

The Feld-Hell System

The most famous machine in this family is the well known and much loved German Army Feldfernschreiber, or "Field Text Writer". This machine dates from about 1936, and was designed by Siemens as a portable military unit, for field telephone and radio use, and manufactured by Siemens & Halske. About 14,000 of the most common model, the Siemens A2, were made in the period up to 1945. It was described in detail in a technical article by Siemens in the first issue of the Hell "Technical Notes", May 1940. The techniques, protocol and font used by this machine are still in use today.

Overview

The Feldschreiber operates from 12V DC, at about 2.5A (click [here](#) for full specifications). It has a DC motor which not only drives the transmitter and receiver mechanics via a beautiful gearbox, but also acts as a generator, producing +165 - 180V DC for the HT supply. One of the four identical pentode valves acts as a regulator, controlling the motor field current, and so not only regulates the HT voltage, but keeps the transmitter and receiver speeds constant. The motor has a centrifugal governor which drives the regulator valve, and the speed is adjustable to provide correct reception. The governor is able to keep the speed within 0.5% of the set speed.

The other valves are a 900 Hz audio oscillator, a line amplifier, and a solenoid driver. The units were built by Siemens in large quantities, over many years. As shown in the picture to the left, the equipment is in two assemblies, in a wooden box.



- A. The mechanical section with keyboard, transmitter drum, receiver system, power supply and motor, mounted vertically with gearbox below
- B. The terminal unit with all the electronics, connectors and line interface
- C. The wooden cover (meaning of text in this photo is "Hell Long Distance Writer" in Polish)

The Transmitter

The transmitter is different to all other systems before or since, as it uses a drum with contact on it, which rotates once when a key was pressed (other machines used cams). An interlocking system prevents further key-presses until the current character is complete. The typing technique takes some skill to perfect, as the next key needs to be lightly pressed during the transmission of the previous character, or else a blank will be transmitted. Although the unit has a space key, the skilled user will generally simply slip a character "slot" to obtain a space. The [keyboard](#) has four rows, in QWERTY format, except the "X" and "Z" were interchanged from the normal positions. There are two extra keys, one on the right labelled with a special red symbol, which locks the unit in "test" mode, the one on the left labelled with a green dot which cancels test mode. A really skilled operator could press two keys at once, and thus obtain "impossible" characters:



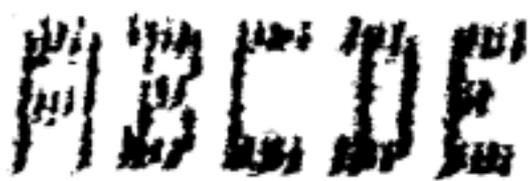
TEST TEST DE PA0AOB
TEST TEST DE PA0AOB
TEST TEST DE PA0AOB

Arie PA0AOB presses "0" and "/" to send his call sign

Probably because of the skill required to use the keyboard, the Feldschreiber only operates at 2.5 characters/sec(122.5 baud). Previous machines operated at 245 baud, and later ones even faster, but none of these used a drum based transmitter.

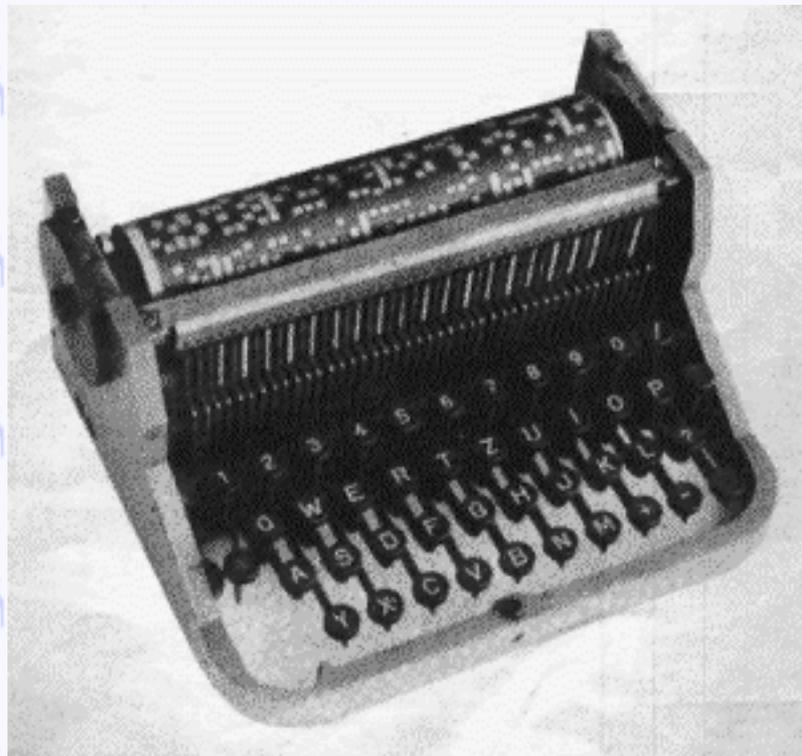
Each character of a Feld-Hell transmission is portrayed as a series of marks, in a matrix, just like the printing of a dot-matrix printer. The marks are sent one at a time, as an on-off keyed tone, just like Morse. The Feldschreiber transmits in the following order - up each column from bottom to top, then up each successive column from left to right.

