ФИАЛКА



FIALKA M-125

Detailed description of the Russian Fialka cipher machines

by

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with contributions by
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Contents

	Preface	**7**
1	**The Fialka Cipher Machine**	**9**
1.1	Introduction	11
1.2	History	12
1.2.1	Introduction	12
1.2.2	Breaking Fialka	12
1.2.3	Improvements of Fialka	13
1.2.4	Fialka security procedures	13
1.2.5	Fialka keys and key procedures	14
1.2.6	Fialka in case of war	15
1.2.7	The GAZ-66 and the R-142 Radio Set	16
1.2.8	The R-142 Radio Set	17
1.2.9	Fialka and the R-142 Radio Set	18
1.3	Terminology used in this manual	20
1.4	Identifying a Fialka machine	22
1.4.1	Introduction	22
1.4.2	Establishing the model	22
1.4.3	Establishing the serial number	23
1.4.4	Identifying the wheels	24
1.4.5	Establishing the wheel series	25
1.5	Controls & Connections	26
1.5.1	Fialka M-125 model	26
1.5.2	Fialka M-125-3 model	28
1.5.3	Fialka interior	30
1.5.4	Fialka Power Supply	31
1.6	Checklist	32
1.7	Accessories	35
1.7.1	Introduction	35
1.7.2	Crank	35
1.7.3	Metal triangle	35
1.7.4	Power Supply	36
1.7.5	Paper tape holder	39
1.7.6	Spare wheel set in container	40
1.7.7	Test reflector	41
1.7.8	Additional print head(s)	41
1.7.9	Chad box	42
1.7.10	Toolkit	43
1.7.11	Wheel Opening Tool	44
2	**Using the Fialka**	**45**
2.1	Introduction	47
2.2	Check the drum	47
2.3	Check whether the mechanism is blocked	48
2.4	Safety first	48
2.5	Connecting the power supply	49
2.6	Turning the Fialka *on* for the first time	50

2.7 Using the copy-holder 51
2.8 Loading paper tape into the printer/puncher 52
2.8.1 Loading the standard 17.5 mm paper tape 52
2.8.2 Loading the special 10mm paper tape 52
2.8.3 Printer alignment 53

2.9 Five-letter groups 53
2.10 The Counters 54
2.11 Setting up the key 55
2.11.1 The Daily Key 55
2.11.2 The Message Key 56
2.11.3 The Indicator Book for Common Traffic 57
2.11.4 Changing the key 57

3 Detailed description 59

3.1 Introduction 61
3.2 Keyboard 63
3.2.1 Introduction 63
3.2.2 Standard keyboard layout 64
3.2.3 Keyboard letter mapping 64
3.2.4 Special characters 64
3.2.5 Notes on the German keyboard layout 65
3.2.6 Different keyboard layouts 66
3.2.7 Key legend 68
3.2.8 Text Mode 68
3.2.9 Numbers-only mode 69
3.2.10 Mixed Mode 69
3.2.11 Testing the print head movement in Midex Mode (C) 69

3.3 Wheels 70
3.3.1 Introduction 70
3.3.2 Removing the wheels 71
3.3.3 Fixed versus Adjustable wheels 72
3.3.4 Disassembling an adjustable wheel 73
3.3.5 Ring-setting and core-selection 73
3.3.6 Wheel wiring 74
3.3.7 Wheel stepping 76
3.3.8 Test reflector 80

3.4 Printer & Puncher 81
3.4.1 Introduction 81
3.4.2 Ink ribbon auto-reverse 82
3.4.3 The printer 82
3.4.4 The print head(s) 83
3.4.5 The print head lifter 83
3.4.6 Print head layout of the M-125 84
3.4.7 Error detection 84
3.4.8 Print head layout of the M-125-3 85
3.4.9 Replacing the print head 86
3.4.10 Printer & Puncher control switch 86

3.5 The digital 5-bit code 87
3.6 Card Reader 88
3.7 Sequence of Events 90

4 Technical details & Circuit Diagrams 91

4.1 Introduction 93
4.1.1 Enigma 93
4.1.2 Block diagram of the M-125 94
4.1.3 Block diagram of the M-125-3 95
4.1.4 Negative logic 96
4.1.5 Symbols 96
4.1.6 Location of the various circuits 96

4.2 External Power Supply 97
4.2.1 Introduction 97
4.2.2 Circuit Description 97
4.2.3 The alternative Power Supply 98
4.2.4 TEMPEST 98
4.2.5 Fialka and TEMPEST 98

4.3 Power Module 99
4.4 Keyboard 100
4.4.1 The switch-array 100
4.4.2 Circuit Description 101
4.4.3 Mechanical 5-bit Encoder 102
4.4.4 Auto-repeat 102
4.4.5 Tape Reader 102

4.5 MODE Switch 103
4.6 Card Reader 107
4.7 Entry Disc 109
4.8 NumLock Switch 110
4.9 Magic Circuit 113
4.10 Reflector 115
4.11 The 5-bit Encoder (Diode Matrix) 117
4.12 Printer Driver 118
4.13 Connectors 119

5 Hints & Tips 127

5.1 Introduction 129
5.2 Power Supply or cable(s) missing 129
5.3 No sign of life when power is turned on 131
5.4 One of the fuses is missing 132
5.5 The printer mechanism is damaged 133
5.6 Replacing the ink ribbon 134
5.7 Oil and Grease 135
5.8 Adjusting the motor speed 135
5.9 Creating your own key cards 136
5.9.1 Key cards 136
5.6.2 Test triangle 137

Appendix A - References 139
Appendix B - Glossery of terms 141

Foreword to the 2nd edition

In this new 2nd edition many chapters have been enhanced and new information has been added. Furthermore, new and better photographs and a number of new detailed drawings have been added. Detailed information about the use of Fialka in the R-142 radio set, the setup procedure for the daily key and message key, and information about the advanced Polish power supply are now included as well.

Preface

I first heard of the Russian Fialka Cipher machine in 2003, when someone told me that a limited number of these machines had become available for sale. But it wasn't until mid-2005 when the first machines became publicly available to collectors. The Fialka attracted my attention, mainly because it appeared to be a close relative of the Enigma cipher machine that had 'infected' me with the crypto-virus a few years earlier.

Furthermore, the Fialka was designed, built and used in an era of great tension and threat between east and west, also known as the cold-war. A mainly technical war, that had been the subject of many books, films, documentaries, protest demonstrations and, of course, our lessons at school. With the fall of the iron curtain in 1989, all this changed instantly. We gradually came to know our former 'enemy' and learned about their technological skills and achievements. In the past 10 - 20 years, a lot of Russian civilian and military equipment has become available to collectors and the likes, mainly in the form of Russian military radios. Cipher machines have always been a rare-find and the Fialka is no exception to this rule, not least because it still isn't officially declassified by the Russian authorities.

As there was no technical information available about this machine when I started writing this paper, I decided to reverse-engineer it, in order to find out exactly how it works and to make this information publicly available. A good starting point was the website of Professor Tom Perera in the USA [4] who, together with well-known Enigma researcher David Hamer [5], had already worked out the wiring of the wheels of the Polish Fialka machines. His website contained a large number of detailed images of each part of the machine which appeared to be of great help. But the real breakhrough came when Tom provided me with a partly disassembled drum mechanism of a defective Fialka machine, which he allowed me to take apart. I subsequently spent many weekends, evenings and nights tracing each and every wire in the machine, until I finally got a good insight in the machine's inner secrets and was able to draw the full circuit diagram.

When I started this research project, I had no idea about what I would find and who I would meet. One of the great advantages of our modern age is the internet, which makes your world a lot larger and yet brings it much closer to you. As I published the intermediate results of our research on my website, I was contacted by numerous people all over the world, giving their support and offering new information on the subject. These contacts have been, and still are, a tremendous help. Without them, this manual would not be what it is today. Furthermore, I have the feeling that I've aquired many new friends, although I've never actually met the majority of them.

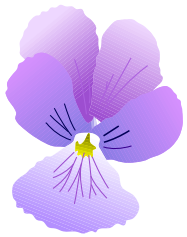
This manual is an attempt to explain the technical and operational backgrounds of the Russian Fialka machines, which are – in my opinion – great examples of the Russian technological skills during the cold-war. The machines are very well-built and are highly compact. Besides a 10-wheel coding machine, it also contains a text printer, a 5-bit tape puncher and a tape reader, all in a single machine which is actually a lot smaller than the western teletype machines of the same era. All in all, it's a wonderful piece of history. I hope you'll experience the same enthousiasm when reading this paper as I did when writing it.

January 2006,
Paul Reuvers

Chapter 1
The Fialka Cipher Machine

1.1 Introduction

Fialka is a Russian word that means 'Violet', which can be either a colour (purple) or a flower. Around 1965, the Russian Army introduced a brand new cipher machine, which was given the codename FIALKA. Two versions of this machine are known to exist: the M-125-xx and the M-125-3xx, with country-specific variants of each model. In principle, the *machine* is called M-125, whereas Fialka is the name of the cipher *procedure* but, as the machine is now commonly called Fialka, we will use that name throughout this manual.



The design of the Fialka is largely based on the well-known Enigma machine, that was used by the German Forces during WWII. Like the Enigma, it uses a number of coding wheels to scramble the letters typed on the keyboard. With each key-press, the wheels move into a new position, thereby effectively changing the alphabet-substitution for each letter typed on the keyboard. And that's where the similarity with the Enigma ends. Rather than presenting the output on a lamp panel, the Fialka prints the coded letter directly onto a paper tape. At the same time it can punch the letter into the same paper tape in a 5-bit digital code, much like the baudot code of a teletype machine. In addition, the Fialka contains a paper tape transmitter which can be used to transmit or duplicate a message. The Russians have clearly learned from the flaws in the Enigma's design and its operating procedures, as they've implemented the following improvements:

- 10 wheels, rather than 3 or 4 on the Enigma,
- More frequent wheel turn-overs,
- Adjacent wheels move in opposite directions,
- Wheel wiring can be changed (i.e. mixed and/or mirrored) in the field (from 1978 onwards),
- A punch card is used to replace the Steckerbrett (allowing daily change of letter-substitution),
- A letter can be encoded into itself (which was impossible on Enigma, making is vulnerable to breaks).

In addition to this, the following extra features are available:

- The machine can be set to use letters, numbers (or both) and punctuation marks (M-125-3 only),
- The machine can be used to duplicate a punched-paper tape,
- The machine can be used as a standard teletype machine (i.e. generate plain-text),
- It can be used for Russian (Cyrillic) as well as Latin,
- 30 characters can be encoded, rather than 26 on the Enigma.

The Fialka has been kept secret by the Russians for a long time, not least because it was used well into the 90's! After the fall of the iron curtain in 1989, some of these machines surfaced in the DDR (the former Eastern-Germany), but they were all collected by the Russians and subsequently destroyed. The collapse of the Soviet Union in 1991 further led to a decreasing Russian influence in the East-European countries of the Warsaw Pact. Finally the machines were withdrawn from operation and subsequently destroyed. Luckily some machines have miraculously escaped demolition and recently a small number of them has become available to collectors.

This manual is an attempt to give a complete picture of the Fialka machine and the technology behind it. It's a very complex machine and it's a fine piece of craftmanship. It uses both mechanics and electronics and we'll try to explain both. The rest of this chapter describes the history of the Fialka and gives a quick tour around the various controls and connections.

If you've just obtained a Fialka, you might want to skip this part and move directly to chapter 2 - *Using the Fialka*. It explains how to connect your machine and turn it on for the first time. Chapter 1.7 lists the various accessories that may or may not have been included with the machine. If your machine doesn't work, or if it appears to be blocked or incomplete, refer to chapter 5, where we've collected some useful hints and tips for restoring a damaged machine.

If you want to know exactly how the machine works, chapter 3 explains each part of the Fialka in more detail, whilst chapter 4 reveals the very complex circuitry of the machine. Chapter 6 finally explains in detail how the Fialka was operated by the East-German Army and how it was setup for the daily key.

1.2 History

1.2.1 Introduction

The M-125 was developed by the Russians in the period following WW-II. It was first introduced around 1965 and is largely based on the design of the German Enigma coding machine, used during WW-II, albeit with a number of improvements. First of all, the machine uses 10 coding wheels, compared to 3 or 4 on the Enigma, which greatly increases the maximum number of permutations. The plug board (German: Steckerbrett) of the Enigma, was replaced by a punch card reader, producing even more permutations and making it far less prone to mistakes when setting it up.

It was thought for a long time, that the Russians had no knowledge of the weaknesses of the Enigma machine prior to 1974, when details about large-scale breaking of the Enigma codes during WW-II were released by Captain Fredrick Winterbotham in his book *The Ultra Secret* [1]. However, with the knowledge we now have about the Fialka machine and its resemblance to the Enigma, one might be led to believe that the Russians had detailed knowledge of the Enigma and its flaws when they designed Fialka. This idea is backed by a story that has surfaced in 1999. It appears that the British communist-turned student, John Cairncross, worked at Bletchley Park [1] during WW-II, and was in fact a Russian spy [2]. It is more than likely that detailed information about Enigma's weaknesses was passed on to the Russians.

Initially the M-125 Fialka was built for use by the Russians only, which is shown by the keyboard layout. Later versions were equipped with a keyboard that had both Cyrillic and Latin letters on it. With a switch on the top of the machine, one could select either the Russian or the Latin character set (РУС ↔ ЛАТ). Finally the M-125-3xx was introduced, making the machine suitable for the other countries of the Warsaw Pact. Fialka is known to have been used in, Russia, Poland, Czechoslovakia and East Germany (the former DDR), but may have been issued in other countries as well.

The German Enigma machine had 26 contacts on either side of each coding wheel, one for each letter of the alphabet. As the Russian alphabet consists of more than 26 characters, the wheels of the Fialka have been given 30 contacts. This isn't enough for the entire Russian alphabet, which contains 33 characters. Some less frequently used letters have therefore been omitted. Some characters in the Latin character set have also been omitted, in favour of the numbers 2-9. The numbers 1 and 0 are replaced by the letters I and O respectively.

1.2.2 Breaking Fialka

Whether or not Fialka was safe in terms of cipher security, remains to be seen. Although the machine is far more complex than the Enigma, and thererfore far more difficult to penetrate, the widespread use of computers in later years must have posed a threat to its secrecy. It was believed by Russian crypto experts up to 1989, that Fialka messages could be read by an outsider after approx. 24 hours [3]. It is also known that in 1967, during the 6-Day War, Israel captured some Fialka machines. It is more than likely that they studied the machines thoroughly, which may have compromised the entire cipher for many years. By the 1970's the American NSA [2] had developed special software on a so-called 'super computer' that enabled them to read Fialka messages relatively quickly [9]. It is rumoured that the Austrians intercepted and decoded quite a substantial amount of East-European Fialka traffic. Although Austria isn't part of NATO, they have a very good relationship with the USA and the NSA. Whether or not NATO took part in the Fialka intercept and code-breaking effort is still unknown.

With the current raw processing power available on modern computers, it is theoretically possible to break Fialka messages within a few seconds, provided that exact details of the machine's operation are known.

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1) Bletchley Park was a property in Bletchley (now part of Milton Keynes), about 50 miles north of London in the UK. During WW-II the Government Code & Cipher School (GCCS) was located here, employing around 12,000 people in their successful attempt to break the German ciphers (including the well-known Enigma). Bletchley Park (BP for short) is now a museum, dedicated to the history of Code & Ciphers and is open to the general public.

2) The National Security Agency (NSA) is the real secret service of the USA. They advice companies and governments about security, develop their own cipher equipment and probably have the largest intercept and code breaking operation in the world. The NSA still exists to this day.

1.2.3 Improvements of Fialka

In 1978 the Fialka operating procedure was changed and new –more complex– wheels were introduced. At least this was the case in the DDR, but it is believed to be true for the other countries as well, as some finds in other countries have shown that the complex –adjustable– wheels were used in those machines as well. With the introduction of the new operating procedure in 1978, the name 'Fialka' was depricated as the procedure name, in favour of the name 'M-125'. The name *Fialka* however is still widely used for this machine. The new procedure remained in force to around 1987.

1.2.4 Fialka security procedures

In order to preserve security, most military cipher systems are always protected by extreme safety precautions. One not only needs to protect the cipher *machine* itself, but also the *keys* and the *keying* procedures. The Eastern-block countries were, of course, no exception to this rule. Like all other cipher devices, Fialka was heavily safeguarded. Information about Fialka was on a need-to-know basis. In practice, only the operator and, under strict control, some maintenance technicians, had access to the machines. Even the originator and recipient of a message were hardly ever granted access to a room if Fialka was present.

On big military excersises, Fialka would often be placed in a restricted place, such as a house or tent, whilst the surrounding area was completely sealed off. Warning signs indicated the presence of a secret device and a red light was often used to announce that the device was in operation. Everyone entering the restricted area without the appropriate passes and permits, was likely to be arrested immediately and exposed themselves to the risk of being shot on the spot.

The Fialka can be used both *on-line* and *off-line*. Off-line means that a message had to be prepared in advance, whilst Fialka was not connected to, say, a radio. On-line means that the machine was connected directly to a transmitting device, such as a radio, and that any message typed on the Fialka was sent immediately. On-line messaging has the advantage of speed, but it also has a number of disadvantages. For example, when the operator has accidently left his mode switch in the *clear-text* position, the message will be sent unencrypted. Furthermore, each operator will have a certain way of typing and his speed will depend on his skills, which sometimes gives away valuable information about the contents of a message.

Although Fialka can be connected directly to a radio, in practice this was never done. At least this was the case with the East-German Army (NVA). Operating procedures dictated that Fialka always had to be used off-line. A message would first be enciphered and stored on a punch paper tape. Once the message was complete, the Fialka was set to decoding mode and the enciphered message would first be decoded on the same machine. This was done to ensure that no text was ever sent as plain text, and that the correct wheel settings were used. Once the message had been verified, the encoded tape was taken to a radio station where it was sent from a paper tape reader.

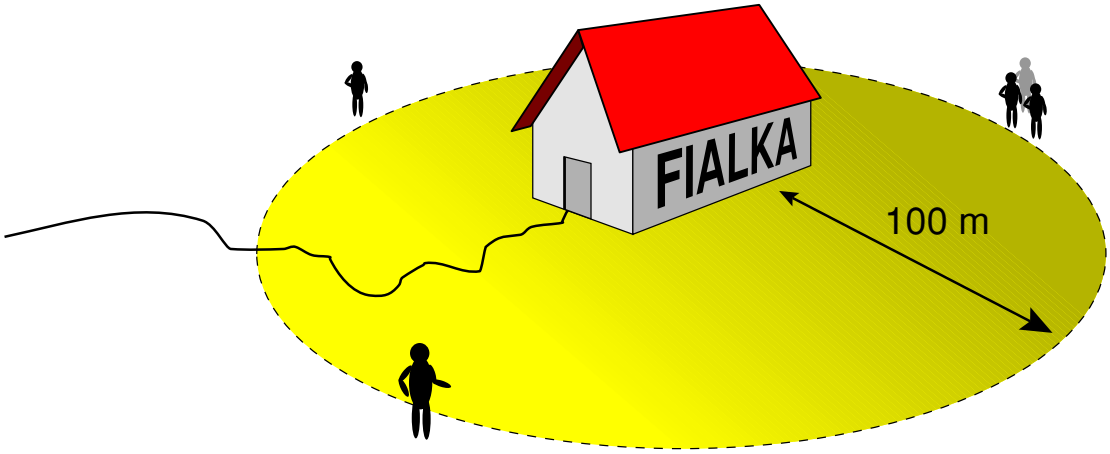


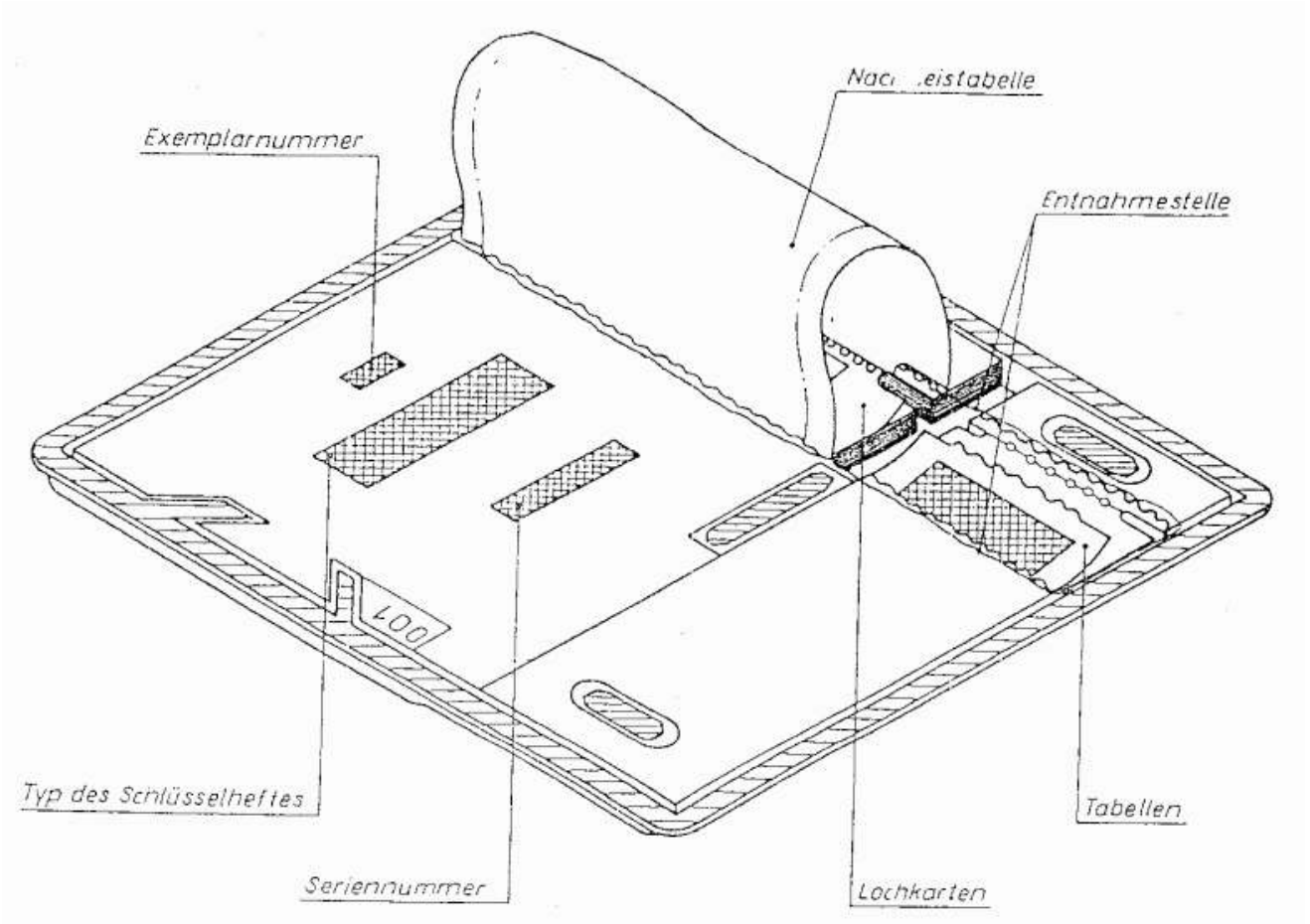
Illustration of the 100 meter safety area around the position of a Fialka

1.2.5 Fialka keys and keying procedures

Before coding or decoding a message on a Fialka, the operator first has to set the daily key and the message key. As the name suggests, the dayly key had to be changed every day, whilst the message key was unique for each message. The daily keys are supplied in a sealed plastic bag for one month in advance. Each day the operator would extract a new punched card (Lochkarte) and enter it in the drawer of the card reader (chapter 3.6). He would also tear-off a small table with instructions on the wheel settings (Tabelle). The wheels of the Fialka would then be taken from the machine, layed-out on the table and disassembled. They would then be reassembled in line with the key table. Once that was done, he would follow the instructions in the manual to setup the message key.

The punched key cards were made of very thin paper, to ensure they could only be used once. After removing the key card from the drawer, the paper would often rip itself. All keying material had to be destroyed once it was no longer needed (i.e. at the end of the day).

The image below shows a drawing of a seal bag with the cipher keys. It is taken from the Fialka M-125 Instruction Manual. As far as we know, no real samples of a seal bag have survived the Cold War. Detailed information about the exact dimensions of the key cards can be found in chapter 5.9.



1.2.6 Fialka in case of war

The M-125 Fialka was used in may countries of the former Warsaw Pact. In priciple, all Fialka machines of a particular module are identical, but there are some small differences for each country as will become obvious when reading this reference manual. One of the most prominent differences is the wiring of the cipher wheels. The wiring if the inner cores of the wheels is different for each country. The prefix of the serial number on each wheel is used to identify the country. The prefixes are 1K (Russia), 3K (Poland), 4K (DDR), 6K (Chechoslowakia), etc. Please refer to chapter 1.4.5 and chapter 3.3.6 for more information on this topic.

As each country had its own specific wiring of the wheels, it would be impossible for East-Eurpoean countries to use Fialka to exchange messages with their neightbours. To overcome this problem, two possible measures were taken:

- In case of war, identical wheels would be issued to all Warsaw Pact countries. The serial number on these wheels would probably have a 0K prefix. This was all subject to the available time.

- In case of an unexpected war, each country could use a special sealed box that contained the wheels of the neightbouring countries. Each such box contained a maximum of four wheel sets. The box was closed and sealed with a tiny rope all around it, ending up in a wax seal. Below is an image of such a sealed box.



1.2.7 The GAZ-66 and the R-142 Radio Set

During the Cold War, the Russians developed a wide range of radios for use on the HF, VHF and UHF bands. Many of these sets have appeared on the surplus market in recent years and are very popular among collectors. Normally, only a single radio would be used in a military vehicle. Command vehicles, on the other hand, were often issued a large collection of radio equipment – a so-called *Radio Set* – that enabled them to contact various radio nets. The R-142 is a popular example of such a radio set. The picture below show a Russian military truck, a GAZ-66, converted into a radio command vehicle.



The GAZ-66 command vehicle. Photograph copyright http://www.nva-ddr.co.uk [10]

This image shows the rear of the truck. The radio shack is entered through the (opened) door on the right. The door at the rear gives access to the command cabin. Left of the rear door is a power generator that can be used in case no mains power is available. The roof is packed with antennas. There are in fact eight different antennas present, each one for a dedicated radio or frequency band. The two window-like antennas are clearly visible in the above picture. When driving, they are folded down. On the front right the vehicle even has a retractable mast with a VHF antenna.

The radio shack is stuffed with radio equipment that can be controlled from anywhere in the vehicle: in the radio shack itself, from the command cabin and even from the driver seat. Almost any radio band can be operated. In addition to that, the R-142 can be hooked up to external radio equipment, such as a point-to-point connection or even a field phone line.

Very few complete GAZ-66 radio vehicles have ended up in the hands of collectors and they remain a very rare item. The one in the picture was bought by a British collector in 2004, who shipped it to the UK and has since fully restored it. More information can be found on the website: http://www.nva-ddr.co.uk/

1.2.8 The R-142 Radio Set

The picture below shows part of the R142 radio set as built into the radio shack of the GAZ-66 command vehicle. The room is very small and is packed with radio equipment. There is hardly any room for one or two operators left. The center of the image shows the various radios; one for each frequency band. The top row shows various displays and panels with signalling lights. On the left, the legs of the operator are just visible. In front of him is the (inclined) control panel. To the left of the control panel is an empty space that could take an additional piece of equipment. It is sometimes suggested that this space is suitable for a Fialka machine.



The R-142 inside the radio shack of the GAZ-66

The majority of radio equipment is painted in the standard Russian Hammerite grey colour. In the bottom right of the image, part of a closed yellow/green box is visible. This is the so-called R-014D *Burst Encoder*. A burst encoder is used to minimise the risk of detection and interception. A message is first stored in some kind of memory and then transmitted in morse code at very high speed.

Unlike the rest of the quipment this box is yellow, indicating that the R-014D is also used in (semi) portable situations. It was, for example, used during the Russian-Afganistan war by the Special Forces. The R-014D is therefore a popular item for collectors. In recent years, quite a few of these devices have appeared on the surplus market. The device first appeared around 1975 and is also very interesting from a technical point of view. When opened, the many printed circuit boards can be folded away like the pages of a book. Each PCB is packed with Russian Integrated Circuits (ICs). Nevertheless, the device can only store 62 characters in its memory, making it less suitable for larger messages. In the late 90's, the Russian Special Forces dropped the R-014D in favour of the newer digital Spy Radio Sets, such as the R-394KM.

1.2.9 Fialka and the R-142 Radio Set

It has often been speculated that Fialka was sometimes used in a mobile environment, in combination with the R-142 radio set. Although most former Fialka operators are convinced that Fialka was never used inside a command vehicle, some seem to think that Fialka would fit nicely in the empty space of the R-142. Our own invenstigation has shown that Fialka does indeed fit the empty space of the R-142 set. The four feet of the machine can be slotted into the four holes of a base plate that is present in the empty space.

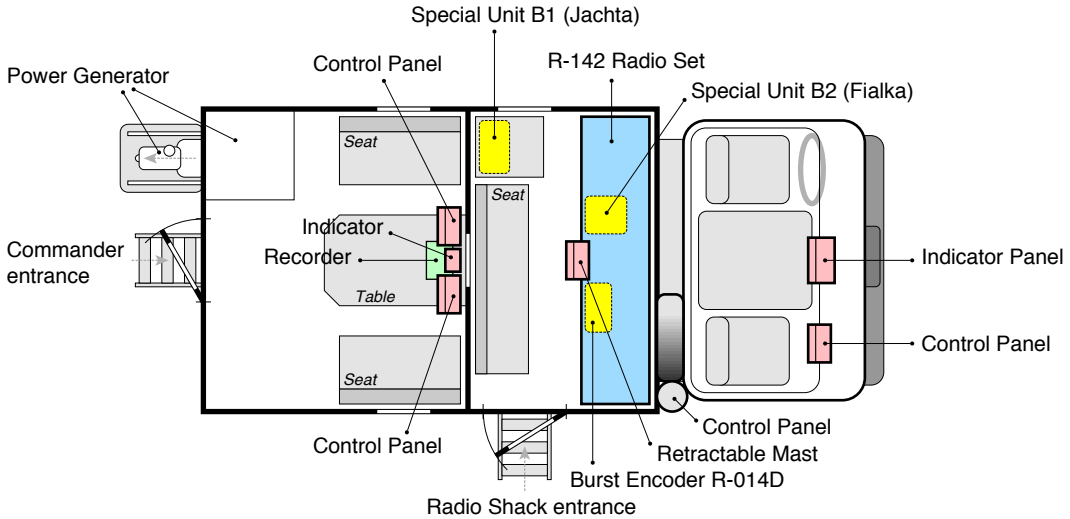
The block diagram of the R-142 radio set has always shown two secret devices, called Special Unit B1 and Special Unit B2 respectively. This block diagram has been revised several times over the years, but we recently discovered what we think is the last release. It was issued in 1983 and shows many more details that the older versions. More importantly, it reveals the true identity of the two special units. Special Unit B1 appears to be the T-219 voice scrambler, also known as Jachta, a smaller version of the wide-spread T-217 Elbrus. And Special Unit B2 now has the word ФИАЛКА printed next to it, which is Russian for... Fialka.

This doesn't prove that Fialka *was* indeed used in combination with the R-142 radio set, but it does prove that it *could* be used with the R-142. The 1983 manual explains that Special Unit B1 and B2 aren't supplied with the set and that these devices will be issued in the event of a conflict. It is therefore quite possible that special *Fialka* and *Jachta* machines were kept in a depot, only to be released in case of war. In such a situation, the operator would collect the Fialka, slot it into the empty space in the radio set and connect the cables. So far, we haven't been able to locate the appropriate connectors for this. Furthermore, it appears that the P-590A interface is also missing from the R-142. The P-590A is a co-called serialiser that converts the 5-bit parallel data from the Fialka, into a single-bit CW or RTTY stream. To this day, the P-590A has never been spotted on the surplus market and its appearance is unknown. It is believed to be a rather small unit with connectors similar to those on the Fialka.

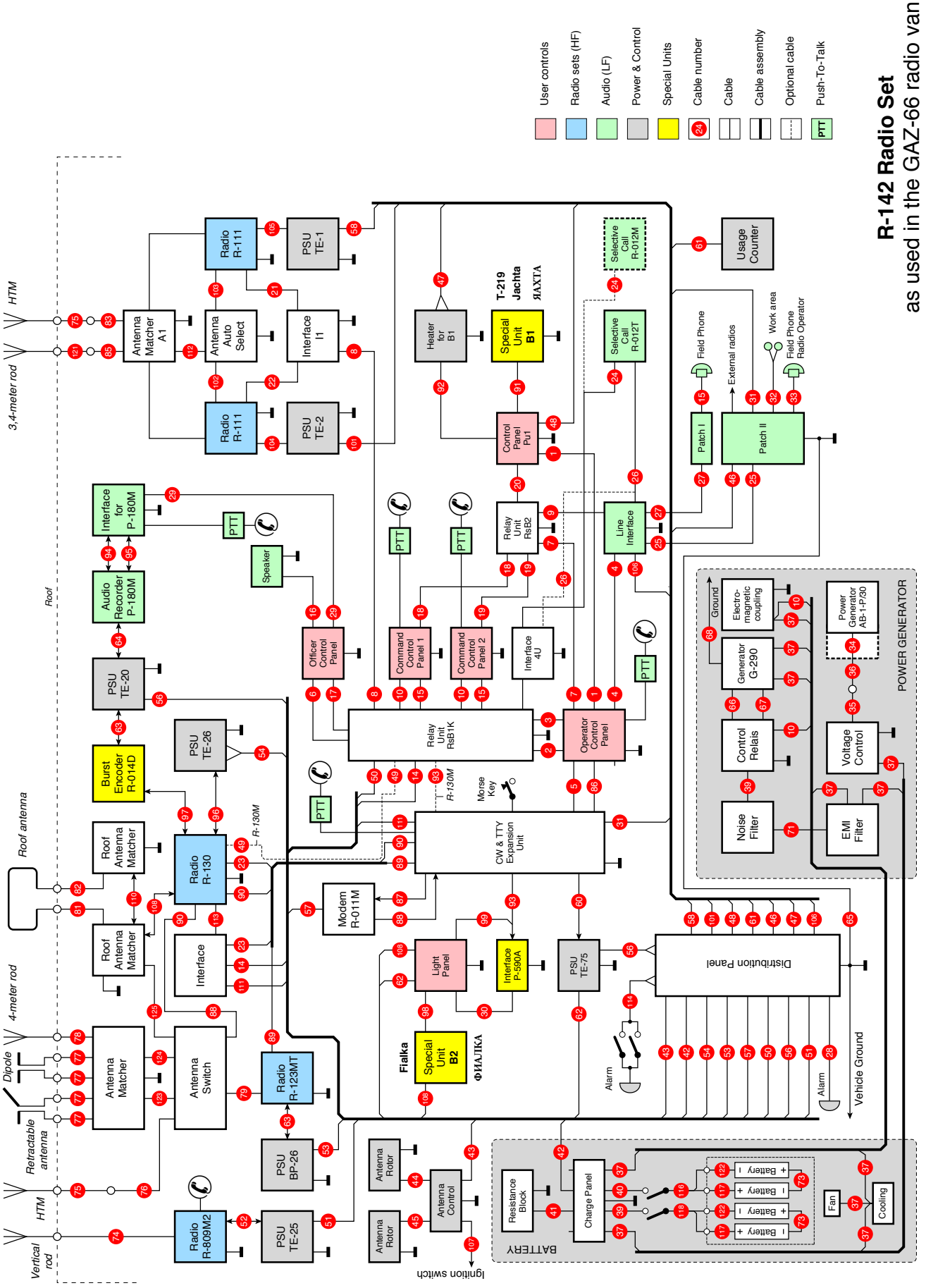
The drawing on the next page shows an improved version of the 1983 block diagram of the R-142. The special units are printed in yellow. The following items are considered *special units*:

- Special Unit B1: T-219 - Jachta Voice Scrambler (on the right in the diagram)
- Special Unit B2: M-125 Fialka cipher machine, with the P-590A parallel to serial interface (on the left)
- Burst Encoder R-014D (at the top center)

In this situation, Fialka messages would still be prepaired off-line and stored on a paper tape first. Once verified, the tape reader of the Fialka would be used to transmit the message on-line.



GAZ-66 Command Vehicle top view showing the position of the R-142 and the controls


R-142 Radio Set
as used in the GAZ-66 radio van
User controls
Radio sets (HF)
Audio (LF)
Power & Control
Special Units
Cable number
Cable
Cable assembly
Optional cable
Push-To-Talk
PTT
HTM
3,4-meter rod
Roof
Roof antenna
4-meter rod
Dipole
Retractable antenna
HTM
Vertical rod
Antenna Matcher A1
Antenna Auto Select
Interface I1
Radio R-111
PSU TE-1
PSU TE-2
Heater for B1
T-219 Jacht ЯАХТА
Special Unit B1
Selective Call R-012M
Selective Call R-012T
Usage Counter
Field Phone
External radios
Work area
Field Phone Radio Operator
Patch I
Patch II
Control Panel Pu1
Relay Unit RsB2
Line Interface
Interface for P-180M
Audio Recorder P-180M
PSU TE-20
Burst Encoder R-014D
PSU TE-26
Speaker
Officer Control Panel
Command Control Panel 1
Command Control Panel 2
Interface 4U
Relay Unit RsB1K
Operator Control Panel
Roof Antenna Matcher
Radio R-130
R-130M
Morse Key
CW & TTY Expansion Unit
Modem R-011M
Interface
Light Panel
Interface P-590A
PSU TE-75
Distribution Panel
Fialka
Special Unit B2
ФИАЛКА
Alarm
Vehicle Ground
Ground
Electro-magnetic coupling
Generator G-290
Power Generator AB-1-P/30
POWER GENERATOR
Control Relais
Voltage Control
Noise Filter
EMI Filter
Antenna Matcher
Antenna Switch
Radio R-123MT
PSU BP-26
Antenna Rotor
Antenna Control
Ignition switch
Radio R-809M2
PSU TE-25
Resistance Block
Charge Panel
Battery
Fan
Cooling
BATTERY

1.3 Terminology used in this manual

Writing a manual in the English language for a foreign piece of equipment can be difficult. Many items on the Fialka machines are labelled with Russian text and an Operating Procedure Manual was only available to us in the German language. Furthermore we have to deal with the differences between US-English and UK-English, e.g. one could use the word 'wheel' or 'rotor' for a coding disc. As the UK-English terminology is commonly used to describe Enigma machines in European literature, we've choosen to do the same for this manual.



Request
At various places in the manual, you'll find this symbol. Generally, it marks a request for additional information. If you happen to known more about the subject, please contact the authors.



Warning
If you see this symbol, it generally means a warning. In such situations, you should be certain of what you are doing. Please read (and re-read) the text carefully, before commencing.

Cyrillic	Latin	Example
А	A	Bath
Б	B	Bar
В	V	Victory
Г	G	Golf
Д	D	Day
Е	Ye	Yet
Ё	Yo	Beyond
Ж	Zje	Vision
З	Z	Zero
И	I	Meet
Й	J	Boy
К	K	King
Л	L	Wall
М	M	Mother
Н	N	November
О	O	Stop
П	P	Pipe
Р	R	Radio
С	S	Silver
Т	T	Total
У	OO	Boot
Ф	F	Filter
Х	Ch	Loch
Ц	Ts	Rats, Blitz, Zeit
Ч	Ch	Champion
Ш	Sh	Short
Щ	Shch	Khrushchev
Ы	*hard* - I	Rhythm
Ъ	*Hard-sign*	
Ь	*Soft-sign*	
Э	E	Next
Ю	Yu	Yule
Я	Ya	Yard

We've tried to stay as close to the original Russian or German expressions as possible. In some cases the original Russian expression or label will be given in brackets, for example:

ON ↔ OFF (ВКЛ. ↔ ВЫКЛ)

When trying to read the Russian labels, it may be useful to refer to the table on the left. It shows the Russian alphabet and some kind of phonetic pronunciation. If you find an unexplained label, try to pronounce it first and you'll notice that some words actually make sense.

The left column shows the Russian letter whilst the second column gives the Latin equivalent if it exists. If it doesn't exist, some kind of phoneme is presented instead. The right column should give some idea of the pronunciation.

Some letters aren't frequently used in the Russian language (e.g. the letter Ё, or the *hard-sign* Ъ) and may therefore be omitted from the alphabet.

Inside the Fialka and on its wheels, only 30 letters are used to identify the contacts. These 30 characters are a subset of the full Russian alphabet. The subset can be found in the description of the wheels in chapter 3.3.

In some cases, the symbol below will be used to point to another part of this manual:



Whenever you should refer to the *Glossary* as the end of the manual, you'll see this symbol:



Some Russian expressions and abbreviations

At various places on the body of the Fialka machine, Russian text and abbreviations can be found on specific tags, or directly engraved on the body of, e.g., a switch. Throughout this manual, we'll use these abbreviations to indicate a certain setting of switches, or a mode of operation. The table below shows the Russian meaning of the abbreviations, a Latin transcript (to show the pronunciation) and a suitable English translation.

	Short	Russian	Latin transcript	English
Mode Switch	О	Открытый Текст	Otkrytyj Tekst	Plain Text
	З	Зашифровать	Zashifrovat'	Cipher (coding)
	Р	Расшифровывать	Rasshifrovyvat'	Decipher (decoding)
Text Mode	Б	Буквы	Bukvy	Letters
	С	Смешанные	Smjeshannyje	Mixed
	Ц	Цифры	Cifry	Numbers
Printer/Puncher	Пф	Перфорация	Perforacija	Perforation
	Пч	Печатание	Pechatanije	Printing
Power Switch	Вкл	Включено	Vkjucheno	(switched) On
	Выкл	Выключено	Vykljucheno	(switched) Off
Various	Пр	Пробел	Probjel	Space
	Ш	Штепсель	Shtjepsjel'	Socket, Connector
	Ш	Штеккер	Stekker	Plug, Connector
	Д	Диод	Diod	Diode
	Т	Трансистор	Transistor	Transistor
Send/Receive lever	Предварит(ельный) Режим		Predvaritjel'nyj Rezhim	Stand-by Mode
	Передача в линию		Peredacha v liniju	Transmit to the line
	Прием		Prijom	Receive

Pronunciation of the Latin transcripts:	C	Sounds like German 'Z' in 'Zeit'
	J	Sounds like German 'Ja'
	Sh	Sounds like English 'Sh' as in 'Short'
	Ch	Sounds like English 'Ch' as in 'Chimney'
	Y	Sounds like English 'Y' as in 'Body'
	Zh	Sounds like French 'G' as in 'Gendarme'
	Kh	Sounds like Spanish 'J' as in 'Juan'

All other letters have their standard Latin pronunciation.

1.4 Identifying a Fialka machine

1.4.1 Introduction

When you first encounter a Fialka machine, it's important to identify it, as there are a number of important differences between models and variations. First you have to establish whether it's an M-125-xx or an M-125-3xx. Next it's important to establish the country (or army) of origin, as it's significant for the wheel wiring. Further differences concern the keyboard layout and the layout of the print head (i.e. the 'xx' part of the model number).

1.4.2 Establishing the model

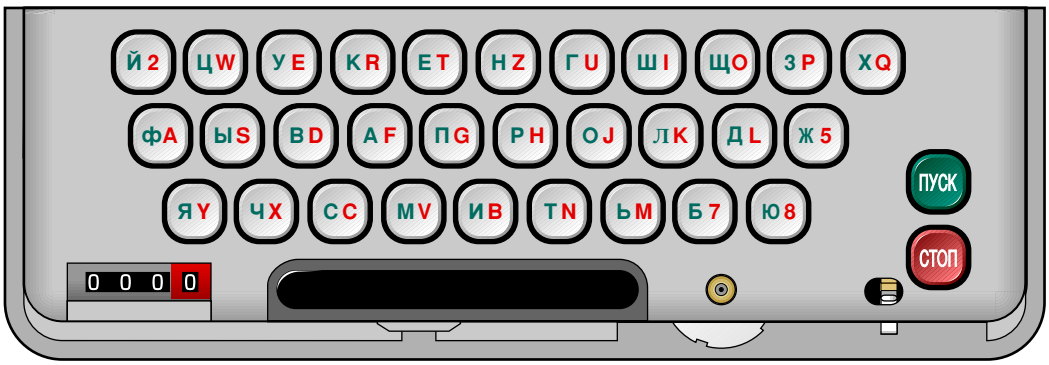
The initial version of the Fialka machine was the M-125. This version was suitable for the Cyrillic alphabet (Russian) and had a keyboard with Russian and Latin characters on the key tops. The keys themselves were rounded. The later M-125-3 version is a much enhanced machine, with a number of extra's. The most obvious difference is the keyboard, on which the keys are square-shaped and contain 4 characters each (letters, numbers and punctuation marks).

The Fialka **M-125-3** has some extra's over the earlier **M-125** model:

- Additonal characters and puctuation marks on the keyboard.
- A Send/Receive lever on the right side of the machine, just below the keyboard.
- A 3-position TEXT-MODE switch at the back of the machine.
- A switch 10 ↔ 30 underneath the punch card reader at the left of the machine (numbers ↔ letters).
- A rotary switch at the bottom of the machine (modifies the print/punch functions).
- The wheels don't move when the MODE switch is in the 0 position.
- Extended copy holder (two arms hidden behind the copy holder).

The easiest way to identify the model, is by looking at the keyboard. If it has rounded keys, it's an M-125. If it has square keys, it has to be an M-125-3. Here are some examples (note that the actual keyboard layout may differ between countries). Refer to chapter 3.2 - *The Keyboard* - for a more detailed description of each known keyboard layout.

M-125



▲ Example of a Fialka M-125

Example of a Fialka M-125-3 ▼

M-125-3



1.4.3 Establishing the serial number

Each fialka machine has a unique serial number. This serial number is normally found on the serial number tag on the front of the machine, e.g.:





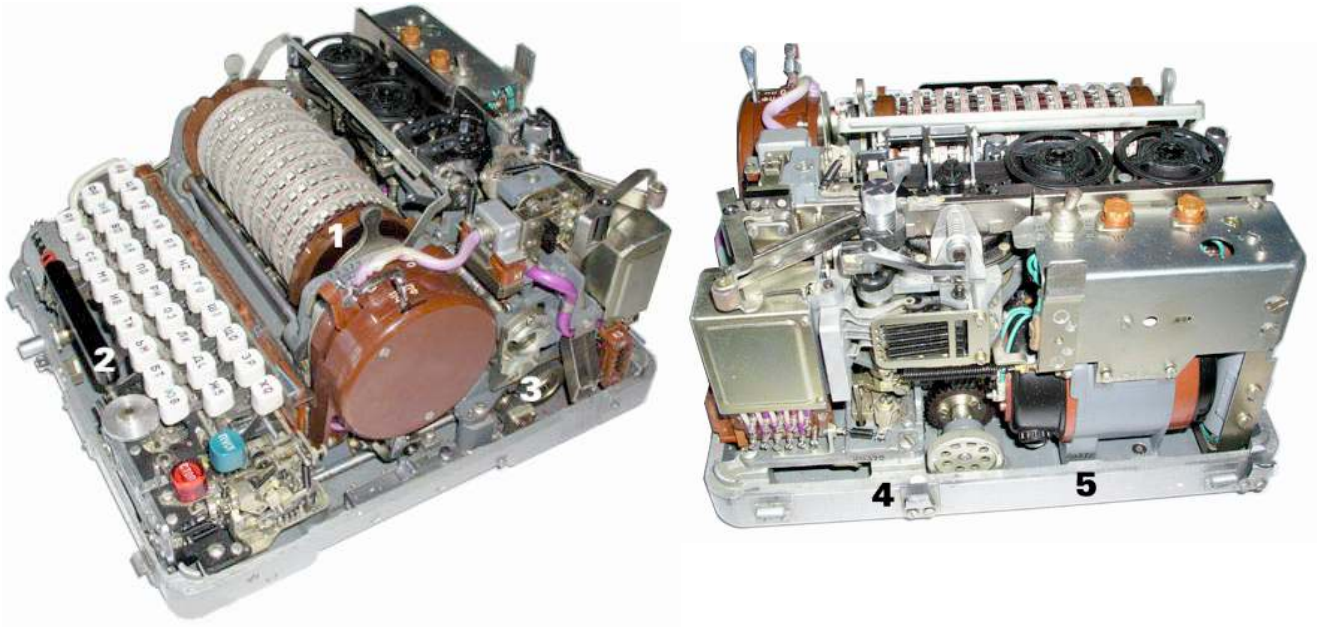
On the older M-125 machines, the model isn't printed on the serial number tag, but if it has rounded keys on the keyboard, it will be an M-125-xx.

On many machines however, the serial number tag has been removed as part of the 'demolition' process, to avoid the possibility of tracing it back (e.g. when a picture of the machine is published on the internet). Nevertheless it is still possible to establish the original serial number as it is engraved at several places inside the machine. In order to see the 'internal' serial numbers, you'll have to remove the cover first (➔ Chapter 3.1). The original serial number can be found:

1 On the grey metal, to the right of the drum,
2 On the black metal, underneath the space bar,
3 On the grey metal below the crank slot, on the right of the machine (M-125-3 only),
4 At the rear of the printer assembly (M-125 only),
5 On the grey metal of the motor, at the back of the machine.
6 On the inside of the lid, close to the hinge *),
7 On the outside of the dust cover *)

Note (*): The serial numbers found on the inside of the lid (near the hinge) and on the outside of the dust cover, aren't reliable sources for identification, as these items are likely to have been swapped with other machines during its lifetime.

Please don't publish your serial number in any public source, such as a magazine or on the internet, as it may upset the authorities in certain countries, which may subsequently lead to a more thorough demolition of the machines. It may be a good idea however, to register your serial number(s) with a common body (e.g. another collector) so that stolen machines can always be traced. Furthermore it gives researchers the opportunity to establish certain key features on a particular range of machines. You may use the address fialka@xat.nl for this



Locations of the serial number

1.4.4 Identifying the wheels

If you want to use the Fialka , it's important to have a full set of 10 unique wheels. Unique means that all wheels have to be different. Each wheel is identified by a single letter of the Russian alphabet and the following ones should be present:

А Б В Г Д Е Ж З И К

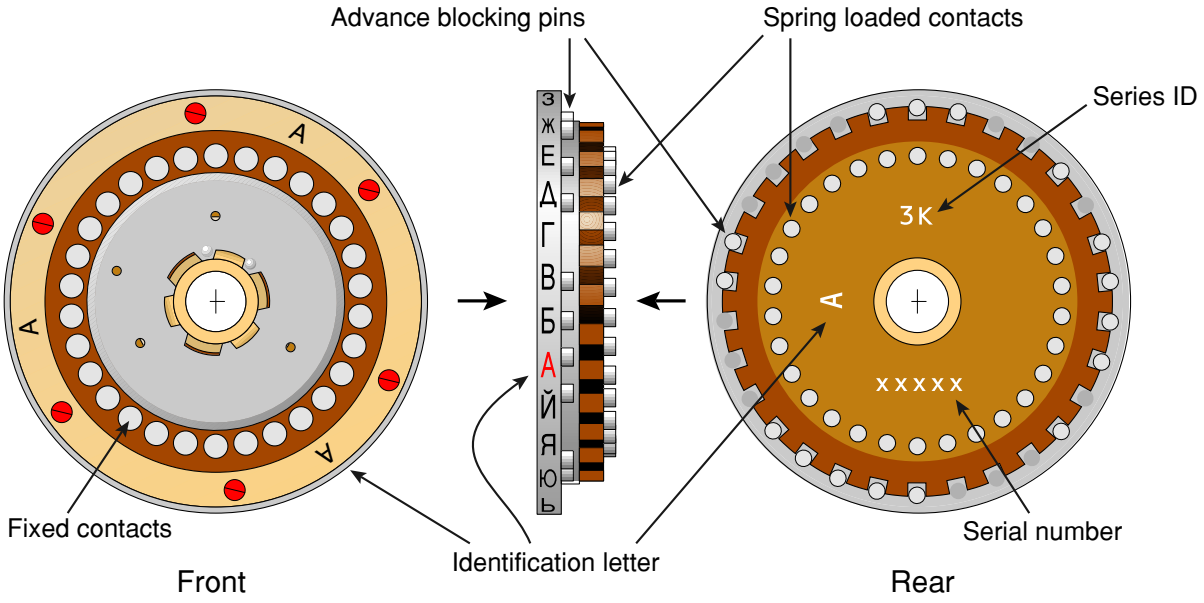
In practice, many machines come with an incomplete set of wheels, or with some duplicate wheels, which makes using the machine somewhat complicated. If your set is incomplete, you might want to contact other collectors, to see if you can make a swap. Alternatively, you may want to find another *complete* set of wheels. In order to access the wheels, you need to remove the drum first (➔ Chapter 2.2).

Broadly speaking there are two types of wheels:

- Fixed wheels
- Adjustable wheels (supplied from 1978 onwards)

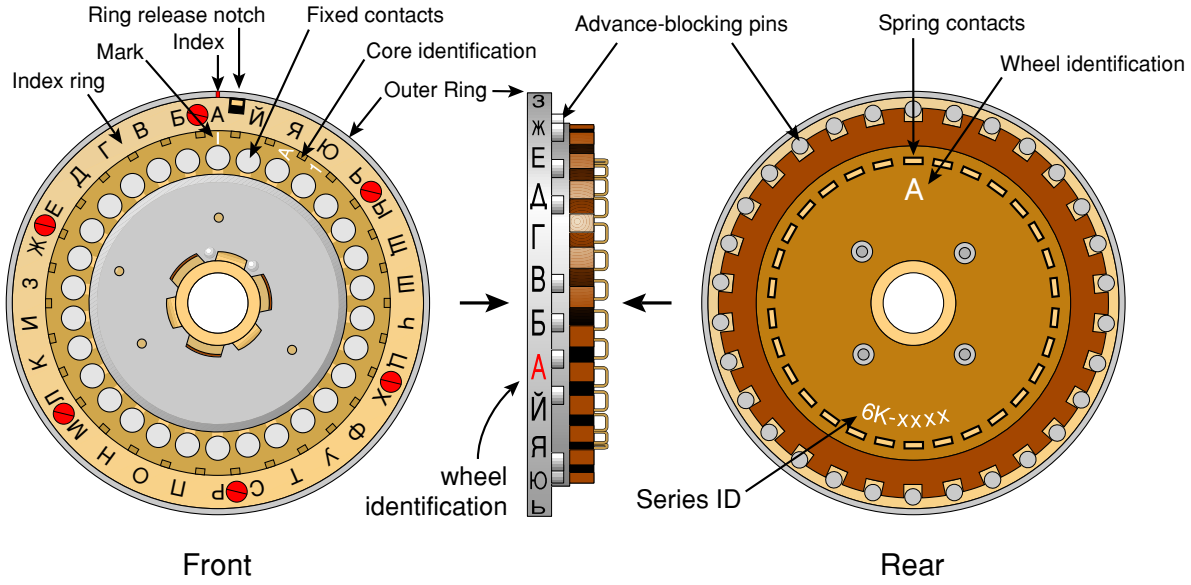
One half of each wheel is is created out of metal and the other half is either Pertinax (brown) or plastic (black). The text on the metal part can be either black or red. On the adjustable wheels, one letter may be printed in the alternative colour to allow easy identification of the wheel. It's important to determine which type of wheels you've got; *fixed* or *adjustable*. According to some 'eye witnesses', the standard wheels had their letters in black and the spare wheels (inside the container) were printed in red.

