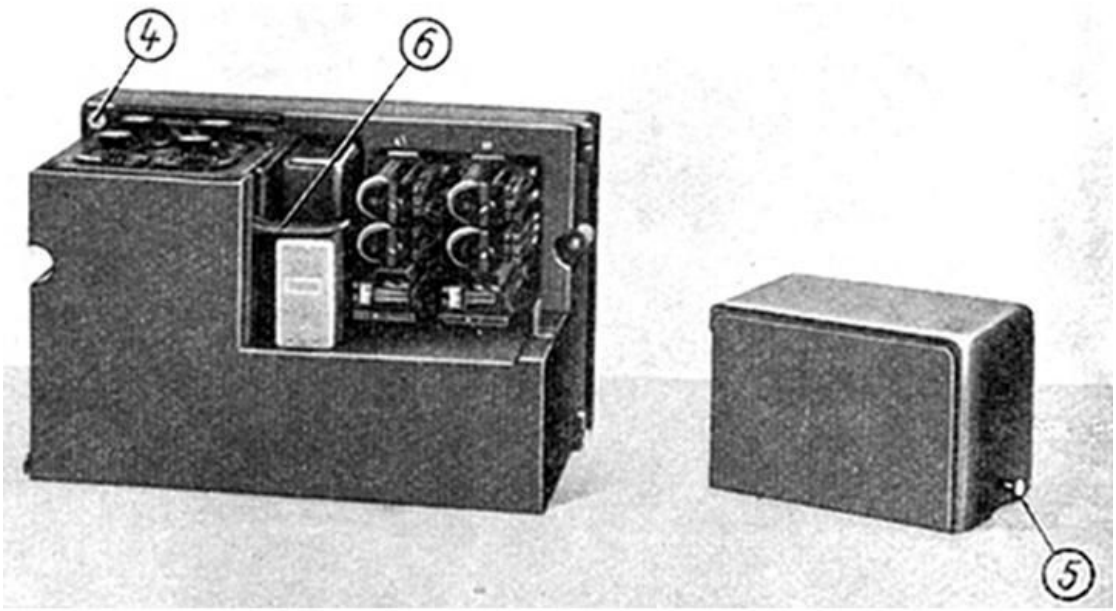


Figure 235: Feldverstaerker back view. On the top left the four amplification valves can be seen. The top right section contains the relays to switch the direction of amplification.

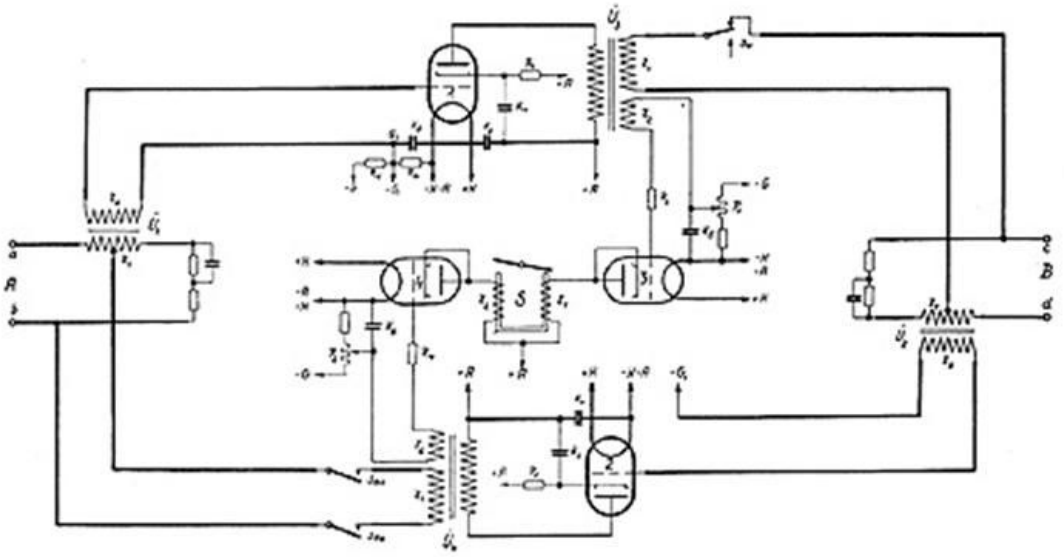


Figure 236: Feldverstärker a basic schematic

A FF 33 field telephone could be connected to monitor the proper functioning of the unit.

Other types of amplifiers include the Verstärker 38, a four-wire version that could be used with the Schweres Feldfernkabel.

Carrier wave equipment

Development and description

Carrier wave equipment serves to create multiple communication channels over a single wire connection. Speech signals generally only use a bandwidth from 400 Hz to 2 kHz. It is however possible to pass much higher frequencies through a cable.

By modulating a speech signal with a carrier wave, a lower and a higher sideband are created around the carrier frequency. This trick can be repeated several times, creating multiple channels that can later be unscrambled using band pass filters and demodulators.

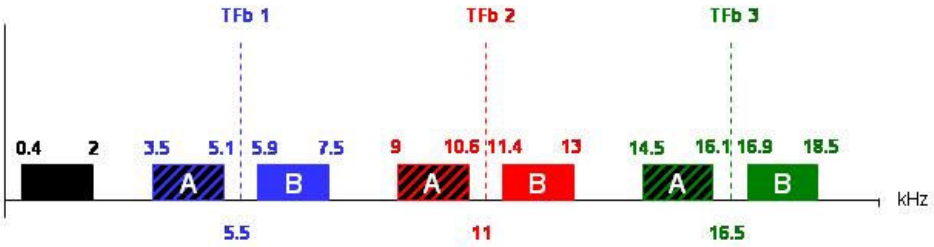


Figure 237: Signals generated when using 5.5, 11 and 16.5 Khz carrier waves

In the above figure, the black area is the normal speech bandwidth from 400 Hz to 2 kHz. The blue areas represent a speech signal modulated with 5.5 Khz. “A” is called the lower sideband, “B” is the upper sideband. The red and green areas show two more signals modulated at 11 and 16.5 kHz. The bands have sufficient distance to be filtered and demodulated again to recreate the original speech signal.

Figure 238: TFb 1

The Germans developed a variety of carrier wave equipment for single and multiple channels. A widely used type was the "*Träger Frequenzgerät b*" (TFb) series, a 12 V powered single channel carrier wave unit that was small and flexible enough to be used as field equipment. The units are numbered TFb 1 to 5, each with a carrier frequency incremented with 5.5 kHz.

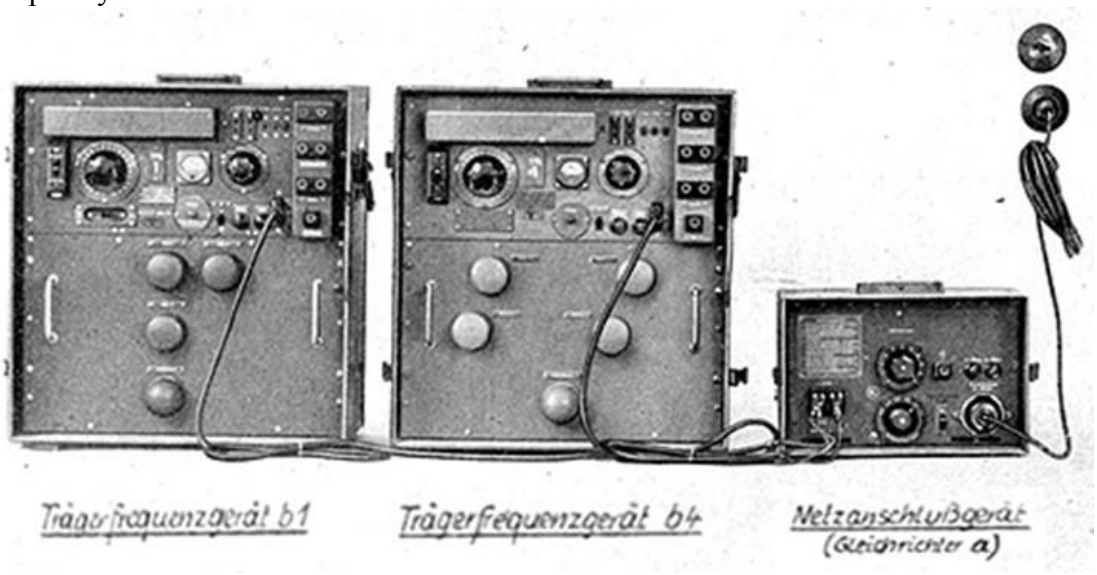


Figure 239: TFb 1 and TFb 4 used together. Note that the higher frequency TFb 4 has an extra valve