The picture to the right shows a magnified fragment of printed Feldschreiber text "ABCDE", and you can see the individual pixels (they are rough vertical marks rather than dots).



The transmit order is up each column from left to right, then each successive column from left to right. If you look carefully, you will see a time displacement of the dots on the right side of the "B". This provides a resolution equivalent to one half of a dot, but at no expense of transmitted bandwidth. Looking at this picture, it is easy to see that the transmitter duty cycle is quite low (about 22%).

150 characters are transmitted every minute. Each character takes 400ms, and all characters have the same number of columns. Since there are 49 pixels per character, each pixel is 8.163ms long. The effective baud rate is $1/8.163 \text{ ms} = 122.5 \text{ baud}$, and the throughput is 2.5 characters/sec, or about 25 WPM.



Feldfernsehreiber Keyboard and Drum assembly

Since the transmitter drum rotates only once per character, one ring of contacts on the drum is used per character, and the character matrix described above is rearranged to wrap around the drum.

In this picture, you see the keyboard in front and the transmitter drum with its contacts behind it. The drum is driven by the gear on the left. (Picture from Ham Radio December 1979)

The Font

The font used by the Feldschreiber is very special - it was designed to provide very clearly readable text in noise, and has a number of unique features:

- An upper case only font set, with numbers and four symbols, +, -, ? and /.
- A 7 x 7 dot matrix with marks twice as high as they are wide.
- Unusually shaped numbers to ensure uniqueness, like the long tailed "3".

- Dot allocation carefully designed, so that although the font is in essence a 14 x 7 dot matrix, the transmitted bandwidth is the same as a 7 x 7 font (122.5 baud), since single dots are never transmitted alone. This has the effect of improving the shape of the characters without adding to the bandwidth.



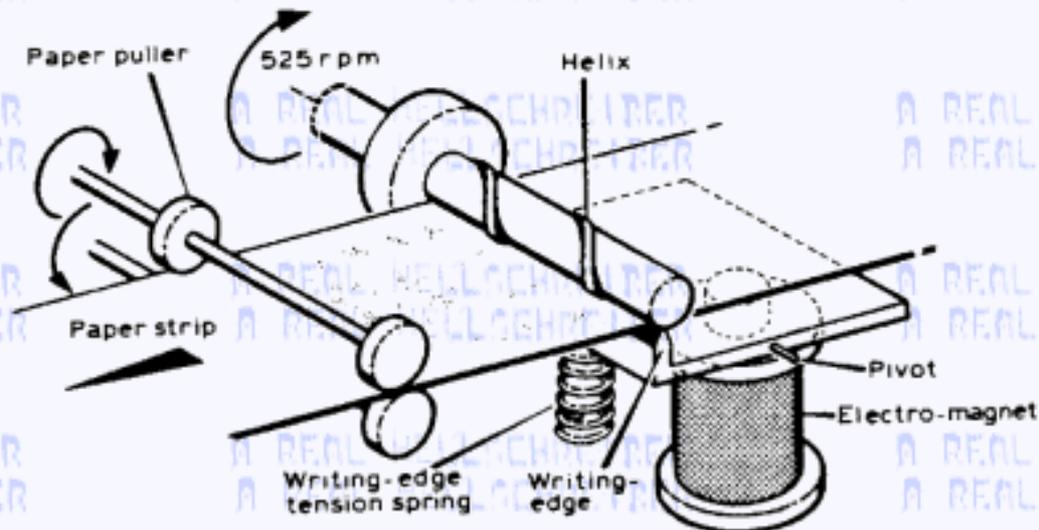
Transmission from a 1944 Feldfernsehreiber