The *fixed* wheels are all similar to the drawing below. Each wheel contains 30 circular contacts on either side. The contacts on the front are all disc shaped and fixed in place, whilst the contacts at the rear are all spring-loaded pins. The wheel can be opened by removing the metal disc (shown on the left), but the wiring in this kind of wheels is fixed.



A fixed wheel seen from the front, side and rear

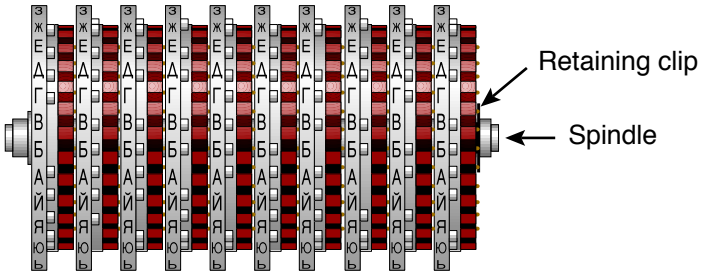
The *adjustable* wheels clearly show some extra features. First of all, the contacts at the rear are all U-shaped springs (rather than spring-loaded pins) and the front of the wheel (left) shows 30 letters on the ring. Furthermore the wheel can be disassembled by rotating the center disc and removing the inner wiring maze. This wiring maze is called the *core*. The core has two sides and can be inserted into the wheel in two different ways: with side 1 or side 2 to the front. See chapter 3.3 for more information on adjustable wheels.



An adjustable wheel seen from the front, side and rear

1.4.5 Establishing the wheel series

It is also important to determine which *series* of wheel wiring you've got. Apperently differently wired wheels were used in different countries or armies. The series are identified with an xK number on the wheel (e.g. 3K or 6K).
More information on wheel wiring and disassembly can be found in Chapter 3.3 - *The Wheels*.



A complete set of 10 unique wheels

First of all, check whether you've got 10 unique wheels, marked with the first 10 letters of the Russian alphabet. This means that all wheels have to be different. The following wheels should be present:

А Б В Г Д Е Ж З И К

Next, check that all wheels are from the same series, e.g. 3K, 6K, etc. This number is printed at the rear of each wheel as can be seen in the previous images. In the examples, the image of the *fixed wheel* is marked as '3K' which means it was used in Poland. The image of the *adjustable wheel* is marked with a serial number of 6K-xxxx, which means that it is a series '6K' wheel, which was used in Czechoslovakia. As different wiring was used for each series, it is important that all your wheels are from the same series.

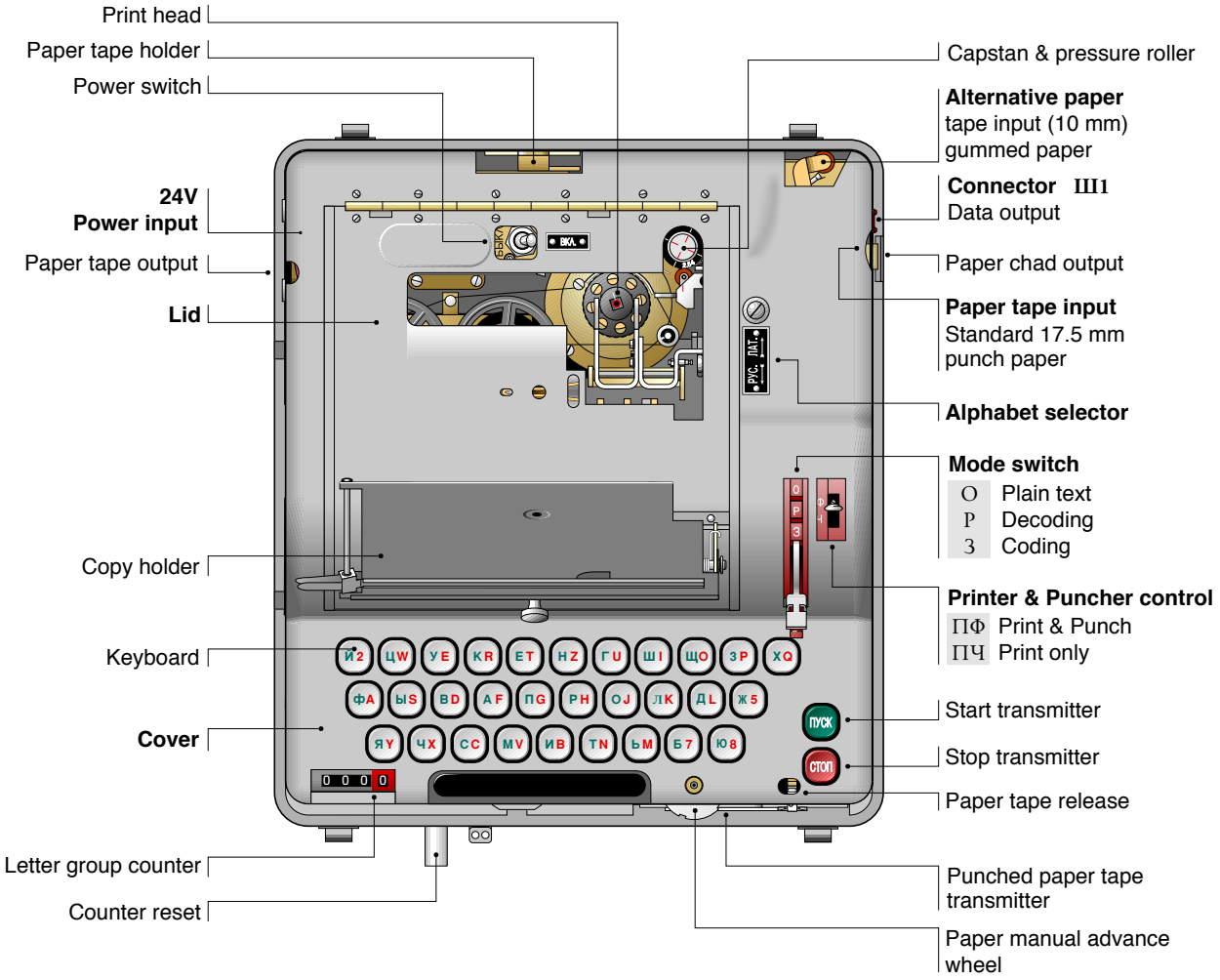
A number of Fialka machines that have surfaced so far, came with a random collection of wheels, both fixed and adjustable, some wheels missing and some wheels double or even tripple. If this is the case with your machine, try to contact other collectors to see if you can make a swap.

1.5 Controls & Connections

In this chapter, we'll give you a quick tour around the Fialka. First we'll start with the older M-125 machine. Details about the later M-125-3 machine can be found further down this chapter.

1.5.1 Fialka M-125 model

The drawing above shows the (older) Fialka M-125 machine as seen from the top. The copy holder has been raised to show the lid and part of the printer mechanism and the ink-ribbon. Details on how to feed paper into the machine and how to prepaire it for use, can be found in chapter 2.



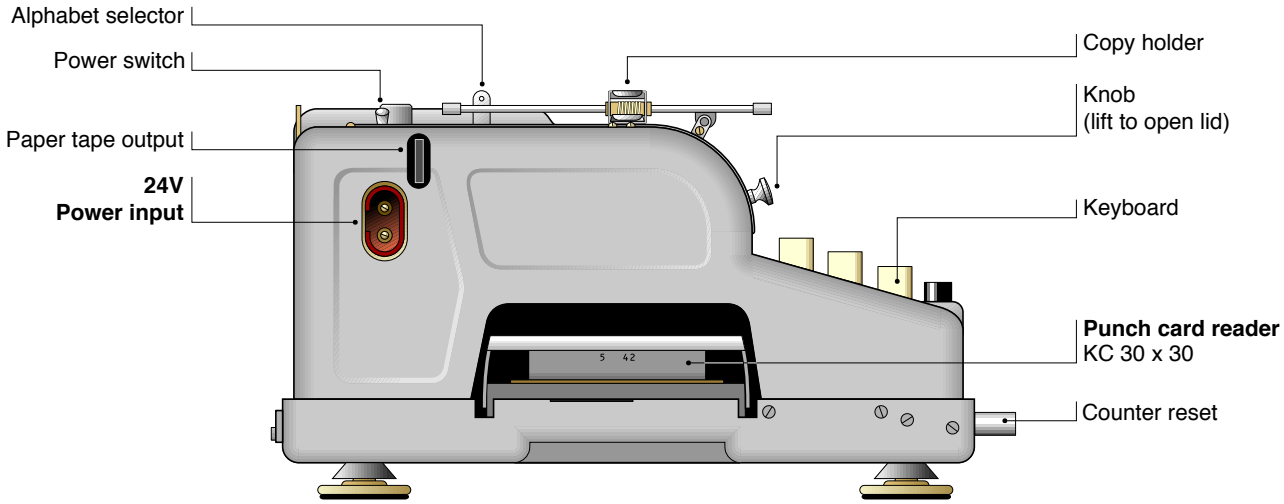
Fialka M-125 Top View

On the center right of the machine, two large switches can be identified. The leftmost one is the *mode* switch, which is used to select the mode of operation: **O** Plain-text (i.e. no coding), **P** Decoding (used when decoding a message) and **3** Coding (used when encrypting a message). The rightmost switch is used to control the paper-puncher and/or the printer. The *green* and *red* buttons at the bottom left are the *Start* and *Stop* controls for the punched-paper tape reader. It is used to send a message directly from a punched paper tape.

Note the rather large counter-reset button at the front of the machine below the keyboard. It has to be pushed inwards when fitting the dust cover, forcing the counter to be in a reset state when the machine is next used again.

The appropriate alphabet (Latin or Russian) can be selected with the *Alphabet selector* which can be accessed through the hole in the lid

The image below shows the Fialka M-125 as seen from the left. On the left is the power connector that allows the machine to be connected to a 24V source (➔ Chapter 2.5 - *Connecting the power supply*). Just above the power connector is the *paper tape output*. This is where the printed and/or punched message leaves the machine. At the lower center is the punch card reader. To open the card reader: first push down the metal bar, then pull out the tray. If no punched card is used, a metal triangle should be present in the drawer.

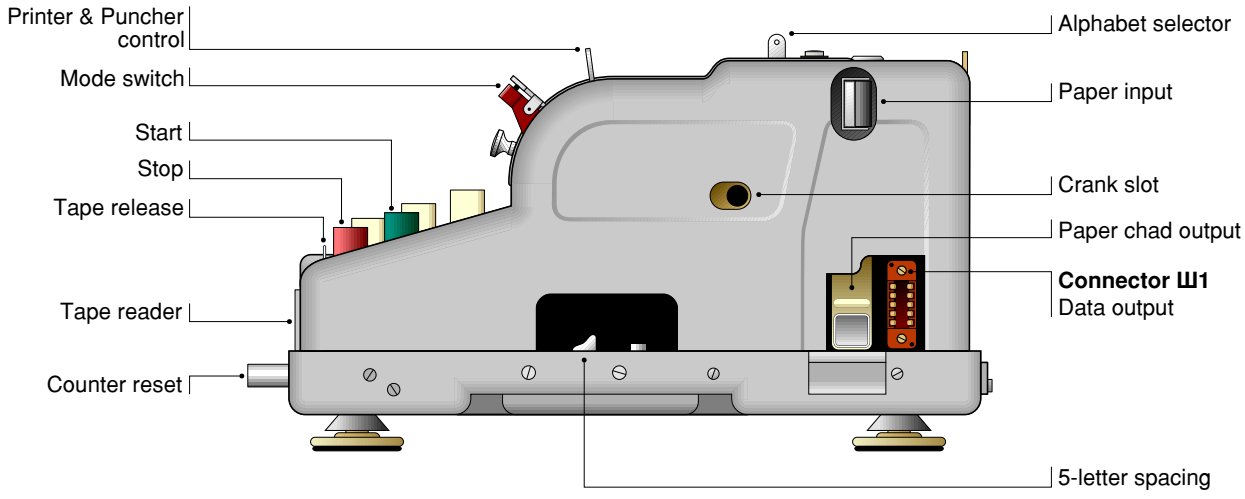


Fialka M-125 Left view

The right side of the machine gives access to the paper tape input, the data connector and a small extendable gutter that guides the paper chad (i.e. the punched-out holes) from the paper-puncher. Refer to chapter 2.8 for instructions on loading the paper tape. The data output connector (Ш1) can be used to connect the Fialka directly to a modem or radio-set, although it is unlikely that it was ever used as such.

At the center is a slot for the crank (if present). The crank (➔ Chapter 1.7) can be used for de-blocking of the mechanism in case of a crash, although it hardly ever solves such problems. The crank was never used for manual coding/decoding.

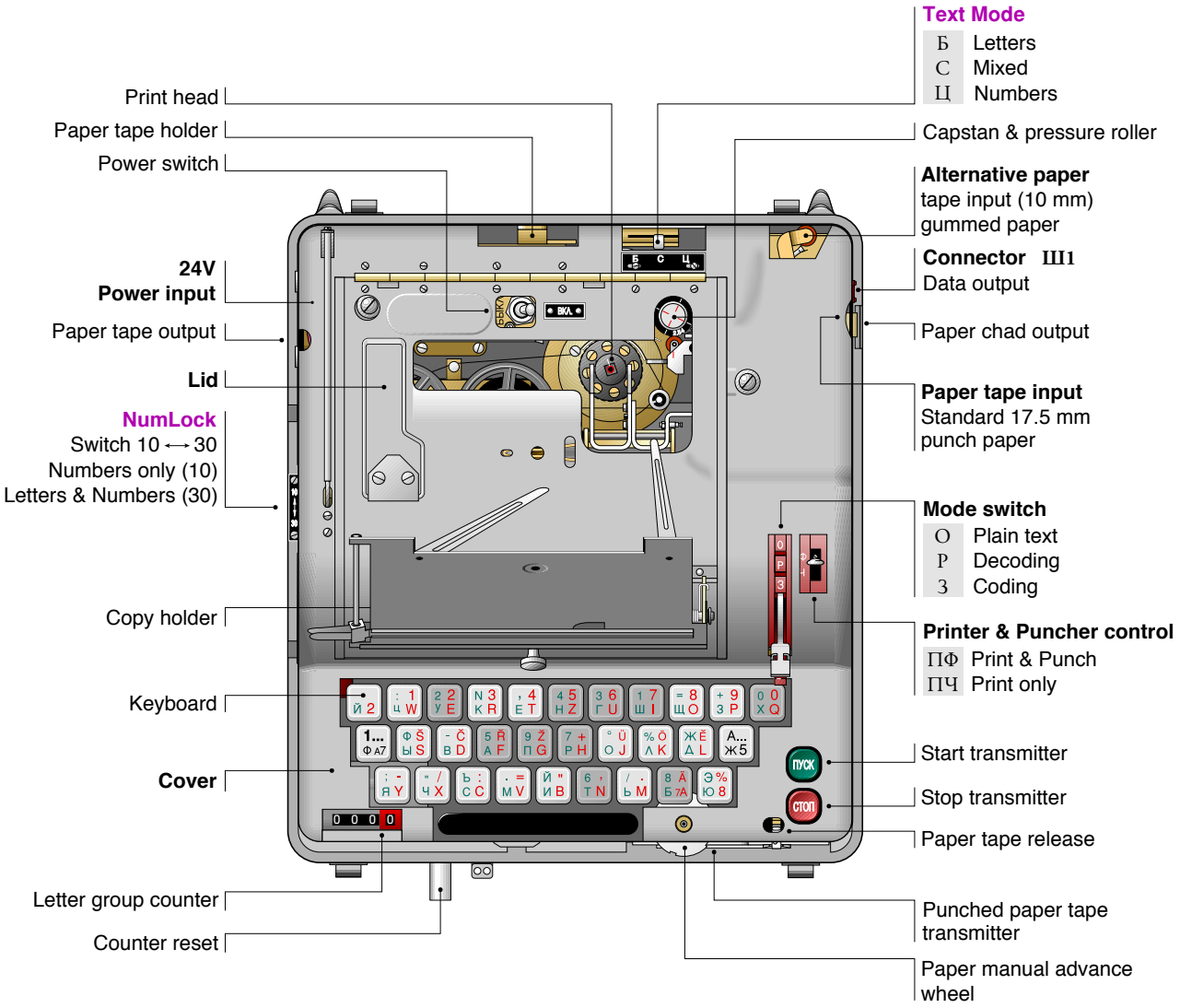
At the lower center, two buttons are present. The leftmost one has a triangular shape. Pushing this switch towards the rear of the machine, turns *on* the 5-letter spacing. The circular button to the right of it can be pressed to turn the 5-letter spacing *off* again.



Fialka M-125 Right view

1.5.2 Fialka M-125-3 model

The drawing below shows the Fialka M-125-3 as seen from the top. Although this version looks similar to the older M–125 shown on the previous pages, it is in fact quite different and contains a number of powerful improvements. We'll only describe the differences between the M-125 and the M-125-3 here.



Fialka M-125-3 Top view

The most obvious difference is the keyboard: the keys of the M-125-3 are square (rather than rounded) and contain up to four characters each (as opposed to 2 characters on the M-125 key tops). In the drawing above, the copy holder has been raised and the two extendible arms have been unfolded. When opened, the lid is held in place by a new movable arm, that rests on the left side of it.

At the back of the machine, a new *Text mode* selector has been added, to allow improved alphabet support to be selected as well as a *numbers-only* mode. More information about the use of the various alphabets can be found in chapter 3.2 - *Keyboard*.

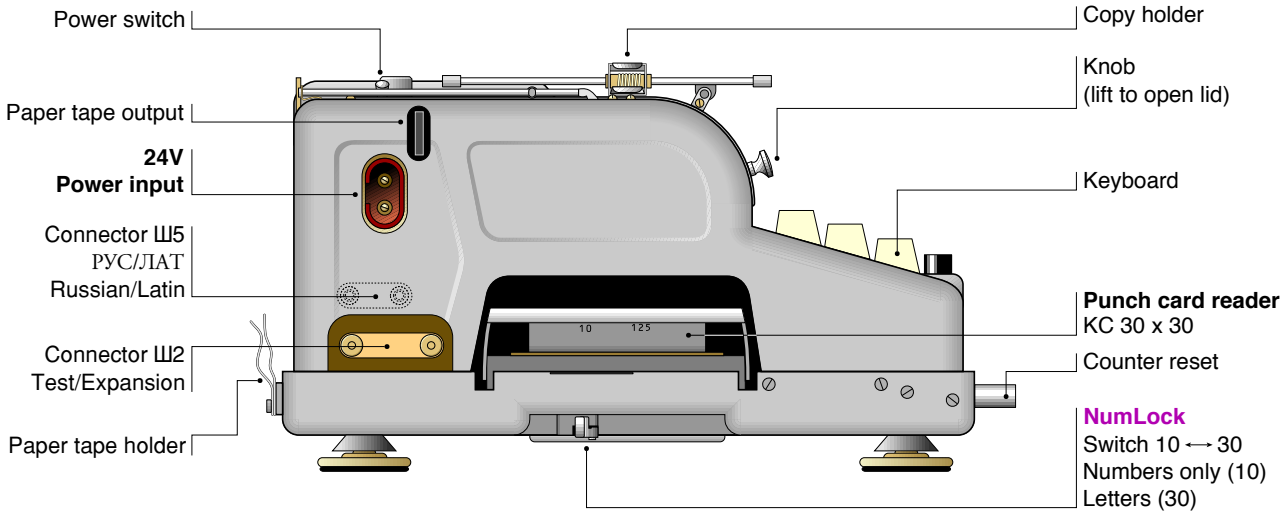
Also new on this machine is the *NumLock*-switch at the bottom left of the machine. The switch is controlled by a metal lever with can be accessed from the left of the machine. Abobe the lever is a label marked as 10 ↔ 30. This switch should be set to 30 when using *letters*, *numbers* and *punctuation marks*. It should be set to 10 when using *numbers only*.

A rotary switch (which isn't visible here) has been added to the bottom of the machine. It modifies the use of the Printer & Puncher control lever (➔ Chapter 3.4).

This drawing below show the left side of the Fialka M-125-3. At the bottom left, two new connectors are present. The lower one (Ш2) is visible and can be accessed without removing the cover. It was probably used for testing and/or expansion. It contains the 24V power rail, data lines, etc. This connector MUST be present.

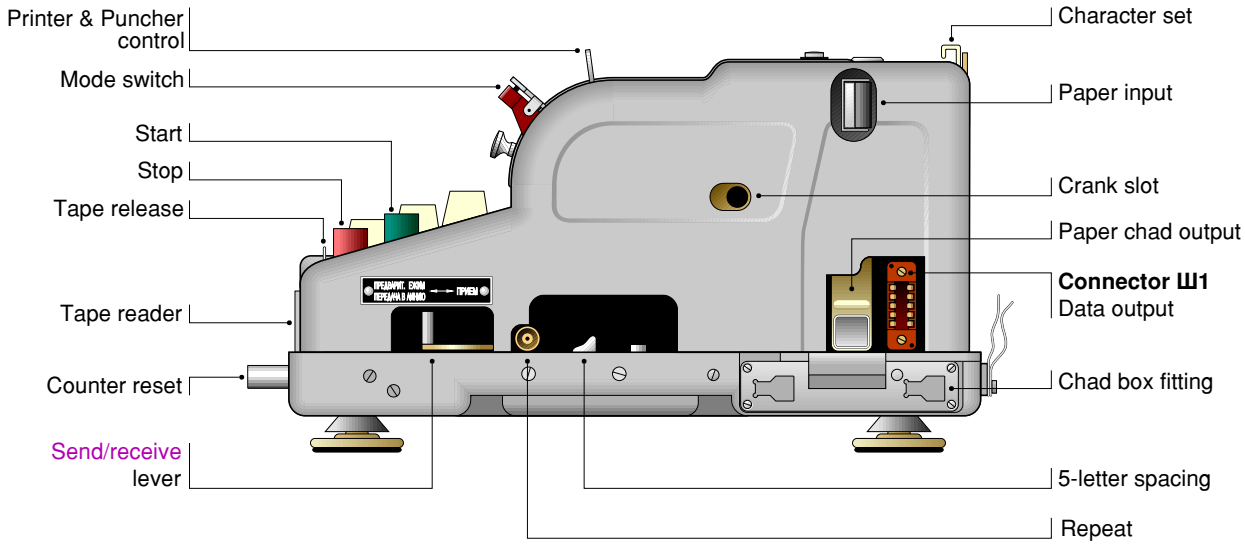
Just above this connector, hidden behind the cover, is connector Ш5 which can be inserted in two ways. By default it is inserted so that the text РУС (Russian) is readable. It can also be mounted upside down, so that the text ЛАТ (Latin) is readable, although no evidence has been found to prove that the machine has been used in this way. If the connector is set to the ЛАТ position, the number of possible characters is reduced from 30 to 26, which suggests a possible use of the Fialka in Latin-only configuration. This connector MUST be present.

The lever of the new *NumLock*-switch (marked 10 ↔ 30) can be seen just below the drawer of the punch-card-reader. New support guides have been added to the rear of the machine to lock the paper roll holder in place. These support guides can be seen at the bottom left in the drawing below.



Fialka M-125-3 Left view

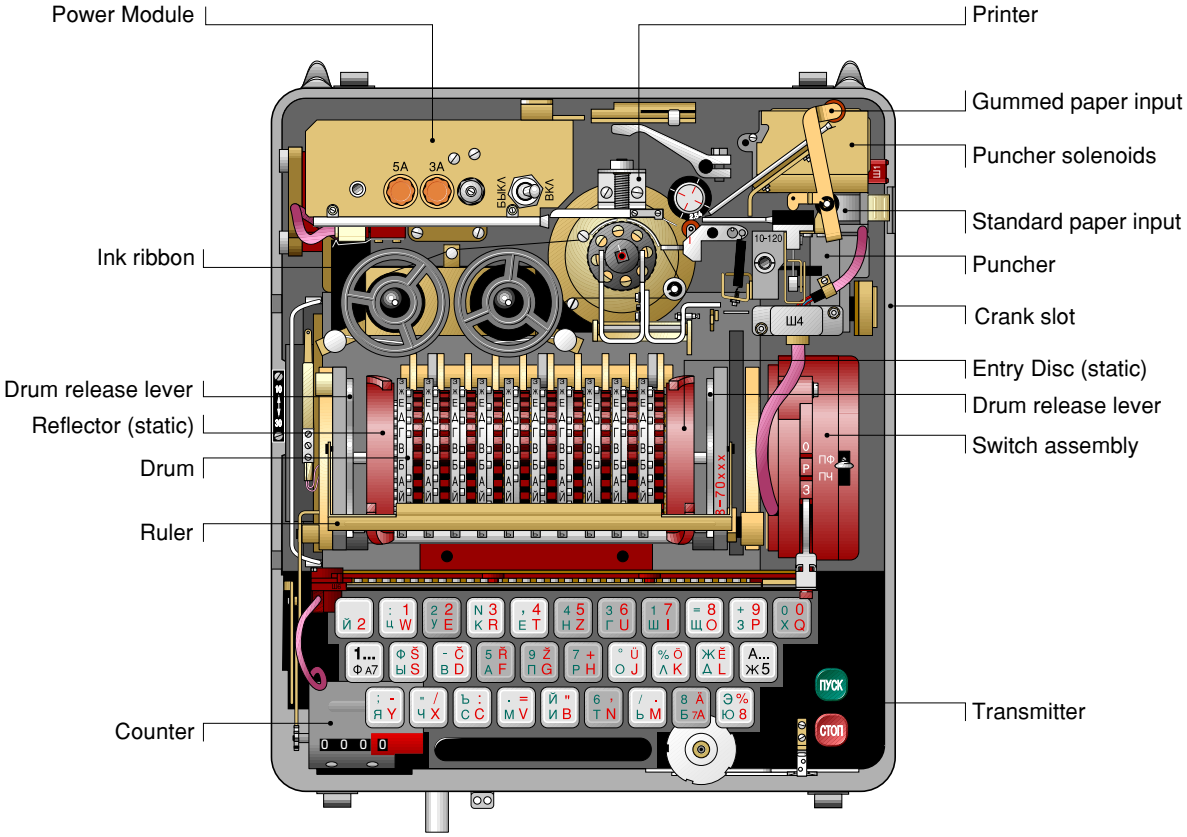
The drawing below shows the right side of the Fialka M-125-3. At the bottom right, a lock has been added to allow the connection of a paper chad box (if present). This box will 'catch' the punched-out holes from the paper tape as they fall down the extentible gutter. At the bottom left in the drawing is new *Send/Receive lever*, which is part of the paper-tape reader mechanism. To the right if this, hardly visible, is the *Repeat* connector (see the circuit diagram in chapter 4.4). It is unclear what this connector was used for.



Fialka M-125-3 Right view

1.5.3 Fialka interior

The drawing below shows the interior of a Fialka M-125-3, which is quite similar to the interior of the M-125. The cover can be removed by releasing the two large bolts on the top of the machine and a small one on the front. On the M-125-3, one of the large bolts can be accessed through a hole in the lid (top left). On the M-125 you'll have to open the lid first. The other bolt is located to the right of the lid. Finally a small bolt at the front of the machine has to be loosened. Before removing the cover, you must put the *Mode switch* in the **O** position (➔ Chapter 3.1).



Fialka M-125-3 interior

The metal box in the top left is the Power Module. It contains the power connector, the fuses and the power switch. It is directly connected to the motor and it provides power to the rest of the machine.

To the right of the Power Module is the printer mechanism. This is a very clever mechanical device with a fast rotating head. The ink-ribbon is guided around the print head. Text is printed directly onto the paper tape that is punched with the same information by the paper-tape-puncher on the right. The paper-tape-puncher uses standard 17.46 mm tape and punches its holes in a 2.54 mm grid, just like western teleprinter devices used to do. The data however, is in a non-standard encoding, i.e. it is not baudot compatible (➔ Chapter 3.5).

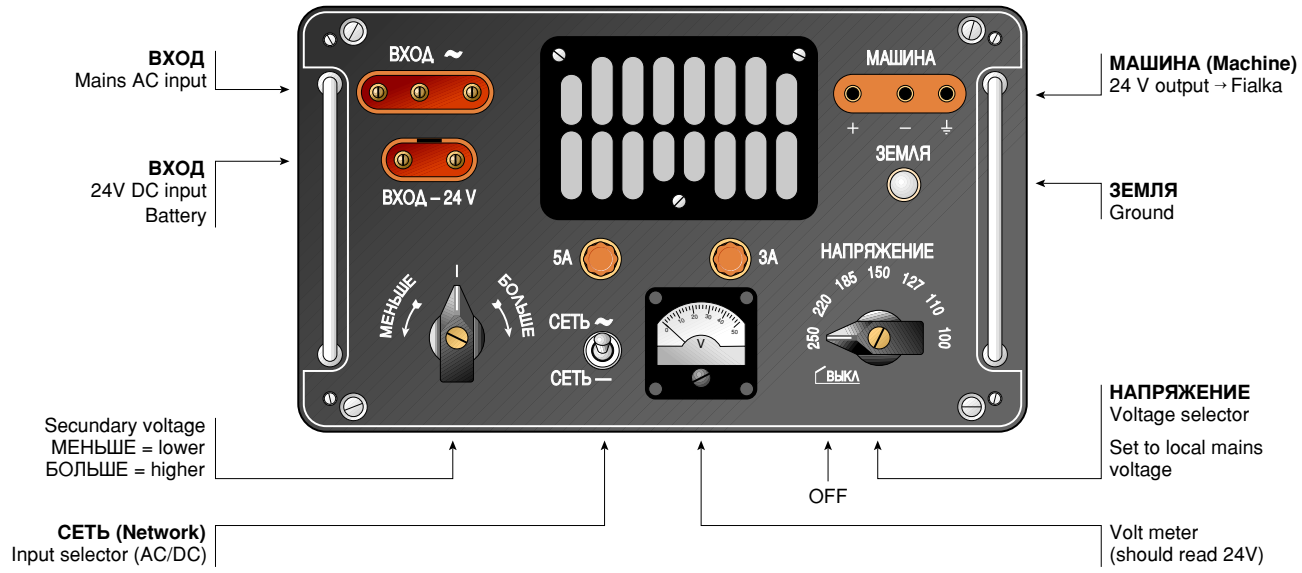
The center of the machine contains the coding mechanism which consists of a drum with 10 movable wheels (rotors). The wheels are moved at each key-press and multiple wheels can move simultaneously. Please note that adjacent wheels move in the opposite direction. Two large static bakelite discs are used to connect both ends of the drum to the electric circuits of the Fialka. The rightmost disc is called the *entry disc*, whilst the one on the left is called the *reflector*. A drum-release lever is available at either side of the drum. Please read the notes in the chapter 2.2 before removing the drum.

The frontmost part of the machine contains the *keyboard*, the character *counter*, the paper-tap *reader* and the paper-tape *transmitter* mechanism.

1.5.4 Fialka power supply

The Fialka is powered from a 24V DC source which suggests that the machine was designed for mobile operation. However, to this day no evidence has been found to support this. In fact, it is known that the machine was always operated from a secured area in a base station, which is probably the reason why most machines came with a suitable power supply.

Two types of power supply are known to have been distributed with the Fialka (➔ 1.7.2). The drawing below shows the one that came with most of the machines that were found in Chechoslovakia.



Power Supply Controls

The mains connector is at the top left and its two rightmost pins should be connected to the mains source. The leftmost pin is the ground. Immediately below the mains connector is the input for an external 24V source. It can be used to connect to the 24V battery of a truck or tank. The rightmost pin is the +24V input. The mains voltage selector is at the bottom right. The secundary voltage (i.e. the output of the transformer) can be adjusted with the selector at the bottom left. The exact output voltage can be read from the volt meter. To the left of the voltmeter is a switch (СЕТЬ) that allows selection between mains (AC) and the external 24V input (DC).

The 24V output is at the top right. It can be connected directly to the power input connector of the Fialka. Use the standard cables (that came with the power supply) for all connections. If these cables are missing, refer to chapter 5.2 for more information.

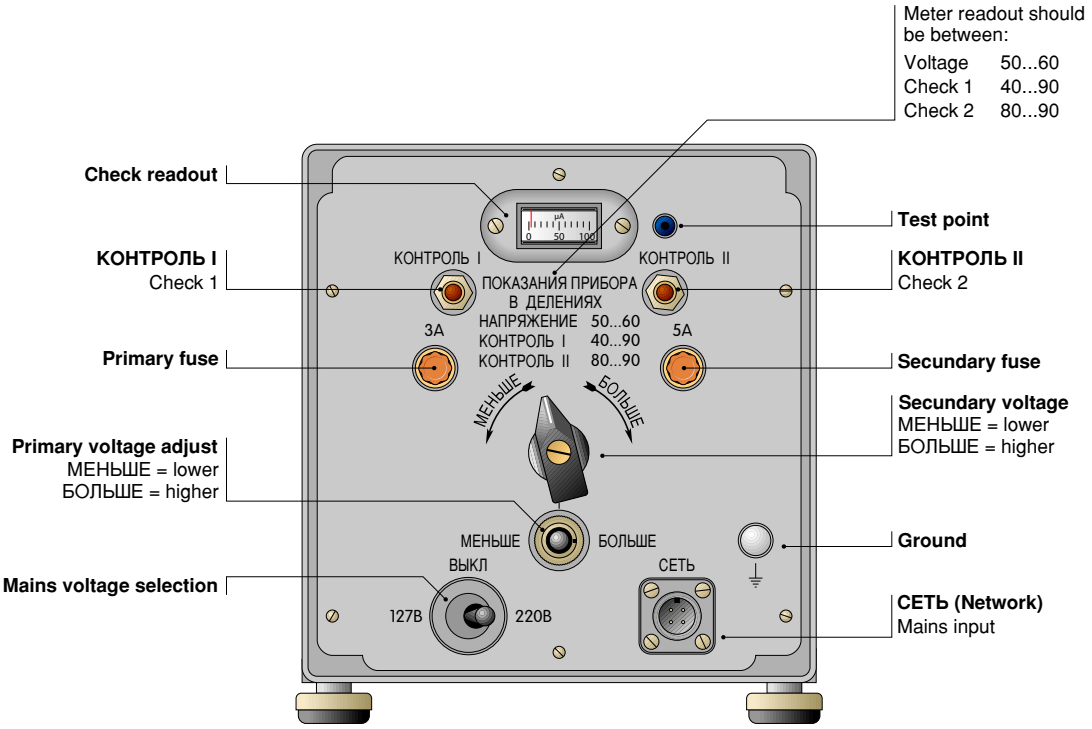


Please note that the plugs used for the mains input and the 24V DC output have opposite gender, which means that they can physically be connected together. **Never connect these plugs together** as it will most definitely destroy your Fialka! Always check and double check your connections before connecting the Fialka and turning it on.

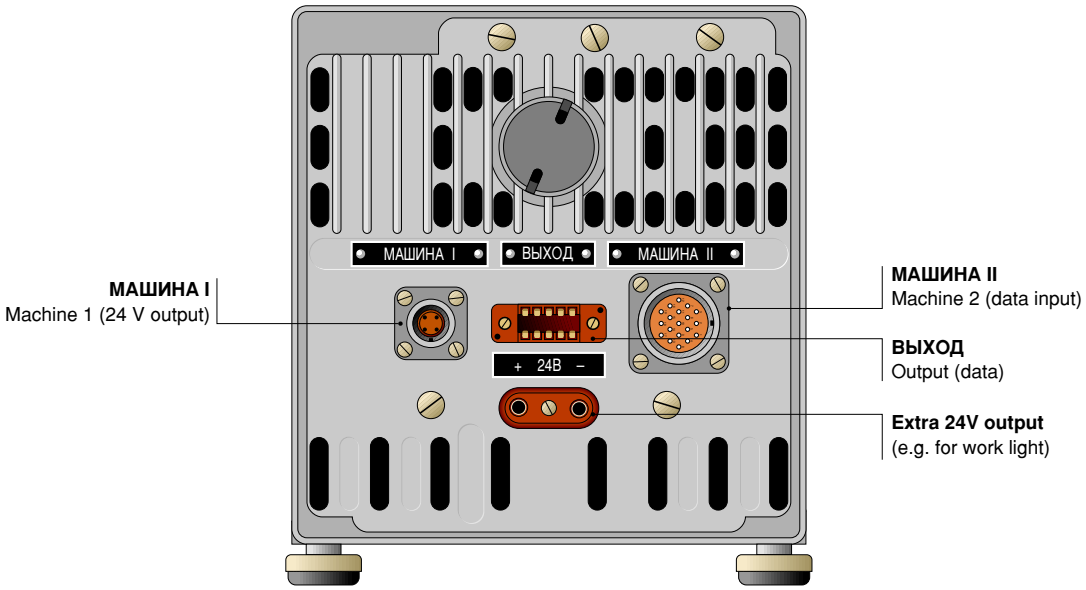


So far, two different types of power supply have been identiefied. The one described above is the standard issue power supply that came with most machines. There is however another model, that contains further circuitry to drive an external transmitter. Apart from the normal power connections, this power supply also connects to the Data Output Connector Ш1 at the right side of the machine. At present, the circuit diagram of the extended power supply is unknown. If anyone has a surplus power supply of this type, please step forward.

Polish Fialka PSU Controls



Front view

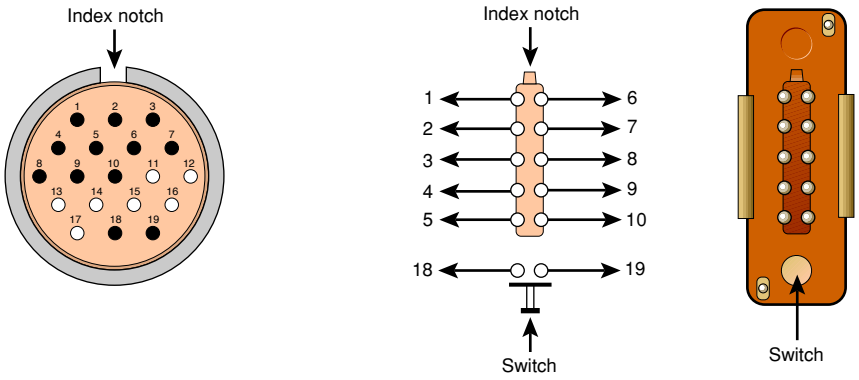


Rear view

Please note that all cables between the Fialka and the power supply must be present, or else the Fialka won't work. The power supply has to 'read' the data output of the Fialka in order to activate any of the internal 5 dummy loads that are present in order to avoid TEMPEST problems. If the data cable is not present, the power supply will not produce any output power.

The meter is used to adjust the primary and secundary voltages prior to turning the Fialka on. First select the mains voltage with the (locked) switch in the bottom left corner of the front panel. In the drawing above it is set to 220V. Set all other switches as indicated. Connect all cables between Fialka and the PSU. Leave the Fialka in the OFF position. Connect the mains cable and perform a check. Press **Check 1** and ensure the reading is between 40 and 90. If not, use the **Primary Voltage Adjustment** to decrease or increase it. Next, press **Check 2** and verify that the reading is between 80 and 90. If not, adjust the secundary voltage by using the rotary switch. If all goes well, the meter should read between 50 and 60 when no button is pressed. If this is the case, turn Fialka ON.

Polish Fialka PSU Connections

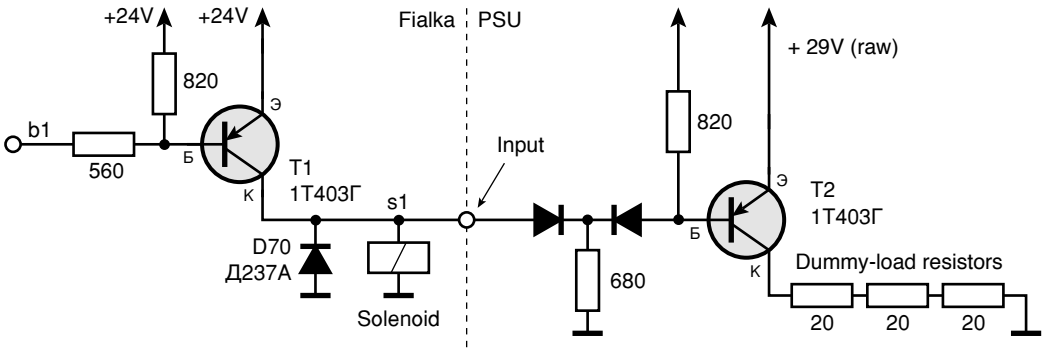


Connectors on the data cable

The above connectors are both part of the data cable between the Fialka and the PSU. The parallel 5-bit data from the Fialka is fed from the 10-way connector (on the right of the machine) into the PSU. Please note that this connector has a built-in switch. The switch is used to 'sense' the presence of the plug in the Fialka data socket. The big circular connector goes to the data input of the PSU. If the Fialks needs to be connected directly to a transmitter, a 10-way socket (similar to the one on the Fialka itself) is present at the rear of the PSU.

The data cable MUST be present and connected, or else the PSU will not work. The reason for this is the fact that the PSU contains 5 dummy load resistors. Depending on the number of active bits in the Fialka output, the remaining bits (i.e. the inactive bits) are used to drive the dummy loads. This way the Fialka will draw a constant current from the mains, avoiding the possibility for an intercepting enemy to acquire the plain text from tapping the mains (TEMPEST).

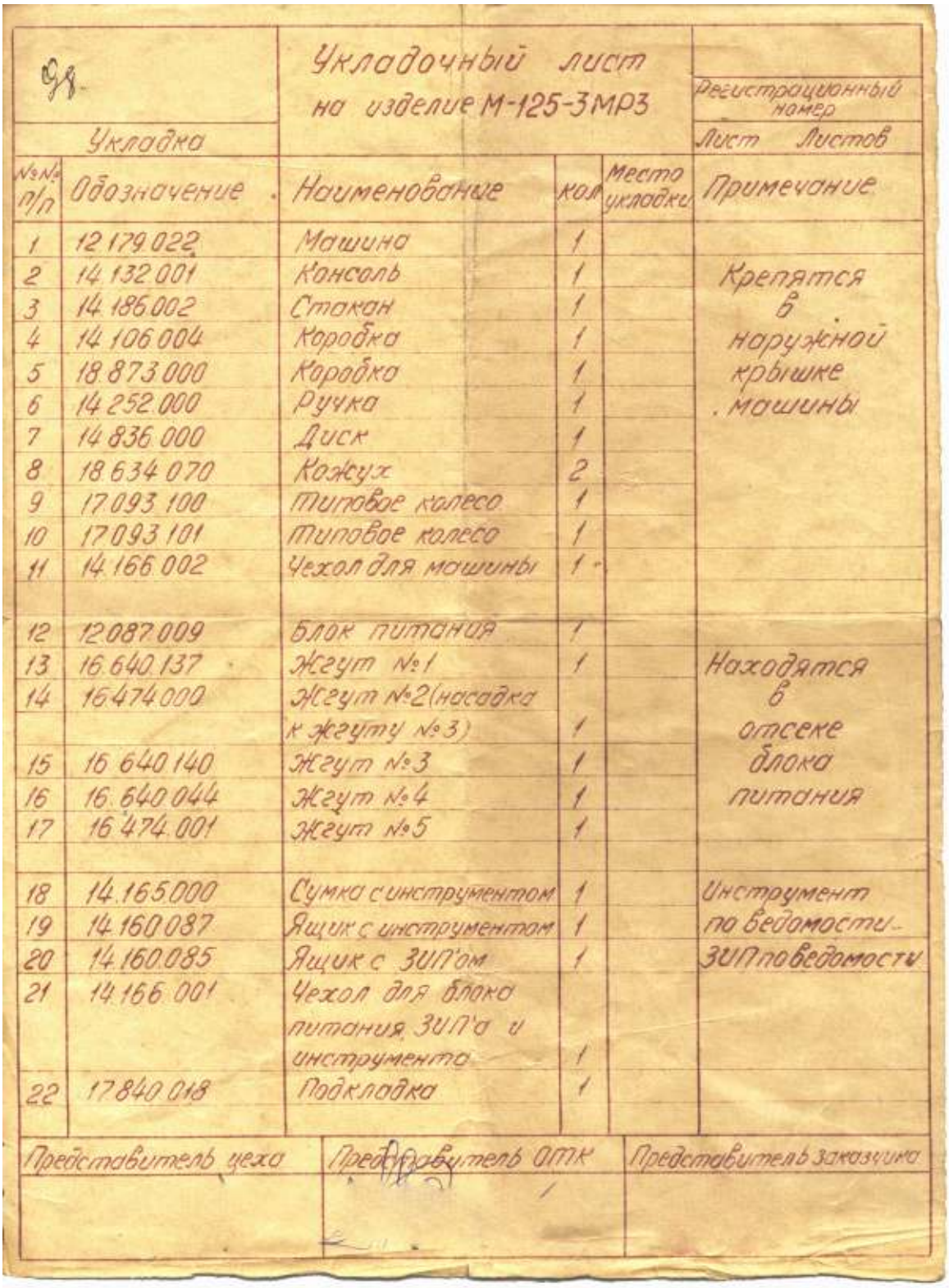
Below is a simplified driver circuit of the dummy loads.



Dummy load dreiver

1.6 Checklist

Originally, each Fialka was supplied with an maintenance box, containing the toolkit and some additional spares. A checklist was supplied in some cases, to show exactly which items should be present. The image below shows one of the very rare checklists that have survived. The signatures and the serial numbers have been ereased.



Укладочный лист на изделие М-125-3МРЗ

Регистрационный номер

Укладка

Лист Листов

№№ п/п	Обозначение	Наименование	кол	Место укладки	Примечание
1	12179022	Машина	1		
2	14.132.001	Консоль	1		Крепятся в наружной крышке машины
3	14.186.002	Стакан	1		
4	14.106.004	Коробка	1		
5	18.873.000	Коробка	1		
6	14.252.000	Ручка	1		
7	14.836.000	Диск	1		
8	18.634.070	Кожух	2		
9	17.093.100	Типовое колесо	1		
10	17.093.101	Типовое колесо	1		
11	14.166.002	Чехол для машины	1		
12	12.087.009	Блок питания	1		
13	16.640.137	Жгут №1	1		Находятся в отсеке блока питания
14	16.474.000	Жгут №2 (насадка к жгуту №3)	1		
15	16.640.140	Жгут №3	1		
16	16.640.044	Жгут №4	1		
17	16.474.001	Жгут №5	1		
18	14.165.000	Сумка с инструментом	1		Инструмент по ведомости
19	14.160.087	Ящик с инструментом	1		
20	14.160.085	Ящик с ЗИП'ом	1		ЗИП по ведомости
21	14.166.001	Чехол для блока питания, ЗИП'а и инструмента	1		
22	17.840.018	Подкладка	1		

Представитель цеха | Представитель ОТК | Представитель заказчика

Image courtesy of Tom Perera [4] Enigma Museum http://www.w1tp.com/enigma/

The drawing below shows a suitable English translation of this form. The serial number of the machine is normally present in the top right of the form, whilst the three boxes at the bottom should hold the signatures of the various departments involved in the approval of this machine. The first section of the form (items 1-11) refers to the Fialka machine itself and the various accessories located in the top cover. The second section (items 12-17) corresponds to the external power supply and the various cables needed to connect to the Fialka. Finally, the third section (items 18-22) describes the various spare parts, tools and dust covers that were originally supplied with each machine.

Signature		Packing list of system M-125-3MP3			*Machine serial #*
Packing					Registration Number
					List / Lists
Item	Part number	Description	Qty	Packing Place	Remark
1	12 179 022	Machine	1		
2	14 132 001	Holder (for paper tape)	1		Located in the top cover of the machine
3	14 186 002	Cylindrical case	1		
4	14 106 004	Box	1		
5	18 873 000	Box	1		
6	14 252 000	Crank	1		
7	14 836 000	Disk (test reflector)	1		
8	18 634 070	Cover for print head	2		
9	17 093 100	Print head	1		
10	17 093 101	Print head	1		
11	14 166 002	Canvas dust cover	1		
12	12 087 009	Power Supply Unit	1		
13	16 640 137	Cable No 1	1		Stored in cable compartment of the Power Supply
14	16 474 000	Cable No 2			
		(extension to cable No 3)	1		
15	16 640 140	Cable No 3	1		
16	16 640 044	Cable No 4	1		
17	16 474 001	Cable No 5	1		
18	14 165 000	Toolkit in canvas pouch	1		List of tools
19	14 160 087	Toolkit in wooden box	1		
20	14 160 085	Wooden box with **ZIP**	1		List of spares
21	14 166 001	Canvas cover for Power Supply, **ZIP** and tools	1		
22	17 840 018	Lining (shock absorber)	1		

Manufactoring Representative	Approval Department Representative	Client's Representative
Signature	*Signature*	*Signature*

ZIP = **З**апасные части **И** **П**ринадлежности (**S**pare parts **A**nd **A**ccessories)

1.7 Accessories

1.7.1 Introduction

A number of accessories is available for the Fialka machine. Most of these items were stored away inside the dust cover, which can be useful during transport. Many of the recently found machines had one or more accessories missing, and some machines had no additional items at all. Although, from a collector's point of view, it is nice to have a complete machine, it is by no means vital to have all of the accessories. The machine can be used perfectly well without them.

Depending on the find, one or more of the following items can be present. Please note that some items may not have been supplied in certain countries at all.

1.7.2 Crank

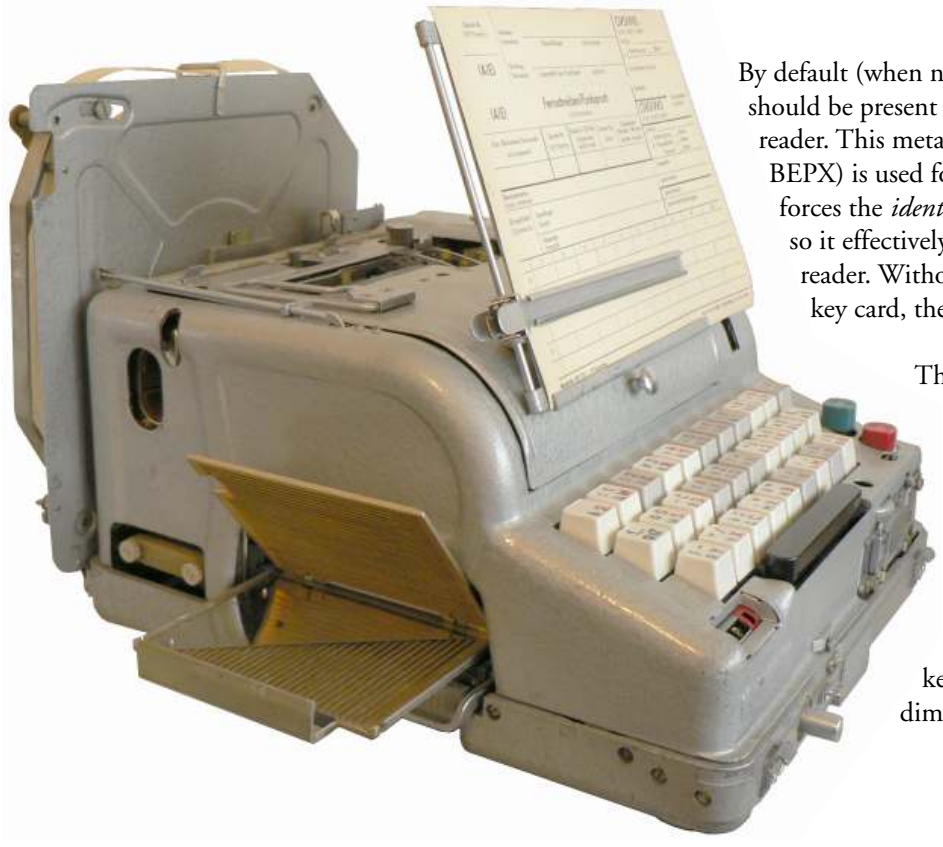
The Fialka is an electro-mechanical machine that relies on electric current for the coding and decoding process. A hand-crank (if present) can be inserted into a slot at the right side of the machine. It allows you to operate the wheel stepping mechanism, but it won't rotate any of the printing and punching mechanism (these are electrically operated). According to the manual, the crank should never be used when coding a message.

The crank was used to move the entire mechanism back or forth one or more steps. This was particularly useful when trying to decipher a 'broken' message, such as a message in which one or more letters have been lost in transmission.



The Hand Crank. Photo by Tom Perera [4]

1.7.3 Metal triangle



By default (when no key card is used) a metal triangle should be present in the drawer of the punch card reader. This metal triangle (marked with the text BEPX) is used for verification of the card reader. It forces the *identity-matrix* (i.e. a 1:1 translation), so it effectively, eleminates the use of the card reader. Without this metal triangle *or* a suitable key card, the Fialka will not work correctly.

This image shows the metal triangle in the opened card reader. The triangle has two alignment holes that should match the two index pins in the drawer (at the left). Details about the triangle and the coding cards can be found in Chapter 3.6. If you want to create your own metal triangle or key cards, you can find the exact dimensions in Chapter 5.9 .

