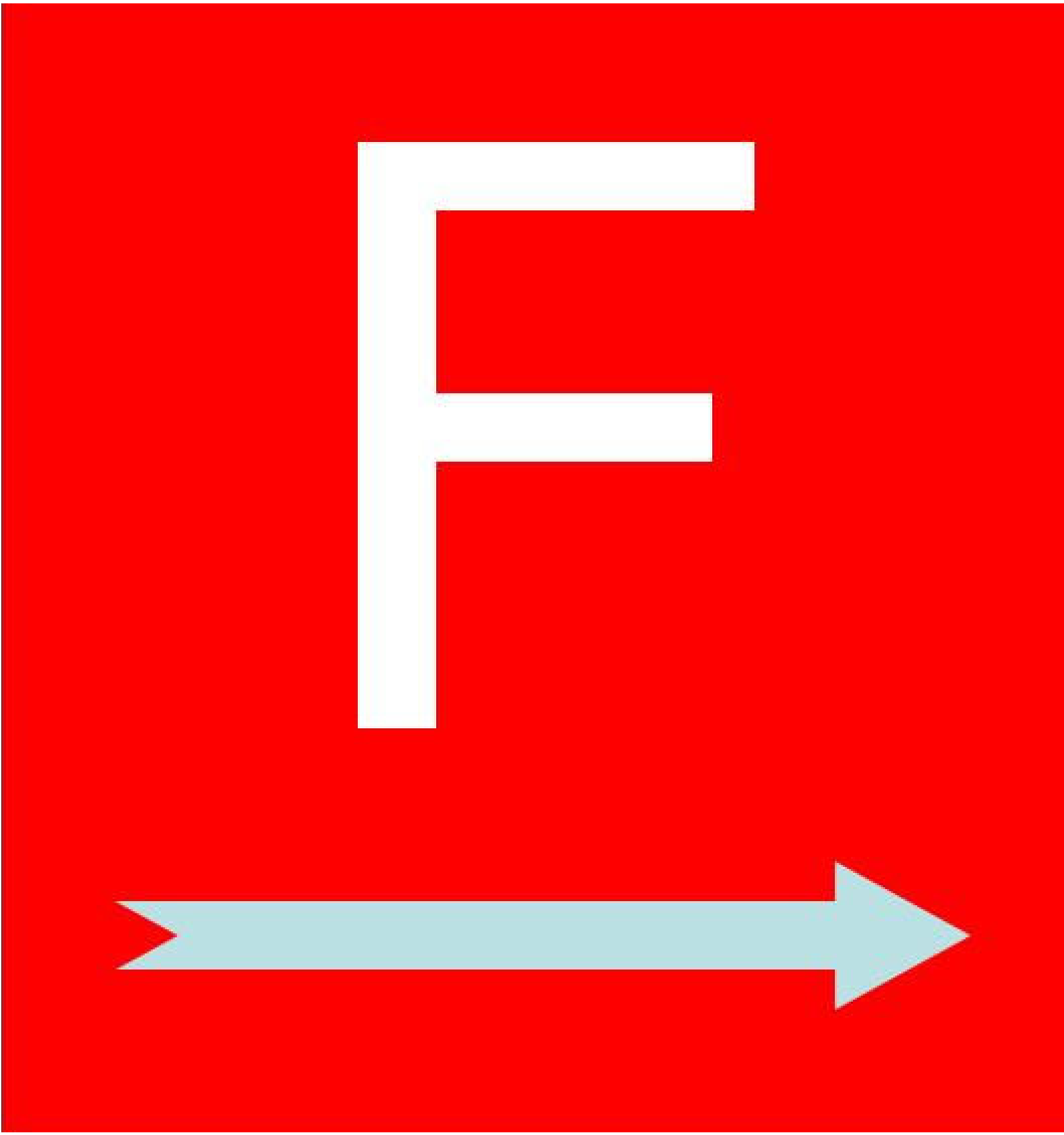
German Field Line Communication equipment of WW 2



Funksammler Publications

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.