The Electronics

The four valves are all type [RV12 P4000](#), and fit into the top of the [electronics box](#). The transmitter consists only of the 900 Hz oscillator, "Ton-Summer" with its output keyed by the drum mechanism onto the line. The motor speed is controlled by the speed regulator "Reglerstufe", in association with the governor contacts on top of the motor. The receiver has switchable 900 Hz bandpass filter, a pre-amplifier valve "Vorstufe" followed by a copper-oxide full wave rectifier (detector) and the print hammer driver "Endstufe". The power supply fuse holder is also mounted in the top of the electronics box.

The Receiver

The receiving system is very simple. An electro-magnet is driven by the received signal. This pulls the hammer, which taps on the back of a continuously moving strip of 15mm wide gummed paper tape. When the hammer taps, its writing edge causes the paper to momentarily touch a spiral protrusion on the helix drum above the paper. This spiral is coated with ink, similar in consistency to stamp-pad ink, and so leaves a mark on the paper. The spiral drum rotates at 525 RPM, corresponding to the column rate of the transmitted signal.



Sketch of the Printing Helix (courtesy *Radio Communication* 1981)

The spiral is re-inked by an ink-soaked felt roller rotating above the helix. The spiral on the drum actually has two turns, so two marks are made on the paper, and the text prints twice, each letter replicated one above the other.

An excellent [drawing](#) of the receiving mechanism was printed in the war-time technical manual. The receiving mechanism is also visible at the bottom left corner of the next photograph.