1.7.4 Power Supply

If a Fialka machine comes with its original power supply, it's a great boon. So far, we've seen two different designs of power supply, and some variations of each of them. They are beautifully crafted and some of them even carry the circuit diagram inside the cover. The circuit diagram of the power supply is discussed in more detail in chapter 4 - *Technical Description*. If the original power supply is missing, you can use any 24V/3A power supply as an alternative. Details on how to do this are given in chapter 5 - *Hints & Tips*.

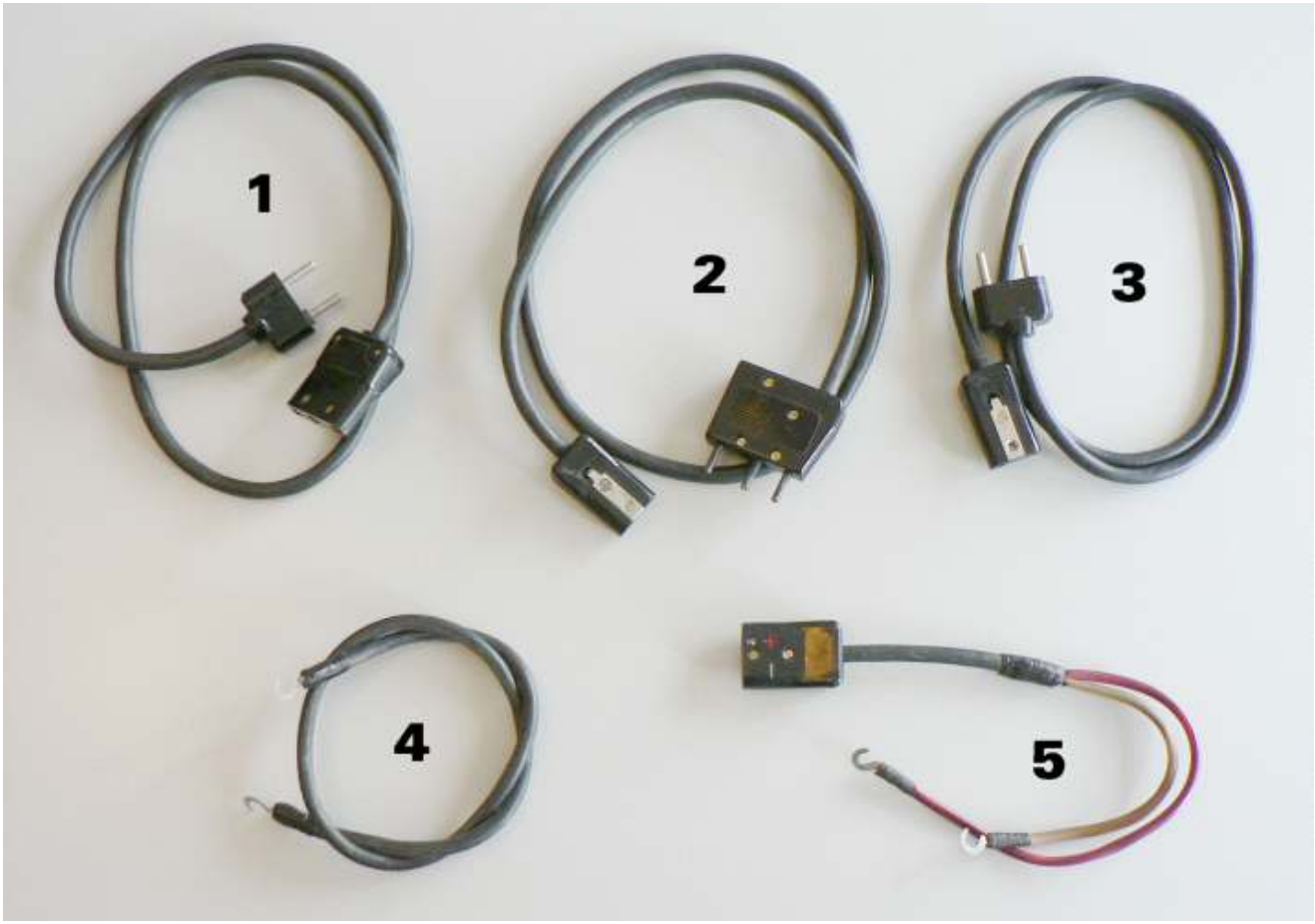
The image below shows a common power supply that was issued frequently with the M-105 (Agat) and the M-125 (Fialka) cipher machines. The power supply can be connected to a range of mains voltages, including 110V and 220V and the secundary voltage can be 'tuned' to 24V by selecting the appropriate *tap* on the transformer. A voltage meter is present to read the current output voltage. Some power supply units carry their circuit diagram inside the top cover (➔ Chapter 4,2).



Power Supply Unit as supplied with Fialka machines in Czechoslovakia

A lid at the front of the unit gives access to a small compartment that was used to store the power cables. Loosen the two screws to open the lid. A complete overview of the cables supplied with this unit is given on the next page. If these cables are missing, refer to chapter 5.2 for possible solutions.

Power Cable Set



A complete set of power cables

1 Mains cable
This cable connects the power supply to the mains. A 3-pin female connector is connected to the power inlet of the power supply, whilst a standard European 2-pin plug is used at the mains end.

2 Standard 24V cable
This cable is used to connect the 24V output of the power supply to the 24V input of the Fialka. A 3-pin male connector is used to connect to the power supply. Please note that this plug physically fits the the mains cable (**1**). **Never** connect the 24V cable directly to the mains cable!

3 Alternative 24V cable
This cable is used to feed an external 24V DC source to the power supply or to connect the Fialka to an alternative 24V source. Please be careful as the 24V connector is identical to a 2-wire mains connector in the majority of countries in Europe. Do **not** connect the machine directly to the mains!

4 Ground cable (earth)
This cable was used to connect the power supply to a suitable (external) ground. The cable can be connected to the ground terminal (ЗЕМЛЯ).

5 24V Battery cable
This cable can be used to provide 24V directly from, say, a battery. The female plug can be connected directly to the 2-pin 24 plug of cable (**3**)

Alternative power supply

The image below shows a standard Power Supply Unit as supplied with Fialka machines in Poland. A removable panel at the right side of the unit gives access to a small compartment where the various cables are stored. The following cables were used:

1. Mains cable
2. 24V cable
3. Data cable
   This cable connects to the RTTY connector (Ш4) of the Fialka. It is assumed that this type of PSU contains an interface between the Fialka and a radio set.



Power Supply Unit as supplied with Fialka machines in Poland. Photo by Tom Perera [4]



Complete cable set as supplied with the above Power Supply Unit. Photos by Tom Perera [4]

1.7.5 Paper tape holder

The Fialka can take two different sizes of paper tape:

- Standard 17.5 mm punch paper tape
- Gummed 10 mm text-only paper tape

With some machines the original paper tape holder is present. It can hold a full reel of paper tape and is attached to a metal bracket the rear (top) of the machine. Standard 17.5 mm paper tape can be fed in from the right of the machine. This is the same paper tape as is used on European and US teletype machines. The Fialka can punch a (de)coded message (in some kind of internal 5-bit code ➔ 3.5) and can also print the text in a readable form on the same paper tape.

Gummed 10 mm paper tape may be a bit harder to find. It should be fed into the machine through the hole at the back of the machine. This tape will bypass the paper puncher, so that only the readable text will be printed onto it. Once printed, this tape could be glued directly onto a message form, similar to an old-fashioned telegram.



The Paper-tape holder attached to a Fialka machine

The above image shows the paper tape holder attached to the rear of a Fialka machine. It also shows the correct flow of the paper tape. The tape is guided over the rolls and through the supporting guides into the hole at the rear of the machine. 10 mm tape should be entered in the special gutter described elsewhere in this manual (➔ Chapter 2.8).

Standard 17.5 mm tape however should also be entered through this hole, until it exits at the hole at the right of the machine. Then it should be re-entered through that hole into the paper puncher (➔ Chapter 2.8). There are several supporting rolls and wheels inside the Fialka to ensure a correct paper transport. When typing text on the Fialka, the small wheel (visible through the hole at the back) moves left and right to pull the paper from the reel.

1.7.6 Spare wheel set in container

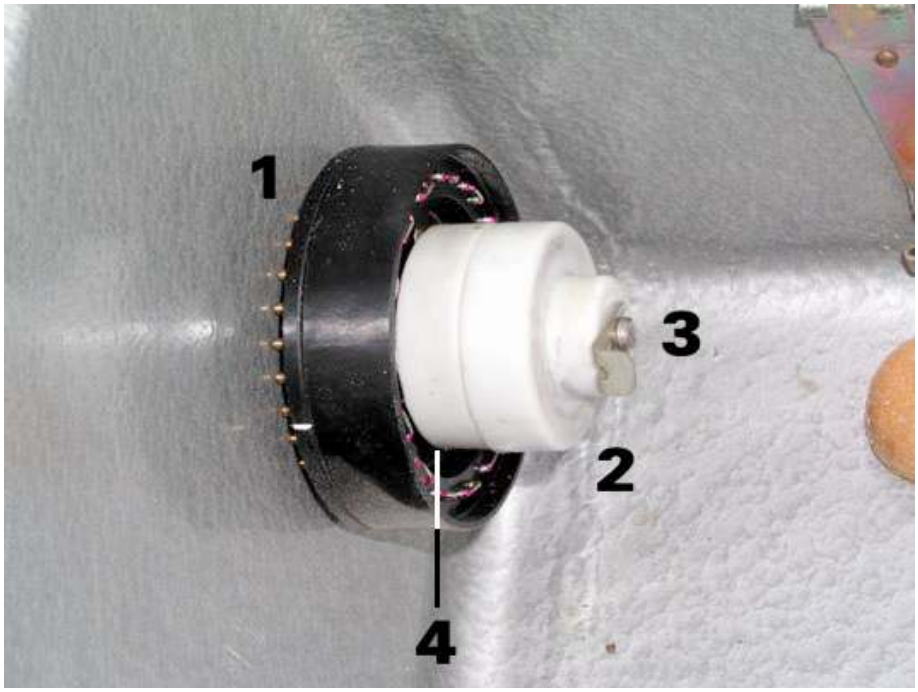
In its original use, the Fialka came with two complete sets of wheels. One set was present in the machine (i.e. the drum) and a spare set was supplied in a metal container inside the dustcover. The spare wheel set is missing from most machines, but the container is sometimes present. The letters on the outer ring of the wheels was printed in **red** as opposed to **black** for the standard wheels.



Spare wheel set in container. Photo by Tom Perera [4]

Optional accessories

A number of additional accessories may (or may not) be present on a shaft inside the dust cover. The image below shows a test reflector and two additional print heads mounted on a small shaft in the corder of the dust cover.



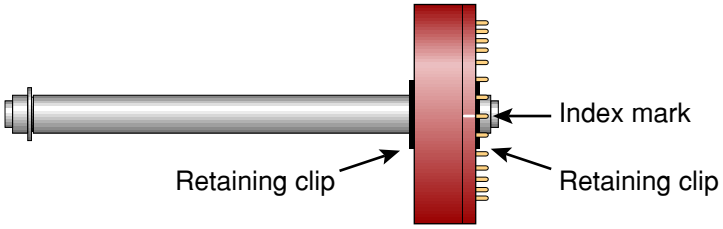
Test reflector and two print heads stored on a shaft inside the dust cover. Photo by Tom {Perera [4]

1	Test reflector	Used for testing the card reader (➔ 1.7.7)
2	Print head(s)	Spare print heads or heads for alternative alphabets (➔ 1.7.8)
3	Locking clip	A small clip to retain the heads on the shaft.
4	Retaining clip	A larger retaining clip to keep the test reflector on the shaft and to mount it on the spindle when in actual use (➔ 1.7.8)

1.7.7 Test reflector

Some Fialka machines come with a test reflecter that is usually stored on a shaft inside the dust cover, with a retaining clip holding it in place. The test reflector can be mounted on its own on the spindle that normally holds the wheels. Two retaining clips are needed to keep the reflector in place. The test reflector has 30 spring-loaded contacts on one side. These contacts are connected together in pairs, as can be seen at the rear of the wheel. It should be fitted on the far right of the spindle so that it aligns with the entry disc. The *index mark* on the test reflector should be aligned with the *index dot* on the entry disc.

The use of the test reflector is described in chapter 3.3 – The Wheels.



Test reflector mounted on the spindle

1.7.8 Additional print head(s)

Some machines were supplied with additional print heads, e.g. heads for an alternative alphabet, or just spare heads. When present, they are usually stored inside the dust cover, on the same shaft as the test reflector. A retaining clip is used to fixate the spare heads onto the shaft. The image below shows a test reflector and two spare print heads with their protective (white) covers.

At present the following print heads are known:

- Cyrillic/Latin (as supplied with the M-125) with country-specific variations
- Cyrillic only
- Latin only
- Country specific Latin alphabet

More information about the various print heads and their layout can be found in Chapter 3.4.



The test reflector and two print heads taken from the shaft

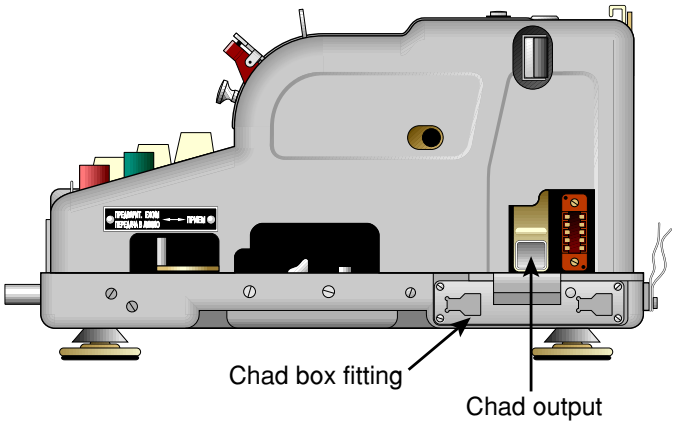
1.7.9 Chad box

When punching the digital 5-bit code in the paper tape, the Fialka produces some paper chad. To avoid blocking of the mechanism as a result of this, the paper chad is guided through some kind of 'gutter' until it leaves the machine at the right hand side. When a chad box is present (usually inside the dust cover) it can be attached to the right hand side of the machine. The channel can then be pulled out, so that the paper chad is guided nicely into the box.

This item is not present with the M-125 machines.



This is the chad box as supplied with some machines. It's a small container with a lid that can be opened when you need to empty it. The black hole on the left is the input hole. Through this hole the punched-out pieces of paper enter the container. Left and right of the hole are the fittings that are used to attach the box to the Fialka.



At the right side of the Fialka is the chad output gutter, next to the Data Output Connector Ш1. Below this channel are the fittings that holds the chad box.

Place the box so that the two notches match the fitting on the Fialka and slide the box towards the front of the machine. Now extend the chad output channel by pulling the extendable gutter downwards.



This image shows the chad box mounted to the side of the Fialka. You can clearly see the extended chad output gutter here.

1.7.10 Toolkit

This is a very rare item which is not commonly found with a Fialka machine. It is uncertain whether it was supplied with every machine, but according to the packing list (➔ 1.6) it was standard issue. Ir's a fancy set of tools, consisting of screwdrivers, hooks, brackets, etc. The tools were used for maintenance and repair.



Opened canvas pouch showing the various tools



The individual tools found inside the canvas pouch. Photos by Tom Perera [4]

1.7.11 Wheel Opening Tool

Although the adjustable Fialka wheels can easily be opened by rotating the center disc with the thumbs of both hands, the Russians developed a special tool for this purpose. It's a small aluminum key that is inserted into the center hole of a wheel. The key is then rotated until the three metal pins are locked into the three small holes in the center disc. The key is rotated counter clockwise, until the center disc comes off. This tool is a very rare find, and so far we've only encountered it once.



Fialka wheel opening tool

Chapter 2
Using the Fialka

2.1 Introduction

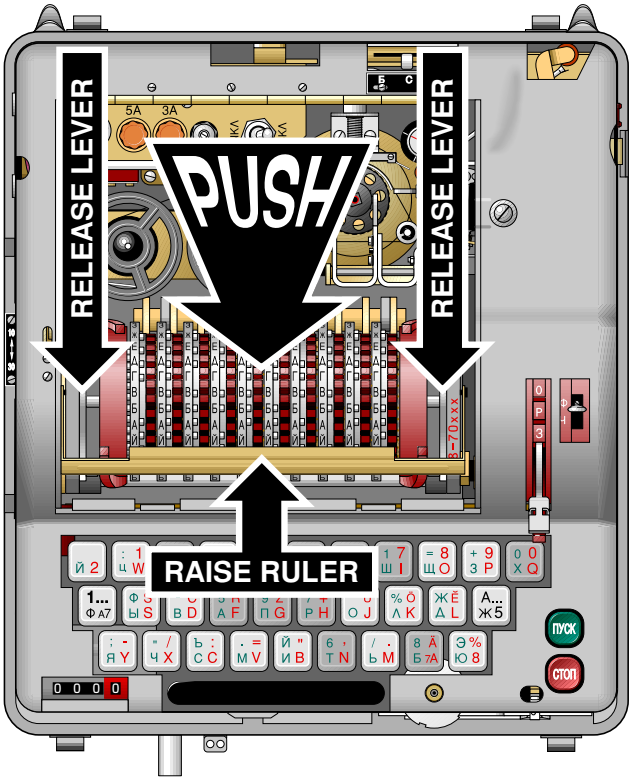
This chapter is of particular interest when you own a Fialka, or when you have access to a machine that you want to operate. If this is not the case, you may want to skip this chapter and move straight to the detailed description of the Fialka in Chapter 3.

If you are about to turn a machine on for the first time, read this chapter prior to doing so. It contains some useful information that will help to prevent permanent damage to the machine.

2.2 Check the drum

Before turning the Fialka on, it's important to check whether the wheels are correctly inserted in the machine. In some cases the spindle that holds the wheels has not been properly pushed down when the locks were enganged. As a result the spindle has not properly been 'seated' and cannot be moved. If you turn the machine on, the wheels or the mechanism may be damanged.

If you are uncertain, try to rotate the wheels manually. If they can be moved easily and click nicely into any of their 30 positions, they are probably fitted correctly. In case of doubt you may remove the wheels and re-insert them. Detailed instructions on how to this are given in Chapter 3.3 - *The Wheels*.



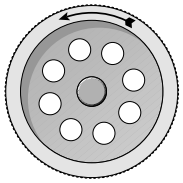
This is in short what you should do:

- Raise the *ruler*,
- Push the *drum* firmly down and try to keep it in that position,
- Release the two *levers* (one at either side of the drum) whilst pushing down the drum,
- Shift both the *entry disc* and the *reflector* aside (these are the two static discs at either side of the drum),
- Release the pressure on the drum and remove it,
- Test the *entry disc* and the *reflector* for free inward movement (see note below),
- Now re-position the drum and check that the *spindle* fits nicely in its holders. Press down the drum firmly and keep it in that position,
- Shift both the *entry disc* and the *reflector* back into position and keep pressing down the drum,
- Lock the two *levers* again,
- Release pressure on the drum,
- Lower the *ruler* again until it clicks.

In case of doubt, refer to chapter 3.3 - *The Wheels* - and read the instructions before you proceed with the rest of *this* chapter. If either the *entry disc* or the *reflector* binds when moving it in and out, you may have to file off any rough edges which may have been caused by a failed attempt to fit the drum. It is also possible that the grease in the center hole of the discs has dried out. Refer to chapter 5 for additional hints and tips.

2.3 Check whether the mechanism is blocked

As we have no idea about what has happened to the machine previously, the mechanism may be (temporarily) blocked. This can be the result of the demolition process, but it can also be caused by a *lock-out* position of the mechanism. Chapter 5 - *Hints & Tips* - gives detailed instructions on how to unblock the machine. This may involve manual rotation of the unblocking wheel at the rear of the machine (needs removal of the cover).



If you have a crank with your Fialka, you might want to try it instead. If a key was pressed prior to turning the Fialka on, it may be a bit too difficult for the small motor to get the entire mechanism going. The fact that most of the oil and grease is already way overdue, makes it even worse. The crank was supplied to release the keyboard mechanism before turning the machine on, but on all encounters with a blocked mechanism we had to turn the unblocking wheel.

Never turn the wheel whilst the machine is on! Turn the power off and rotate the wheel until the mechanism clicks. Then turn the power on again. If you've blown the fuse at this stage, refer to chapter 5.

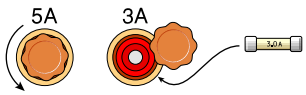
2.4 Safety first

If the Fialkia was supplied with the original power supply, you might want to use that. If the original cables are present, you should use them in preference over anything else. If the cables are missing, you must think of a suitable solution first. In Chapter 5 - *Hints and Tips* - some suggestions are made about what you can do when either the power supply or the cables are missing.

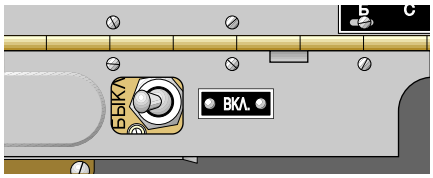


If it's just the cables that are missing, you may use standard measurement cables with banana-plugs on either side. However, you have to **be careful** when doing so, as you are connecting equipment to the mains. Only do this if you are absolutely certain about what you are doing. If you are unexperienced or if you lack the necessary knowledge about electrical equipment, don't do it and ask for advice.

The Fialka needs a 24V power source, which must be connected to the power connector on the left side. The power supply should be able to deliver a current of between 3A and 5A. Although the machine needs only about 700mA when in use, it needs far more than that to start the motor.



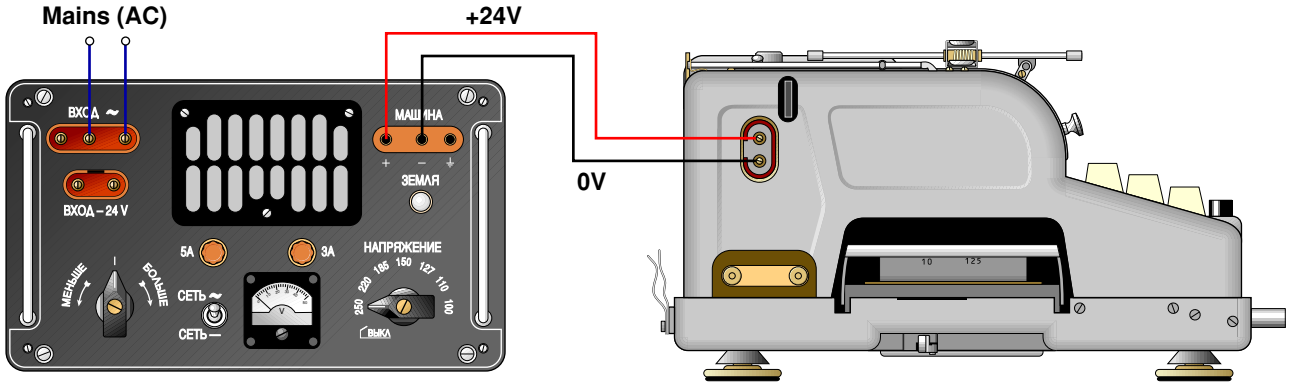
Both the power supply and the Fialka itself contain one or more fuses that will protect the circuitry to some extent. If one of these fuses is missing, you won't be able to use the machine. If you have access to spare fuses, replace them first. However, Russian fuses are difficult to get hold of and in some cases the fuse holder will be missing. Refer to chapter 5.4 - *One of the fuses is missing* - for possible solutions.



Check all connections and settings carefully before connecting it to the mains. Ensure that the power switch on top of the Fialka is set to the off position (ВЫКЛ). This means that the lever of the power switch should point to the left.

2.5 Connecting the power supply

You may now connect the power supply to the Fialka. Depending on the model of power supply, some cables may be different to the ones described here (➔ 1.7.2). In some cases the cables may be missing altogether. Refer to chapter 5.2 for information about the power connector. The power supply should be connected to the Fialka as follows:



Check the setting of the primairy voltage selector at the bottom right of the power supply. It should match your local mains voltage. Please note that the mains voltage in Europe is 230V these days, rather than 220V. In such cases, you should select the 250V setting in order to avoid saturation of the transformer.

The secundary voltage selector (bottom left) should be set to the center position (at the mark). The network selector (СЕТЬ) should be set to ~ (AC). Now connect the power supply to the mains and check the reading on the volt meter. It should read about 24V. If it is higher or lower, turn the secundary voltage selector (at the bottom left) left or right, until the voltage meter reads 24V.

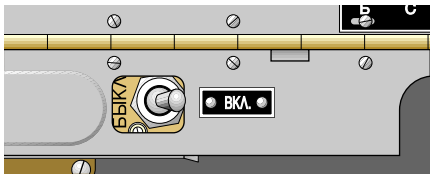
The image below shows a Fialka connected to its power supply using the standard cables.



A Fialka M-125-3 connected to its power supply

2.6 Turning the Fialka *on* for the first time

If you've come this far, we'll assume that you've found a suitable 24V (DC) supply, that is connected to the Fialka. Now is the time to turn on the Fialka for the first time. Turn the power switch, on top of the Fialka, ON (ВКЛ.).

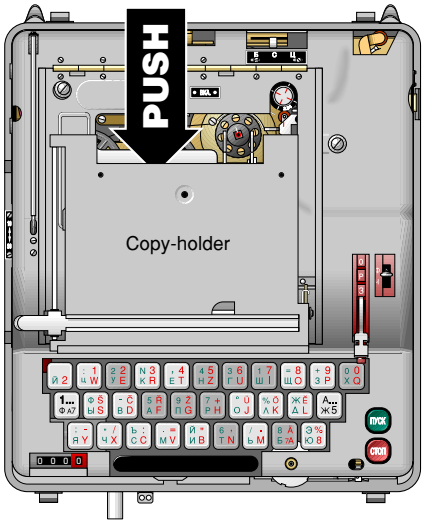


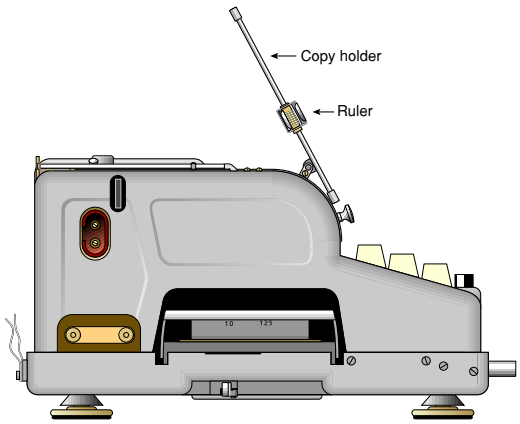
The motor should now come to life and should sound somewhat like an old vacuum cleaner. If it doesn't start at all, turn *off* the power immediately and refer to chapter 5.3 - *No sign of life when power is turned on.*

If the motor *does* come to life you can go ahead, but please ensure that everything runs smoothly. If the motor makes a rather 'dry' sound, you might want to apply some oil to the gears, just to re-activate the dried-out grease inside the machine (➔ 5.7 - *Oil and Grease*). You may also want to lower the speed of the motor slightly so that it sounds less overloaded (➔ 5.8 - *Adjusting the motor speed*).

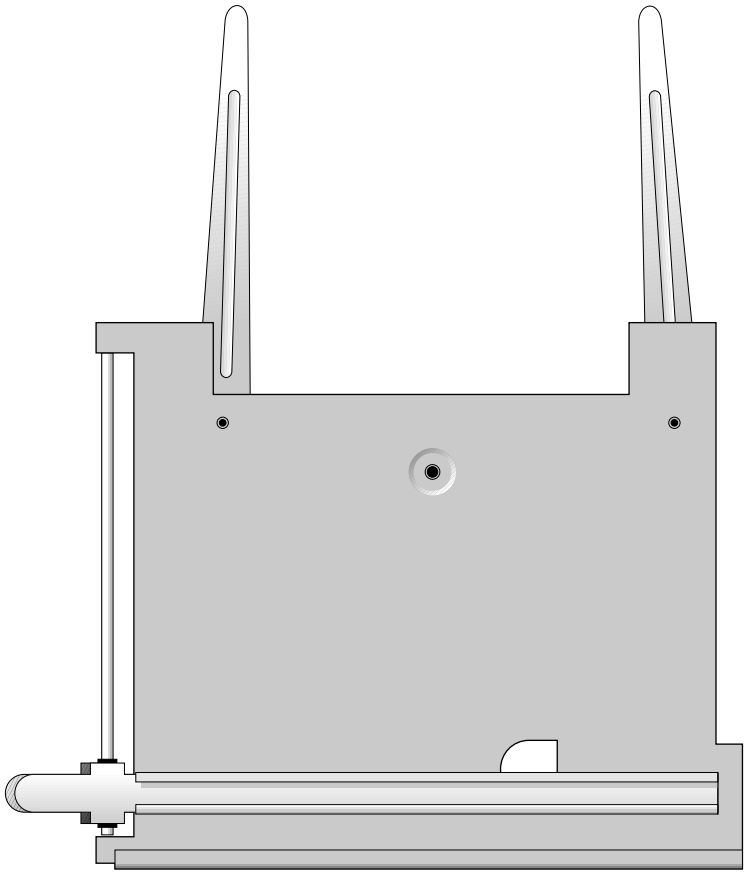
2.7 Using the copy-holder

When typing a message on the Fialka, the original text (e.g. a message form) can be attached to the so-called copy-holder on the top of the machine. After unpacking the machine, you'll find the copy-holder in a horizontal position, locked to the lid of the machine. It can be released, by pushing your fingers between the copy-holder and the top of the Fialks's cover, until it unlocks. Once released, it is kept in the upright position by a single spring.





The copy-holder of an M-125-3 machine can be extended further, to allow a larger sheet of paper to be used. Hidden behind the copy-holder, are two thin metal 'arms' that can be rotated into position. The drawing below shows what it eventually looks like. Place the paper-sheet in the small metal gutter at the bottom and hold it in place with the ruler. The ruler itself can be adjusted by pusing the two metal 'fingers' on the left together and moving it up or down.



Note that when the copy holder is up, it can be shifted sideways to allow a wider piece of paper to be used.

Note:
When storing the copy-holder back onto the lid, ensure that the two extensions are folded back again behind the copy-holder, and that the ruler is in its lowest position. The latter is important to avoid damage to the case when lowering the copy-holder.

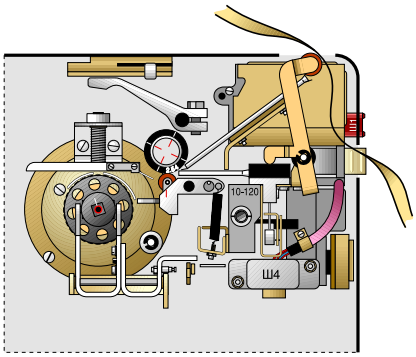
Once this has been done, push the copy-holder back in its storage position, until it 'clicks' to the lid again.

2.8 Loading paper tape into the printer/puncher

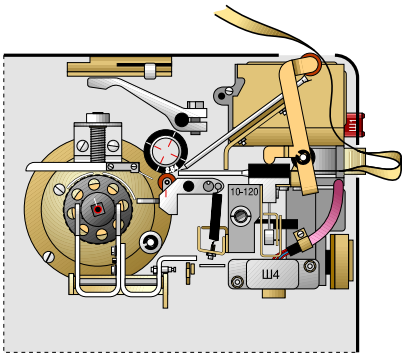
Unlike the Enigma coding machine, which uses lamps for its output, the Fialka prints its results onto a paper tape, or punch the data as a five bit digital code as a series of holes. Furthermore, the Fialka accepts two types of paper tape: standard 17.5 punch paper tape or narrow 10 mm text-only paper.

2.8.1 Loading the standard 17.5 mm paper tape

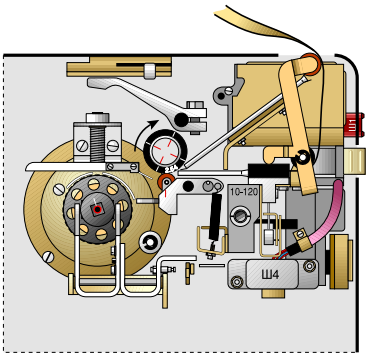
This is the standard paper tape commonly used on teletype machines around the world. The tape is fed into the puncher from the right of the machine, but loading it is slightly more complex than this. The image in chapter 1.7 - *Accessories* (Paragraph: *Paper tape holder*) clearly shows how to load this type of paper.



1. Insert the tape through both holes



2. Re-insert the tape from the right

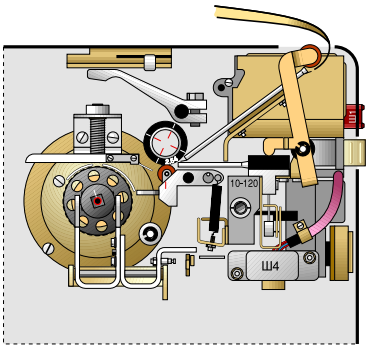


3. Rotate the capstan to load the paper

First insert the tape into the hole at the rear until it exits the hole at the right. Now fold the tape back, so that it can be re-inserted into the hole at the right. This time, guide the tape into the puncher until it meets the capstan and the pressure roller. Whilst pushing the paper inwards, rotate the capstan clockwise until it 'grabs' the paper. Next rotate the capstan clockwise so that the paper tape is completely 'eaten' by the mechanism and ensure the tape is nicely guided past the print head, into the output paper gutter at the left (mounted onto the *Power Module*).

2.8.2 Loading the special 10 mm paper tape

This paper tape is narrower than the standard tape and can therefore only be used for text output (not for digitally punched data). It sometimes comes with a pre-gummed back, so that the ouput can be glued onto a paper sheet, much like a telegram in the old days. The 10 mm paper roll can be loaded onto the standard tape holder, which is suitable for both sizes of tape.



The tape should be loaded as described above, but enters the special diagonally mounted 10 mm gutter that runs from the input guide-roller to the the capstan, so that it by-passes the puncher. Insert the tape into the guide until it meets the capstan roller. Now rotate the capstan clockwise, so that the tape is loaded into the printer mechanism. Ensure the tape is nicely guided past the print head into the output paper gutter.

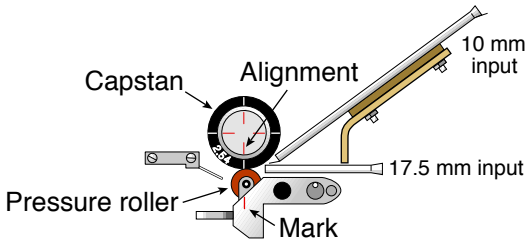
Loading the 10 mm tape into the input guide can be difficult at times, as it's a 'tight-fit'. If the paper doesn't fit the input guide easily, cut-off a millimeter or so from the first 10 cm of the tape, using a pair of scissors, as shown in the drawing below.



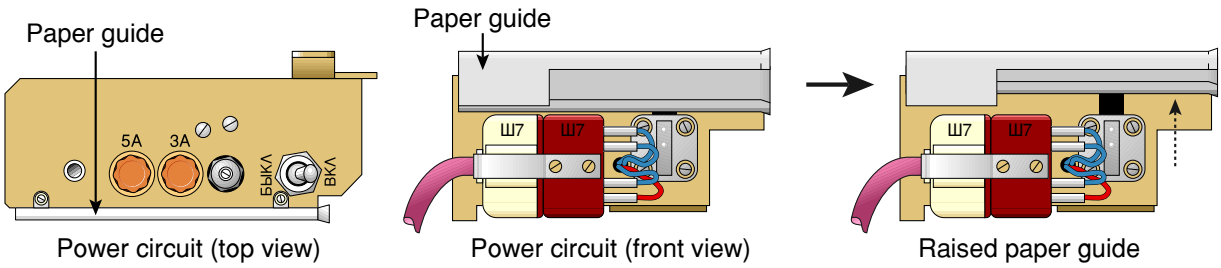
Modifying the 10 mm tape for easy insertion

2.8.3 Printer alignment

Once the tape has been loaded correctly into the machine, rotate the capstan clockwise until one of the 4 lines match the mark on the pressure roller, as shown in the drawing below. It is necessary to align the tape this way, prior to encoding **each** message, as it ensures the correct 5-letter group separation in coding-mode.



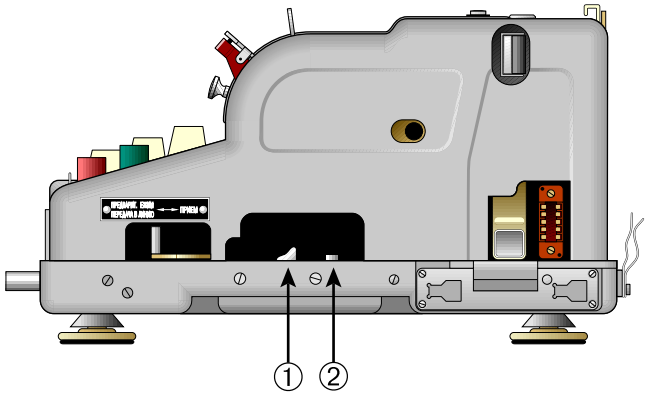
Whenever 10 mm paper tape is used, the output paper gutter must be adjusted to avoid paper-blocking. The output paper gutter can be adjusted by raising its lower part as shown in the drawing below. You may need a dedicated tool to raise the lower part, but you could also use a screwdriver to do this (carefully) or raise it by hand. It is likely that the original canvas toolkit contained a special tool for this.



2.9 Five-letter groups

Cipher-text is usually printed in 5-letter groups and the Fialka contains mechanisms to do this automatically. Whenever coding a message, the letters on the paper tape are automatically printed in groups of five. A space is automatically inserted by the machine. In decoding-mode, the 5-letter group separators are omitted automatically, so that the ouput (plain) text is presented as a contiguous block, with spaces inserted at the appropriate places.

When in *numbers-only* mode, the Fialka can be used to send and receive pre-coded numerical messages. As these messages don't produce readable text directly, spaces can be inserted into the output text (in decoding-mode) automatically at 5-letter group intervals, by turning the 5-letter group separation mechanism *on*.



The controls for the 5-letter group separation are located at the right of the Fialka.

① Slide the triangular switch backwards (towards the rear of the machine) to turn the mechanism *on*.

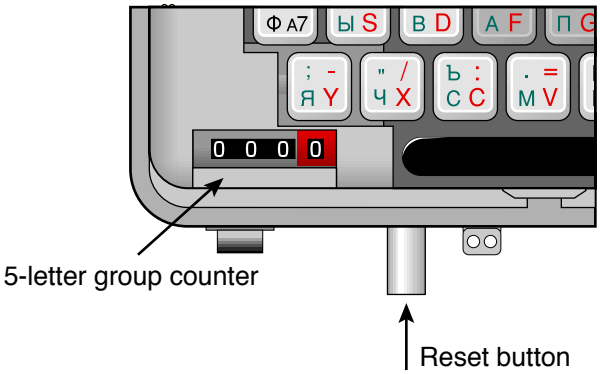
② The 5-letter group separation can be turned *off* again by pushing down the release button.

2.10 The Counters

Some Fialka machines have two counters. One is visible from the outside and one is hidden on the inside, below the keyboard. The counter that is visible from the outside is the most important one, as it is used to count 5-letter groups.

5-letter group counter

The Fialka M-125 and the M-125-3 both have a 4-digit counter to the left of the space bar. This is the so-called letter group counter that counts the number of 5-letter groups. It works much in the same way as a regular counter, but the rightmost digit is a special one, as it counts to 5 (rather than to 10). All other digits count to 10 as expected. With each letter pressed on the keyboard, the rightmost digit (marked in red) is incremented. When it reaches 5, it carries the next digit, etc.



The counter can be reset, by pushing the large round metal button on the front of the machine inwards. Note that the machine's dust-cover contains a metal bracket that keeps the reset button depressed when the cover is closed. This is probably done to ensure that the counter is already reset next time the machine is used. It also deletes all traces about the last message sent.

Usage counter

The M-125-3 contains an extra counter which is hidden under the keyboard. This sealed counter has no meaning to the average user and was only used as a usage-indicator. A large cog-wheel is advanced by one cog, with every key that is pressed on the keyboard. It is driven directly by the keyboard and cannot be reset.



This image shows the sealed usage-counter mounted on a mechanical arm at the bottom of the machine, after the keyboard has been removed.

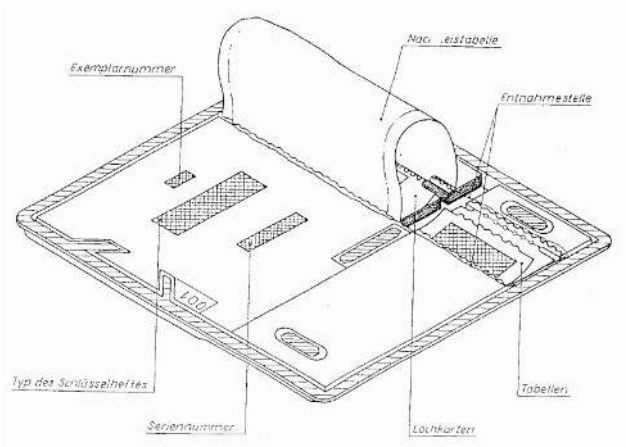
This counter is **not** present in the M-125.

2.11 Setting up the key

2.11.1 The Daily Key

At the beginning of each day, the Fialka had to be setup for the current *daily key*, plus the *message key*. As the name suggests, the daily key would be used during one day. The message key, however, would be different for each message sent with the daily key. The daily key was taken from a sealed bag (Schlüsselheft) similar to the one shown here. The bag was marked with the following information:

- Type of key (Typ des Schlüsselheftes)
  OSB-25-N or OSB-25 for non-adjustable wheels,
  OSB-25-MN for adjustable wheels.
- Serial number (Seriennummer)
- Level of secrecy
- Date interval (Geltungszeitraum)



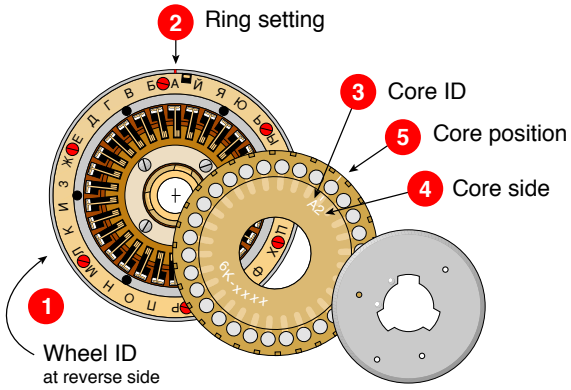
The seal bag contained the following items:

- 31 Daily key tables
- 31 Punched key cards
- 1 Usage table

Both the daily key tables and the punched key cards are numbered from 01 to 31, one for each day of the month. The punched key cards contained a 30 x 30 matrix, in which a single hole was punched in each row/column. They key card was placed in a drawer (card reader) at the left side of the Fialka. More information about the key cards and the card reader can be found in chapters 3.6 and 5.9.

Adjustable wheels

The daily key table for machines with adjustable wheels was a small card with 8 groups of 5 letters each, and 2 groups of 5 numbers each, similar to the one shown here:



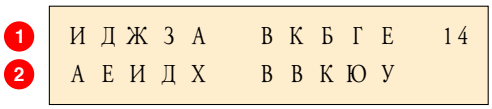
1	И	Д	Ж	З	А		В	К	Б	Г	Е	14
2	О	С	А	Н	Е		Р	Т	Ь	Б	Ы	
3	Б	Д	В	И	А		Г	Е	З	К	Ж	
4	2	1	1	2	2		1	2	2	1	2	
5	К	У	Л	К	Ю		Ы	Х	В	У	Г	

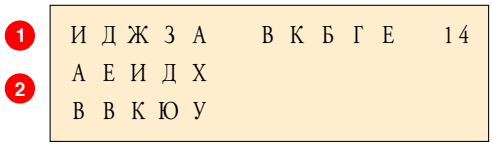
The number in the top right corner of the card (14 in the example above) indicates the day of the month. The number has to match the number of the punched key card. The above card would be used on the 14th of the month.
The first row of letters defines the order of the wheels on the spindle. The second row specifies the setting of the indicator ring (Ringstellung). The third row specifies the order of the inner cores of the wheels. The forth row specifies which side of the core should be visible from the outside. The fifth row finally specifies the index position of the core.

In the above example, the first position on the spindle would be taken by wheel И with a ring setting of О. Inside the wheel is core Б with side number 2 up, rotated to position К.

Non-adjustable wheels

The key table for machines with the non-adjustable wheels is, of course, much simpler. It can take the following shapes:





The first row specifies the order of the wheels on the spindle, just like with the adjustable wheels. The second row specifies the start position of the wheels when encoding the *message indicators* (Kenngruppen) for common traffic.

2.11.2 The Message Key

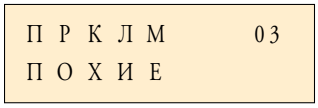
Apart from the daily key, each new message had to be given a message key, which was taken from the *Message Key Book* (Spruchschlüsselheft). The cover of the Message Key Book contained the following information:

- Type of key
  KV-25-MN or KV-25-N for individual traffic (individuellen Verkehr)
  ZV-25-MN or ZV-25-N for broadcast traffic (zirkularen Verkehr)
- Serial number
- Volume number (Exemplarnummer). Unless stated otherwise, volume 1 would be used for encoding and all other volumes were used for decoding.
- Level of secrecy

Each *Message Key Book* contained the following items:

- 40 Message Key Tables
- 2 Indicator Tables
- 2 Usage tables

Each *Message Key Table* for individual or broadcast traffic, contains two groups of 5 letters each. This is called the Message Key. It defines the starting position of the wheels for that message. Each message key can only be used once. The number in the top right corner is the message key number (ranging from 01 to 40).



Each *Indicator Table* contains 20 groups of 5 letters each (for alphanumerical messages) and 20 groups of 5 numbers each (for numbers-only messages), e.g.:

ЧЧШХР	ФИОКБ	ИПГУЛ	ЖЮЯФБ	61449	56442	81770	12327
ЛЧРХА	ОКРРД	ТВХРН	АБГБЧ	19804	66262	63452	86367
КВНСП	ИРСЗО	ПЗТРЧ	АРБГС	25477	24262	35715	34194
ОКШКК	КТМНО	ОЛДРИ	ЫЧМЛТ	83271	37012	81576	38721
САВЕС	ДИМТК	ЛХРАХ	ФЯТЬЖ	92421	70875	69640	65856

УПРАХ	АЛЛУБ	ПУЦЕЙ	ЫКЛСТ	17828	13695	22384	75607
ЦИКЛМ	ЬЬТРУ	ОКРИК	ЕЗТРА	29083	52365	41026	21319
ХХЕЕЕ	МККОП	СЕМВЯ	АЙВСУ	66775	28694	48333	62978
ОКТСА	ББГРС	ИАИИХ	ХХДАД	39666	68988	34515	97492
ВДТИЬ	ТАЛРА	ЧСЖБЦ	ОЛКРА	20250	75921	73905	79110

2.11.3 The Indicator Book for Common Traffic

The cover of each Indicator Book contains the following information:

- Type number
- Serial number
- Level of secrecy

Each *Indicator Book* contains the following items:

- 50 Indicator tables
- 1 Usage table

Each *Indicator Table* contains 48 *Indicators* that can be used for 24 messages. Each time, two adjacent 5-letter groups should be used to create a *Message Key*. Each indicator should be used only once for the creation of a message key.

2.11.4 Changing the key

Each *Daily Key* was valid for 24 hours and was changed at 01:00 hours. Each *Message Key* was valid only for a single message. Keying material (i.e. tables and key cards) that was damaged or compromised, had to be reported immediately to headquarters by courier. The new key, that had to be used instead of the compromised key, would be issued by headquarters and would either be sent encrypted or by courier.

Once a key was no longer used (i.e. when it had expired), the wheels of the Fialka had to be put back in their default position. This means that all cores had to be returned to their original wheels, inserted at position 'A' with side '1' up. Furthermore, the ring setting had to be reset to 'A' and all wheels had to be put on the spindle in the order of the alphabet.

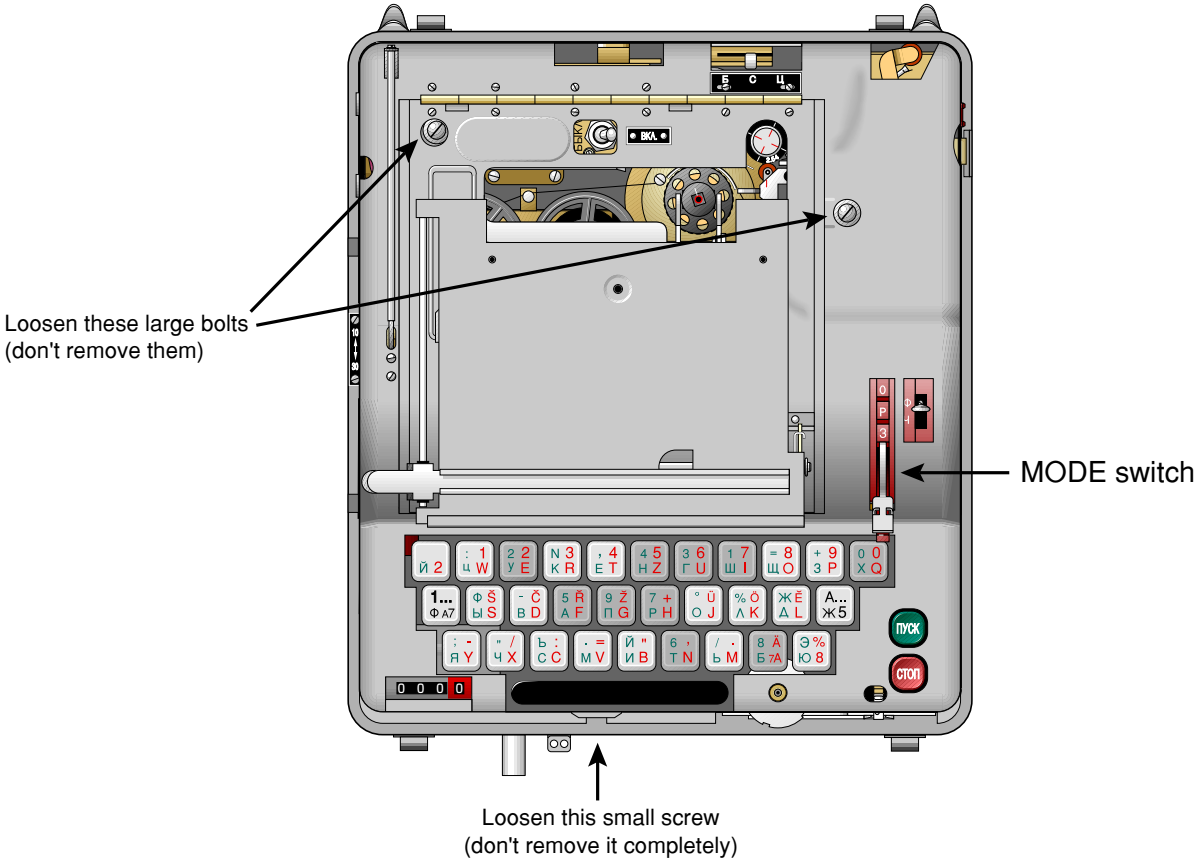
Chapter 3
Detailed description

3.1 Introduction

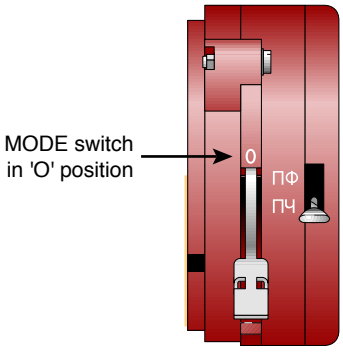
In this chapter, each of the major components inside the Fialka are discussed in great detail. It describes the keyboard, the wheels, the wheel-wiring, the printer, the puncher, etc.

Accessing the interior

Most of the components discussed in this chapter cannot be accessed from the outside, but require the cover to be removed. The cover is held in place by three bolts. Two large ones are found on the top; one to the right of the lid and one on the left, close to the hinge. A third –ather small– bolt is found on the front of the machine, just below the space bar. Loosen the 3 bolts, but don't remove them completely. The bolt on the top left can be accessed through hole in the lid of the M-125-3. On the M-125 you need to open the lid first in order to access this bolt.



Position of the bolts to remove the cover



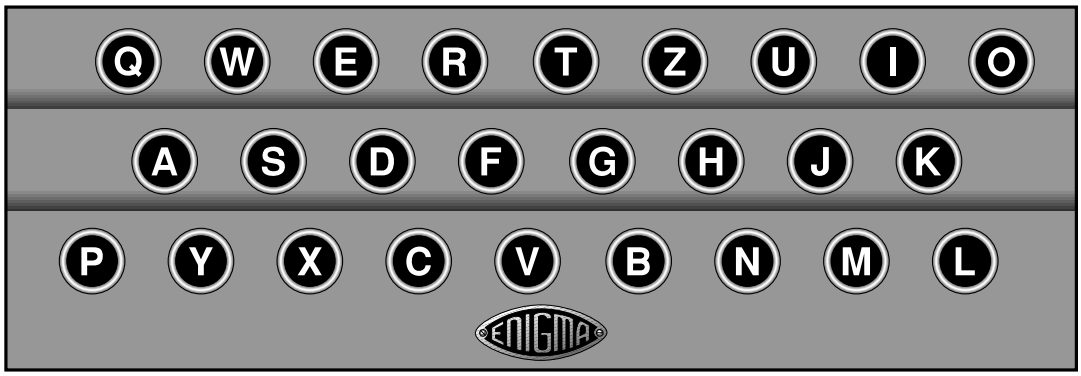
Next, put the MODE switch in plain-text mode (position marked as 'O') and remove the cover by pulling it up. Please ensure that the MODE switch is also in the 'O' position when closing the cover again.

Mode switch

3.2 Keyboard

3.2.1 Introduction

The keyboard of a Fialka machine looks like a standard typewriter keyboard. However, there are a number of differences. The Fialka was designed by the Russians and therefore supports the Russian alphabet (Cyrillic). As the Cyrillic alphabet contains more letters than the basic Latin alphabet, more keys, and hence more contacts on the wheels, are necessary. Let's compare the keyboard of the Fialka with that of the well-known Enigma cipher machine.



