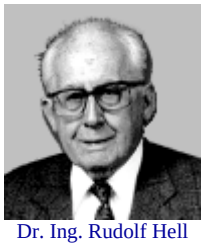
A History of Hellschreiber

Hellschreiber - Hell Writing - is a fascinating, but little known facet of communications engineering. Hellschreiber, the first really successful Facsimile mode, is as old as electronics itself.

Hellschreiber is a method of sending text by radio or telephone line that involves dividing each text character into little pieces and sending them as dots. Hellschreiber was invented by the German inventor, Rudolf Hell, who patented Hellschreiber in 1929.

This web site aims to accurately document the history and development of the Hellschreiber, and related "Fuzzy" techniques. My grateful thanks to DL1OY, EA2SN, G4AKD, IZ8BLY, ON4ASZ, PA0AOB, PA0SE, PE1AQB, SM6MOJ, the late G5XB and others for the information here. For information about "Fuzzy" modes and modern Hellschreiber activity, visit the Fuzzy Modes web site.



Dr. Ing. Rudolf Hell

Hell Timeline

1838 The Morse telegraph was invented.

1901 Rudolf Hell was born 19th December, in Eggemuehel, Bavaria.
In December 1901 Guglielmo Marconi succeeded in transmitting radio signals across the Atlantic.

1902 Teleprinters (made by Frederick Creed) first used by the British Post Office.

1903 Donald Murray (New Zealander) developed a five digit code for teleprinter use, from which evolved CCITT Code No 2 (ITA2).

1907 Rudolf Hell moved to Eger (now in the Czech Republic), and started school.

1927 Hell gained Doctorate in Electronic Engineering, for a paper describing his invention of an automatic direction finder for aircraft navigation.

1929 Hell patented a "Device for the electric transmission of written characters" - the Hellschreiber.
Dr. Rudolf Hell GmbH company formed in Berlin, to manufacture the Hell recorders.

1931 Hell tested an electrochemical Hellschreiber transmitter using dampened paper.

1932 Hell demonstrated the electromechanical helical scan printing system.

1933 900 Hz audio tone first used with an electromagnetic synchronising system.
Siemens& Halske Hellschreiber described.

1937 A Concurrent MT-Hell type system first demonstrated by the Le Matériel Téléphonique company, on a path from Algiers to Paris.

1940 Landmark technical paper "Die Entwicklung des Hell-Schreibers" (The Development of Hell Writers), published by Rudolf Hell.
The Siemens A2 Feldfernschreiber for military use was described in detail.

1941 "Bernhard" navigation system began operation, with Hellschreiber bearing transmissions.

1944 Numerous press agencies were active on LF and HF using Hellschreiber.

1947 His company bombed out of existence toward the end of the war, Hell started the company up again, this time in Kiel.

1950 Hell patented the Klischograph, a process for half-tone photo engravure.
GL-Hell (start-stop machine) introduced. Used by the Bundeswehr (German Army) and the Bundesbahn (German Railways).

1954 First HF FSK teleprinter links introduced.

1958 First amateur Hell contact on HF, DL1GP - DM3KG March 1958.

1967? Transistorized Hell 80 machine introduced, intended for military applications.
Thomson Hell machine dates from about this time.

1974 Bundeswehr released numerous GL-Hell machines, which amateurs such as DJ2HN started using.

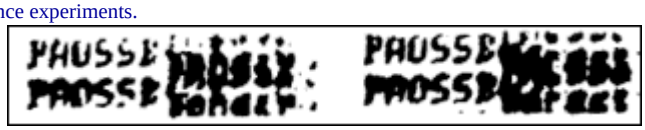
1977 Article by Hans PA0CX appeared in *Electron*.

1978 The "PA Hell gang" started up, PA0SE, PA0CSC and PA0VYL meeting at the QTH of PA0AOB.

1979 Widely read article by Hans PA0CX published in *Ham Radio Magazine*.
Article by PA0SE in *Reflekties*

1980 Apple II Hell program developed by Klaas PA0KLS.
First DARC Hell Contest April 12 & April 16 1980. 9 stations took part on 80 & 40m, 5 on 2m.

1982 First amateur Hell moon-bounce experiments.



Jan PA0SSB bounces Hell off the moon

1990 Dr. Rudolf Hell GmbH company merged with the Linotype Corporation.

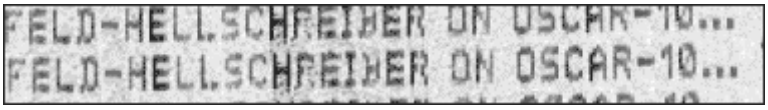
1997 Hell software for the PC by Sigfus LA0BX became widely available.
Concurrent MT-Hell using 16 tones developed by Peter G3PLX.

1998 Term "Fuzzy Modes" coined, and the Fuzzy Modes web site started.
Sequential MT-Hell Mosaic II invented by Murray ZL1BPU, and used to work antipodean DX.

First Mosaic II QSO

EVM Hell by G3PLX used to work world-wide Hell DX for the first time.
Long time Hell exponent Hans DL1GP dies.

1999 Peter KD7MW successfully transmitted Hell via amateur satellite Oscar 10.
Windows 95 Hell software by Nino IZ8BLY released and widespread Hell DXing results.
Very slow Hell (2.7 baud) used by G3PPT for beacon tests with FFT receiving software.
New MFSK Hell mode developed by IZ8BLY - "DuploHell" - is highly noise immune.

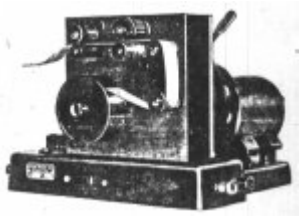


Peter KD7MW on Amateur Satellite AO-10.

