SIEMENS

Differential Protection System of Busbars

Erlangen, May 1969
TS 137 S/n 513.123
4 TS 1375 B 38041 I

Page

Notes

This protection system is used for both single or multiple busbar systems in high- and extra-high-voltage plants, also if sectionalizers and bus couplers exist. The protection system is of the quick-response and fully stabilized type to ensure instantaneous and selective tripping of the faulted section. The various buses may be coupled with each other as desired.

Design

The protective system is designed for an ambient temperature of up to 35° C. The tropical type should be used in damp rooms or where considerable condensation occurs owing to greatly varying temperatures.

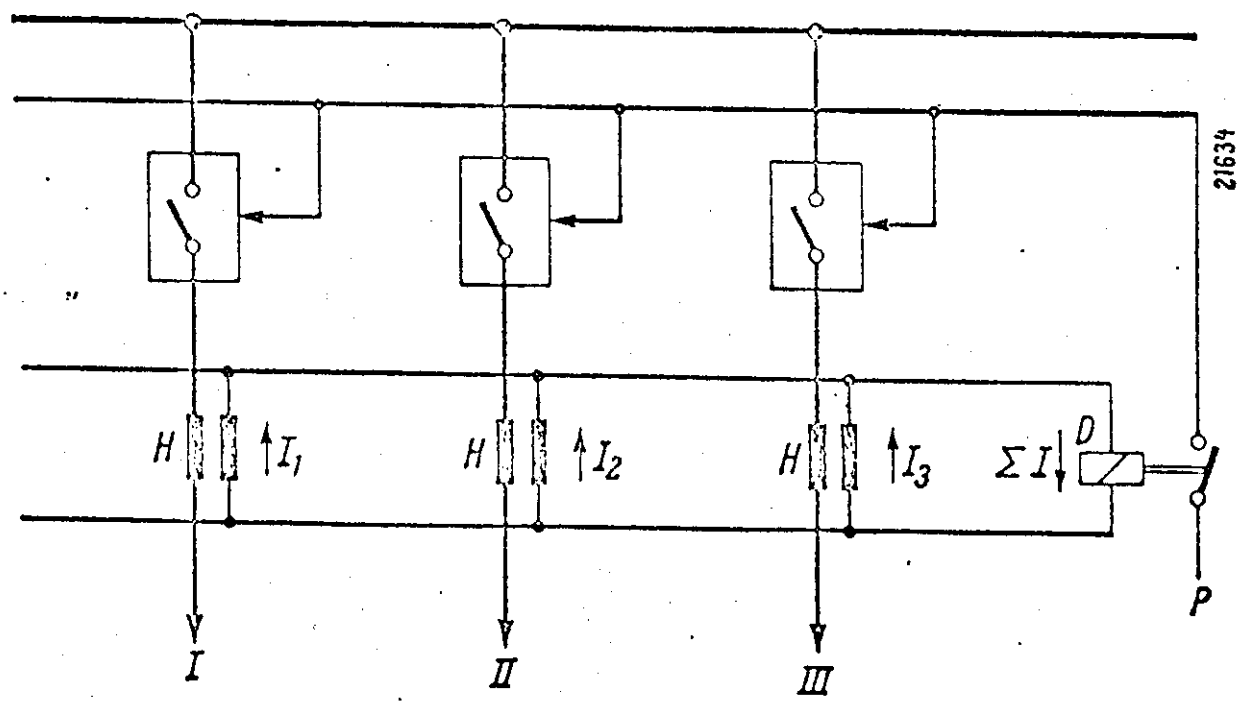
The case of the type RN 23a protection system provides protection against harmful dust deposits in the interior (enclosure P 42). The case of unit RN 24p, -r, -s provides the protection corresponding to enclosure P40. All cases can be lead-sealed. They are suitable for surface- and semi-flush mounting (with rubber civer frame). Special models are available with a hinged cover.

The bases of the cases are of cast aluminium. The caps which have a glass front are of deep-drawn sheet. The differential relay RN 23a has a 10-terminal strip recessed in the base at the bottom for front or rear connection. The summation supplementary unit RN 24 has 10 terminals of identical type at the top and bottom.

Operation:

In healthy conditions the sum of the currents flowing to the busbar equals that of the currents leaving it, i.e. the vectorial sum of the currents in the busbar connections is zero.

