

Character submission

HELLSCHREIBER PAUSE SYMBOL

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August 5, 2017

This is a proposal to add the Hellschreiber pause symbol *A* to the Unicode standard. That character is used in some Hellschreiber telegraphs, notably the Feldfernschreiber of the German army.

The Hellschreiber pause symbol is used during speed adjustment of the Feldfernschreiber and the opposite station and for signaling to the opposite station and, if necessary, to the telecommunication switchboard, that the current connection is to be maintained during the pause in transmission.

The new character should have the following properties:

Property	Value
Block	Miscellaneous Technical
Code Point	2BFF
Name	HELLSCHREIBER PAUSE SYMBOL
General Cat	So
Script	Zyyy
BIDI Class	ON
Combining Cl	0
BIDI Mirror	N

2BFF;HELLSCHREIBER PAUSE SYMBOL;So;0;ON;;;;;N;;;;;

Please find the attached images of the Hellschreiber pause symbol and the corresponding push buttons (circled in red). The pause symbol is also described in the attached manual of the Feldfernschreiber. This appliance is still in military use and the character is required for 1. literal reproduction of Hellschreiber texts and 2. printing that character in manuals for those machines.

The Hellschreiber is a teleprinter similar to a telefax which is still common military and amateur radio, because it provides a robust slow data connection, even in environments which are susceptible to interference. Because the Hellschreiber sends text as pixels, it is

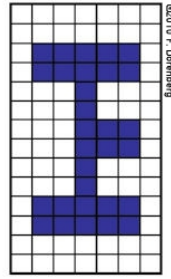


Figure 1: The Hellschreiber pause symbol

technically able to work with any script. The Hellschreiber use a tape where the received data is printed twice, so that the text is still readable, when there are synchronization failures.

The Hellschreiber pause symbol can be activated with a special key on the device. If it is pressed, that character is automatically send with a reduced frequency proportional to the original frequency (to avoid wasting too much tape and bandwidth).

The character consists of three lines to help to align the motor speed until the character is properly aligned. It also signals, that the other station should hold the line. It is also different to any other character like latin I or E to prevent confusion with real message payload. A separate Unicode character has the following benefits:

- The character can be used by software products which render the text and convert them into waves for radio transmission. (At the moment, certain Hellschreiber fonts need to abuse another character coding point, like U+0023 NUMBER SIGN, which causes this character to be missing, as a consequence)
- For literal repetition of Hellschreiber tapes (for archival purposes) It may be relevant to show that there was a break in the communication.
- It can be also used in manuals or on websites discussing the Hellschreiber and in computer user interfaces and buttons on physical devices



Figure 2: Samples of Hellschreiber teletypers with pause keys

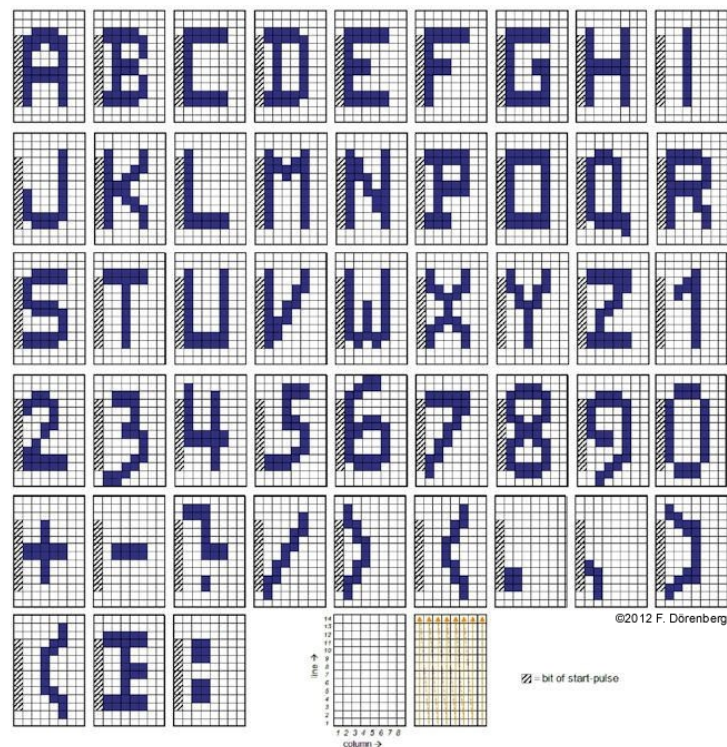


Figure 3: A sample Hellschreiber font including the Hellschreiber pause symbol

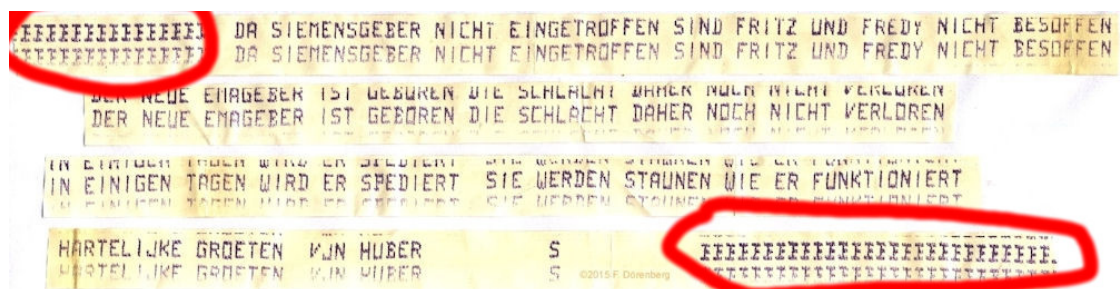


Figure 4: A Hellschreiber message using the pause symbol

**ISO/IEC JTC 1/SC 2/WG 2
PROPOSAL SUMMARY FORM TO ACCOMPANY SUBMISSIONS
FOR ADDITIONS TO THE REPERTOIRE OF ISO/IEC 10646¹**

Please fill all the sections A, B and C below.

Please read Principles and Procedures Document (P & P) from <http://std.dkuug.dk/JTC1/SC2/WG2/docs/principles.html> for guidelines and details before filling this form.

Please ensure you are using the latest Form from <http://std.dkuug.dk/JTC1/SC2/WG2/docs/summaryform.html>.

See also <http://std.dkuug.dk/JTC1/SC2/WG2/docs/roadmaps.html> for latest Roadmaps.

A. Administrative

1. Title:	<i>Character Proposal: Hell pause character</i>
2. Requester's name:	<i>Marius Spix</i>
3. Requester type (Member body/Liaison/Individual contribution):	<i>Individual contribution</i>
4. Submission date:	<i>30 April 2017</i>
5. Requester's reference (if applicable):	
6. Choose one of the following:	
This is a complete proposal:	<i>yes</i>
(or) More information will be provided later:	

B. Technical – General

1. Choose one of the following:	
a. This proposal is for a new script (set of characters):	
Proposed name of script:	
b. The proposal is for addition of character(s) to an existing block:	<i>yes</i>
Name of the existing block:	<i>Miscellaneous Technical</i>
2. Number of characters in proposal:	
3. Proposed category (select one from below - see section 2.2 of P&P document):	
A-Contemporary ☐ B.1-Specialized (small collection) ☒ B.2-Specialized (large collection) ☐	
C-Major extinct ☐ D-Attested extinct ☐ E-Minor extinct ☐	
F-Archaic Hieroglyphic or Ideographic ☐ G-Obscure or questionable usage symbols ☐	
4. Is a repertoire including character names provided?	<i>yes</i>
a. If YES, are the names in accordance with the "character naming guidelines" in Annex L of P&P document?	<i>no</i>
b. Are the character shapes attached in a legible form suitable for review?	<i>yes</i>
5. Fonts related:	
a. Who will provide the appropriate computerized font to the Project Editor of 10646 for publishing the standard?	<i>there are existing fonts by Frank Dörenberg, in doubt I can provide one myself, as the character is simple</i>
b. Identify the party granting a license for use of the font by the editors (include address, e-mail, ftp-site, etc.):	<i>see above</i>
6. References:	
a. Are references (to other character sets, dictionaries, descriptive texts etc.) provided?	<i>yes</i>
b. Are published examples of use (such as samples from newspapers, magazines, or other sources) of proposed characters attached?	<i>yes</i>
7. Special encoding issues:	
Does the proposal address other aspects of character data processing (if applicable) such as input, presentation, sorting, searching, indexing, transliteration etc. (if yes please enclose information)?	<i>no</i>

8. Additional Information:

Submitters are invited to provide any additional information about Properties of the proposed Character(s) or Script that will assist in correct understanding of and correct linguistic processing of the proposed character(s) or script. Examples of such properties are: Casing information, Numeric information, Currency information, Display behaviour information such as line breaks, widths etc., Combining behaviour, Spacing behaviour, Directional behaviour, Default Collation behaviour, relevance in Mark Up contexts, Compatibility equivalence and other Unicode normalization related information. See the Unicode standard at <http://www.unicode.org> for such information on other scripts. Also see Unicode Character Database (<http://www.unicode.org/reports/tr44/>) and associated Unicode Technical Reports for information needed for consideration by the Unicode Technical Committee for inclusion in the Unicode Standard.

¹ Form number: N4502-F (Original 1994-10-14; Revised 1995-01, 1995-04, 1996-04, 1996-08, 1999-03, 2001-05, 2001-09, 2003-11, 2005-01, 2005-09, 2005-10, 2007-03, 2008-05, 2009-11, 2011-03, 2012-01)

C. Technical - Justification

1. Has this proposal for addition of character(s) been submitted before?	<i>no</i>
If YES explain	
2. Has contact been made to members of the user community (for example: National Body, user groups of the script or characters, other experts, etc.)?	<i>no</i>
If YES, with whom?	
If YES, available relevant documents:	
3. Information on the user community for the proposed characters (for example: size, demographics, information technology use, or publishing use) is included?	<i>no</i>
Reference:	
4. The context of use for the proposed characters (type of use; common or rare)	<i>rare</i>
Reference:	
5. Are the proposed characters in current use by the user community?	<i>no</i>
If YES, where? Reference:	
<i>military and amateur radio</i>	
6. After giving due considerations to the principles in the P&P document must the proposed characters be entirely in the BMP?	<i>no</i>
If YES, is a rationale provided?	
If YES, reference:	
7. Should the proposed characters be kept together in a contiguous range (rather than being scattered)?	<i>no</i>
8. Can any of the proposed characters be considered a presentation form of an existing character or character sequence?	<i>no</i>
If YES, is a rationale for its inclusion provided?	
If YES, reference:	
9. Can any of the proposed characters be encoded using a composed character sequence of either existing characters or other proposed characters?	<i>no</i>
If YES, is a rationale for its inclusion provided?	
If YES, reference:	
10. Can any of the proposed character(s) be considered to be similar (in appearance or function) to, or could be confused with, an existing character?	<i>no</i>
If YES, is a rationale for its inclusion provided?	
If YES, reference:	
11. Does the proposal include use of combining characters and/or use of composite sequences?	<i>no</i>
If YES, is a rationale for such use provided?	
If YES, reference:	
Is a list of composite sequences and their corresponding glyph images (graphic symbols) provided?	
If YES, reference:	
12. Does the proposal contain characters with any special properties such as control function or similar semantics?	<i>no</i>
If YES, describe in detail (include attachment if necessary)	
13. Does the proposal contain any Ideographic compatibility characters?	<i>no</i>
If YES, are the equivalent corresponding unified ideographic characters identified?	
If YES, reference:	

D 758/1

The Feldfernschreiber

Model 24a : 32

1. 4. 41

Berlin 1941

Printed at the German Central Print Office

Translated by Frank M.G. Dörenberg from the original 1941 German version.
Annotations are in *[italics]*. The translator does not assume any liability for correctness of the translations nor for any damages that may result from following the instructions contained therein.

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A. GENERAL

1. The purpose of the Feldfernschreiber is the transmission of text messages via wires. There is a Feldfernschreiber at both ends of the communication link. The two machines are connected via single-wire [*plus ground*] or dual-wire phone lines.
2. The Feldfernschreiber is particularly suited for field operation due to its simple construction, operation, and maintenance and utility.
3. Operation of Feldfernschreibers is subject to Teleprinter Operation Directives H Dv 421/3 e.
4. The Feldfernschreiber¹ combines a sender- and a receiver-unit, so both terminals can send and receive messages. The encoder is actuated by a typewriter keyboard; the receiver prints the messages sent by the opposite terminal on a paper strip. The text sent to the opposite terminal is simultaneously printed on the own paper strip, for monitoring purposes.
5. Operation of the Feldfernschreiber requires a 12 volt battery (e.g., a car battery). This makes operation of the machine independent of electrical power networks. Where an AC-power network is available, a Feldfernschreiber rectifier unit can be used to power the machine.
6. **Only telephone lines are suitable as interconnection between a pair of Feldfernschreiber stations.** The connection may pass via capacitors, transformers, telephone switchboards, and line amplifiers. Operation via field amplifiers is not possible. The Feldfernschreiber can be operated on lines that are subject to interference, in particular provisional wiring.
7. The Feldfernschreiber can not be operated on teleprinter networks that pass via teleprinter switch boards [*relays*], voice-frequency telegraphy (VFT), or sub-audio telegraphy.
8. The range of Feldfernschreiber communication depends on the attenuation along the interconnection. The largest allowable attenuation is about 5 neper [*43 dB*]. Hence, the range is $\frac{1}{4}$ to $\frac{1}{2}$ times larger than that of voice telecommunication.
Feldfernschreiber operation may still be possible on lines with an attenuation level that precludes proper voice communication.
9. Regarding telegraphy speed, the teleprinter outperforms the Feldfernschreiber. With a teleprinter, up to 428 characters can be sent per minute. With a Feldfernschreiber, only up to 150 characters per minute can be sent. If this speed is not managed proficiently, only 75 characters may be sent per minute, due to the keystroke mechanism.
10. As the Feldfernschreiber does not have a calling function, it is always operated in conjunction with a field telephone set, that can be connected to the phone line with its hookup cable.
11. The Feldfernschreiber has a case that contains accessories, the terminal itself, and tools.

¹ This machine used to be referred to as Typenbildschreiber [*text character printer*] and Hellschreiber, after its inventor Dr. Rudolf Hell.

B. DESCRIPTION OF MAJOR COMPONENTS

12. The Feldfernschreiber comprises the following major components (Figure 1):

- a) Backpack case
- b) Backpack case lid with operating instructions, and
 - 1 battery cable, 2 meters long, dual connector at one end, 2 spade connectors at the other end
 - 1 connection cable, 2-conductor, 1.2 meters [4 ft] long, dual connector at both ends
- c) Keyboard-transmitter Unit with
 - 1 transmitter [*Keyboard-Drum Unit*]
 - 1 motor-generator
 - 1 bottom unit
 - 2 paper drawers
 - 2 rolls of printing paper, gummed [*on one side*] for moisture protection
 - 1 ink roller
- d) Amplifier and Interconnect Unit with
 - 4 tubes [*valves*] RV 12 P 4000
 - 1 fine-wire fuse, 6 amp. [5 x 20 mm]
 - 1 screw-top jar for fuses
 - 1 indicator light bulb 12 V, 2 W, with bayonet base
 - 1 lamp cover with red lens, 16.5 mm diam.



- | | |
|---------------------------------|-------------------------------------|
| 1 = backpack case | 4 = bottom unit |
| 2 = keyboard-encoder unit | 5 = motor-generator |
| 3 = receiver [<i>printer</i>] | 6 = Amplifier and Interconnect Unit |

Figure 1 *Feldfernschreiber, ready for operation*

Backpack case

13. The backpack case is equipped with a carrying handle and hardware for a back cushion and carrying straps. A water-spray tight lid covers the equipment inside the case. The lid can be removed upon undoing the four buckles on the sides of the case.
14. The operating instructions with circuit diagram and two cables are stored on the inside of the lid.
A two-conductor cable with dual connector at one end, 2 spade connectors at the other end, is for connecting an electrical power source to the Amplifier and Interconnect Unit.
A two-conductor cable, with a dual connector at both ends, is for connecting a radio receiver to the Feldfernschreiber for radio operation.
15. The Mechanical Unit and the Amplifier and Interconnect Unit are installed in the backpack case (Figure 1). The Mechanical Unit is latched into its parked position. Upon releasing the latch, the unit is slid into its operating position, which is also latched.

Mechanical Unit

16. The Mechanical Unit comprises the encoder [*character drum*], the receiver [*printer*], the Bottom Unit and the motor-generator (Figure 1, items 2, 3, 4, 5).

Encoder [*drum*]

17. The encoder decomposes the image of text characters [*glyphs*], figures and punctuation marks, and converts them into correspondingly shorter or longer electrical pulses.
18. The encoder is equipped with a typewriter keyboard that has 43 keys (Figure 2).

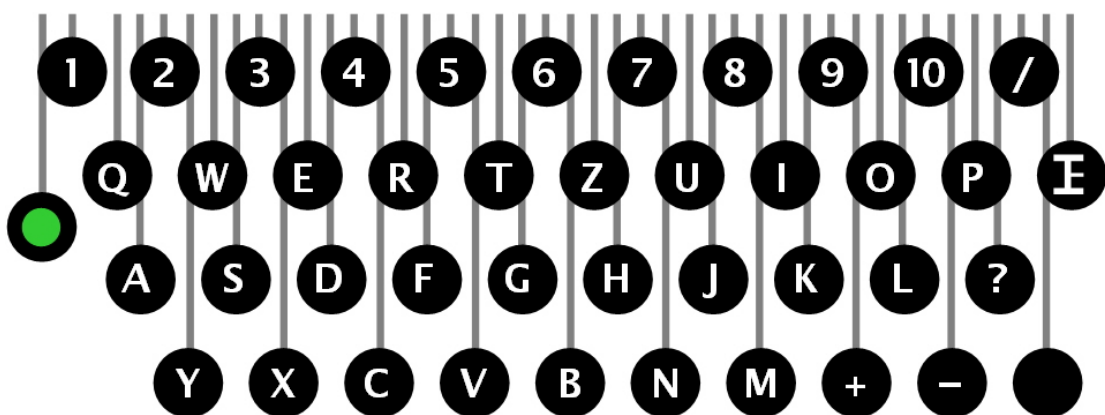


Figure 2 **Keyboard layout**

The 26 letters of the alphabet and the figures 0 through 9 are arranged in the standard layout, just like an office typewriter or teleprinter. For the punctuation marks + - ! ? four additional keys are available [*note: there is no period or comma; slashes are often used as quotes*]. At the bottom right is a blank key for writing a space without interrupting a typing sequence. Furthermore, two special keys are available: the pause character ⏏ and the Morse key ●.

Switching between upper-case and lower-case characters is not possible; only upper-case characters are used. Also, as letters, figures and punctuation marks have dedicated keys, there is no switching between letters and figures – unlike teleprinters [*“figures shift”*].

19. The pause character ⏏, located at the right hand side of the keyboard, is used
 - during speed adjustment of the Feldfernschreiber and the opposite station.
 - for signaling to the opposite station and, if necessary, to the telecommunication switchboard, that the current connection is to be maintained during the pause in transmission.

Contrary to the other keys, the pause key remains latched by itself in the depressed position. The pause character ⏏ is transmitted as long as the key is engaged, in such a way that only every third character is sent. The key is released by pushing any other key.

20. The Morse key $\bullet$ is located on the left hand side of the keyboard, and is marked with a green dot. Morse characters can be sent to the opposite station during interference on the line.

The Morse characters can either be printed on the paper tape, or listened to with a headset connected to the Amplifier and Interconnect Unit. When printing on the paper tape, transmission should be at low speed.

21. Transmission of a character requires a very specific time, namely 0.4 seconds. To preclude actuation of the next key while a character is already being transmitted, all keys are locked out during transmission. The lockout is removed only upon completion of the transmission of the character, at which time all keys are briefly enabled. If this momentary enabling window is missed, then the lockout is activated again.

|| The design of the keyboard and transmitter [drum] requires rhythmic typing. The typing speed is 2½ characters per second.