Enigma keyboard

The Enigma keyboard has a German layout (QWERZU) and features only the standard Latin alphabet. There are no punctuation marks, special characters, accented characters, numbers or spaces. Just the standard 26 letters: A-Z. Spaces and carriage returns were often replaced by the letter X (which is hardly ever used in German), and numbers were fully written out (e.g. 'DREI' instead of '3').

The Russian alphabet features more than 26 letters. In fact, there are 33 characters in the Cyrillic alphabet, but some of these are not frequently used. The standard Fialka (M-125) allows 30 characters to be encoded. As a result the keyboard has exactly 30 keys and each wheel has 30 contacts on either side. In the initial design the Fialka was used for the Russian language only. The 30 most frequently used characters were implemented and numbers, punctuation marks, etc. were simply omitted. Just like on the Enigma, numbers and some other characters were replaced by a specific sequence or fully written out.



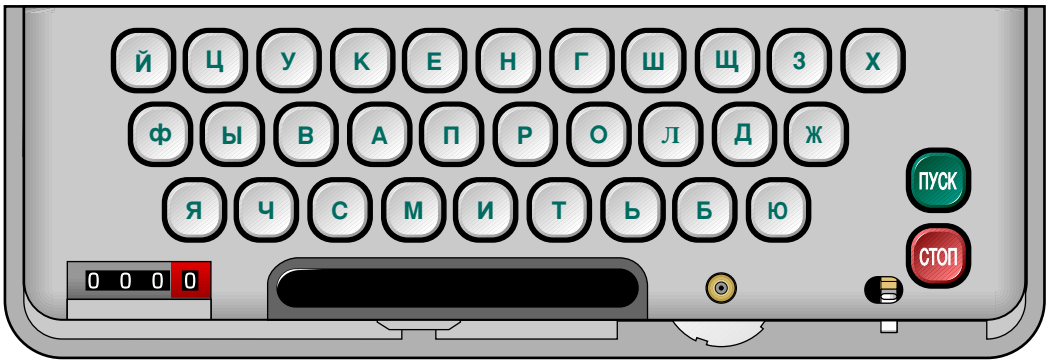
Later versions of the Fialka (e.g. the M-125-MN) were bi-lingual; supporting both the Cyrillic and the Latin character set. The keyboard of these machines had two characters on each key: a Russian one (shown in green) and a Latin one (shown in red). The print heads of these machines were also bi-lingual and a switch on top of the Fialka was used to toggle between Russian and Latin (РУС ↔ ЛАТ). As the Latin alphabet contains only 26 letters, some of the remaining ones were used to add numbers to the character set.

The Fialka was used in a number of countries outside Russia, such as East-Germany, Poland and Czechoslovakia. Each of these countries had its own language and each had its own language-specific variations on the Latin alphabet. In order to accomodate these differences, a new –modified– version of the Fialka was introduced: the M-125-3 variant. It added support for the local languages, without losing compatibility with the older machines. Customised versions of the print head and the keyboard were issued to each of these countries. Furthermore, the character set was much enhanced by introducing an –optional– *number shift* and *letter shift*, just like on a regular teletype machine.

Another new feature of the M-125-3 machines was the introduction of *numbers-only coding*. This allowed the coding of already coded numerical messages. In this mode, only numbers can be typed on the keyboard; all other keys are blocked. This mode can only be used in combination with the Russian print head. The use of the various modes is fully explained further down this chapter.

3.2.2 Standard keyboard layout

Although we've never seen the Russian version of the Fialka yet, it is likely that its keyboard layout was as shown here. All other versions of the Fialka are bi-lingual and show both the Cyrillic and the Latin alphabet on the key tops.



3.2.3 Keyboard letter mapping

Different keyboard layouts have been issued for individual countries as you can see in the following paragraphs. The only alphabet that is the same on each machine is the Cyrillic one. As this alphabet is also used to identify the 30 contacts throughout the machine, we'll use this as the reference. The following tables specify the keyboard letter mapping for each of the known layouts. The lowest row of each table specifies the *special* characters and is therefore only applicable to the M-125-3 machines.

Keyboard character mapping - Poland

Cyrillic	А	Б	В	Г	Д	Е	Ж	З	И	К	Л	М	Н	О	П	Р	С	Т	У	Ф	Х	Ц	Ч	Ш	Щ	Ы	Ь	Ю	Я	Й
Latin	F	A	D	U	L	T	5	P	B	R	K	V	Z	J	G	H	C	N	E	7	Q	W	X	I	O	S	M	8	Y	2
Special	Ą	%	-	6	)	4		9	?	3	(	=	5	+	Ę	Ł	:	,	2		0	1	/	7	8	Ž	.	°	'	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

Keyboard character mapping - East Germany (DDR)

Cyrillic	А	Б	В	Г	Д	Е	Ж	З	И	К	Л	М	Н	О	П	Р	С	Т	У	Ф	Х	Ц	Ч	Ш	Щ	Ы	Ь	Ю	Я	Й
Latin	F	8	D	U	L	T	5	P	B	R	K	V	Z	4	G	H	C	N	E	A	3	2	7	I	O	S	M	9	6	J
Special	V	:	W	6	)	4		9	/	3	(	X	5	J	Ä	Ü	Y	,	2		0	1	F	7	8	Q	.	-	Ö	*
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

Keyboard character mapping - Czechoslovakia

Cyrillic	А	Б	В	Г	Д	Е	Ж	З	И	К	Л	М	Н	О	П	Р	С	Т	У	Ф	Х	Ц	Ч	Ш	Щ	Ы	Ь	Ю	Я	Й
Latin	F	A	D	U	L	T	5	P	B	R	K	V	Z	J	G	H	C	N	E	7	Q	W	X	I	O	S	M	8	Y	2
Special	Ř	Ä	Č	6	Ě	4		9	"	3	Ö	=	5	Ü	Ž	+	:	,	2		0	1	/	7	8	Š	.	%	-	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

3.2.4 Special characters

The mapping of the Latin character set for the Polish and Czech versions of the Fialka is identical. All 26 characters of the Latin alphabet are present and the remaining space is filled with the numbers 2, 5, 7 and 8. Whenever *mixed mode* is used (i.e. letters, number and punctuation marks), the numbers 5 and 7 are given up for the *Number shift* (1...) and *Letter shift* (A...). Numbers should then be entered by first pressing the *Number shift* (1...) followed by the appropriate number from the *Special* character set. The same is true for the punctuation marks (e.g. '%') and the accented characters (e.g. Ö). Once the special character is entered, the *Letter shift* (A...) should be pressed to revert to the standard alphabet.

3.2.5 Notes on the German keyboard layout

Please note that the Latin keyboard mapping for the German version of the Fialka is completely different from the others. In standard mode (letters only) the Germans have given up some of the characters of the Latin alphabet, to allow the numbers 0-9 to be used. As a result, the letters Q, W, X and Y are lost. Furthermore the letter 'J' is lost as it is part of the special Й-key, which is used for the *space* character when coding a message. The lost letters are replaced by the following sequences:

Letter	Replacement	Example	
J	I	MAJOR	MAIOR
Q	KV	QUADRAT	KVUADRAT
W	VV	EWALD	EVVALD
X	KS	TEXT	TEKST
Y	I	MEYER	MEIER

Although some (infrequently used) characters are lost on the German keyboard, it has the advantage that numbers can be used directly in *standard* mode (i.e. letters-only mode). The numbers 0-9 are assigned as follows in this mode:

Keyboard character mapping - East Germany (DDR)																													
Cyrillic	**А**	**Б**	**В**	**Г**	**Д**	**Е**	**Ж**	**З**	**И**	**К**	**Л**	**М**	**Н**	**О**	**П**	**Р**	**С**	**Т**	**У**	**Ф**	**Х**	**Ц**	**Ч**	**Ш**	**Щ**	**Ы**	**Ь**	**Ю**	**Я**	**Й**
Latin	F	8	D	U	L	T	5	P	B	R	K	V	Z	4	G	H	C	N	E	A	3	2	7	I	O	S	M	9	6	J
Special	V	:	W	6	)	4		9	/	3	(	X	5	J	Ä	Ü	Y	,	2		0	1	F	7	8	Q	.	-	Ö	*
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

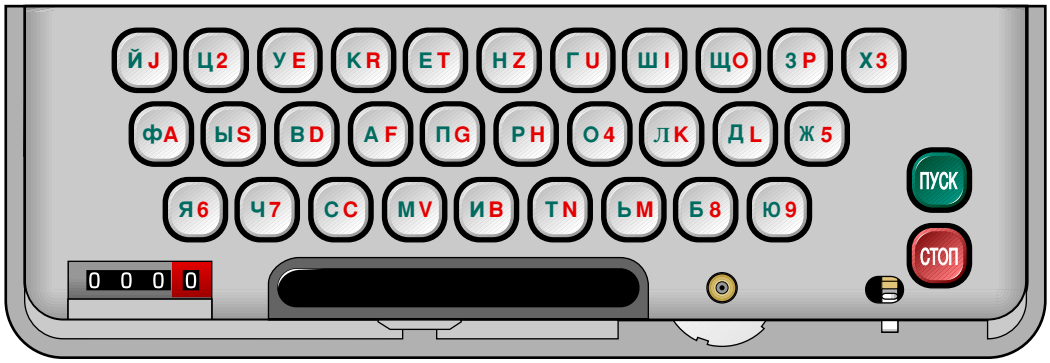
Please note that the numbers '1' and '0' are replaced by the letters 'I' and 'O'. Accented characters, which are frequently used in the German language, can also be entered easily, by replacing them by the following bigrams:

Letter	Replacement	Example	
Ä	AE	GÄBLER	GAEBLER
Ö	OE	MEYERHÖFT	MEIERHOEFT
Ü	UE	KÜGELN	KUEGELN
ß	SZ	STRAßE	STRASZE

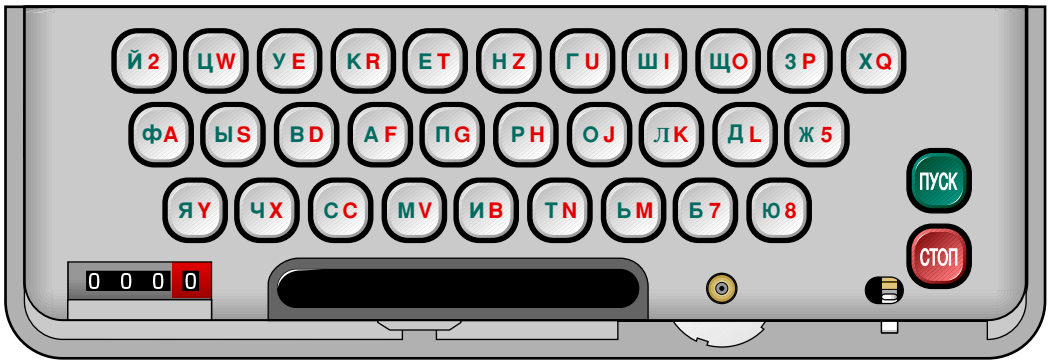


3.2.6 Different keyboard layouts

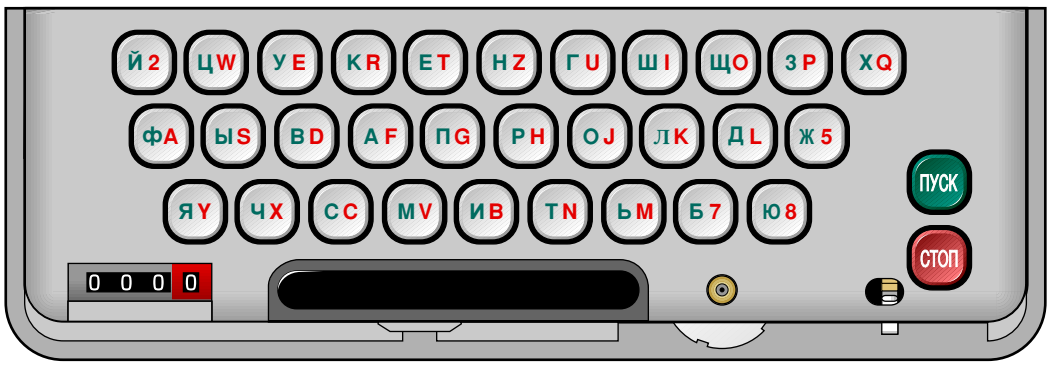
The Fialka is known to have been used in some East-European countries, such as the former East-Germany (DDR), Poland, the former Czechoslovakia and Russia. Each of these countries has its own language and its own specific alphabet. A customised version of the Fialka was therefore supplied to each country. To date, only a limited number of Fialka machines have been discovered, from a limited number of countries. In fact, the authors haven't yet seen any machines from Russia or the former DDR at all. The information presented below has been derived either from direct investigation of available machines, or from verbal contributions by 'people in the know'.



German version of the M-125-MN



Polish version of the M-125-MN



Czech version of the M-125-MN

The keyboard of the M-125-3 version is far more complicated. Rather than just Cyrillic and Latin letters, each key top contains up to 4 different characters. Which of the 4 symbols are used, is subject to:

- The selected print head (Cyrillic or Latin),
- The setting of the TEXT MODE switch at the back (Letters, Numbers or Mixed),
- The settings of the NumLock switch (10 ↔ 30) at the bottom left of the machine.



German version of the M-125-3MN



Polish version of the M-125-3MP3

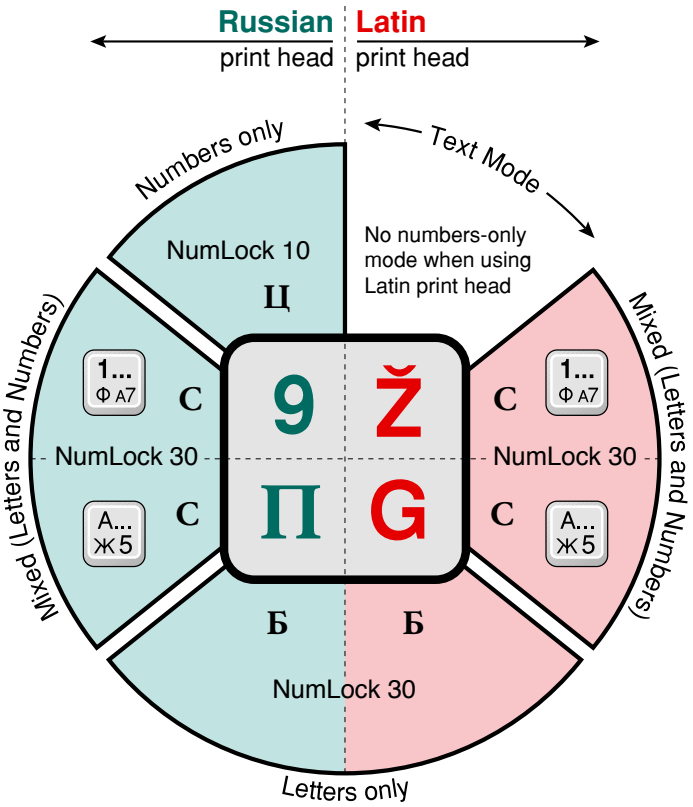


Czech version of the M-125-3MP2

3.2.7 Key legend

When using the M-125, the keyboard mapping is straight forward. The green letters on the key tops (i.e. the left half) are used when the Russian print head is selected (switch: **РУС** ↔ ЛАТ). Likewise, the red letters (i.e. the right half) are used when the Latin print head is selected (switch: РУС ↔ **ЛАТ**).

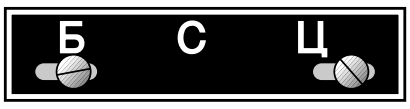
The M-125-3 is much more complex and has three modes of operation: *Numbers-only*, *Letters-only* and *Mixed* (i.e. both *letters* and *numbers*). This is probably the reason for the '3' in the serial number. Each of the key caps show up to four different characters and a complex scheme of configurable options is used to determine which of the four characters is being used. This scheme is explained in the diagram below:



Layout of the key-top on the Fialka M-125-3

3.2.8 Text Mode

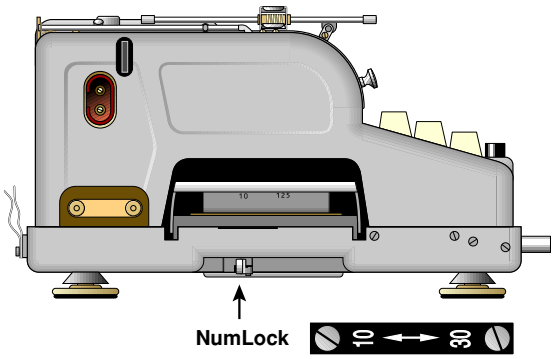
When the Russian print head is present, the left half of the key cap should be used, whilst the right half represents the Latin print head. On the M-125-3 the (text) mode of operation can be selected with a lever at the back of the Fialka, just behind the printer mechanism. Push down the lever and select one of the following three text modes:



Setting	Russian	Transcript	Translation
Б	Буквы	Bukvy	Letters
С	Смешанные	Smjeshannyje	Mixed
Ц	Цифры	Cifry	Numbers

Text-mode settings on the Fialka M-125-3

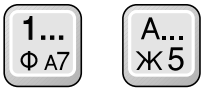
3.2.9 Numbers-only Mode



Numbers-only mode (Ц) can only be used when the Russian print head is present. Furthermore, when this mode is selected the NumLock (10 ↔ 30) switch at the bottom left of the machine should be set to **10**. In this mode, only the (coloured) number keys can be used and all other keys are blocked. In all other cases, this switch should be set to **30**. *Numbers-only* mode is used for ciphering pre-coded numerical messages.

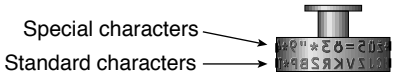
3.2.10 Mixed Mode

In *letters-only* mode (Б) the machine is compatible with the older M-125. In order to allow numbers, letters and punctuation marks to be used simultaneously, the complex *mixed* mode (C) has been added. As we've only got 30 keys on the keyboard, two keys are given up in favour of the *Letter-shift* and *Number-shift*, similar to a standard teletype machine. Press the *number* key **1...** to use the top half of the key top and press the *alpha* key **A...** to use the lower half.

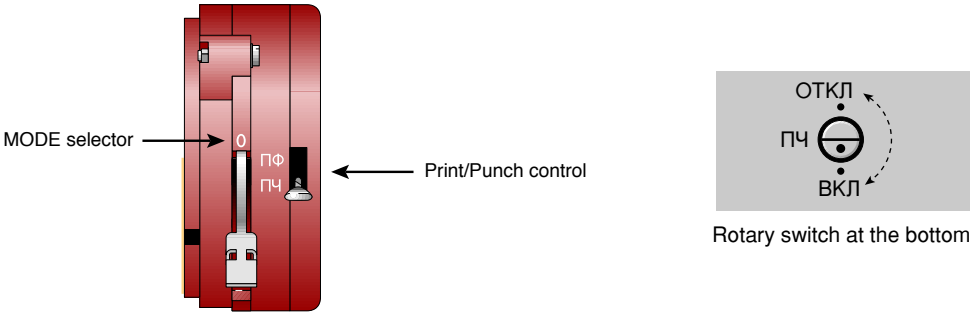


3.2.11 Testing the print head movement in Mixed Mode (C)

The print head contains two rows of characters. The lower row is used for the standard characters. These characters are more or less the same for all versions of the Fialka. All other characters (numbers, punctuation marks, special characters) are on the upper half. These characters are language dependant and will differ between the various Fialka versions. In *mixed* mode (C), the print head is moved up and down as appropriate by the printer mechanism.



Please note that the functionality of the TEXT-MODE switch is also affected by the setting of the MODE selector, the *Print/Punch* control and the rotary switch at the bottom of the machine. More information is available in chapter 3.4. The printer and the print head can be tested by setting up the machine as follows:



Set the MODE selector to '**О**' (Plaintext) and the Print/Punch control switch to '**ПЧ**' (Printing). Ensure the rotary switch at the bottom is set to **ВКЛ** (ON). If this switch is in the ОТКЛ (OFF) position, the printer won't work when the Print/Punch control is set to 'ПЧ'. Use a suitable screwdriver to change this setting if necessary. The black dot indicates the current setting and the switch can only be rotated in the direction of the arrow.

Press **A...** and type some text. You'll see that the print head is raised and that the lower half of the head is used to plot text onto the paper tape. Now press **1...** and type some more. If all goes well, the print head should be lowered, so that the upper half of the print head is used. Press **A...** again to revert to standard mode.

3.3 Wheels

3.3.1 Introduction

A Fialka machine uses 10 coding wheels which are mounted onto a spindle. Stories have circulated that the Fialka was sometimes used with 8 wheels and a spacer disc, but this is believed to be untrue. Some machines were supplied with a thick bakelite disc with spring-loaded contacts, but this is a test-reflector, rather than a spacer disc.

Each machine needs a *set* of 10 unique wheels labelled with the first 10 letters of the Cyrillic alphabet (Russian):

А Б В Г Д Е Ж З И К

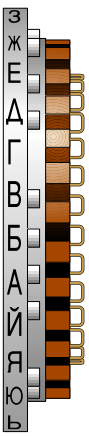
Alternatively (e.g. in English correspondence) you may use numbers and (Latin) letters to identify the wheels. The Latin letters have been choosen to resemble the Cyrillic letters somewhat. If you choose to do so, we suggest the following conversion:

1(A) 2(b) 3(B) 4(r) 5(D) 6(E) 7(X) 8(3) 9(N) 10(K)

Each wheel has 30 contacts on either side connected in some scrambled manner. The wheel therefore has 30 positions in which it can be rotated. Each position of the wheel is identified by one of the letters of the Russian alphabet, in the following order:

А	Б	В	Г	Д	Е	Ж	З	И	К	Л	М	Н	О	П	Р	С	Т	У	Ф	Х	Ц	Ч	Ш	Щ	Ы	Ь	Ю	Я	Й
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

Again, numbers may be used in publications when it's difficult to produce Cyrillic characters, e.g. А[1], Б[2], В[3], etc. Please note that this sequence doesn't strictly follow the sequence of the Russian alphabet (➔ Chapter 1.3). Furthermore it is in no way related to the sequence of the letters on the keyboard. It should only be treated as the sequence of the contacts on the wheels and various other parts inside the machine (e.g. the card reader, the diode matrix, etc.).



Each wheel also has a number of a*dvance blocking pins* on its perimeter. Again, there are 30 possible positions for a *blocking pin* on each wheel. Each possible pin location is lined up with one of the letters on the outer rim. The presence or absence of a pin, controls the stepping mechanism of the Fialka's drum. In this mechanism, adjacent wheels move in the opposite direction. Likewise, the pins control the movement of the alternate wheels (e.g. wheel 2 controls the stepping of wheel 4, etc.).

If a pin is absent on, say, wheel 2, wheel 4 will also move when a key is pressed. The presence of a pin however, will prevent that wheel (wheel 4 in this case) from moving. For this reason they are called *advance blocking pins*, or just *pins* for short. Also note that when a letter, say 'A', is visible above the ruler, the active blocking pin location is a number of positions further on the wheel; at the bottom of the drum. It is this position that is sensed by the stepping mechanism below the drum.

More information on wheel stepping further down this chapter (➔ Wheel stepping).

Wheels can be found in many different flavours, depending on their country of origin, manufacturing date, etc. So far, we've seen the following variations:

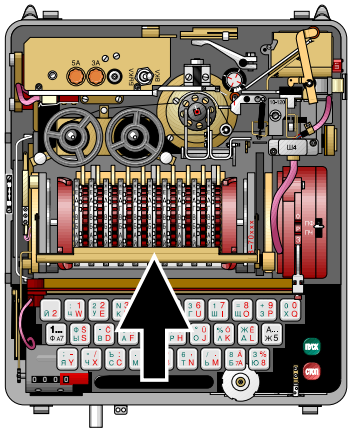
- Non-metal parts: black or brown,
- Fixed or adjustable wheels,
- Black or red letters on the outer rim
- One letter in the alternative colour to identify the wheel (adjustable wheels only),
- Differences in wheel wiring –here called *series*– (depending on country or army of origin).

Each of these differences will be discussed further in this chapter.

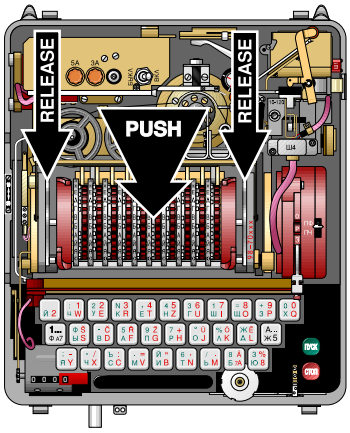
3.2.2 Removing the wheels

The wheels can be removed as follows:

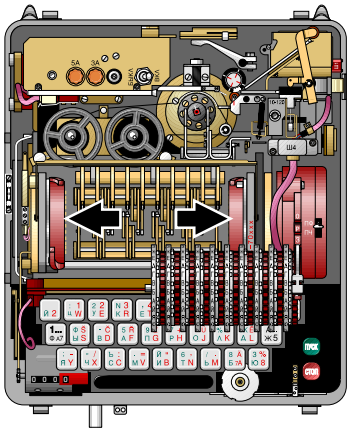
1 Open the *lid* (or remove the cover of the Fialka).
2 Raise the *ruler*.
3 Push the wheels firmly downwards and release the two *levers* that hold the drum.
4 Keep pressing down the drum and push the two static discs aside; then gently release the pressure on the drum.
5 Remove the drum from the machine.
6 Remove the *retaining clip* at the right end of the spindle. (You may use a screwdriver to do this, but be careful not to damage the spring-loaded contacts. In most cases the *retaining clip* can be removed easily).
7 Remove the wheels from the spindle and place them on the table in front of you.



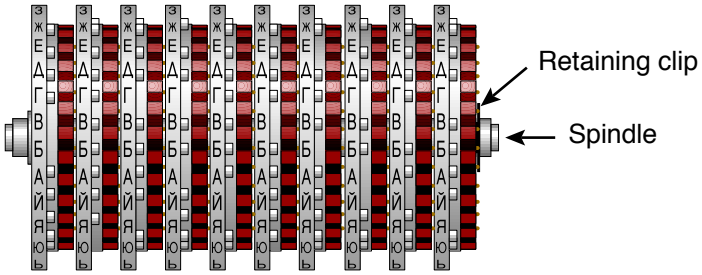
2. Raise the ruler



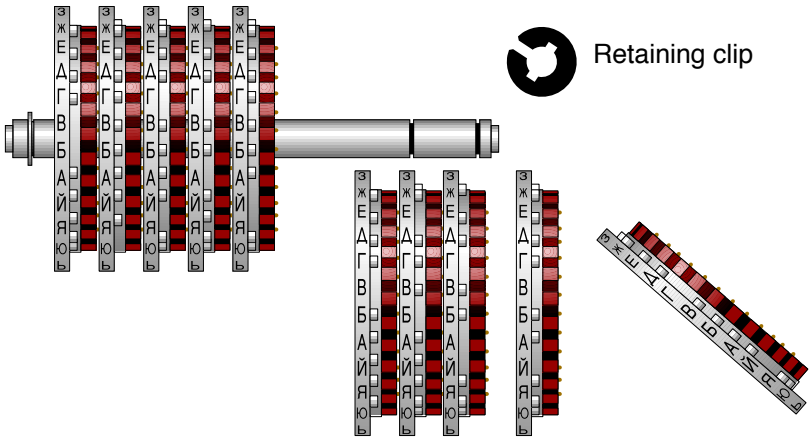
3. Press down and release levers



4. Move static discs aside
5. Remove the drum



6. Remove the retaining clip



7. Remove the wheels from the spindle

3.3.3 Fixed versus Adjustable wheels

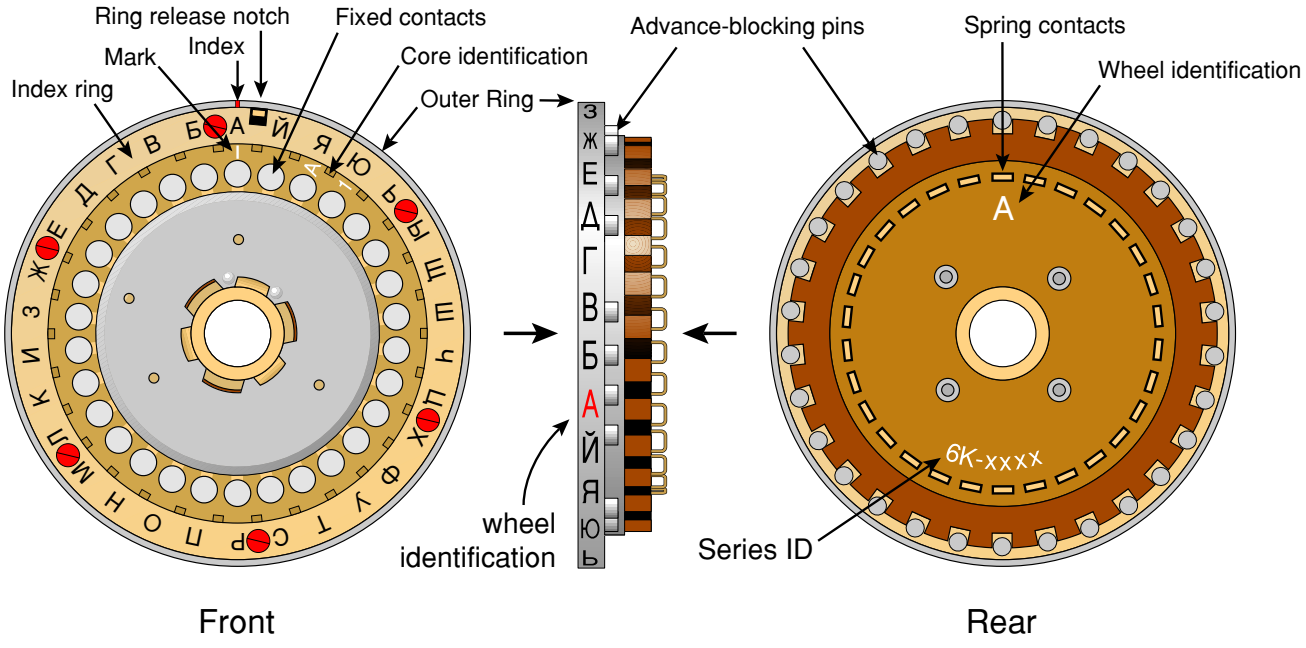
In recent founds, two different types of wheel have been identified: *fixed* and *adjustable*. Initially the Fialka was issued with a set of 10 *fixed* wheels. Each wheel has 30 contacts on either side and a varying number of so-called *advance blocking pins* on its perimeter, to prevent other wheels from moving when *that* wheel is stepped. When setting the Fialka to the daily key, the operator could adjust the following:

- Wheel order (Enigma: *Walzenlage*),
- Initial wheel setting (Enigma: *Grundstellung*, German Fialka manual: *Wartungsschlüssel*).

In 1978, the standard *fixed* wheels were replaced by the so-called PROTON-2 set. This is a set of 10 unique *adjustable* wheels. In its **basic** setting, each *adjustable* wheel behaves exactly like its *fixed* counterpart. E.g. the *adjustable* wheel **A** in its **basic** setting, behaves exactly like the *fixed* wheel **A**. *Adjustable* wheels have the following extra settings:

- Ring-setting (30 positions. Enigma: *Ringstellung*),
- Core-mixing (the core of one wheel can be put into another wheel),
- Core-orientation (i.e. which side of the inner core is visible).
- Core-setting (30 possible positions)

The ring-setting moves the *blocking pins* relative to the outer ring, whereas the core-setting moves the *wiring* relative to the rest of the wheel. This works in the same way as the *Ringstellung* on an Enigma machine, except for the fact that a Fialka wheel generally has much move turn-over pins, causing the wheels to step more frequently. Besides, the pins are used to **prevent** the next wheel from moving, whereas a *notch* on an Enigma wheel **causes** the next wheel to step. In the adjustable wheels, the wiring is in fact a removable core which can be inserted into any of the other wheels, in two basic orientations: side 1 (default) and side 2.

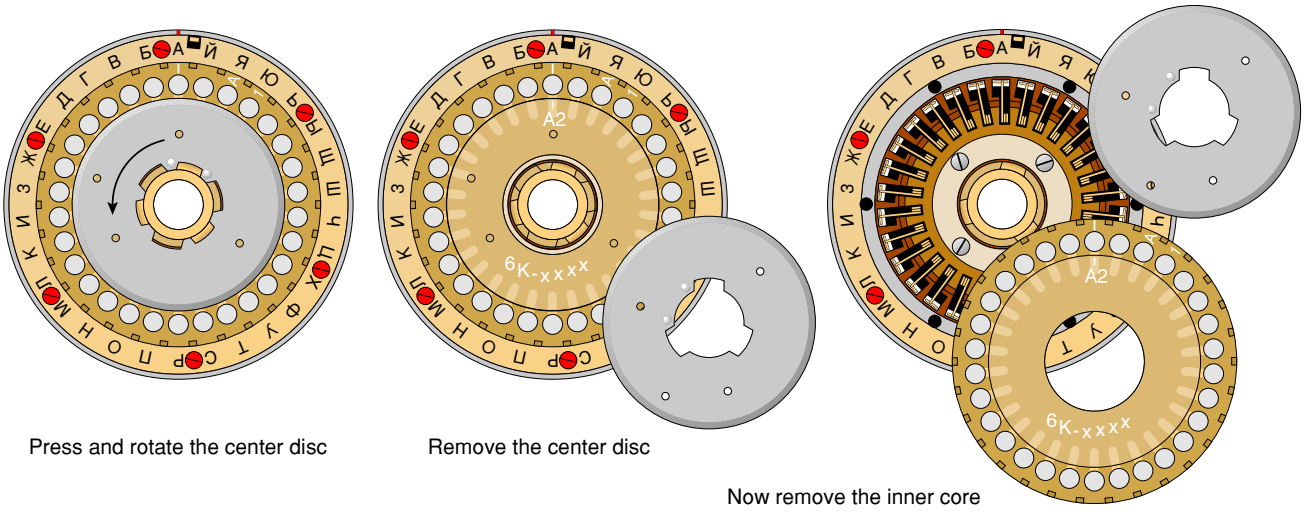


Adjustable wheel seen from the front, side and rear

The drawing above shows a typical *adjustable* wheel. The front side consists of 30 circular fixed contacts. They are connected in a scrambled manner to the 30 spring-contacts at the rear. The front of the wheel shows the ring which can be set to any of thirty positions by removing the core and pushing the notch downwards. The letters on the outer rim are used to set the start position of the daily key. The rear of the wheel shows the identification letter ('A' in the example above) and the serial number. The first part of this serial number is important, as it identifies the wheel series ('6K' in the example). The removable core is also marked with an identification letter, which is visible without removing it.

3.3.4 Disassembling an adjustable wheel

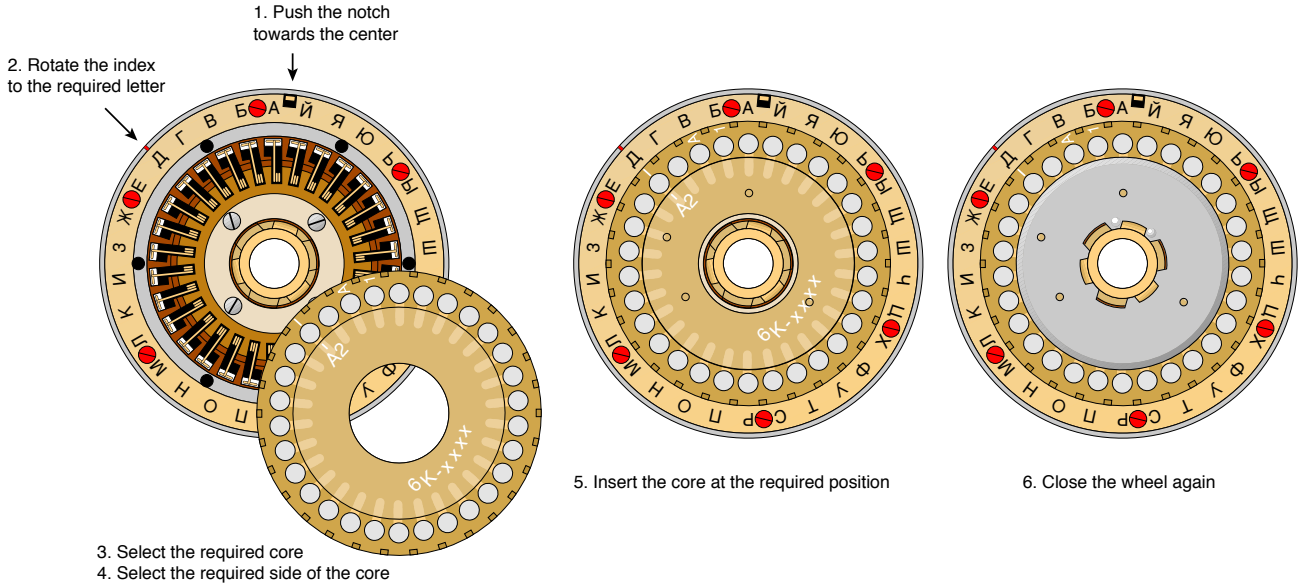
The adjustable wheels can be configured in a number of ways. Before any of the settings can be altered however, the wheel has to be disassembled as follows:



Each core carries an identification letter (the letter A in the example above) and belongs to the wheel with the same letter. It can however be inserted into another wheel, subject to the operating procedure and the actual codebook. A core has two sides, marked with '1' and '2' respectively. It can be inserted into a wheel in one of two ways: with side '1' visible, or with side '2' visible. Again, this is subject to the information in the codebook. When inserting the core, the index mark of the core (a small white line) has to line up with one of the letters of the index ring. When set to 'A', the core is in its base position.

3.3.5 Ring-setting and core-selection (adjustable wheel only)

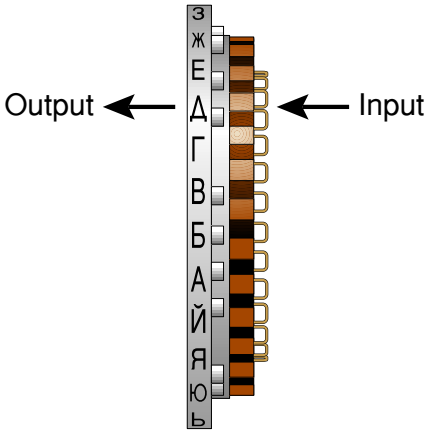
Once the core has been removed, you can adjust the ring. Use a sharp object (e.g. a screwdriver) to push the notch towards the center of the wheel, then rotate the outer ring so that the *index mark* lines up with the required letter on the index ring (the inner ring). Then re-insert the core and verify that the *index* on the core lines up with the required letter on the index ring (subject to codebook procedures). When both the outer ring and the core are set to 'A', the wheel is in its bas position.

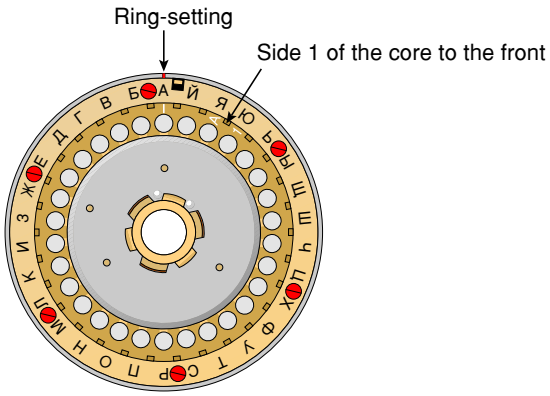


3.3.6 Wheel wiring

A complete machine uses a *set* of 10 unique discs, as described in the first paragraph of this chapter. However, different *series* of wheels have been found, each which a unique scheme for *wheel wiring* and a*dvance blocking pin* positions. The series can be identified from the serial number that is present on each wheel and on each core. So far, two different series have been identified and measured: **3K** and **6K**. Different series may have been used in different countries or by different army units. It is known that 4K wheels were in use in the former DDR and 1K is Russia, but to date the wiring hasn't been recovered. The 0K prefix was reserved for a universal wheel set that would be issued to all countries of the Warsaw Pact in the event of war.

The tables on the next page show the wiring information of the known series of wheels. The locations of the *advance blocking pins* are marked with a red square. Note that a red square marks the presence of a pin adjacent to the letter on outer rim of the wheel (ensure the ring-setting is at the letter A). The actual pin that affects the stepping mechanism is at position 18 or 21 (i.e. 17 or 20 positions further on the wheel) depending on the direction in which the wheel is rotated. See the next paragraph for further information on wheel stepping.





The tables define the *output* contact number that is wired to each of the 30 *input* contacts of all 10 wheels. The *input* contacts themselves are listed on the top row of each table. Both the *contact number* and its Cyrillic equivalent are given. The *input* is defined as the contact on the right side of the wheel when mounted in a Fialka. The *output* is therefore on the left. *Output* contact numbers can be converted back to Cyrillic letters, by using the table below.

А	Б	В	Г	Д	Е	Ж	З	И	К	Л	М	Н	О	П	Р	С	Т	У	Ф	Х	Ц	Ч	Ш	Щ	Ы	Ь	Ю	Я	Й
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

Important note

When using the *adjustable* wheels in combination with the following tables, please note that you have to set them to their **base position**. This means that the ring-setting should be at '**A**' and the *core* has to be inserted in such a way that side '**1**' is visible from the front of the wheel. Both the index mark on the core and the index mark on the wheel have to be lined up with the letter 'A' on the index ring (i.e. the inner ring). In the *base setting*, the *adjustable* wheel behaves exactly like the *fixed* wheel with the same identification letter from the same series.



The 3K wheels that have surfaced so far, all come from Poland, whilst the 6K wheels were discovered in the former Czechoslovakia. It would be interesting to know whether the same sets have been used in other countries, or whether other series exist. If you have any information about wheel wiring, series of wheels and/or their usage, please contact the authors, so that it can be included in a future release of this manual.

Advance Blocking Pin location

3K SERIES

Wheel		Contact																												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
		А	Б	В	Г	Д	Е	Ж	З	И	К	Л	М	Н	О	П	Р	С	Т	У	Ф	Х	Ц	Ч	Ш	Щ	Ы	Ь	Ю	Я	Й
1	А	23	22	3	7	4	8	16	6	10	20	15	17	24	9	30	12	25	11	1	28	27	5	29	26	2	18	21	14	13	19
2	Б	3	24	20	2	6	21	26	7	18	4	17	23	15	19	10	30	13	28	29	11	9	25	1	14	22	8	27	5	12	16
3	В	20	5	7	15	21	27	4	1	22	17	23	13	30	6	26	10	16	14	19	18	29	24	3	12	9	11	2	28	8	25
4	Г	16	21	28	11	27	3	15	12	24	30	9	17	4	20	25	8	1	29	19	18	14	10	5	23	26	7	6	22	2	13
5	Д	18	15	1	22	19	16	29	8	17	4	3	14	6	30	23	5	26	13	25	10	12	21	27	20	7	11	24	9	2	28
6	Е	9	14	13	20	24	8	2	6	5	19	11	28	30	3	18	15	7	25	16	1	12	23	27	29	17	10	21	4	22	26
7	Ж	7	9	5	26	6	4	19	3	8	28	22	12	21	24	23	10	13	1	16	29	2	25	27	15	18	11	14	17	30	20
8	З	29	27	15	13	8	2	25	12	6	23	9	18	24	1	14	21	17	10	3	11	22	7	16	4	19	26	5	30	28	20
9	И	5	19	2	27	20	26	7	11	16	18	3	13	4	23	28	21	6	24	29	30	15	17	9	12	8	22	25	10	1	14
10	К	20	24	8	25	19	1	17	5	15	27	9	12	22	10	18	3	16	30	4	14	7	23	11	2	29	26	28	21	6	13

Wheel wiring for the 3K series (Poland) - Data from Tom Perera [4]

5K SERIES

Wheel		Contact																												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
		А	Б	В	Г	Д	Е	Ж	З	И	К	Л	М	Н	О	П	Р	С	Т	У	Ф	Х	Ц	Ч	Ш	Щ	Ы	Ь	Ю	Я	Й
1	А	13	11	10	15	1	20	24	2	4	9	27	17	26	3	12	8	5	16	19	22	23	28	14	25	18	6	30	29	7	21
2	Б	6	19	22	1	21	13	28	26	30	10	9	7	12	23	17	24	25	8	20	16	4	2	15	5	18	29	3	27	11	14
3	В	25	15	28	7	19	18	14	10	24	6	16	9	4	20	3	27	22	5	8	29	1	12	21	23	17	26	13	2	30	11
4	Г	23	3	24	13	4	26	18	15	11	6	29	22	25	7	9	21	20	2	14	17	19	30	8	10	12	1	16	28	5	27
5	Д	16	22	9	2	6	5	1	12	4	17	14	21	18	15	28	27	8	11	29	3	25	10	19	26	23	13	24	20	7	30
6	Е	10	6	8	20	23	27	26	4	29	18	17	21	24	11	14	28	1	5	13	12	22	3	16	19	7	9	25	30	2	15
7	Ж	21	30	26	3	16	28	20	9	25	1	7	17	10	6	27	23	12	2	22	24	14	11	8	4	19	5	13	15	29	18
8	З	24	17	11	20	30	29	19	10	7	21	6	18	2	1	5	13	27	12	15	25	4	23	14	28	9	3	26	16	8	22
9	И	17	9	2	4	20	27	16	10	21	7	15	29	26	25	18	14	11	30	22	12	28	23	13	8	1	6	5	3	24	19
10	К	2	12	5	8	13	29	10	19	25	24	16	7	22	27	36	28	30	6	4	9	11	18	17	23	1	3	14	20	15	21

Wheel wiring for the 5K series (Hungary)

6K SERIES

Wheel		Contact																												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
		А	Б	В	Г	Д	Е	Ж	З	И	К	Л	М	Н	О	П	Р	С	Т	У	Ф	Х	Ц	Ч	Ш	Щ	Ы	Ь	Ю	Я	Й
1	А	13	22	8	18	20	12	28	4	15	27	3	5	16	14	23	26	1	25	17	11	30	10	24	7	6	21	29	2	9	19
2	Б	20	8	5	15	4	28	21	1	24	13	29	12	14	23	25	7	9	30	27	3	11	18	17	19	22	10	2	26	6	16
3	В	29	11	4	22	24	16	18	2	23	3	17	8	20	5	28	12	15	26	30	7	21	19	13	10	27	25	9	1	14	6
4	Г	4	12	19	29	24	23	7	30	15	1	20	14	18	2	16	27	10	25	17	28	6	21	11	8	22	5	9	3	26	13
5	Д	18	2	15	7	20	28	8	13	23	12	19	27	4	24	10	14	11	6	30	3	17	26	22	1	29	25	16	21	5	9
6	Е	16	4	14	24	23	19	30	3	1	8	27	13	9	5	29	10	15	26	22	7	25	17	20	11	2	6	21	28	18	12
7	Ж	26	23	7	5	13	8	24	30	29	20	22	9	12	10	25	16	3	21	19	18	4	1	28	27	6	2	15	17	11	14
8	З	16	22	14	30	24	15	17	20	4	7	27	12	6	13	25	21	1	5	26	8	11	23	29	28	3	18	10	19	2	9
9	И	12	1	17	29	6	4	7	11	15	3	21	25	9	26	30	13	22	20	10	24	27	14	28	23	2	5	19	18	16	8
10	К	9	21	8	16	25	5	20	22	4	27	14	19	1	15	30	2	10	17	7	24	12	18	29	3	23	6	13	28	26	11

Wheel wiring for the 6K series (Czechoslovakia)

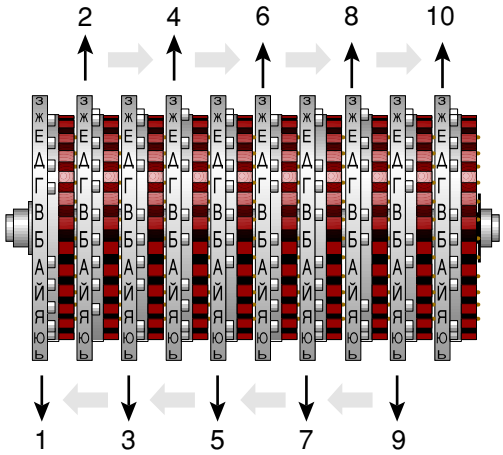
3.3.8 Wheel stepping

With each letter typed on the keyboard, the wheels inside the Fialka (i.e. the drum) are placed in a new position, which results in a new wiring maze for each new letter. This principle is similar to the operation of the Enigma machine, but there are some important differences. First of all, wheel-stepping takes place **after** the letter is encyphered.

On the Enigma, the rightmost wheel steps with every key-press. It is therefore called the *fast wheel*. Whenever the rightmost wheel has made a full revolution, it moves the wheel to the left of it by one step. Once this second wheel has made a full revolution, it moves the next wheel, which is often called the *slow wheel*, as it hardly ever steps during the encipherment of a message. This was one of the weaknesses of the Enigma. During the course of WWII, other wheels were introduced, that had two positions where they would move the wheel next to it. This would lead to a more frequent stepping of the *slower* wheels.

The Abwehr Enigma (often called the Enigma G) used three wheels, with 11, 15 and 17 turn-over positions respectively. This resulted in a very complex scheme of wheel movements, making it far more difficult to penetrate. In certain positions, a key press would cause three –or even all four– wheels to step. Each Enigma wheel contained a *notch* at the position where it would cause the next wheel to step. This is sometimes referred to as the *turn-over notch*.

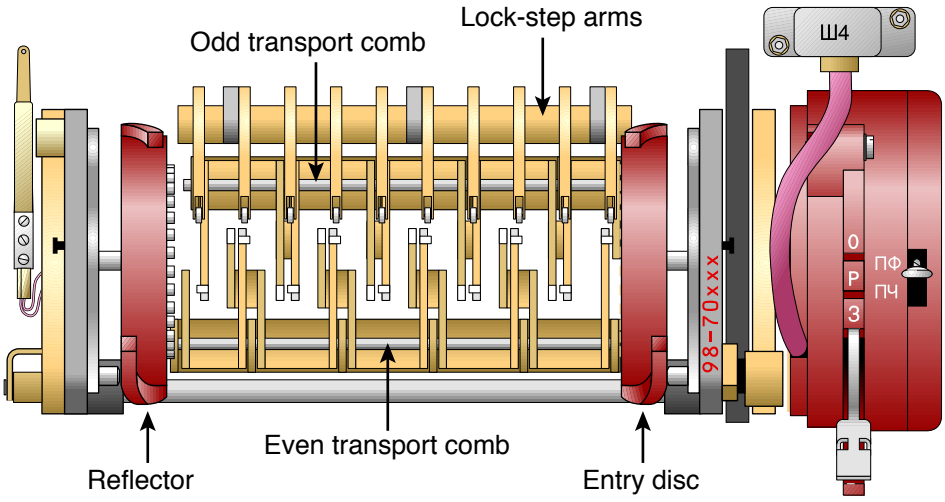
Wheel stepping on the Fialka is completely different. First of all a wheel can never affect the movement of the wheel next to it. Instead it is connected to the wheel next to its neightbour. We've called this *alternate stepping*. Secondly, adjacent wheels move in the opposite direction. If one wheel moves clockwise, the wheel next to it will move anti-clockwise, etc. Unlike the Enigma, all wheels on the Fialka will move with each key press, unless there is an *advance blocking pin* present at a certain position on a wheel. To explain this further, we will number the wheels of the drum, and the direction in which they are rotated (seen from the top of the Fialka), as follows:



In fact there are two independant wheel movements; the even wheels move independantly from the odd ones. The even wheels (2, 4, 6, 8 and 10) move away from the keyboard when viewed from the top, whilst wheel 2 is the fast one. It will move with each key-press and it will drive wheel 4, which will in turn drives wheel 6, etc. If an *advance blocking pin* is present in a certain location on a wheel, all wheels to the right of it, will not be stepped.

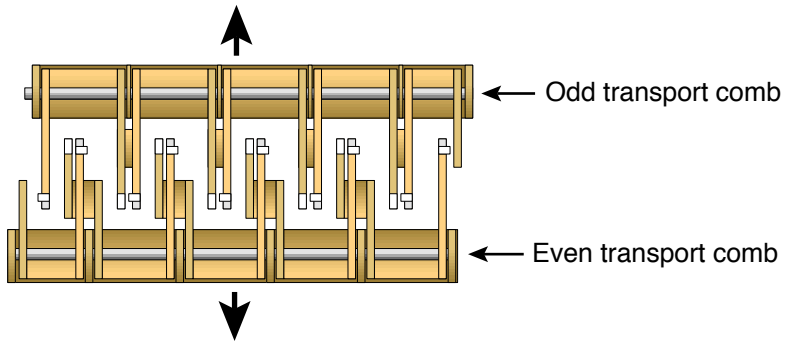
The odd wheels (1, 3, 5, 7 and 9) move towards the keyboard when viewed from the top. They are driven from the right, so in this case, wheel 9 is the fast wheel. It drives wheel 7, which in turn drives wheel 5, etc. until finally wheel 1 is driven. Again, the presence of an *advance blocking pin* prevents all wheels to the left of that wheel from stepping.

In order to understand the sequence of the Fialka's wheel-stepping, we need to take a close look at the mechanism underneath the drum, in between the *entry disc* and the *reflector*. When we remove the drum, a complex mechanism of wheels, arms and metal 'fingers' is exposed. Although this looks very complex at first sight, it is in fact very simple and clever. The image on the next page shows the various components. The drawing shows the mechanism when seen from the top of the machine. The *reflector* is on the left, whilst the *entry disc* is on the right. On the top we find an axle with 10 spring-loaded arms. At the end of each arm is a small wheel that locks a wheel in each of its 30 steps.



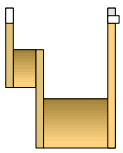
Wheel stepping mechanism

These lock-step arms are completely independant. They are not connected to any other part of the mechanism. Below the lock-step arms are two *transport combs*, each containing a number of 'fingers' The upper comb is responsible for the movement of the *odd* wheels (1, 3, 5, 7 and 9), and is therefore called the *odd transport comb*. Likewise, the lower comb is called the *even transport comb*, as it is responsible for the movement of the *even* wheels (2, 4, 6, 8 and 10). If we 'remove' the lock-step arms from the drawing above, we'll see a series of similar 'fingers':



Even and odd transport combs

When the Fialka is operated, the two combs are moved –independantly– away from each other (in the direction of the fat arrows). Each comb consists of a series of similar *arm segments*, mounted together on a thin axle. If we take a closer look at a single arm segment from the *even* transport comb, we'll see that it is in fact a three-dimensional component that is cleverly intertwined with the others.