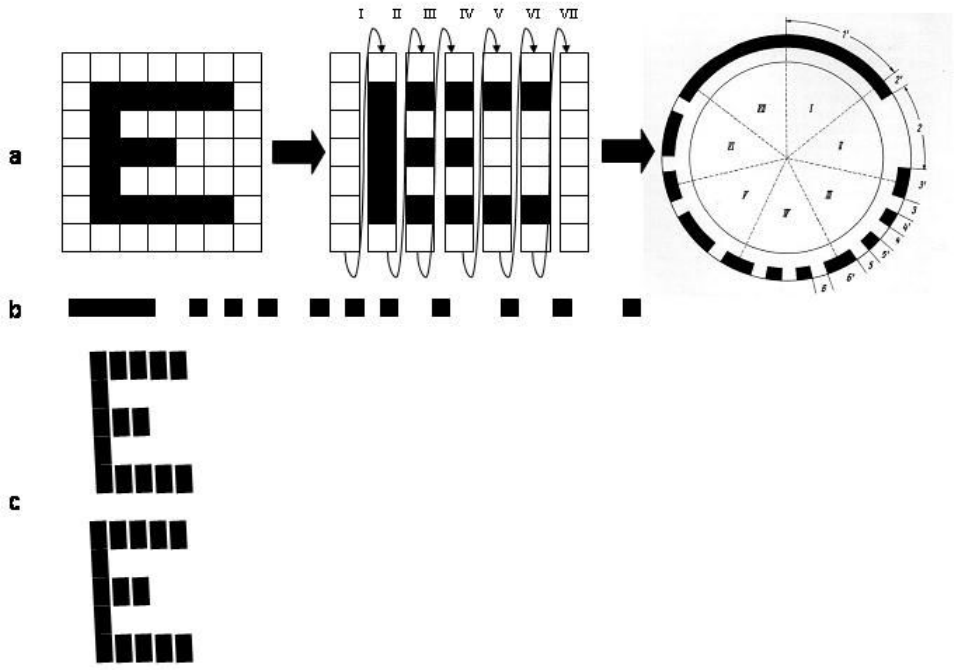


Figure 72: Principles of the Hell code

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

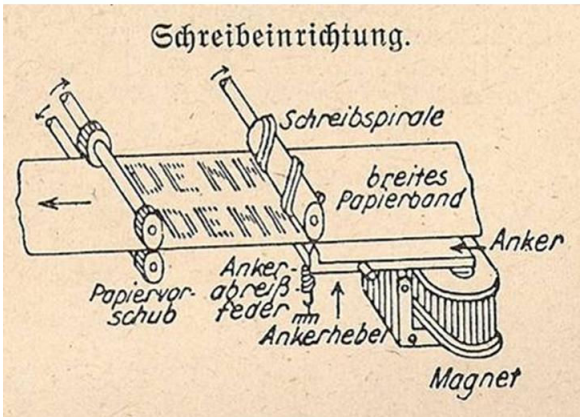


Figure 73: Printing unit principles

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.

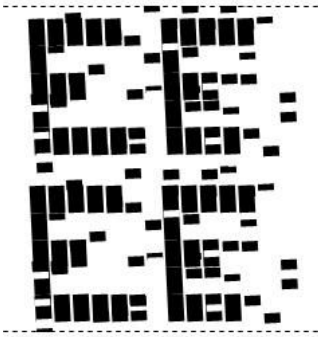


Figure 74: Interference

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.

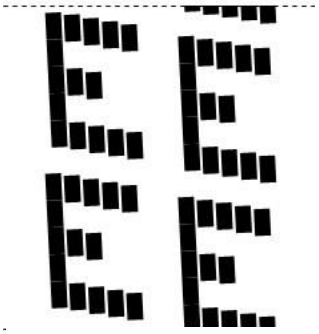


Figure 75: Loss of synchronisation

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

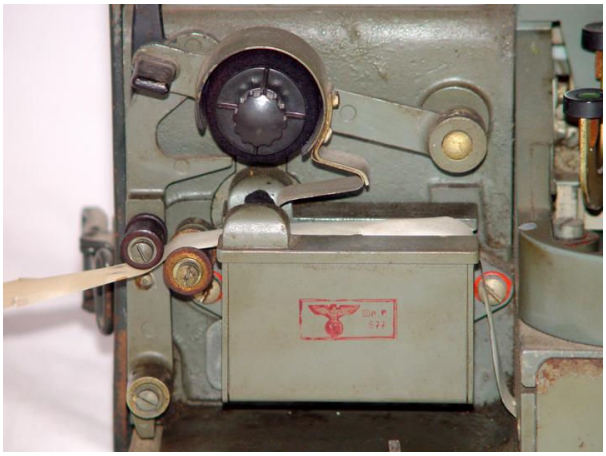


Figure 78: Printing unit

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.