If the typing proficiency is insufficient, typing may be done at half speed, i.e., at 1¼ character per second. However, the printed text will be spread out.

22. The character drum is located behind the keyboard, under a removable cover, and is driven by the motor-generator via the gear box. The drum consists of a cylinder made of insulating material, on the outside of which metal patches are embedded, arranged in rings that correspond to the decomposed image of each character (see line items 48 through 50 for details).

When a key is depressed, the associated slip contact touches the corresponding ring of the character drum during the revolution of the drum, thereby scanning the ring. Thus, the sequence of electrical pulses that correspond to the character image are transmitted to the opposite station.

Receiver

23. **The electrical pulses arriving from the opposite station, are – after amplification in the interconnect unit – plotted on the paper tape by the receiver, thereby rendering the image of the received characters.**

The own receiver continues to run during transmission. The transmitted characters appear on the paper tape. This is for monitoring purposes.

24. The receiver contains an electromagnet that converts the received electrical pulses into correspondingly shorter or longer strokes. The armature of the electromagnet is actuated in the rhythm of the electrical pulses. The edge of the armature pushes the paper tape against the printer spindle, such that each electrical pulse is printed.

The spindle transfers ink from the ink roller onto the paper tape (Figure 3), thereby reconstituting the individual strokes into the complete character image (see line items 56 through 58 for details).

25. The paper transport roller continuously pulls the paper tape between the printer spindle and the edge of the armature of the electromagnet. Contrary to teleprinters, the paper tape continuous to move in the absence of characters to be printed.

26. The pinch roller on the hinged lever presses the paper tape firmly against the [powered] paper transport roller.

The freewheeling ink roller is attached to the ink roller lever, lightly rests on the printer spindle, and transfers ink to the latter.

To insert the paper tape or to replace the ink roller, push the paper release lever a little to the left [about 1 cm, ½"] and lift the ink roller lever until it latches. This interrupts the transportation of the paper (since the pinch roller is lifted), as well as inking of the spindle.

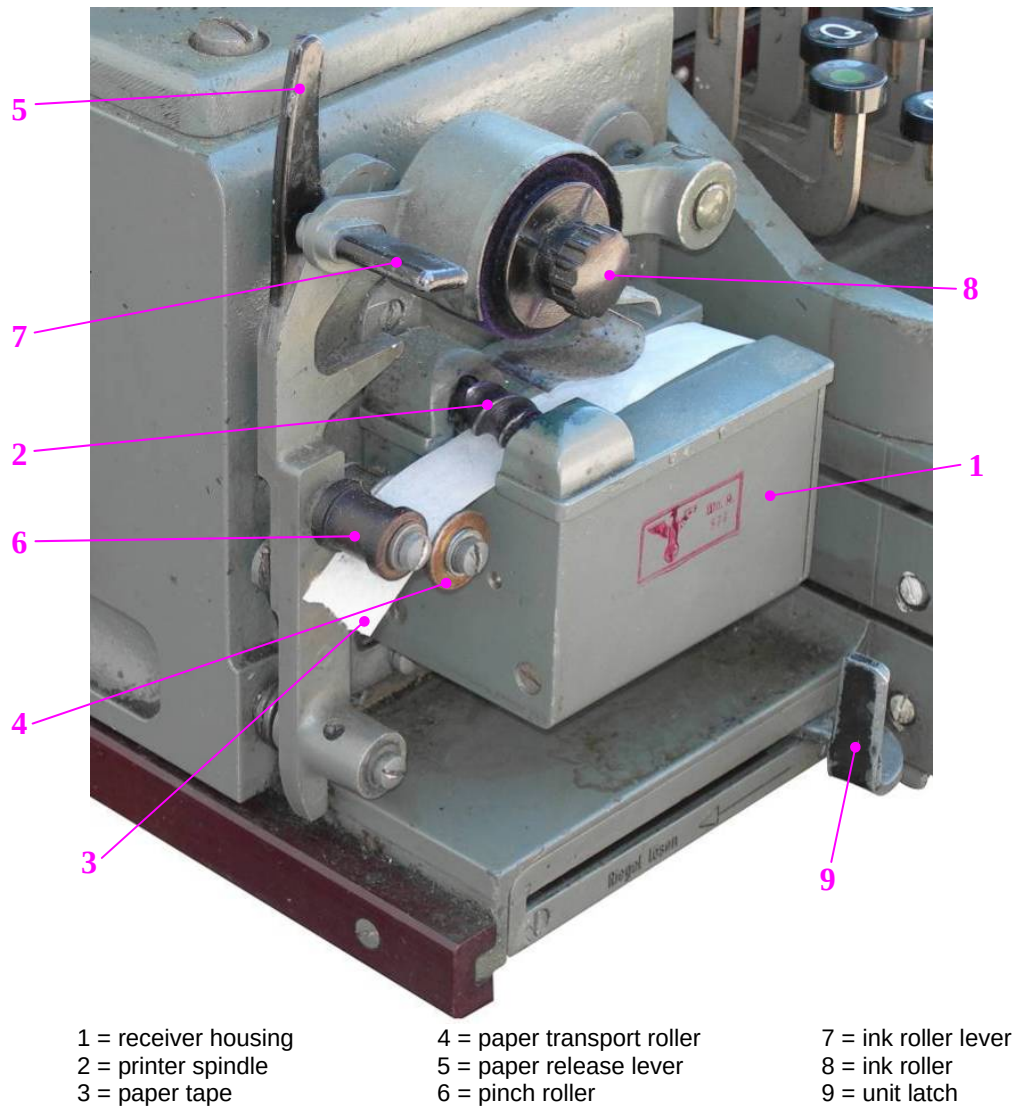


Figure 3 Receiver [printer]

The latch is released by pulling the paper release lever fully to the left. This causes the ink roller to drop back onto the spindle. Upon release of the paper release lever, the pinch roller is re-engaged against the paper transport roller.

27. The printer spindle is designed so as to obtain double printing on the paper tape. This implies significant relief for the need to maintain synchronization between the own Feldfernschreiber and the opposite station. If the synchronization is not exact, the printed text line will be slanted up or down to some degree (Figure 6).

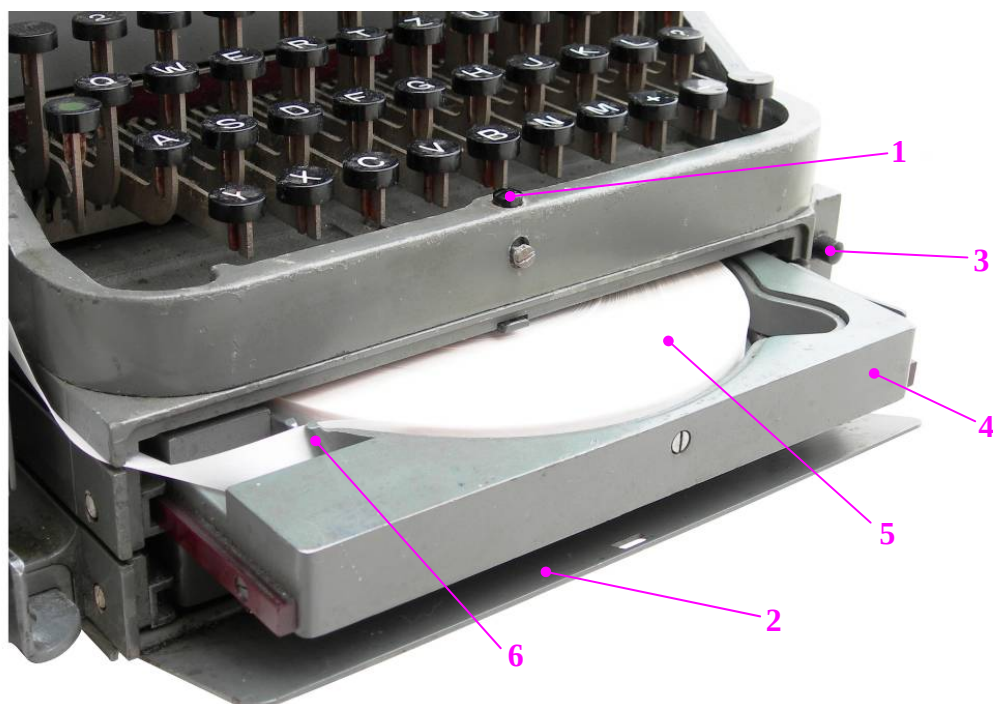
The text remains legible despite slanting of the text line, as each character is printed in full at least once, due to the fact that text lines are printed twice, one above the other. Coarse adjustment of the synchronization is done with the centrifugal speed regulator of the motor-generator (see line items 59 through 63).

Bottom unit

28. The bottom unit comprises:

- the gear box
- the paper drawers and
- the latching mechanism

29. The gear box is located behind the receiver [*printer*], and below the motor-generator. It contains the gearing for driving the character drum of the transmitter, the printer spindle, the paper transport roller and the enabling mechanism of the pause character (inside the [*gear*] box).
30. The two paper drawers are located below the keyboard. They are covered by a hinged lid. By pushing the [*black*] release button that is embedded in the frame of the keyboard, the lid is released and the paper drawers are unlocked. Pushing one of the [*black*] release buttons to the right of the drawers, the associated drawer will pop out. The drawer can be fully removed when the button remains pushed (Figure 4).
31. The paper roll is placed in the drawer such that it unwinds clockwise. The paper tape is passed through the paper guide of the drawer, such that the gummed side is down. The paper leaves the paper drawer box through a slit in the side, and continues on to the receiver.
- A complete paper roll has about 250 m [820 *ft*] of tape. About 28 m [92 *ft*] are used per operating hour. Hence a roll suffices for nearly nine hours total operating time.



- | | | | |
|--------------------|---------------------------------|-----------------|----------------------|
| 1 = release button | 3 = upper drawer release button | 5 = paper roll | 7 = paper guide slit |
| 2 = hinged lid | 4 = upper paper drawer | 6 = paper guide | |

Figure 4 Paper drawers, opened

32. The lever that is visible below the receiver (Figure 3 [*item 9*]) latches the writing unit into the parked position or into the operating position, or alternatively, allows the unit to be removed from the case. The lever is all the way to the right when in the parked position. To place the unit into the operating position, the [*spring loaded*] lever must be moved to the left, the unit pulled out about 1 cm [$\frac{1}{2}$ "], and the lever released; then the unit is pulled out further, until the lever latches again. This way the unit is pulled out of the case enough to allow the keyboard to be operated comfortably, and the paper tape to freely pass through the receiver.
33. To completely remove the machine from the case, the release lever must be pushed [*and held*] to the left while simultaneously pulling out the unit. To place the machine back into the case, insert it into the guide tracks [*at the bottom*] on the inside of the case, and slide it all the way back into the case.

Motor-generator

34. The motor-generator drives the gear box and generates the anode current for the tubes [valves] in the Amplifier and Interconnect Unit.



Figure 5 Motor-generator

The motor-generator (Figure 5) is powered by a 12 volt battery or a rectifier unit that has a 12 volt output. Current draw is about 2.5 amperes. It is switched on with the main switch on the Amplifier and Interconnect Unit.

The carbon brushes of the motor windings are located inside on the left and right of the upper part of the motor housing.

35. The shaft of the motor-generator is coupled to the gear box in the lower part. There, the rotation speed is reduced to the level required for the character drum of the transmitter, for the printer spindle, for the paper transport and for the pause character.
36. Besides the motor windings, the armature of the motor-generator also has generator windings that produce about 165 volt direct current [DC] at 15 mA peak current, as anode voltage for the tubes [valves] in the Amplifier and Interconnect Unit. The carbon brushes for the anode current are located at the front and rear of the base of the generator housing.

37. To obtain horizontal text lines on the paper tape, the speed of the motor-generator must be constant and the same as the speed of the motor-generator of the opposite station. To maintain synchronization, the motor-generator has a centrifugal regulator that creates a constant rotational speed via the regulator tube [valve] of the Amplifier and Interconnect Unit. Adjustment of the synchronization with the opposite station is done by turning the regulator cap on top of the motor-generator, which changes the setting of the centrifugal regulator.

The regulator cap has a scale of 0–10 that passes by an index-pointer on [the front of] the motor housing when the cap is turned. Turning the cap to the left (higher scale value) increases the speed of the motor generator, turning the cap to the right (lower value) reduces the speed.



Figure 6 Printed text for speed of the own motor-generator that is too high (a), correct (b), and too low (c)

38. Speed differences between the two stations are only noticeable on the receiver side. Text printed by the own receiver of the sending station is independent of the speed differences, as the gearing between the character drum and the receiver [printer] is fixed. Hence, adjustment is always done based on the text sent by the opposite station.

If the printed received text is slanted upward (Figure 6a), then the speed of the own machine must be reduced (raise the regulator cap to a smaller value).
If the printed received text is slanted downward (Figure 6c), then the speed of the own machine must be increased (lower the regulator cap to a larger value).

If the synchronization is correct at one station, then it is automatically correct at the opposite station as well.

39. Two 6-conductor cables come out of the back of the motor-generator. They form the electrical connection between the motor-generator of the transmitter and receiver, with the Amplifier and Interconnect Unit. The cables are connected to the latter unit with two 6-pin connectors that can not be swapped [as they are keyed differently; they cannot be installed upside down either], and that are furthermore marked "vorn" ["front"] (red dot) and "hinten" ["rear"] (green dot). They can [only] be unplugged from the Amplifier and Interconnect Unit after pulling that unit forward.

Amplifier and Interconnect Unit

40. The Amplifier and Interconnect Unit contains the tone generator (900 Hz tube [valve] oscillator), the receiver amplifier, the [motor-generator] regulator tube and the connections for the [phone] line, field telephone set, radio transmitter and electrical power.
41. The tone generator produces 900 Hz audio oscillations. These oscillations are keyed by the character drum in the rhythm of the character pulses, when a character is being transmitted. The keyed audio tone is output onto the line to the opposite station, as well as to the own receiver amplifier.
If the current pulses that represent the image of the character that is to be transmitted, would be put on the line as direct current [DC] pulses, then transmission beyond capacitors and line amplifiers would not be possible. By using an audio tone of 900 Hz, all switching elements that can pass voice frequencies will also pass the audio frequency of the Feldfernschreiber.
42. The receiver amplifier first pre-amplifies the received audio frequency – from the opposite station or from the own transmitter. Subsequently, the pulses are passed to two dry rectifiers [cuprous-oxide-on-copper diodes]. The resulting direct current [DC] pulses control the tube of the final stage, the anode current of which energizes the [electro]magnet of the receiver.
43. The purpose of the regulator tube [valve] is to maintain constant speed of the motor-generator. Too low, or too high, speed of the motor-generator causes the contacts that are actuated by the centrifugal regulator to be switched, such that the anode current of the tube is reduced or increased respectively. The anode current passes through special windings of the motor, and causes the motor to turn faster or slower.
44. The switches and connectors that are required for operation of the Feldfernschreiber are arranged on the front panel of the Amplifier and Interconnect Unit. They are (Figure 7):

The main switch

with the three positions “Aus – Bereit – Ein” [“Off – Ready/Standby – On”]

In the “Aus” position, the equipment is switched off.

In the “Bereit” position, the tubes [valves] of the unit are pre-heated, and the red indicator light above the switch illuminates.

In the “Ein” position, the motor windings of the motor-generator are also powered, and the motor spools up. The indicator light is turned off.

|| Only switch from “Bereit” to “Ein” after one minute, otherwise the tubes [valves] will be damaged.

The red indicator light

This light illuminates when the main switch is in the “Bereit” position, and indicates that the Feldfernschreiber is connected to a power source. If the light bulb is burnt out, it can be replaced after removing the red lens of the lamp.

Gain control

This controls a voltage divider at the input of the receiver amplifier, and reduces the input voltage more or less. Full amplification is obtained in position 10. The effect of interference can be largely suppressed by using this control.

|| The gain control must be turned down such that the receiver still prints properly.

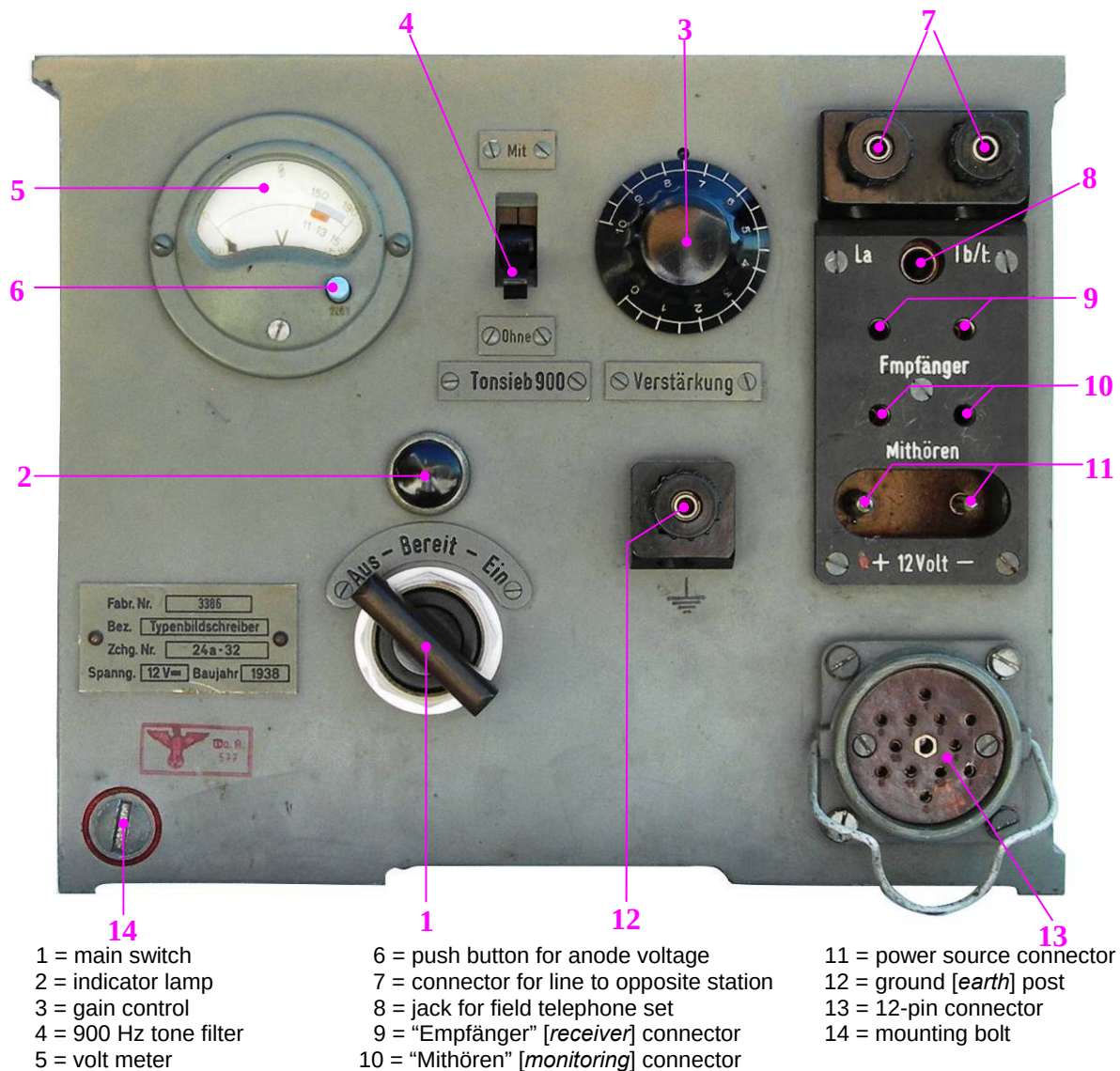


Figure 7 Amplifier and Interconnect Unit, front view

Switch for the 900 Hz tone filter

with positions "Mit – Ohne" ["*With/on – Without/off*"]. The filter is placed at the input of the receiver amplifier, and in the "Mit" position, suppresses interfering frequencies while only slightly attenuating the 900 Hz operating frequency.

|| The filter should only be used when there is strong interference with the reception.