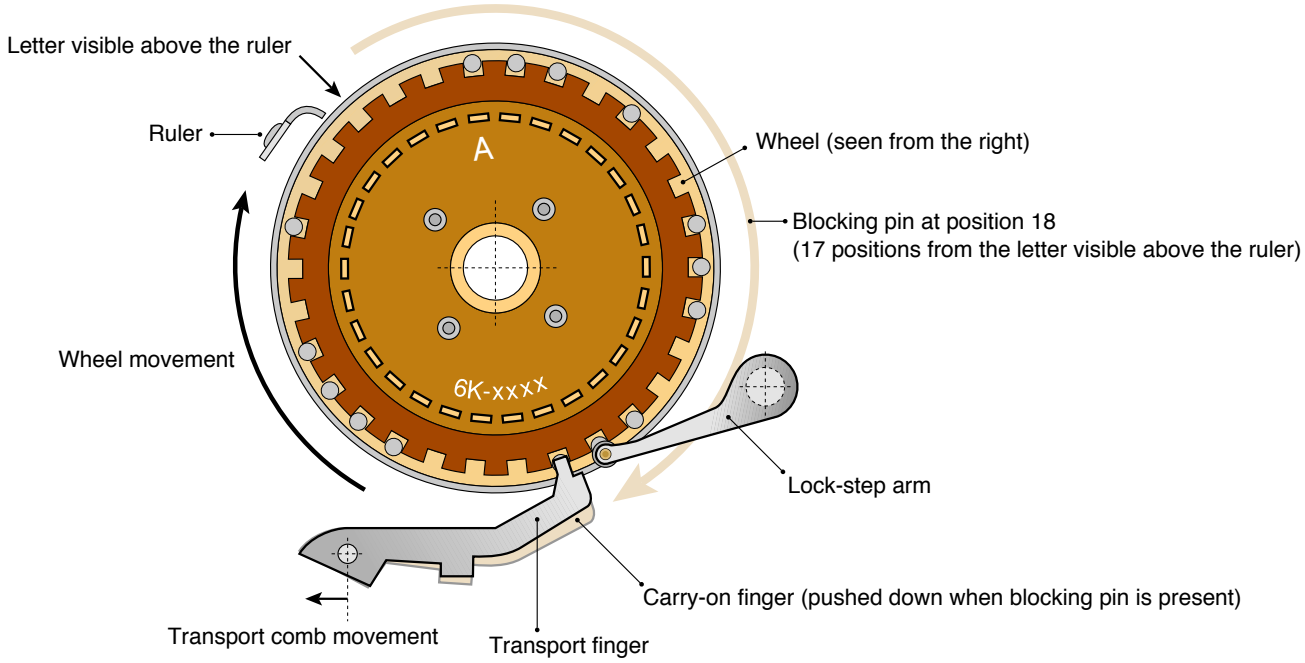


Single arm segment from the even transport comb

An arm segment consists of two arms, each with a finger at the end. The rightmost finger is designed to fit in one of the 30 gaps of the bakelite part of each wheel. The leftmost finger is the one that senses the presence of an *advance blocking pin* on the wheel two positions to the left. The rightmost finger is the one that actually moves the wheel if no *advance blocking pin* was present. If such a pin *was* present however, the arm would have been pushed down by the pin, and the rightmost arm would not be able to move the wheel. Consequently, the wheel would not be able to move the next even wheel to the right of it, etc.

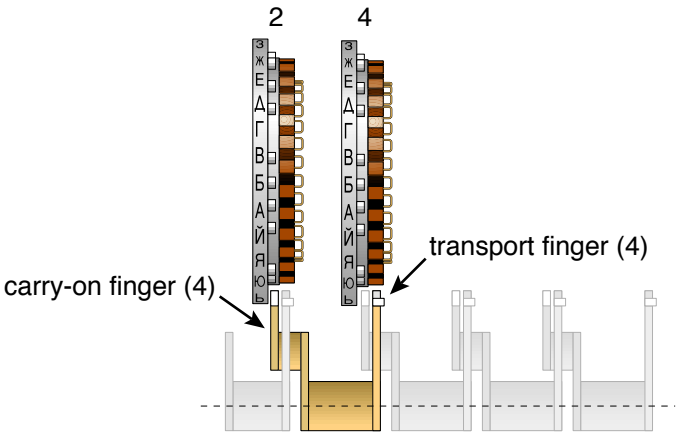
Stepping of the even wheels

To illustrate this further, we'll take a look at a cross-section of the *fast* wheel of the *even* row, i.e. wheel 2. In this cross-section, we are looking at the wheel from the right (i.e. from the entry disc). In the diagram below, we can clearly identify the bakelite part of the wheel, with the 30 gaps. At the bottom right is the lock-step arm that allows the wheel to be locked in any of its 30 positions. At the top left is the ruler that is used to set the start position of each wheel.



Cross-section of wheel 2

When a key is pressed, the two transport combs are moved away from each other and back. For the *even* transport comb (the one closest to the keyboard) this means that it will move to the left in the diagram above. When doing so, the *transport finger* engages one of the gaps of the wheel and pulls the wheel towards the front of the machine. As a result, the wheel will move clockwise (when viewed from the entry disc).

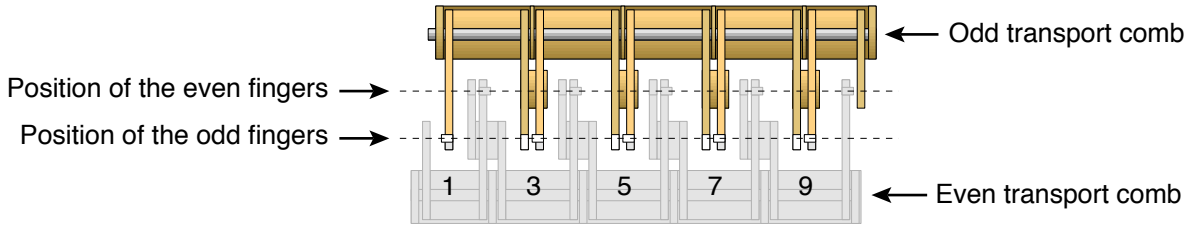


Carry-on from wheel 2 to wheel 4

Slightly to the left of the transport finger of wheel 2 is the carry-on finger of wheel 4. If an *advance blocking pin* is present at position 18 (i.e. 17 positions further clockwise from the letter that is visible just above the ruler), the carry-on finger will be pushed down (as shown in the cross-section), which effectively removes the transport finger from wheel 4. When the transport finger of wheel 4 is pushed down, it also pushes down the carry-on finger of wheel 6, etc. So, effectively, it inhibits the rotation of all *even* wheels to the right of it.

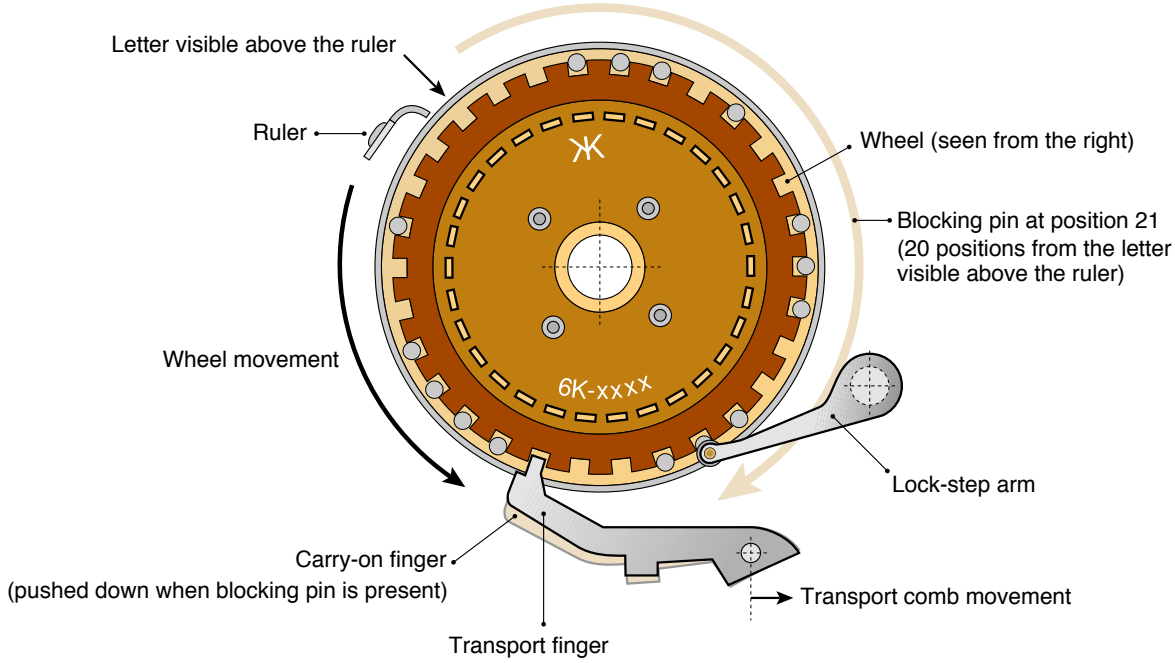
Stepping of the odd wheels

The mechanism for the *odd* wheels is similar, but there are a number of important differences. First of all, the entire transport comb is mounted upside down. As a result, all movements are mirrored when compared to the *even* comb. This also means that the odd wheels are driven from the right. In other words: wheel 9 is the *fast* wheel.



Position of the odd transport fingers

However, there is another important difference: the *carry-on fingers*, and hence the *transport fingers*, of the *odd* wheels are not at the same position as for the *even* wheels. They are 3 gaps further on the wheel than for the *even* wheels, which means that sensing of the *advance blocking pin* for the *odd* wheel takes place at position 21 (i.e. 20 positions further clockwise from the letter above the ruler).

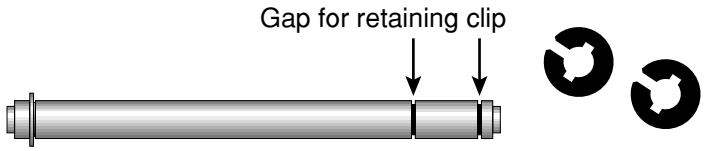


Cross-section of wheel 9

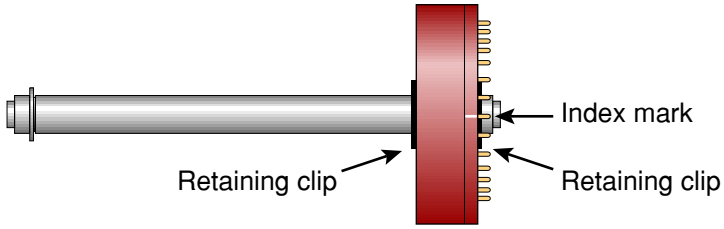
As the transport comb is moved to the right in the drawing above, the wheel will be pulled towards the back of the machine. As a result, the wheel will be moved anti-clockwise (when viewed from the entry disc).

3.3.8 Test reflector

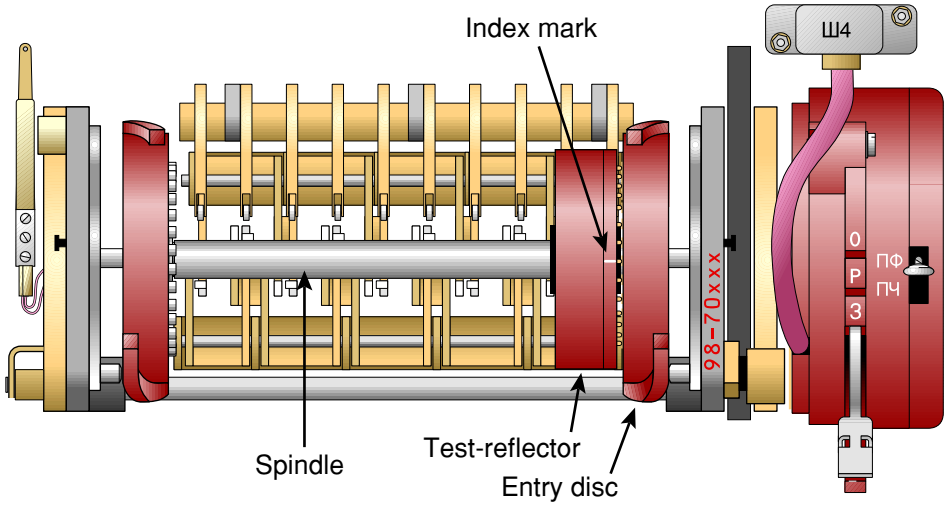
Some machines have been supplied with a thick bakelite disc, with 30 spring-loaded contacts on one side and 15 shorting wires on the other side. This is the so-called *test reflector* that was used to test the operation of the commutator (puch card reader). If the test-reflector is present, it is usually stored inside the dust cover, locked on an axle with a retaining clip. Remove the retaining clip, but be careful not to lose it, as you'll need it later. The spindle (that normally holds the wheels), has two places where a retaining clip can be fitted:



Put one retaining clip in the leftmost gap, then put on the test-reflector with its spring-loaded contacts pointing to the right. Finally fit the other retaining clip to hold the reflector in place.



The spindle can now be placed inside the machine as if it was a complete drum. The spring-loaded contacts of the test-reflecter, should be facing the entry disc (i.e. to the right) and the index mark on the test-reflector should be lined up with the white dot on the entry disc (i.e. centered).



Substitution matrix

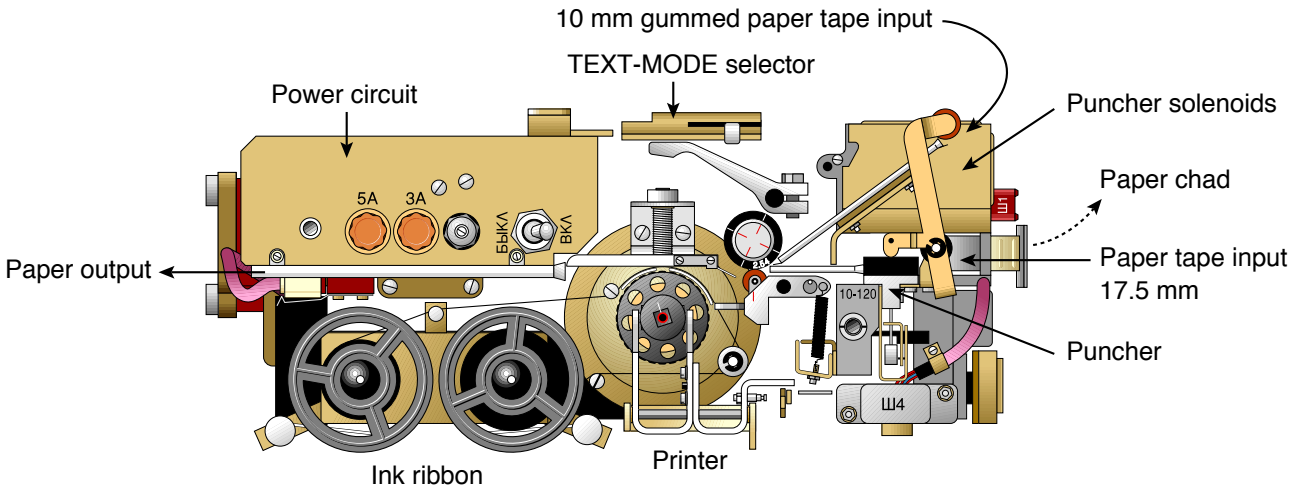
The wires of the test-reflector are connected in adjacent pairs, i.e. contact 1 is connected to 2, 3 is connected to 4, etc. It can be used to test the operation of the card-reader, as both the *drum* and the *reflector* are ignored. The substitution matrix of the test reflector is as follows:

Test-reflector																											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
2	1	4	3	6	5	8	7	10	9	12	11	14	13	16	15	18	17	20	19	22	21	24	23	26	25	28	27	30	29

3.4 Printer & Puncher

3.4.1 Introduction

The Fialka contains an impressive printer mechanism. When the cover is removed, the printer mechanism can be found in the top right corner together with the paper puncher. The printer itself is in the center, to the right of the ink ribbon. The rightmost part of the mechanism is the paper puncher.



The mechanism accepts two types of paper tape:

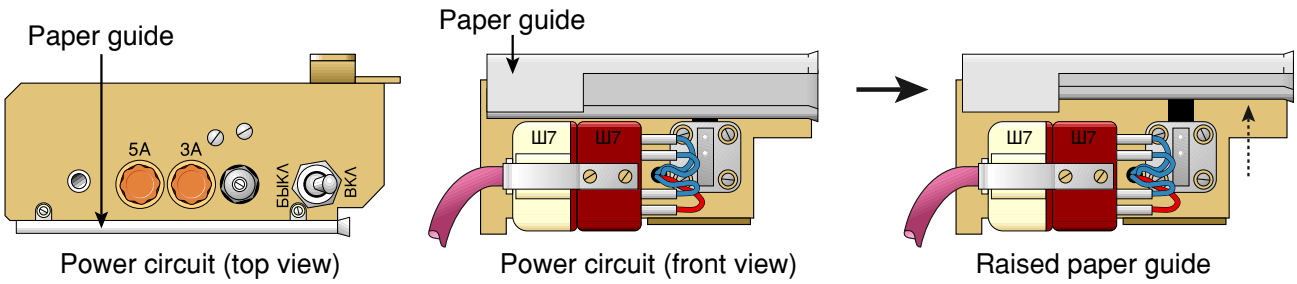
- Standard 17.5 mm punch paper tape, commonly used in teletype machines. This tape is fed in from the right and moves through the puncher, alongside the print head, until it finally comes out on the left. When the puncher is *on*, it will punch a 5-bit code in the tape, which represents the (de)coded character. When the printer is also on, the same character is printed in a readable form, approx. 75 mm to the left of the corresponding 5-bit code.

- 10 mm gummed paper tape, commonly used in telegrams. This tape is fed in from the right/rear corner, through a metal guide, straight to the printer. This way the puncher is bypassed. Printing on 10 mm tape was used for text that had to be glued onto a message form (similar to a telegram). If your 10 mm paper won't fit the entry guide easily, cut of a millimeter or so from the first 10 cm of the tape, using a pair of scissors.



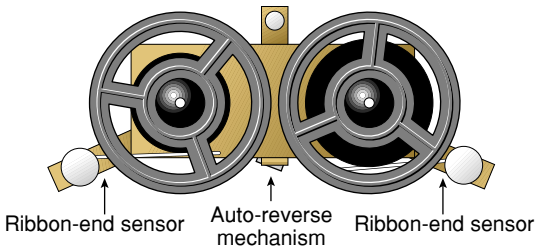
When punching, the paper chad (i.e. the small pieces of paper that are punched-out of the paper tape) is guided through an extendible 'gutter' to the right of the puncher. This is intended for use in combination with a paper chad box (one of the accessories) that can be attached to the right of the machine (M-125-3 only).

When the narrower 10 mm paper tape is used, the paper output guide may be too wide, causing the paper to block. To overcome this, the width of the output guide can be minimised, by pulling up its lower half. You may need to use a dedicated tool to do this. Alternatively you may remove the ink-ribbon and raise the lower part manually.



3.4.2 Ink ribbon auto-reverse

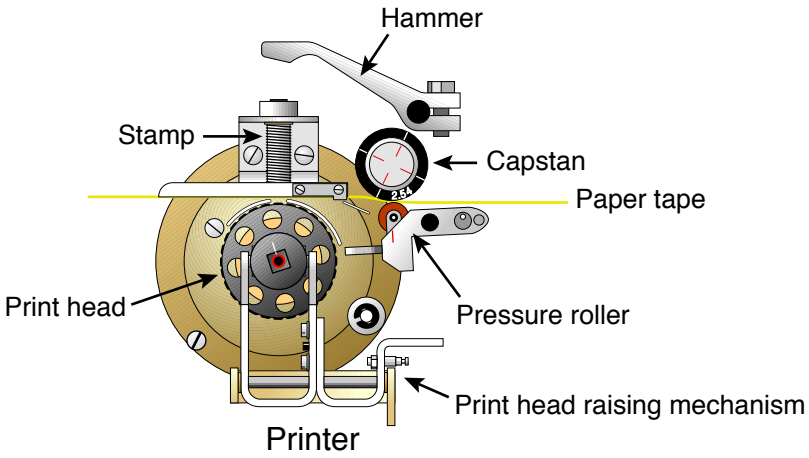
The ink ribbon is guided around the print head and is moved automatically when characters are printed, just like on an old-fashioned typewriter. When the ribbon reaches its end, it is automatically reversed. If a Fialka has been 'demolished' this mechanism might have been damaged and the ribbon transport or the auto-reverse mechanism might be blocked. Refer to Chapter 5 – *Hints & Tips* – for more information.



Ink ribbon assembly

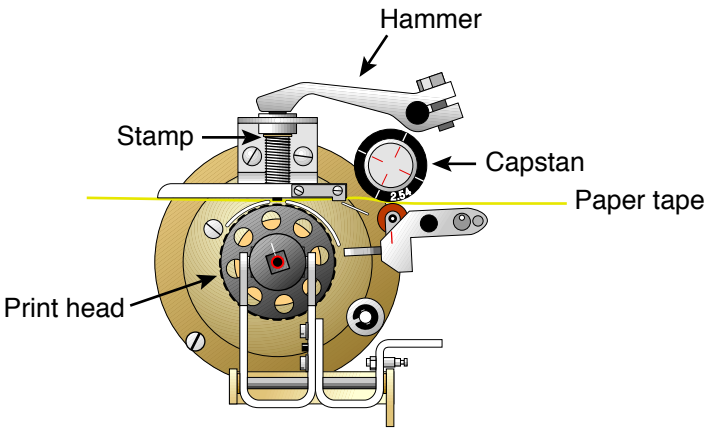
3.4.3 The printer

The printer mechanism is shown in the diagram below. It consists of a fast rotating *print head* that is stopped when the correct letter is facing the *stamp*. The paper tape moves between the print head and the stamp, together with the ink ribbon, and is driven forward by the *capstan* and the *pressure roller*. Please note that one of the 4 lines on the capstan must be aligned with the index mark on the pressure roller prior to typing a message.



Printing mechanism with the hammer released

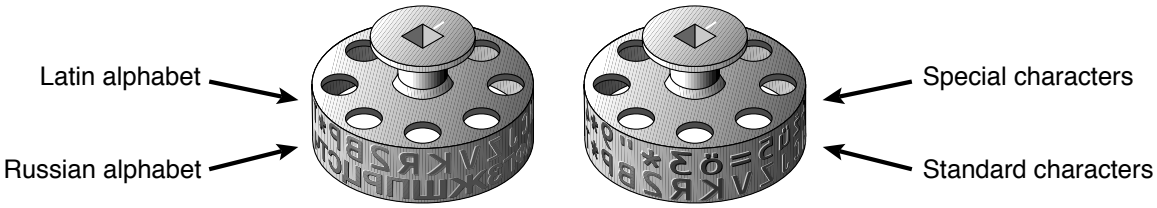
When the print head is stopped (i.e. when the required letter faces the stamp), the *hammer* hits the stamp, which causes the *paper tape* and the *ink ribbon* to be pressed against the head, resulting in the letter to be printed on the paper tape.



Printing mechanism with the hammer engaged

3.4.4 The print head(s)

The M-125 has only one print head, but sometimes a spare one was supplied. The lower half contains the Cyrillic characters (Russian), whilst the Latin characters are on the top half. A mechanical switch close to the print head, marked РУС/ЛАТ, is used to select between the two character sets. When set to РУС the Russian character set is used, whilst ЛАТ selects Latin.



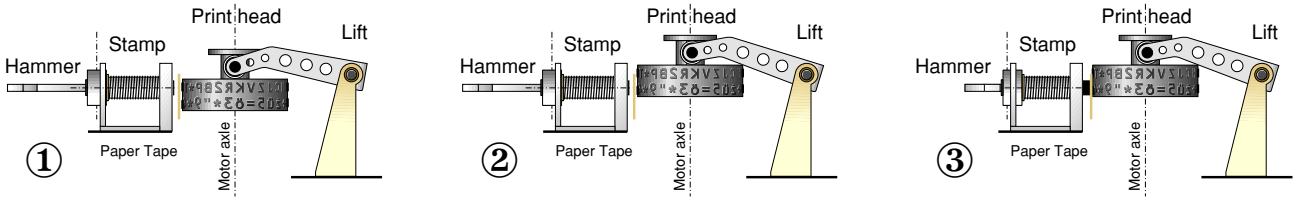
A combined Russian/Latin print head and a country-specific print head side-by-side

The M-125-3 uses a much more complicated system and can be used for other languages as well (e.g. German, Polish and Czech). It also allows the simultanous use of letters, number and punctuation marks. For this reason it uses a dedicated print head for each language. Depending on the country of origin, the Fialka may have been supplied with two (or more) print heads. One print head is used for *Russian*. This head (if supplied) is the same for all country-specific models. The other head is the *country-specific* head, which matches the keyboard layout. It is believed that the country-specific variation is reflected in the model number of the machine.

On the country-specific print head the lower row is used for the standard characters. These characters are more or less the same for all versions of the Fialka. All other characters (numbers, punctuation marks, special characters) are on the upper half. In this mode, the print head is moved up and down by the printer mechanism as appropriate. Please note that the head movement is affected by the setting of various switches and selectors on the machine (➔ Chapter 3.2). The layout of each print head is specified further down this chapter.

3.4.5 The print head lifter

As the print head contains two rows of characters, the printer mechanism may raise or lower the head as appropriate. This is done by the *print head raising mechanism* or *lifter*. The drawings below show how it works. The print head is rotated by a square axle and its vertical position is controlled by a double arm with ball-bearing wheels at the end of each arm. The paper tape (and also the ink ribbon) moves between the print head and the stamp.



The print head lifter in operation

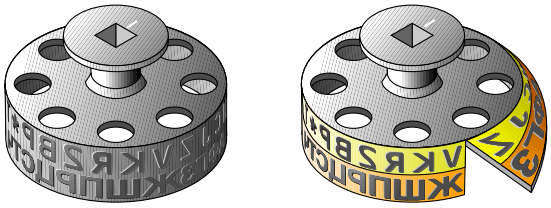
Drawing ① shows the print head in the lower position, whilst drawing ② shows it in the upper position (i.e. raised by the lifter). Drawing ③ finally shows the effect of the hammer when a letter is printed. You can clearly see the stamp coming out of its holder and hitting the tape.



For a correct operation of the Fialka, it's important that the lifter can be moved freely. Check this mechanism carefully as it has been damaged intentionally in many Fialka machines as part of the 'demolition' process when the machines were phased out. The mechanism may be blocked and in some cases one of the two arms of the lifter may have been broken off. Generally, this should not be a problem and in most cases the mechanism can be repaired. Refer to chapter 5.5 – *The Printer Mechanism is damaged* – for tips on repairing it. You should be able to move the print head up and down easily by hand, simply by lifting the arms. If it blocks, or if it binds, it needs attention before proceeding.

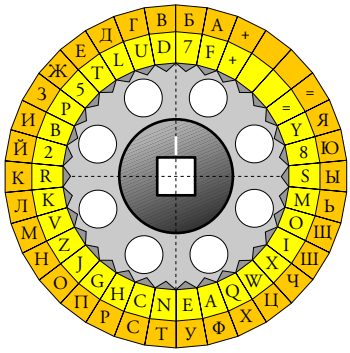
3.4.6 Print head layout of the M-125

Different print heads have been supplied with the various Fialka models. Each print head has one or two rows of characters, with 34 positions each. These are the standard 30 characters, plus some redundancy to allow errors to be detected. The original Fialka machine probably had a Cyrillic-only print head, but the later M-125-xx versions had a combined Cyrillic/Latin print head. A slide switch at the top of the machine was used to selected the appropriate alphabet (РУС ↔ ЛАТ). In the diagrams below, the layout of each known print head is given. For clarity, the print heads have been 'unfolded' in the following manner:

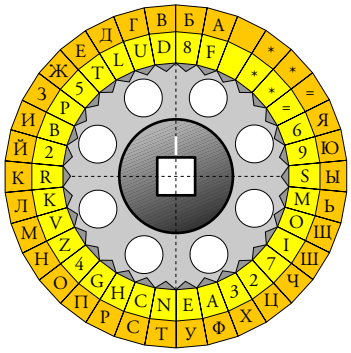


Unfolding the printhead in order to create the 'flattened views' below

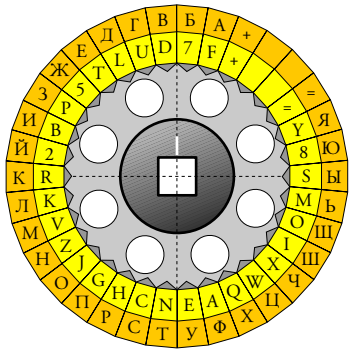
Poland



East Germany (DDR)



Czechoslovakia



Country-specific print heads of the Fialka M-125

3.4.7 Error detection

The ✱ symbol is present at various positions on the print head. In some cases it is present on both the upper and the lower ring of the print head. This symbol will be printed whenever coding has failed, e.g. due to a bad contact between the wheels. In other words: if a letter can't be encoded, the ✱ will be printed instead. If this character appears frequently in the printed output, the Fialka needs to be serviced and contacts should be cleaned.

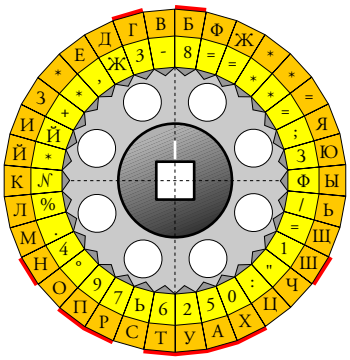
```
A*HJE KLEIA FEKTY SSV*Q VLKHI QP*ZF GPO
```

Another symbol that appears a number of times on the print head is the '='. Again this symbol should not normally appear. However, whenever the print head has been inserted in the wrong orientation (i.e. when the index marks don't line up) the '=' symbol will appear in the output. Should you see this character appearing in the output, turn the Fialka off and re-insert the print head (see the next paragraph for more information).

```
WDRGH Z=POE ==DB VHJWD HTA=C GGQPD JHUV
```

3.4.8 Print head layout of the M-125-3

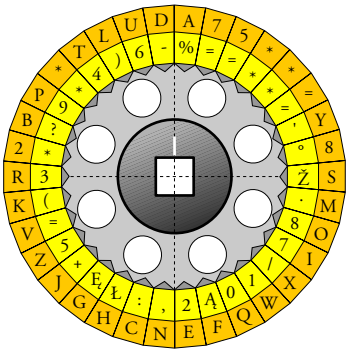
The M-125-3 models were often supplied with two different print heads: one for the Cyrillic alphabet *and* the *numbers-only* mode, and one for the Latin alphabet. The layout of the Cyrillic print head is given below. The outer circle shows the standard Cyrillic alphabet, which is present on the lower row of the print head. The inner circle shows the characters available on the upper ring of the print head. These characters are available in *Number-shift* mode.



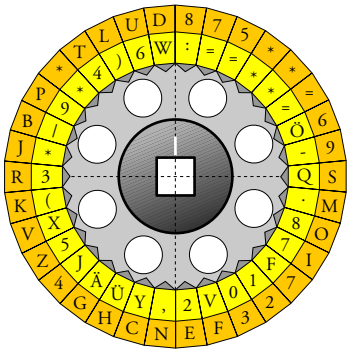
In *numbers-only* mode (i.e. the NumLock switch set to 10) only the numbers on the upper ring (i.e. the inner circle) can be used. These are marked with a *red* line in the drawing above. Please note that the Cyrillic print head **must** be present when using the *numbers-only* mode. Furthermore the *Text-mode* switch should be set to Ц (numbers).

Each language-variant of the Fialka M-125-3, not only has a unique keyboard layout, but also requires a matching print head. A language-specific print head contains two rows of characters. The lower row contains the standard Latin character set, whilst the upper row contains the language-specific character set. The drawings below show the order of the characters for each known print head. The language-specific characters (i.e. the upper row) are displayed in the inner circle.

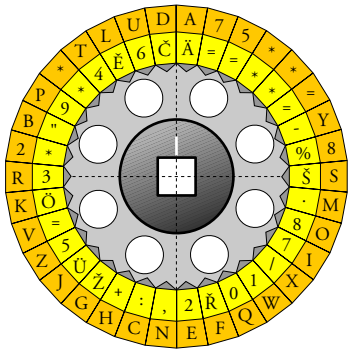
Poland



East Germany (DDR)



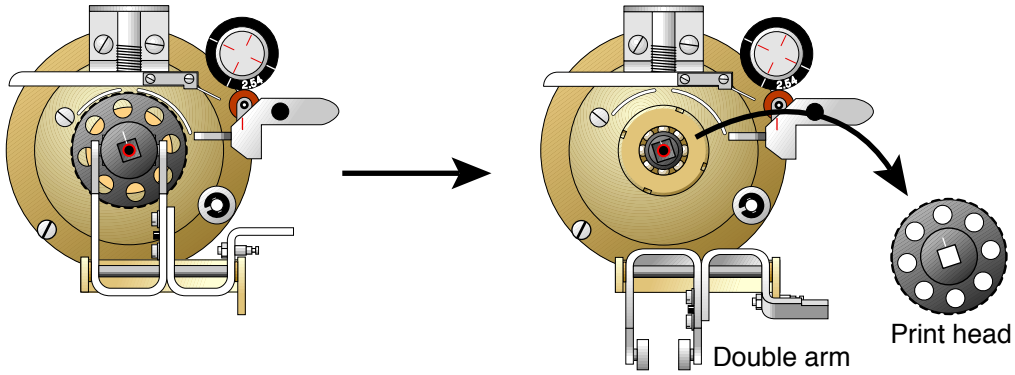
Czechoslovakia



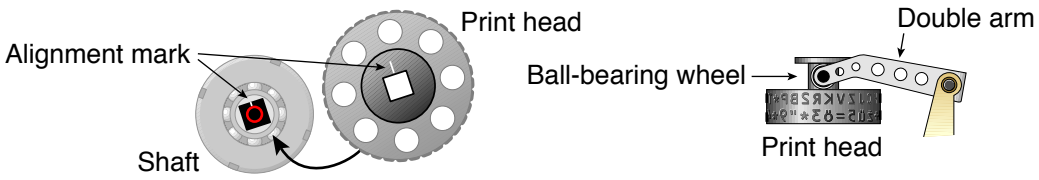
Country-specific heads of the Fialka M-125-3

3.4.9 Replacing the print head

If you have more than one print head, you may want to replace it at some stage (e.g. when moving from Russian to Latin or vice versa). Swapping the print head is easy and involves the following steps. First you'll have to remove the existing head. This is done by raising the double *ball-bearing wheel* arm to the point where it won't fall back. The print head can now be removed.

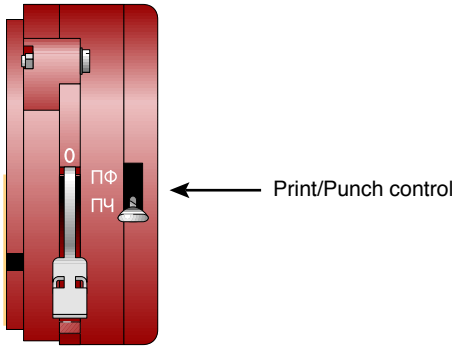


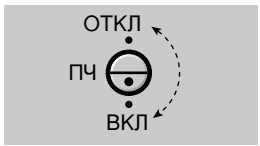
Now put the new print head into place. It can be entered in 4 different ways, but only one way is correct. The mark on the print head has to be aligned with the mark on the square shaft. Also, ensure that the ball-bearing wheels on the double arm are inserted correctly into the print head, in such a way that they can raise it if necessary.



3.4.10 Printer & Puncher control switch

The large bakelite block to the right of the drum, contains two important switches. The leftmost one is the MODE switch, which is discussed elsewhere. The rightmost one controls the operation of the printer and the puncher. Pleae note that this switch is also affected by a rotary switch at the bottom of the machine.





Rotary switch at the bottom

The rotary switch controls the operation of the printer in the **ПФ** setting of the print/ punch control swicth. When set to the *on* position (ВКЛ) the printer will be *activated*. When set to *off* (ОТКЛ) the printer will be *off* when the print/punch control lever is in the **ПФ** position.

The print/punch control lever can be set to two different positions:

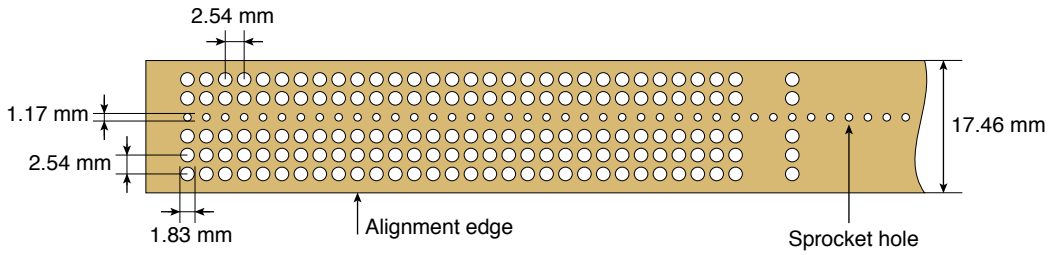
ПФ	Puncher	(or both Puncher and Printer when rotary is set to ВКЛ)
ПЧ	Printer	

If you want both the printer and the puncher to work simultaneously, you may have to alter the setting of the rotary switch at the bottom of the machine. Use a screwdriver to change the setting and note that it can only be rotated in *one* direction (follow the arrows). You should feel a 'click' when it is correctly set to its new position.

3.5 The digital 5-bit code

The Baudot standard

Many years ago, before satellites and the internet became commonly available, teletype machines were widely used to send messages from one part of the world to another. These teletype machines used a 5-bit digital code to encode the text typed from the keyboard. Each character was converted into a unique pattern of *ones* and *zeros*, which allowed a total of $2^5 = 32$ characters. This process is called encoding. The common standard for 5-bit encoding is the *Baudot* standard. A teletype machine could 'save' a message to a paper-tape, by punching the digital data as a pattern of holes. This tape could be read (i.e. loaded) by a suitable tape-reader.

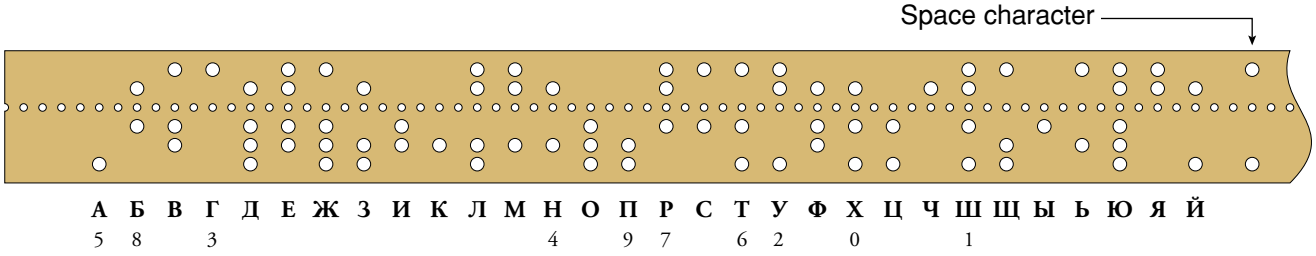


Standard 5-bit paper-tape specification

Most of the sizes are based on *inches*, hence the rather odd *mm* figures. All holes are punched in a 0.1 x 0.1 inch grid. The tape moves horizontally, and a character is stored as a column of holes. An extra *sprocket hole* is punched between the 2nd and the 3rd row. It is used to transport the tape in a tape-reader.

Fialka 5-bit encoding

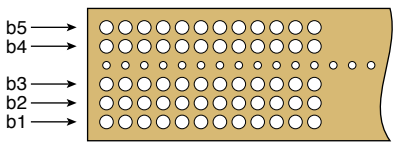
The Fialka contains both a paper-tape reader and a puncher, so it can store messages as well as play them back. It uses paper-tape with exactly the same dimensions as shown above. However, it **doesn't use the Baudot standard**. Instead it uses some kind of internal encoding scheme, which is given here:



The Fialka standard for 5-bit encoding of the Cyrillic alphabet

Only the letters A to Й are normally used. The space character can be used in plain-text only. When creating a coded message, it is always replaced by the letter Й.

The data-bits are numbered as shown below. The bottom row (i.e. closest to the alignment edge) is bit 1 (b1) and the one at the top is bit 5 (b5). The sprocket hole is not recorded as a bit. Please note that the bits are numbered 1-5, rather than the more commonly used 0-4 notation. We have simply followed the numbering scheme that we found inside the Fialka.



Order of the digital bits

3.6 Card Reader

The card reader is located at the left side of the Fialka. It can be opened by lowering a shiny metal bracket and pulling out a drawer. The key card (if present) should be placed inside this drawer in order to 'program' the card reader. Two small metal index pins are present in the drawer for correct alignment of the card. If no key card is available, a metal triangle should be used to force the identity matrix. The image below shows a Fialka machine with the opened drawer.

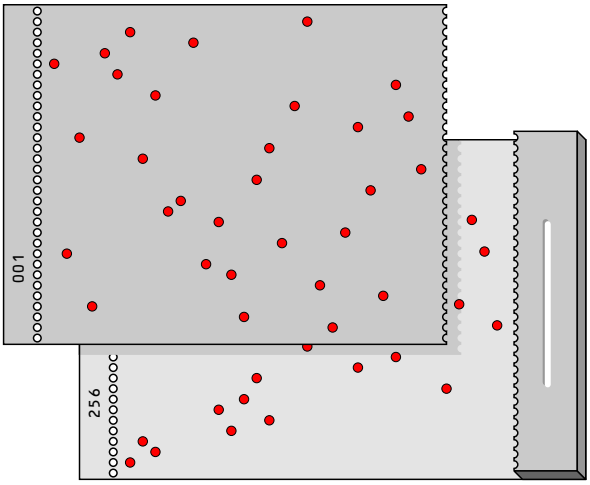
Please note that either a key card or the metal triangle must be present for a correct operation of the Fialka.

The card reader itself consists of a 30 movable contacts that are used to 'sense' the holes in the key card. When the drawer is closed, each of the 30 switches will 'lock' in the corresponding hole. Press the drawer firmly to make sure it is closed properly, and raise the shiny metal bracket again.

In actual use, the key card was changed daily. They key cards were manufactured by the Russians for all countries of the Warsow Pact for one year. Each country had its own unique set of cards that was sewed together as a stack. The key card had to be changed daily, so the Fialka operator had to tear-off a single card from the stack each day, and place it in the Fialka. The cards were made of rather thin paper which would get ripped after opening and closing the drawer several times. The exact weight of the paper is unknown.



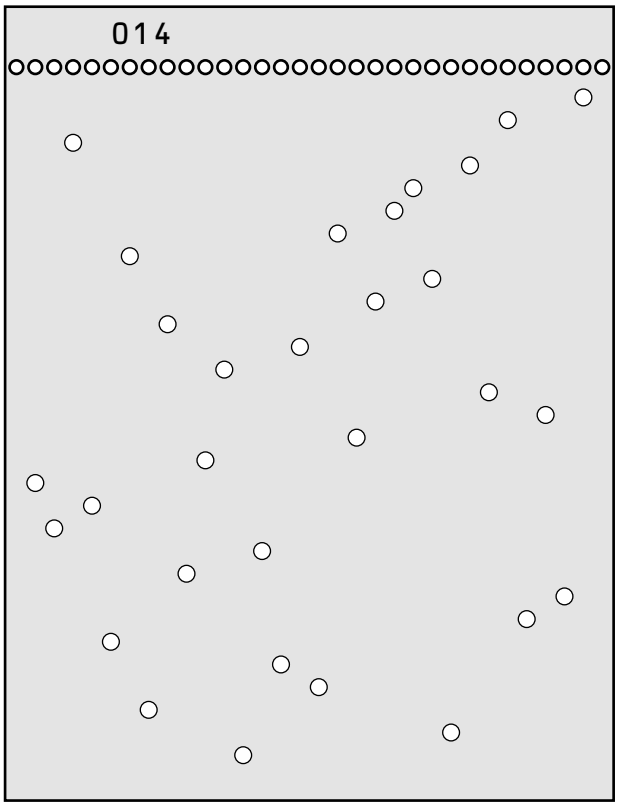
Fialka M-125-3 with opened card reader, showing the metal triangle



A single card taken from the stack

Each card has a number printed in the top left of the card (**014** in the example below). This number should match the number of the daily key. In practice this would mean that the code for the 14th day of the year was used. Each card has two perforations: one at the top (just below the card number) and another one at the bottom where the stack is sewed together. The lower perforation is the place where the key card would be separated from the stack. The perforation at the top is used to align the card within the drawer. Two holes of this perforation should match the index pins in the drawer and the card should be lined up nicely with the edges of the drawer. The card number is visible through a cut-out in the lid of the drawer.

The card contains exactly 30 key holes; one for each row/column combination. The columns can be seen as the input of the card reader (i.e. the lines from the keyboard), whilst the rows are the output (i.e. connected to the entry disc). Further information about the card reader can be found in Chapter 4.6 – *Card Reader*. Information about the dimensions of the key card as well as the metal triangle is given in Chapter 5.9 – *Creating your own key cards.*



Example of a key card for day 014, shown at actual size

3.7 Sequence of Events

When trying to comprehend the operation of the Fialka, it is important to recognise the various events and the sequence in which they happen. This is particularly necessary if one wants to create a computer simulation of a Fialka machine. In order to verify the information below, check the discovered wheel wiring and 'simulate' the reverse-engineered circuit diagram in Chapter 4, we've created a simple computer simulation to verify the output against a real Fialka machine.

When creating a computer simulation yourself, it is better to use a contact range 0-29 rather than 1-30. This way each following step can simply be added to or subtracted from the current step. Ensure that, after each conversion step, the result is converted back to the 0-29 range (either by adding or subtracting 30 to or from the result).

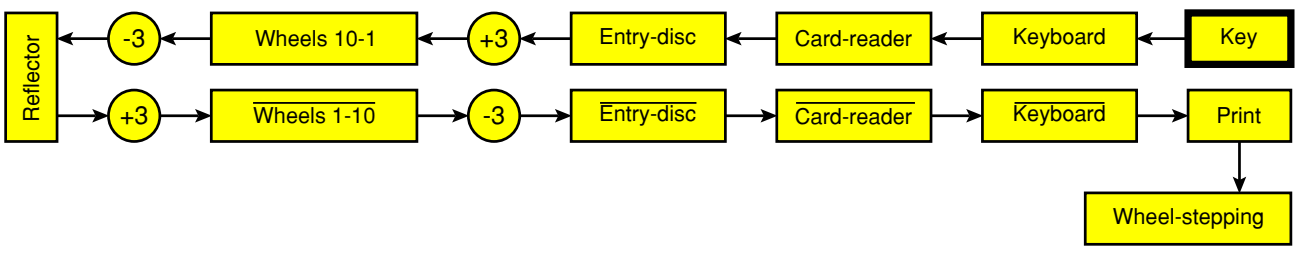
The events take place in the following order:

- A key is pressed.
- Convert key-top letter to Cyrillic letter (e.g. F → A).
- Substitution from keyboard to card-reader (➔ Chapter 4.5).
- Substituation by the card-reader itself (or identity matrix if the metal triangle is present).
- Substituation from card-reader to entry-disc (➔ Chapter 4.7).
- + 3 (difference between contact 1 of the entry-disc and letter above the ruler).
- **Apply substitution for each of the rotors from 10 to 1** (see below).
- - 3 (difference between letter above the ruler and contact 1 of the reflector).
- Substitution by reflector (different reflector for coding and decoding).
- + 3 (difference between contact 1 of the reflector and letter above the ruler).
- **Apply *inverse* substitution for each of the rotors from 1 to 10** (see below).
- - 3 (difference between letter above the ruler and contact 1 of the entry-disc).
- *Inverse* substitution from entry-disc to card-reader (➔ Chapter 4.7).
- *Inverse* substitution by the card-reader itself (or identity matrix when using triangle).
- *Inverse* substitution from card-reader to keyboard (➔ Chapter 4.5).
- A letter is printed.
- The wheels are stepped (according to the advance blocking pins, the current position and the current ring-setting).

The substitution by each of the rotors in forward direction (i.e. from right to left) is as follows:

1. Add current position of the wheel (i.e. letter visible above the ruler).
2. Add ring-setting.
3. Subtract core-setting.
4. Apply substitution by the wheel wiring matrix.
5. Add core-setting.
6. Subtract ring-setting.
7. Subtract current position of the wheel (i.e. letter visible above the ruler).

The substitution by each of the rotors in reverse direction (i.e. from left to right) is identical to the above, except that the *inverse* wheel wiring matrix should be applied at step 4. When a core is inserted the other way around (i.e. if side 2 of that core is visible from the outside), the mirrored wheel wiring matrix or the *inverse* mirrored wheel wiring matrix has to be applied at step 4.



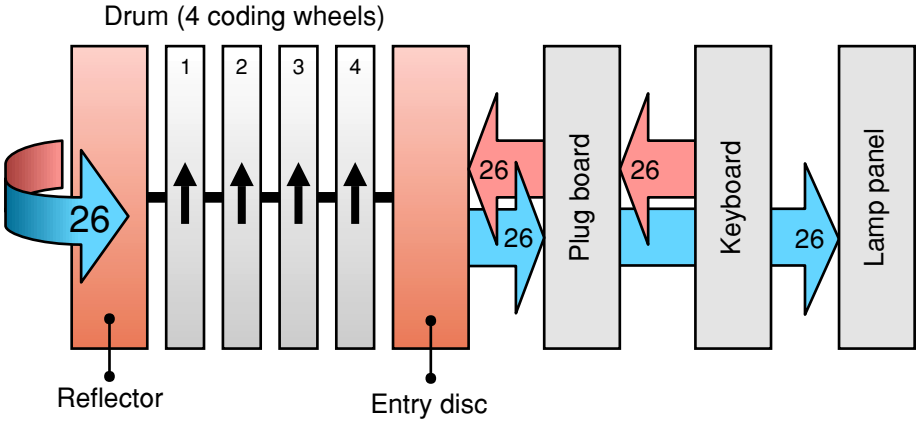
Chapter 4
Technical details & Circuit Diagrams

4.1 Introduction

4.1.1 Enigma

The internal wiring of the Fialka is *very* complex and extremely difficult to reverse engineer. Almost all wires have the same colour and are bound together in nice bundles which doesn't make the process of tracing the wires any easier. The wiring of the later M-125-3 machines is even more complex, due to the addition of the NumLock switch (30 ↔ 10). Fortunately, we were supplied by a partly disassembled rotor mechanism by Professor Tom Perera [4], who allowed us to take the whole unit apart in order to discover its inner secrets.

This chapter gives a detailed technical description of the electronic circuits inside the Fialka machine, including a full circuit diagram. Although it's our intention to be as complete as possible, we've simplified some of the diagrams for the sake of readability. Rather than trying to fit the entire circuit diagram onto a single page, we've cut it into several functional blocks. But first we'll show you how it works.



Block diagram of an Enigma machine

Let's consider the block diagram of an M4 Enigma machine. At the heart of the Enigma is a set of moving coding-wheels, called the *drum*, between an *entry disc* (right) and a *reflector* (left). It uses a *keyboard* for input and a *lamp panel* for its output. The keyboard has 26 keys (one for each letter of the alphabet). When pressing a key, an electric current is sent from the keyboard through a series of coding devices. First the signal passes the *plug board* which allows pairs of letters to be swapped. From the plug board, the signal is sent to the *entry disc*, which passes it on to the rightmost wheel (4), which in turn passes it to wheel 3, etc. until it hits the *reflector* at the left. Inside the reflector, each contact is connected to one of the other contacts (i.e. 13 pairs of contacts) which effectively 'reflects' the current back into the set of wheels. The current passes all 4 wheels (in reverse direction this time), the entry disc and the plug board, until it arrives at the l*amp panel* where it will lit one of the 26 lamps.

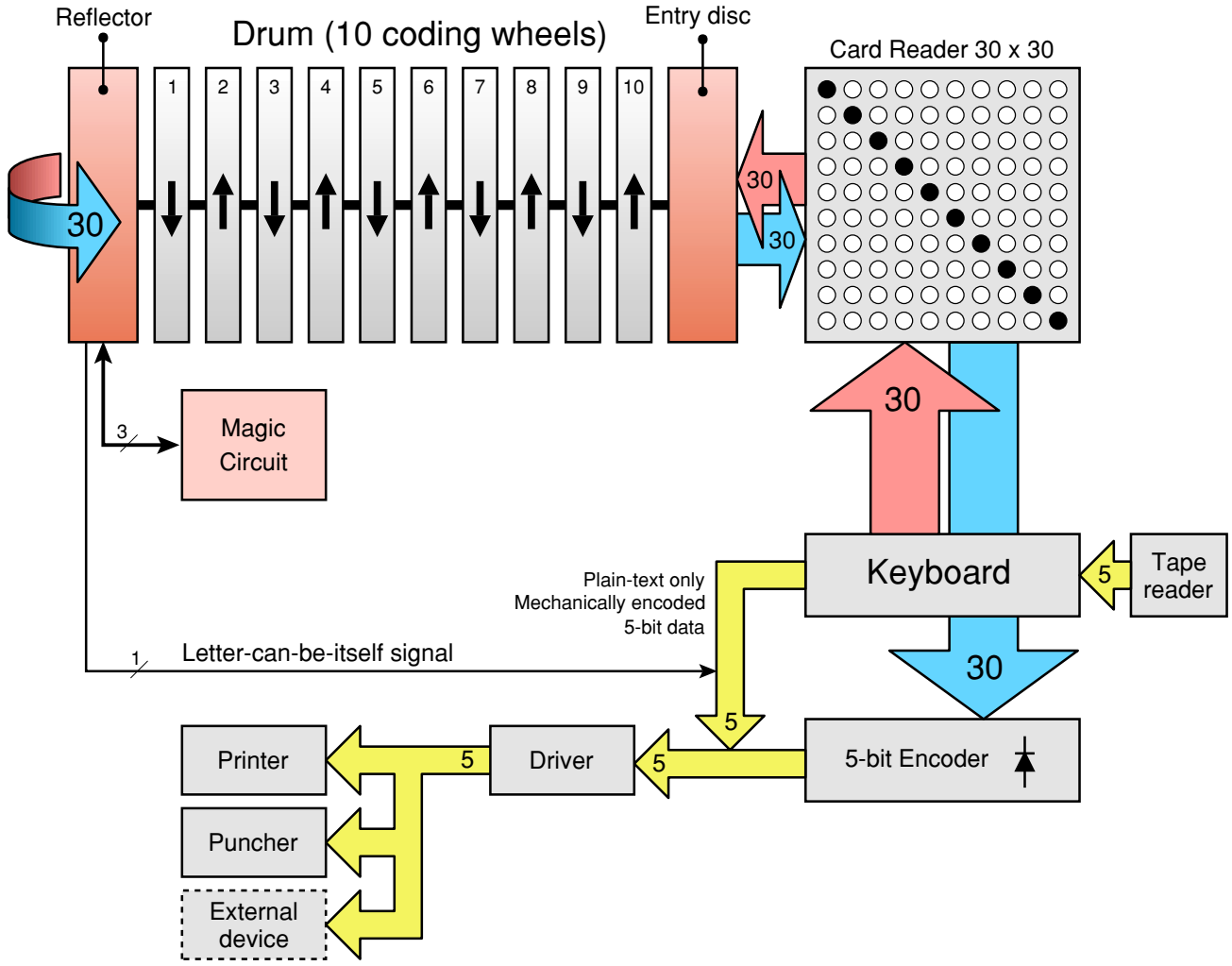
The advantage of the use of a reflector is that it is a reciprocal operation. In other words: the whole process is reversable. To decode an Enigma message, one would use exactly the same settings as those that were used to create the message in the first place. One of the disadvantages of this method however, is that a letter can never be encoded into itself. This appeared to be one of the weaknesses of the Enigma.