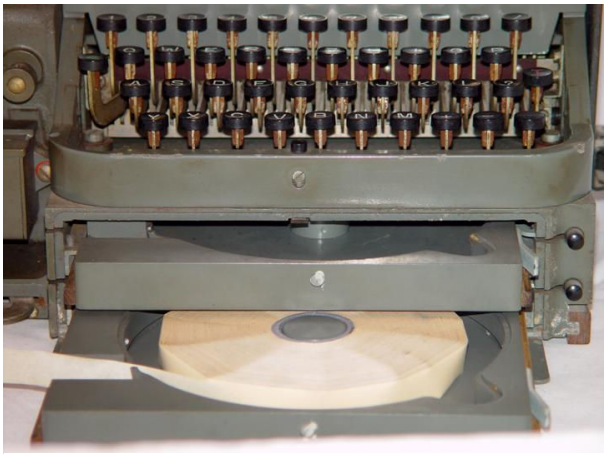


Figure 80: Keyboard unit with paper drawers

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.

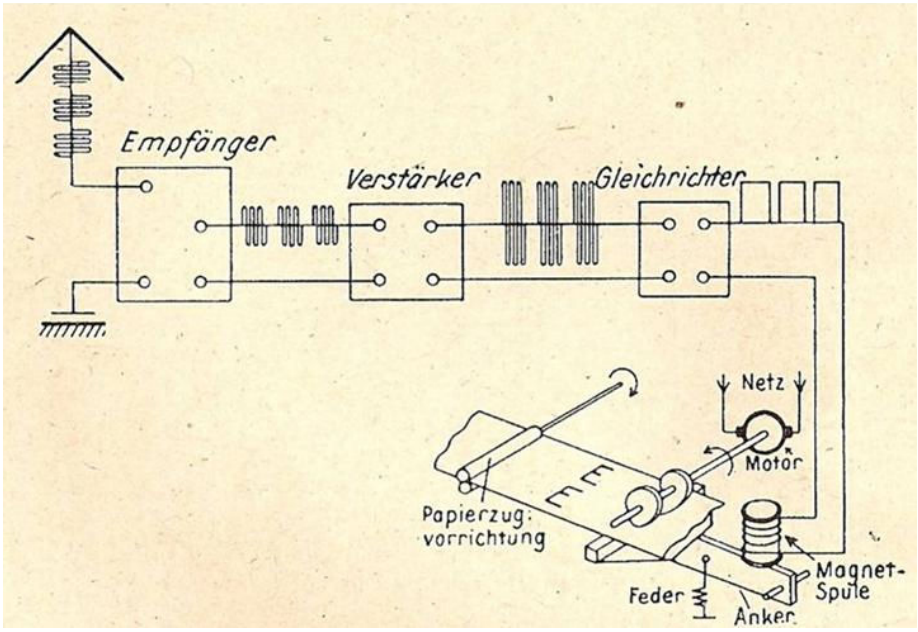


Figure 82: Operating principles of the amplifier (connected to a radio receiver)

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).

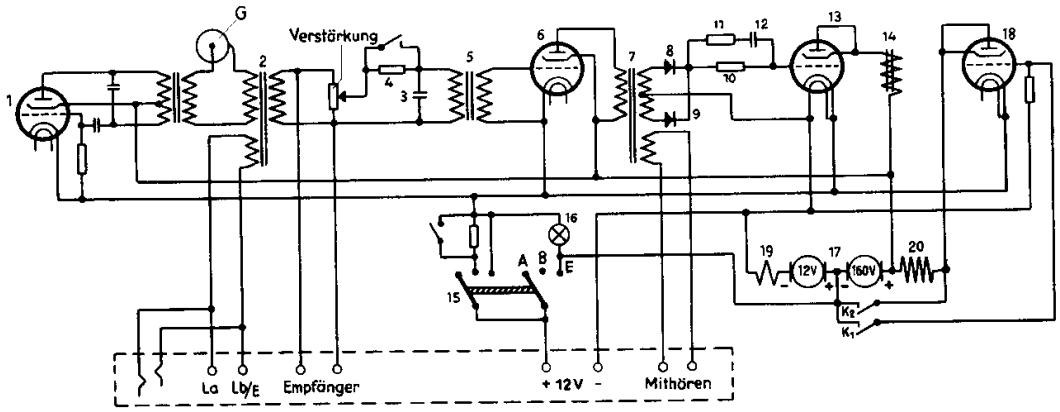


Figure 83: Feldfernschreiber circuit diagram

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:

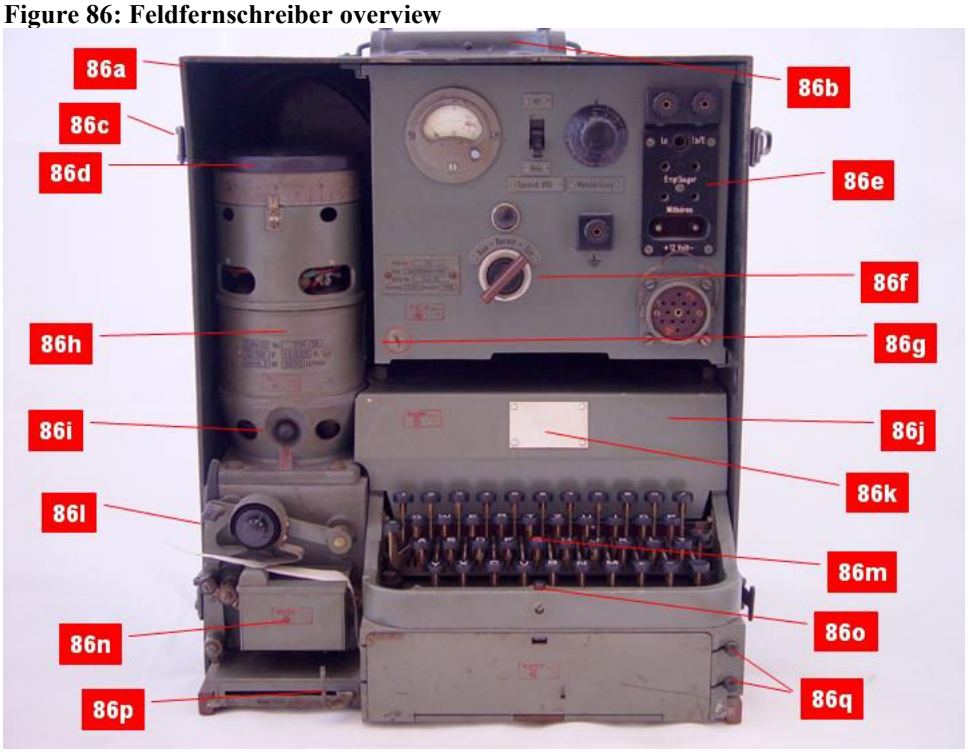
Figure 85: amplifier unit

- 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.