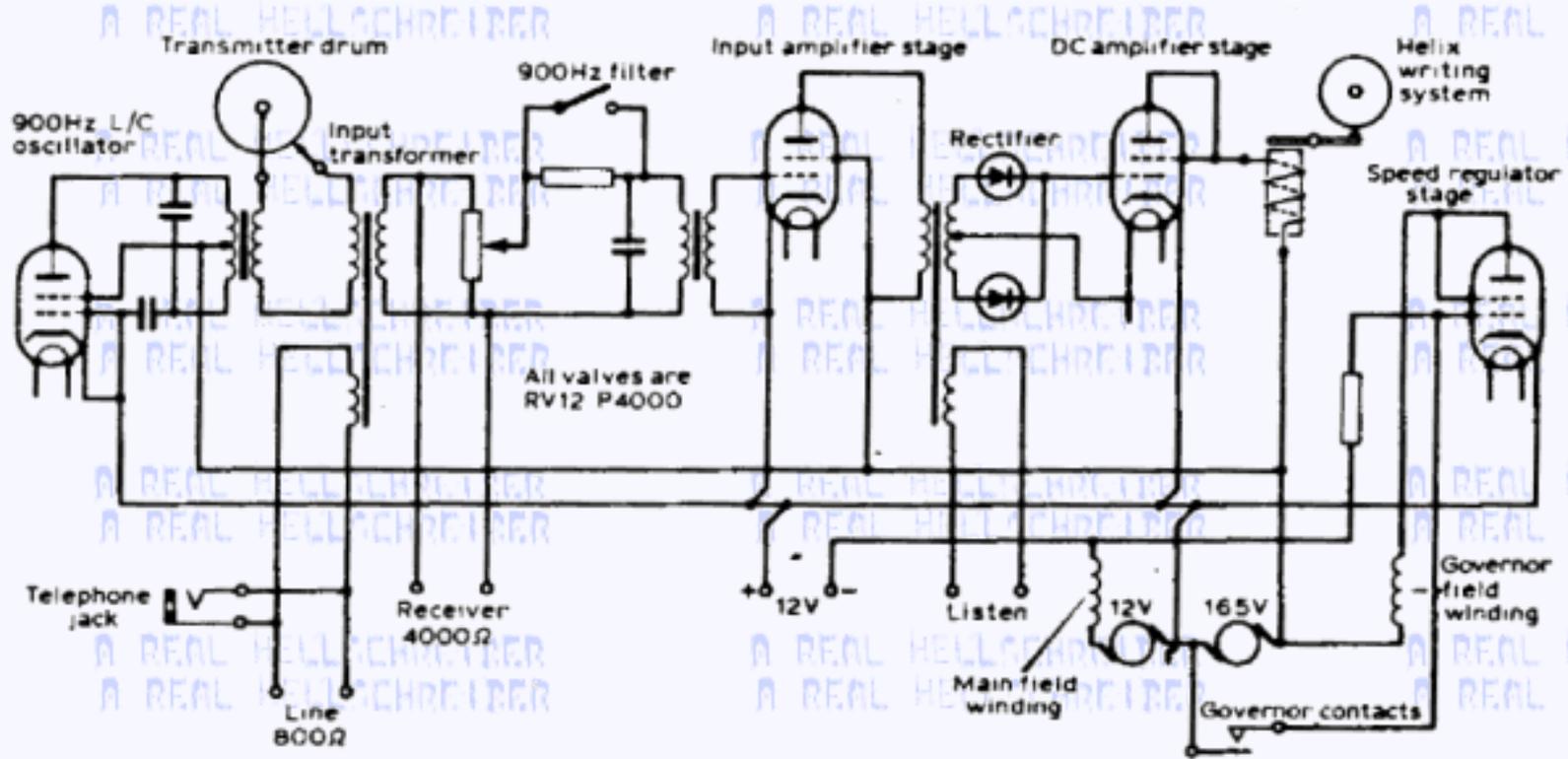


The Feldfernschreiber machine above (Model A2, Serial Number 15672) was built in 1944, and is still in operation. Many of these well-made machines are carefully stored or still in use by Amateurs. (Photograph courtesy Dick PA0SE)

Connections

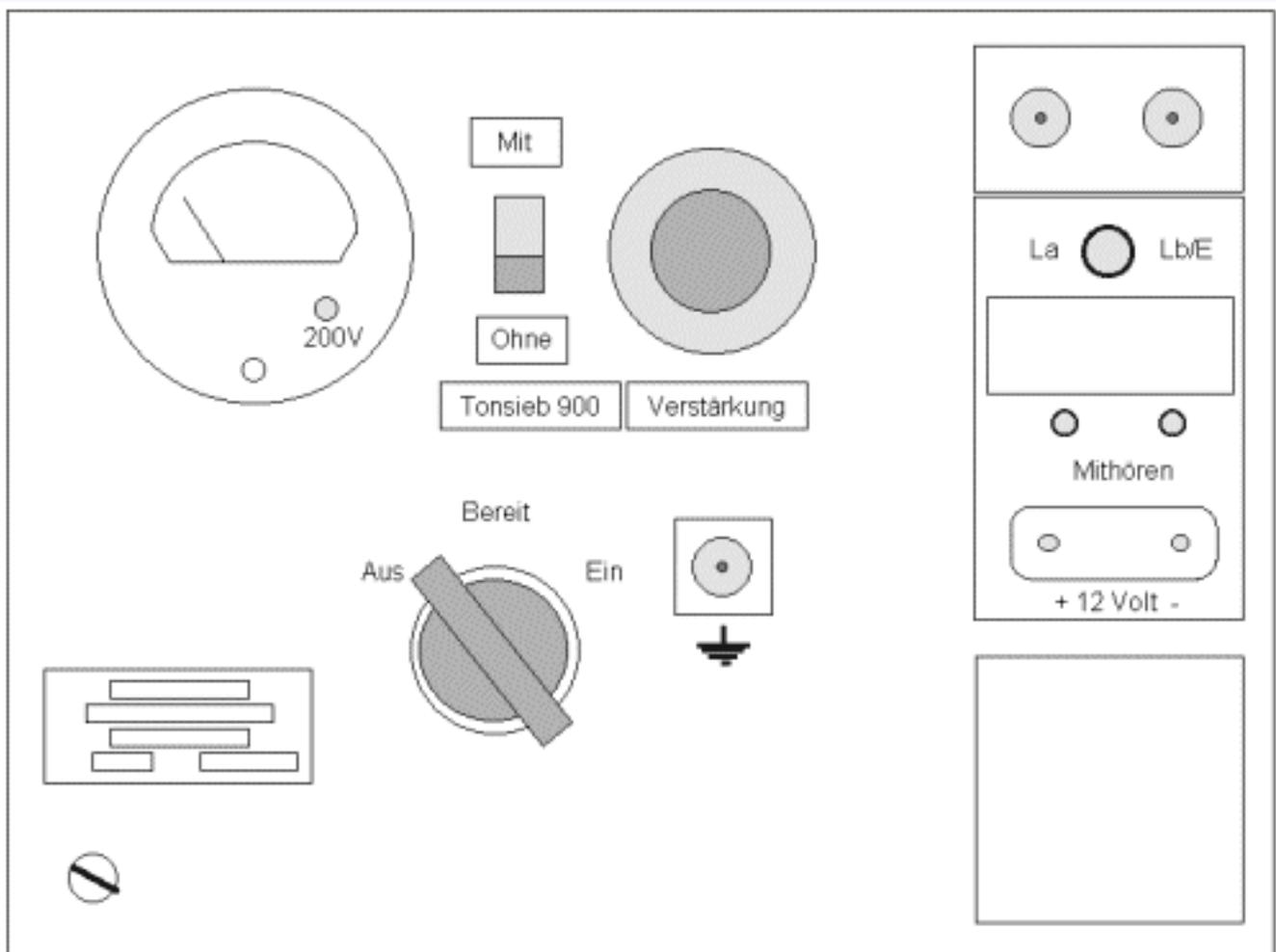
The machine was designed for field-telephone land-line and radio use, and a series of plugs is arranged on the panel to allow flexibility. The transmitter consists of an on-off keyed 900 Hz oscillator. As you can see in the simplified schematic below, the oscillator runs continuously, while the output is keyed to the line and the receiver via the transmitter contacts. The machine was used on both four-wire and two-wire field telephone circuits. When used on radio circuits, it was generally used by sending the land-line tones directly to the modulator of an AM transmitter.

