Zeitschrift: Technische Mitteilungen / Schweizerische Post-, Telefon- und Telegrafenbetriebe = Bulletin technique / Entreprise des postes, téléphones et télégraphes suisses = Bollettino tecnico / Azienda delle poste, dei telefoni e dei telegrafi svizzeri

Herausgeber: Schweizerische Post-, Telefon- und Telegrafenbetriebe

Band: 52 (1974)

Heft: 12

Artikel: The determination and tracing of faults in telephone exchanges

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DOI: https://doi.org/10.5169/seals-874787

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The Determination and Tracing of Faults in Telephone Exchanges

Willy GRUNDBACHER, Berne

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Summary. *With new switching systems the requirements for monitoring and test equipment are increasing. In the present article the author briefly surveys current circuit monitoring facilities and outlines developments in this field.*

1. Introduction

In the operation of telephone exchanges Swiss PTT tries to offer its customers a high quality service while keeping the maintenance costs as low as possible. The methods employed for testing and supervising the exchanges vary according to the system and type of installation. The choice of the method of maintenance is made, in the final analysis, by the Post Office.

The present paper describes the possibilities which exist for preventive and corrective maintenance. For the sake of simplicity, we have here compared the determination of faults with preventive maintenance and the tracing of faults with corrective maintenance. *Figure 1* provides an illustration.

2. Determination of faults

2.1 The telephone user as a control aid

The telephone user constitutes one of the sources of information concerning faults. However, he only reports a very small number of faults and the data he supplies are nearly always insufficient. The faults affecting the connection of the subscriber at the moment when the call is set up are often heard as a busy tone and, consequently, not differentiated from busy connection paths. Finally, the user wishes to make a telephone call rather than detect and report faults.

2.2 Determination of faults by means of traffic observation equipment

This equipment is used to gain a picture of the telephone service offered to the subscribers. It enables the signalling and quality of any call to be monitored semi-automatically. In this way faults can be discovered which occur during the trunking process, the metering and the transmission. However, it is impossible to trace the fault source without additional aids.

2.3 Determination of faults by means of traffic measuring equipment

If certain circuits in an exchange can no longer be seized due to faults, only the occupancy statistics can be used to determine the causes, apart from visual inspection. However, in some modern switching systems the connection condition of the crosspoints cannot be checked by visual inspection. Only by measuring the traffic is it possible to locate the faulty circuits which are unserviceable for subscriber traffic. It is important that this measurement should be made regularly on all circuits.

2.4 Determination of faults by means of test connections

The establishment of such connections by test operators at present constitutes the greater part of preventive maintenance. Though monotonous work, it requires great concentration on the part of the personnel if faults of rare occurrence are to be reliably discovered. It is becoming increasingly difficult to find staff meeting this requirement, and the degree of efficiency achieved is therefore unsatisfactory.

2.5 Determination of faults by manual circuit testing

In preventive maintenance of circuits equipped with open relays and detectors, the best method is still manual testing of the circuits after readjustment of the electromagnetic elements. In this way, any incorrect relay operating times can be determined and corrected at little cost. Various testing devices are used for this purpose. In centrally controlled switching systems, the systematic execution of manual tests is not only a laborious, time-consuming and costly task, but also practically impossible in most cases.

2.6 Determination of faults by means of the manual testing unit

Manual testing unit used for certain types of circuit. As mentioned in 2.5, the devices used for manual testing of circuits facilitate the work involved. The operation of the circuit to be checked can thus be tested without involving the counter connection. By previously blocking each busy circuit, all the identical circuits can be checked more rapidly.

Manual testing device for setting up calls via predetermined selection stages. In SDM switching systems, only a suitable testing device makes it possible to check the establishment of a call through a number of selection stages. Each stage of operation in the system can be tested by predetermining the selection stage and control circuit necessary for the trunking process. Moreover, all the circuits used by a test call appear on an indicator panel or some other output device. As soon as a fault is noticed, the call and the control circuits involved should be blocked and the fault traced, but only on condition that subscriber traffic continues to flow over the rest of the circuits. By suitable testing manoeuvres it is possible to make a distinction between busy, interrupted and blocked circuits.