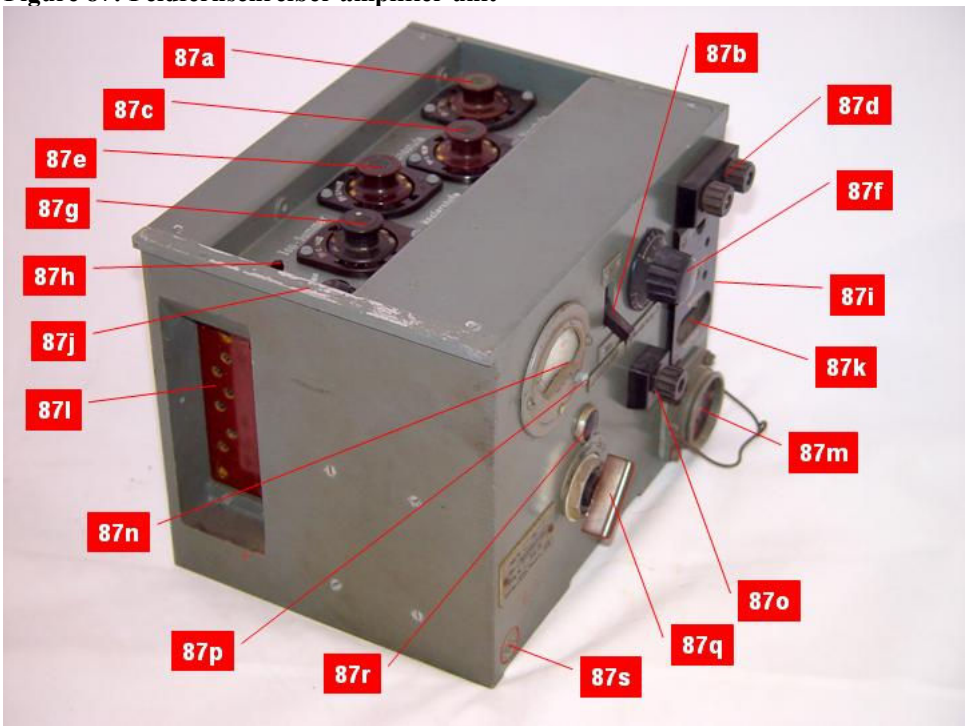
Construction

Figure 86: Feldfernschreiber overview



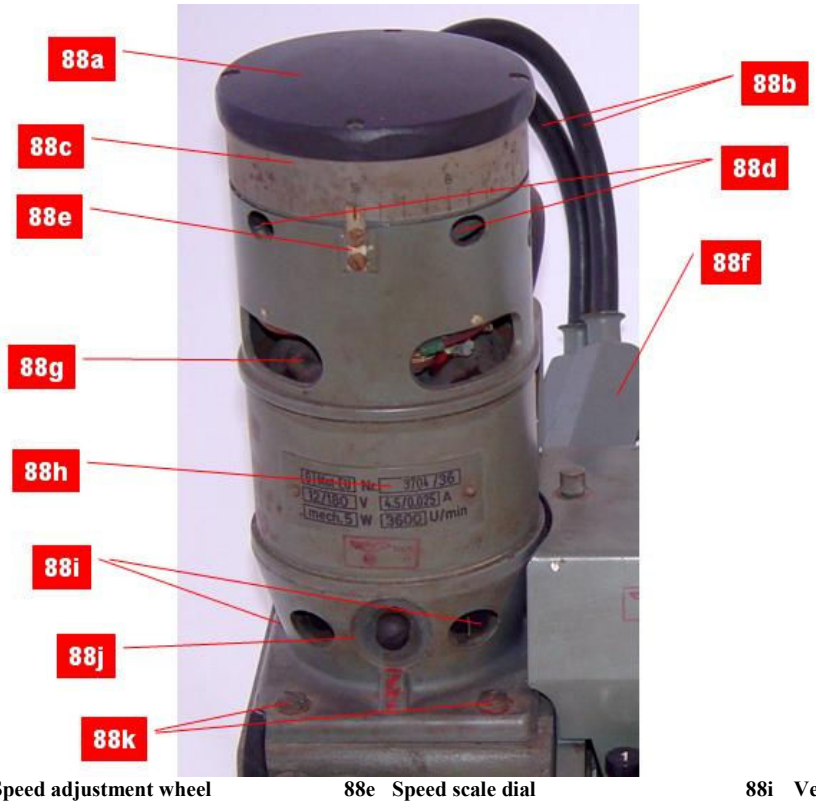
86a Outer casing
86b Carrying handle
86c Locking handle for lid
86d Speed adjustment
86e Electrical connection panel
86f Main switch
86g Amplifier unit lock screw
86h Motor unit
86i HV brush cover
86j Coding unit cover
86k Writing tab
86l Ink roll lock mechanism
86m Keyboard
86n Printing unit
86o Paper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