The Equipment

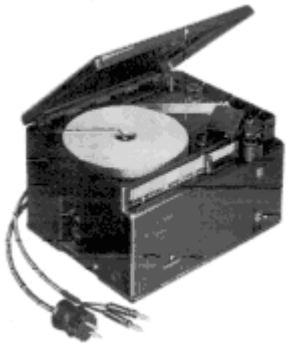
This information is very much a "work in progress", as information on some of this equipment is now very hard to find. All assistance is appreciated. The machines are grouped by "system". Not all these systems were developed by Hell or the Hell company. Click on each system title or picture for further information.

Early Developments



In 1929 Hell demonstrated an electrochemical character scanning device for transmitting the text. This used fingers to measure the characters on moistened paper, but for that reason was not practical. In 1931 the helical worm and hammer electromechanical scanning device first appeared. Another early system used an electrochemical printing system. In 1935 Hell supplied portable Hellschreiber machines in "kit bags" to the German Army (the Wehrmacht). By 1940 when the landmark paper *Die Entwicklung des Hell-Schreibers* (The Development of the Hell-Printer) was published, all the important technology had already been developed. (Picture of experimental electrochemical device from *Die Entwicklung des Hell-Schreibers*, 1940 by R. Hell)

F-Hell



The F-Hell machine was a synchronous machine which operated at 5 characters/sec (245 baud), and used ITA2 code punched tape as a transmitter source. This machine was intended for press service and was widely used before, during, and after WWII. The F-Hell machine was receive only, as the transmissions were from paper tape. The F-Hell equipment was introduced in 1932, and incorporated the double line printing technique. Nothing is yet known about the companion transmitter, although the system was known to be still transmitting sports news on 44.25 kHz as late as the mid 1980s. (Picture courtesy of Arie PE1AQB)

Feld-Hell

The now well known portable military machine, the Feldfernschreiber or "Field Text Writer" dates from 1932. It is a four-valve, motor driven, 12V DC operated unit with a drum based transmitter and a worm and hammer receiver system. The Feldschreiber operates at 2.5 characters/sec, probably because of the limitations of the keyboard mechanism. The machine was designed for field-telephone land-line and radio use. The keyboard is very limited - only upper case letters, numbers and the symbols + - ? /, and a special technique is required to press the keys to maintain correct typing speed without gaps. The Feldschreiber uses double row printing and a specially designed 14 x 7 font with minimum possible bandwidth. The on-off keyed tone is 900 Hz. The techniques, protocol and font used by this machine are still in use today. (Picture courtesy of Ko Versteeg NL9222)

GL-Hell

The GL-Hell machine (Siemens model 72C) is a post-war asynchronous machine (1950) intended for land-line press service. It operates at 6.1 characters/sec (300 baud), and includes a paper tape reader. It transmits a single tone, 1000 or 3000 Hz, on - off keyed. The purpose of the 3000 Hz tone was to allow the GL-Hell and a voice telephone to share the same circuit. The transmitted signal has a start pulse up the left edge of each character, and although text no longer slopes if the speed is in error, individual characters can slope. The GL-Hell featured automatic call answering, signalling and clearing, so could be used on a common public telephone line. The system is not suitable for use on HF due to serious garbling of text caused by received noise. The machine prints a single row of text, and the keyboard is normal typewriter style. (Picture courtesy of Arie PE1AQB)

L-Hell

The L-Hell machine (Siemens model L) dates from about 1950, and is an asynchronous receive-only unit for land-line press service. The L-Hell is believed to operate at 6.1 characters/sec (300 baud). The machine prints a single row of text. More information required. (Picture courtesy of Arie PE1AQB)

Hell-80

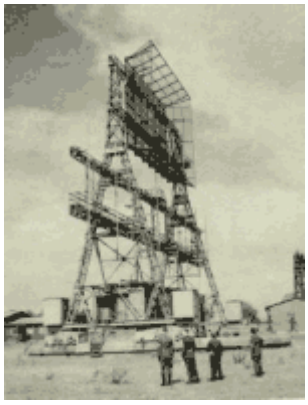
The Hell-80 machine is a portable transistorised machine for military service, introduced about 1960. It will operate from -20 to +50°C in both synchronous and asynchronous modes, at 5 characters/sec (315 baud), and includes a CCITT No. 2 code paper tape reader and NATO standard line interface. This machine uses a different (9 x 7) font to all the others, and was the first Hell machine to use FSK. It uses 1625 Hz white, 1925 Hz black, and 1260 Hz signal tones, and the receiver uses an AM technique. In asynchronous mode, this machine is ideal for unattended operation. (Picture courtesy of Arie PE1AQB)

LMT

The French company Le Matériel Téléphonique developed a concurrent tone system using seven wide spaced tones. Using a largely mechanical technique, this equipment used seven tone generators and generated characters as horizontal vectors. The receiving equipment used seven separate matched filters and amplifiers, each with independent AGC, driving seven stylii to write on carbon strip paper. The input to the transmitter was from punched tape or buffered parallel keyboard, both using the ITA2 code. The equipment was demonstrated on a path from Algiers to Paris in July 1937, but apparently never used commercially.

Bernhard

The "Bernhard" radio navigation system was developed to counter the Allied jamming that made the earlier "Knickebein" beam navigation system unusable. Bernhard and the companion "Bernhardine" and "Hermine" receivers were developed by Telefunken and first deployed in 1941.



This system used Hellschreiber technology to transmit the current azimuth of a huge rotating antenna, as it rotated. The small "Bernadine" receiver printed the bearing to the ground station on paper tape in the aircraft twice per minute, at a range of 400 km with an accuracy of ±1°. As well as having remarkable accuracy, later improved to ±0.5°, this system, unlike "Knickebein", used a rotating beam which gave no clue as to the course of the aircraft using it.