The attenuation – small as it is – of the filter in the "Mit" position reduces the range of the Feldfernsehreiber by about 15 percent.

Voltmeter

with two ranges. It is used to check the battery voltage and the anode voltage.

When the main switch is in the "Bereit" or the "Ein" position, the instrument measures the battery voltage (12 volt). The allowed range of the voltage (11 – 13 volt) is marked in red on the scale.

When the main switch is in the “Ein” position and the blue button of the instrument is pushed, the instrument indicates the anode voltage (165 volt) produced by the motor-generator. The allowed range of the voltage (150 – 190 volt) is marked in blue on the scale.

Two binding posts,

marked La and Lb/E, to which the [*phone*] line to the opposite station is connected.

A jack,

wired in parallel to the La and Lb/E connectors. A field telephone set can be connected here, for calling and voice communication with the opposite station.

Two female connectors,

marked “Empfänger” [*receiver*]. During radio operation, one end of the cable that is stored on the inside of the lid of the backpack case, is hooked up to these connectors and the other end to the headphone output of the radio receiver.

Two female connectors,

marked “Mithören” [*listen along, monitor*]. They allow a headphone to be connected, in order to

- have better audio understanding than is possible with the field telephone, due to the amplification,
- listen to the Morse characters during Morse operation (actuation of the Morse key [*of the keyboard*]).

A double socket connector,

marked “+ 12 Volt –”, for hooking up the electrical power source to the Feldfernschreiber, using the battery cable stored inside the lid.

A ground [*earth*] binding post,

for grounding the Feldfernschreiber.

A 12-pin receptacle²

intended for connecting the Feldfernschreiber during operation via radio. As the matching device is not yet available, this connector will not be used for the time being.

Mounting bolt

for the Amplifier and Interconnect Unit. Upon loosening the bolt, which has a red ring around it, the unit can be pulled forward and be removed from the case.

45. When the Amplifier and Interconnect Unit is removed, the two removable 6-pin [*male*] connectors become accessible on the left hand side of the unit; they are inserted into the corresponding 6-pin socket connectors of the unit.

46. The following items are located on the top cover plate of the Amplifier and Interconnect Unit (Figure 8):

² in older Feldfernschreiber models, there is a cover plate instead of the receptacle. Note that a switch contact for the transmitter [*drum*] is located behind the cover plate, and this contact is opened when the plate is removed. In this case, the lines to the opposite station can not be connected to the La – Lb/E connector [as *this switch interrupts the connection to La – Lb/E of the 900 Hz tone that is keyed by the drum*].

4 tubes [valves]

- all of type RV 12 P 4000, one each
- for the tone oscillator,
- for the [motor] regulator stage,
- for the final [amplifier] stage,
- for the pre [amplifier] stage.

One 6 amp fuse

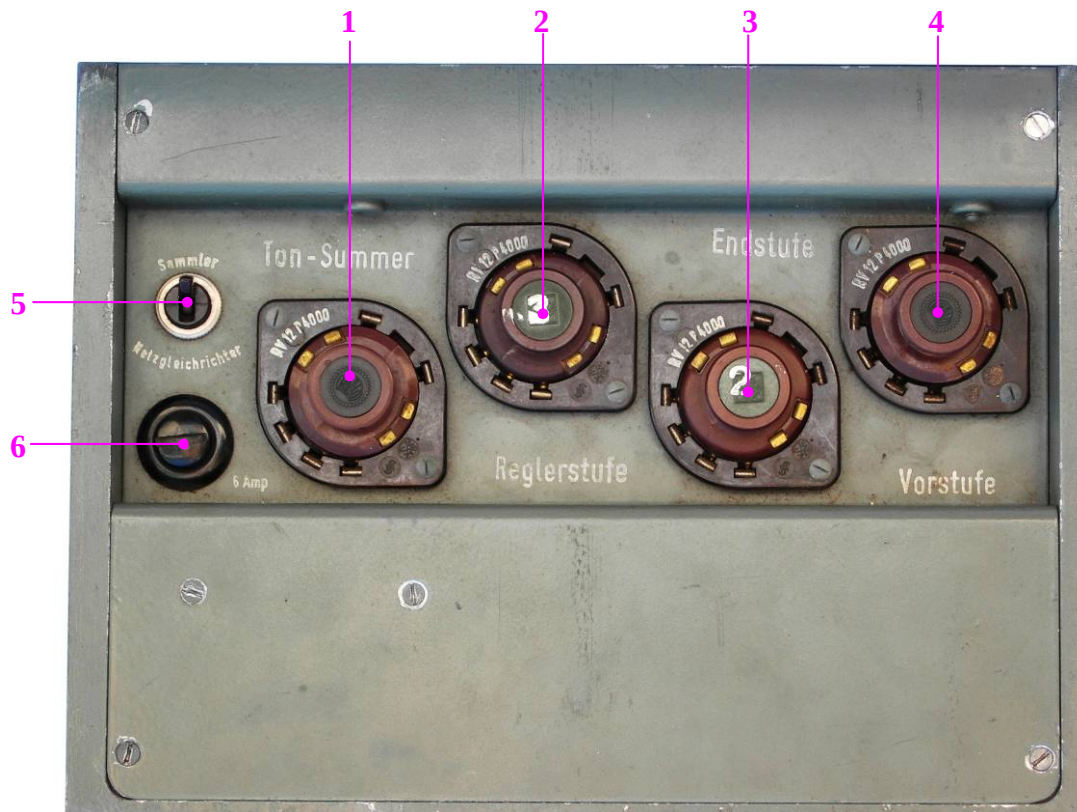
to protect the line coming from the source of the 12 volt electrical power.

The switch with positions

“Sammler” – “Netzgleichrichter” [“Battery” – “Mains transformer rectifier”]

The switch must remain in the “Sammler” [“accumulator”, “battery”] position, both for operation with a battery and for operation with a [transformer]-rectifier unit. The position “Netzgleichrichter” was intended for reducing the voltage of older models of a particular rectifier unit while in the “Bereit” position [of the main switch]. The Feldfernsehreiber rectifier unit performs this voltage reduction by itself.

Newer models of the Feldfernsehreiber do not have this switch.



1 = tube for the tone oscillator

2 = tube for the [motor] regulator stage

3 = tube for the final stage

4 = tube for the pre-amplifier

5 = 6 amp. fuse

6 = “Battery – Rectifier” switch

Figure 8 **Amplifier and Interconnect Unit, top view**

C. MODE OF OPERATION

Decomposition of characters in the transmitter

47. With Feldfernschreibern, unlike teleprinters, text characters are not printed by typing of a key, but rather, each text character is decomposed into longer and shorter line segments that, when lined up, reproduce the image of the character. Hence, the Feldfernschreiber is a character-image writer.

It is this form of text decomposition that brings forth the low noise sensitivity of the Feldfernschreiber as compared to teleprinters, and thereby its suitability for field operation.

In a teleprinter, noise interference can cause incorrect interpretation of the pulse sequence that arrives at the receiver. This causes a wrong character to be printed. The same interference with a Feldfernschreiber only causes an additional pulse that may make the printed character fuzzy, but can not affect its legibility.

48. Upper-case letters from the Latin alphabet and Arabic figures are the basis of the font. Each character is decomposed into so-called 7-column lettering. The field available for the characters is divided into seven columns, five of which are allocated to the actual characters, and two for the space between characters. Each column is further decomposed into one or more longer or shorter line segments, corresponding to the particular character. The minimum length of a line segment, and of the pauses between successive line segments [*within a column or between line segments at the top and bottom of two adjacent columns*], is 1/7 of the overall column height. Each character has been mapped to a special and proven column pattern, such that misinterpretation of characters is impossible in the presence of noise interference.

Figure 9 shows the column patterns of E and 6, as example of a simple and of a complex character.

The blue column segments represent “current intervals”, whereas the white column segments represent “breaks”.

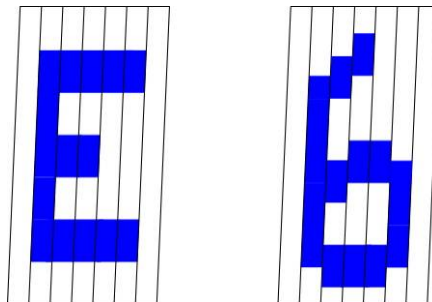


Figure 9 **Decomposition of E and 6 with 7-column lettering**

49. The letterings that have been graphically captured this way, are transferred to a contact ring. For this mapping, the individual columns are scanned bottom to top, and left to right. E.g., Figure 10 shows the contact ring for the letter E.

The “breaks” are formed by insulating material (black), whereas the “current intervals” are formed by metal segments (white).

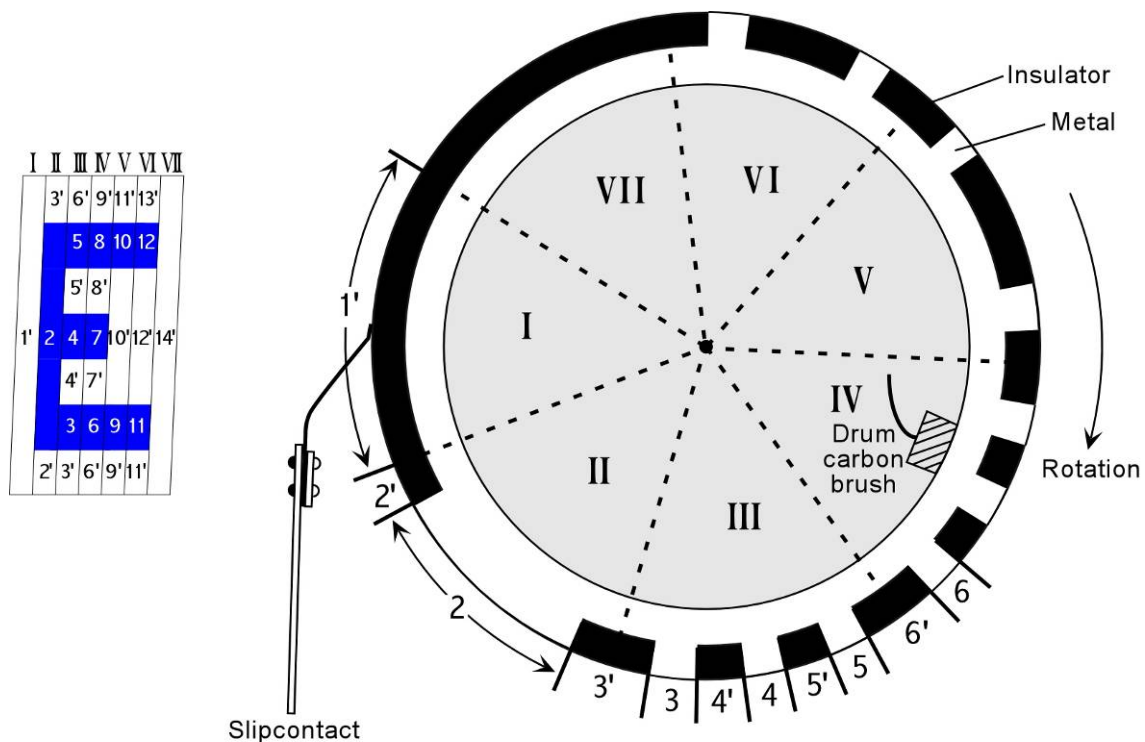
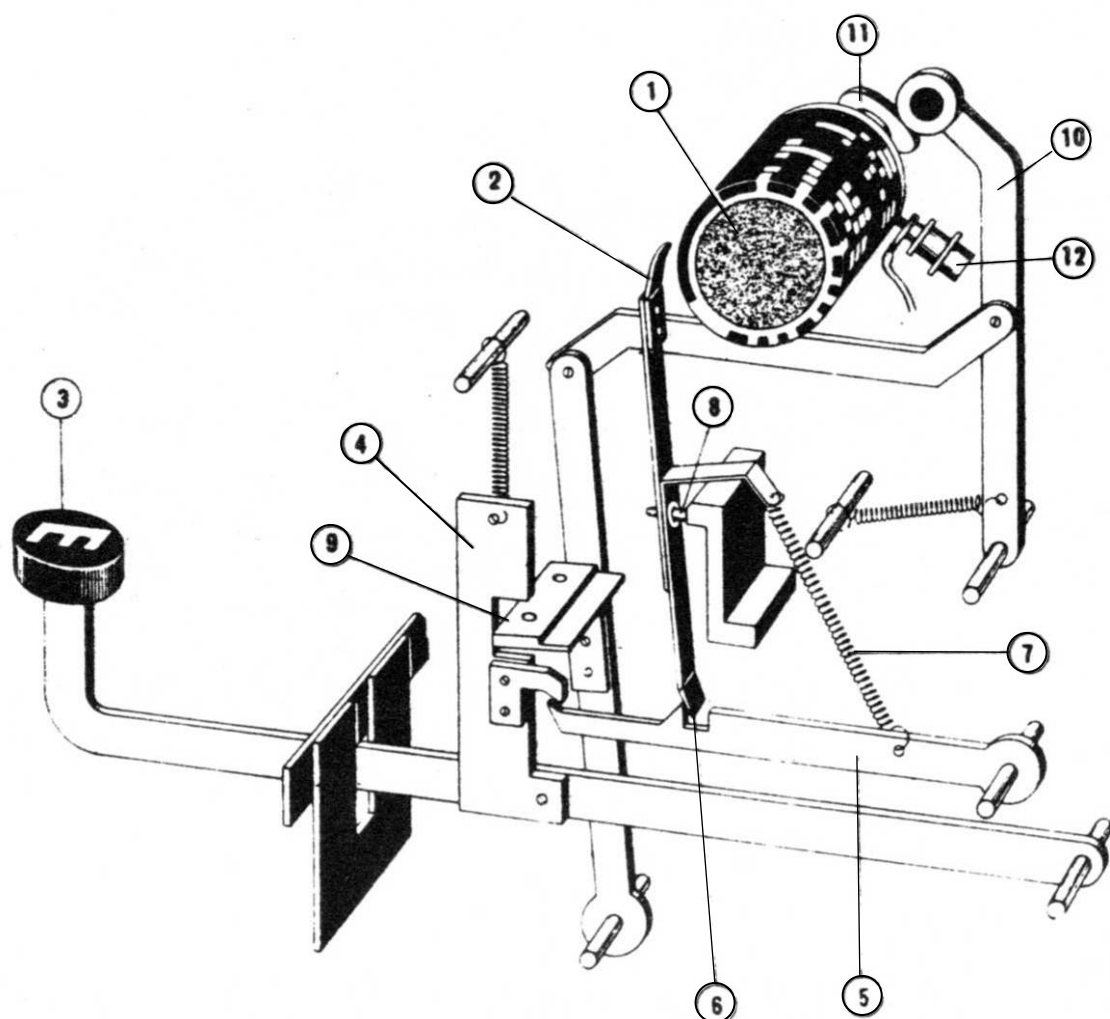


Figure 10 Contact ring for E

50. Each character has a dedicated contact ring. The metal segments of the various contact rings are combined into a character contact drum (item 1, Figure 11). There is a slip contact (item 2) in front of each contact ring of the drum. By depressing a key (item 3), the intermediate link (item 4) pulls down the interlocking lever (item 5), thereby lifting the detent-end (item 6) of the slip contact (item 2). Spring (item 7) pulls the slip contact about its pivot (item 8) against the contact ring. During one revolution of the drum, the slip contact passes all the current pulses that correspond to the letter pattern, to the [phone] line. The keys are locked out by a blade (9), such that scanning of a contact ring does not start at some arbitrary point along the ring. This blade is moved by the notch (11) via the transfer link (10), such that the keys are only briefly free to be depressed, and the slip contact touches the drum just before the starting point of the contact ring that is to be scanned. Upon completion of the scan, the blade (9) moves the slip contact back into its detent position, and disengages the lock-out of the keys.
51. When the pause character key is depressed, the associated slip contact is also applied to the corresponding contact ring of the drum. Additionally, this key is latched into the engaged position. The latch is released by the release bar underneath the keyboard, which moves to the right when any other key [other than the Morse key and the space key] is depressed.

Furthermore, there is a "normally closed" contact underneath the pause character key (see Appendix 8, item 1), that is opened when the pause key is depressed. The circuit at this point is disconnected, and routed via the [notch driven] pause character gate in the gear box (see Appendix 1). This gate consists of a contact that is actuated by a slowly turning camshaft (see Appendix 4, item 1), such that the contact only closes every third revolution of the drum. Hence, only every 1st, 4th, 7th, etc. pause character is transmitted.



1 = character contact drum
 2 = slip contact
 3 = key
 4 = intermediate link

5 = interlocking lever
 6 = slip contact detent
 7 = spring
 8 = pivot

9 = lock out blade
 10 = transfer link
 11 = notch
 12 = drum carbon brush

Figure 11 *Transmitting mechanism of the Feldfernschreiber*

52. There is neither a contact ring nor a slip contact for the blank [space] key. Hence, no character is sent when this key is depressed.
53. There is no contact ring or a slip contact for the Morse key either. Furthermore, it is the only key that is independent of the key lockout mechanism. Instead, there is a contact (see Appendix 8, item 2) underneath the lever of the Morse key. It is closed when the Morse key is depressed. The contact is connected in parallel to the slip contacts and the pick-off carbon brush [of the drum], so it bypasses the scanning device (see Appendix 1). Morse characters are sent independent of the position of the drum.
54. The slip contacts are electrically connected in parallel and to ground [earth]. The [metal segments of the] individual contact rings are also conductively interconnected by the contact drum. At one end, the drum has a continuous contact ring on which a carbon brush glides (Figure 11, item 12) and provides current. So, as soon as any key is depressed, the circuit of the corresponding contact ring is closed in the rhythm of the character.

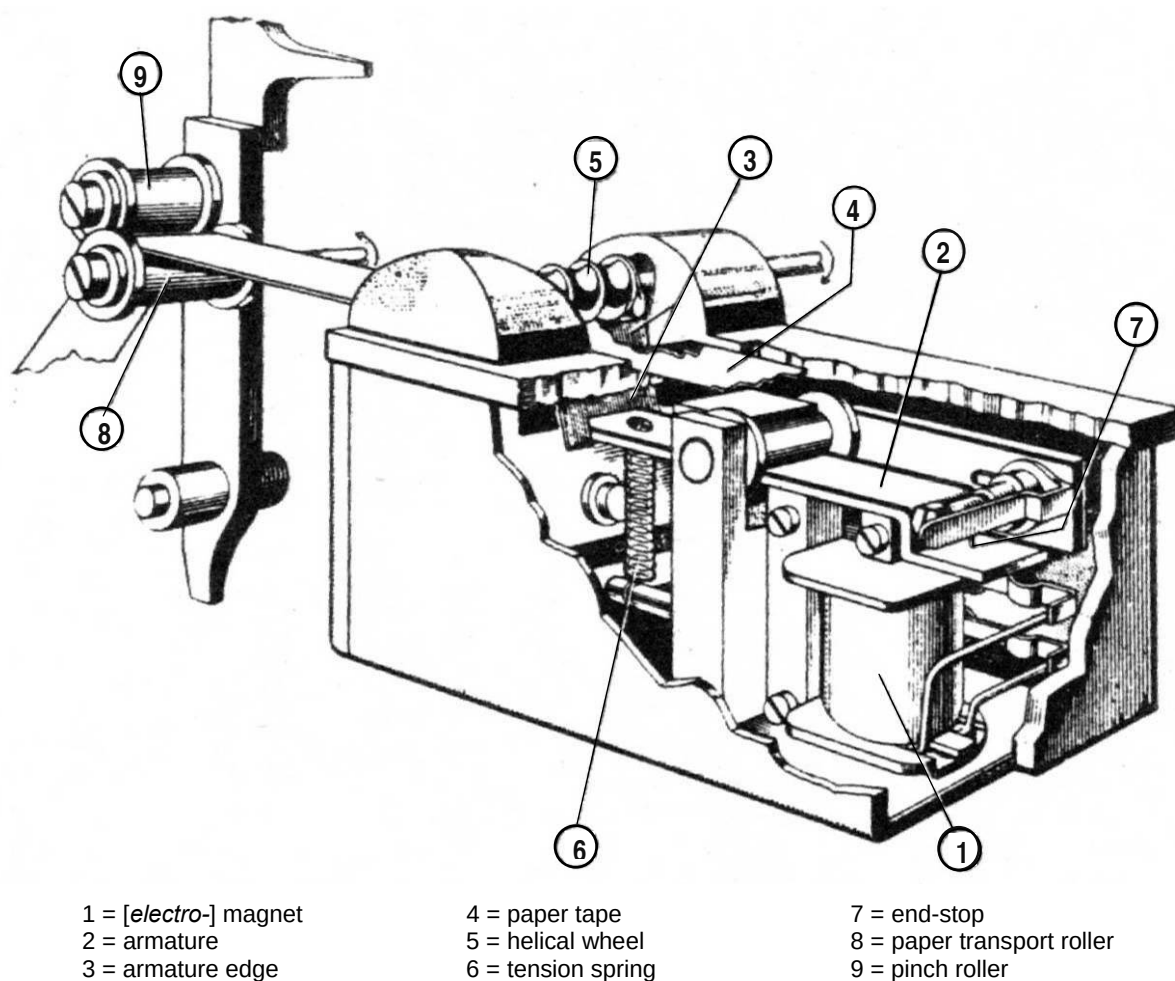
55. The contact drum is driven by the motor, and turns with a constant speed of $2\frac{1}{2}$ revolutions per second. The printing speed is therefore $2\frac{1}{2}$ characters, or $7 \times 2.5 = 17.5$ image columns per second. A single image column requires $\frac{1}{17.5} = 0.0572$ seconds, or 57.2 milliseconds. As each current interval and each break takes at least $\frac{1}{7}$ of the column length, the shortest current pulse or pause is therefore $57.2 \times \frac{1}{7} = 8.16$ milliseconds.