2.7 Determination of faults by transportable test robot

By using a selection device capable of automatically setting up test calls between one given subscriber station and another, we are able to detect the faults which occur in fully or partially established calls. The defective calls

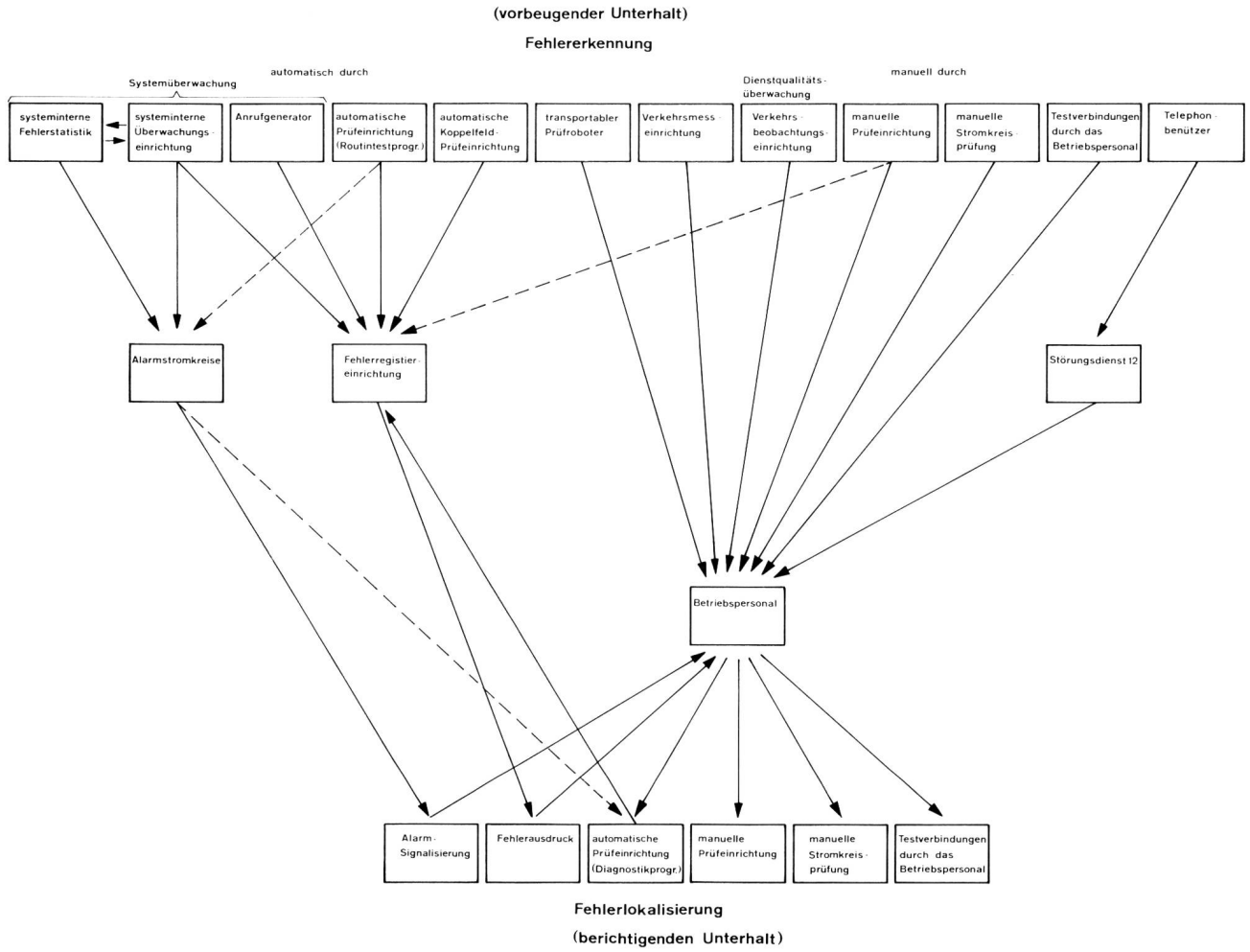


Fig. 1
Diagram of the possibilities for determination and tracing of faults in telephone exchanges