Figure 87: Feldfernschreiber amplifier unit



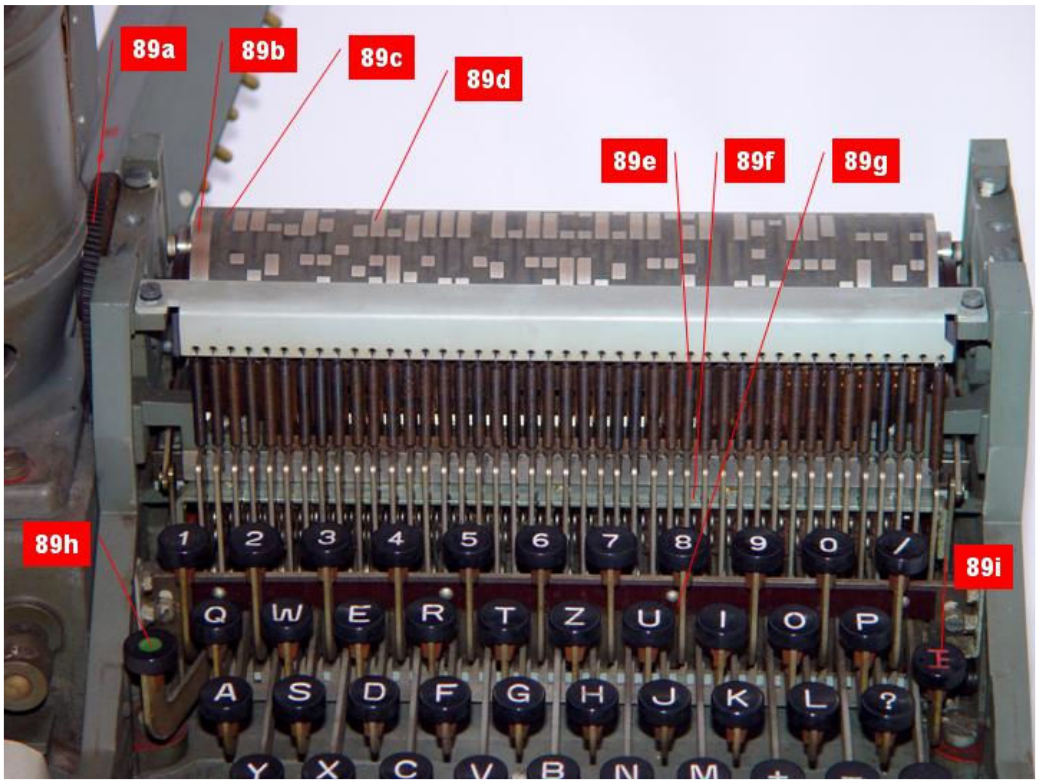
87a First stage amplifier tube
87b Filter switch
87c Second stage amplifier tube
87d Line connection terminals
87e Motor speed regulator tube
87f Amplification control
87g Oscillator tube
87h Power supply filter switch
87i Electrical connection plate
87j Fuse
87k Power supply socket
87l Keyboard unit 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



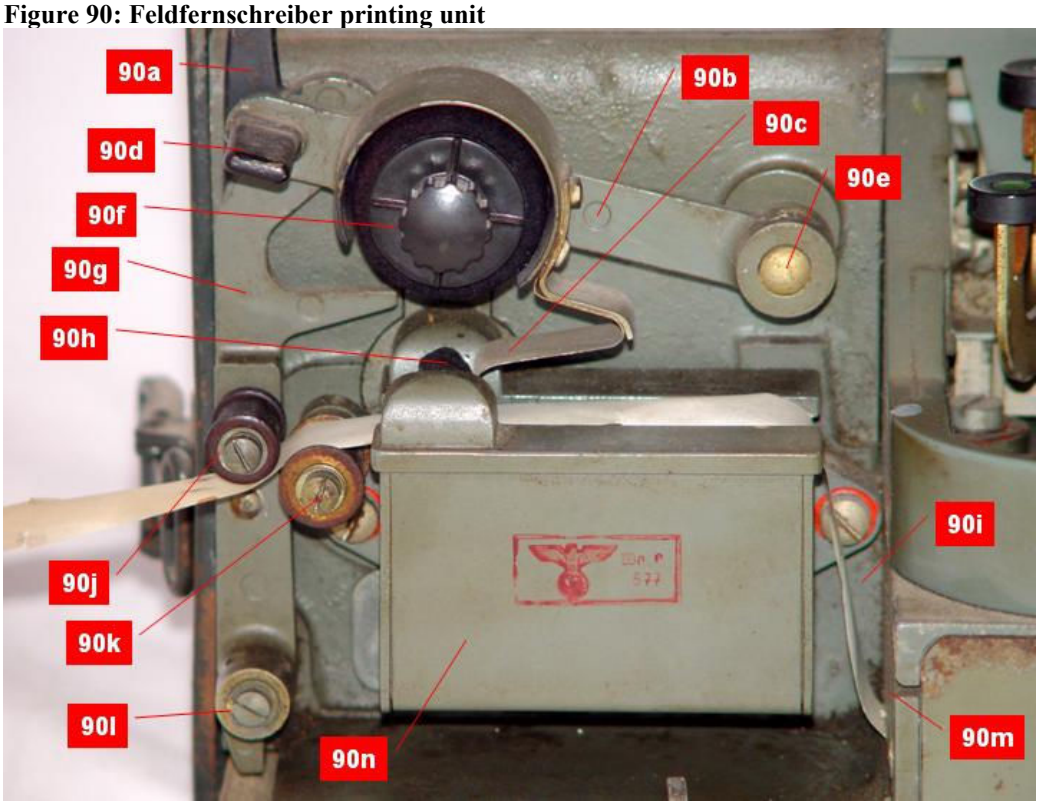
88a Speed adjustment wheel
88b Connection cables
88c Speed scale
88d Ventilation holes
88e Speed scale dial
88f Connection plugs
88g Access to LV brushes
88h Date plate
88i Ventilation holes
88j HV brush lock screw
88k Motor unit mounting screws