The types could be used on their own or in combination. By combining all five types a maximum of six communication channels could be created on a single line. The communication channels could be used for telephone or telex, allowing a single connection to do the job of six.

The working principles are explained using the next figure. Each TFb unit contains a transmitter and a receiver for the speech signal:

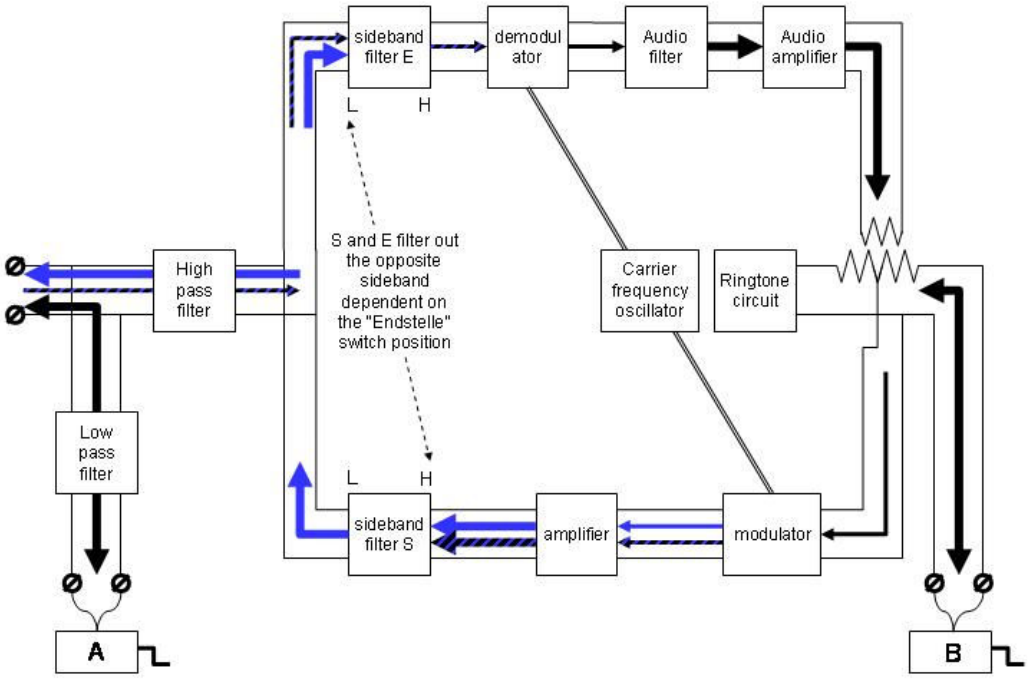


Figure 240: TFb working principles

Transmitter: The signal from telephone B enters the unit via an input/output transformer towards the transmitter and is mixed with the carrier frequency in the modulator. The signal now consists of a lower and and upper sideband as indicated in figure 230. The signal is amplified before it is passed through a band pass filter that either filters out the lower or the upper sideband. The two TFb units at either end of the connection need to be set to a different "*Endstelle*" so that one unit transmits the lower sideband while the other transmits the upper sideband. The signal now passes through a high pass filter and is combined with the normal speech signal from telephone A onto the outgoing line.

Receiver: The signal arrives at the unit, the normal speech signal is filtered through a low pass filter to telephone A. The carrier wave signal passes through the high pass filter into the receiver. The signal passes through a band pass filter which selects either the lower or upper sideband. Since the receiver filter is filtering the opposite sideband from the transmitter, feedback from the own transmitter is prevented. The signal passes through a demodulator and an audio filter, recreating the original speech signal. This signal is amplified and fed via the input/output transformer to telephone B. The input/output transformer prevents the signal from the receiver to enter the transmitter.

Ringtone circuit: A separate circuit was used to detect and modulate the 20 Hz bell frequency. If telephone B rights turns the alarm generator, a special detection circuit operates a number of relays that temporarily switch off the receiver and -dependent on the "*Endstelle*" selection- either reduce or increase the carrier frequency by 500 Hz (in the TFb1 to 5 kHz). This unmodulated reduced carrier frequency is amplified and transmitted on the line. On the other end the carrier signal passes through the high pass and sideband filters and enters the receiver, where it is mixed with the normal carrier frequency, creating a 500 Hz tone. After filtering in the audio filter and amplificaiton, this 500 Hz signal is detected by the ringtone circuit. Again via relays, the transmitter is temporarily switched off and a ringtone generator is activated, causing the bell of Telephone B on the other end to ring.

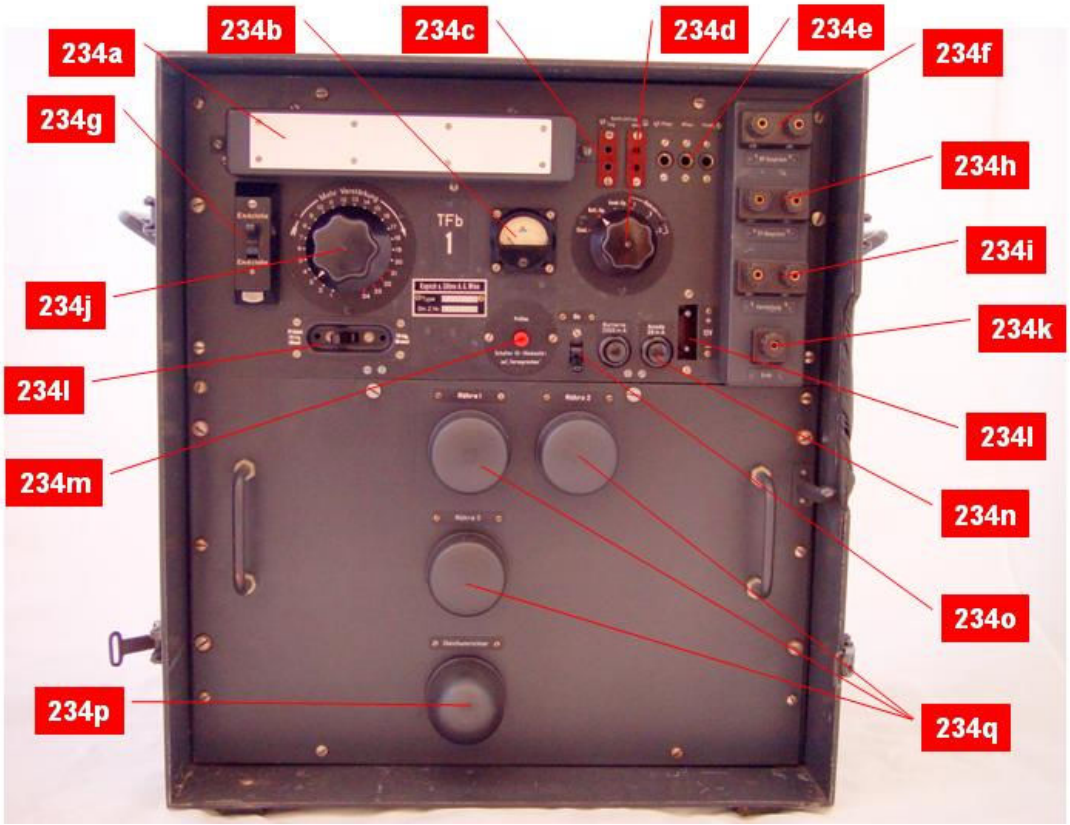
A drawback of using higher frequencies in a line connection is that the stray capacity of the line is starting to play a greater role, limiting the range of carrier wave equipment. The largest ranges could be achieved using overhead lines. For example 3 mm solid copper overhead conductors, the TFb 1 had a range of 500 km, the range of the TFb 2 about 400 km. As can be seen the range decreases with increasing frequency.