Vorbeugender Unterhalt – preventive maintenance
Fehlererkennung – fault determination
automatisch durch – automatically by
Systemüberwachung – system supervision
manuell durch – manually by
Dienstqualitätsüberwachung – service quality supervision
Systeminterne Fehlerstatistik – intra-system fault statistics
Systeminterne Überwachungseinrichtung – intra-system supervision equipment
Anrufgenerator – call generator
Automatische Prüfeinrichtung (Routineprogramm) – automatic testing device (routine program)
Automatische Koppelfeld-Prüfeinrichtung – automatic switching matrix testing device
Transportabler Prüfroboter – transportable testing robot
Verkehrsmesseinrichtung – traffic measuring equipment
Verkehrsbeobachtungseinrichtung – traffic observation equipment
manuelle Prüfeinrichtung – manual testing device
manuelle Stromkreisprüfung – manual circuit testing
Testverbindungen durch Betriebspersonal – test connections by operating personnel
Telefonbenützer – telephone users
Alarmstromkreis – alarm circuits
Fehlerregistereinrichtung – fault-recording equipment
Störungsdienst – fault clearance service
Betriebspersonal – operating staff
Alarmsignalisierung – alarm signalling
Fehlerausdruck – fault print-out
Automatische Prüfeinrichtung (Diagnoseprogramm) – automatic testing device (diagnostic program)
Testverbindungen durch Betriebspersonal – test connections by operating personnel
Fehlerlokalisierung (berichtigender Unterhalt) – fault tracing (corrective maintenance)

are held so that we can locate the affected circuits and the cause of the fault. This requires the presence of operating personnel.

Robots intended for call establishment tests are used for checking the setting-up of calls and for rapid evaluation of the attenuation of local, subzone and trunk calls.

Robots intended for permanent call establishment tests detect the other possible transmission faults which affect calls set up at choice for up to halt an hour. The crosstalk, the external voltage level and the attenuation of a noise signal simulating speech are checked on this occasion.

2.8 Determination of faults by means of automatic testing equipment

The central controls of the process-controlled exchanges are not all engaged in productive work. This is why a routine test program is implemented during the breaks. For this purpose, the central control automatically tests various control functions until the arrival of the instruction to carry out a priority task (trunking etc.).

The automatic testing device installed in the conventional exchanges performs the same function. Certain circuits and control devices are tested at night when there is very light traffic. In the morning, the results are presented in the form of recorder print-outs. The defective circuits can be repaired or at least blocked before the peak traffic period. Besides the normal test programs, automatic abbreviated programs and semiautomatic tests are possible. Consequently, it is no longer necessary to resort in each case to manual equipment for testing circuits.

2.9 Determination of faults by means of an automatic switching matrix tester

This device is closely associated with the automatic testing installation. The calls are thus set up and checked via predetermined selection stages. The use of automatic

switching matrix testing is a question of cost more than in the case of the automatic testing device. Therefore, the permanent installation of such testers is customary only in local exchanges with at least 5,000 subscriber lines.

2.10 Determination of faults by means of monitoring equipment

The supply voltage monitoring device was the first supervisory unit used in the old electromechanical exchanges. The present conventionel exchanges are equipped with additional means of supervision. They are assigned, for example, to the meters and signal breakdowns immediately. The centrally-controlled switching installations are inconceivable without perfected monitoring systems. The repercussions from faults affecting the central circuits are often very serious. Therefore, an effort will be made to eliminate completely or as much as possible the consequences of faults, by incorporating a fault determination system, by providing for redundancy and by means of stand-by switching programs.

Supervision of supply voltages. As soon as the supply voltage of a circuit fails, the latter is automatically blocked. The fault is signalled in the alarm circuit which is capable of assessing urgency.