These days an SSB transmitter is used, so the transmission is CW, indistinguishable in spectrum from 80 WPM Morse. By disconnecting the transmitter drum, it is possible to use the Feldschreiber to directly key a CW transmitter, but when used in this way no local copy is possible, since the local copy is provided by the keying of the audio oscillator. For a full schematic of the Feldschreiber, download [circuit.gif](#) (87k).



Instructions

The Feldfernsehreiber has three switches, a meter, several connectors and a speed adjustment lever. Most of the controls are on the [front panel](#) (see drawing below). The meter, top left, indicates the DC supply voltage, or when its little blue button is pushed, the high voltage supply. To the right of the meter is the 900 Hz filter on/off switch "Tonsieb 900", and beyond it the receiver audio gain control "Verstärkung".



Below the audio gain control is an earth terminal, and to its left, the Off/Ready/On main switch, labelled "Aus - Bereit - Ein". The connections at the right, from top to bottom, are the telephone line terminals "Leitung", a telephone jack (across the phone line), and

terminals for listening to the incoming signal with high impedance headphones "*Mithören*". These terminals are also connected across the line when the unit is not in use, so the line can be monitored. Below is the 12V DC supply socket. The blank rectangle at the lower right may have an optional large round 12 pin receiver connector, labelled "*Empfänger*". This version also has an extra signal light. At the lower left corner is a latch which secures the shock mounts during transit.

The simplified setting up instructions are printed in the lid, along with a simplified schematic similar to the one above. The instructions are as follows:

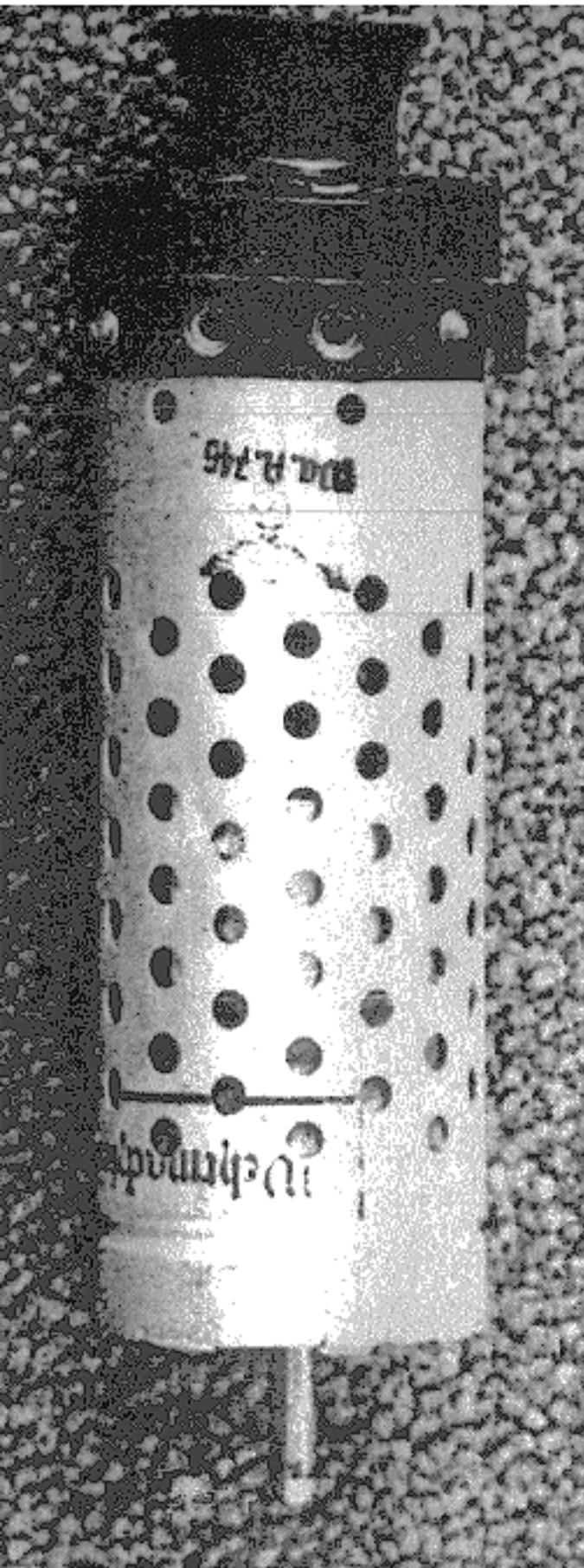
Setting-up Instructions for the S-H-Feldschreiber