With Heavy field cable the range of the TFb 1 would be about 22 Km, with Light field cable the range would reduce to 15 Km. Likewise, the higher frequency units would have shorter ranges still.

Another limitation were lines fitted with Pupin coils as these have a poor high frequency response. So if *Schweres Feldfernkabel* (FFK) was to be used in combination with carrier wave equipment, the Pupin coils had to be removed. In most cases however, the gained communication channels outweighed the loss of range.

Construction

Figure 241: TFb 1 controls



234a Relay cover with writing tab
234b Test voltage instrument
234c Interconnections used for multiple carrier waves
234d Test voltage selector
234e Interconnection cable sockets
234f Connections for normal speech signal
234g "Endstelle" switch
234h Connections for carrier speech signal
234i Connections for outgoing line
234j Amplification adjustment
234k Earth connection
234l Cable type selector
234m Test button
234n Fuses
234o Main On/Off switch
234p Cover for power supply vibrator
234q Cover for oscillator and amplifier valves

Figure 242: Ring tone generators (left) and relays (right) with relay cover

The TFb units have a modular design. The top section is reserved for all controls and connections while the bottom of the unit contains power supply module, carrier frequency generator, filters, amplifiers, modulator, demodulator and ringtone circuits.

The modular design allowed for a quick exchange of faulty modules

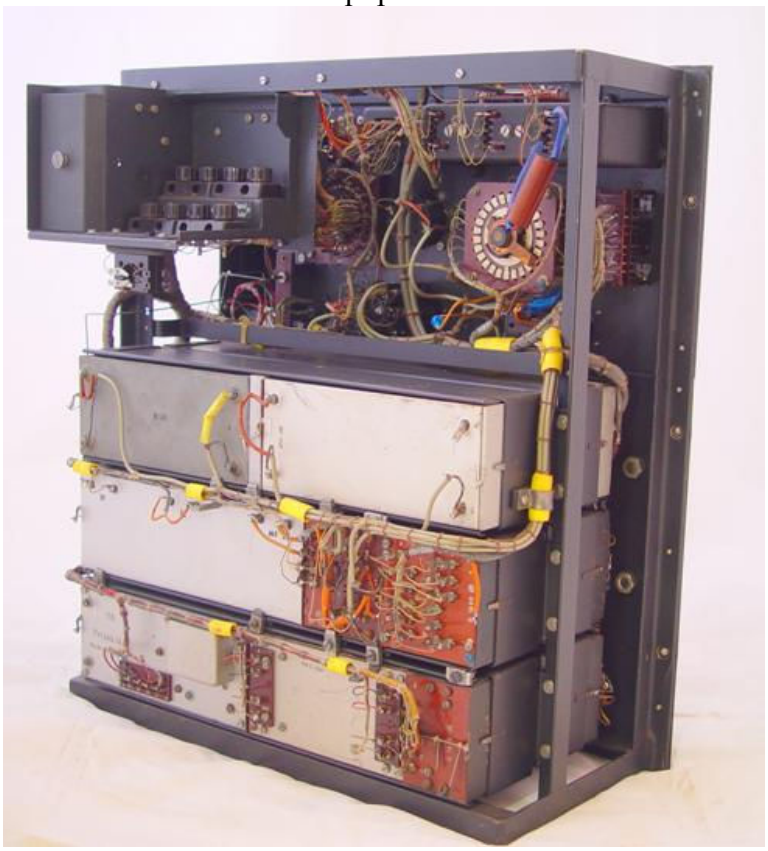


Figure 243: Right-rear internal view

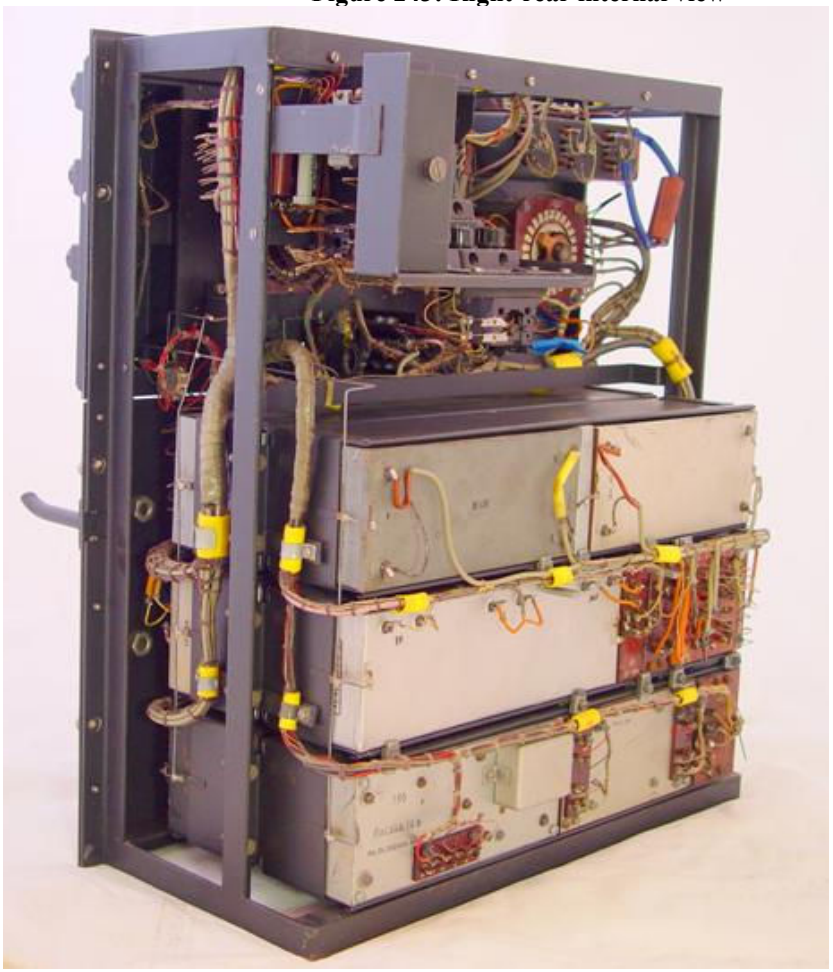
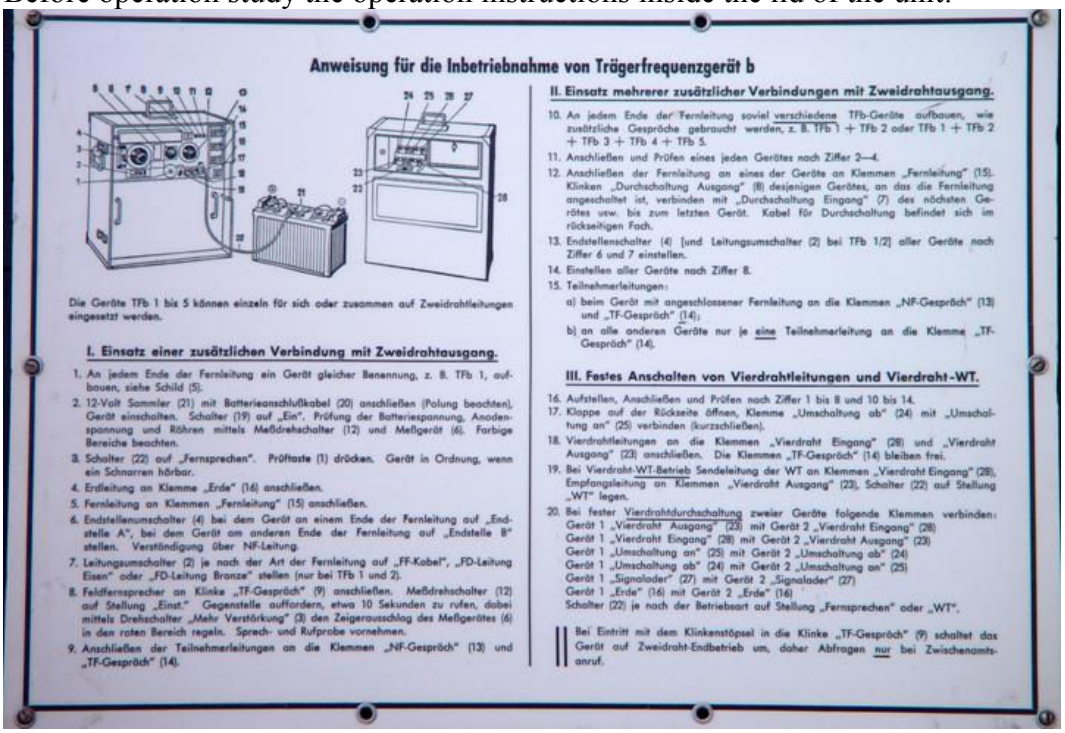