Hence, the maximum pixel frequency is $\frac{1000}{2 \times 8.16} = 61.25$ Hz.

Reconstruction of characters in the receiver

56. Current-pulses arrive either on the phone line, or from the own transmitter [drum]. After amplification in the Amplifier and Interconnect Unit, they are passed to the [electro-] magnet (item 1) of the receiver (Figure 12).

The armature (item 2) of the magnet-system has an edge that pushes the paper (4) against the printer spindle (5) in the rhythm of the arriving current pulses. The retention spring (6) pulls the armature down against the end-stop (7), such that the paper is backed off the spindle immediately upon the end of a current pulse. The paper transport roller and the pinch roller continuously pull the paper between the printer spindle and the edge of the armature. The printer spindle is driven by the motor, turns with a constant speed, and is continuously inked by the ink roller that lightly rests on it.



1 = [electro-] magnet
2 = armature
3 = armature edge

4 = paper tape
5 = helical wheel
6 = tension spring

7 = end-stop
8 = paper transport roller
9 = pinch roller

Figure 12 Receiver [printer] of the Feldfernschreiber

57. The printer spindle has a two-turn screw thread on its circumference. If the armature is engaged, a single point of each of these turns touches the paper. As the spindle turns, these points move front-to-back across the paper strip, such that for each half revolution of the spindle, two line segments appear, one above the other. As the spindle only prints when the edge of the armature pushes the paper against it, in reality two line segments are created, in the rhythm of the character column. That is,

during half a revolution of the two-turn printer spindle [*while the armature is engaged*], two line segments are simultaneously drawn bottom-to-top, one above the other.

As the spindle makes one full turn, the paper moves over the distance of a column width. Therefore, the printed characters lean slightly to the right.

58. The next character column is laid right next to the preceding column, such that upon completion of the seven columns belonging to the same character, two [*identical*] copies of the complete character appear on the paper, one above the other. The reason for this double-printing has already been mentioned in line item 27.

Regulation of the motor-generator speed

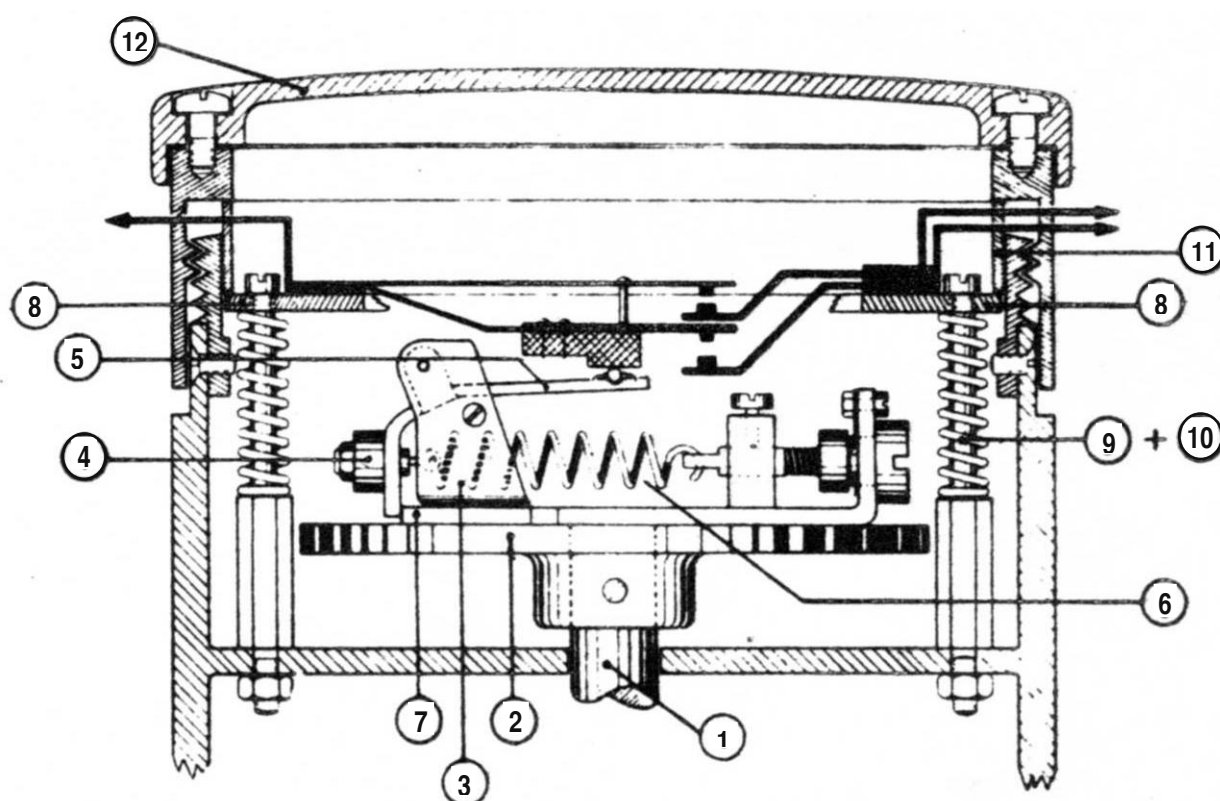
59. To have text lines that appear straight [*but not necessarily horizontal*], the motor speed has to be as constant as possible. This is done by the autonomous speed regulation provided by the centrifugal regulator located in the upper part of the motor, and the regulator stage of the Amplifier and Interconnect Unit.
60. The design of the centrifugal regulator is shown in Figure 13. A flange (item 2) is centered on top of the motor shaft (1). Swivel (3) is installed on it, to which the centrifugal weight (4) and rigid lever (5) are attached. The tension spring (6) pulls the weight towards the end-stop (7), thereby pulling the end of that lever (5) upward. When the motor shaft turns, the centrifugal force pushes the weight outward, and therewith the lever-end downward.
61. Besides the main windings, the motor has secondary windings (governor windings), whose circuit includes the regulator tube [*valve*] (anode – cathode). The grid of the regulator tube receives a voltage that depends on the position of contacts of the centrifugal regulator, which drives the amount of anode current (control current). So, the regulator tube acts as a variable resistor. The control current through the governor windings of the motor, results in a field that compounds that of the main windings. The higher the control current, the stronger the total field and the lower the motor speed. This stabilizes the motor speed at a fixed value.
62. The regulation works as follows:
- a) When the speed is too low, both contacts are open. The control grid of the regulator tube (Appendix 1, RÖ44) is connected to the cathode via a sensing-resistor (W45), such that the grid bias voltage has a certain negative value. This causes the anode current to be low and the resulting [*governor*] field to be weak, which in turn causes the motor speed to increase.
 - b) At medium speeds, the upper contact is closed, and the lower one remains open. The control grid of the regulator tube (RÖ44) is now connected directly to the cathode, such that it receives no bias voltage. Compared to case a) the anode current increases, so that the field becomes stronger. This prevents further increase of the motor speed.
 - c) During over-speed, both contacts are closed. The anode, grid, and cathode of the tube (RÖ44) are shorted to each other, such that the current through the governor windings assumes its maximum value. The strength of the regulator field increases, and the motor speed goes down.

63. The contact plate (Figure 13, item 8) is guided by two pins (9). Spring (10) pushes this plate up against the ring (11), which is lowered when the regulator cap (12) is turned down.

When turning the regulator cap, the contact plate moves up or down accordingly. This reduces or increases the required amount of travel of the contacts, thereby moving the set point of the regulation.

When the regulator cap is turned upward, the contacts close at a lower speed, such that the motor speed settles at a lower speed.

Conversely, the motor speed increases when the controller cap is turned downward.



1 = motor shaft
2 = flange
3 = swivel
4 = centrifugal weight

5 = lever
6 = tension spring
7 = end-stop
8 = contact plate

9 = pin
10 = spring
11 = ring
12 = regulator cap

Figure 13 Centrifugal regulator of the motor-generator

Circuitry of the Amplifier and Interconnect Unit.

64. The top-level circuitry of the Amplifier and Interconnect Unit has already been described in line items 40 through 46. The description of the regulator stage follows from line item 62; that of the transmitter follows from line items 50 through 54. Appendix 1 shows the complete circuit diagram in detail.
65. The tone generator is a tube [valve] oscillator (Rö16) in a three-point configuration, tuned to a fixed frequency of 900 Hz. The tone is transferred to the transmitter circuit by transformer SÜ. Line transformer LÜ couples the keyed tone separately to the line interconnect La–Lb/E and the input of the receiver amplifier.

66. Audio signals received from the opposite station are passed to the receiver amplifier via line interconnect La–Lb/E and line transformer LÜ.

For operation with a radio receiver, the secondary side of this transformer is also connected to the "Empfänger" [*receiver*] connectors.

The variable voltage divider W24 is parallel to this, and acts as gain control, by adjusting the high input voltage to the amplifier.

67. The 900 Hz tone filter precedes the amplifier. It comprises switch U26, that bypasses resistor W25 when in the "Ohne" [*without*] position.

With series resistor W25, the filtering is achieved as follows.

The audio input coming from gain control W24 is passed to a resonant circuit that consists of capacitor C28 and input transformer EÜ. This circuit is tuned precisely [$\pm 3\%$] to 900 Hz. It has a very high resistance at the 900 Hz operating frequency, but at frequencies above and below 900 Hz, the larger the frequency deviation from 900 Hz, the lower the resistance. In the position "Ohne" [*without*] the signal passes directly, whereas in the "Mit" [*with*] position, it passes through series resistor W25 of 30,000 ohm.

- a) Operating frequency of 900 Hz.

In the "Ohne" [*without*] position, the full signal voltage is passed to the resonant circuit; in the position "Mit" still a major part of this voltage is passed, as series resistor W25 is relatively small compared to the resistance of the resonant circuit at resonance, and only causes a small voltage drop.

With the filter is turned off, the signal voltage at the 900 Hz operating frequency is only slightly reduced: small attenuation.

- b) Audio interference above or below 900 Hz.

In the "Ohne" [*without*] position, interference signals arrive in full at the resonant circuit (ignoring the resistance of gain control W24). However, in the "Mit" position, the resistance of the resonant circuit is on the order of that of the series resistor W25, or even much smaller if the frequency of the interference signal deviates significantly from the operating frequency. In this case, only a small fraction of the voltage of the interference signal is effective at the resonant circuit.

With the filter is turned on, the farther the frequency of the interference signal is removed from the 900 Hz operating frequency, the more it is suppressed: strong attenuation.

68. The characters' audio signals arrive at the preamplifier stage via input transformer EÜ, are amplified by tube RÖ29, and are transferred via intermediate transformer ZÜ to the dry rectifiers [*cuprous-oxide-on-copper diodes*] GL34 and GL35 where they are rectified. The intermediate transformer has an additional secondary winding that goes to the "Mithören" [*monitoring*] connectors. However, this winding is only connected via contacts U53, when the main switch U7 is in the "Ein" [*On*] position. If the main switch is in the "Aus" [*Off*] or "Bereit" [*Ready/Standby*] position, then the "Mithören" connectors are connect to the secondary side of the line transformer LÜ. The DC-pulses are input to the final stage, after smoothing by a resistor-capacitor filter. They control the anode current of tube RÖ29 [43!] that energizes the magnet in the printing mechanism of the receiver.

D. OPERATION OF THE FELDFERNSCHREIBER

69. Preparation

Attention!

When the case is opened, the Feldfernschreiber must be protected from moisture, dirt and dust. The ground [earth] binding post must be connected to a proper ground. Only field mechanics trained on this machine are allowed to undo the screws that are marked with a red ring, with exception of the mounting bolt of the Amplifier and Interconnect Unit.

When the equipment is not in use, the case shall be closed.

70. Setting up the machine

- 1) Opening of the equipment: by undoing the four buckle latches.
- 2) The keyboard unit is put into its operating position by pushing the latch lever to the left ("Riegel lösen" ["*release latch*"]) and simultaneously pulling the keyboard unit out by about 1 cm [$\frac{1}{2}$ "], then the lever must be released and the unit pulled out farther, until the latch catches again.
- 3) The paper supply must be checked. To this end, the hinged lid [*that covers the paper drawers*] is opened by pushing on the [black] release button that is embedded in the frame of the keyboard, and the paper drawers are opened by pushing on the corresponding [black]. New paper rolls are to be installed in accordance with line items 23 and 24.
- 4) The ground [earth] lug must be connected to a good ground.
- 5) The main switch of the Amplifier and Interconnect Unit must be put in the "Aus" ["*Off*"] position.
- 6) The "Tonsieb 900" ["*900 Hz Filter*"] switch must be put into the "Ohne" ["*Without*"] position.
- 7) It must be checked that the voltmeter reads "0".

71. Connecting the power source

- 8) The battery cable must be inserted into the 12 volt connector socket of the Amplifier and Interconnect Unit, + to +, – to – (the connector is polarized [*one socket pin has 5 mm diam., the other 4 mm*]). The spade connectors at the other end of the cable must be connected to the terminals of a 12 volt accumulator (e.g., a [*automotive*] starter battery), or, when using a mains [*transformer*] rectifier unit, to the 12 volt terminals of the latter unit.

The + spade connector must be connected to the + terminal, the – spade connector to the – terminal.

72. Connecting the [phone] line and the field telephone set (Appendix 2)

- 9) When using a two-wire line, the wires must be connected to the La and Lb/E connectors.
- 10) When using a single-wire line, the wire must be connected to the La connector, and the Lb/E connector must be grounded.
- 11) A "Feldfernsprecher 33" field telephone set must be connected to the Amplifier and Interconnect Unit, by inserting a patch cable into this unit and into the phone set.

73. Calling the opposite station

- 12) The opposite station is called by turning the inductor crank of the field telephone set.

If the distance to the opposite station is too large to pass a call to the opposite station, then operation can be conducted as follows: the equipment is activated on both sides, according to a predetermined schedule (e.g., for ten minutes at the beginning of each full hour).

74. Starting up the Feldfernschreiber

- 13) Change the main switch over to the "Bereit" ["*Ready/Standby*"] position. The indicator light will illuminate and the voltage of the power source must be in the red range [11–13 *volt*] of the voltmeter.
- 14) The main switch must be left in the "Bereit" position for one minute, to allow warming up of the tubes.
- 15) After this waiting period, the main switch must be changed to the "Ein" ["*On*"] position. The indicator light will be turned off, the motor spools up, and when the blue button on the voltmeter is pushed, the indicated anode voltage is in the blue range [150–190 *volt*]. The field telephone set remains hooked up during operation.

75. Transmitting

- 16) The keys [*of the keyboard*] are enabled at regular intervals; hence, the typing finger must be put onto the key **lightly and without applying pressure**, until the key goes down. The key must then be let go of immediately and the next key must be actuated.

When typing correctly, 2½ characters are sent per second. If one is not proficient at this typing speed, then one should type at half speed.

76. Receiving

- 17) At the start of reception, the "Verstärkung" ["*Amplification/Gain*"] knob must be turned so as to obtain the best print quality.
- 18) When interfering noise is received from the line, the "Tonsieb 900" ["*900 Hz Filter*"] switch must be put into the "Mit" ["*With*"] position, and the "Verstärkung" knob must be readjusted for best print quality.

77. Adjustment of synchronization

- 19) First, the regulator cap of the motor-generator must be set to 5 at both operating stations.
- 20) Then characters must be requested from the opposite station, and the regulator cap must be turned so as to obtain horizontal text lines.

If the received text lines are slanted upward: turn the regulator cap to the right (raise it), to a higher value on the scale.

If the received text lines are slanted downward: turn the regulator cap to the left (lower it), to a lower value on the scale.

Adjustment of the synchronization is basically only done on one side: the receiving station. Synchronization at the transmitting station is then automatically correct.

If the adjustment range of the regulator cap is insufficient, then the regulator on the transmitting side must be changed from 5 to a higher or lower value as appropriate, followed by repeating the synchronization adjustment on the receiver side.

78. Pause and termination of traffic

- 21) For short breaks in the transmission, the pause key must be depressed to signal the opposite station and the switch boards along the line, if any.
- 22) Upon termination of the transmission, the main switch must be changed to "Aus" ["Off"], and if necessary, the switch boards must be notified by turning the inductor crank [*of the field telephone set*].

79. Inserting paper

- 23) The start of the paper roll must be separated from the roll, and the roll must be placed into the paper drawer, such that it unrolls clockwise. The paper tape must then be pulled through the guides [*on the left hand side of the drawer*] and must be turned such that the gummed side is down. When pushing the drawer back into the drawer box, the tape must be guided through the slit [*in the left hand side of the box*].
- 24) The paper tape is inserted into the printer system by putting the ink roller lever into its upper detent position and feeding the paper under the printer spindle and between the paper transport roller and the pinch roller.

80. Replacing the ink roller

- 25) To replace the ink roller, the ink roller lever must be turned upward and held, the used ink roller pulled off, and a new roller pushed on.
- 26) A removed ink roller must be re-inked immediately. For this purpose, only the printer ink (special ink "HB 45 violett") may be used; it is stored in station box B. The ink must be applied evenly 8 to 10 times, with the brush that is attached to the screw cap of the bottle. After resting for 4 to 6 hours, the ink roller is ready for use again. Ink rollers that are worn out must be disposed.

81. Replacing the fuse and the tubes [valves]

To pull out the Amplifier and Interconnect Unit for replacement of the tubes or the fuse, the mounting bolt that is marked with a red ring, must be loosened with the aid of a screwdriver or a coin. The tubes must be pulled out of their socket by their head. When inserting a tube, it must be turned about its axis until its pins align with the corresponding notches of the socket. The tube is then carefully pushed in with light pressure. To replace the fuse, the screw cap [*of the fuse holder*] must be unscrewed and the fuse taken out. Putting in a fuse is done in reverse order.

82. The name [*callsign or station designator*] of the Fernschreiber must be written on white placard on the cover of the character contact drum.

E. TESTING OF THE EQUIPMENT AND CORRECTION OF MALFUNCTIONS

83. Due to the simple construction of the Feldfernschreiber, equipment failures are rare when it is properly maintained. In most cases, problems are not caused by equipment failure, but by improper and incorrect operation. Therefore, in case of problems, correct operation must be checked first.