Figure 89: Feldfernschreiber keyobard and coding unit



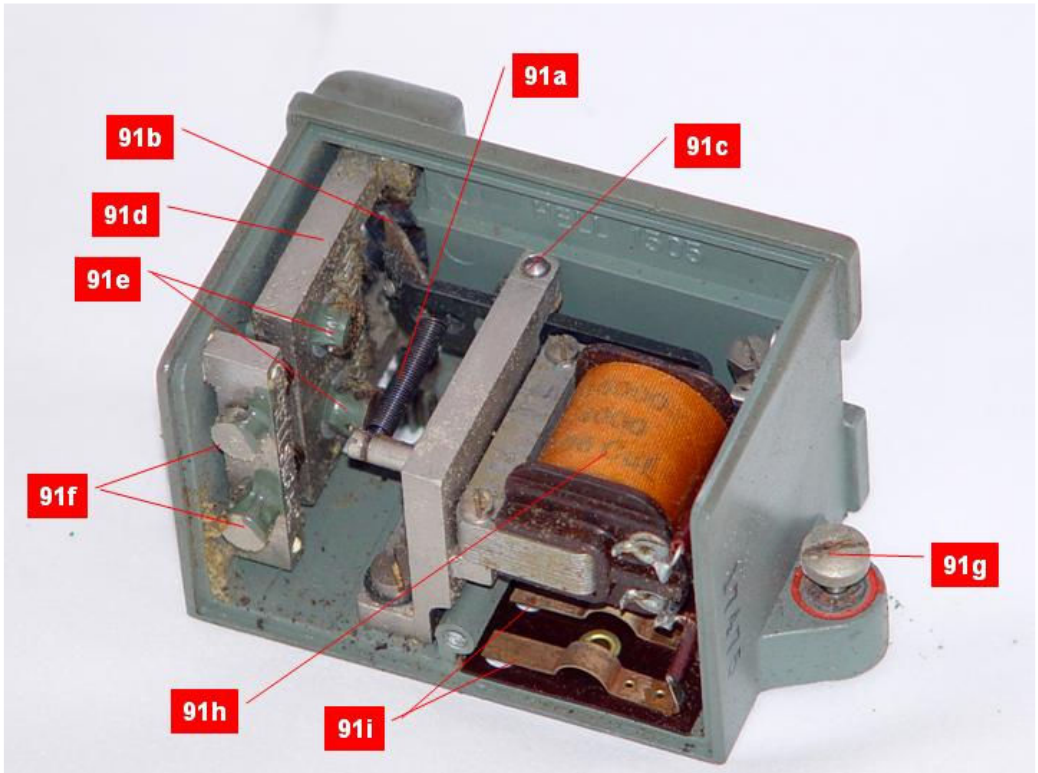
89a Code wheel driving gear
89b Code wheel mass contact
89c Isolated area
89d Conducting area
89e Key return spring
89f Contact and locking mechanism
89g Key
89h Morse key (green dot)
89i Pause key