Hell Myths and Legends

A number of stories have gone around about the magic of Hellschreibers, their history, and their performance in the field. Are they true?

- The wartime Feldfernschreiber was used to transmit Enigma coded messages.
- It was common for troops at the front to send messages back to base using a Felsdchreiber and radio transmitter with only a barbed-wire fence antenna.
- During WWII the 6th German Army at Stalingrad was completely surrounded by the Russians, and the only link back to Hitler's headquarters was a radio Hellschreiber link.
- Stan Cook G5XB claimed in an article in *Radio Communication* 1981 to have built a Feldschreiber receiver from Meccano (an Erector-like construction kit) as early as 1942. (Stan apparently worked for the BBC during the war, receiving German Hell signals at their Beaconsfield receiving station).
- The Japanese built copies of the Hellschreiber machine which they used during WWII (Sony did make 10 - 20 units from about 1947 - see the interview with Nobutoshi Kihara).

Historical Links

- A Short History of Telegraphy by Sam Hallas G8EXV
- Donald Murray - a brief biography of a famous New Zealander.
- Biography of Rudolf Hell.
- Five Unit Codes, an explanation of Baudot, Murray and ITA2 codes, by Alan Hobbs G8GOJ.

Historical Bibliography

- "Murray Printing Telegraph" by Donald Murray, M.A. Sydney, 23/2/1905. Published by Unwin Bros., The Gresham Press, Woking, London (G.P.O. Library).
- "Die Entwicklung des Hell-Schreibers" (The Development of Hell Writers), Rudolf Hell in *Hell Techniche Mitteilungen* number 1/1940 pp 2-11.
- "Der Siemens-Hell-Feldschreiber" (The Siemens-Hell Field Writer), G. Ege & H. Promnitz in *Hell Techniche Mitteilungen* number 1/1940 pp 11-20.
- "Der Siemens-Hell-Schreiber" (The Siemens-Hell Writer), Siemens & Halske AG, in *Siemens Fernmelde Technik* SH 8354.443.TT1, 1943.
- "Stand der Siemens-Hell-Fernschreibtechnik" (The Status of the Siemens-Hell Printing Technology), by R. Zimmerman, Siemens & Halske AG, in *Siemens Fernmelde Technik* SH 7997.0,5..8.40.TT1, 1940.
  Specially reprinted in *Techniche Mitteilungen der Fernmeldewerks Abterilung für Telegrafengerät*, May 1940.
- "Der Feldfernschreiber" (The Field Text Writer, technical manual for Siemens model A1/A2 Feldschreiber), printed in Gothic script by the *Deutschen Zentraldruckerei, Berlin* D 748/1 dated 1/4/41.

- "Bernhard Anlage", from unknown German publication, more information being sought (thanks to Jan ON4ASZ).
- "Nostalgia or Reality?", Helmut Leiblich DL1OY, published in *Amateur Funk*.
- "Hellschreiber, What it is and How it Works", Stan Cook G5XB, in *Radio Communication* April 1981.
- "The Hellschreiber", by Richard König, *Radio Bygones* No. 51, Feb/Mar 1998.
- Letters, photographs, emails and personal experiences from DL1OY, G4AKD, ON4ASZ, PA0AOB, PA0SE, PE1AQB, SM6MOJ.

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 militaryunit, 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 theHell "Technical Notes", May 1940. The techniques, protocol andfont 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 onlydrives 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 valvesacts 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 whichdrives the regulator valve, and the speed is adjustable to provide correct reception. The governoris 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 pictureto 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

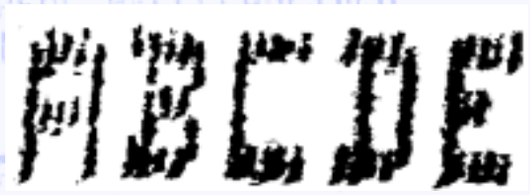
The transmitter is different to all other systems before or since, as it uses a drum with contactson it, which rotates once when a key was pressed (other machines used cams).An interlocking system prevents further key-presses until the current character is complete. The typingtechnique takes some skill 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 slipa character "slot" to obtain a space. Thekeyboard has four rows,in QWERTY format, except the "X" and "Z" wereinterchanged from the normal positions. There are two extra keys, one on the right labelled with a special redsymbol, which locks the unit in "test" mode, the one on the left labelled with a green dot whichcancels test mode. A really skilled operator could press two keys atonce, and thus obtain "impossible" characters:

Arie PA0AOB presses "0" and "/" to send his callsign

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 theseused 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 columnfrom 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 individualpixels (they are rough vertical marks rather than dots).