The design of the Fialka is similar to this, but has a number of powerful additions. First of all the plug board has been replaced by a card reader (German: *Kommutator*) which greatly simplifies the setup procedure. Next, the Fialka uses 10 coding wheels and an advanced stepping mechanism (➔ Chapter 3.3 - *The Wheels*). Like on the Enigma, a reflector is used to send the current back in to the drum, until it finally arrives at the keyboard again. Unlike the Enigma, a printer is used to show the final output.

However, it's not as simple as that. The Russians clearly have learned from the flaws in the Enigma design and have come up with some clever solutions to avoid the principle that a letter can never be encoded into itself. In the next paragraphs we'll show how this was achieved.

4.1.2 Block diagram of the M-125

In order to understand the circuit diagram, it's important to know how the various parts of the machine are connected together. First we'll consider the block diagram of the 'simpler' M-125 machines:



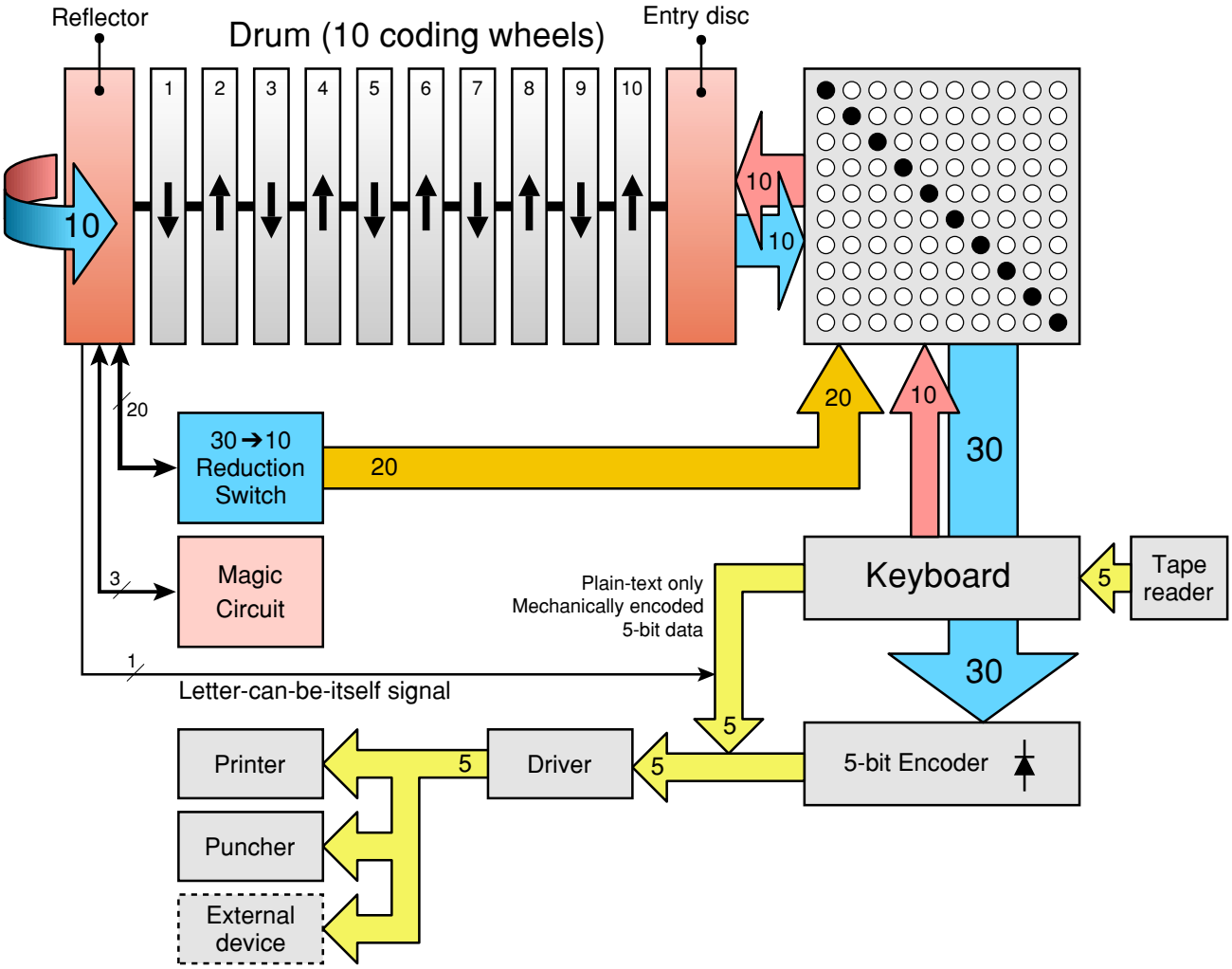
We'll start at the keyboard (center right), which has 30 keys in order to accomodate (a subset of) the Cyrillic alphabet. When pressing a key, an electric current is sent to the Card Reader, which behaves more or less like Enigma's plug board. From the card reader, the signal goes to the *entry disc*, which passes it on to the *drum*. At the end (on the left) the signal is *reflected* back into the drum, through the entry disc and the card reader, until it arrives at the keyboard again. There it is fed to a diode matrix which converts it into a unique 5-bit pattern, similar to (but different from) the 5-bit Baudot code used on teleprinter machines. The 5-bit data from this *encoder* is used to drive both the printer and the paper puncher.

In addition to driving one of the 30 switches, the keyboard also contains a mechanical 5-bit encoder, which produces a digital code (identical to the one above) of the original plain-text letter. This code is used when the Fialka is configured as a 'standard' teleprinter device (i.e. in plain-text mode). However, the plain-text 5-bit code can also be used to override the 5-bit data of the enciphered letter. This is controlled by a single contact of the reflector. When the current hits *that* particular contact on the reflector, *no* signal is sent back into the drum and the 5-bit code of the original letter is used instead. As a result, there is a chance of 1:30 that a letter is enciphered into itself.

In addition to this, 3 other wires from the reflector are fed into the so-called Magic Circuit, which uses a clever rotational principle that makes the Fialka partly lose its reciprocity. This circuit will be discussed in more detail later. The remaining 26 contacts of the reflector are interconnected in pairs, just like on the Enigma.

4.1.3 Block diagram of the M-125-3

The circuitry of the later M-125-3 machines is much more complex. Although the machine is backward compatible with the earlier models, some powerful new features have been added, which greatly enhances the possibilities.



In its basic setting, the machine behaves exactly like the M-125 shown on the previous page. However, the introduction of a reduction circuit, adds the possibility to encode messages consisting of numerical data only (i.e. pre-coded messages). We've called this *numbers-only* mode throughout the manual. The reduction circuit is operated by a switch at the bottom left of the machine, which is marked as 30 ↔ 10. In this manual we've called this the *NumLock* switch.

When set to '30' (i.e. using the full set of 30 characters) it behaves as before. When set to '10' however, the keyboard is reduced to 10 keys only (both mechanically and electrically). These are the 10 coloured keys on the keyboard. Only 10 of the contacts on the reflector are used (i.e. the 4 magic wires plus 3 fixed loops). The remaining 20 contacts are fed back into the card reader on the contacts of the 20 unused keys. This way the signal is looped around until it finally produces a usable numerical result. Exact details of how this is achieved can be found in one of the following chapters.

Both types of machine have a *paper-tape reader* that is cleverly integrated with the keyboard. The tape reader generates 5–bit data from a paper-tape and feeds it to the mechanics of the keyboard, which 'translates' it into a signal on one of the 30 switches. The same mechanics are used to generate the plain-text 5-bit data when typing on the keyboard.

In the following chapters the various circuits of the M-125-3 will be discussed further. Please note that, when the additional features are ignored, the circuit diagrams are also applicable to the M-125.

4.1.4 Negative logic

The Fialka uses so-called negative logic. This means that the 0V line is used to send a letter through the coding path, rather than the +24V line as one might expect. As a result, driving a line low (i.e. 0V) generally activates a certain part. This is also true for the punched-tape reader and the tape puncher. A 0V signal represents a logical 1 in the bit pattern.

4.1.5 Symbols

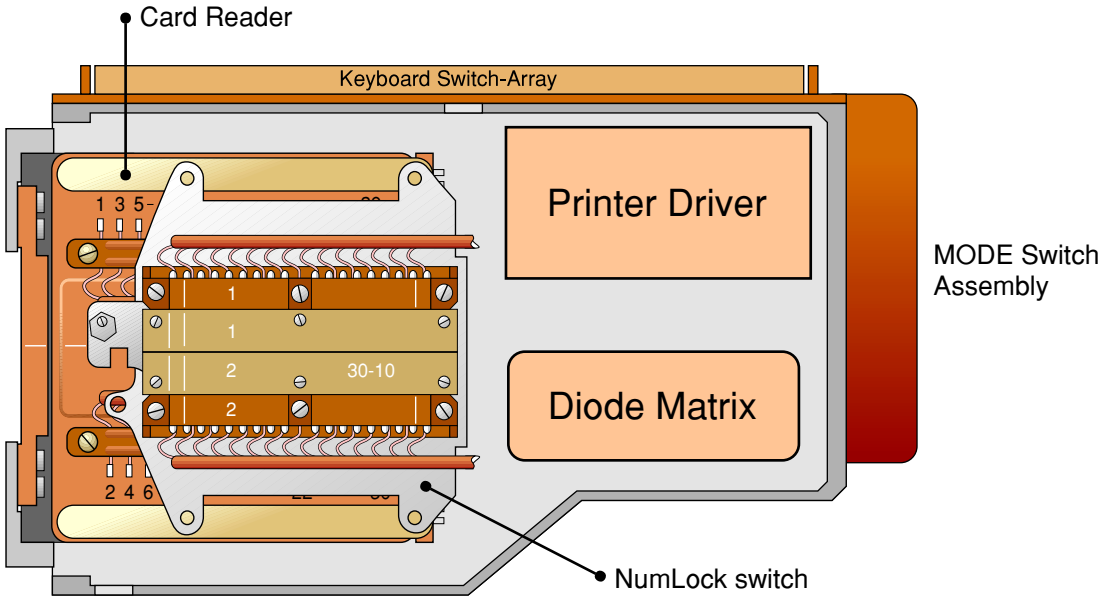
In the circuit diagrams shown in this manual, we've used the following symbols:

○	Connection or terminal (e.g. +24V)
⊥	0V rail
⏚	Ground
Ш	Connector or plug (Russian: Штеккер = *stekker* = plug)

In some circuit diagrams, we've tried to clarify the situation, by adding a part of another circuit. If this is done, the added part (i.e. the section that is not part of the current circuit) will be enclosed in a box with a dashed outline.

4.1.6 Location of the various circuits

Most of the Fialka's electronic circuits and electrical wiring is hidden uderneath the drum mechanism, inside a heavy grey metal block. To access this block, the machine has to be disassembled completely. Looking at the block from the underside, we can identify the following components:



Bottom view of the electronic circuits

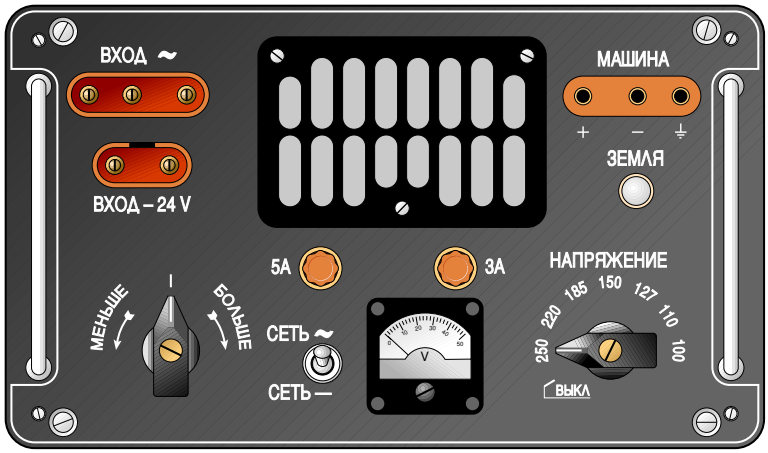
On the left is the drawer of the card-reader (➔ 4.6). The card-reader itself is partly hidden behind the NumLock Switch (➔ 4.8) that has this incription '30-10' on it. You can clearly identify the two parts of the NumLock switch, marked as '1' and '2' respectively. The right half of this assembly, contains the electronic parts. At the top right is the Printer Driver (➔ 4.12) and the rounded box at the bottom right is the Diode Matrix (➔ 4.11). On the top of the drawing, stretching to the full width, is the Keyboard Switch-Array (➔ 4.4) consisting of 31 individual SPDT switches.

All components of the Fialka are wired together with thin pink-coloured teflon wires, nicely packed together in sturdy brown bundles. Several holes in the grey metal block, allow the bundles to access the other parts of the machine, such as the configuration and test connectors (Ш2 and Ш5 ➔ 4.13) and the complex MODE Switch (➔ 4.5). The latter also encloses the famous Magic Circuit (➔ 4.9) that is directly connected to the *reflector*.

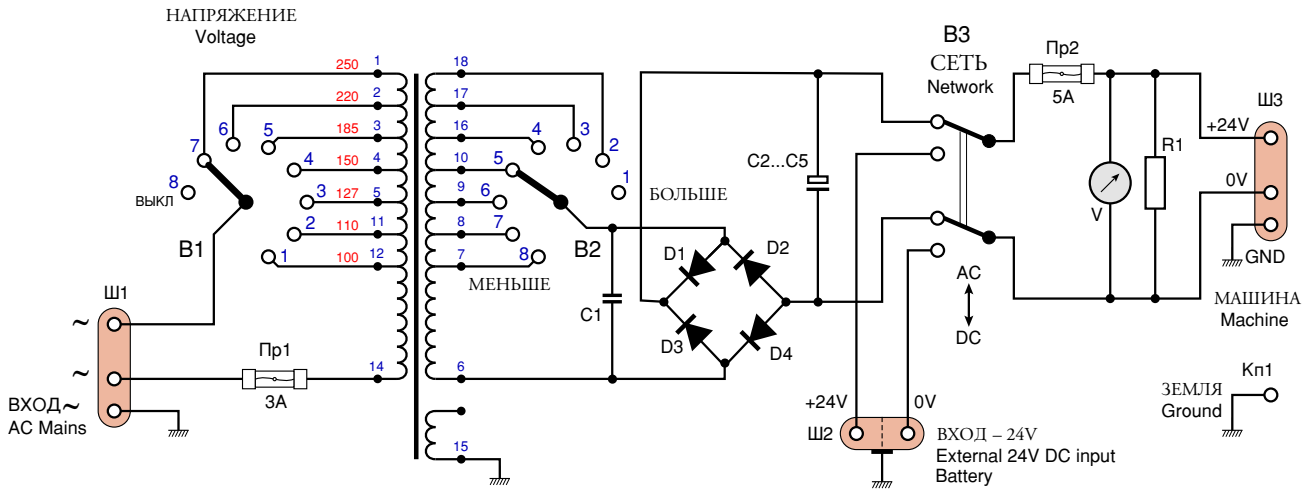
4.2 External Power Supply

4.2.1 Introduction

The Fialka uses a single 24V power supply. This could be obtained from the 24V battery of a large vehicle, e.g. a tank or a truck, or from a suitable 24V power supply. Various models of power supply have been issued in combination with the Fialka, but most models are equivalent to the one shown here:



Power supplies of this model are known to have been found in the former Czechoslovakia. Other models may have been issued in other countries (e.g. the vertical model that was used in Poland) but they are technically nearly identical. The circuit diagram of the model shown above is as follows:



4.2.2 Circuit description

The design of this power supply is rather conventional. A multi-tap transformer is used to allow a variety of mains voltages to be used. The AC mains input is shown on the left. The first switch (B1) is used to select the input voltage. The second switch (B2) is used to select the secondary voltage. This should normally be set to 24V (i.e. the marked position). The rectifier bridge consists of 4 diodes (D1...D4) and the DC voltage is smoothened by a range of capacitors (C2...C5).

The supply can also take an external 24V DC input (e.g. from the battery of a truck). The switch (B3) is used to select between the mains (AC) or the battery (DC) input. The output connector (Ш3) is marked Машина (Machine) and should be connected to the power input of the Fialka. The volt meter (V) should be used to verify the output voltage prior to turning the Fialka *on*. It should read approx. 24V.

4.2.3 The alternative Power Supply

Apart from the power supply described on the previous page, Fialka machines in some countries have been issued an alternative one. The PSU described on this page is often found with Polish Fialka machines and it is believed that the same one was used in the DDR as well. Although in principle it is just a 24V DC power supply, it has some very special features that are described below.

4.2.4 TEMPEST

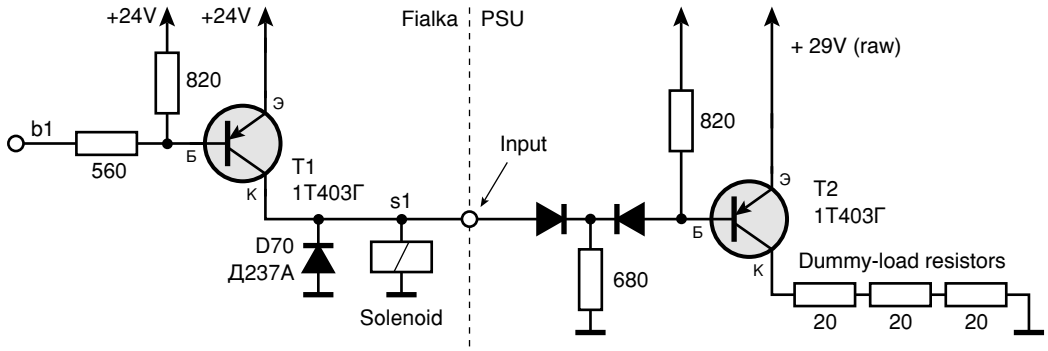
TEMPEST is a codename, issued by the NSA, to describe intelligence gathered from unintentional emanations of cipher equipment. Such compromising emanations (CE) consist of electrical, mechanical or acoustical energy radiated by the machine, or a device attached to it, that could lead to the recovery of the original plain text. Lab tests have proven that CE can be propagated through space and over conducting lines; sometimes even over very long distances. The emission of unwanted signals is often an underestimated issue. During the Cold War, both sides developed techniques to exploit CE. As both parties expected the other one to do the same, they also developed methods to protect their own equipment against CE. If a cipher machine is sufficiently shielded and does not produce CE, it is said to have a high TEMPEST. The term TEMPEST itself is not an abbreviation nor an acronym; it is just the codename given to the study of CE.

4.2.5 Fialka and TEMPEST

Machines like Fialka often produce a specific acoustical pattern. Each key-press initiates a series of mechanical events and movements, each with their own specific sound. It is sometimes possible for an eavesdropper to work out the plain text, simply by recording and analysing the sound of the machine. The mechanics of the Fialka have been constructed in such a way that each key-press produces exactly the same sound. So, from an acoustical point of view, Fialka has a high TEMPEST. But that doesn't mean, however, that the machine is safe from eavesdroppers. Whenever a key is pressed, the machine prints a letter on the printer and/or the paper puncher. Each letter is produced by a 5-bit digital code, but there are differences in the number of bits used for each letter. Consider for example the letters A (10000) and Д (11110). When the Д is printed, 4 solenoids are driven, but when the letter A is printed, only one solenoid is driven. As a result, printing the letter Д draws four times as much current from the power supply than an A. If an eavesdropper had the ability to tap the mains power line, he would theoretically be able to discover part of the plain text even from miles away simply by registering very small differences in the current drawn by the system.

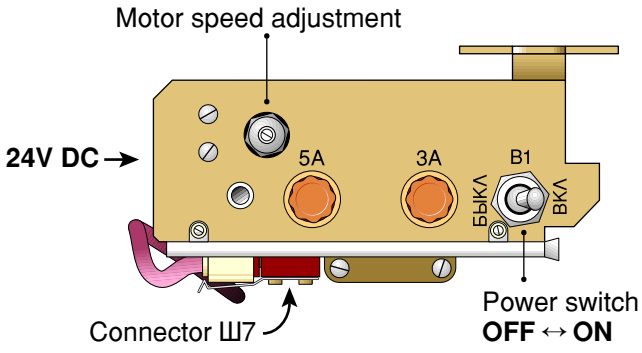
To overcome this problem, the Russians developed a special power supply that not only produced a stabilised voltage, but also a constant current. Apart from the standard stabilised power circuit, this unit also houses five identical high power resistors that are used as artifical loads. Each resistor produces a load that is equivalent to a solenoid inside the Fialka. By feeding the 5-bit digital output of the Fialka through the power supply, it 'knows' exactly how many bits are driven. The PSU then compensates for differences in the number of bits, by turning on some of its dummy loads, so that it always seems that all five solenoids have been activated. In case the letter A was printed, four additional dummy loads would be activated, but when the letter Д was printed, only one additional dummy load was enabled.

The simplified circuit diagram below shows the output of a single bit from the Fialka (left) and the input circuit of the PSU (right). If the solenoid is not activated, the input is floating, the transistor (T2) will be conducting and the dummy load is activated. As soon as the solenoid is driven, the input is taken high and the dummy load will be de-activated.

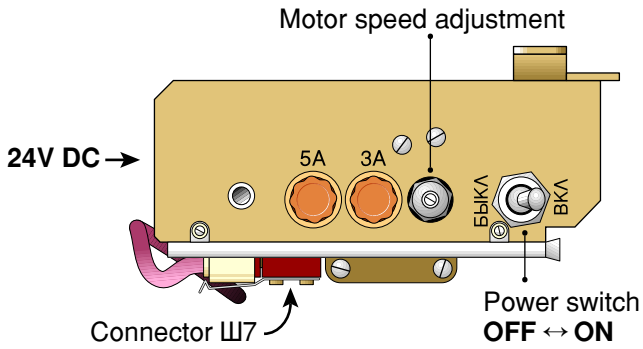


4.3 Power Module

The 24V supply should be connected to the *Power Input Connector* Ш3 on the left side of the machine. Please ensure that the topmost pin carries the +24V rail. The power input circuit is located in the metal case on the left side of the machine. We've called this the *Power Module*. The Power Module of the M-125 is slightly different from the one of the later M-125-3 as you can see in the drawings below, but the circuit diagram is identical.



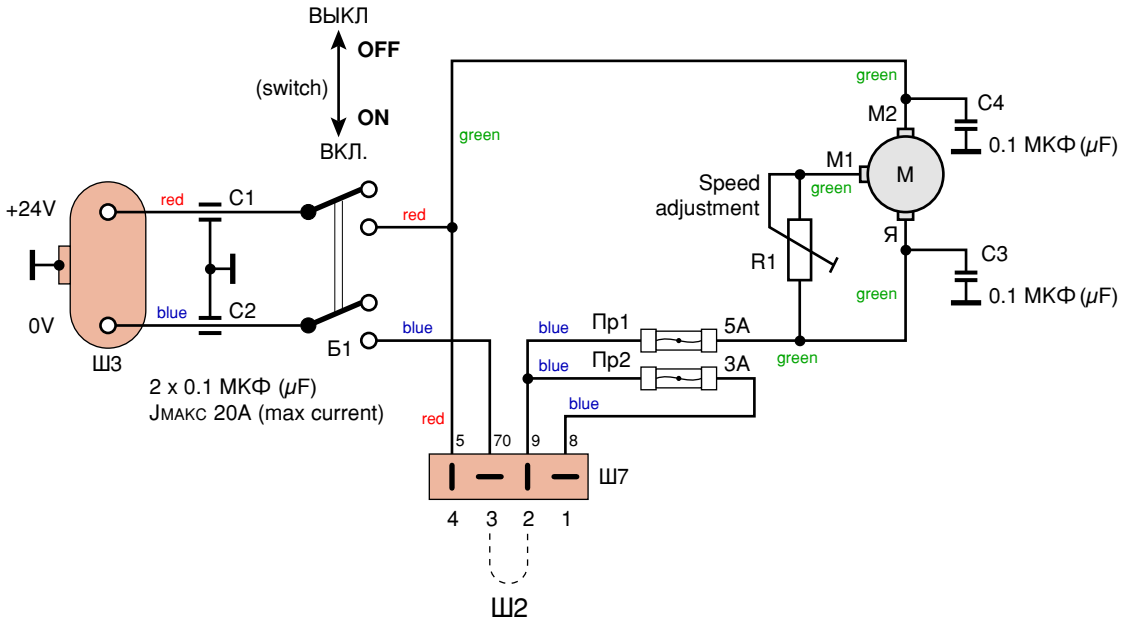
Power Module of a Fialka M-125



Power Module of a Fialka M-125-3

Circuit description

The circuit diagram of the power circuit is given in the diagram below. The 24V DV supply comes in on connector Ш3. Both power lines are filtered by a feed-through filter (C1 and C2) before they reach the power switch. (Б1). Power is distributed to the rest of the machine via connector Ш7, which is located on the front of the power module. For this, the 3A fuse is used (Пр2). The motor (M) is powered directly from the Power Module via a 5A fuse (Пр1). A wire-wound potentiometer is used to adjust the motor speed. This potentiometer can be accessed through a hole in the top of the Power Module. Note that the motor has three connections (M1, M2 and Я).



Power Module circuit diagram

The colour of each wire and, in some cases, the wire numbers, are printed in the diagram above. This can be useful when repairing a defective unit. Please note that the 0V line is interrupted by Ш7. Once Ш7 is connected to the rest of the machine, pins 70 and 9 will be connected by the shorting plug in connector Ш2 (on the left side of the machine).

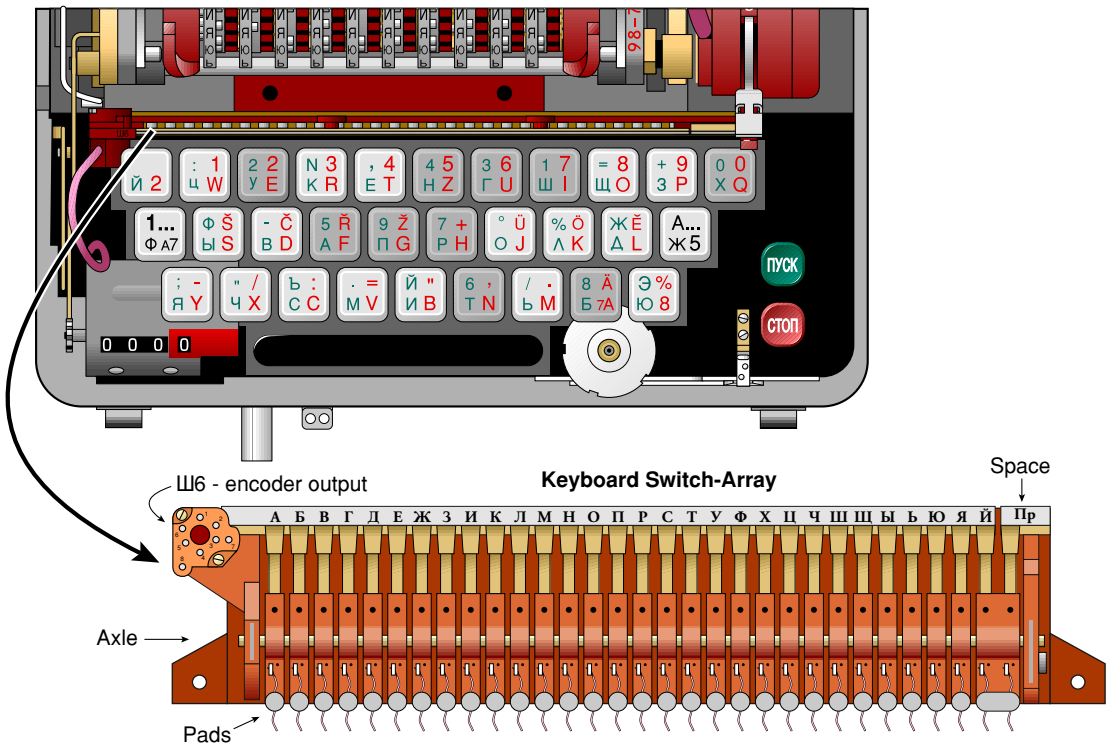
4.4 Keyboard

The keyboard is a fundamental part of the Fialka machine. It is used for entering a plain-text or a coded message and – on the M-125-3 – can be used in a variety of ways. Although the keyboard looks simple at first glance, it is in fact a very complex device. Hidden under the key caps is a complex mechanical maze of metal pawls, arms, levers, springs and notches. This mechanical structure is used for a number of things:

- Close one of the 30 contacts on the Switch-Array
- Translate a key to a 5-bit digital pattern
- Allow the paper-tape reader to play back both the above
- Lock all other keys, when a key is pressed
- Lock-out certain keys in a specific mode of operation
- Release the keys once a letter has been coded
- Remember the last key pressed (M-125-3 only)

4.4.1 The switch-array

The keyboard contains 30 keys plus the *space bar*. Between the keyboard and the drum unit is a large array of switches, one for each key. When a key is pressed, one of these switches will be closed. Which switch will be engaged, is determined entirely by the physical position of the switch on the keyboard, not by the text printed on the key cap. There are many different keyboard layouts (for the various countries in which the Fialka was used), but the switches are all related to the Cyrillic alphabet (Russian). The Cyrillic layout (bottom left of the key cap) is the same on all variants of the M-125.



All switches are mounted on a horizontal axle and have a circular pad at the bottom which can be engaged by the keyboard's mechanics. When a key is pressed, the vertical contact 'finger' (at the top) moves towards you. It will *make* one contact (i.e. a current that is sent to the drum) and *break* another (the returned current that is sent to the diode matrix). This is identical in operation to the keyboard of an Enigma machine.

The switches of the array are arranged in the order of the Cyrillic alphabet, identical to to the sequence on the wheels. As there are only 30 contacts on each wheel, something special has been arranged for the *space bar*. As you can see, the rightmost switches, Й and Пр (space) will always be moved together. The keys for these switches are mutually exclusive; you can only use one of them in a particular mode of operation. Both switches are routed via the Mode Switch (➔ 4.5).

4.4.2 Circuit Description

The circuit diagram of the Keyboard Switch-Array is rather straight forward. All switches are placed in the order of the alphabet and each switch has three contacts:

- Common (on the left)
- Normally Closed (upper)
- Normally Open (lower)

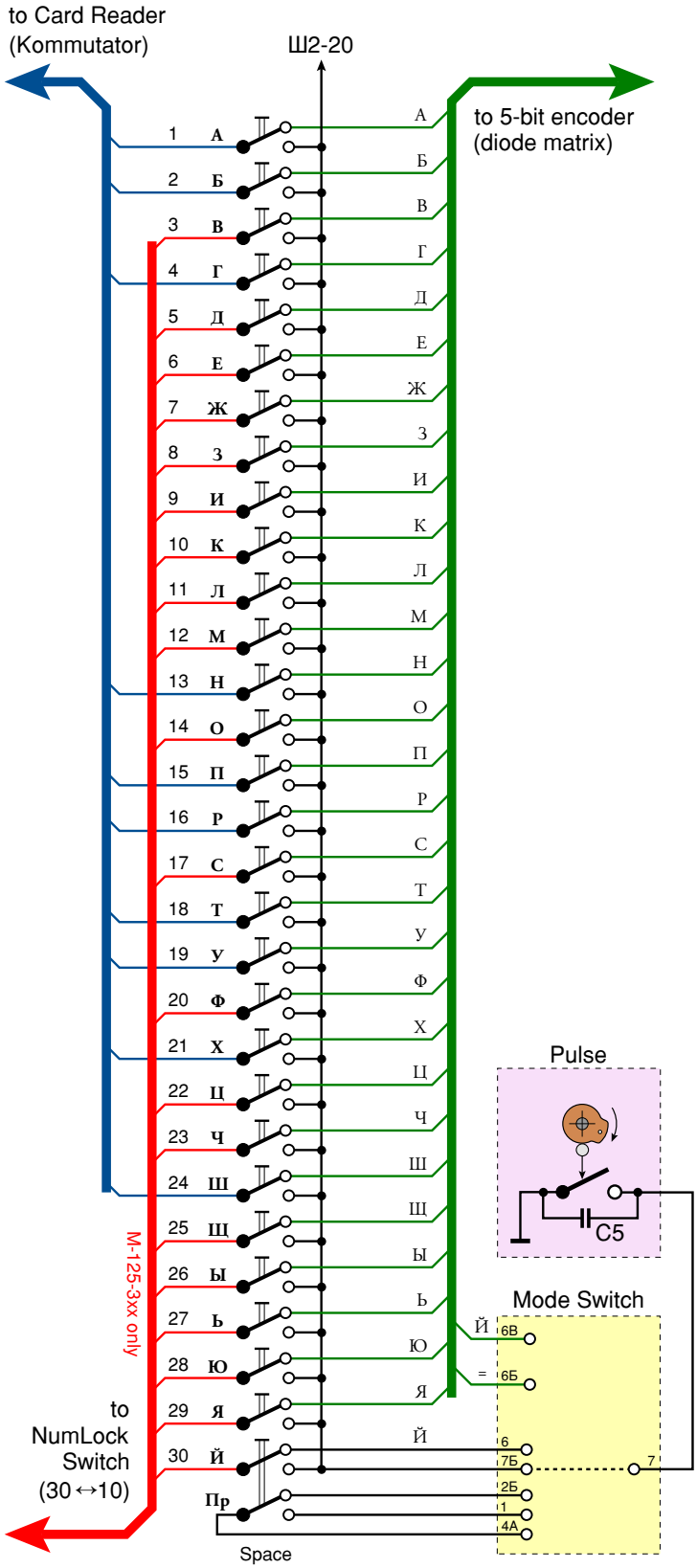
The *normally open* contacts are all connected to a common rail. This rail is controlled by the *Mode Switch* and the *Pulse Switch*. When a key is pressed, the wheel stepping mechanism starts rotating. At a certain point, the pulse switch will close and the common rail will be connected to the 0V rail.

The *pulse* leaves the keyboard circuit on the left (the red and blue bundles). On the M-125, all wires go straight to the Card Reader, but on the M-125-3 only the 10 number keys are directly wired to the *Card Reader* (blue). All other lines (red) go to the complex *NumLock* switch first. When this switch is set to '30', all these lines will be connected to the *Card Reader* in the same manner as on the M-125.

Once the *pulse* has passed the drum, it is reflected back (by the reflector) until it arrives back at the left of the diagram. By definition in a system with a reflector, it will return **another** letter than the one that was pressed. The *pulse* now passes the contacts of the corresponding switch, and leaves it through the normally *closed contact* on the right. From there is it sent to the diode matrix, which will convert it into a unique 5-bit pattern.

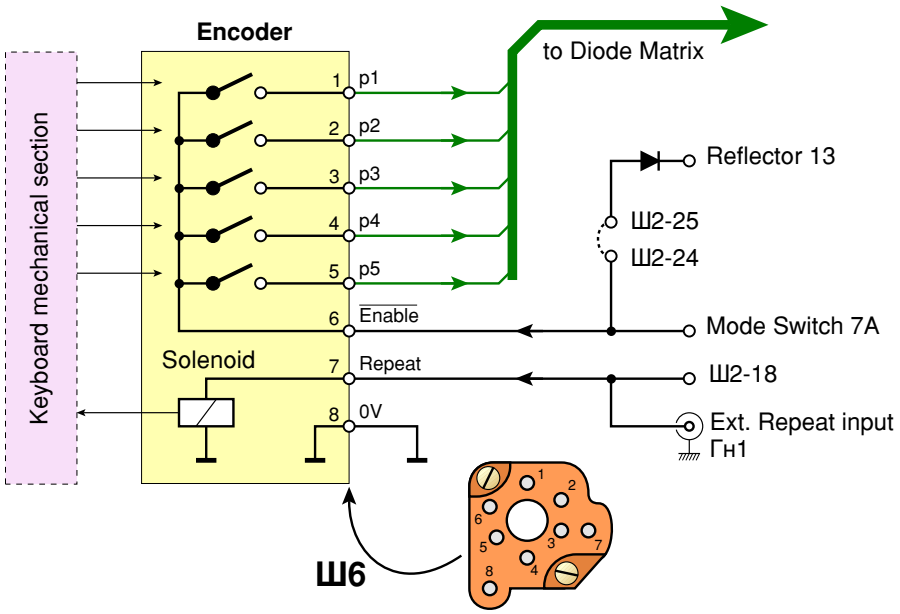
The only special part of this circuit diagram is at the bottom. Two switches, the ones for Й and Пр (space) always move together. This is because only 30 characters can be used. When coding a message, the space character will be converted into a Й. When decoding a message, the reverse will take place.

The dotted sections in the drawing are not actually part of the keyboard circuit. They are shown here to clarify the way the *Keyboard Switch-Array* is driven.



4.4.3 Mechanical 5-bit Encoder

Below the keyboard (at the left, close to connector Ш6) is a small metal box containing 5 switches. These 5 switches are driven by the keyboard's complex mechanical structure. When a key is pressed, this key will be translated –mechanically– into a 5-bit digital pattern. The 5-bit code used here, is the same as the one produced by the diode matrix (➔ 4.x). It is the digital representation of the plain-text letter. More information about the 5-bit data format can be found in Chapter 3.5. The circuit diagram of the mechanical 5-bit encoder is as follows:



The 5 switches are directly driven by the keyboard's mechanical structure. The $\overline{\text{Enable}}$ line at pin 6 is used to determine whether the Fialka's *output* is generated by the *diode matrix* or by the *mechanical encoder* shown here. This *enable* line is driven *low* by the Mode Switch when in plain-text mode. Furthermore it is driven by pin 13 of the *reflector*, which results in a 1:30 chance of a letter being enciphered as itself. All electrical connections to and from the encoder run through connector Ш6. This rather strange connector is located to the left of the keyboard, close to the Switch Array. It allows the keyboard to be removed easily.

4.4.4 Auto-repeat (M-125-3 only)

Also hidden away under the keyboard is a solenoid that controls the keyboard's mechanical *repeat* function. When applying a +24V pulse to pin 18 of Ш2 or to the coaxial connector Гн1 at the right of the machine (close to the 5-letter spacing switch), the last key pressed will be repeated. This was probably used by a repair facility to trap intermittent failures. The solenoid is located under the keyboard and can be seen from the front when the cover is removed. It sits in between the two counters. The two wires (purple and white) are clearly visible. The solenoid is connected via pins 7 and 8 of Ш6. Please note that these 2 pins are *not* available on the M-125.

4.4.5 Tape Reader

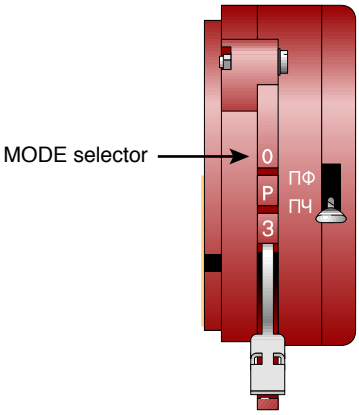
To the right of the keyboard is the punch-tape reader. It accepts the same tape as the one that is used by the puncher and it uses the same 5-bit digital pattern. The tape reader is fully integrated with the keyboard and is physically connected to the same mechanical structure. As a result, characters can be played-back by the tape-reader as if they were typed in on the keyboard. A character, generated by the tape-reader, will therefore have the same effect as pressing the equivalent key:

- Close one of the 30 contact of the Keyboard Switch-Array, and
- Generate a 5-bit digital code through the *mechanical* 5-bit Encoder.

Operation of the tape-reader is described in Chapter 2.13.

4.5 MODE Switch

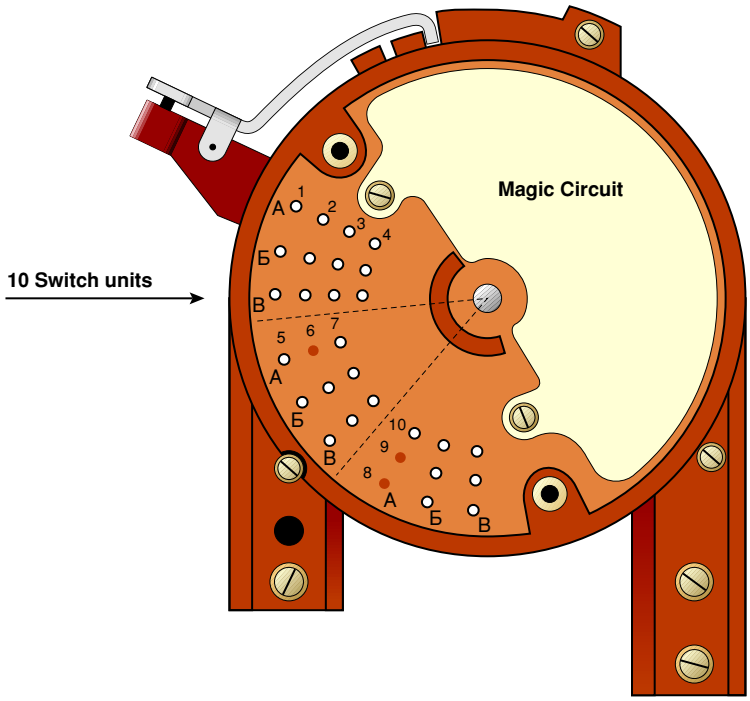
To the right of the drum is a large bakelite assembly, containing two adjustable levers. The leftmost lever is the MODE switch, which is used to set the Fialka's mode of operation. The switch can be set to three different states: **O** forplain-text, **P** for decoding and **3** for coding. The drawing below shows the MODE switch in *coding* mode.



О	Открытый Текст	Otkrytyj Tekst	Plain Text
Р	Расшифровывать	Rasshifrovyvat'	Decipher (decoding)
З	Зашифровать	Zashifrovat'	Cipher (coding)

The three settings of the MODE switch

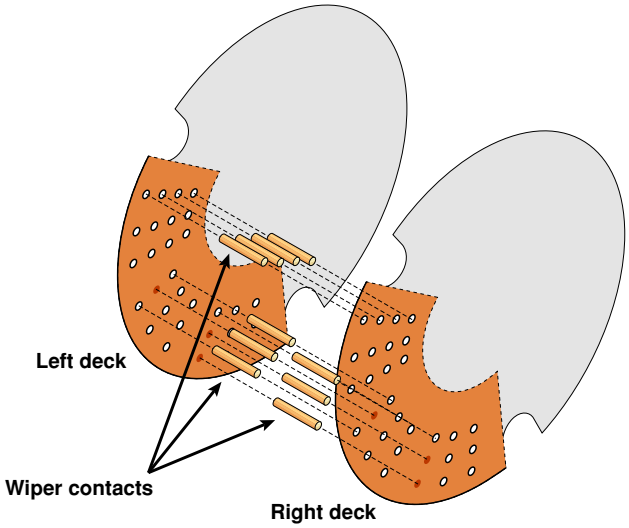
A large number of wires, from various places inside the machine, disappear into this switch assembly. The assembly itself consists of 10 independant 3-stage switches, part of which can be accessed from the right of the machine. The drawing below shows the switch assembly with the cover removed, seen from the right.



Switch assembly seen from the right

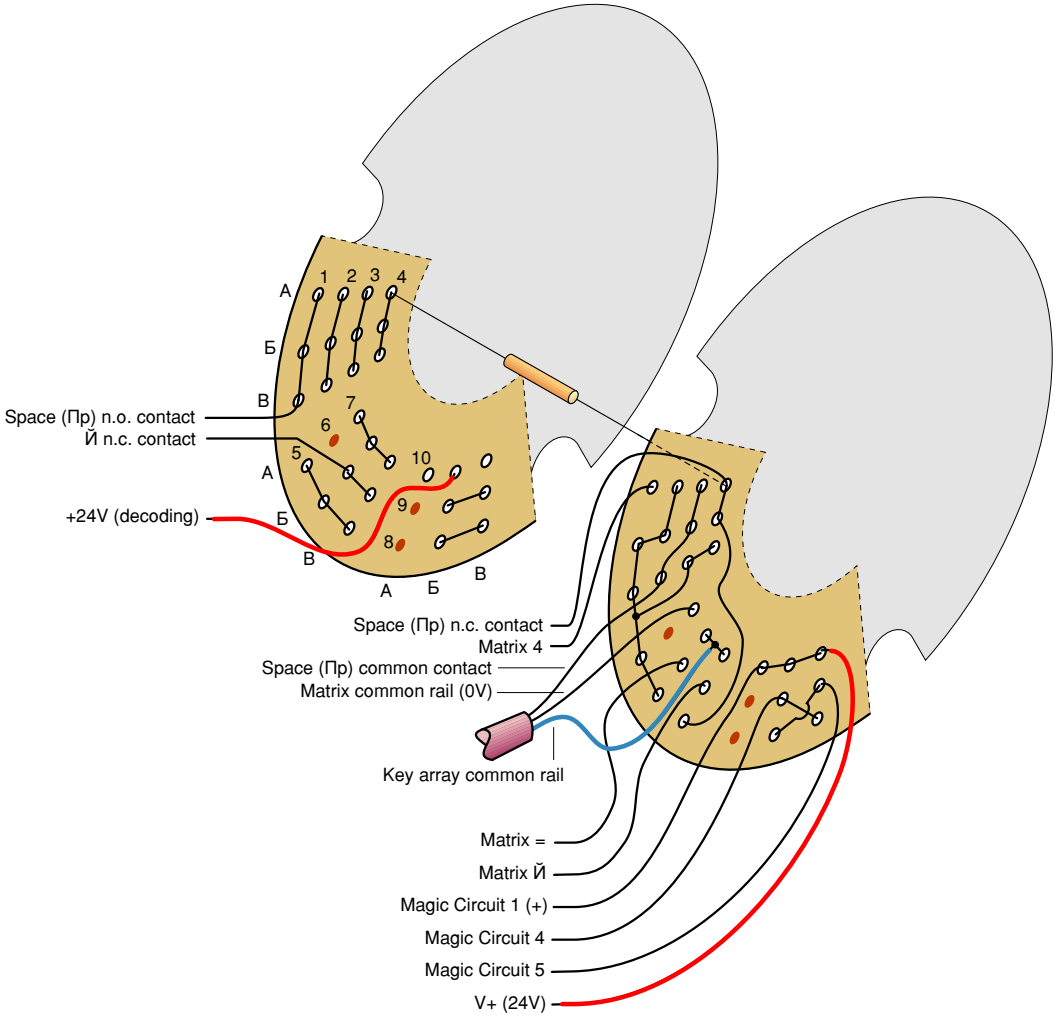
The right half of the assembly is occupied by the Magic Circuit (➔ 4.9). The lower left half contains the 10 switch units. The units are numbered from 1 thru 10, whilst the three stages are identified as A, Б and B (the Russian letters A, B and V). Each switch unit consists of two decks as can be seen in the drawing on the next page.

A set of wiper contacts can be moved between the two decks. Each wiper contact connects the right deck with the left deck. When moving the MODE switch from, say, *plain-text* to *decoding* mode, all wiper contacts are rotated around the axle of the switch, causing different pairs of contacts to be closed between the left and right decks.



Exploded view of the MODE switch

The drawing above clearly show the wiper contacts between the two decks. The switch is shown here in plain-text mode. The rows of contacts can be seen as the spokes of a wheel. The drawing below shows the internal connections of the two decks, as well as the external connections.



Wiring of the two decks of the MODE switch

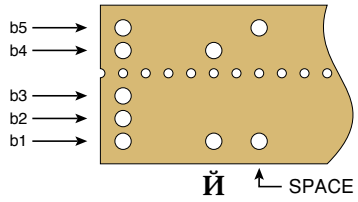
Circuit Diagram

Although the MODE switch appears to be very complex, it is in fact rather simple. The equivalent of the various wiper contacts is shown in the circuit diagram on the next page. The MODE-switch itself sits in the middle and consists of 10 simultaneously operated 3-stage switches. Inside the bakelite enclosure, a number has been molded into the bakelite, next to each *unit* of the switch, which is the same as the numbers shown in the circuit diagram. The three stages (plain-text, decoding and coding) are internally marked as А, Б and В.

Swapping the Й-key and the Space bar (Пр)

The top 6 units of the switch are used to cleverly swap the use of the space-bar and the Й key. When typing a message in *coding mode* (З) the space character is automatically converted to Й. This is necessary as only 30 characters can be used. The Й character is lost for this purpose. Whenever it occurred in Russian text, it was replaced by the similar И character. This method avoids the appearance of a space character in the coded output.

In *decoding mode* (Р) the space-bar is blocked. Й characters that appear in the coded message can be typed in by using the top left key on the keyboard. This will be converted back into a space character by swapping of bits 4 and 5 of the 5–bit data stream, *only* when this character is typed. Let's take a look at the paper-tape output:



Difference between Й and Space (Пр)

This illustration shows what happens when bits 4 and 5 are swapped. The letter Й is built-up by bits 1 and 4, whereas the space character (Пр) – which isn't part of the total set of 30 characters – consists of bit 1 and 5. So by swapping bit 4 and 5 this character is converted. For this reason both the Й-key and the Пр-key (space) are routed via the MODE switch.

Synchronisation pulse

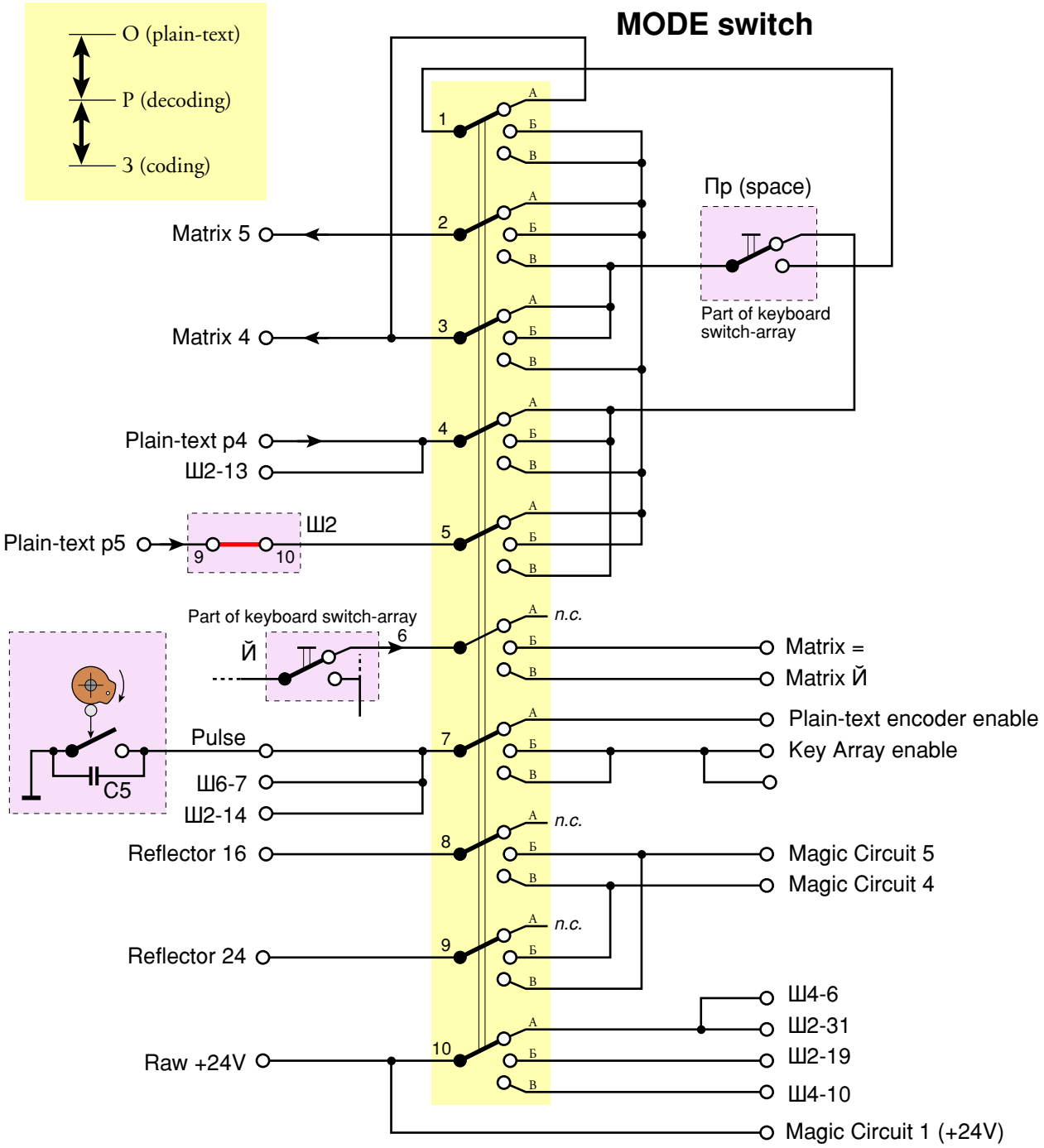
Unit 7 of the MODE switch controls the routing of the *pulse switch* which is mounted to the left side of the drum-mechanism. The switch is controlled by a rotating 'shaped' disc, which effectively creates a timing pulse to ensure synchronism between the mechanical and electrical parts of the Fialka. The electric current through the coding wheels is directly controlled by this pulse. Depending on the mode of operation, the switch drives either the keyboard switch-array or the plain-text encoder (under the keyboard).