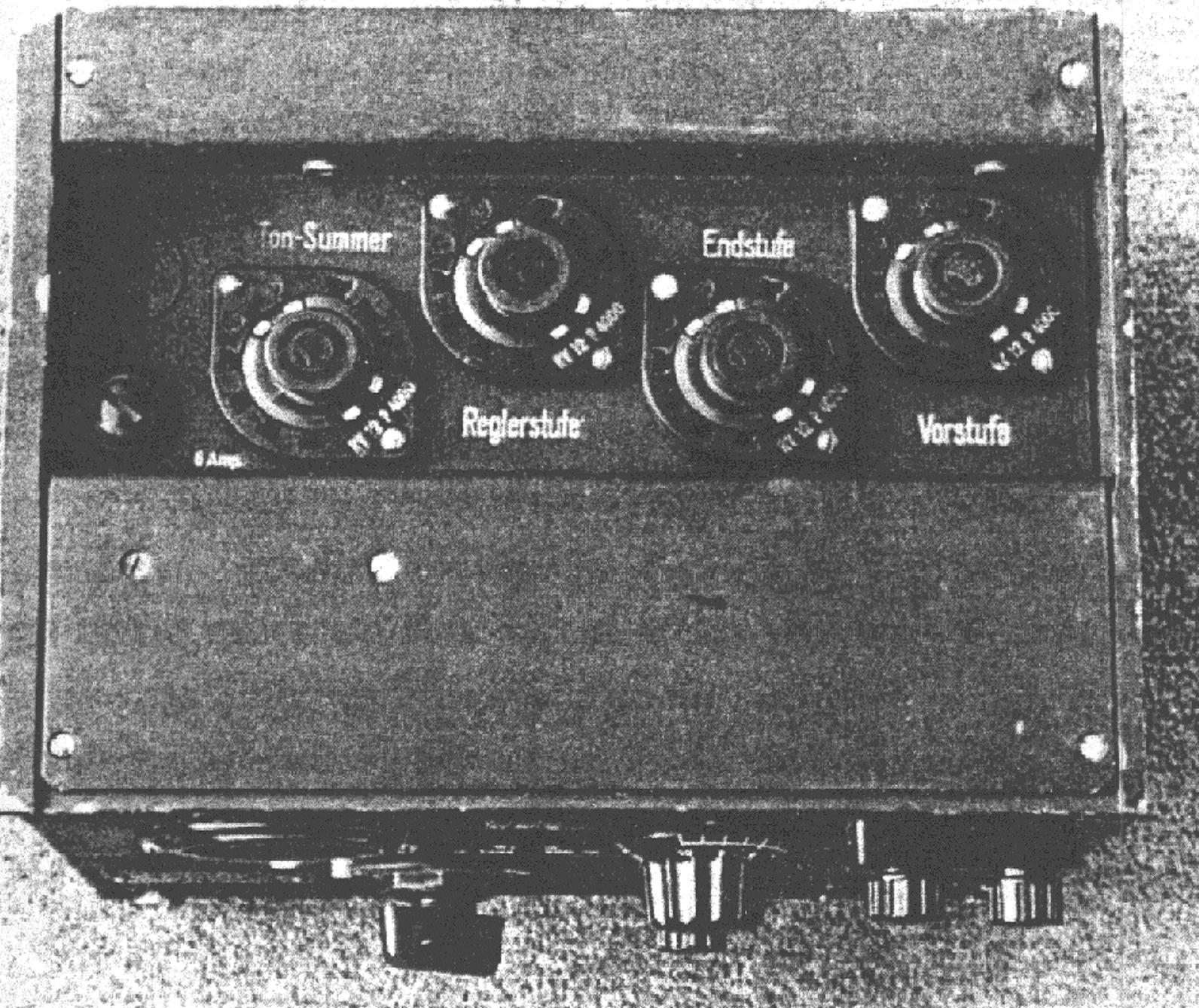
- 1. Place the equipment in the working position.**
Release the latch at the lower left corner with a 1cm tool (or coin). Pull the catch (labelled Riegel lösen - "Release lock") until the latch plate releases. Pull the machine forward in the case until the latch catches again.
- 2. Check the paper supply.**
Pull the knob under the centre of the keyboard and lift the lid. Press the locking buttons on the right to release and pull out the paper boxes.
- 3. Insert the paper.**
Separate the start of the paper roll in such a way that the paper roll and the paper runs clockwise. Pull the paper strip through the guide in the box, and rotate it 90° so the glue side is down, and while pressing in the box, lead it through the guide slot in the baseplate. Load both boxes.
- 4. Introduce one paper roll to the system.**
Pull the ink roller lever upwards and pull the paper under the printing spindle and between the feed rollers.
- 5. Connect the 12V Supply.** Ensure that it is the correct polarity!
- 6. Connect the telephone line.**
- 7. Switch the Main Switch to "Ready".**
The pilot lamp lights, and the Voltmeter indicates the correct battery voltage in the red area.
- 8. Wait one minute** while the equipment warms up.
- 9. Switch the Main Switch to "On".**
The pilot light goes out, the motor starts, and the Voltmeter indicates the correct anode supply in the blue area when the blue button is pressed.
- 10. Typing Hints.**
When a finger presses a key lightly, it will move slightly, and lower itself fully when the drive mechanism allows. When the key releases the following key will depress.
- 11. Adjust reception for best writing quality.**
- 12. Adjust for straight text.**
If the writing moves upward, rotate the governor cap on the motor upscale; if down, rotate the cap down.
- 13. Ink Roller replacement.**
Pull the ink roller lever upwards until it latches. Take off the used roller and fit a replacement from the accessory box. Reink the used roller before storage.