84. Problems with the equipment can usually be judged by the quality of the received text. It must always be determined first, whether the problem is caused by the own station, the communication line, or by the opposite station.
85. The verifications under item 1 through 18 below, are done without an opposite station; to this end, the line must be disconnected from connectors La and Lb/E. For the remaining items, the Feldfernschreiber must be in the operational configuration.

Fault:	Cause and correction:
1. Mains switch is on "Bereit", voltmeter shows no voltage; indicator light is not illuminated	a) Electrical power source is not connected. b) The 6 amp. fuse in the Amplifier and Interconnect Unit is blown. Replace fuse per line item 81 above.
2. Main switch is on "Bereit", voltmeter indication is not in the red range; indicator light is dim.	Battery is depleted. Replace battery.
3. Main switch is on "Bereit", voltmeter shows no voltage; Indicator light is illuminated.	Electrical power source is connected incorrectly, change polarity! Observe correct polarity!
4. Main switch is on "Bereit", voltmeter indication is correct. Indicator light is not illuminated.	Indicator light bulb is burned out. Replace light bulb. [Check continuity of the motor carbon brushes circuit]
5. Main switch is on "Bereit", motor does not spool up.	a) The 6-pin connectors in the Amplifier and Interconnect Unit are not firmly inserted. Check proper seating b) The carbon brushes of the motor are worn, or the collector [<i>commutator</i>] is dirty. Have the unit checked by the teleprinter mechanic.
6. Main switch is on "Ein". When the [<i>blue</i>] pushbutton [<i>of the voltmeter</i>] is pushed, no voltage is indicated.	The carbon brushes of the generator are worn. Have the unit checked by the teleprinter mechanic.
7. No text is printed on the paper tape.	Check with the receiver of the connected field telephone set if a 900 Hz tone is heard when the Morse key is depressed. a) If no tone is heard, check proper seating of the tubes [<i>valves</i>]. b) Replace "Tone-Summer", "Endstufe" and "Vorstufe" tubes in accordance with line item 81 above. c) Have the unit checked by the teleprinter mechanic.
8. A continuous line appears on the paper tape.	Replace the "Endstufe" tube in accordance with line item 81 above.
9. Printed characters appear very faint.	Replace the ink roller in accordance with line item 80 above.
10. Printed characters are smeared. Horizontal character lines flow into each other.	The felt ring [<i>of the ink roller</i>] has too much ink. Roll the felt ring on blotting paper or newspaper. Clean the printer spindle and printing system with a rag lightly dipped in some denatured alcohol. Do not use gasoline [<i>UK: petrol</i>]!
11. Characters of the upper text line are properly inked, whereas those of the lower text line appear faint, or the other way around.	The ink roller is primarily inked on one side, or not evenly around the roller. Replace the ink roller in accordance with line item 80 above.

Fault:	Cause and correction:
12. The background of printed characters is lightly colored with ink at certain spots.	The leaf spring of the ink roller does not push down hard enough on the paper strip. Have the leaf spring adjusted by the teleprinter mechanic.
13. The same spot of several characters is not printed.	The [common/continuous] contact ring or the carbon brush of the drum is dirty. Have the contact ring cleaned by the teleprinter mechanic.
14. Individual characters printed poorly.	The character contact drum is dirty. Have the character contact drum cleaned by the teleprinter mechanic.
15. Irregular dots appear all along the paper tape.	Replace the "Endstufe" tube in accordance with line item 81 above.
16. [When transmitting] only the center text line of the monitoring print is legible; there is half a line above and below this line respectively.	The printer spindle is misaligned. Have the printer spindle properly adjusted by the teleprinter mechanic.
17. The pause characters are printed incompletely.	The [notch-driven] pause character gate [in the gear box] is skewed with respect to the position of the character drum. Have proper alignment done by the teleprinter mechanic.
18. Characters are printed too close together; the paper tape does not move forward.	a) The paper supply is used up. b) Verify that the paper is inserted correctly, in accordance with line item 79 above. It must be possible to pull out the tape without too much resistance. c) The paper transport roller is dirty. Clean the grooved flanges of the roller with a steel brush.

86. The checks of line items 19 through 23 below are performed in cooperation with the opposite station. The line must be connected to connectors La and Lb/E, and the opposite station must be requested to send the pause character.

Fault:	Cause and correction:
19. No characters are received from the opposite station.	Check with the receiver of the connected field telephone if the characters can be heard. a) If no tones are heard, notify the opposite station. b) Replace the "Vorstufe" tube, followed by the "Endstufe" tube, in accordance with line item 81 above.
20. Printed text is slanted, and cannot be straightened by turning the regulator cap.	Have the equipment checked by the teleprinter mechanic.
21. Text lines are severely slanted downward and the motor speed goes down audibly.	a) Check the battery voltage. Check the anode voltage of the generator. b) Remove the Interconnect Unit [from the case] but do not disconnect the [two] cables; pull the "Reglerstufe" tube out of its socket, then one by one, the other tubes. If the speed increases to an approximately normal level, then the tube that was just removed is damaged and must be replaced. c) Have the teleprinter mechanic check the low voltage [= motor] carbon brushes and clean the collector [commutator].

Fault:	Cause and correction:
22. Text lines are severely slanted upward and the motor speed goes up audibly.	a) If additionally the anode voltage is low: check the "Reglerstufe" tube. b) Have the teleprinter mechanic check the high voltage [= <i>generator</i>] carbon brushes and clean the collector [<i>commutator</i>].
23. When operating over long lines, characters appear twice.	This is caused by echoes due to splices in the line. Attenuating the received signals usually corrects this. Set the gain control to the lowest amplification that still produces legible print; "Tonsieb 900" [900 Hz <i>bandpass filter</i>] to "Ein". Such echoes can also appear in the own monitoring print, if such a line is connected.

87. **|| All interventions into the equipment beyond what is mentioned in line items 83 through 86 above, is forbidden.**

88. Other failures that may occur are to be determined and corrected only by a teleprinter mechanic, whose tasks are provided in line items 95 through 114.

F. TECHNICAL DATA OF THE FELDFERNSCHREIBER

89. General

Application:	Transfer of text characters by operation via [<i>phone</i>] lines or radio.
Construction:	Housed in the backpack case: the Keyboard-transmitter Unit (transmitter, receiver, bottom unit, motor-generator) and the Amplifier and Interconnect Unit. Accessories: 2 connection cables, 2 rolls of printing paper.
Weight:	About 25 kg [55 lbs].
Size:	Height: 455 mm [$\pm 18''$], Width: 390 mm [$\pm 15''$], Depth: 240 mm [$\pm 9\frac{1}{2}''$].
Required power source:	1 starter battery 12 V, at least 40 Ah (for about 10 hours of operation), or a Feldfernschreiber rectifier unit.
Voltage variation:	11 – 13 V acceptable.

90. Transmitter

Transmitting speed:	150 characters per minute or 2½ characters per second.
Font decomposition:	7 columns per character.
Telegraphy speed:	122.5 baud.
Rotational speed of the character drum:	150 revolutions per minute.

91. Receiver

Current-draw of the printer system:	About 10 mA at a nominal voltage of 165 volt.
DC-resistance of the printer system:	4200 ohm
Rotational speed of the spindle:	525 revolutions per minute.

92. Bottom unit

Roll of printing paper, gummed [<i>on one side</i>] for moisture protection:	Length: about 250 m [820 <i>ft</i>], Width: 15 -0.1/+0 mm [0.6"], Thickness: 0.065 ±0.005 mm [25.6 <i>mils</i>], Diameter of the core of the roll: 29 -0/+1 mm [1 ⁹ / ₆₄ "].
Paper consumption:	About 28 m per operating hour.
Rotational speed of the paper transport roller:	12.5 revolutions per minute.
Rotational speed of the pause character gate:	16.7 revolutions per minute (= ¹ / ₉ the speed of the character drum).

93. Motor-generator

Rotational speed of the motor-generator:	3600 revolutions per minute.
Power of the motor-generator:	For a supply voltage of 12 V and a current draw of 2.5 A, the secondary electrical power dissipation is 4 W (165 V / 25 mA), the mechanical dissipation is 4 W.
Accuracy of the speed regulation:	± 0.15 percent.
Range of the speed control:	± 4 percent, by turning the regulator cap.

94. Motor-generator

<i>Circuitry:</i>	1 tone generator for 900 Hz, 1 receiver-amplifier comprising: 1 pre-amplifier stage, 1 rectifier, 1 final stage, 1 regulator stage for the motor-generator.
Tubes [<i>valves</i>]:	4 tubes of type RV 12 P 4000.
<i>Current</i> draw of the tubes:	About 0.9 A.
Tone filter:	Bandwidth about ± 100 Hz, in "Mit" [" <i>With</i> "] position.
Required input signal level:	With tone filter switch in "Mit" [" <i>With</i> "] position: at the La–Lb/E connector: 0.3 – 3 volt, which corresponds to -3.4 to +1.2 neper [-29 to +10 <i>dB</i>]. With tone filter switched to "Ohne" [" <i>Without</i> "]: about 0.7 neper [6 <i>dB</i>] more sensitive.
Input resistance:	At the "Empfänger" connector: about 4000 ohm. At the La–Lb/E connector: about 800 ohm. Voltage at the "Mithören" connector for 0.05 V input voltage: about 3 to 4 V.

Tone generator output voltage:	At the La–Lb/E connector: 2.5 V, 900 Hz at 800 ohm.
Tone generator frequency:	900 Hz $\pm$ 3 % at 165 V anode voltage and 800 ohm load at the La–Lb/E connector.
Output level:	Under the above conditions: +0.8 to +1.2 neper [<i>-7 to +10 dB</i>].

G. CARE AND MAINTENANCE OF THE FELDFERNSCHREIBER

General

95. **Attention: the tasks and adjustments outline below are only allowed to be performed by a teleprinter mechanic, i.e., a precision-mechanic who has received special training as a Feldfernschreiber mechanic.**
96. **Attention: the extent to which the equipment may be disassembled for maintenance and correction of failures, is prescribed by the following line items. All disassembly that is not absolutely necessary is forbidden.**

Cleaning

97. After about 100 operating hours, but at least every 4 weeks, excess oil, dust and other dirt must be removed from the equipment with a dusting brush and a [*lint-free*] cleaning rag.
98. For cleaning the character drum, the transmitter unit must be completely removed from the backpack case, but the cables to the Amplifier and Interconnect Unit must remain connected. The cover of the drum is removed after loosening the two red knurled-head screws [*also marked by a red ring*], and the motor-generator is switched on. The turning drum, and especially the continuous contact ring, is cleaned with a clean [*lint-free*] cloth and a small amount of kerosene [*UK: paraffine oil*].
- The contact drum shall not be oiled or sanded. Also, the installed drum shall not be turned by hand, as this will damage the gearing to the motor.**
99. If the [*motor and generator*] commutators are only lightly fouled, then they are to be cleaned with a [*lint-free*] cloth that is lightly dampened with kerosene [*UK: paraffine oil*]. If they are heavily fouled, then the converter [*motor-generator*] must be removed in accordance with line item 119, and made to run by applying 12 V = [*DC*]. The commutators must be very carefully rubbed down with very fine sandpaper [*emery paper*], and then the remains of this sanding and other dirt must be thoroughly cleaned off with a cloth that is lightly dampened with kerosene.

Maintenance

100. Every 100 operating hours, but at least every 8 weeks, the Feldfernschreiber must be oiled and greased in accordance with line items 135 through 142.

Parts requiring special maintenance

101. Regulator

The accuracy of the regulator can only be retained with careful treatment [*of the equipment*]. **Removal of the regulator is forbidden.** For oiling, the regulator cap is to be

removed in accordance with line item 120. A small strip of paper is to be dipped in [*teleprinter*] selector-bar oil, the oil is to be squeezed off with 2 fingers, and the paper strip is to be inserted between the ball of the regulator lever (Appendix 3, item 1) and the insulator block of the lower contact spring (Appendix 3, item 2). The paper strip is pulled through, while both parts [*i.e., the ball and the insulator piece*] are lightly pushed together. The regulator cap is to be put back on in accordance with line item 120.

102. Carbon brushes of the motor

The carbon brushes of the motor must be replaced if they are worn down to a length less than 5 mm [$\frac{3}{16}$ "].

The carbon brushes must be replaced in accordance with line item 130.

103. Carbon brushes of the generator

The carbon brushes of the generator must be replaced if they are worn down to a length less than 6 mm [$\frac{1}{4}$ "].

The carbon brushes must be replaced in accordance with line item 131.

104. Carbon brush of the drum

The carbon brush of the drum must be replaced if it is worn down to a length less than 3 mm [$\frac{1}{8}$ "].

The carbon brush must be replaced in accordance with line item 132.

105. || Attention: only pre-ground carbon brushes shall be used for line items 102, 103, and 104.

Particularly difficult adjustments

106. Adjustment of the rotational speed of the motor in the transmitting equipment

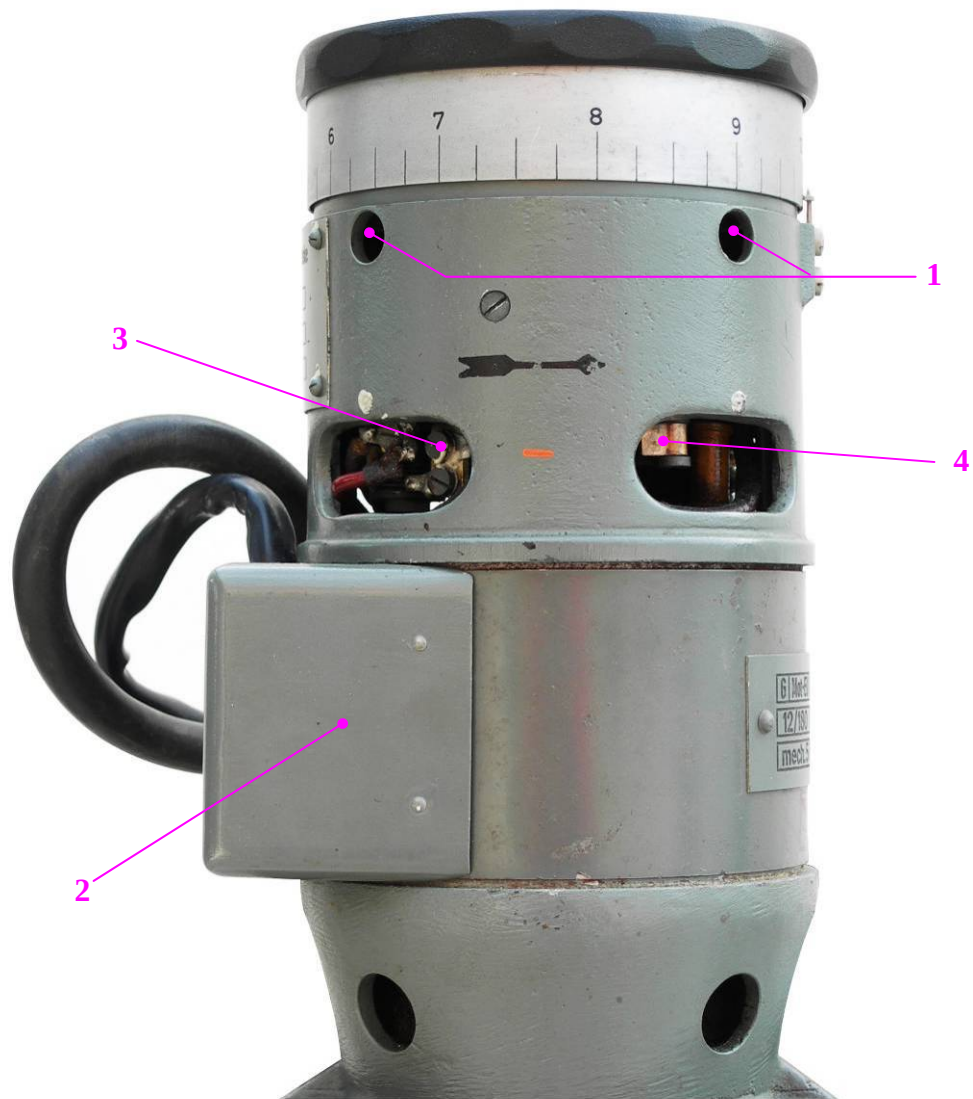
The regulator must set to 5 by turning the regulator cap, the motor switched on, and the pause character key pushed. For correct speed of the motor-generator (3600 rpm), 50 pause characters are sent in 80 ± 2 seconds. If no 50 characters are sent and the failures covered by line items 99 and 103 have been excluded, then the regulator must be re-adjusted by turning the set screw with the aid of a screwdriver that has a wide blade. To do this, the motor must be switched off.

The set screw (Figure 14, item 1) is accessible via any one of the 4 round holes below the adjustment ring [*that has the 0-10 scale tape on it*].

Turning the set screw clockwise increases the speed of the motor. Turning the set screw counterclockwise reduces the motor speed.

107. Adjustment of the rotational speed of the motor in the receiving equipment

Deviations of the rotational speed are only noticeable on the side of the receiving equipment. In the transmitting equipment, the monitoring printing is not affected, due to the fixed gearing [*between the motor, character drum, paper transport, and the printer*]. If the printed text lines cannot be made to be parallel to the edge of the paper tape by changing the speed of the motor in the transmitting machine, then the machine must be checked and adjusted in accordance with line item 106.



1 = set screw for the regulator
2 = protective cover

3 = terminal for the lead-wire of the carbon brush
4 = bearing pin of the motor's carbon brush

Figure 14 **Motor-generator with regulator**

108. Adjustment of the printed text lines

If on the transmitting side, the two printed [*transmitted*] text lines are not one above the other, but there is one line in the middle and the other line is half above and half below that middle line, then the printer is misadjusted. The printing mechanism must be removed in accordance with line item 123, and the crown gear of the spindle turned until the two text lines appear above each other. Turning the gear clockwise by one tooth moves the printed characters up by 1 mm [$\frac{5}{132}$ "]. Reinstalling the printer is done in accordance with line item 123.

109. Adjustment of the pause character gate

The adjustment of the pause character must be done in accordance with line item 116b.

H. REMOVAL AND INSTALLATION OF MAIN PARTS AND REPLACEMENT OF COMPONENTS

Amplifier and Interconnect Unit

110. Removal

The Amplifier and Interconnect Unit must be pulled out after loosening the mounting bolt [*at the lower left-hand corner of the front panel of the unit*] that is marked with a red ring. Then, both of the 6-pin connectors must be pulled out and the unit completely taken out [*of the case*].

111. Installation

For installation, both of the 6-pin connectors must be plugged back into their respective socket. The connectors are marked as follows:

- a) motor connector with a red dot and "vorn" [*"front"*].
- b) connector with a green dot and "hinten" [*"rear"*].