Figure 244: Left-rear internal view

Operation

Before operation study the operation instructions inside the lid of the unit:



Anweisung für die Inbetriebnahme von Trägerfrequenzgerät b

Die Geräte TFb 1 bis 5 können einzeln für sich oder zusammen auf Zweidrahtleitungen eingesetzt werden.

I. Einsatz einer zusätzlichen Verbindung mit Zweidrahtausgang.

1. An jedem Ende der Fernleitung ein Gerät gleicher Benennung, z. B. TFb 1, aufbauen, siehe Schild (5).
2. 12-Volt Sammler (21) mit Batterieanschlußkabel (20) anschließen (Polung beachten). Gerät einschalten. Schalter (19) auf „Ein". Prüfung der Batteriespannung, Anodenspannung und Röhren mittels Meßdrehschalter (12) und Meßgerät (6). Farbige Bereiche beachten.
3. Schalter (22) auf „Fernsprechen". Prüftaste (1) drücken. Gerät in Ordnung, wenn ein Schnarren hörbar.
4. Erdleitung an Klemme „Erde" (16) anschließen.
5. Fernleitung an Klemmen „Fernleitung" (15) anschließen.
6. Endstellenumschalter (4) bei dem Gerät an einem Ende der Fernleitung auf „Endstelle A", bei dem Gerät am anderen Ende der Fernleitung auf „Endstelle B" stellen. Verständigung über NF-Leitung.
7. Leitungsumschalter (2) je nach der Art der Fernleitung auf „FF-Kabel", „FD-Leitung Eisen" oder „FD-Leitung Bronze" stellen (nur bei TFb 1 und 2).
8. Feldfernsprecher an Klinke „TF-Gespräch" (9) anschließen. Meßdrehschalter (12) auf Stellung „Einst." Gegenstelle auffordern, etwa 10 Sekunden zu rufen, dabei mittels Drehschalter „Mehr Verstärkung" (3) den Zeigerausschlag des Meßgerätes (6) in den roten Bereich regeln. Sprech- und Rufprobe vornehmen.
9. Anschließen der Teilnehmerleitungen an die Klemmen „NF-Gespräch" (13) und „TF-Gespräch" (14).

II. Einsatz mehrerer zusätzlicher Verbindungen mit Zweidrahtausgang.

10. An jedem Ende der Fernleitung soviel verschiedene TFb-Geräte aufbauen, wie zusätzliche Gespräche gebraucht werden, z. B. TFb 1 + TFb 2 oder TFb 1 + TFb 2 + TFb 3 + TFb 4 + TFb 5.
11. Anschließen und Prüfen eines jeden Gerätes nach Ziffer 2—4.
12. Anschließen der Fernleitung an eines der Geräte an Klemmen „Fernleitung" (15). Klinken „Durchschaltung Ausgang" (8) desjenigen Gerätes, an das die Fernleitung angeschaltet ist, verbinden mit „Durchschaltung Eingang" (7) des nächsten Gerätes usw. bis zum letzten Gerät. Kabel für Durchschaltung befindet sich im rückseitigen Fach.
13. Endstellenschalter (4) [und Leitungsumschalter (2) bei TFb 1/2] aller Geräte nach Ziffer 6 und 7 einstellen.
14. Einstellen aller Geräte nach Ziffer 8.
15. Teilnehmerleitungen:
    a) beim Gerät mit angeschlossener Fernleitung an die Klemmen „NF-Gespräch" (13) und „TF-Gespräch" (14);
    b) an alle anderen Geräte nur je eine Teilnehmerleitung an die Klemme „TF-Gespräch" (14).

III. Festes Anschalten von Vierdrahtleitungen und Vierdraht-WT.

16. Aufstellen, Anschließen und Prüfen nach Ziffer 1 bis 8 und 10 bis 14.
17. Klappe auf der Rückseite öffnen, Klemme „Umschaltung ab" (24) mit „Umschaltung an" (25) verbinden (kurzschließen).
18. Vierdrahtleitungen an die Klemmen „Vierdraht Eingang" (28) und „Vierdraht Ausgang" (23) anschließen. Die Klemmen „TF-Gespräch" (14) bleiben frei.
19. Bei Vierdraht-WT-Betrieb Sendeleitung der WT an Klemmen „Vierdraht Eingang" (28), Empfangsleitung an Klemmen „Vierdraht Ausgang" (23), Schalter (22) auf Stellung „WT" legen.
20. Bei fester Vierdrahtdurchschaltung zweier Geräte folgende Klemmen verbinden:
    Gerät 1 „Vierdraht Ausgang" (23) mit Gerät 2 „Vierdraht Eingang" (28)
    Gerät 1 „Vierdraht Eingang" (28) mit Gerät 2 „Vierdraht Ausgang" (23)
    Gerät 1 „Umschaltung an" (25) mit Gerät 2 „Umschaltung ab" (24)
    Gerät 1 „Umschaltung ab" (24) mit Gerät 2 „Umschaltung an" (25)
    Gerät 1 „Signalader" (27) mit Gerät 2 „Signalader" (27)
    Gerät 1 „Erde" (16) mit Gerät 2 „Erde" (16)
    Schalter (22) je nach der Betriebsart auf Stellung „Fernsprechen" oder „WT".

Bei Eintritt mit dem Klinkenstöpsel in die Klinke „TF-Gespräch" (9) schaltet das Gerät auf Zweidraht-Endbetrieb um, daher Abfragen nur bei Zwischenamtsanruf.