Supervision of steady states. Important signal distribution multiples (supply for metering, coding etc.) are often connected ungrounded. A wire break, short-circuit or earth fault can now easily be detected with an external voltage or with no useful signal at the end of the distribution wire.

Supervision of the central control devices. It will be advantageous to equip the control devices, which are of very great importance for the operation of the installation, with special supervisory systems capable of switching them and of signalling them automatically in the event of a fault.

Supervision of the phases of the trunking process. The fault which occurs while a call is being set up usually interferes with the control process. Each fault must prevent the normal triggering of the control circuits, so that a 'rejection' device can be triggered after a certain period of supervision. The function of this device is to transmit a busy tone to the calling subscriber and to disconnect all the circuits which are no longer necessary.

In the new types of exchange an attempt is made to record each 'rejection' due to failed attempts at connection. The value of this recording depends primarily on the degree of centralization of the exchange system. Ideally, the recording should show up the cause of the fault directly.

2.11 Communication of faults from statistical data

From the viewpoint of economy, it is practically inconceivable to define accurately the faults affecting the establishment of calls. The circuits involved are usually incorporated in the recording of a fault. A comparison between a number of recordings shows which circuit is always involved for a particular type of fault. The faulty circuit thus determined can the be taken out of service and reported. The purpose of automatic fault statistics consists in thus discovering the defects in the central control devices (circuits) and then having them switched over to an intact stand-by unit.

2.12 Determination of faults by call generator

The faults which have serious consequences (partial blockages of the installation etc.) should be located as promptly as possible. Using the call generator, it is possible to discover immediately any faults which are not detected by the monitoring device. The call generator should satisfy the following requirements:

- Set up automatically on other connections assigned to the robot the calls from subscriber lines or junction lines;
- Check alternately all possible kinds of calls;
- Set up calls from and to all the groups of subscriber lines, junction and trunk lines with their own control;
- Provide a permanent testing service. As soon as any parts of the installation are overloaded, it must temporarily cut off the tests and record the duration of the interruption;
- Check the metering, attenuation, crosstalk and insulation for each test call;
- Record any faulty test calls and indicate all the circuits involved.

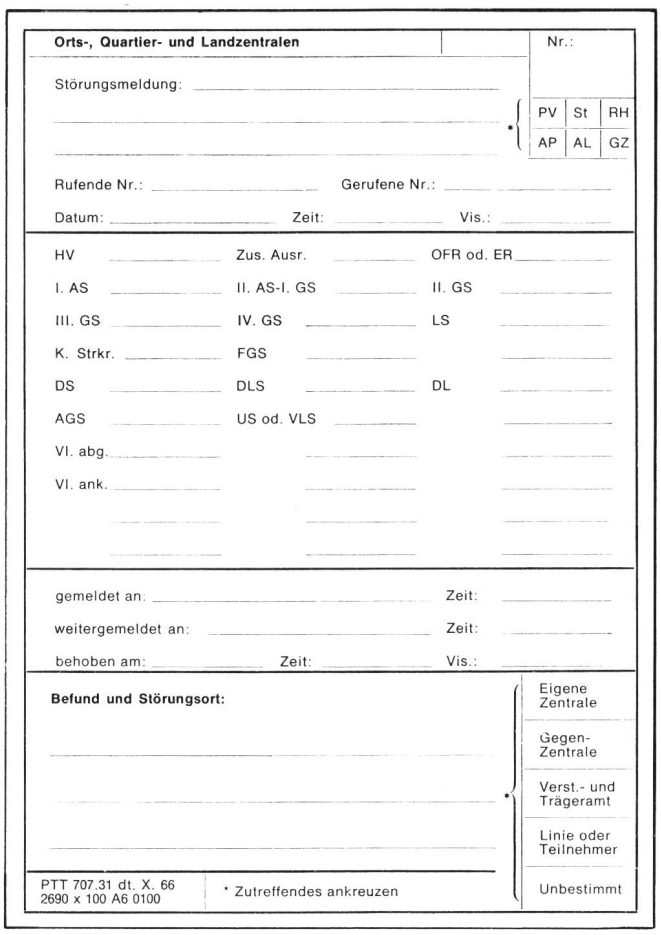
3. Recording and transmission of fault reports

Fault reports come in sporadically. Each one is noted on a card or ticket, so that the service personnel can deal with them in order of priority. *Figure 2* shows a sample of the fault report used for conventional exchanges.