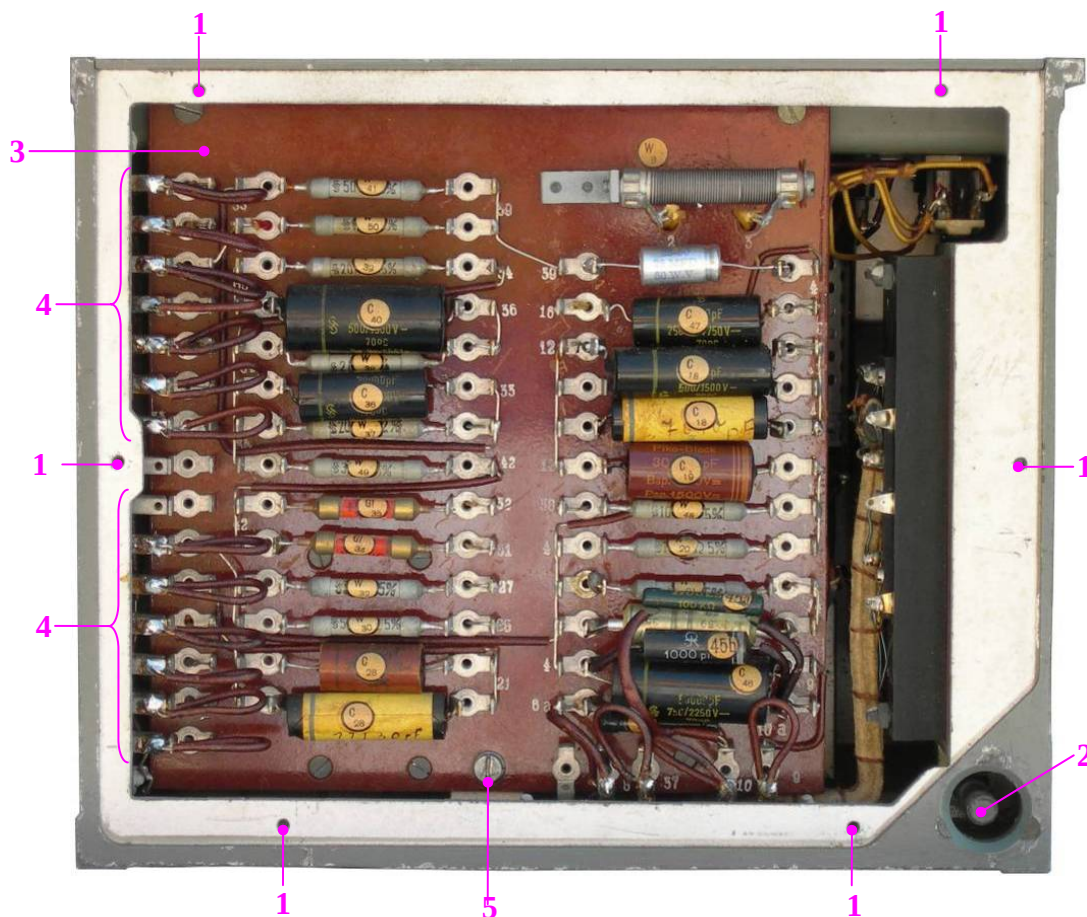
The connectors cannot be plugged into the wrong socket [*nor upside down*]; besides the dot markings, each connector has a guide pin that is placed such that one connector does not fit into the socket of the other. The Amplifier and Interconnect Unit is then inserted into the guide tracks [*at the top and right hand side inside the case*], slid in, and tightened down with the mounting bolt.

112. Replacement of the voltmeter

- a) Loosen the screws with which the voltmeter is attached to the unit, and carefully pull out the instrument, until the connecting wires are exposed. De-solder the wires, while noting their polarity!
- b) Solder the wires to the terminals of a new or refurbished voltmeter, while observing the polarity; then carefully insert the meter into the case and tighten the screws.

113. Replacement of parts in the Amplifier and Interconnect Unit

- a) Remove the unit from the case in accordance with line item 110, and remove the rear cover after loosening the 6 mounting screws. De-solder the two strips of solder lugs on the [*pertinax*] card that carries the capacitors and resistors, and then unscrew the single retainer screw on one of the edges of the card. Then loosen the 4 mounting screws of the top cover plate (through which the tubes are installed) of the unit, remove this plate and carefully remove the card with the capacitors and resistors. All components are now accessible and can be replaced.
- b) Reinstallation of the card with the capacitors and resistors and the cover plate is done in reverse order.



1 = hole for mounting screws of the rear cover
2 = tip of unit mounting bolt

3 = pertinax card
4 = strip of solder lugs

5 = card mounting screw

Figure 15, supplementary: rear view of Amplifier and Interconnect Unit, cover removed
Figure added by the translator, F. Dörenberg, for clarification purposes.

Mechanical Unit

114. Removal

To take the Mechanical Unit out of the case, the latch must be released and the [latch] lever continued to be held to the left, until it moves farther to the left by itself when the unit is pulled out. Only then, the lever may be let go and the unit pulled out completely. The two 6-conductor cables must be removed from the Amplifier and Interconnect Unit, in accordance with line item 111.

115. Installation

To install the Mechanical Unit, its two guide bars must be inserted approximately 3 cm [1¼"] into the guide tracks [at the bottom of the inside] of the backpack case. Then the latch lever must be pushed to the left and the unit inserted half way. Now let go of the lever and insert the unit all the way into its parked position. The connector of the two 6-conductor cables must be inserted into the [respective] socket of the Amplifier and Interconnect Unit, in accordance with line item 111.

116. Replacement of components in the transmitter drum

- a) The Mechanical Unit is to be removed from the backpack case in accordance with line item 114, and the protective cover of the character drum to be removed after

loosening the two knurled-head screws. The Keyboard-Drum Unit can be lifted off, after loosening the two screws of the keyboard [one below and to the right of the *I* and *E* keys, the other below and to the left of the *1* key and the Morse key], and the screw of the mounting bracket on the back of the Keyboard-Drum Unit (Figure 16).

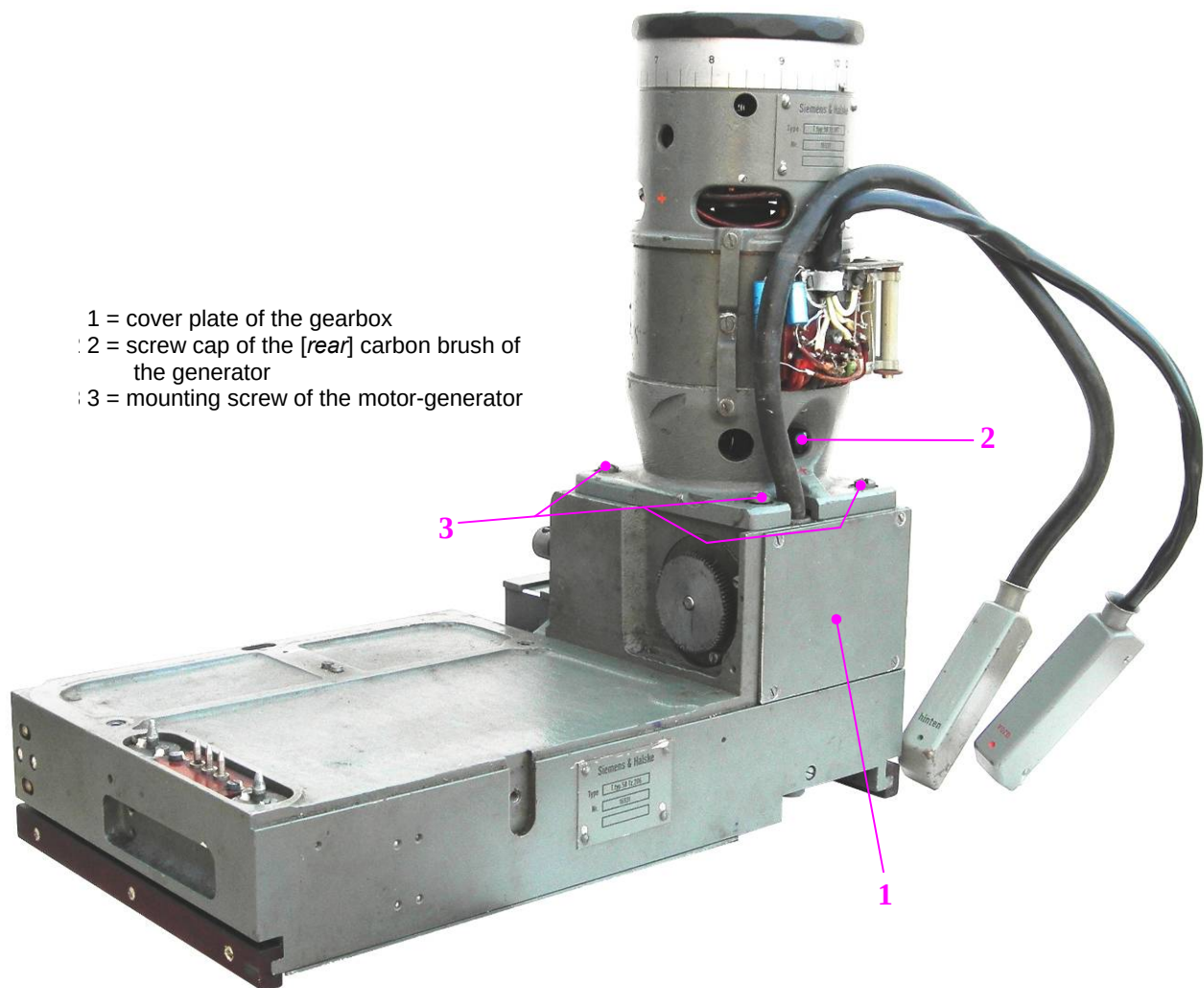


Figure 16 **Mechanical Unit with Keyboard-Drum Unit removed – rear view**

- b) Before putting back the Keyboard-Drum Unit, the cover of the gear-box (Figure 16, item 1) must be removed, after undoing its 4 mounting screws. The [rotor of the] motor-generator must be turned by hand, such that the contact-spring of the pause character contacts (Appendix 4, item 1) touches the middle of one the [three] notches of the cam wheel. Next, the drum must be turned by hand until the slip contacts [of the drum] are at the middle of the contacts segments. In this position, the Keyboard-Drum Unit must now be positioned onto the Bottom Unit, while paying attention to the alignment of the teeth [of the spur gear of the drum and matching spur gear on the outside of the gear-box], and fixed in place with the two mounting screws of the keyboard, and the screw of the mounting clip on the back [of the Keyboard-Drum Unit]. Then, the protective cover of the drum must be put back on, and the two knurled-head screw tightened.
 Putting the Mechanical Unit back into the backpack case must be done in accordance with line item 115.

117. Replacement of the transmitter drum

- a) To do this, the Mechanical Unit must be removed in accordance with line item 114, and the Keyboard-Drum Unit must be removed from the Bottom Unit in accordance with line item 116. Next, the [2+2] screws (Appendix 5, item 1 and 2) must be loosened, the right-angle [saddle] bracket (Appendix 5, item 3) removed, and the carbon brush of the drum taken out after unscrewing its screw cap. Carefully lift off the contact drum and its bearings.
- b) To install a new or refurbished drum, the contact springs must be locked into detent by pulling the control bar (Appendix 6, item 1) strongly rearward. Then, the drum is to be seated, the right-angle [saddle] bracket put back and the bracket-screws lightly tightened. Further adjustments are to be performed in accordance with line item 116. Before putting the protective cover back on, the two [round] adjustment nuts (Appendix 5, item 4) must be turned with a set pin such that the spur gear of the drum meshes with the spur gear of the gear-box with small but noticeable play. Then the [bracket-] screws are to be fully tightened, while making sure that the adjustment nuts do not turn. Finally the protective cover is to be put back on, and the Mechanical Unit to be reinstalled in accordance with line item 115.

118. Replacement of a slip contact

- a) First the transmitter drum is to be removed, in accordance with line item 117. Then the mounting screws (Appendix 6, items 2 and 3) are loosened and the spring bar (Appendix 6, item 4) is lifted **without taking off any of the springs that are attached to it**; take off the spring that belongs to the slip contact that is to be replaced, and remove that slip contact.
- b) The new slip contact must be stuck into the free slot, and pushed beyond the guide pin (Appendix 5, item 5); the associated spring must be put in place, and the spring bar **carefully** put back on the bracket of the keyboard and bolted down. The remainder of the reinstallation is done in accordance with line item 117.

119. Replacement of the motor-generator

- a) Remove the Mechanical Unit [*from the case*] in accordance with line item 114, and remove the protective cover of the drum. Remove the cover (Figure 15, item 2) on the rear of the converter [*motor-generator*] after loosening its mounting screw. Then remove the four mounting bolts [*marked with a red ring*] at the base, and **carefully** remove the motor-generator.
- b) When installing the new or refurbished motor-generator, the tappet [*of the pin coupling on the gear-box side*] (Appendix 7, item 1) must be turned such that the red line on the tappet is aligned with the red line on the alignment ring (Appendix 7, item 2) [*on top of the gear-box*]. The coupling (Appendix 7, item 3) must be aligned so as to be parallel to the red line on the tappet [*of the gear-box*]. The tappet (Figure 17, item 2) of the motor-generator must be turned such that its red line is aligned with the red line on the guide ring (Figure 17, item 2). Then, the motor-generator is **carefully** mounted [*onto the gear-box*], such that pin of its tappet engages the hole in the [*follower of the*] tappet of the gear-box (Appendix 7, item 4).

Turn the rotor of the motor-generator by hand to check that the contact drum follows in both directions. Finally, the motor-generator is bolted down with the 4 mounting bolts, the protective cover on the back of the converter [*motor-generator*] and the protective cover of the drum are put back and the mounting screws tightened, and the Mechanical Unit is installed into the case in accordance with line item 115.

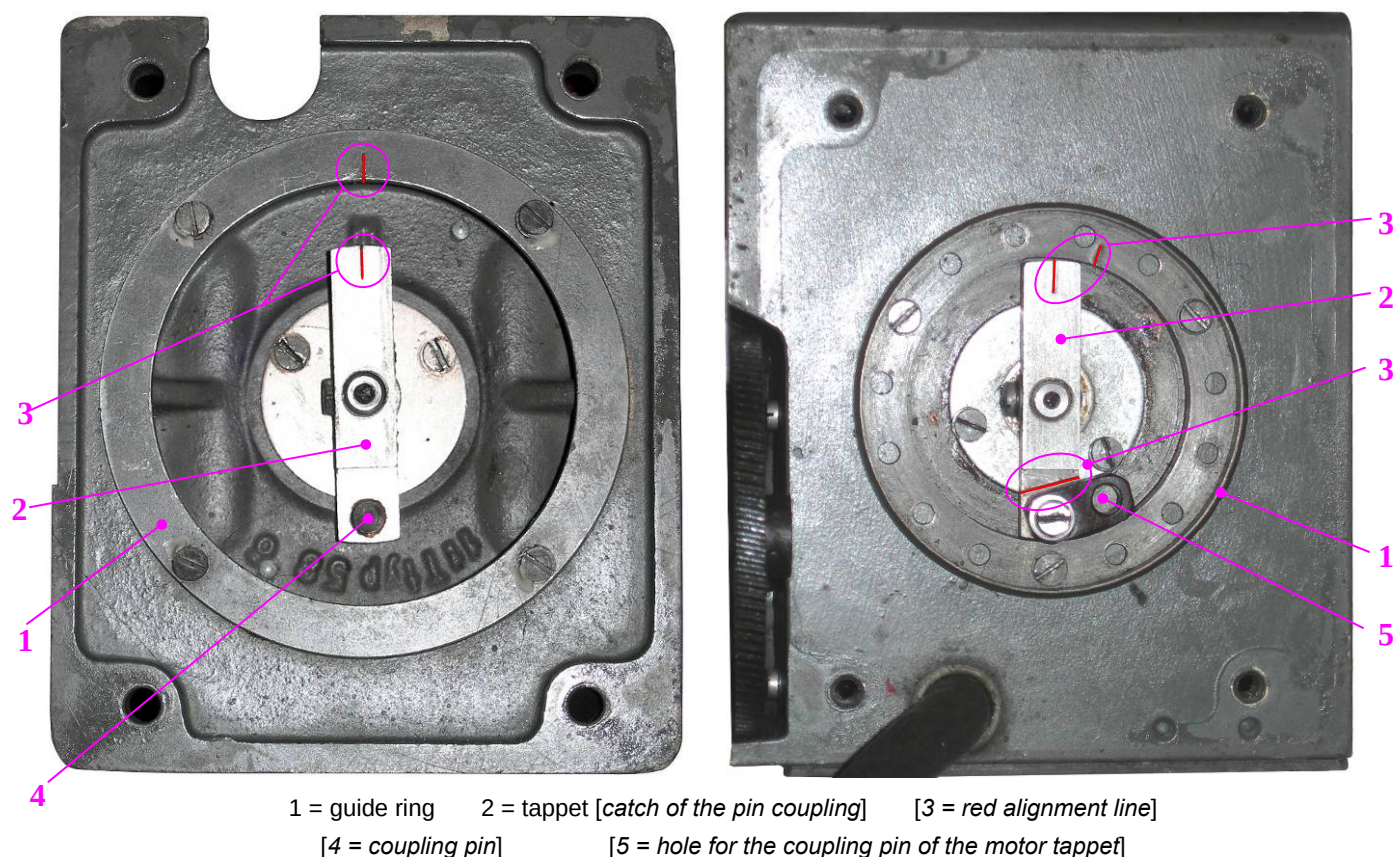


Figure 17 Bottom view of the motor-generator (left) and top of the gear-box (right)

Photo on right added by the translator, F. Dörenberg, for clarification purposes.

120. Replacement of the contact plate of the regulator

- a) Remove the Mechanical Unit [from the case] in accordance with line item 114. Remove the index pointer of the [motor speed] adjustment tape-scale, after undoing the two mounting screws. Remove the regulator cap with its tape-scale by turning the cap counter clockwise. De-solder the wires from the terminals (Appendix 3, items 3, 4 and 5), and unscrew the two clips (items 6 and 7). After loosening the two screws (Appendix 3, item 8 and 9), remove the contact plate.
- b) When installing a new or refurbished contact plate, the Turbax® piece must be lightly oiled. *[Turbax is a brand name dating back to Jaroslaw's Erste Glimmer-Waren Fabrik of Berlin-Weißensee in the 1930s, for a "Hartgewebe", a cotton-reinforced laminate of thermosetting material (phenol-formaldehyde (PF) resin, similar to bakelite®); today it is still used for gears due to its flexible and quiet-running properties; in sheet form, it is often referred to as Harex®. It can machined like wood and metal, or be molded. Related (registered) brand names are Novotext, Tenazit, Thesit, Taumalit, Esconit, Bernit, Resinol, Tenatext, Trolitan, Tufnol and Micarta].* The contact plate must be inserted and fixed in place with the two screws; the wires soldered back on, the two clips screwed back on, and the regulator cap with the scale-tape screwed on and turned until the end-stop, then turned back until the 5 on the scale is aligned with the two screw holes for the index-pointer. Then the index-pointer is screwed back on, and equipment put back into the case in accordance with line item 115.

121. Replacement of the gear-box drive gear for the Keyboard-Drum Unit

- a) Remove the Keyboard-Drum Unit from the Bottom Unit in accordance with line item 116. Next, loosen the 3 mounting screws (Appendix 7, item 5) and **carefully** pull out the drive gear (Appendix 4, item 2) of the Keyboard-Drum Unit.
- b) The installation of a new or refurbished drive gear is done in reverse order, while paying attention to the meshing of the gears; the Keyboard-Drum Unit is re-installed on the Bottom Unit and the Mechanical Unit is put back into the case in accordance with line item 116.

122. Replacement of the drive shaft of the gear-box

- a) The motor-generator must be removed in accordance with line item 119. The 3 mounting screws (Appendix 7, item 6) must be removed and the drive shaft **carefully** pulled out.
- b) The installation of a new or refurbished drive shaft is done in reverse order, while paying attention to the meshing of the gears. **Special attention** must be paid when screwing the alignment ring back on, to ensure that the red line is back at the position where it was when the drive shaft was taken out. The remainder of the re-installation is done in accordance with line item 119.

123. Replacement of the printer mechanism

- a) Put the Feldfernschreiber in the operating position, lift the ink roller lever into its upper detent position, and remove the paper. Undo the two mounting screws (Appendix 7, item 7) [*marked with a red ring*] and take off the printer mechanism.
- b) When putting the same printer mechanism back on, **carefully** mesh the teeth [*of its crown gear with the drive gear of the gear-box*] and push it against the edge guide (Appendix 7, item 8).

When installing a new printer mechanism, loosen the two screws of the edge guide, push the edge guide down, **carefully** mesh the teeth of the [*crown gear of the*] printing system [*with the drive gear of the gear-box*] and lightly tighten the mounting screws of the mechanism. Move the printing mechanism such that there is a small but noticeable play between the meshing gears of the printer spindle and the drive gear [*of the gear-box*]. Then tighten the mounting screws in this position, push the edge guide against the printer mechanism and tighten its mounting screws. Printing must be adjusted in accordance with line item 108.