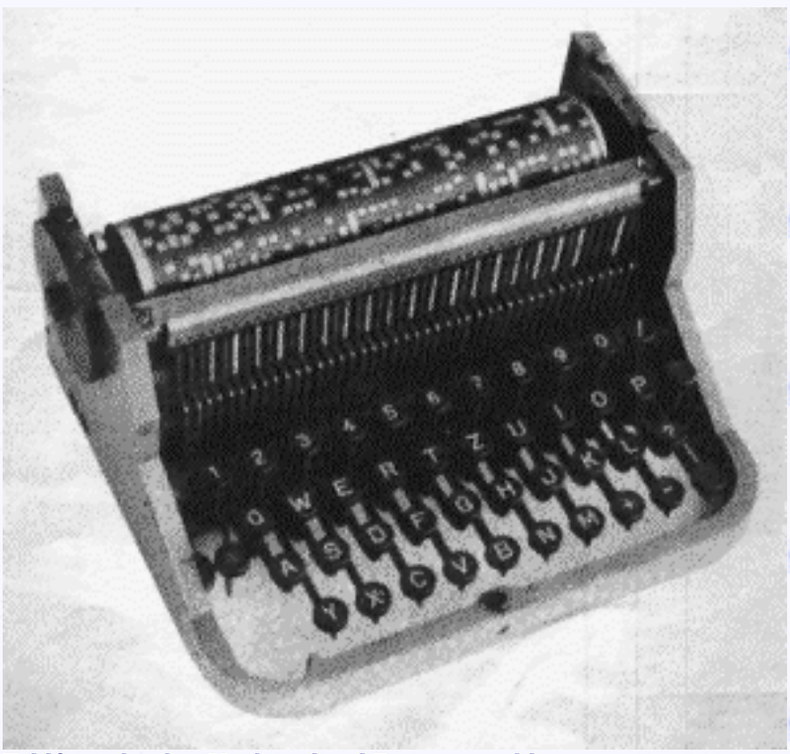


The transmit order is up each column from left to right, then each successive column from left to right.If you look carefully, you will see a time displacement of the dots on the right side of the "B".This provides a resolution equivalent to one half of a dot, but at no expense of transmitted bandwidth.Looking 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 havethe 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 ms = 122.5 baud, and the throughput is2.5 characters/sec, or about 25 WPM.

Since the transmitter drum rotates only once per character, one ring of contacts on the drum is used 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 itscontacts behind it.The drum is driven by the gear on the left. (Picture from Ham Radio December 1979)



Feldfernschreiber Keyboard and Drum assembly

The Font

The font used by the Feldschreiber is very special - it was designed to provide very clearlyreadable 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 nevertransmitted alone. This has the effect of improving the shape of the characters without addingto the bandwidth.

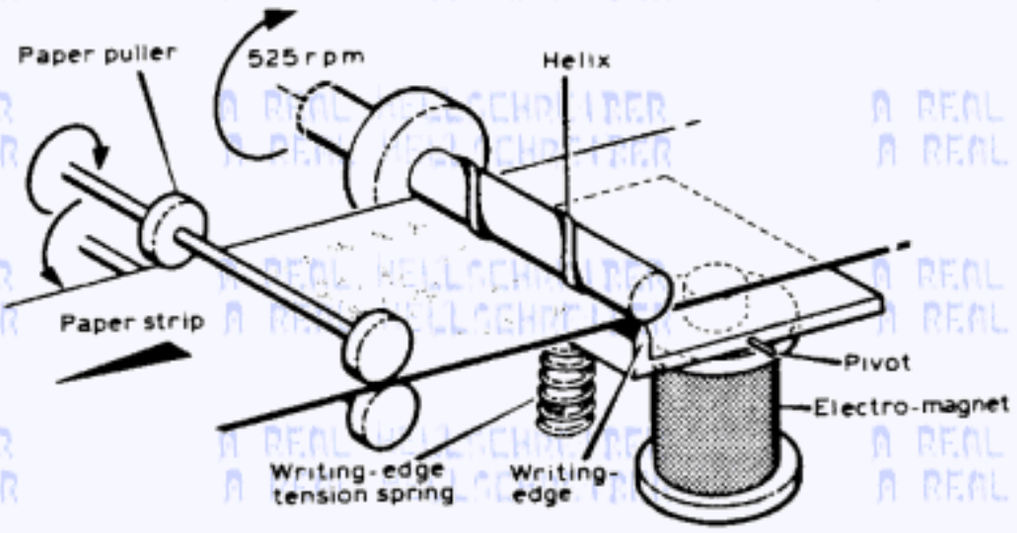
Transmission from a 1944 Feldfernschreiber

The Electronics

The four valves are all type RV12 P4000, and fit into the top of theelectronics 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 controlledby the speed regulator "*Reglerstufe*", in association with the governor contacts on top ofthe motor. The receiver has switcheable 900 Hz bandpass filter, a pre-amplifier valve"*Vorstufe*" followed by a copper-oxide full wave recitifer (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 tapson the back of a continuously moving strip of 15mm wide gummed paper tape. When the hammer taps, its writing edge causes thepaper 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 at525 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 drumactually has two turns, so two marks are made on the paper, and the text prints twice,each letter replicated one above the other.