Figure 245: Operating instructions inside the lid

To bring a single carrier frequency connection into operation, the following steps have to be taken:

1. On both ends of the line connection, place a unit of the same type, e.g. TFb1
2. Connect a 12 V battery wit the battery cable. Switch on the unit and check the voltage and the valves using the test control selector
3. Ensure that the switch in the back compartment is set to "*Fernsprechen*". Push the test button. The unit is functional when a buzzing sound can be heard.
4. Connect an earth line to the earth connection
5. Connect the wires of the line connection to the "*Fernleitung*" connectors
6. Place the "*Endstelle*" selector on one end on "*Endstelle A*" and on the other end on "*Endstelle B*". Use the unmodulated telephone to communicate to the other end.
7. Place the cable type switch on "*FF-kabel*", *FD-Leiting Eisen"* or "*FD-Leitung Bronze*" dependent on the cable type used

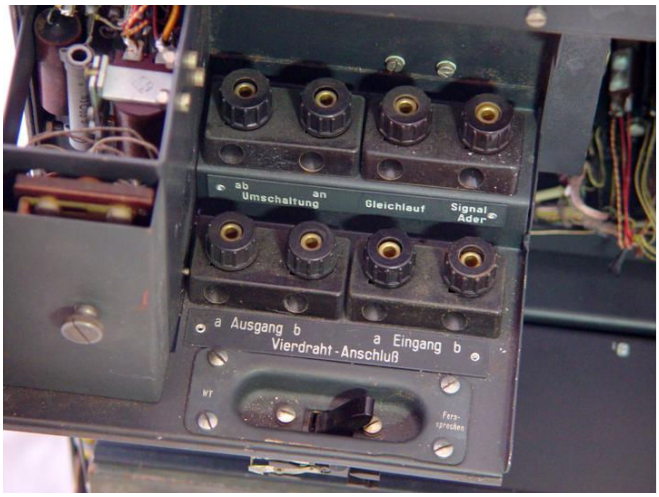


Figure 246: The Telephony - Telegraphy selection switch in the back compartment

8. Connect a field telephone to the "*TF-Gespräch*" interconnection cable socket and set the test control selector on "Einst". Call the other end for about 10 seconds, while moving the amplifier control until the needle of the test instrument sits on the red area. Test the alarm circuits and voice communication from both ends.
9. Connect the end users to the "*NF-gespräch*" and "*TF-Gespräch*" connectors

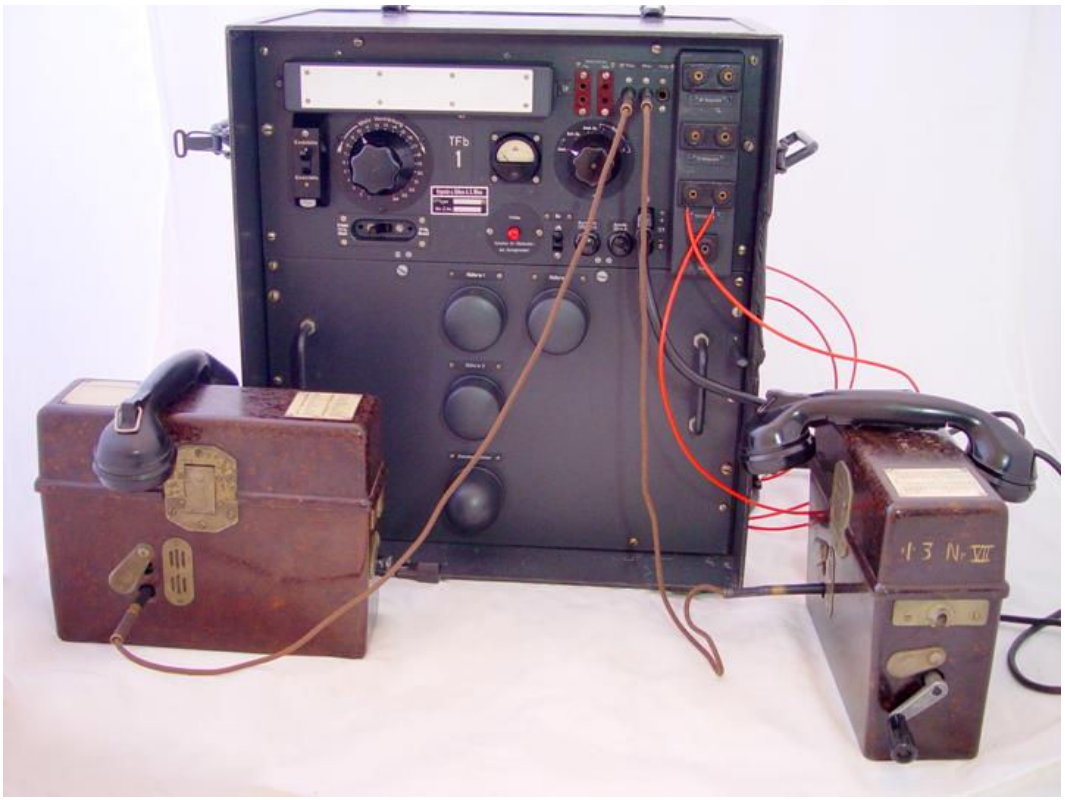


Figure 247: TFb 1 connected and ready to operate

If several carrier wave connections are used on a single line, the following steps have to be taken:

10. On both ends of the connection, place as many different units as required, eg TFb 1 + TFb 2 for three channels, TFb 1 + TFb 2 + TFb 3 + TFb 4 + TFb 5 for six channels
11. Connect and test each unit as per steps 2 -4
12. Connect the wires of the line connection to the "*Fernleitung*" connections on one of the units and plug in the special two-plug cable (The two plug cable is stored in the back compartment) into the "*Durchschaltung Ausgang*" socket of this unit. The other end of the cable is plugged into the "*Durchschaltung Eingang*" socket of the next unit. Repeat the interconnection with all subsequent units

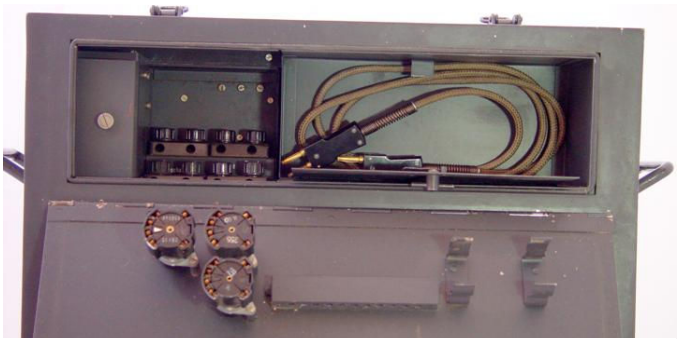


Figure 248: Two plug cable stored in back compartment

13. Place the "*Endstelle*" switch and the cable type switch (TF b 1 and 2 only) as per steps 6 – 7
14. Adjust all units as per step 8
15. Connect the end user
    a. On the unit to which line connection is made, connect two users using the "*TF Gespräch*" and "*NF –Gespräch*" connections
    b. On all other units only use the "*TF Gespräch*" connections

The connection is the back compartment could also be used for four-wire telephony or four-wire AC-telegraphy connections (WT or "*Wechselstrom Telegrafie*")

A number of filter units were supplied so that telephones could be connected directly to a carrier frequency line. The "*Anschaltfiler*" or connection filter allowed a single telephone to tap into the line:

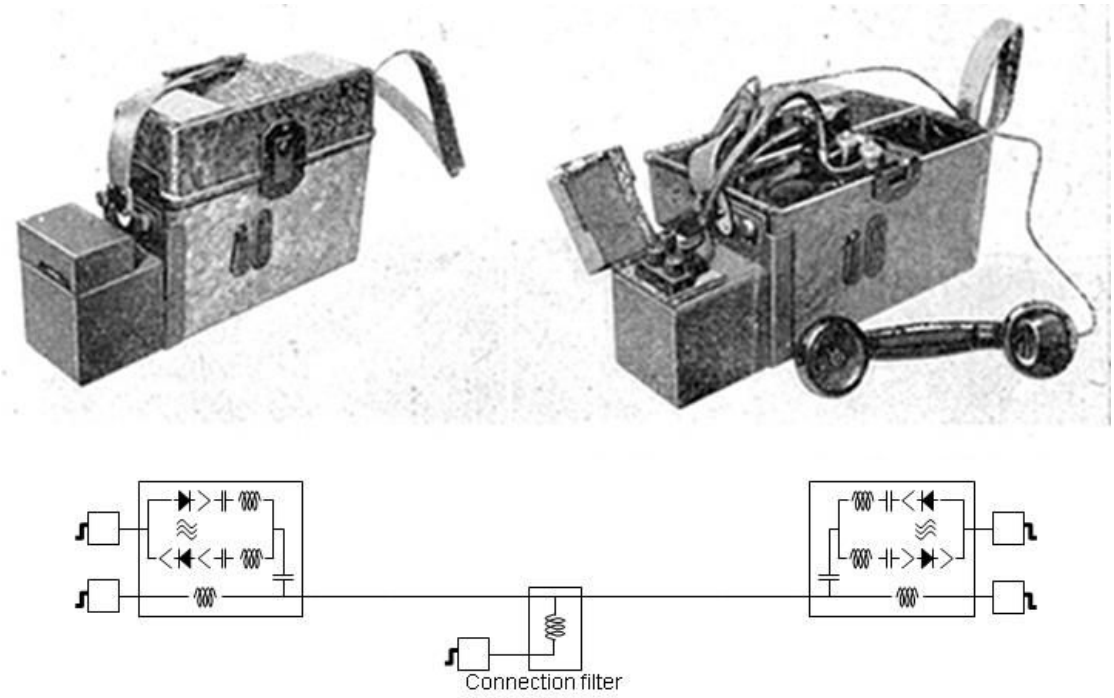


Figure 249: "Anschaltfilter" connection filter

Another type was the "*Umgehungswieche 3.3 T*" or Ring filter. This allowed the carrier frequency to pass through, but the speech frequency (smaller than 3.3 Khz) was segregated. Two telephones could be connected to the ring filter, each would provide a separate connection to opposite ends of the line.

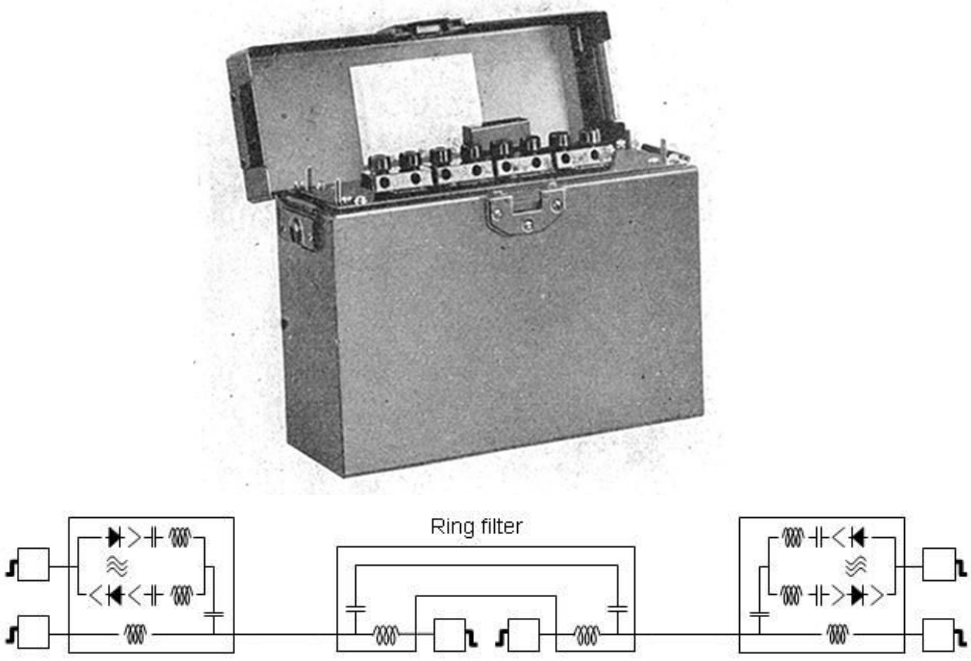


Figure 250: "Umgehungswieche 3.3 T" ring filter

DLE (kl) Intercept Receiver

Development and Description

During the First World War it was found that enemy field telephone connections in forward areas could be intercepted and that important tactical information could be learned. The German signal troops tapped into the allied lines either directly or by picking up earth currents and amplifying the signal using the "Moritz" intercept receiver.

When the German Armed forces started their rapid expansion in the early 1930's a new line intercept receiver , the "*Lausch Empfänger 35"* (L.E. 35) was developed. In 1940 the intercept receiver was replaced by the "*Lausch Empfänger 40*" (L.E. 40). The L.E. 40 was a portable line intercept amplifier, together with batteries in one enclosure. It employed a three stage amplifier using *RV2P800* Pentode tubes. It contained a filter for 50 Hz and higher harmonics to reduce mains interference and a switchable band pass filter.

Figure 251: Lausch Empfänger 40

An interesting auxiliary was the "*Lausch Zange 35"* (LZ 35), a pick up coil that could be clamped around a line, without the need to make a physical connection.

In 1942 the final development of a compact intercept receiver was made: the "*Draht Lausch Empfänger (Klein)*" *D.L.E. (kl)*. A marvel of miniaturization, the unit only measures 17 x 9 x 5 cm with a battery box of the same size. The *D.L.E. (kl)* is essentially a two stage audio amplifier using two RL 2.4 P 45 Pentodes.

Figure 252: Draht Lausch Empfaenger klein

The receiver has all its controls on the top section, made out of bakelite. It has three controls:

- Left: On/Off switch and sensitivity control;
- Middle: Input balance control;
- Right: "*Lautstärke*" volume control.

It has a three pin headphones jack which can be used by either the standard headphones, or the smaller plug of the telephone headphone

Three spring loaded wire terminals marked e (earth), a and b (line connection) complete the control panel of the receiver. A lid on the bottom of the receiver can be opened for access to the two valves. Connections and locking pins to attach the battery box are mounted on the left side of the receiver.

Figure 253: D.L.E. (kl) with accessories in leather carrying bag

The D.L.E. (kl) consists of the receiver and battery box which are linked together when in operation. The receiver, battery box and accessories were stored in a leather bag when not in use.

The battery box has the same size and has lids on top and bottom leading into two separate battery compartments taking 3 V cells, very similar in size to current AA batteries. In the top section eight cells are placed in series to make 12 V anode voltage. In the bottom section the eight batteries are placed in parallel to make 3 V filament voltage. A resistor is used in series with the tube filaments to reduce this to 2.4 Volts.

Figure 254: D.L.E (kl) battery box

The signal is led through two attenuation resistors and two decoupling capacitors into a balancing circuit. The signal then passes through a low pass filter and a transformer into the first amplification stage. Via a coupling capacitor and a volume control resistor the signal enters the second stage amplifier. An output transformer allows headsets with different impedances to be used.