The automatic fault-recording installations operating in the new centralized control systems print the faults on punched tapes or endless paper rolls. Samples of these two systems of printing are shown in *figures 3 and 4.* For the faults to appear in a file, it is essential that they be entered on a fault ticket. This paper work can be cut down if the recording device produces a form which is ready for classification such as the internationally standardized punched card. This card, subdivided into 80 columns of 12 lines can also be analysed for statistical purposes by all

	Störungsmeldung: (PV, St, GZ)		**Gestörter Stromkreis:**	
1	Falschwahl		Teil.-Stromkr.	1
2	Taxiert nicht		Schnursucher	2
3	Taxiert falsch		ASS	3
4	Taxiert ohne Antwort		I. AS	4
5	Verbindung unterbrochen		II. AS - I. GS	5
6	Uebersprechen und Doppelverbindung		II. GS	6
7	Schwund		III. GS	7
8	Geräusch		IV. GS	8
9	Schlechte Lautwirkung		LS	9
10	Verbindung geht nicht durch		Kuppl.-Stromkr.	10
11	Kein Summton		OFR	11
12			ER	12
13			DS	13
14			DLS, DL	14
15	Andere Fehler		FGS	15
			AGS	16
	Fehlerort:		US, VLS	17
			VL = abg.	18
a	Relais-Kontaktfehler		VL = ank.	19
b	Relais-übrige Fehler		VL ~ abg.	20
c	Sucher		VL ~ ank.	21
d	Registerschalter			22
e	Zeitschalter			23
f	Zähler			24
g				25
h				26
i				27
k				28
l				29
m	Sicherungen			30
n	Kondensatoren und Widerstände		LD	31
o	Röhren und Halbleiter		Anrufumleiter	32
p	Verdrahtung		GA	33
q	Verschiedenes		Kass. stat.-Ausr.	34
r	Unbestimmt		Versch. Stromkr.	35

Back



Orts-, Quartier- und Landzentralen

Nr.:

Störungsmeldung:

PV | St | RH
AP | AL | GZ

Rufende Nr.: Gerufene Nr.:

Datum: Zeit: Vis.:

HV Zus. Ausr. OFR od. ER

I. AS II. AS-I. GS II. GS

III. GS IV. GS LS

K. Strkr. FGS

DS DLS DL

AGS US od. VLS

VI. abg.

VI. ank.

gemeldet an: Zeit:

weitergemeldet an: Zeit:

behoben am: Zeit: Vis.:

Befund und Störungsort:

Eigene Zentrale
Gegen-Zentrale
Verst.- und Trägeramt
Linie oder Teilnehmer
Unbestimmt

PTT 707.31 dt. X. 66
2690 x 100 A6 0100

* Zutreffendes ankreuzen

Front

Fig. 2
Sample of fault report ticket for conventional exchanges

Störungsmeldung – fault report
Gestörter Stromkreis – faultly circuit
Fehlerort – fault location
Orts-, Quartier- und Landzentralen – local, district and provincial exchanges
Befund und Störungen – finding and location

standard electronic computers provided with a punched card input. But as the punched card must primarily serve for the determination of faults without the aid of an automatic analyser, the data are recorded in such a way as to permit easy reading of the card without any particular accessory. The back of the card is preferably reserved for entries made by the service personnel. As *figure 5* shows, the causes of the faults can be noted for the purpose of statistical analysis. The limited space on the card divided into 80 columns is a disadvantage. But the space reserved for the data can be considerably increased by using it rationally.