Rotation of the Magic Circuit

Units 8 and 9 are a very important part of the Fialka as they control the Magic Circuit, which is in fact located inside MODE switch assembly. Three wires from the *reflector* are connected to the Magic Circuit, but two of these wires are routed via units 8 and 9 of the MODE switch. This way the rotating order can be reversed when changing from *coding* to *decoding* mode. More information in Chapter 4.9 – *The Magic Circuit.*

Power Supply

Unit 10 of the MODE-switch controls the supply voltage to the printer driver and the Magic Circuit. The Magic Circuit is always powered, whereas the control voltages on the printer connectors (Ш1 and Ш4) are switched, depending on the selected mode.

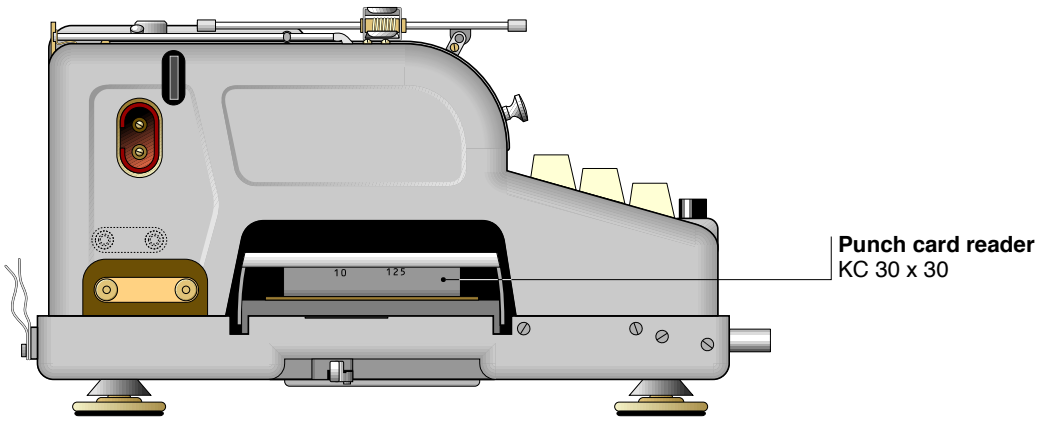


Circuit diagram of the MODE-selector

The dotted sections in the drawing above are not part of the MODE switch assembly. They are located elsewhere inside the Fialka, but they are shown here to clarify the use of this complex switch.

4.6 Card Reader

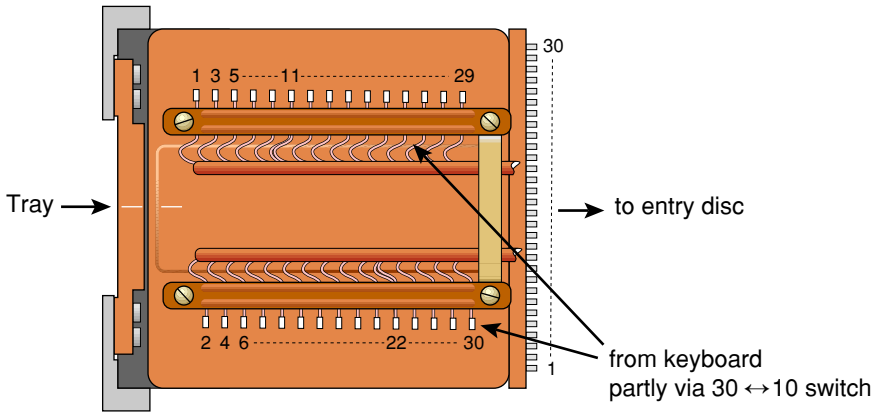
A card reader is present at the left side of the Fialka (➔ 3.6). It can be accessed by lowering a metal bracket and pulling out a drawer. When the drawer is fully pulled out, a punched card can be inserted. If such a card is not present, a triangular metal plate can be used for testing.



The card reader is in fact a 30 x 30 matrix, that allows pairs of letters to be swapped, just like the Steckerbrett of an Enigma does. If you think of the matrix as 30 rows and 30 columns, each punched card must have exactly one hole per row/column combination. Using the metal test-triangle results in the *identity matrix* to be used. This means that if the metal test-triangle is present, input 1 is connected to ouput 1, 2 is connected to 2, etc. Exact details about the sizes of they key card as well as the metal test triangle can be found in Chapter 5.9.

Without the test-trangle or a suitable punched-card present in the drawer, all 30 contacts will be shorted !

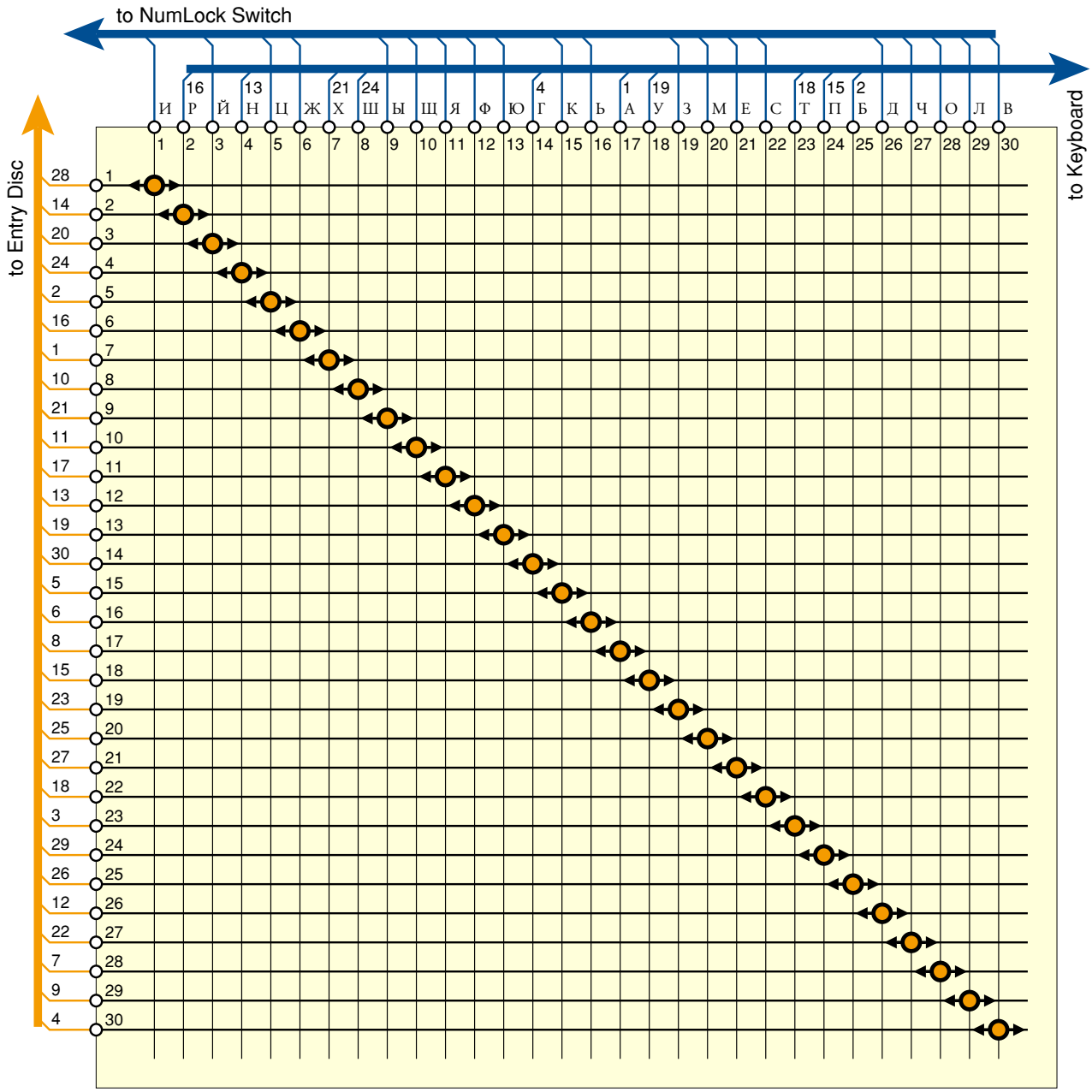
Looking at the card reader from the bottom shows two rows of 15 contacts each. We'll call this the *input* contacts. On the right is a single column with the 30 *output* contacts. The latter contacts are connected directly to the entry disc (➔ 4.7).



On the M-125, the keyboard is connected directly to the two horizontal rows of contacts (in the drawing above) of the card reader. On the M-125-3 however, only 10 keys are connected directly, whilst the other 20 are routed via the *NumLock* switch (➔ 4.8). When the NumLock switch is in the '30' position, the wiring is identical to the wiring of the M-125 and the substitution matrix between *keyboard* and *card reader* would be as follows:

Keyboard ➔ Card Reader																												
А	Б	В	Г	Д	Е	Ж	З	И	К	Л	М	Н	О	П	Р	С	Т	У	Ф	Х	Ц	Ч	Ш	Щ	Ы	Ь	Ю	Я	Й
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
17	25	30	14	26	21	6	19	1	15	29	20	4	28	24	2	22	23	18	12	7	5	27	8	10	9	16	13	11	3

The *card reader* itself is yet another substitution matrix. If *no* key card is present, the metal tirangle should be fitted to force the *identity matrix*. Each row in the card reader contains a switch that can be moved in position. When the drawer is closed, the holes in the card will move the switches into their position. Please note that a key card should have **exactly one hole** per row/column combination, as otherwise we would have a short circuit.



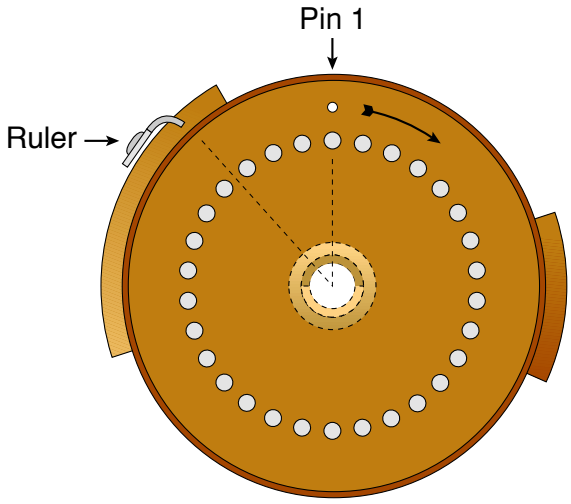
Circuit description

The card reader of the Fialka can be compared to the *Steckerbrett* (plug board) on the Enigma, which is used to swap pairs of letters. If A→B then B→A. The card reader on the Fialka however, is much more powerful than this. It could better be explained as a wheel with user-definable wiring, allowing a letter to be substituted by any other letter, e.g. A→B, B→C, C→X and X→A. The card reader greatly increases the maximum number of permutations, as it can be configured in 265 million-million-million-million-million different ways!

The contacts on the top are either connected to the keyboard (10 keys are wired directly) or to the NumLock switch. The character substitution, when the NumLock switch is in the '30' position, is listed just above the contacts. The contacts on the left are all connected to the *entry disc*, in a scrambled manner (➔ 4.7).

4.7 Entry Disc

The *Entry Disc* is a static bakelite disc with 30 contacts, to the right of the drum. The 30 contacts from the keyboard *Switch Array*, are routed via the *NumLock Switch* and the *Card Reader* to the entry disc. The entry disc forms the link between the static parts of the Fialka and the rotating drum. When looking at the entry disc from the right (i.e. from its soldering side), the pins are numbered clockwise starting with pin 1 at the top (marked with a white dot). Please note that pin 1 (at the top of the disc) is 3 positions away from the letter that is visible above the ruler.



The Entry Disc vieuwed from the right of the machine (soldering side)

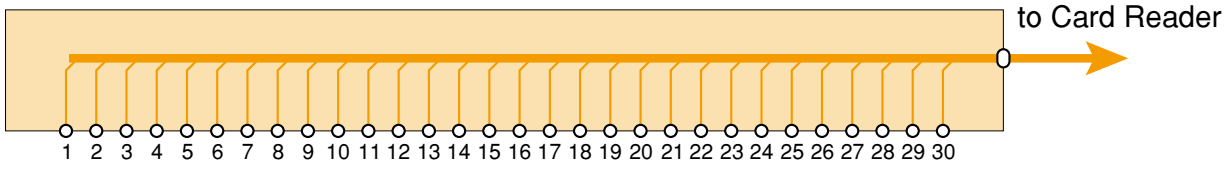
Substitution matrix

All contacts of the entry disc are connected to the card reader in a scrambled manner. The table below defines the substitution matrix between the *card reader* and the *entry disc*. Please note that the connections between the *keyboard* and the *card reader* are also scrambled (➔ 4.6 - *Card Reader*) and that the *key-card* itself adds another substitution.

Card Reader ➔ Entry Disc																											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
28	14	20	24	2	16	1	10	21	11	17	13	19	30	5	6	8	15	23	25	27	18	3	29	26	12	22	7	9	4

Circuit description

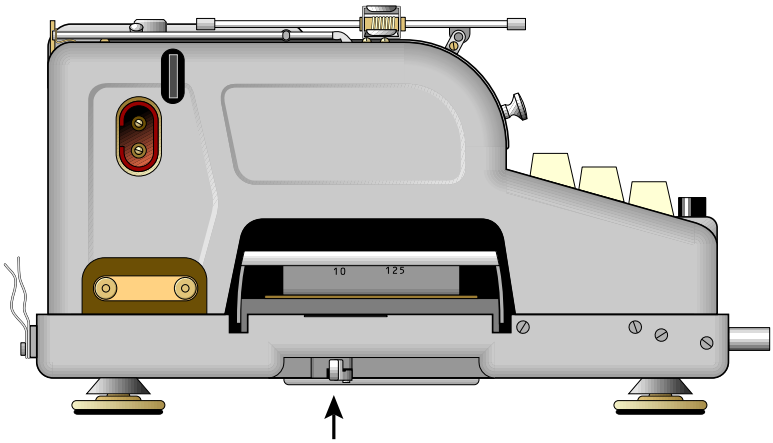
Not much can be said about the wiring of the entry disc. All 30 lines come directly from the card reader and are connected as listed in the table above.



Wiring diagram of the Entry Disc

4.8 NumLock Switch

This chapter is relevant for the M-125-3 machines only. The *NumLock* switch is a powerful but complex addition to the Fialka. It allows the machine to reduce the number of characters to just 10. This was used for numercially-coded or *pre-coded* messages. The switch is located at the left of the machine, below the card reader.

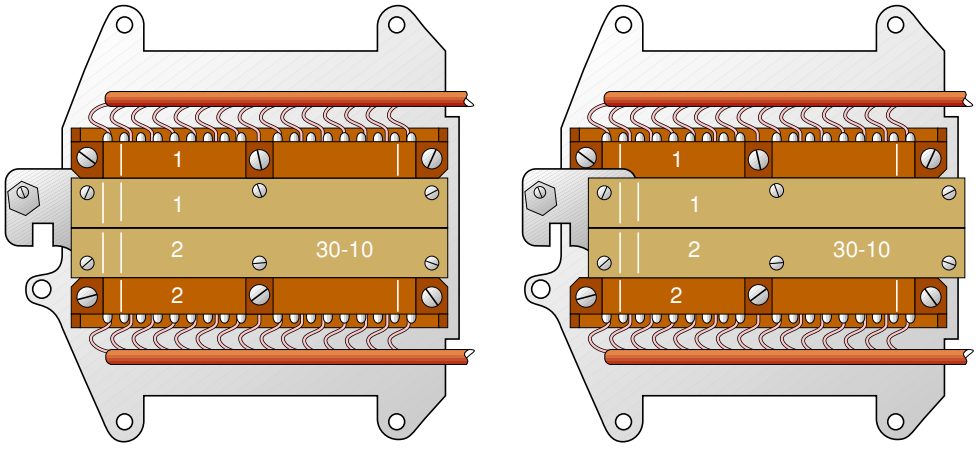




(1) Only the 10 keys with the coloured key caps (grey or blue) can be used. All other keys will be blocked mechanically. The 10 coloured keys are used to enter numerical data and the top left character on the key cap should be used. Please note that this mode of operation can only be used when the Cyrillic print head is present.



At the same time, two large switches are moved as shown below. The upper switch is marked '1' and the lower one is called '2'. The two yellow-ish bars, each containing a series of spring-loaded contacts, are moved in between two static brown bars. The drawing on the left shows the switch in the '30' position. The '10' position is shown on the right.



NumLock switch set to 30 NumLock switch set to 10

Circuit description

The circuit diagram on the next page shows how the *NumLock* switch is wired. It's a very complex part of the Fialka which can safely be ignored when the NumLock switch is set to the '30' position. The switch itself consists of two parts, which are visible at the heart of the circuit diagram. Both switches are moved together when altering the setting of the NumLock lever at the left of the machine, and they are shown here in the '30' postion. The upper switch is marked '1' and the lower one is marked '2'.

Setting NumLock to '30'

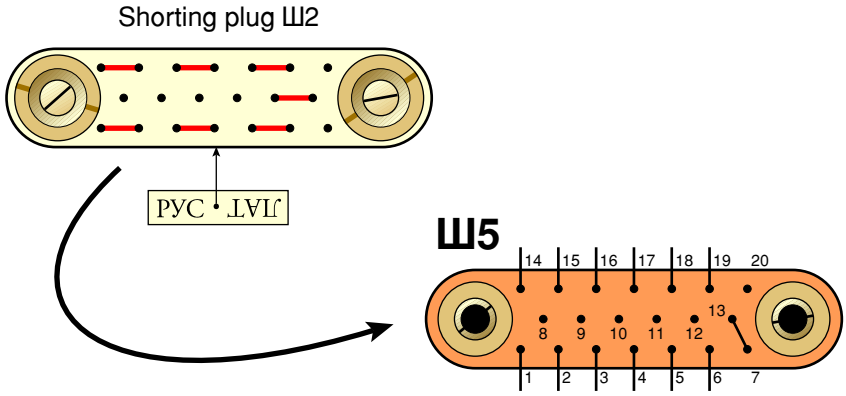
In '30' mode, all connections are made as shown in the circuit diagram. The 20 wires from the reflector are connected together in pairs, producing a *reflector* identical to the one used in the Fialka M-125 machines. Furthermore 20 lines from the *keyboard* are connected to 20 input contacts of the *card reader*. There are no direct connections between the reflector and the card reader in this mode.

Setting NumLock to '10'

When the lever of the NumLock switch is set to the '10' position, both switches move one contact to the right, which effectively changes the entire wiring of the Fialka. All 20 lines from the keyboard will be disconnected; they are not used in this mode. Furthermore, the 20 lines from the reflector are now directly connected to the 20 inputs of the card reader that were previously used by the (now dead) 20 keyboard lines.

Connector Ш5

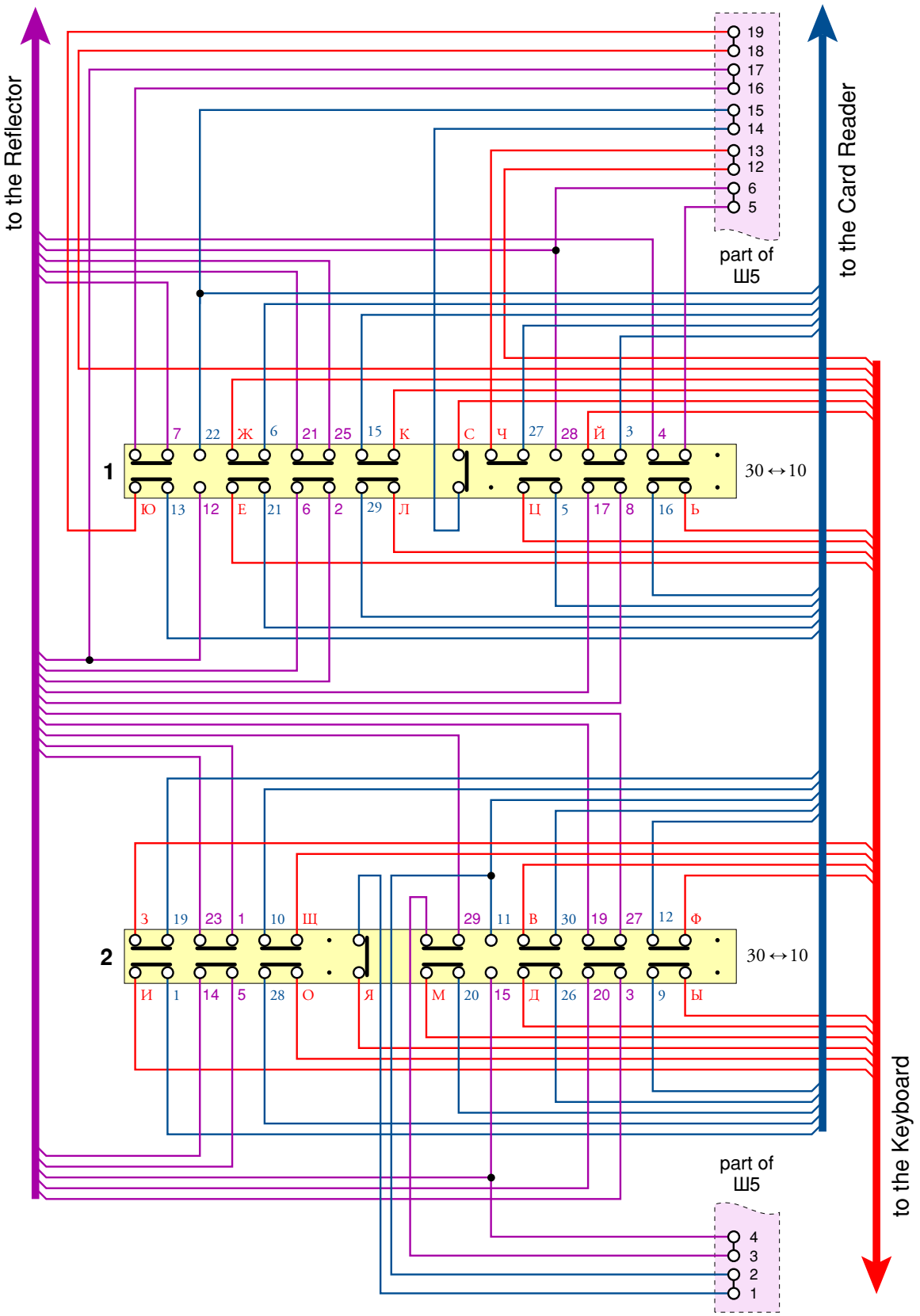
To add to the confusion, some wires are routed via a shorting connector Ш5, which is located on the left side of the machine, just above the test-connector Ш2. This connector can only be accessed when the cover is removed. A shorting plug **must** be present in this connector. The plug is fixed in position with two small bolts, making it a semi-permanent configuration. Whithout this shorting plug, the Fialka cannot be used.



The exact purpose of this connector is currently unknown, but it seems to allow the use of an alternative keyboard (possibly a Latin-only keyboard), as the shorting plug is marked with the two words РУС (Russian) and ЛАТ (Latin). One of these words is printed upside down and the shorting plug can be fitted either way around. To date, we've only seen machines that had the plug inserted as shown here: with the word РУС readable.

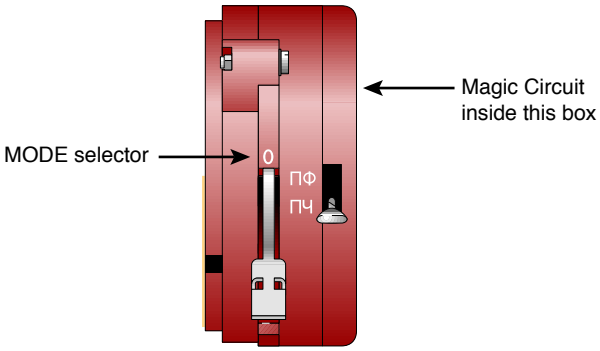
Inserting the connector the other way around (i.e. so that the word ЛАТ is readable) reduces the number of contacts to 26 (rather than 30), which suggests the use of the Latin alphabet. The remaining 4 contacts are looped back to the card reader. Note that the contacts 7 and 13 are permanently shorted on the connector itself. Additional information about the wiring of this connector is available in Chapter 4.13 – Connectors.

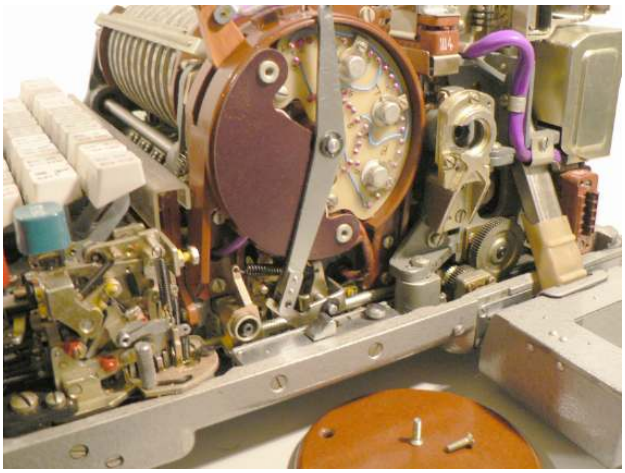
All alphabet substitutions given in this manual are with the shorting plug Ш2 in the position shown here (РУС).


to the Reflector
to the Card Reader
to the Keyboard
part of Ш5
part of Ш5
19
18
17
16
15
14
13
12
6
5
1
7 22 Ж 6 21 25 15 К С Ч 27 28 Й 3 4
Ю 13 12 Е 21 6 2 29 Л Ц 5 17 8 16 Ь
30 ↔ 10
2
З 19 23 1 10 Ш 29 11 В 30 19 27 12 Ф
И 1 14 5 28 О Я М 20 15 Д 26 20 3 9 Ы
30 ↔ 10
4
3
2
1

4.9 Magic Circuit

Like on the Enigma, the *reflector* of the Fialka connects pairs of wires together. When a current hits one contact, it will be reflected back into the drum via the other one and vice versa. Many people have tried to measure the loops in the Fialka's reflector, but to no avail. 26 Contacts are connected together in pairs, just like you would expect, but there are 4 'special' wires that seem to go nowhere. For a long time the purpose of these 4 'special' wires has been unknown. Unlike the other 26 wires, they are not connected in pairs. Instead they are all connected to an electronic circuit that is located inside the large red 'blob' to the right of the drum. We've named it the 'Magic Circuit'.



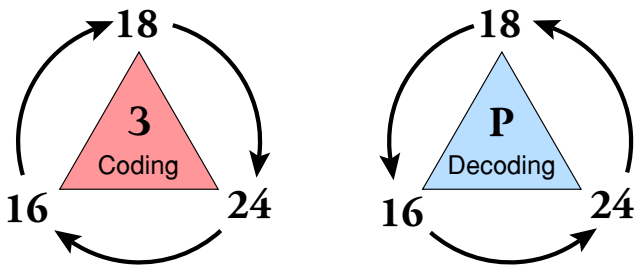


Inside the MODE switch assemby is a circuit board with 3 transistors and 7 diodes and it took us a little while to understand their operation. It is in fact a smal circuit, consisting of 3 transistors and 6 diodes, plus a single diode. The single diode is not connected to the rest of the circuit at all. All 4 'special' wires from the reflector go to this circuit board.

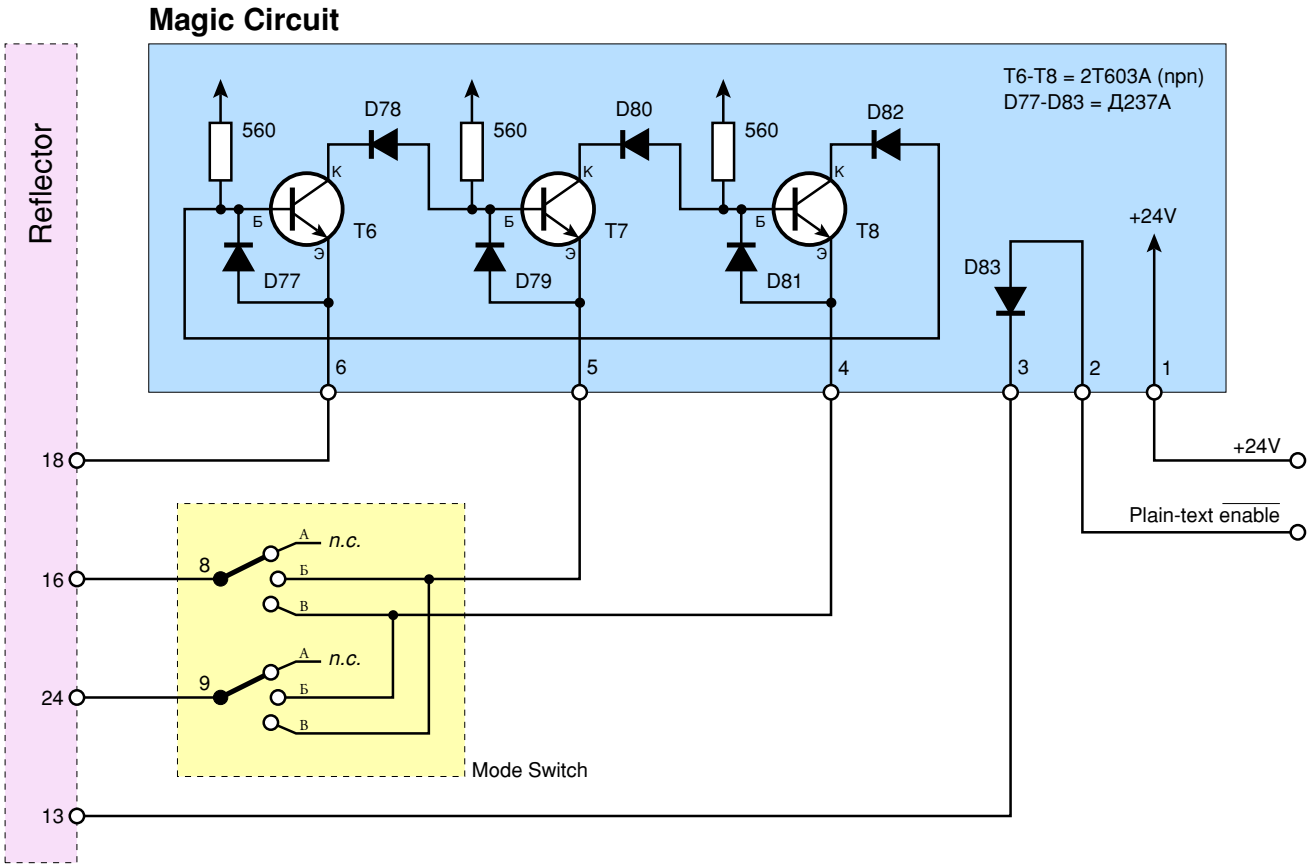
One wire of the reflector (13) is connected only to a diode that is in turn connected to the mechanical 5-bit plain-text encoder (under the keyboard). This line is used to override the coded letter and replace it with the original letter. When the current (through the drum) reaches pin 13 of the reflector, no signal is returned and the plain-text letter is used instead. This results in a 1:30 chance for a letter to be enciphered as itself.

The problem is now that we're left with an odd number of wires, making it impossible to create pairs. They could, of course, have used *two* wires to override the diode matrix, but that would have doubled the chance of a letter becoming itself, which was probably regarded as a cryptologic risk. So, they came up with a clever solution.

The other 3 wires are connected to a transistor circuit, that can best be described as a rotational switcher. When a current hits pin 18 of the reflector in Coding mode (3), it will be returned via pin 24. However, when the current hits pin 24, it will be reflected via pin 16. Finally, if the current comes in at pin 16, the return path will be via pin 18.



This rotational switching has the side-effect that the Fialka loses its reciprocity. However, the solution is equally simple. Pin 16 and 24 are routed via the MODE switch and are swapped in decoding mode (P). This results in the triangle rotating in reverse direction, wich effectively reverses the non-linearity of the above process. The drawing above shows the translation sequence for both Coding (3) and Decoding (P) mode.



Circuit description

The circuit diagram of the Magic Circuit is given above. Three similar circuits, based around T6, T7 and T8, are cascaded. The output of each stage is connected to the input of the next one, via a diode. The output of the third stage (T8) is looped back to the input of the first stage (T6). This results in a **binary circulator**. All three lines (pins 4, 5 and 6 of the Magic Circuit) can be *inputs* as well as *outputs*.

Pin 18 of the reflector is connected directly to pin 6 of the Magic Circuit. Pins 16 and 24 of the reflector are routed via unit 8 and 9 of the MODE switch. In plain-text mode (switch to A) they are left unconnected. In Decoding mode (switch to Б) pin 16 of the reflector is connected to pin 5 of the Magic Circuit and pin 24 of the reflector goes to pin 4 of the Magic Circuit. In Coding mode (switch to B) reflector pins 16 and 24 are swapped.

When pin 5 of the Magic Circuit is pulled *low* by a current from pin 18 of the reflector, the NPN transistor T6 will conduct as it's base is pulled high by the 560 ohm resistor. As a result, the collector of T6 will be pulled low, which also pulls the base of T7 low. T7 will therefore not conduct and the diode (D79) will pull the emitter down. So, pin 5 will be *low* (i.e. the signal from pin 6 is 'reflected' via pin 5). As T7 is not conducting, the base of T8 will be high, so T8 will be conducting, resulting in a *high* on pin 4.

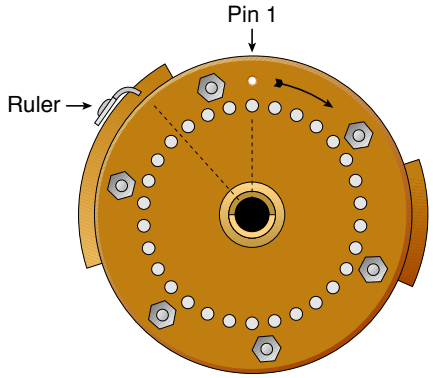
As the end of the circuit (D82) is looped back to the beginning, the above is true for any of the three lines. In other words: a *low* on line **n** will result in a *low* on line **n+1** and a *high* on the remaining line.

Diode D83 is not connected to the rest of the circuit. It is probably only part of the Magic Circuit for convience of wiring. The cathode of D83 is connected to pin 13 of the reflector. When this line is driven *low*, it pulls the *plain-text enable* line of the mechanical 5-bit encoder (under the keyboard) *low*, which will cause the plain-text 5-bit code to override the diode matrix. As no signal is returned into the drum, this doesn't interfere with the rest of the diode matrix. It is *this* signal that can cause a letter to be enciphered as itself.

4.10 Reflector

The reflector plays an important role in the Fialka's secrets. Like on the Enigma, it is used to 'reflect' a current back into the drum, which would make the process of enciphering a reciprocal operation. However, unlike the Enigma, a letter can be enciphered as itself. As we've seen in the previous chapter, this was done by taking 4 wires out of the reflector into the Magic Circuit. The remaining 26 contacts are paired together as one would expect. Due to the 4 'special' wires, the Fialka partly loses its reciprocity.

The reflector is a static bakelite disc with 30 contacts, to the left of the drum. Its pins are defined in the drawing below. Looking at the reflector from the right (i.e. from the entry disc), the pins are numbered clockwise, starting with the pin at the top (marked with a white dot). Please note that this is 3 positions away from the letter that is visible above the ruler.



Circuit description

Two circuit diagrams are presented on the next page. The upper one is the reflector of the M-125. Only the 4 'special' wires are taken out of the reflector, whilst the remaining 26 contacts are paired together internally. On the M-125-3 however, only 6 pins are internally paired, whilst the remaining 20 are taken out (as two bundles of 10 wires each) to the NumLock switch.

When the NumLock switch is set to '30', the reflector behaves exacly like the reflector of an M-125 (top). When set to '10' however, the keyboard allows only 10 keys to be used and the 20 'exported' pins are re-routed towards the card reader, using the lines of the unused letters. This way, the unwanted contacts are looped back to the input circuit, until they finally produce a usable result.

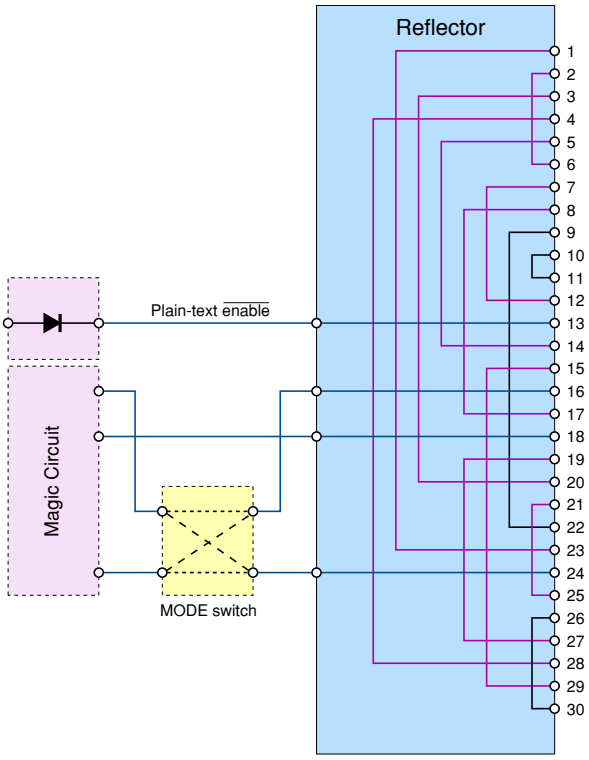
Substitution matrix

The substitution matrix of the reflector in *coding* mode is different from the one in *decoding* mode. This is caused by the triangular rotation of the Magic Circuit. For this reason, we've defined a different matrix for each mode:

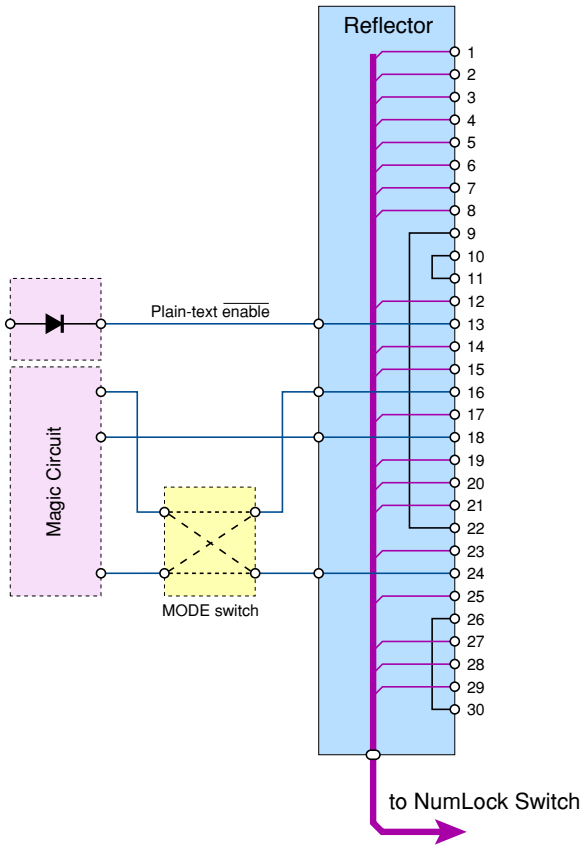
	Reflector in Coding mode (3)																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Coding (3)	23	6	20	28	14	2	12	17	22	11	10	7	13	5	29	18	8	24	27	3	25	9	1	16	21	30	19	4	15	26
Decoding (P)	23	6	20	28	14	2	12	17	22	11	10	7	13	5	29	24	8	16	27	3	25	9	1	18	21	30	19	4	15	26
Plain text (O)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

Please note that contact number 13 is always translated to 13. This means that this contact will cause a letter to be enciphered as itself. Although this is electrically impossible inside the Fialka, it *is* in fact what is happening from a mathematical point of view. This substitution matrix would also work correctly in a computer simulation. Also note the non-reciprocal substitution of contacts 16, 18 and 24, caused by the Magic Circuit.

The bottom row of the table, shows the substitution matrix for *plain-text* mode which is, of course, the identity matrix.



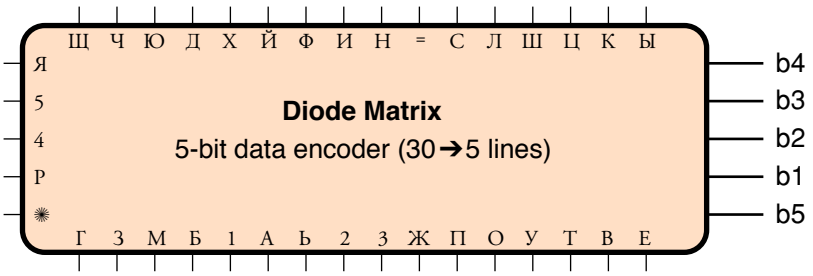
Reflector of the Fialka M-125



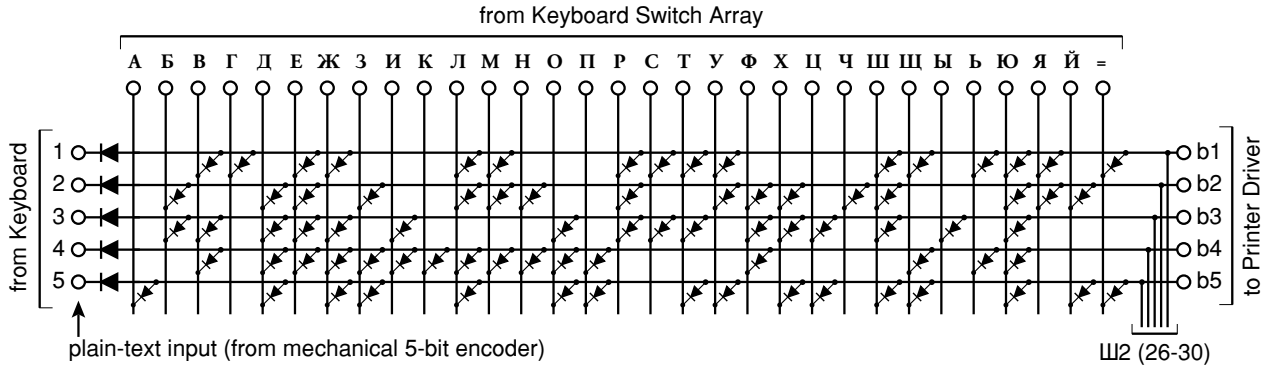
Reflector of the Fialka M-125-3

4.11 The 5-bit Encoder (Diode matrix)

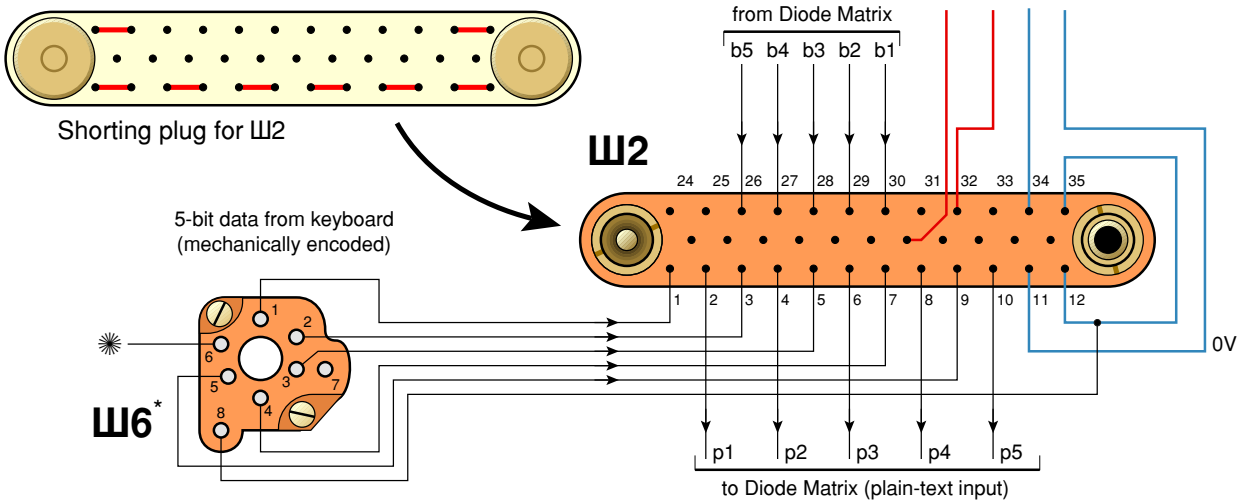
The enciphered letter (i.e. the signal returned from the coding path) is converted into a digital 5-bit code by a diode matrix. This 5-bit encoder is located at the underside of the wheel stepping mechanism. It can only be accessed by taking the entire Fialka machine apart. The diode matrix is contained in a small bakelite box with connections on all sides. The layout of these connections are as follows:



There are markings on the sides of the bakelite box, similar to the ones in the drawing. The 5 data outputs (b1 - b5) are on the right. The other pins are all inputs, with the exception of the bottom pin of the left side. It is marked here as ✺, but has no marking on the actual box. It is not really part of the diode matrix, but it holds the common rail of the mechanical 5-bit encoder that that is part of the keyboard. This line is driven *low* by pin 13 of the reflector, which causes the mechanical encoder to override the matrix (i.e. cause a letter to be enciphered as itself). Five lines on the box are marked with the numbers 1, 2, 3, 4 and 5. These are the inputs of data from the keyboard's mechanical 5-bit encoder. The line marked with the '=' sign is used to create the *space* character. The circuit diagram is shown here:



In reality they've cheated a little bit, by combining diodes between similar letters. This was probably done to reduce the number of diodes, making assembly of the encoder easier and cheaper. The functionality of the above circuit is however identical. The connections on the left (1-5) are used to feed the 5-bit data directly from the keyboard. This data is passed via connector Ш6 (top-left of the keyboard) and the test-connector Ш2.



*) Pin 7 and 8 of Ш6 are not available on the M-125 models.

4.12 Printer Driver

Introduction

The diode-matrix is used to translate the 30 letter-signals into a digital 5-bit code. This is not the standard Baudot code, commonly used on teletype equipment, but rather an internal code (➔ Chapter 3.5 – *The digital 5-bit code*). Five outputs from the diode matrix (b1-b5) are used to drive the printer and the paper-tape puncher, using the driver circuit shown here.

Circuit description

On the left is the 5-bit input (b1-b5). Each bit is used to drive a solenoid that actually punches a hole in the paper tape. The driver is a typical open-collector circuit. The input signal (b1) is fed through a 560 ohm resistor to the base of a PNP transistor (T1). When the input goes *low*, the transistor starts conducting and +24V will be applied to the Solenoid (s1). The diode (D70) will protect the transistor against any reverse current induced by the solenoid.

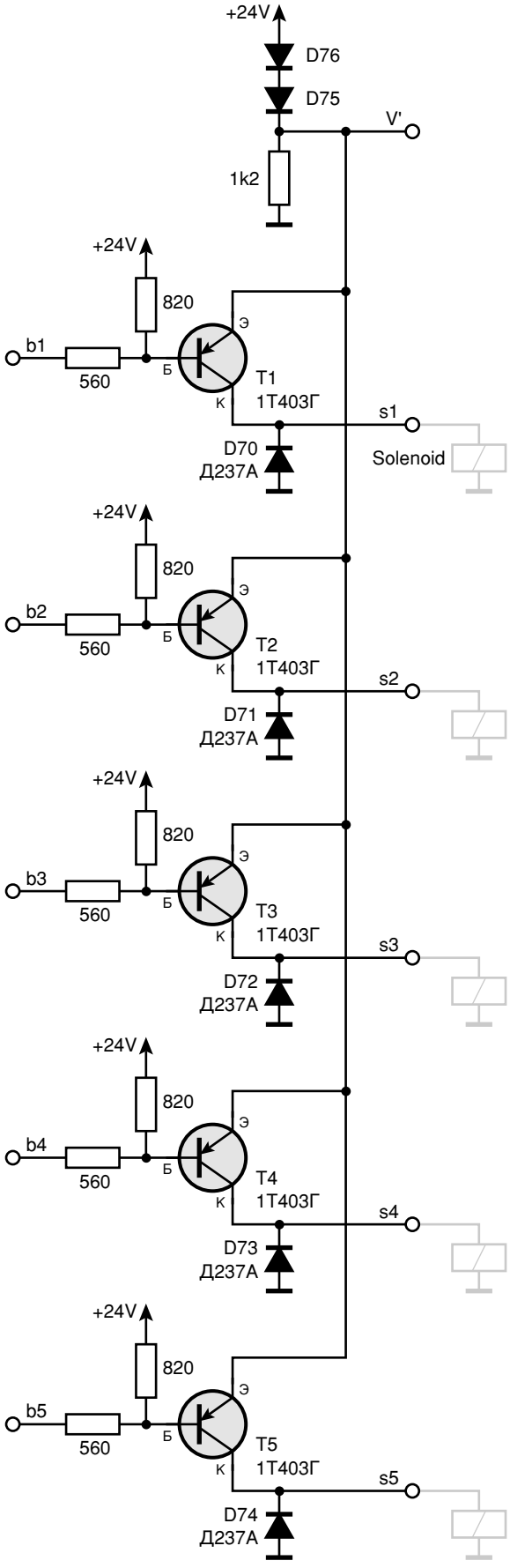
The small power circuit at the top (D76, D75 and the 1k2 resistor) is in fact a protection against reverse polarity of the power supply. As the old-fashioned Germanium-type diodes were of rather poor quality in those days, two diodes have been used in series in order to survive the 24V in reverse.

Mechanical latch

The solenoids directly operate the 5 needles of the paper-tape puncher. Once the solenoids are activated, they are latched mechanically, to allow the printer to stop at the correct letter and engage the hammer, so that the letter is printed onto the paper-tape.

Data output

The output from the Printer Driver is also available on connector Ш4 (on the right of the Fialka) which can be used to connect the Fialka to a modem or radio set. Details about the pinout of this connector can be found in chapter 4.13.



Б = Base
К = Collector
Э = Emitter

4.13 Connectors

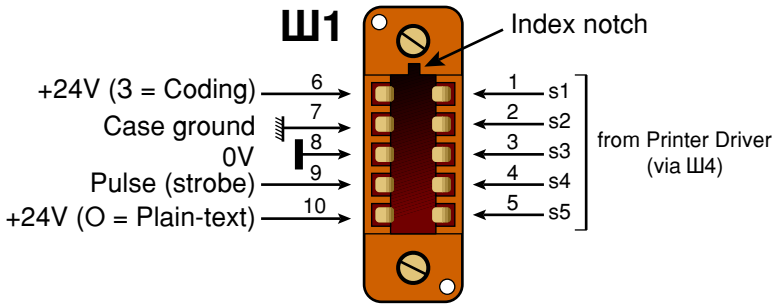
This chapter provides detailed wiring information about each of the connectors of the Fialka. Some of these connectors can be accessed from the outside, but others are used internally to connected the various parts of the machine together. All connectors are marked with the Russian **Ш** symbol, which is the abbreviation of **Штепсель** (socket) or **Штеккер** (plug). Please note that some connectors are only available on the later M-125-3 models. The following connectors are available:

Connector	Function	M-125	M-125-3
Ш1	Printer input	✓	✓
Ш2	Test connector with shorting plug		✓
Ш3	Power input connector	✓	✓
Ш4	RTTY output connector	✓	✓
Ш5	Configuration plug Russian/Lantin (РУС/ЛАТ)		✓
Ш6	Keyboard (mechanical) 5-bit encoder output	✓	✓
Ш7	Internal power connector	✓	✓
Гн1	Last character repeat input		✓

Overview of the various connectors of the Fialka

Ш1 - RTTY output connector

The wiring of this connector is in fact identical to the wiring of Ш4 (shown below). It is connected to the output of the Printer Driver circuit (➔ 4.12), but only when plug Ш4 is fitted to connector Ш4 (which is normally the case). Ш1 is a 10-way socket, consisting of two rows of contacts with a spacing of 4 mm.

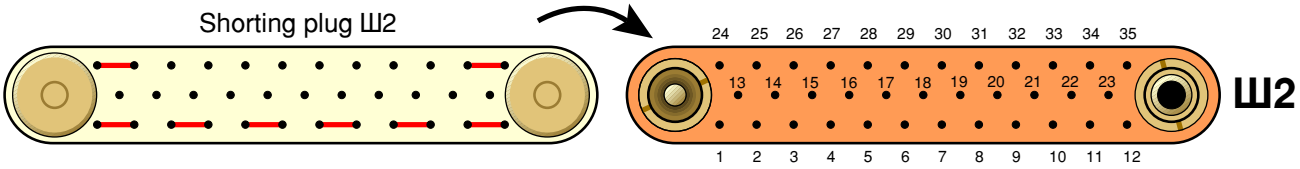


Pin-out of connector Ш1

Pin	Description	Original name
1	Data bit 1	Channel 1
2	Data bit 2	Channel 2
3	Data bit 3	Channel 3
4	Data bit 4	Channel 4
5	Data bit 5	Channel 5
6	+24V when MODE-selector is set to O (plain text)	+24V
7	Case ground (earth)	
8	0V	-24V
9	Pulse (strobe signal)	NM
10	+24V when MODE-selector is set to 3 (coding)	+24V

Ш2 - Test connector with shorting plug (M-125-3 only)

This connector is only available on the later M-125-3 models. It consists of 35 contacts, divided over three rows, and connects to many parts inside the Fialka. Due to the nature of the signals available on this connector, it is assumed that this connector was introduced for test and alignment procedures.