The high input impedance of the receiver will not weaken the original signal strength of the tapped line, so the line user will not know that he is being listened to.

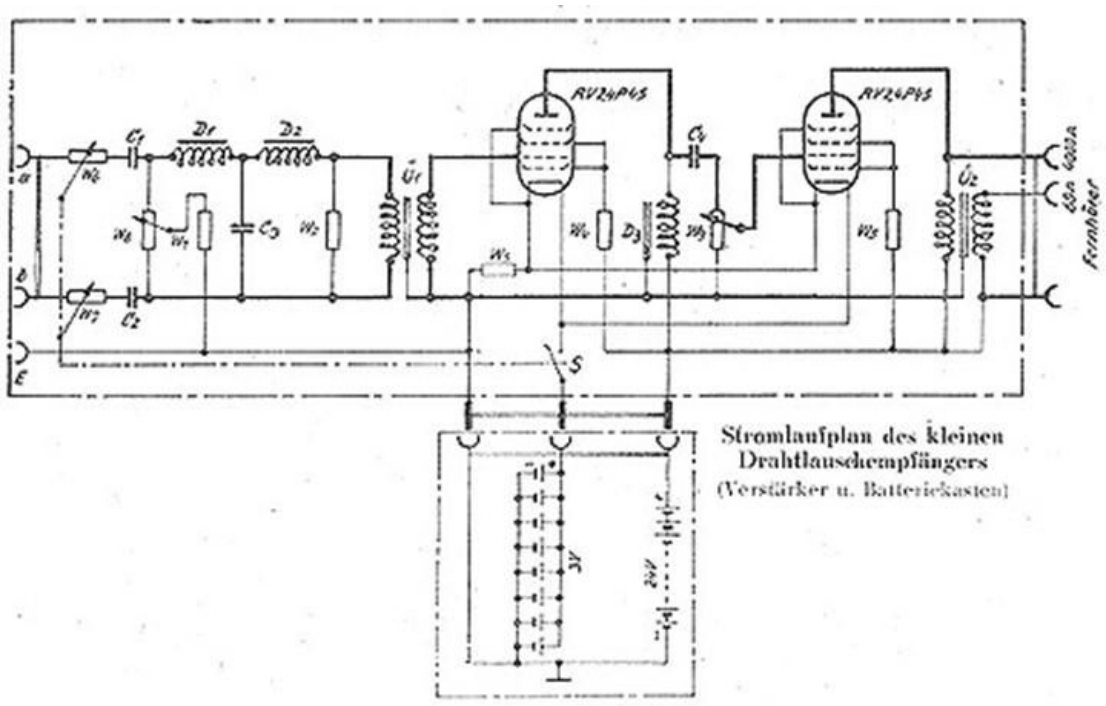


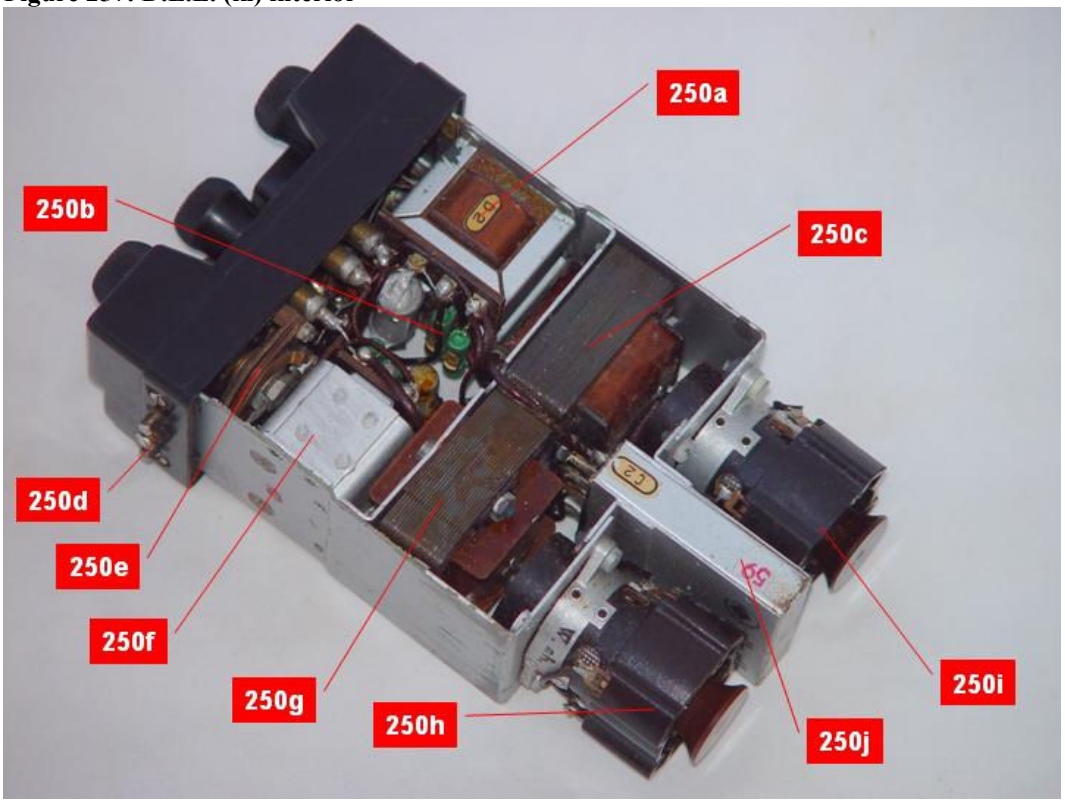
Figure 255: D.L.E. (kl) schematic

Construction

Figure 256: D.L.E. (kl) control panel

249a Connections for intercepted telephone line
249b Balance control
249c Connection for earth wire
249d Volume control
249e Headphone socket
249f Input attenuation control

Figure 257: D.L.E. (kl) interior



250a Input filter self inductions D1/D2
250b Small passive components
250c First stage input transformer
250d Battery contacts
250e On/Off and input attenuation control
250f Output transformer
250g Amplifier self induction D3
250h Second stage amplifier valve
250i First stage amplifier valve
250j Input decoupling capacitor block

Operation

Find a suitable location to place the *Drahtlauschempfänger* near the line to be intercepted. Prepare two wire of sufficient length to connect the receiver to the line. Carefully strip some insulation from the line to be intercepted. Alternatively two *Lausch Zange 35* can be clamped around each wire of the line to be intercepted. Place an earth pick near the receiver and prepare a length of wire to connect the receiver to earth

To bring the receiver into operation:

- Place the batteries in both compartments of the battery box and connect the battery box to the receiver
- Ensure that the receiver is switched off before making any connections
- Connect the intercept wires to the line terminals of the receiver first and carefully connect them to the prepared area of the line to be intercepted. Be careful not to shorted the wires as this will give away that the line is being tampered with
- Connect the earth wire to the earth terminal
- Connect the headset
- Switch on the receiver

It is likely that 50 Hz mains interference is heard. Use the balance control to minimize this interference. Turn the attenuation control clockwise until the signal is maximized without distortion. Retune the balance if required. Tune the volume control for the desired strength.