124. Replacement of the paper transport roller

- a) Undo the retaining screw and pull the transport roller off.
- b) Install the new transport roller in reverse order.

125. Replacement of the printer spindle drive

- a) Remove the printing mechanism in accordance with line item 123, undo the mounting screws (Appendix 7, item 9) [*on the gear-box*], and **carefully** pull the printer spindle drive **straight** out. The paper transport roller must be unscrewed first, in accordance with line item 124. If the spindle drive is hard to pull out, or cannot be pulled out at all, then remove the Keyboard-Drum Unit in accordance with line item 114. Then push the spindle drive out by applying light pressure onto the shaft of the spindle drive with a small wooden rod.
- b) The installation of the printer spindle drive is done in reverse order, while paying attention to the meshing of the gears.

126. Replacement of the pinch roller

- a) Undo the retaining screw and pull the pinch roller off.
- b) Before putting the new pinch roller on, it must be well oiled and the oil removed from the surface of the pinch roller.

127. Replacement of a paper drawer

- a) Push on the release button corresponding to the drawer, keep it pushed, and pull the drawer straight out of the Bottom Unit by its front.
- b) To install the new paper drawer, hook it slightly into the drawer box at an angle, such that the [*Turbax® or Harex®*] guide bar on the left of the drawer is inserted behind the end-stop at the front of the left guide track [*inside the drawer box*], and then [*while keeping the drawer release button pushed, engage the right hand side of the drawer into its guide track, and*] slide the drawer in completely.

128. Replacement of a paper dish break

- a) Remove the paper drawer in accordance with line item 127, remove the left guide bar, and remove the break. [*the break is simply a small piece of bent spring metal that pushes against the center of the left side of the round paper dish inside the paper drawer; it is barely visible at the far left of the dish*]
- b) Installation of a new break is done in reverse order.

129. General issues regarding replacement of the carbon brushes

|| Only pre-ground carbon brushes are allowed to be used.

If the [new] carbon brushes [*for the motor or generator*] are insufficiently pre-ground [*bedded-in*], or not at all, then wrap a round bar or cylinder that has the same diameter as the collector [*commutator*] [*or as the character drum, as appropriate*] with very fine sand paper (emery tape). Pre-grind the carbon brushes by turning the bar. Pay attention to the relative position of the [*concave tip of the*] carbon brush and the collector [*commutator*]. [*The carbons are normally rectangular bars; the axis of the grinding bar must be perpendicular to the two long, wide sides of the carbon. The pre-grinding will make one end of the carbon concave; the carbon must be installed such that this concave part conforms to the curvature of the commutator, or of the continuous contact ring in case of the character drum*].

At every replacement of a carbon brush, it must be checked that the collector [*commutator*] of the motor and the generator are clean.

130. Replacement of the motor carbon brushes

- a) Unscrew the lead-wires from the terminals (Figure 14, item 3), take the pull-springs off their pin, and take the carbon brushes off their bearing pin (Figure 14, item 4).
- b) Installation of new carbon brushes is done in reverse order.

131. Replacement of the generator carbon brushes

- a) The Mechanical Unit must be taken out of the case in accordance with line item 114, but the two 6-conductor cables must not be pulled out of the sockets of the Amplifier and Interconnect Unit. Then unscrew the screw cap (Figure 16, item 2) [*of the carbon brush holder*] at the front [*marked with – and *] and back [*+*] of the motor-generator, and pull out the carbon brushes.
- b) Installation of new carbon brushes is done in reverse order.

The carbon brushes of the generator shall only be replaced when the motor is NOT running. The Feldfernschreiber shall not be turned on without generator carbon brushes.

132. Replacement of the drum carbon brush

- a) The Mechanical Unit must be taken out of the case in accordance with line item 114, but the two 6-conductor cables must not be pulled out of the sockets of the Amplifier and Interconnect Unit. Remove the protective cover of the drum, unscrew the screw cap [of the carbon brush holder] (Appendix 6, item 5) and remove the carbon brush.
- b) Installation of new carbon brush is done in reverse order, while paying attention that the rounded shape of the carbon tip aligns with the shape of the drum. Also, the carbon brush shall only glide on the wide [continuous] contact ring and not touch the insulating layer of the drum.

133. Adjustment of the leaf spring of the ink roller lever

The leaf spring must be adjusted if it presses down on the paper tape too lightly or not evenly; the spring must touch the paper evenly and over the full width [of the paper] when the ink roller is lifted about 5 mm [$\frac{1}{4}$ "].

134. General issues regarding replacement of components

All of the above maintenance actions must be performed without damaging the equipment. If the teleprinter mechanic can not correct the problem, then the equipment must be sent to the Signals Equipment Park for repair.

I. OILING AND GREASING OF THE FELDFERNSCHREIBER

135. Every 100 operating hours, but at least every 4 weeks, the equipment must be oiled after cleaning. Only [teleprinter] selector-bar oil shall be used (i.e., Shell oil P 37).
For oiling, it is convenient to use a wire with about 1 mm Ø [$\frac{1}{32}$ ", 18 AWG] that is dipped about 5 mm [$\frac{1}{4}$ "] into oil. The drop that hangs from the tip of the wire is enough for one oiling point (except for larger bearings).
136. All friction-, glide-, and bearing-points must be oiled, as well as all spring attachment points and [Turbax®] laminate gears. The points to be oiled are marked with  in Appendix 3 through 8.
137. To oil the Keyboard-Drum Unit, it must be removed from the case in accordance with line item 116. Oiling must be done per Appendix 5, 6 and 8.
138. The printer mechanism can be oiled without removing it. Oiling must be done per Appendix 7.
139. Oiling of the Bottom Unit must be done per Appendix 7.
140. To oil the motor-generator, it must be removed in accordance with line item 119. Oiling must then be done per Appendix 7.
141. To oil the regulator, its cap must be removed in accordance with line item 120. Oiling must then be done per Appendix 3 and line item 103.
142. The points that are marked with a  in Appendix 4 through 8 must be greased with gun/rifle grease or Shell Ambroleum [this product has been discontinued decades ago; it

was replaced by Shell Retinax G, which is a "Getriebefließfett" – an acid-free, soft, free-flowing gear grease. Retinax G was manufactured until ca. 2002. It is still used today, by vintage motorcycle and automobile buffs. According to specialists at Shell Lubricants Technical Information Centre, Ambroleum can also be replaced with a 1:1 mixture of Shell Retinax CS 00 (still manufactured in 2008) and a mono-grade engine oil of type Rimula R3+ 30]. The points in Appendix 8 that are marked with a ⊕ must be greased with rust-inhibiting grease "40". Parts must be thoroughly cleaned before applying grease.

143. If greasing of the ball bearings of the gear-box and of the contact drum is necessary, this must be done in the Signals Equipment Park. Highest quality ball bearings grease must be used.
144. The ball bearings of the motor-generator shall not be replaced. [*Dismantling the motor-generator to the point that the rotor can be removed, requires removal of the regulator, contact plate, etc., such that the rotor can be removed without breaking off or snapping any parts (some of which are made of brittle bronze); the motor bearings appear to be of type SKF 625. To avoid damage to the rotor shaft, do not apply a ball bearing puller directly to the end of the shaft. The end surface may have a tapped hole in it, threaded for a standard M3 (3 mm) screw. Put in a short M3 screw for the bearing puller to act on.*]

Berlin, 1 April 1941

Army Supreme Command Army Weapons Department

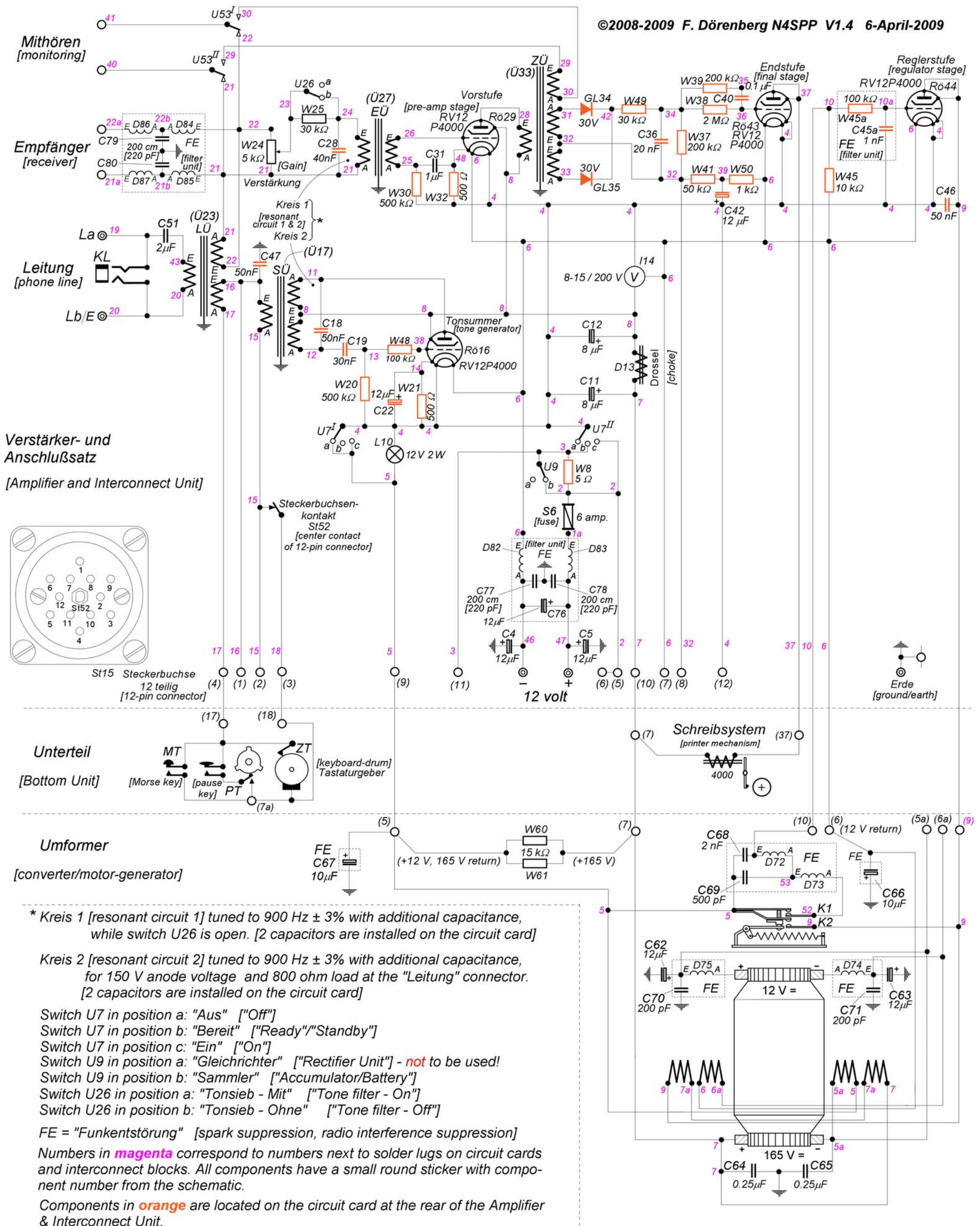
Development and Test Branch

Roch

Appendix 1 Complete circuit diagram of the Feldfernschreiber

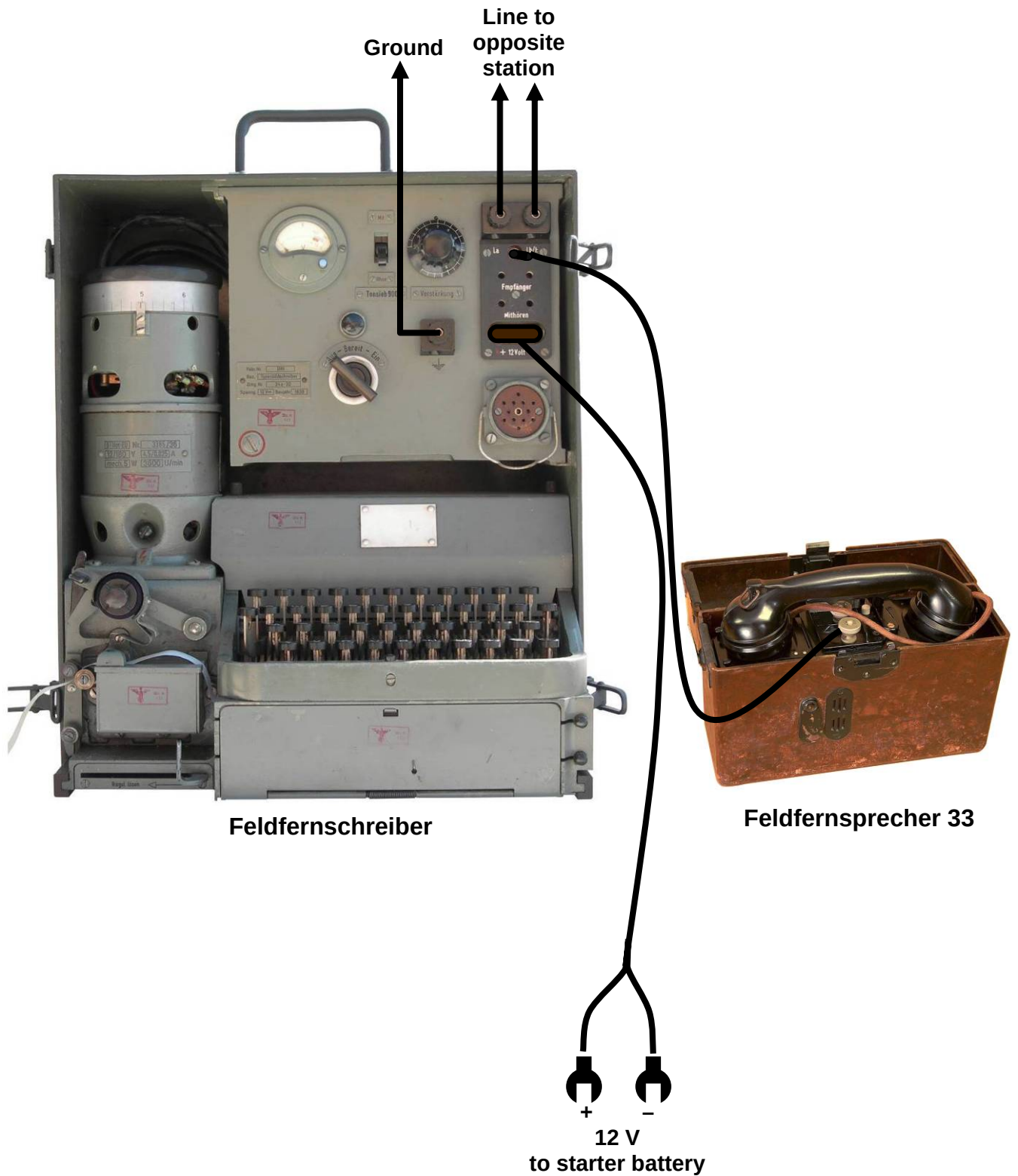
[suited for printing on A3 size paper]

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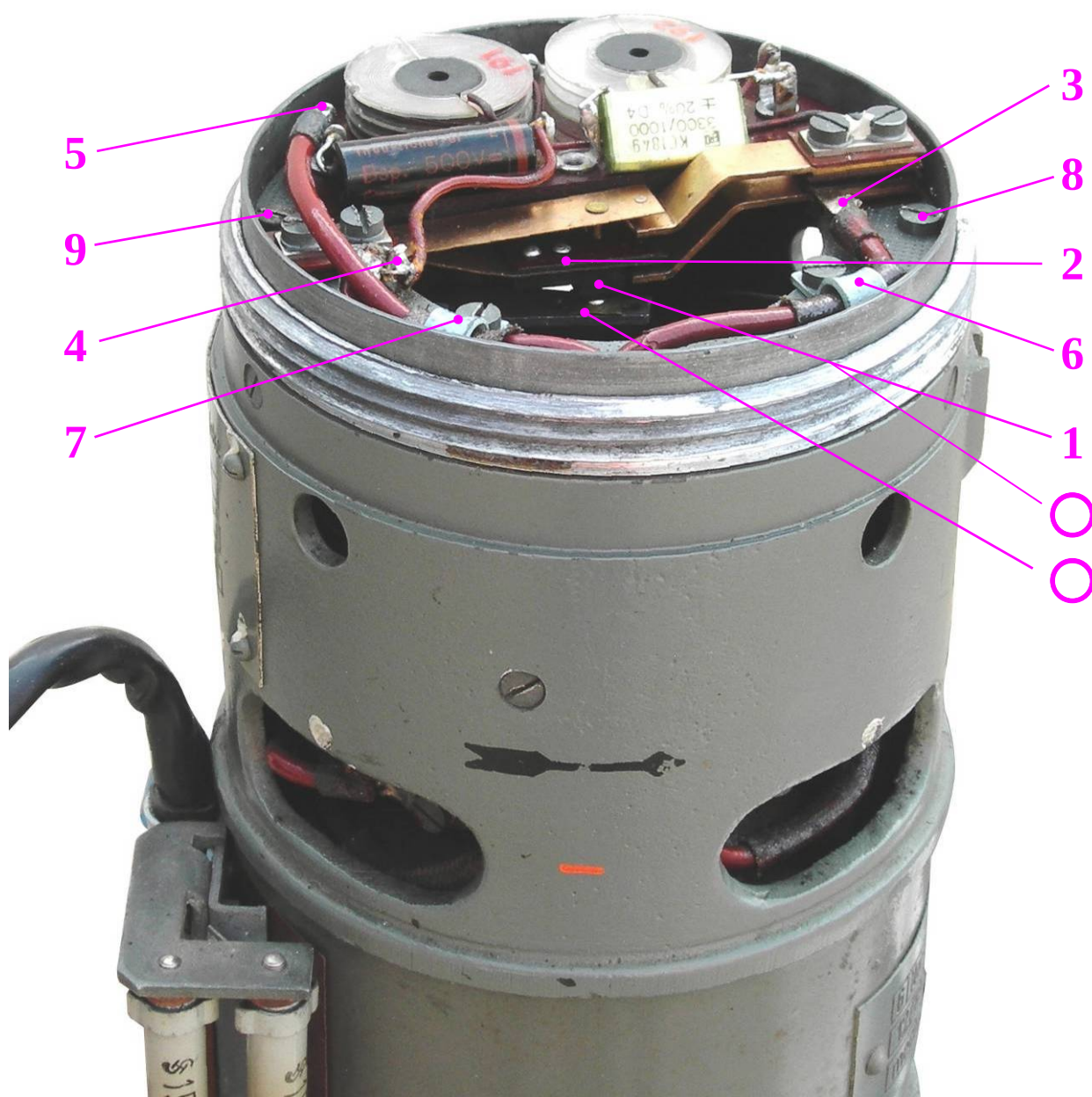
Appendix 2