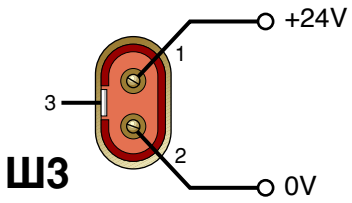


Connector Ш2 and the shorting plug

Pin	Description	Connected to
1	Keyboard mechanical encoder output bit 1	Ш6-1
2	p1 - diode matrix external input bit 1	Diode matrix - 1
3	Keyboard mechanical encoder output bit 2	Ш6-2
4	p2 - diode matrix external input bit 2	Diode matrix - 2
5	Keyboard mechanical encoder output bit 3	Ш6-3
6	p3 - diode matrix external input bit 3	Diode matrix - 3
7	Keyboard mechanical encoder output bit 4	Ш6-4
8	p4 - diode matrix external input bit 4 (via D84)	Diode D84-Kathode
9	Keyboard mechanical encoder output bit 5	Ш6-5
10	p5 - diode matrix external input bit 5 (via MODE)	MODE 5-common
11	0V	Ш7-2
12	0V shorting loop / Auto-repeat solenoid GND	Ш6-8
13	Bit 4 swap	MODE 4-common
14	Pulse (strobe, timing)	ИГ common
15	*no connection*	
16	Ground	Chassis
17	*unknown*	???
18	Auto-repeat solenoid signal	Ш6-7 / Гн1
19	+24V when in decoding mode (P)	MODE 10-Б
20	Key array enable (key array common rail)	MODE 7-Б
21	no connection	
22	no connection	
23	no connection	
24	Plain-text $\overline{\text{enable}}$	Ш6-6 / MODE 7-A
25	Character translates into itself	Diode D83-Anode
26	5-bit Printer Encoder bit 5	Diode matrix b5
27	5-bit Printer Encoder bit 4	Diode matrix b4
28	5-bit Printer Encoder bit 3	Diode matrix b3
29	5-bit Printer Encoder bit 2	Diode matrix b2
30	5-bit Printer Encoder bit 1	Diode matrix b1
31	+24V when in plain-text mode (O)	MODE 10-A
32	+24V (raw)	Ш7-4
33	V+	Diode D75-Kathode
34	0V	Ш7-3
35	*hard wired to pin 12* (solenoid GND)	Ш6-8

Ш3 - Power input connector

This connector is located at the left of the Fialka. It is used to feed 24V DC to the machine and is part of the Power Module (➔ 4.3). The connector consists of two connect pins (used for + and – 24V) and a contact strip (ground). The ground strip also acts as a polarity index; it ensures that the plug (➔ 5.2) cannot be inserted the wrong way around.

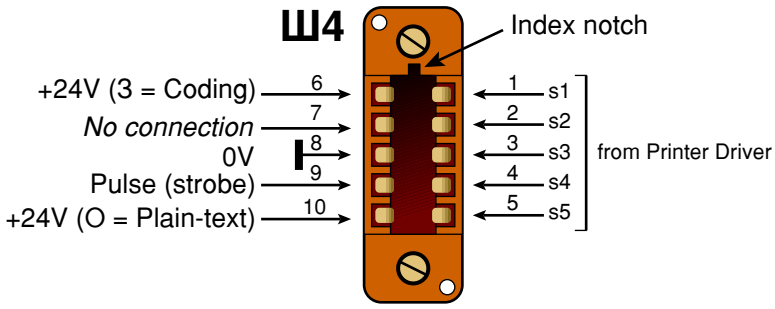


Pin-out of connector Ш2

Pin	Description	Connected to
1	+24V	C1
2	0V	C2
3	Ground	Chassis

Ш4 - Printer driver output

This connector is used to connect the output of the printer driver (➔ 4.12) to the input of the printer mechanism. It can be found behind the large bakelite mode switch on the right of the Fialka and allows the entire printer mechanism to be removed for service and repair. Ш4 is a 10-way connector/socket pair, consisting of two rows of contacts with a spacing of 4 mm.



Pin-out of connector Ш4

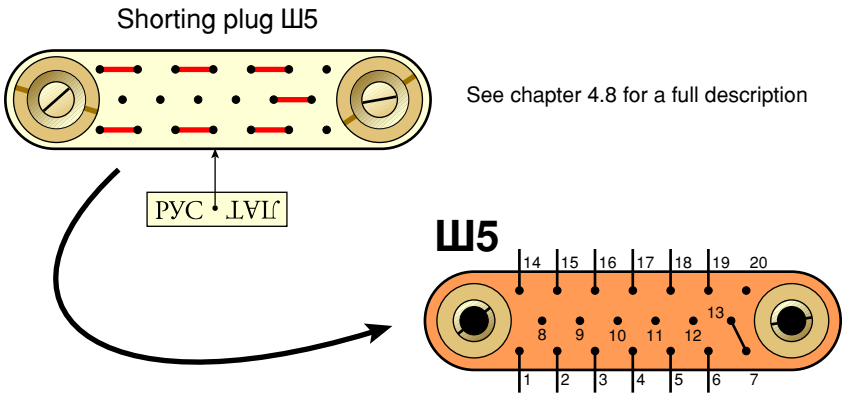
Pin	Description	Original name
1	Data bit 1	Channel 1
2	Data bit 2	Channel 2
3	Data bit 3	Channel 3
4	Data bit 4	Channel 4
5	Data bit 5	Channel 5
6	+24V when MODE-selector is set to O (plain text)	+24V
7	*No connection*	
8	0V	-24V
9	Pulse (strobe signal)	NM
10	+24V when MODE-selector is set to 3 (coding)	+24V

Ш5 - Configuration plug РУС/ЛАТ (M-125-3 only)

This connector is only available on the later M-125-3 models. It allows the machine to be changed from a *dual-alphabet* machine (i.e. Russian and Latin) into a *single-alphabet* machine (i.e. Latin-only).

The wiring of this connector is fully shown in chapter 4.8 – *NumLock switch*. It changes the way in which the NumLock switch – and therefore indirectly the card-reader and the reflector – are wired. Please note that the shorting plug Ш5 **must** be present in this connector for a correct operation of the Fialka. When set to РУС it allows normal operation with all 30 contacts of the wheels used. When set to ЛАТ however, the number of contacts is reduced to just 26.

This suggests that a Latin-only version of the Fialka was anticipated at some stage, although no proof has been found that the machine was ever configured this way (see also chapter 4.8 – NumLock Switch).

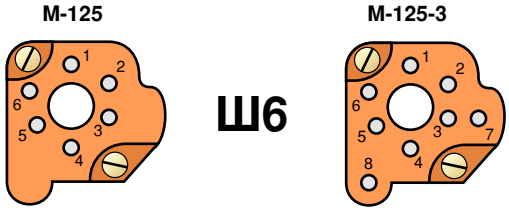


Pin-out of connector Ш5

Pin	NumLock set to 30	NumLock set to 10
1	Keyboard Array Я	*no connection*
2	Card Reader input 11	Card Reader input 11 / Reflector 29
3	Reflector 29	*no connection*
4	Reflector 15	Reflector 15 / Card Reader input 20
5	Reflector 4	*no connection*
6	Reflector 28	Reflector 28 / Card Reader input 27
7	*no connection*	*no connection*
8	*no connection*	*no connection*
9	*no connection*	*no connection*
10	*no connection*	*no connection*
11	*no connection*	*no connection*
12	Keyboard Array Ч	Keyboard Array Ч
13	Card Reader input 27	*no connection*
14	Keyboard Array С	*no connection*
15	Card Reader input 22	Card Reader input 22 / Reflector 7
16	Reflector 7	*no connection*
17	Reflector 12	Reflector 12 / Card Reader input 13
18	Keyboard Array Ю	Keyboard Array Ю
19	Card Reader input 13	*no connection*
20	*no connection*	*no connection*

Ш6 - Keyboard (mechanical) 5-bit encoder output

This connector is used to connect the electric parts of the keyboard to the rest of the Fialka. The connector is located to the left of the keyboard and is part of the Key Switch Array assembly. It carries the data signals from the mechanical 5-bit encoder and the *plain-text enable* and *auto-repeat* signals to the keyboard. Please note the different pin layouts between the M-125 and the M-125-3 models. Pin 7 and 8 (used for the *auto-repeat* signal) are only available on the M-125-3.

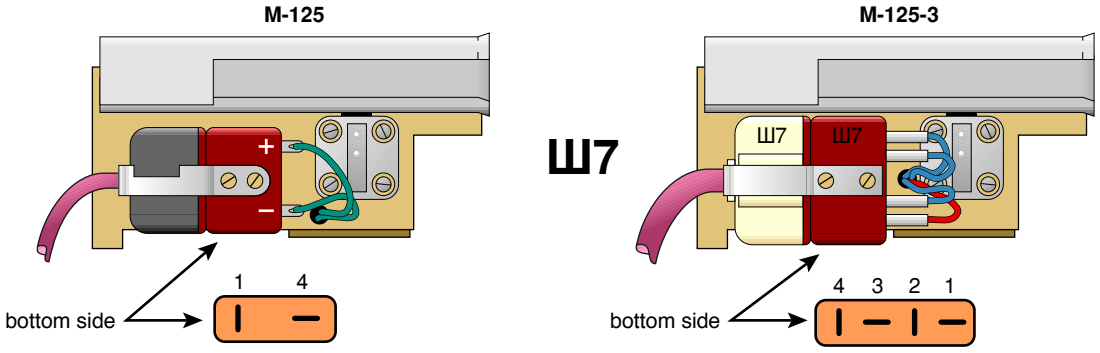


Pin-out of connector Ш6 of both the M-125 and the M-125-3

Pin	Description	Connected to
1	Mechanical 5-bit encoder, bit 1	Ш2-1
2	Mechanical 5-bit encoder, bit 2	Ш2-3
3	Mechanical 5-bit encoder, bit 3	Ш2-5
4	Mechanical 5-bit encoder, bit 4	Ш2-7
5	Mechanical 5-bit encoder, bit 5	Ш2-9
6	Plain-text enable	Ш2-24
7	Last character repeat input	Гн1 / Ш2-18
8	0V (used for *last-character-repeat* solenoid)	Ш2-12 / Ш2-35

Ш7 - Internal power connector

This connector is mounted to the front of the *Power Module* at the left rear. It is used to connect the *Power Module* to the rest of the Fialka. On the M-125, this connector only carries 2 pins, whereas on the M-125-3 it has 4 pins. The latter was done to allow a test device to be connected to the test-connector Ш2, which could then interrupt the power supply and measure the total current taken up by the machine.

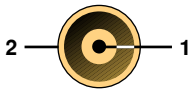


Pin-out of connector Ш7 of both the M-125 and the M-125-3

Pin	Description	Connected to
1	0V (fused, 3A)	Common 0V rail
2	0V (raw) interrupted by Ш2 (M-125-3 only)	Ш2-11
3	0V (raw) from power input connector Ш3-2	Ш2-34
4	+24V (raw)	Raw 24V rail

Гн1 - Last character repeat input (M-125-3 only)

This connector is only available on the later M-125-3 models. It is somewhat hidden at the right of the machine, to the left of the 5-letter group switches. This coaxial-type connector has two contacts. The center contact is connected to the + terminal of the *repeat*-solenoid under the keyboard. The outer ring is connected to the common 0V rail of the machine. Both contacts are routed via pins 7 and 8 of Ш6. When a short 24V pulse is applied to pin 1, the last character that was typed on the keyboard will be repeated.

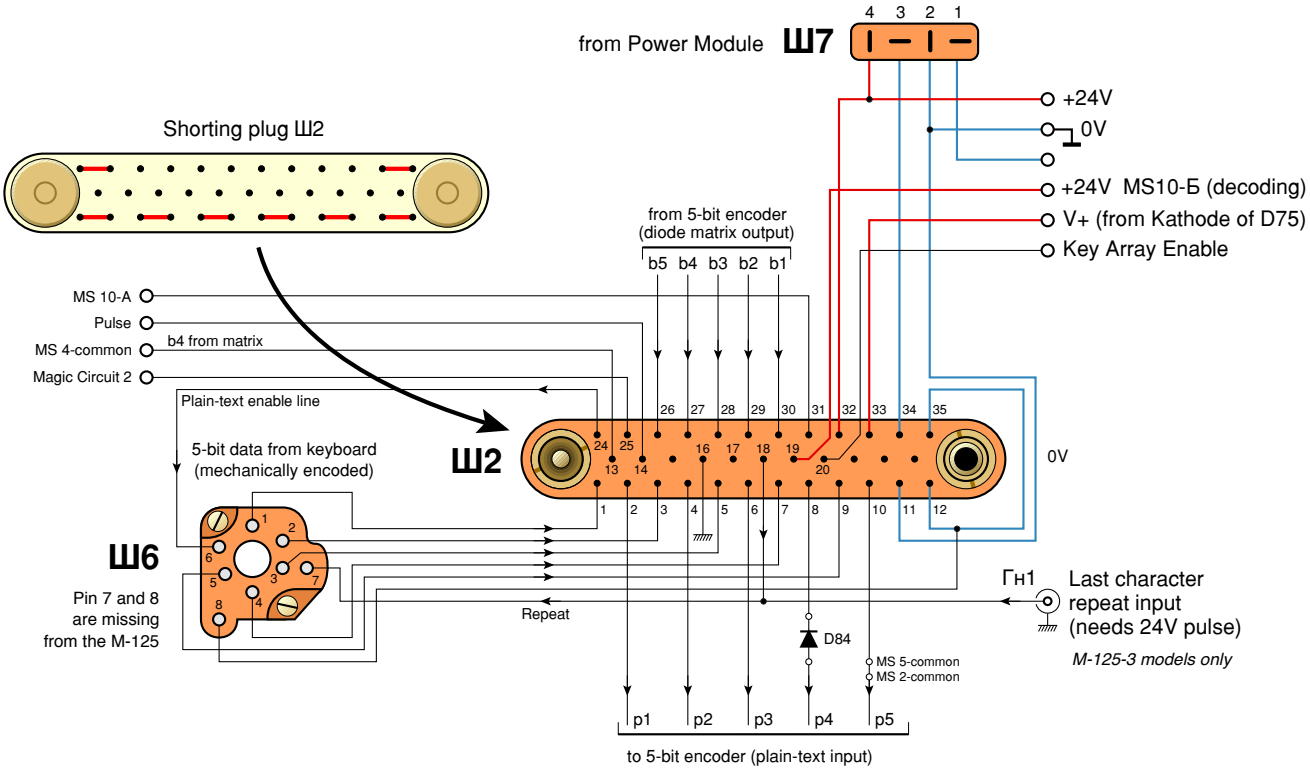


Pin-out of connector Гн1 on the M-125-3

Pin	Description	Connected to
1	+24V pulse input	Ш6-7 / Ш2-18
2	0V (common 0V rail)	Ш6-8

Relation between Ш2, Ш6, Ш7 and Гн1

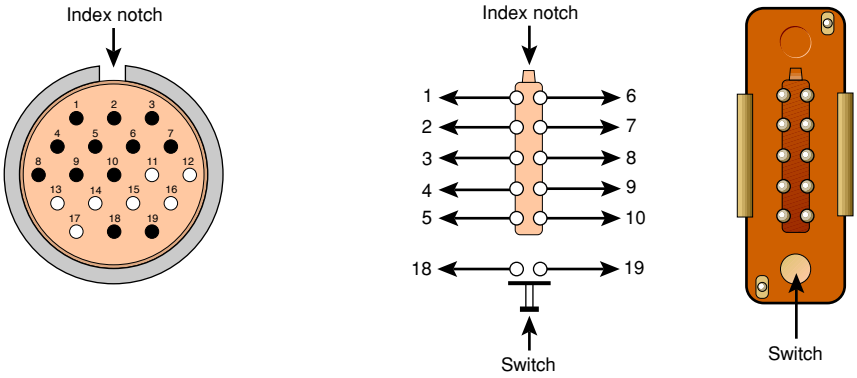
The drawing below has been extracted from the full circuit diagram of the Fialka. It shows how the connectors Ш2, Ш6, Ш7 and Гн1 are connected together. Please note that the shorting plug has to be present in connector Ш2 for normal operation. If the plug is *not* present, some vital signals, such as the data lines from the keyboard and the 24V power supply, are interrupted.



Relation between Ш2, Ш6, Ш7 and Гн1

Connectors on the Alternative Power Supply

The alternative power supply unit (sometimes referred to as the Polish PSU) has a number of connectors. The mains connector is a standard 4-way Russian military connector, wired in the usual manner. The other connectors however, are less obvious. For reasons described in chapter 4.2.3, this PSU wants to monitor the outgoing 5-bit digital data stream of the Fialka. This means that the PSU should be connected in between the Fialka and the transmitter.



A special cable, supplied with the PSU has one 19-way circular connector at one end and a 10-way rectangular connector at the other end. The circular connector should be placed in the appropriate socket on the PSU and the rectangular one fits the digital RTTY output socket at the right of the Fialka. To ensure that the cable is used and that it is properly connected to the Fialka, the rectangular connector has a built-in sensing switch. Only when the connector is seated properly in the RTTY socket of the Fialka, the switch is engaged and the PSU is activated. Without this cable, the PSU cannot be turned on. The cable is wired as described in the above drawing, i.e. pin 1 of the rectangular plug is connected to pin 1 of the circular plug, etc.

Chapter 5
Hints & Tips

5.1 Introduction

Fialka machines come in many flavours and variations, from a variety of sources. Most of the machines that have been found so far, have been used extensively and will therefore shown tear and wear. Once the machines were taken out of service, they may have been stored for many years, without proper maintenance. Although most machines were well greased, it may have dried up by the time they were released.

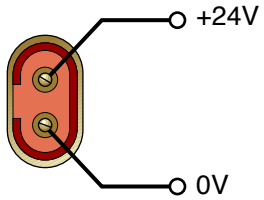
More importantly, orders were given to destroy the machines when they were taken out of service. This means that most machines will show some signs of the demolition hammer. Such damage can vary from a broken keyboard, to broken static discs inside the machine or a damaged printer mechanism. Some machines are so badly damaged, that they can only be used for spare parts, but luckily some machines have survived – or even escaped – the blow with the hammer.

This chapter deals with the restoration and repair of some critical parts of the machine. It also gives some hints and tips that may be useful when trying to make your Fialka fully operational again.

5.2 Power supply or cable(s) missing

The Fialka requires a 24V DC power supply. This was supplied either by the 24V battery of, say, a military truck, or by an external mains power supply. Some Fialka machines that have been found by collectors, came with a power supply but in most cases the cables – between the power supply and the Fialka – were missing.

This should not be a problem, as the Fialka can perfectly well be used with any 24V power supply which can deliver the required current. In use, the Fialka takes about 700mA, but the power supply should be able to deliver at least 3A when the machine is turned on. The 24V DC power supply should be conneced to the Power Input Connector on the left side of the Fialka. Ensure that the topmost terminal is connected to the +24V line.





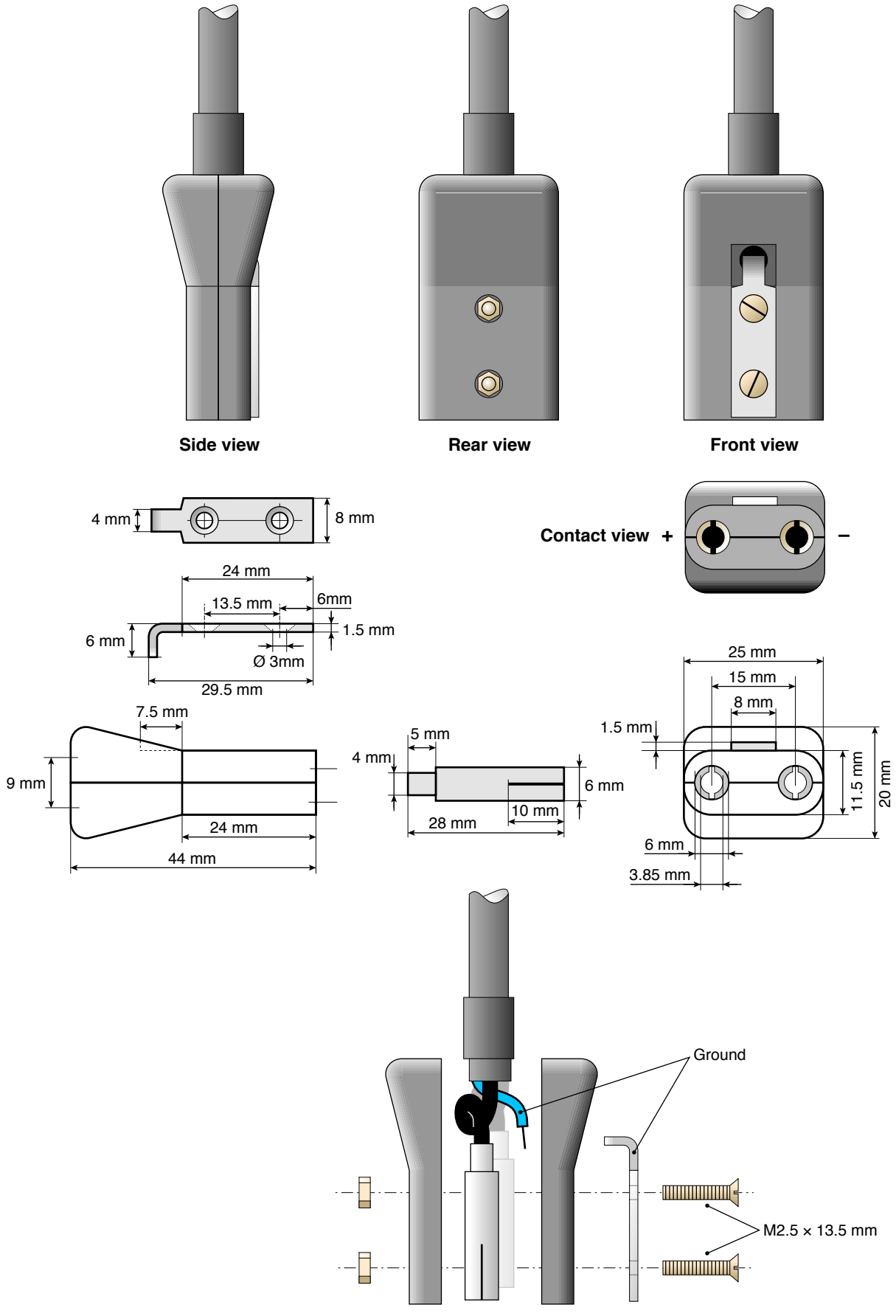
Warning:
Never reverse the 24V power supply as this may cause serious damage to the Fialka.

The Power Connector

The 24V terminal of the Fialka is a rather uncommon type of connector, so it will be difficult to find a suitable plug. A detailed drawing of the original 24V plug is given below. You may use this to find a suitable alternative, or to create your own plug.

If you want to get yourself going rather quickly, there are a few alternatives that are less difficult to achieve.
Standard 4mm banana-type female connectors can be used, e.g.: Hirschmann KUN 30 red and black. They can be inserted into the socket directly and will fit loosely to the terminals.

Alternatively, you may be able to find General Radio twin bananaplugs, that were commonly used on older Tektronics oscilloscopes. These double plugs have exactly the right spacing and can therefore be used directly.



Fialka 24V power connector shown at full size (100%)

5.3 No sign of life when power is turned on

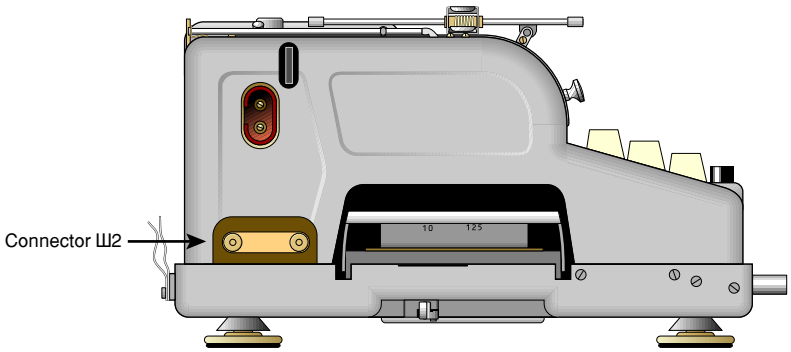
If the Fialka doesn't come to life when it is first turned on, something apparently is wrong. Due to the complex nature of the machine, finding the cause of a problem can sometimes be very difficult. Here are some possible checks:

1. Check the 24V at the input terminals.
   Use a multi meter to verify that you have indeed 24V available at the power input connector at the left side of the machine. Ensure the + wire is connected to the upper terminal.

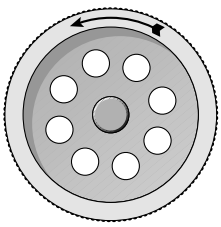
2. Check the maximum current.
   Check whether the power supply is capable of delivering a current between 3A and 5A. Anything less than that will prevent the motor from starting. Although the Fialka will only take about 700mA when in operation, it needs at least 3A to allow the motor to start.

3. Check the fuses.
   The 5A fuse is used to drive the motor, whilst the 3A fuse drives the rest of the circuitry. If a fuse is broken or if it is missing altogether, refer to chapter 5.4 for a workaround.

4. Check the presence of the shorting plug Ш2.
   This connector is located at the left side of the machine and can be accessed from the outside. It is some kind of service connector that is fitted with two semi-permanent bolts. If this connector is missing (i.e. if you look straight into the holes of the socket) the electric circuit is broken. The service connector (that MUST be present) contains a number of shorting wires that allow normal operation of the machine. Creating a workaround for a missing Ш2 connector can be very difficult.



5. Check whether the mechanism is blocked.
   The Fialka may have been left in a lock-out state. This means that the mechanism is in such a position that it won't allow the motor to come on. The unblocking-wheel, at the rear of the machine, can be used to free the mechanism. To access this wheel, you'll have to remove the cover from the machine first (➔ Chapter 1.4). The unblocking-wheel is a rather large wheel to the left of the motor (when viewed from the rear). **Always** turn it in the direction of the arrow (anti-clockwise).



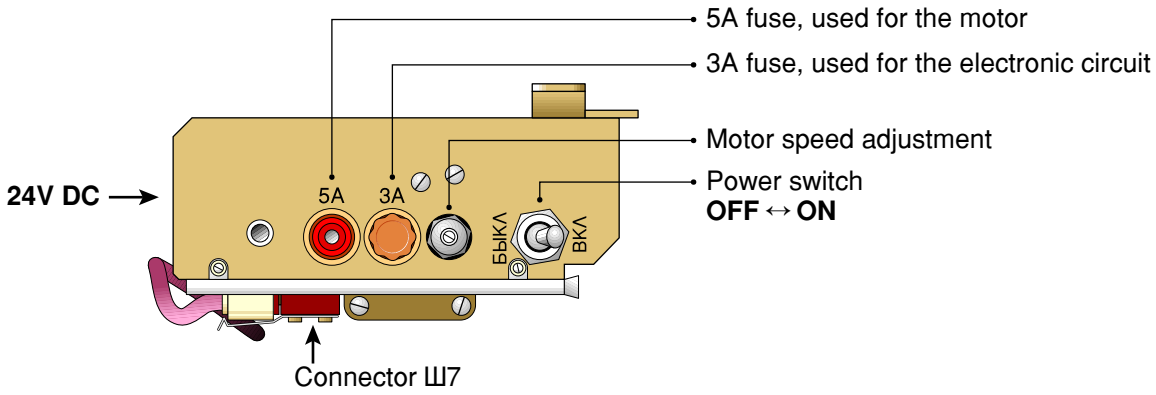
Officially, this wheel is meant for the repairing engineer. When re-assembling the machine, the wheel can be turned at verious stages to ensure all mechanical parts are lined up correctly. The crank should be used in preference to free the mechanism, but on all encounters we've had with a blocked machine so far, we've had to use the unblocking wheel shown here. **Always turn the machine off when turning the wheel. Don't turn the wheel whilst the machine is on!**



6. Check the grease in the gear mechanism.
   As the machines are rather old and haven't been serviced for a while, the grease in the gears may have become too dense, causing the entire mechanism to block. Try turning the machine on and then quickly turning the unblocking wheel (**be careful not to lose your fingers though!**). This may just be enough to get the motor going. If this happens, apply or spray some light oil, such as WD-40, onto the gear mechanisms to rejuvenate the grease.

5.4 One of the fuses is missing

Occasionally, a Fialka will be found with one or both fuses missing. Replacing a Russian-type fuse can be difficult, as the dimensions are different from the ones used in Europe and the USA. In some cases the fuse-holder is missing altogether, making it even harder to repair.



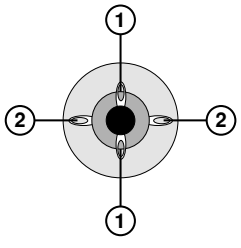
Location of the fuses

If one of the fuses is missing, try to find a replacement fuse first. Although Russian fuses are rather rare, they do turn up on ham radio markets from time to time. Replacing the fuse-holder with a more common type, is not a good idea, as the device would lose its authenticity. Instead it would be better to use a self-restoring fuse (e.g. MultiFuse) and solder it directly to the terminals of the fuse-holder, inside the Power Module.

To do this, you'll have to get access the Power Module first:

- Remove the ink ribbon (you may have to remove the print head as well). Refer to chapter 5.6 – *Replacing the ink ribbon* – for information on how to do this.
- Remove connector Ш7 from it socket.
- Remove the two screws on the front of the module (below the ink ribbon reels).
- Remove the two screws at the back where the Power Module is fitted to the motor.
- Carefully tilt the metal housing of the Power Module, until you can access the wiring inside it.

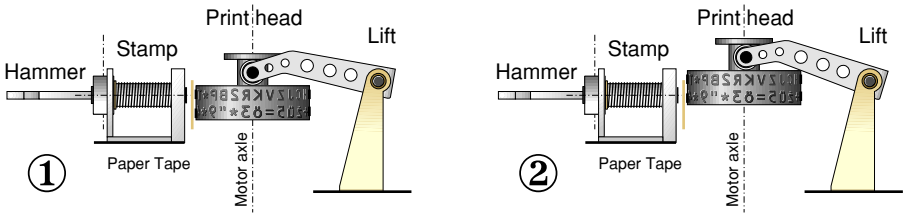
Now solder a MultiFuse of the correct current (3A or 5A) directly to the terminals of the fuse-holder. Note that the fuse-holder has 4 contacts, but these are paired, so effectively, there are only two contacts. When in doubt, use a multi-meter to find out which terminals to use.



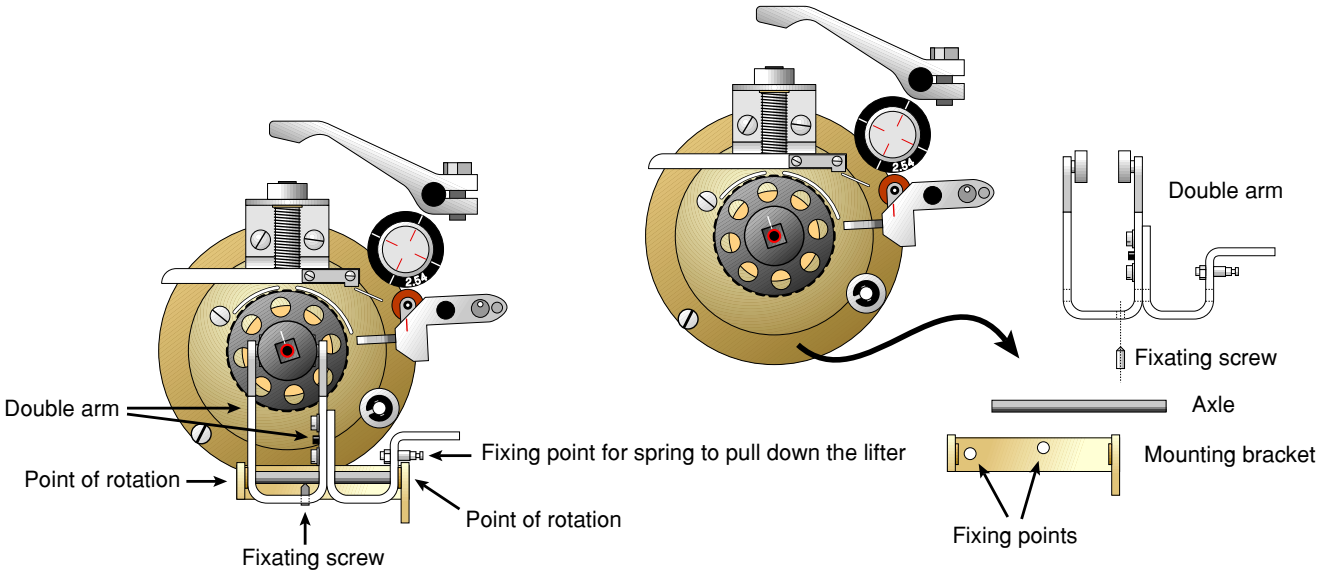
Solder side of the fuse holder (inside the Power Module)

5.5 The printer mechanism is damaged

The printer mechanism of a Fialka machine may have been damaged as part of the 'demolition' process. Usually the printer received a knock on its head with a hammer. As a result the printer mechanism, and especially the print head lifter, may be damaged, blocked or partially missing. The print head can be moved up and down by a raising mechanism, consisting of two metal arms with ball-bearing wheels at the end. The arms can be moved up ② and down ① whilst the print head is rotating (➔ Chapter 3.4).

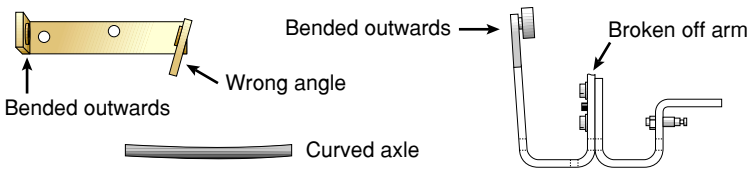


You can easily check this by raising the arms by hand (whilst the machine is turned off). It should move easily and return to its position when it is released. We've seen machines in which one of the two arms was missing (i.e. broken off), but generally this should not be a problem. The drawing below shows a partly disassembled lift.



Check that all parts are straight and that they are correctly aligned. In particular, check the double arm. Make sure that it can freely be moved and that it correctly lifts the print head. Also check whether the axle is straight. If it is misformed, it is likely to block the mechanism (now or in the future) and you should straighten it, or replace it with an axle of exactly the same diameter. The lift can be disassembled by removing the small fixating screw at the back of the lift. Be careful not to lose this screw as it's a rare item. You may want to remove the lift assembly completely, so that it's easier to fix it. It is mounted to the printer mechanism, with two screws at the bottom of the bracket.

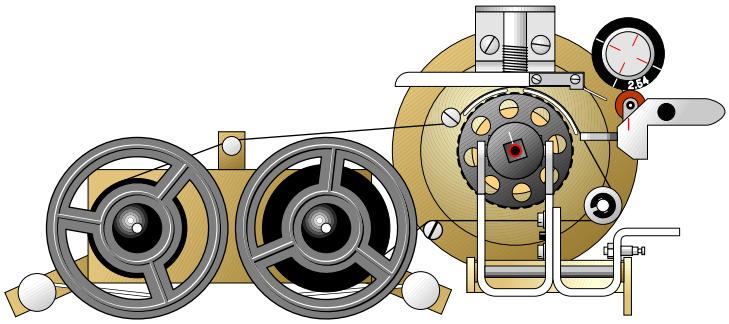
If either of the two arms is mis-aligned, you may try to bend it back into position, but be careful not to break it off. A (partly) broken-off arm can easily be soldered back together. In such cases it is better, an probably easier too, to take the mechanism apart and work on each of the components separetely. Whilst doing this, you might want to straighten out the mounting bracket as well. Here are some examples:



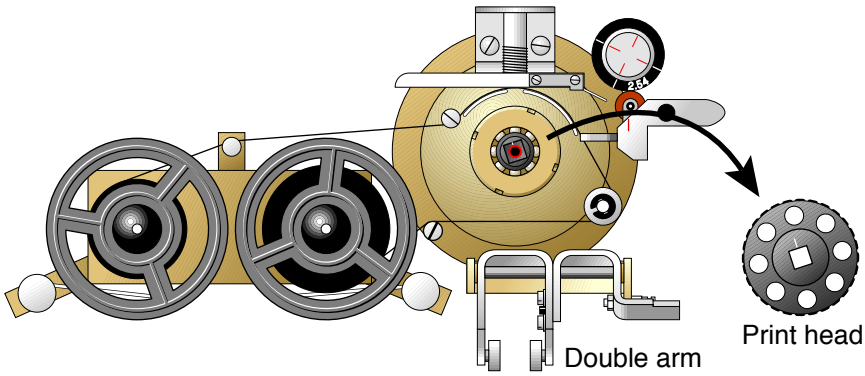
5.6 Replacing the ink ribbon

All cipher text and plain text must be printed on a paper tape, making the ink ribbon a rather critical component of the machine. As the machines may have been stored for many years before they were released, the ink ribbon is likely to have dried up by now. This will result in very poor quality printed text. The only solution is to replace the ink ribbon.

Replacing the ink ribbon isn't difficult at all. The width of the ribbon is identical to the ribbons commonly used on old-fashioned typewriters and teleprinters throughout Europe and the US. The only thing that is likely to be different is the reel. It may have a different diameter, or a different hole through the center, so it's best to wind the new ribbon onto the old reel. In order to do this, you'll have to remove the ribbon completely. As you can see in the drawing below, the ribbon is guided around the print head and can not easily be removed.

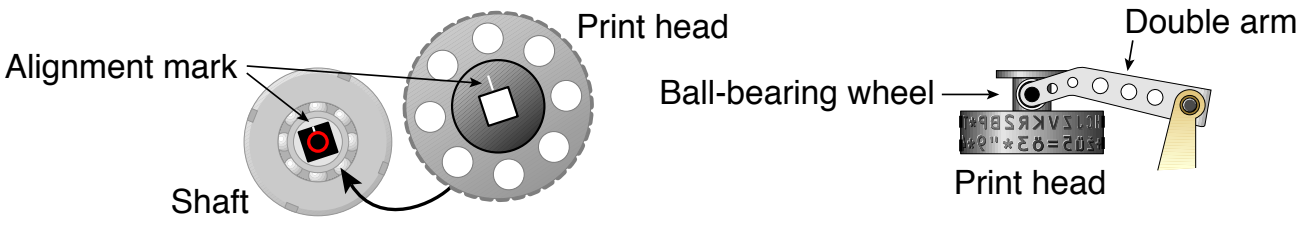


First remove the print head from the printer assembly. This is done by raising the double *ball-bearing wheel* arm to the point where it won't fall back. The print head can now be removed.



You may now remove the ink ribbon from the printer assembly. Remove and discard the old ink ribbon from the old reel. It might be worth cleaning the empty reels now, as old ink and dust may have accumulated onto it. Next, wind the new ribbon onto one of the old reels. This may take some time and can be a 'dirty' job, so you might want to use gloves. Once the ribbon is completely wound onto one of the reels, fix the lose end to the core of the empty reel and place the ribbon back in the machine. Ensure that the ribbon is guided correctly around the print head as shown in the images above.

Once the ribbon has been installed again, the print head can be re-inserted. Please note that the print head can be inserted in 4 different ways, but only one way is correct. The mark on the print head has to be aligned with the mark on the shaft. Also, ensure that the ball-bearing wheels on the double arm are inserted correctly into the wheel, in such a way that they can raise the wheel if necessary.



5.7 Oil and Grease

The Fialka is a good example of Russian mechanical ingenuity during the Cold War era. It's a highly versatile and compact machine which consists of thousands and thousands of individual components. With so many components, the chance that only a single one of them might fail at some point seems to be quite high, and yet the machine appears to have been (and probably still is) extremely reliable. It's hard to imagine this today, in our era of the modern computer, but when this machine was first designed (in the early 60's) it really was state-of-the-art.

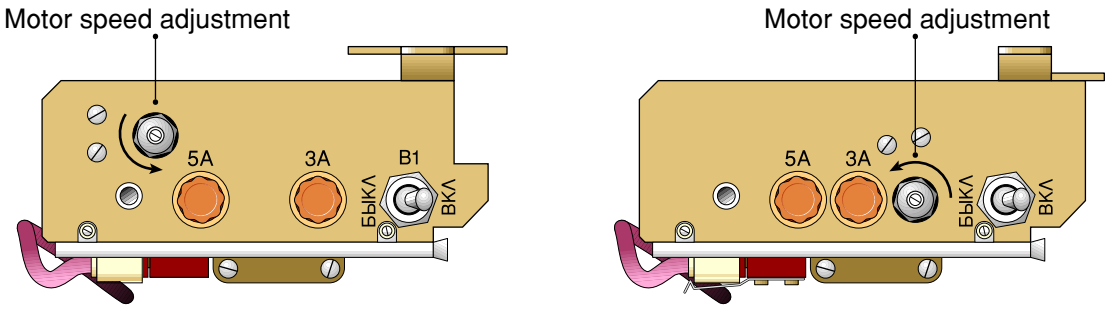
Most of the events inside the Fialka are synchronised to, or influenced by, the movement of the main motor. Through a maze of cog wheels, pawls, arms, notches and levers, the motor controls the rotation of the drum, the printer, the paper-tape puncher, the paper-tap reader, the ink-ribbon transport and the release of the keyboard. All mechanical parts are in one way or another connected together and grease and oil have been used extensively to guarantee a smooth operation of the machine.

During it's lifetime, the machine has been serviced quite a number of times and you'll probably find oil dripping from every major part of it. Over time, the oil and grease may have dried up and probably have collected dust, causing the machine to run less smoothly and in some cases even causing the machine to block completely.

First try to clean the smaller mechanical parts with an old cloth and ear-tips. Don't remove the grease from the larger mechanical parts, unless it completely blocks the machine. Then apply new motor oil (e.g. WD-40) to the dried-up grease, which will eventually rejuventate it. Don't use too much oil; a few drops will usually do the trick. Next apply a single drop to each of the smaller moving parts. Turn the machine on from time to time, to allow the oil to spread and to see whether it runs any smoother. Again, don't use too much oil as it won't help.

5.8 Adjusting the motor speed

When the machine is first turned on, you'll hear the motor spinning at high speed. It is in fact quite noisy and sounds like an overloaded vacuum cleaner. This speed is not critical unless you need to achieve a certain baud-rate when connecting directly to, say, a radio set. As the latter is probably not going to happen in your case, the motor speed can safely be lowered somewhat. This will make the machine less noisy and will greatly extent it's lifetime. The motor speed can be adjusted by rotating the wire-wound potentiometer of the *Power Module* (➔ Chapter 4.3). The Power Module can be accessed by opening the lid of the M-125-3. On the older M-125 machine you need to remove the cover first. Use a suitable screwdriver adjust the speed. Turn the potentiometer counter-clockwise to lower the speed, until it sounds less stressful.

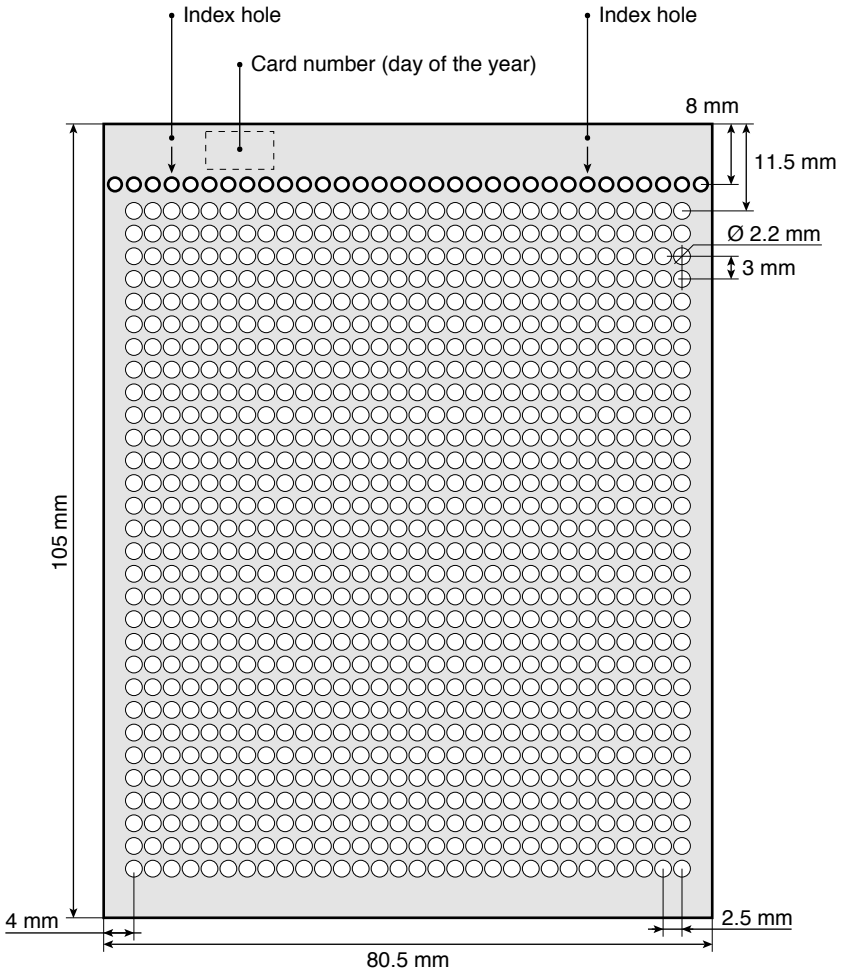


Motor speed adjustment on the M-125 (left) and the M-125-3 (right)

5.9 Creating your own key cards

5.9.1 Key cards

The information presented in this chapter is the result of studying the German Fialka Manual, combined with personal investigation. Furthermore Günter Hütter [8] in Germany has done some experiments to find the best parameters. Each key card is 105 mm long and 80.5 mm wide. The cards were changed daily and each card carries the number of the day it was created for. See Chapter 3.6 for a description of the key card and Chapter 4.6 for a description of the card reader.



Precise dimensions of a Fialka key card (shown here at actual size)

The holes of the perforation (at the top of the card) have a diameter of 1.8 mm. This is important as two of the holes should match the index pins in the drawer. The actual key holes have a diameter of 2.2 mm. Each row/column combination should have exactly one hole. The columns (i.e. from left to right) can be regarded as the input of the substitution matrix, whilst the rows (i.e. from top to bottom) is the output.

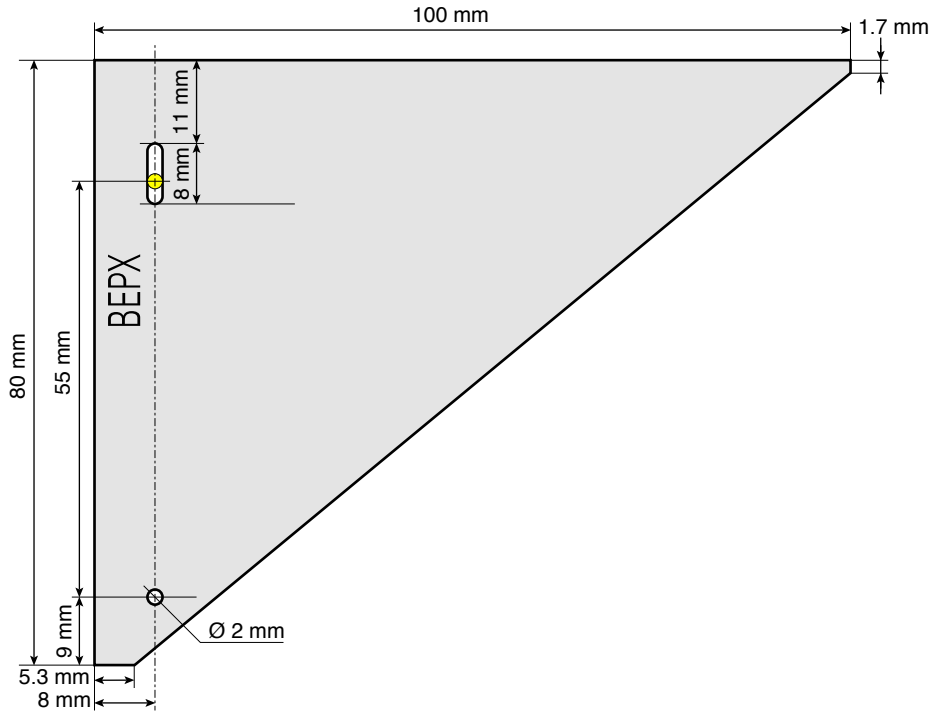
If you want to create your own key cards, you may download drawings of a universal key card and the test triangle from our website:

http://www.xat.nl/fialka/tech/card/

Print the drawings at actual size and use it to create your own cards. Use a paper weight between 80 and 200 grams. The holes can best be made with a 2.2 mm *hollow-pipe*.

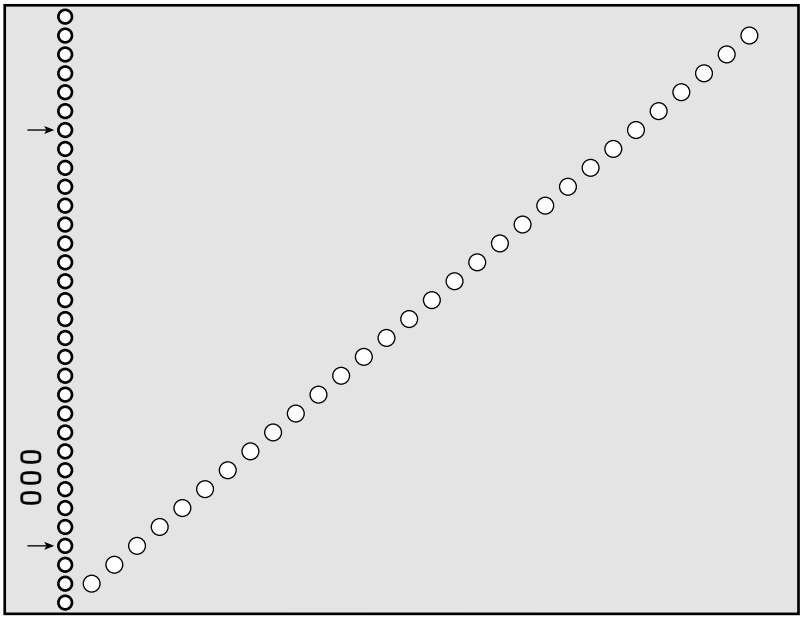
5.6.2 Test triangle

A metal triangle should be present with each Fialka machine. This triangle forces the *identity matrix* and should be present in the card reader when no key card is available. The metal triangular plate is also used, in combination with the test reflector, to verify the operation of the card reader. The exact dimensions are given below. The plate is only 0.2 mm thick, so you could also print it on, say, 150 or 200 gram paper.



Metal test triangle

If a diagonal row of holes is used (i.e. from the top left to the bottom right) the identity matrix is also used. This means that 'A' is transated to 'A', 'B' becomes 'B', etc. A card that is punched in this order, is identical in function to the metal test triangle show above.



Sample key card showing the identity matrix

Appendix A - References

[1] The Ultra Secret, F.W. Winterbotham
1974, ISBN 0 75283 751 6

[2] John Cairncross...
BBC News, 13 September 1999.
http://news.bbc.co.uk/1/hi/special_report/1999/09/99/britain_betrayed/444058.stm

[3] Interview by the authors in 2005 with former DDR Fialka operator *Jörg Drobick*, Germany.
http://people.freenet.de/SASundChiffrierdienst/seiten/fialka.html

[4] Professor Tom Perera Ph.D., USA
The virtual Enigma and Fialka Museum.
http://w1tp.com/enigma/

[5] David Hamer Ph.D., USA
http://home.comcast.net/~dhhamer/

[6] Tom Perera
2005, The Story of the ENIGMA: History, Technology and Deciphering.
CD (3rd edition): http://www.artifaxbooks.com

[7] Wikipedia
http://www.wikipedia.org/

[8] Günther Hütter
Germany

[9] Various undisclosed sources.
The history of breaking Fialka is still very clouded. The fact that is was broken and that a super computer, programmed by the NSA, was used for the code breaking effort, has been confirmed by at least three independant anonimous sources.

[10] http://www.ddr-nva.co.uk
This website contains images of a GAZ-66 truck complete with the R-142 radio set. We've tried to contact the maintainer of the website in order to gain permission to reproduce one of the images in this book, but all e-mail to the supplied address has bounced.

Appendix B - Glossery of terms

Bakelite	Brand name for a brown/red material that was used for case molding. On the Fialka it is used for several enclosures, connectors, switches, etc. It's a termosetting Phenol Formaldehyde Resin (much like ↘Pertinax) that was used for radio and telephone casings and electrical insulators well into the 60's [7].
Baudot	Standard method for digital 5-bit encoding of (Latin) letters. The Baudot code was used on teletype and telegraph machines is Europe and the US. This code is not used in the Fialka, which uses an alternative –internal– coding scheme instead (➔ 3.5).
DDR	Deutsche Demokratische Republik (German Democratic Republic). This is the name of the former East-Germany until it was re-united with West-Germany (BRD) in 1990.
Drum	The stack of *coding wheels*, mounted together on a *shaft*, between the ↘*entry disc* and the ↘*reflector*. On the Fialka, the drum consists of 10 coding wheels. The *drum* is also referred to as the *rotor stack*.
Enigma	Enigma means 'Riddle' (Greek). It is also the name of a well-known coding machine that was used before and during WWII by the German Forces for their secret radio traffic.
Entry disc	The static disc with 30 fixed contacts, to the right of the drum inside the Fialka. When typing a letter, an electric current is sent from this disc into the first coding wheel.
Fialka	The name of the *operating procedure* of the M-125 cipher machine, until 1978. After that date it was called (in German) *Verfahren M-125*. The name Fialka is also used as an alias for the M-125 machine itself.
NVA	Nationale Volks Armee (National People's Army). This was the name of the army of the former ↘DDR, which was part of the Warsaw Pact.
Pertinax	(Hard-paper) Brand name for the brown insulating meterial used to create the early wheels of the Fialka. This material consists of paper, impregnated with Phenol Formaldehyde Resin to create the so-called *hard-paper*. It was also used as the substrate for PCBs (Printed Circuit Boards).
PROTON-2	This is the name that was given to the new *adjustable* wheels for the Fialka, when they were introduced in 1978.
PSU	Power Supply Unit.
Reflector	The static disc with 30 contacts, to the left of the drum inside the Fialka. When typing a letter, an electric current is send by the *entry disc* through the coding wheels, onto the the reflector. The *reflector* sends the current back through the wheels until it comes out on the entry disc again.
SPDT	Single Pole Double Throw switch. This is a switch with a single set of contacts and two posible contact positions. The switch has three terminals: *common*, *normally open* and *normally closed*. SPDT switches are used on the Fialka's *key switch array*.