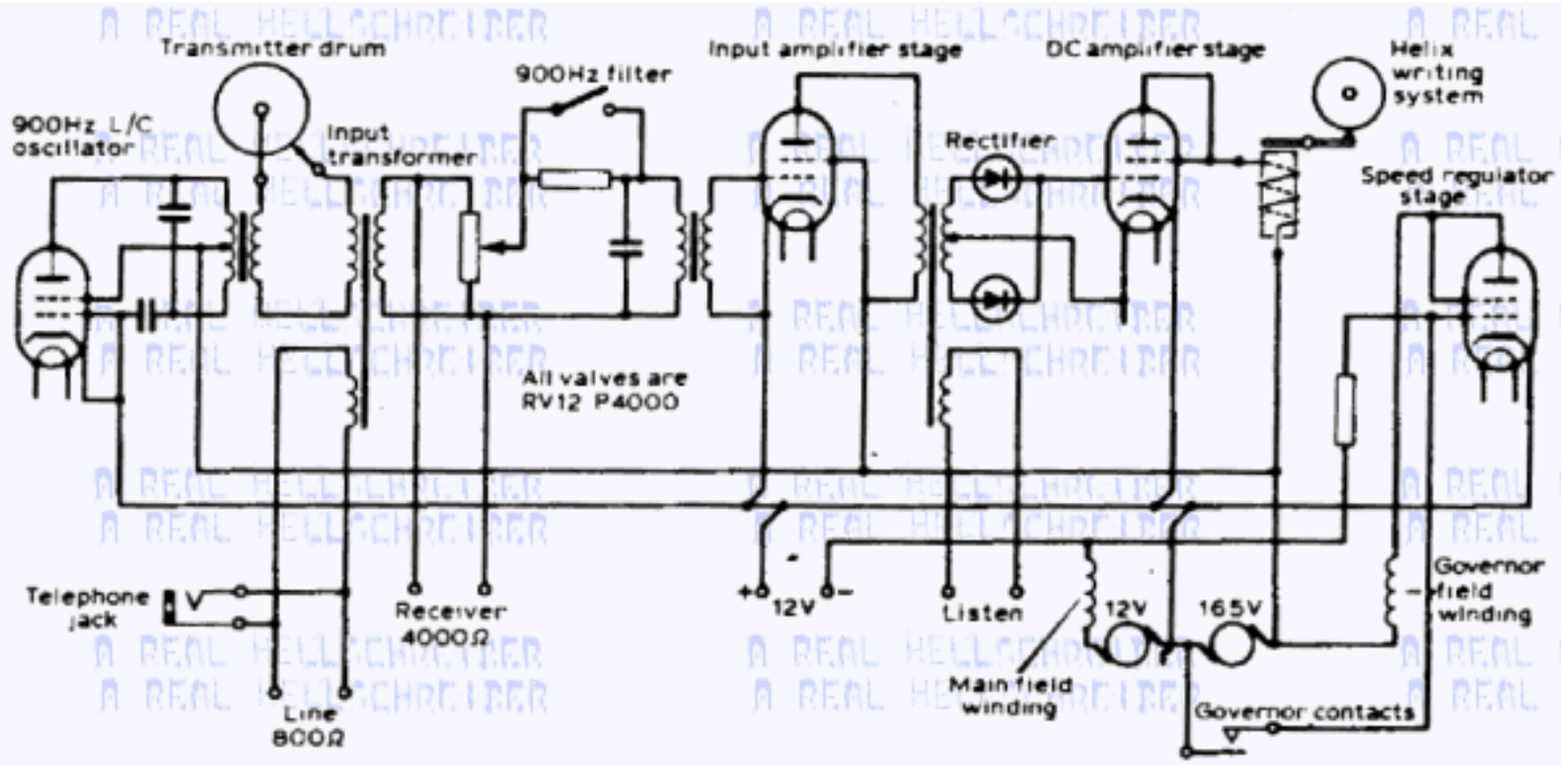
An excellent drawing of the receiving mechanism was printedin the war-time technical manual. The receiving mechanism is also visible at the bottom left corner of the next photograph.

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

Connections

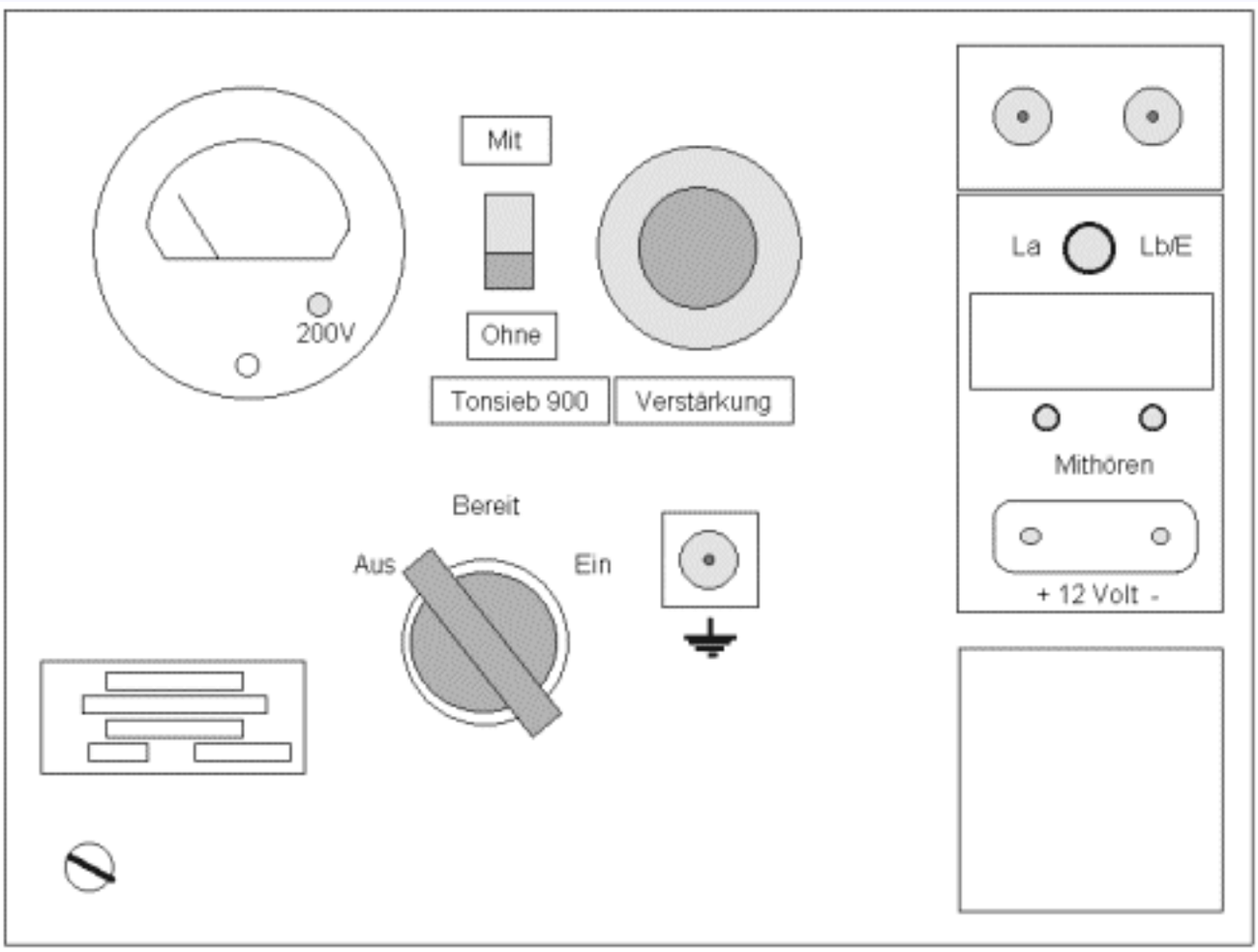
The machine was designed for field-telephone land-line and radio use, and a series of plugsis arranged on the panel to allow flexibility. The transmiter consists of an on-off keyed 900 Hz oscillator.As you can see in the simplified schematic below, the oscillator runs continuously, while the output is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