If a fault occurs on the busbar, the sum of all currents is not equal to zero. The sum of the currents ΣI flowing serves as a criterion and operates a relay (D) which trips the faulted portion of the busbar.



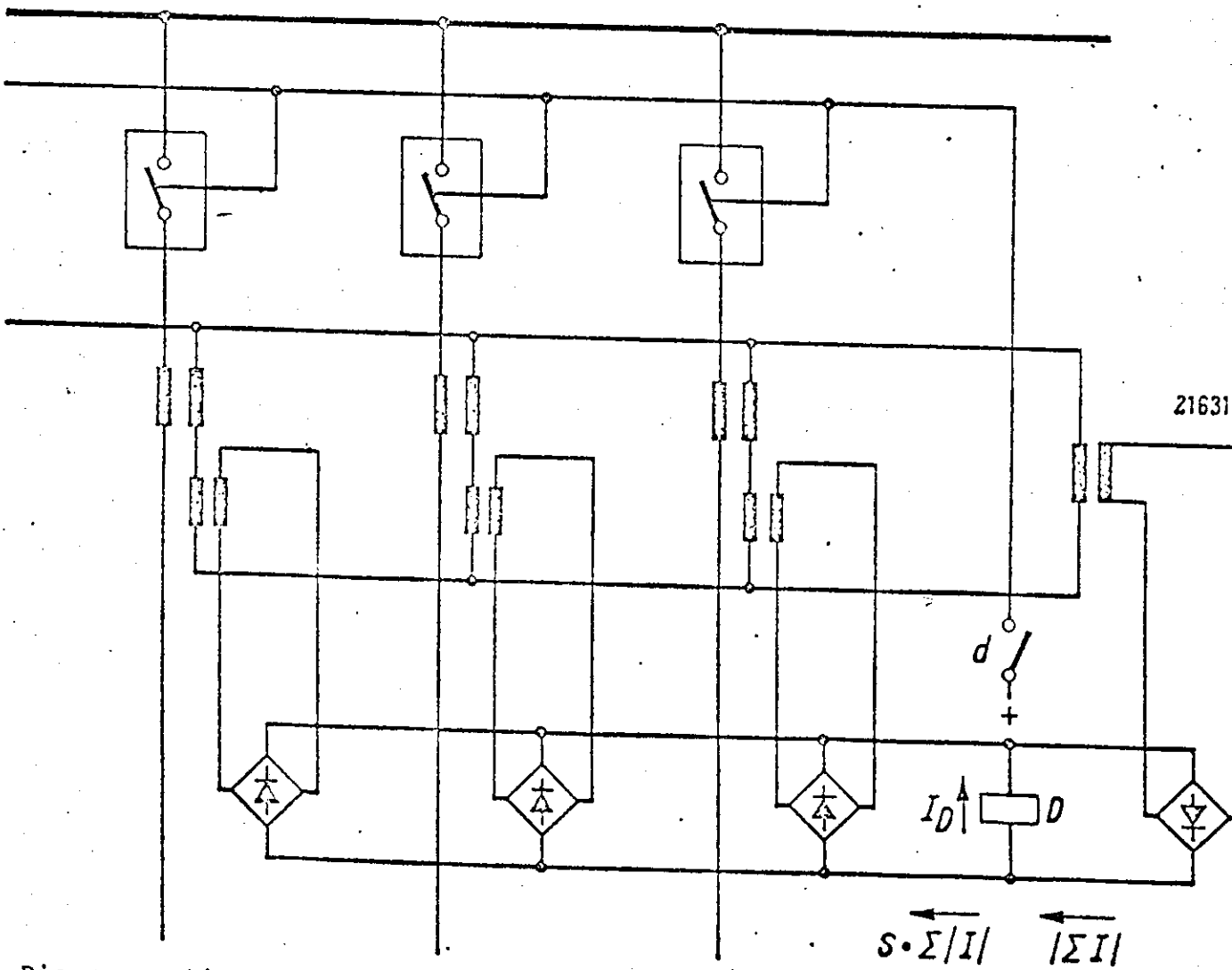
H = Main current transformer
D = Differential relay

Diagrammatic representation of a busbar current differential protection system

Fig. 1

Stabilisation:

If the through-currents are high (e.g. in the event of faults outside the busbar zone) large summation currents ΣI may flow since the current transformers then do not transform the primary currents accurately. To prevent this transformation error from causing undesirable tripping, the protection system is stabilised. For this purpose the scalar sum of all currents $\Sigma|I|$ is formed (by rectifying the currents and summating them in a collective line). The amount $s \cdot \Sigma|I|$ (s = stabilisation factor) is connected in opposition to the vectorial sum $|\Sigma I|$ (rectified vectorial sum of the currents) in a d.c. bridge circuit. A directional moving-coil relay is connected across the bridge, through which the current difference $I_D = |\Sigma I| - s \cdot \Sigma|I|$ flows.