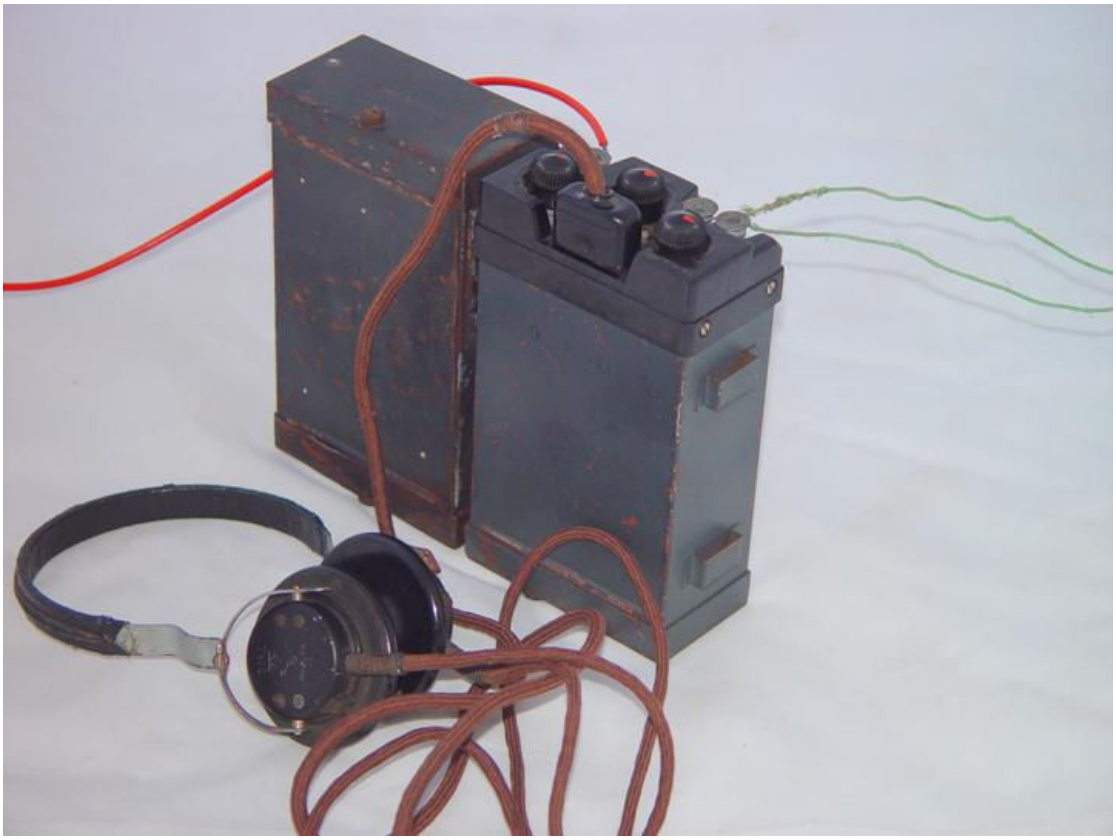


Figure 258 D.L.E. (kl) in operation

7. Glossary

Term	Abbr.	Explanation
Abfragen	Abfr.	To Enquire
Abspuler		Cable dispenser
Ackerschnacker		Colloquial term for field telephone
Amtsanschliesser		Unit to connect a field telephone network to a public telephone exchange
Amtszusatz		Accessory to connect a field telephone network to a public telephone exchange
Anschaltfilter		Low pass filter to connect a field telephone directly to a line using carrier frequencies
Aufspuler		Cable spooling device
Aus		(Switched) Off
Ausgang		Output
Bedienungsanweisung		Operating instructions
Bereit		Standby, ready
Betreibsvorschift		Operating instructions
Bronze		Bronze
Doppelpolwechselschalter		Double ringtone generator
Draht		wire, cable
Drahtgabel		cable fork
Dunkelgelb		dark yellow
Durchschaltung		Interconnection
Ein		(Switched) On
Eingang		Input
Eisen		Iron
Empfänger		Receiver
Endstelle		End point, terminal
Erde	E	Earth
Erdsprechgerät		Telephone device using earth currents
Feind hört mit!		the enemy listens in!
Feldfernkabel		Long distance field cable, a twisted four core cable used for building long distance connections
Feldfernschreiber		Field telex using the "Hell" principle
Feldfernsprecher	FF, Feldfspr.	Field Telephone
Feldkabel		Field cable; single core cable used for field telephone connections
Feldklappenschrank		Field telephone exchange, field switchboard
Feldverstärker		Field telephone amplifier
Fernleitung		Long distance line
Fernsprechanschlusstrupp		Telephone connection troop
Fernsprechen		To use telephone communication
Fernsprecher		Telephone
Fernsprechtornister		Telephone backpack

Term	Abbr.	Explanation
Fernsprechtrupp		Telephone troop
FF Kabel	FFK	Heavy long distance field cable
Flusskabel		River cable
Geschlossene Bau		Closed construction; construction type where the laying of cable and suspension above ground is done simultaneously
Gespräch		Conversation
Getrennter Bau		Split construction, construction type where the laying of cable is done first, followed by the suspension above ground
Grosse		Large
Hochbau		Construction type where cables are suspended 3.3 meters above ground
Hebelumschalter		Kellogg switch; a toggle switch used to control the use of the interconnection cable in a telephone exchange
Kettenkrad		Tracked motorcycle
Klappenschrank		Telephone exchange, switchboard
Kleiner		Small
Kontroll Batterie	KB	Control battery
Kopfhörer		Headphones
Kraftfahrzeug	Kfz	Motor vehicle
Kriegsmarine		German Navy
Lauschen		to Listen, to eavesdrop
Lautstärke		Volume
Leichtes		Light
Leitung	L, Ltg	Connection, cable, line
Mikrofon Batterie	MB	Microphone battery
Mit		With
Mithören		Listen in, monitor
Mittlere		Middle, medium
Nachrichten truppen		Communication troops
Niederfreqeunz	NF	Speech frequency
Ohne		Without
Orstbatterie Betrieb	OB	Local battery operation
Ortfesten Betrieb		Static use
Parallelfeld		Scribner field; a connection field used on large exchanges so that all operators had access to all lines
Polwechselschalter		Ring to generator
Primär		Primary
Pupiniert		Line fitted with Pupin coils
Pupinspule		Pupin coil
Rückentrage		Back pack telephone cable carrying frame
Ruf Taste	RT	Calling button on a telephone exchange; connects to the activation contact of the ringtone generator

Term	**Abbr.**	**Explanation**
Rufen		To call
Schlusszeichen Betrieb	SB	End-pulse operation; used in networks where the end of a phone call was automatically signaled to the switchboard so that the connection could be reset as quickly as possible
Schwere		Heavy
Schweres Feldfernkabel	FFK	Heavy long distance field cable
Secondär		Secondary
Selbstanschlussbetreib	SA	Automatic dialing network
Signal		Signal
Sprechspule		Microphone transformer
Strippenzieher		Colloquial term of back pack telephone cable carrying frame
Tasche		Pouch, bag
Tiefbau		Construction type where telephone cables were laid on the ground or build into trenches
Tischfernsprecher		Table telephone
Ton		Tone
Tonsieb		Tone filter
Träger Freqeunzgeraet		Carrier wave unit
Träger Frequenz	TF	Carrier wave
Trennen		Isolate, disconnect
Überwachung		Monitoring
Überwachungsschrank		Monitoring station
Übertrager		Transformer
Umgehungswieche		Ring filter, allowing the speech frequency component of a carrier wave line to be segregated
Untersatz		Base unit, bottom unit
Vermittlung		Telephone interconnection
Vermittlungskästchen		Telephone interconnection box
Vermittlungsklinke	Vk	Telephone interconnection socket
Vermittlungsschnur		Telephone interconnection cable
Verstärker		Amplifier
Verstärkung		Amplification
Wahlbetrieb		Dialing network
Wechselstrom Telegrafie	WT	Tone telegraphy
Wecker	W	Alarm bell
Wecker batterie	WB	Alarm bell battery
Zange		Clamp
Zentralbatterie Betrieb	ZB	Central battery operation
Zusatz		Accessory