These days an SSB transmitter is used, sothe transmission is CW, indistinguishable in spectrum from 80 WPM Morse. By disconnecting thetransmitter drum, it is possible to use the Feldschreiber to directly key a CW transmitter, but when used in thisway 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 Feldfernschreiber 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 supplyvoltage, or when its little blue button is pushed, the high voltage supply. To the right of the meteris 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 withhigh impedance headphones "*Mithören*". These terminals are also connected across the linewhen the unit is not in use, so the line can also 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:

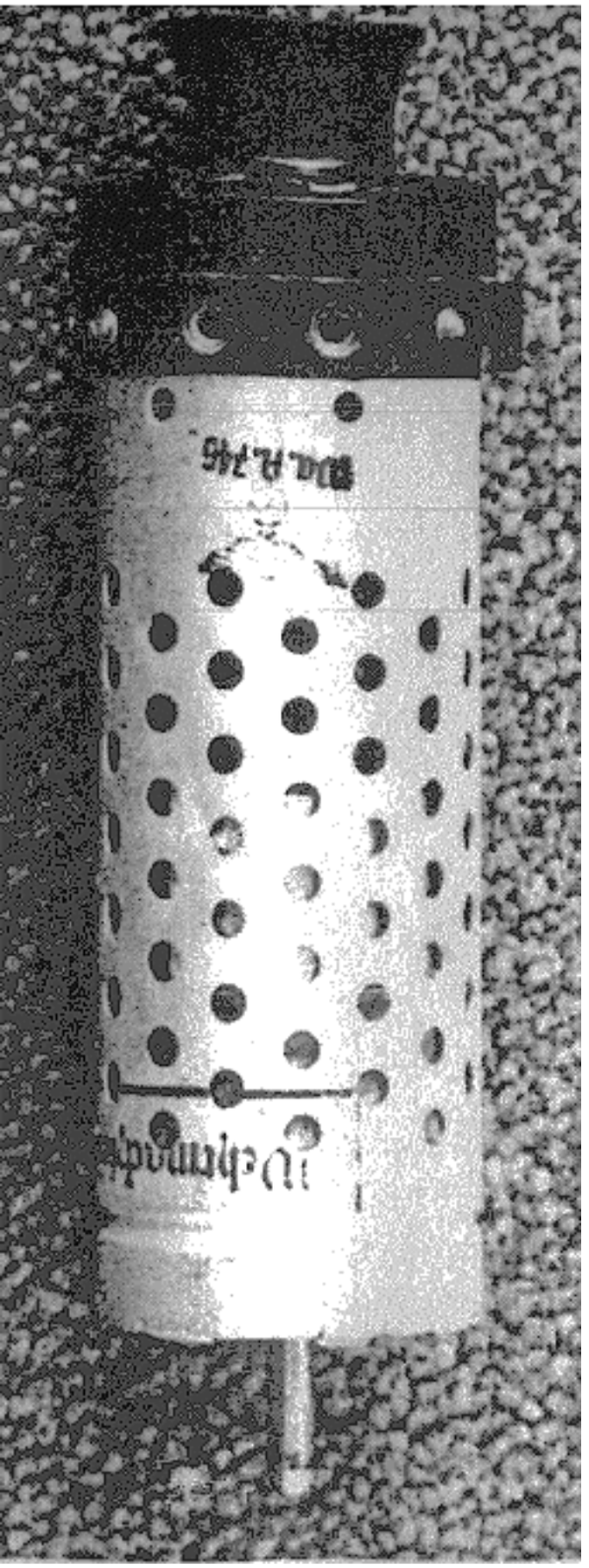
Setting-up Instructions for the S-H-Feldschreiber