Set-up of the Feldfernschreiber for phone line operation



Appendix 3

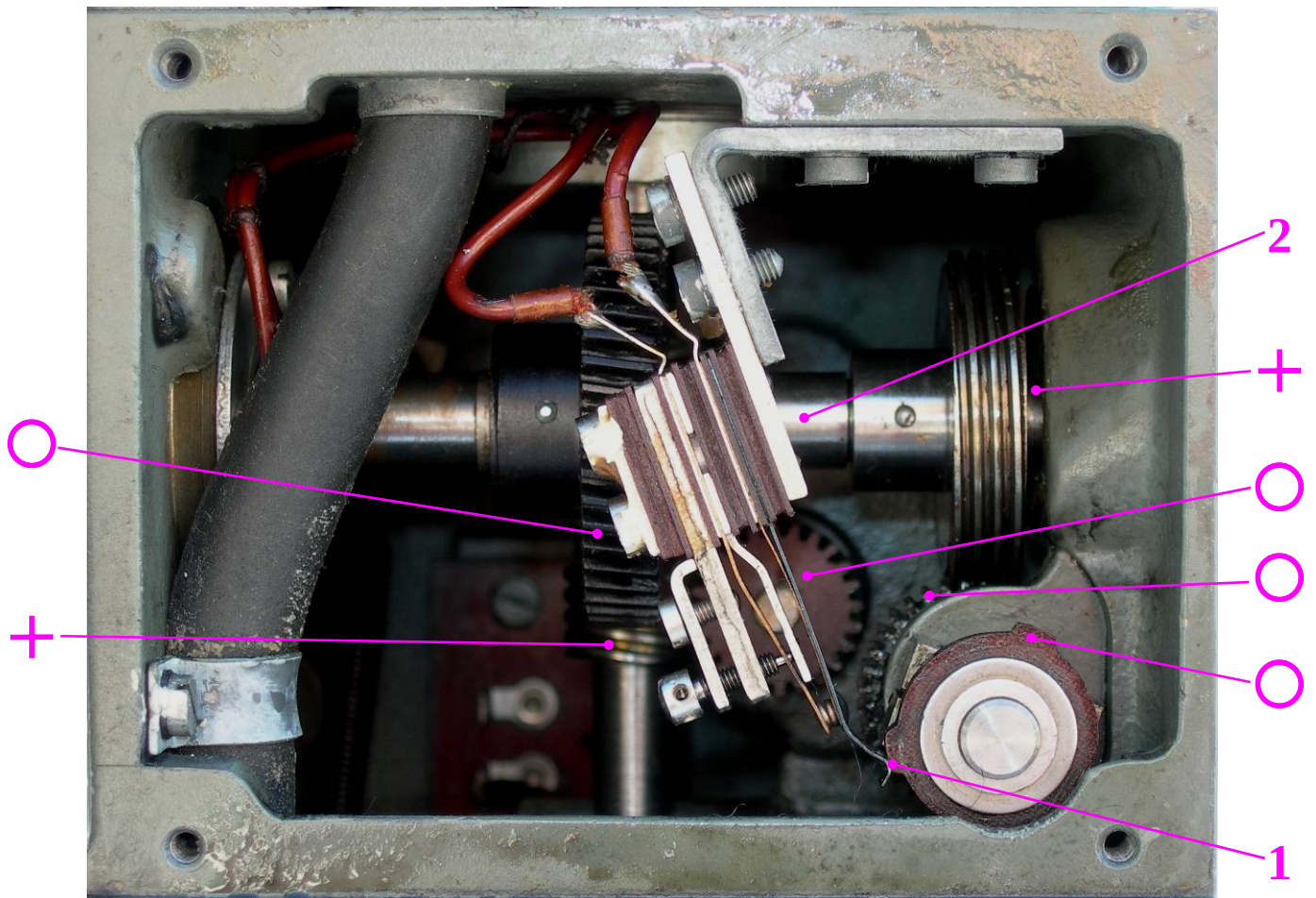
Regulator with cap removed



○ : designated lubrication points

- 1 = regulator lever ball
- 2 = insulating piece of contact spring
- 3 = wire terminal
- 4 = wire terminal
- 5 = wire terminal
- 6 = clip
- 7 = clip
- 8 = mounting screws of the contact plate
- 9 = mounting screws of the contact plate

○ = oil with selector-bar oil



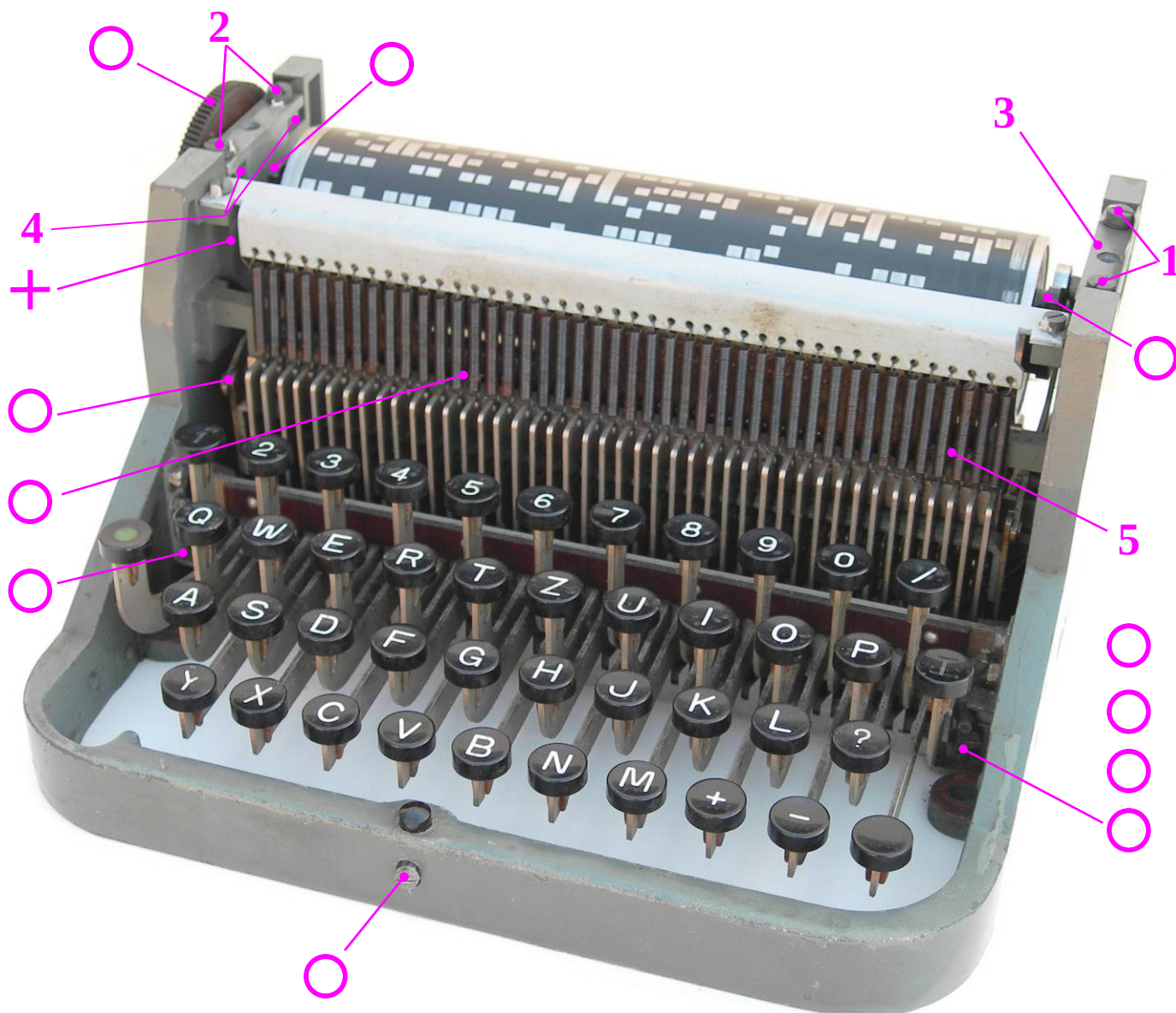
○ + : designated lubrication points

1 = cam-shaft with contact spring
2 = drive shaft for Keyboard-Drum Unit

○ = oil with selector-bar oil
+ = grease with gun/rifle grease

Appendix 5

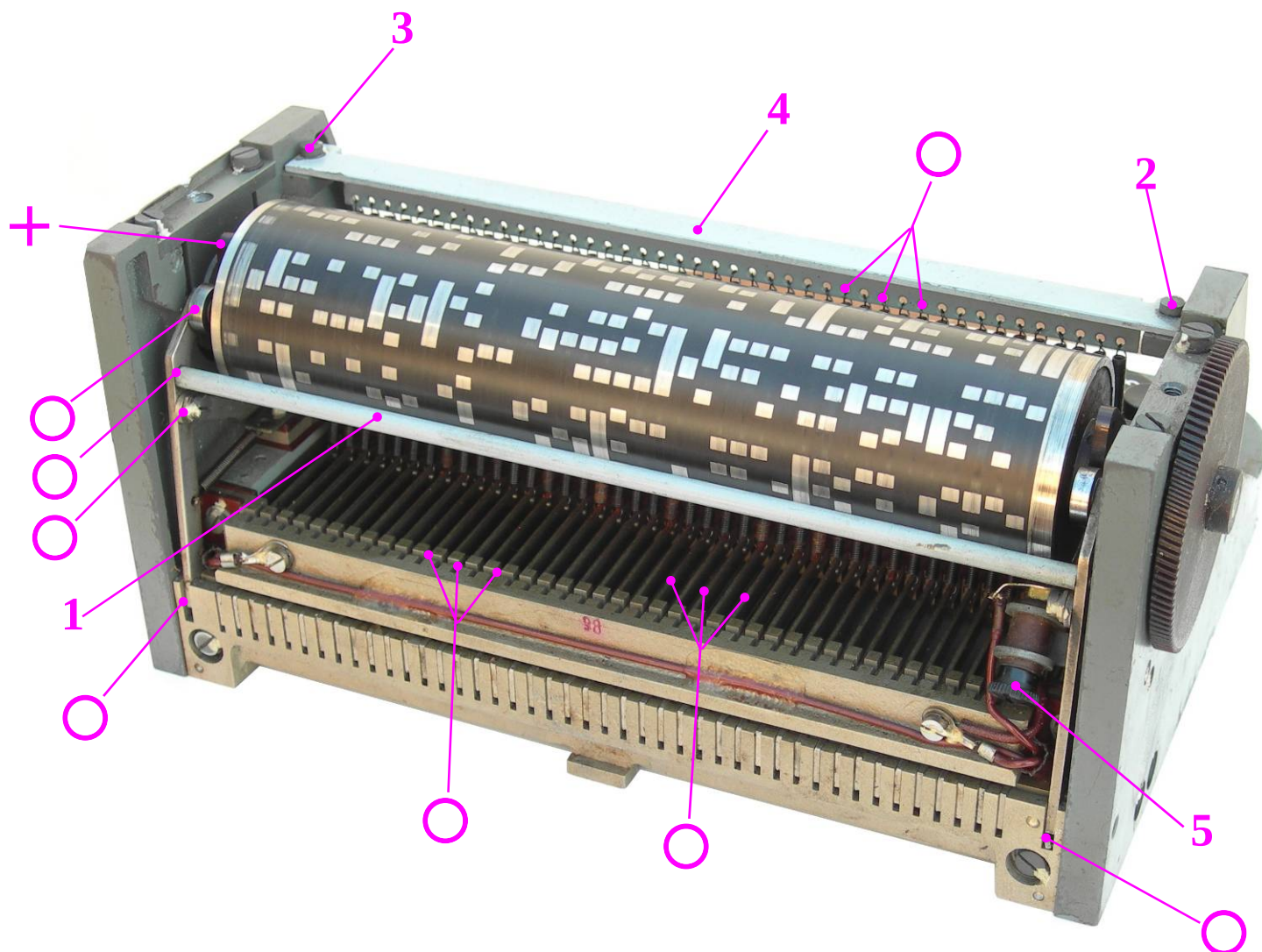
Keyboard-Drum Unit without protective cover, front view



○ + : designated lubrication points

- 1 = mounting screws of the contact drum
- 2 = mounting screws of the contact drum
- 3 = angle-bracket
- 4 = adjustment nuts
- 5 = guide pin for slip contact

- = oil with selector-bar oil
- + = grease with gun/rifle grease

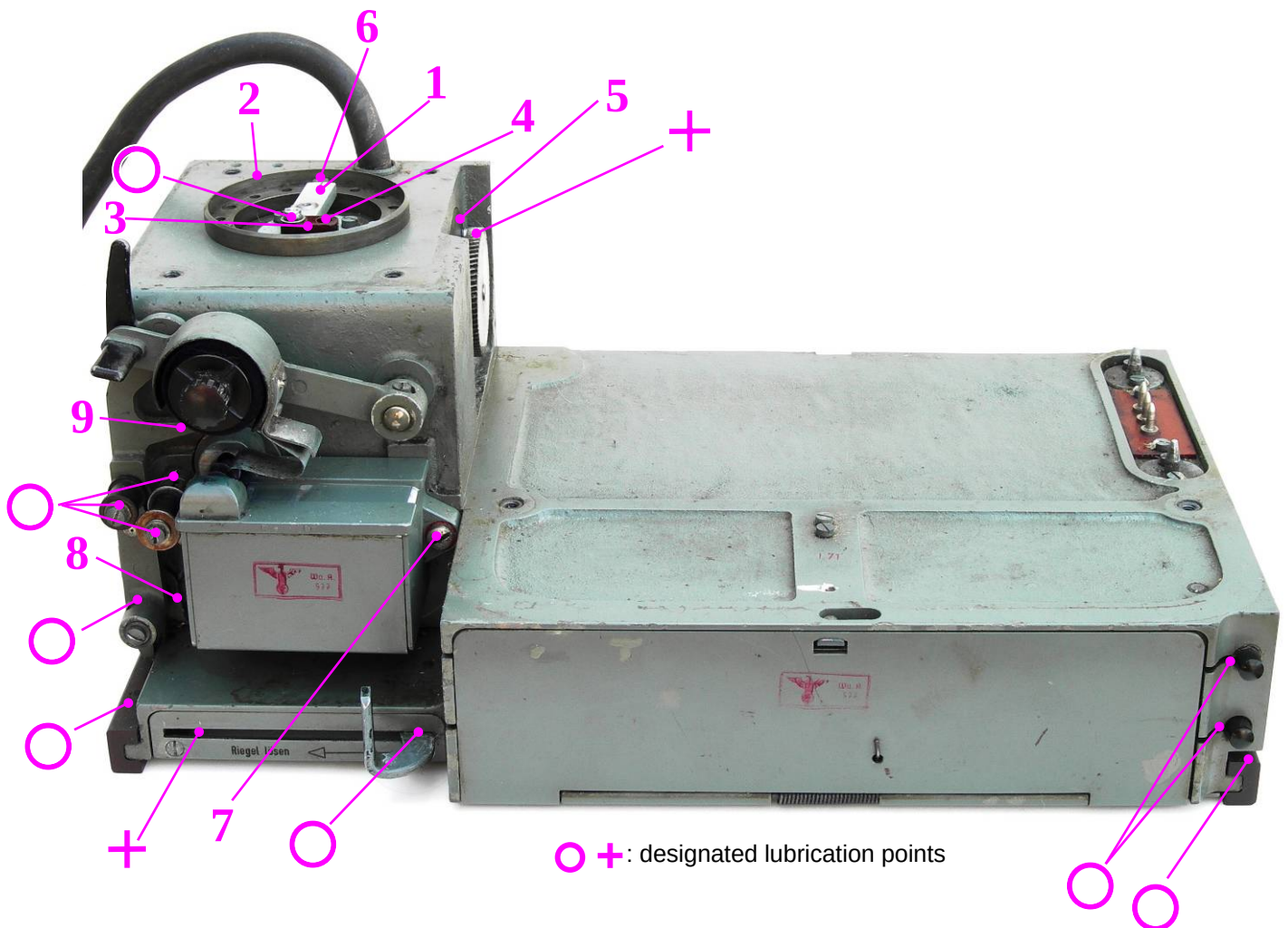


○ + : designated lubrication points

- 1 = switch bar
- 2 = mounting screws of springs bracket
- 3 = mounting screws of springs bracket
- 4 = springs bracket
- 5 = screw cap of the drum carbon brush

- = oil with selector-bar oil
- + = grease with gun/rifle grease

Appendix 7 Bottom 11 without keyboard-drum and motor-generator



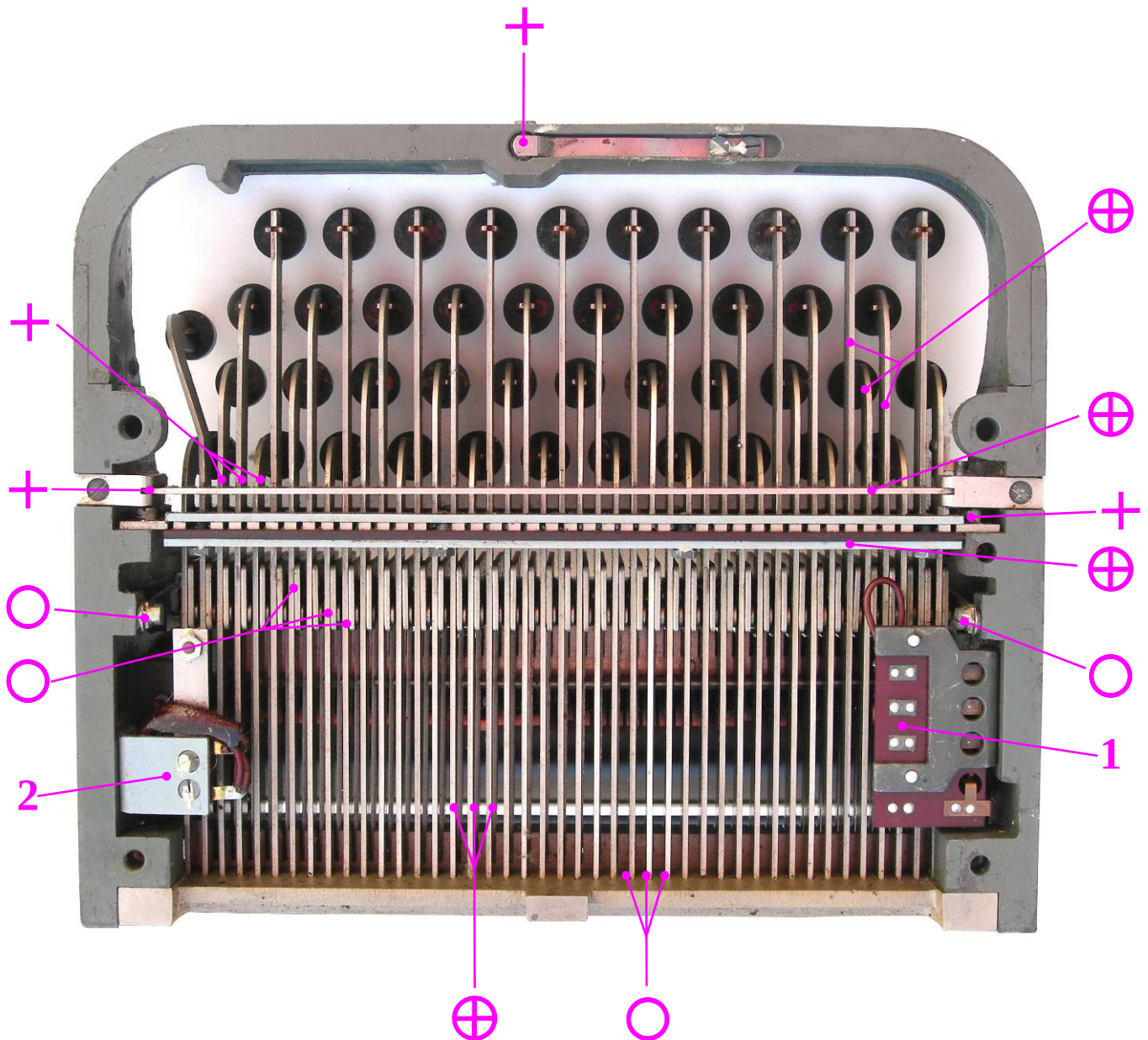
○ +: designated lubrication points

- 1 = tapped (follower)
- 2 = alignment ring
- 3 = link piece
- 4 = hole in link piece
- 5 = mounting screws of drum drive
- 6 = mounting screws of drive shaft
- 7 = mounting screws of printer mechanism
- 8 = end stop of printer mechanism
- 9 = mounting screws of spindle drive

- = oil with selector-bar oil
- + = grease with gun/rifle grease

Appendix 8

Bottom view of the keyboard



○ + ⊕ : designated lubrication points

1 = pause character key contact
2 = Morse key contact

○ = oil with selector-bar oil
+ = grease with gun/rifle grease
⊕ = grease with "rust-inhibitor grease 40"