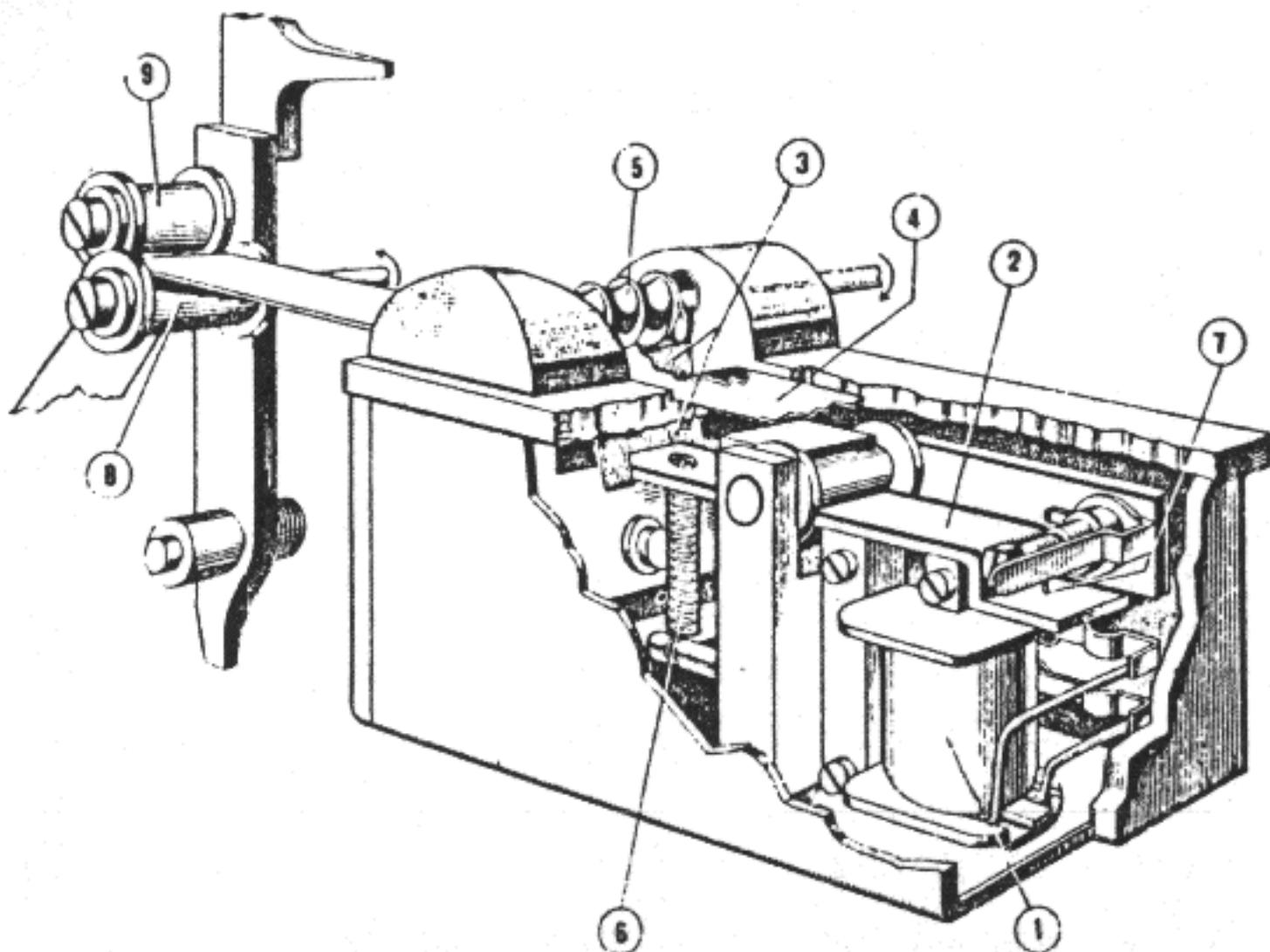
Historical Use

The Feldschreiber was used in great numbers, by the Condor Legion in the Spanish Civil War, by the Wehrmacht during WWII, and by Swedish Army until as late as the 1960's. The Czech Army also used captured German Feldschreibers after the war. The Germans also used the Feldschreibers in aircraft during the war. Feldschreiber copies were built in Britain and the USA to monitor German traffic. There is no confirmation available that these machines were used to transmit Enigma or other cypher traffic.

Amateur use of these machines dates from March 1958, when DL1GP first worked DM3KG. Operation in Holland, where many of the machines ended up at the end of the war, was not officially recognised until mid 1976.







Empfänger des Feldfernsehreibers

The Hellschreiber Printing mechanism

Legend

- | | |
|---------------------------------------|--|
| 1. Electromagnet (Magnet) | 6. Armature Tension Spring (Ankerrückzugfeder) |
| 2. Print Hammer Armature (Anker) | 7. Stop Pin (Anschlagstift) |
| 3. Print Hammer (Schneide des Ankers) | 8. Paper Drive Roller (Papiervorschubrolle) |
| 4. Paper Strip (Schreibstreifen) | 9. Pinch Roller (Andruckrolle) |
| 5. Rotating Scan Helix (Schraubenrad) | |