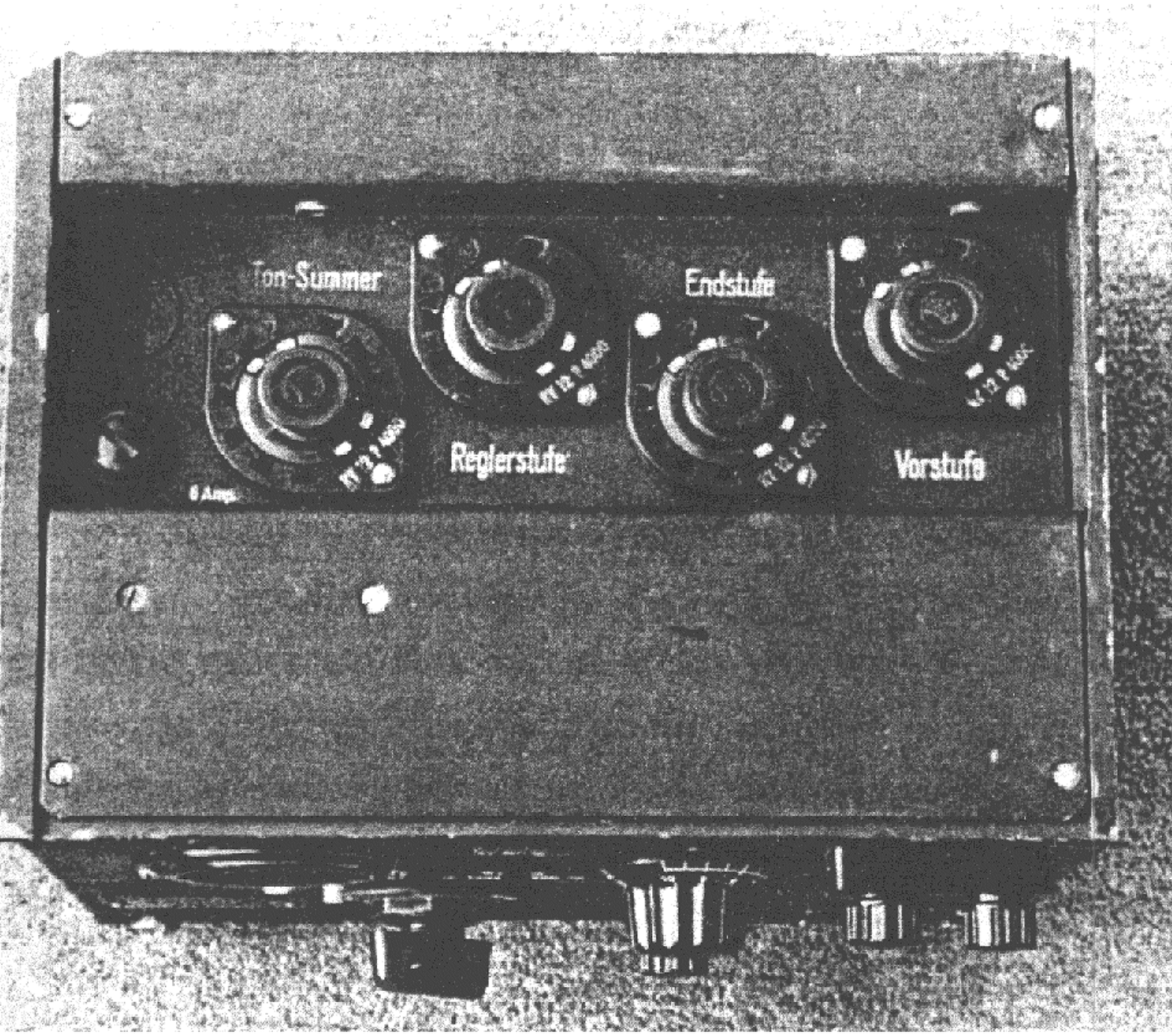
1. **Place the equipment in the working position.**
   Release the latch at the lower left corner with a 1cm tool (or coin). Pull the catch (labelled Riegel lösen - "Release lock)until the latch plate releases. Pull the machine forward in the case until the latch catches again.
2. **Check the paper supply.**
   Pull the knob under the centre of the keyboard and lift the lid. Press the locking buttons on the right to releaseand pull out the paper boxes.
3. **Insert the paper.**
   Separate the start of the 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 whilepressing 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 supplyin 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 drivemechanism 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 fromthe accessory box. Reink the used roller before storage.