4. Tracing the faults

When a fault has been sought out or reported, its origin is nearly always unknown. The method of tracing it is left to the service personnel. The auxiliary operating equipment which seeks out the fault lends itself to this work. In most cases, an attempt is made to restore the condition which existed at the time when the fault occurred. If the call can be held, the fault can be traced without difficulty. However, this procedure is found to be difficult in the centralized control exchanges now in service. Only a testing device protected against incorrect handling and guaranteeing that the installation continues to operate can be considered.

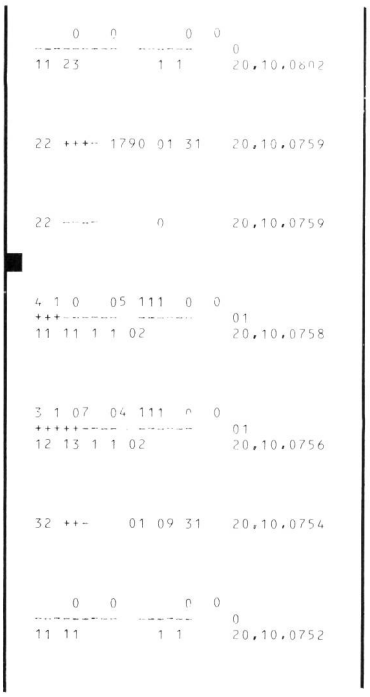


Fig. 3
Sample of an automatic fault print-out on endless paper

4.1 Tracing faults by means of test calls

This method can only be used in conventional exchanges which do not require any testing device for path determination.

4.2 Tracing faults by means of manual circuit tests

In circuits equipped with open relays and detectors, it is advisable to check each function manually. This method makes it easy to locate the faults affecting the operating and release times of the relays and also their contact pressure.

4.3 Tracing faults by means of the manual testing device

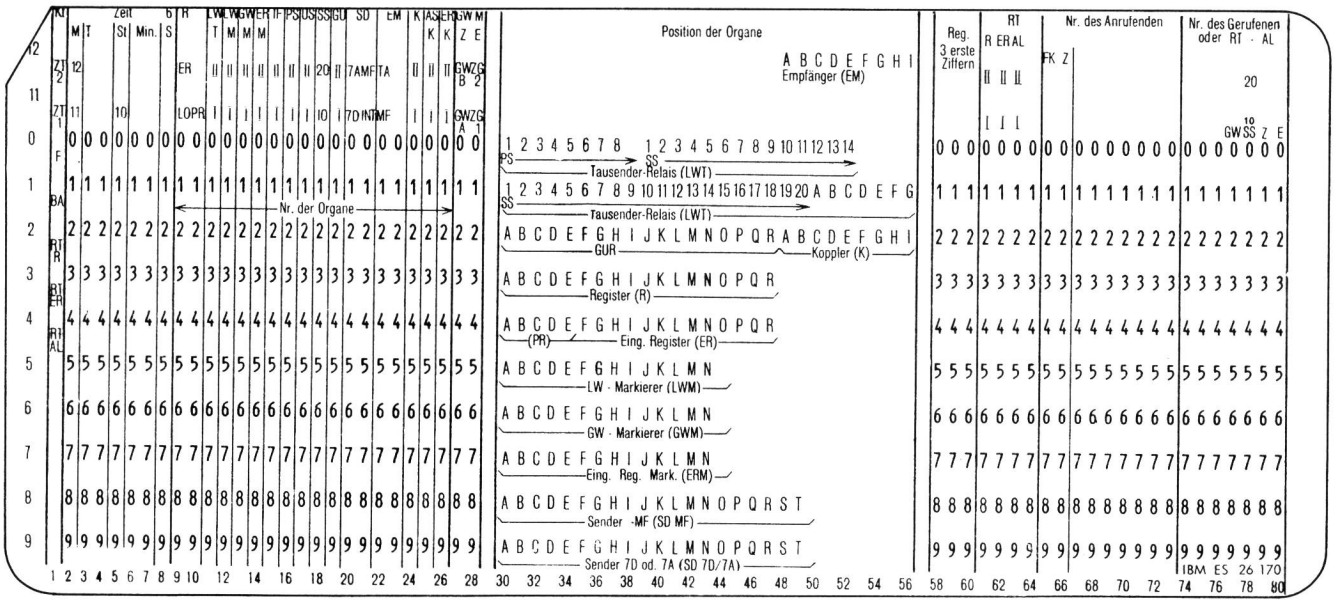
The tracing of faults which occur in SDM telecommunication systems involves setting up test calls via selection stages chosen in advance. If no corresponding automatic switching matrix testing equipment is available, a suitable manual device may be used.