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

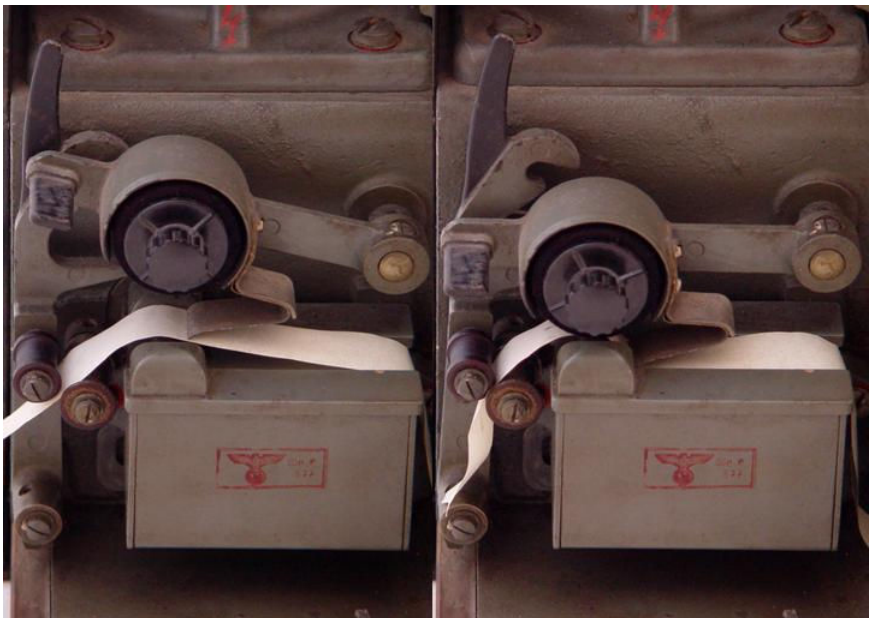
The *Feldfernschreiber* can also be operated over a radio link. In this case a keying unit, or a transmitter prepared to work with the *Feldfernschreiber* must be employed such as the *15 W.S.E.b* or the *AS 59*. In this chapter however, only operation over a telephone line will be described in this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

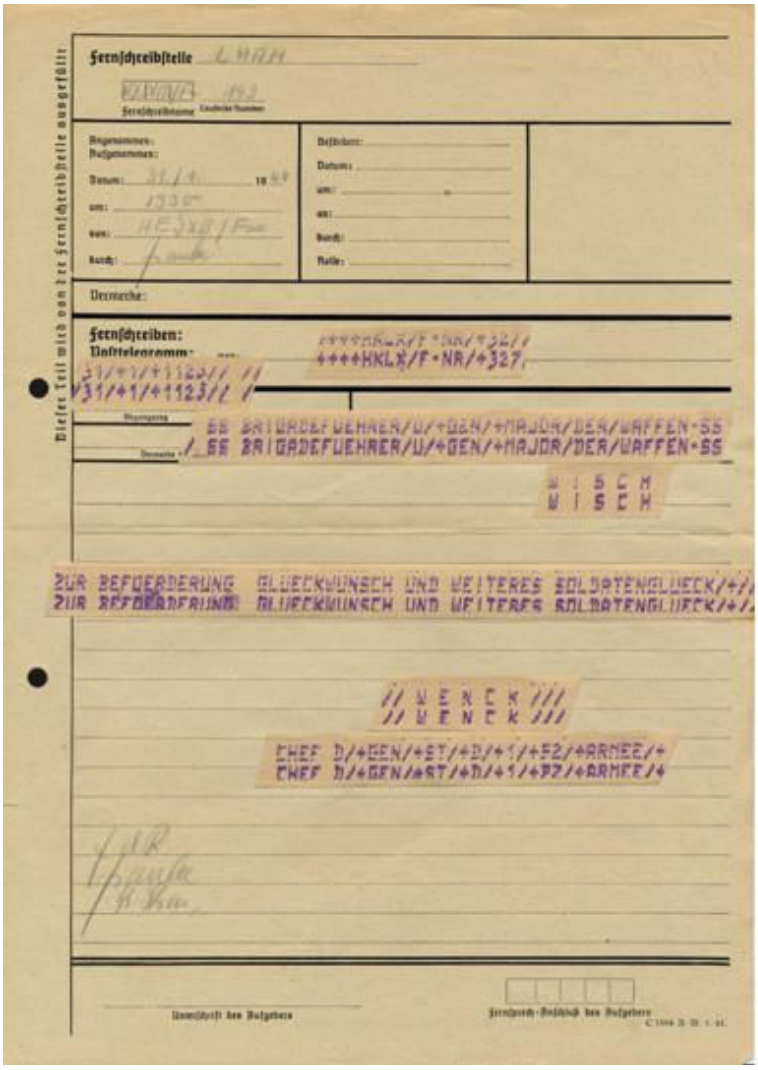


Figure 96: Feldfernschreiber message