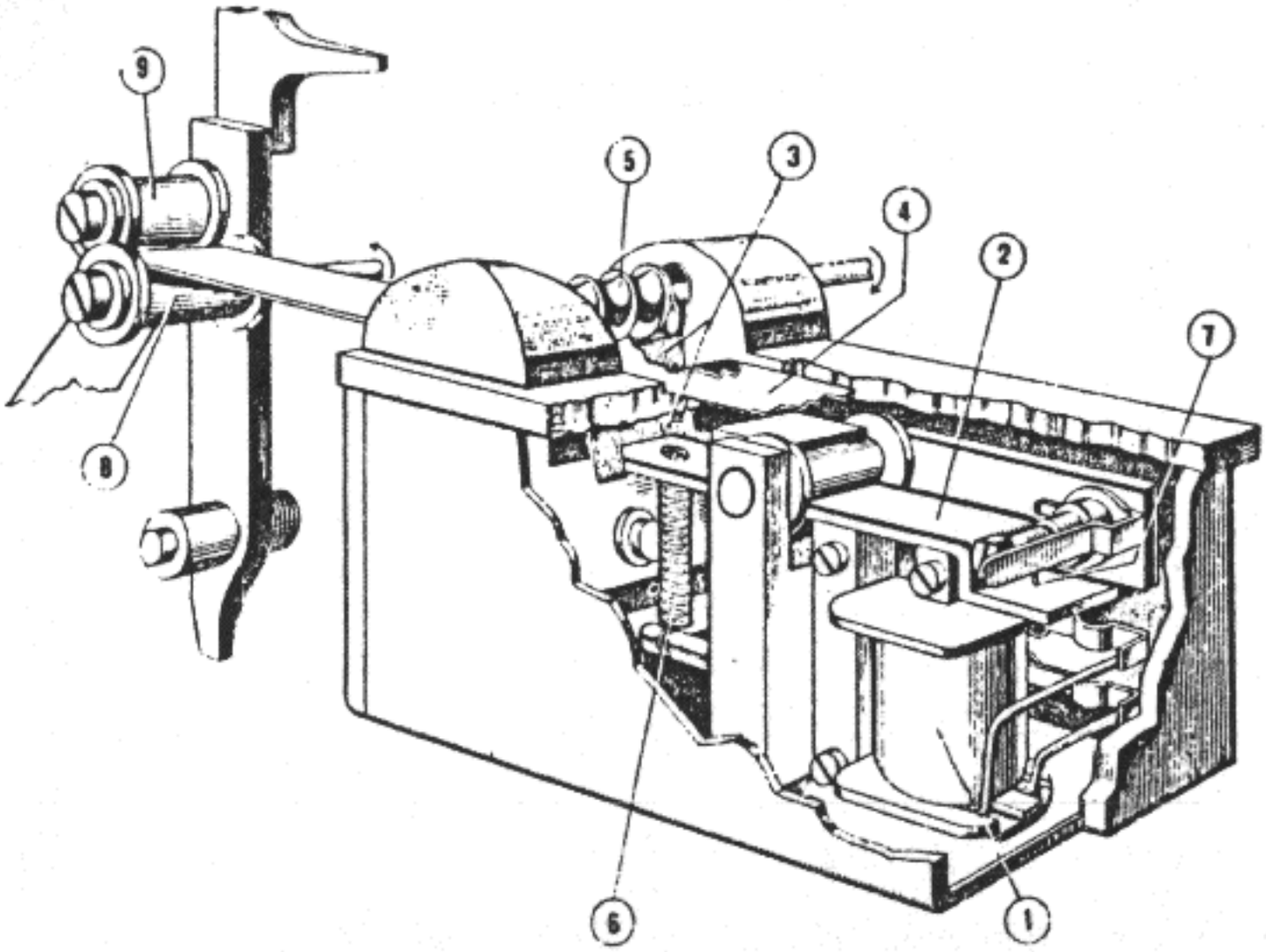
Historical Use

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 theUSA to monitor German traffic. There is no confirmation available that these machines were used totransmit 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.




Ton-Summer
Endstufe
Reglerstufe
Vorstufe
6 Amp.

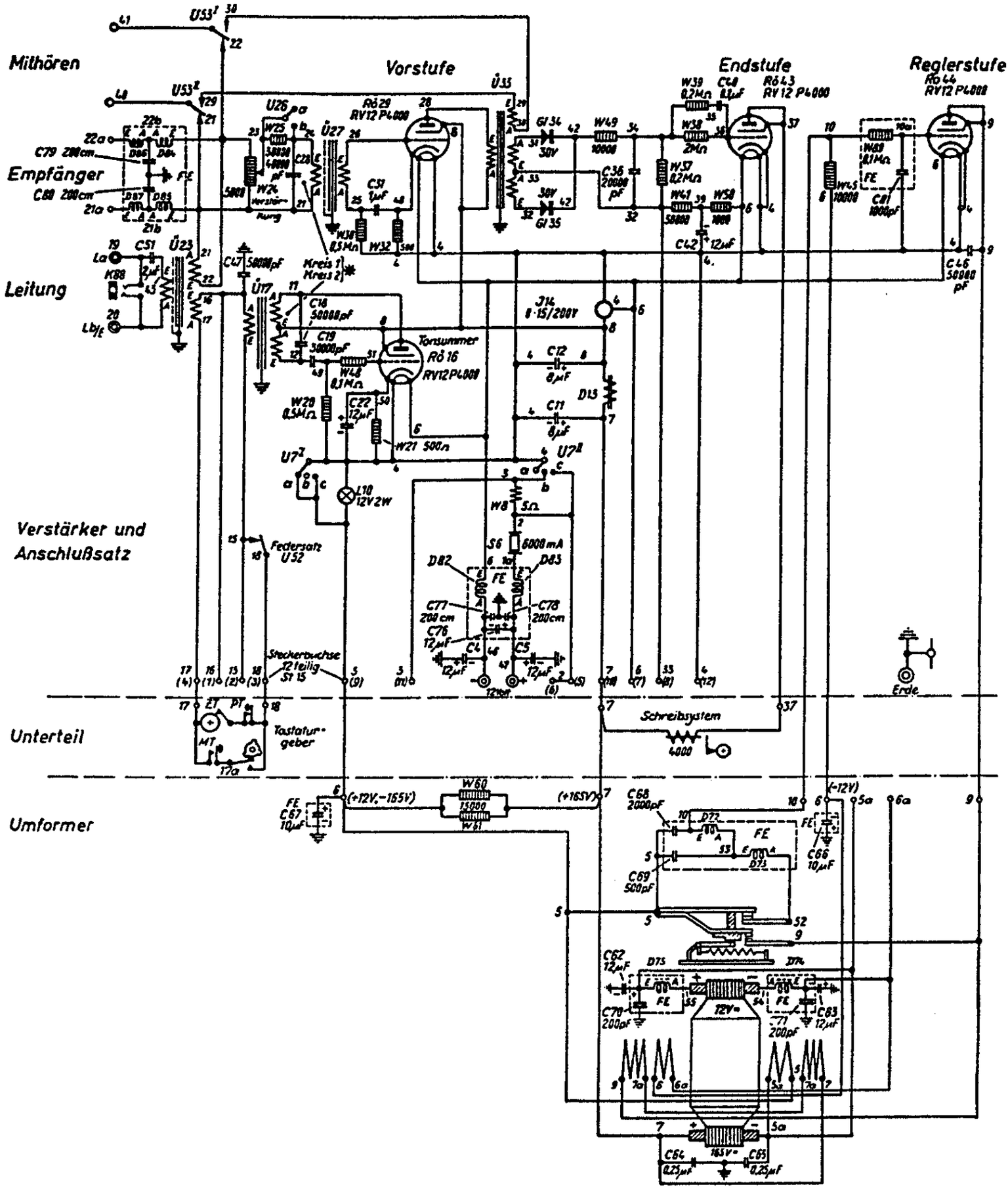


Empfänger des Feldfernſchreibers

The Hellschreiber Printing mechanism

Legend

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




La
Lb/E
Mithören
+ 12 Volt