4.4 Tracing faults by means of the automatic testing device

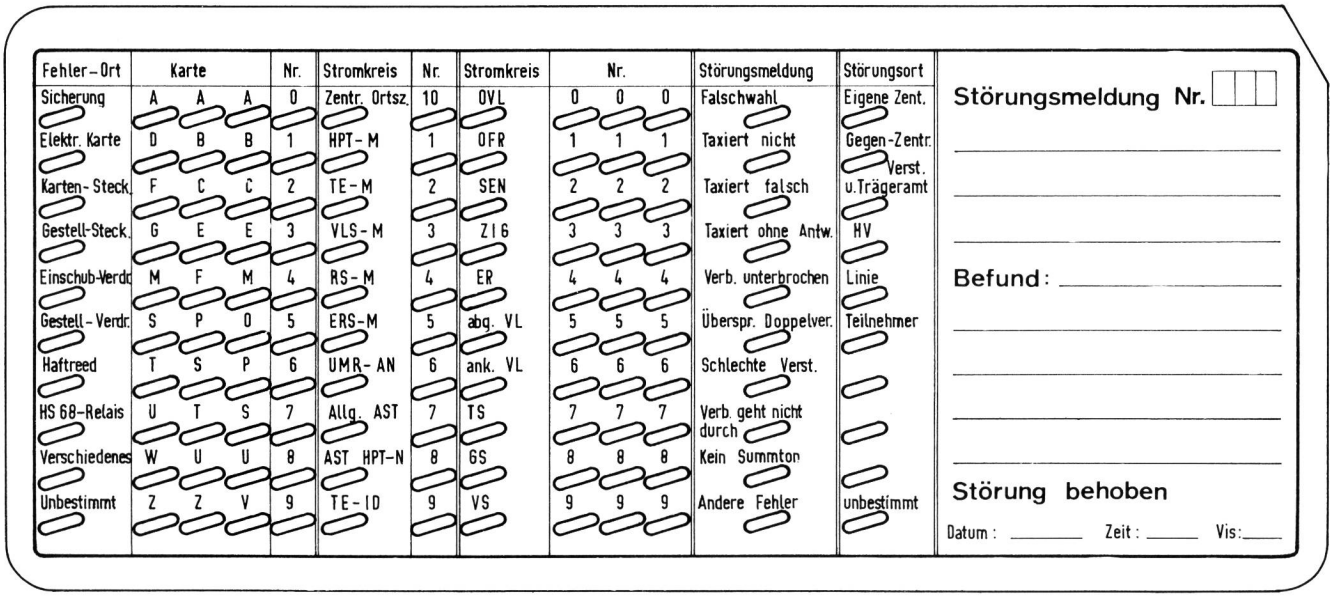
When a processor-controlled exchange discovers a fault by means of the routine test program, the defective circuit is located by a diagnostic program. In most cases, the faulty circuit can also be blocked automatically for subscriber traffic.

The automatic testing devices are very suitable for tracing faults in conventional exchanges. As soon as the position of the fault has been roughly located, the faulty stage can easily be found by means of a corresponding abbreviated program.

Fig. 4
Sample of an automatic fault print-out on punched tape



Front for manual check of fault print-out



Back used as fault notification

Fig. 5
Example of a punched card which is used for automatic fault print-out and also as fault notification

Fehlerort – location
Karte – card
Stromkreis – circuit
Störungsmeldung – fault report
Befund – finding
Störung behoben – fault cleared

(Translated by the Australian Post Office)