Diagrammatic arrangement of the stabilised busbar differential protection system

Fig. 2

The stabilisation factor s is adjustable in steps (0.5 / 0.6 / 0.7 / 0.85).

In the event of a fault all feeder currents flow towards the busbar. The vectorial sum will then equal the scalar sum of currents: $|\Sigma I| = \Sigma|I|$, i.e. all fault points in the tripping diagram (Fig. 3) lie on one line at 45 deg. from the horizontal and vertical, which is referred to as fault characteristic curve.

The tripping current $|\Sigma I|$ thus exceeds the restraining current $s \cdot \Sigma|I|$ in the d.c. bridge $[I_D > 0]$, and the differential relay picks up.

On the other hand, if faults occur outside the protection zone the tripping current $|\Sigma I|$ is zero (except for any spurious currents due to errors of the c.t.), and the differential current I_D now flowing in the reverse direction restrains the moving-coil relay ($I_D = - s \cdot \Sigma|I| < 0$).

The sensitivity of the differential relay is adjustable from 1 to 2.5 times the rated current.

The sensitivity and the stabilisation factor as parameters enable the busbar differential protection system to be closely adapted to the existing conditions (accuracy class of c.t., number of feeders, etc.)

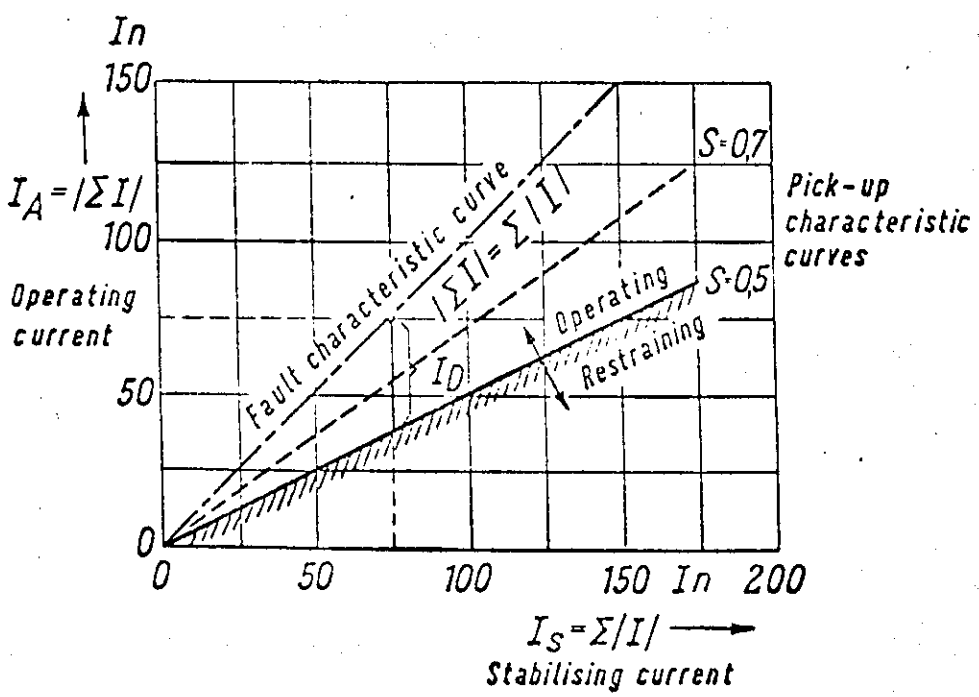
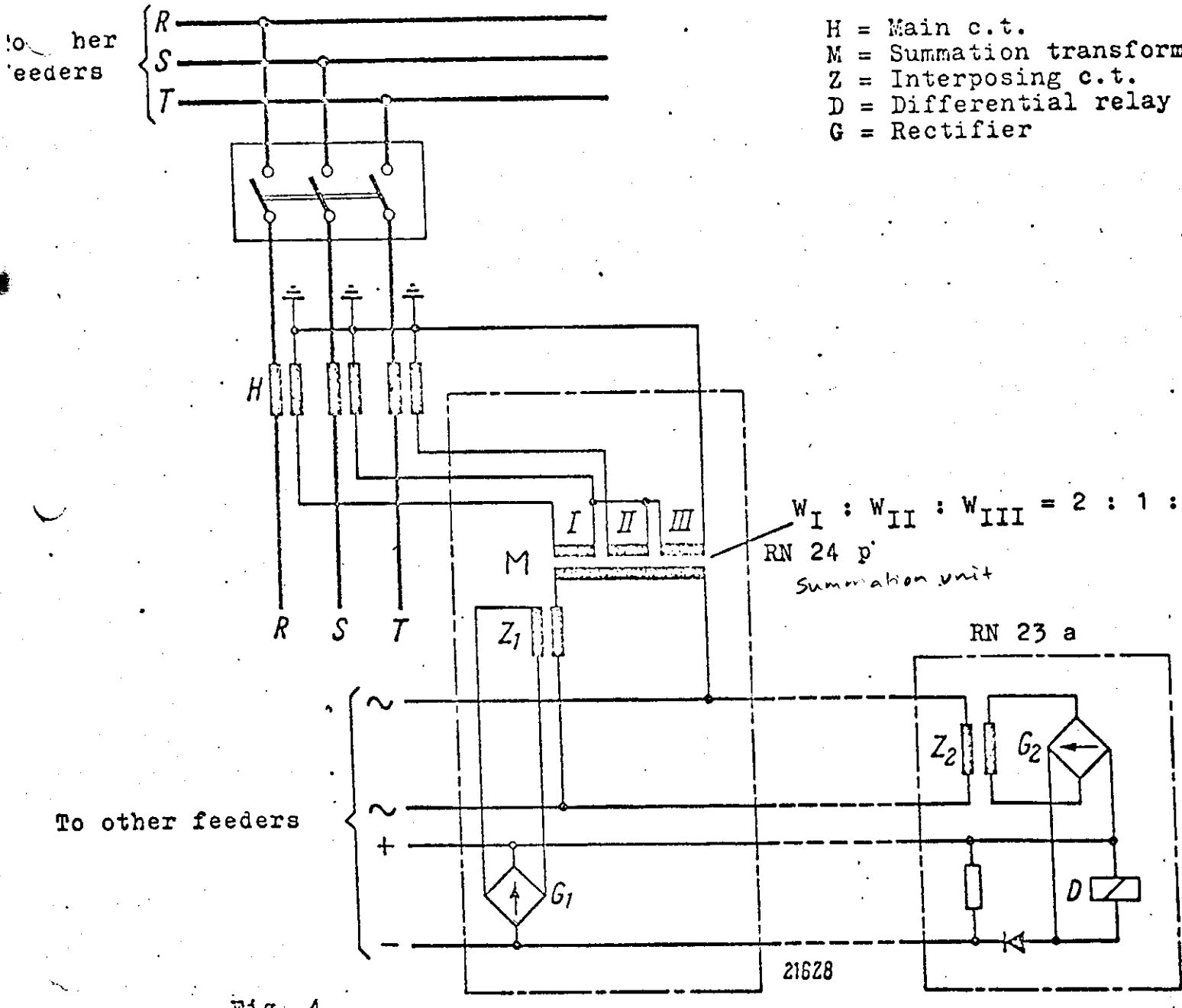


Fig. 3 Tripping diagram

Design of the protection system

A proportional summation current is formed from the three line currents of each busbar feeder or connection by means of a summation transformer lest each phase of the three-phase system have to be provided with a differential circuit of its own. The three line currents are mixed in the ratio 2:1:3, so that a summation current of adequate magnitude is obtained irrespective of the kind of fault occurring (see also Fig. 6).

The protection system can thus be designed as single-phase type.



H = Main c.t.
M = Summation transform
Z = Interposing c.t.
D = Differential relay
G = Rectifier

Fig. 4

A differential relay RN 23a is used for each busbar section that has to be tripped selectively. The following units are employed for each feeder and each bus section panel:

RN 24 p	for single busbars
RN 24 r	for duplicate busbars
RN 24 s	for triplicate busbars

The differential relay RN 23a and the summation current supplementary units RN 24p, -r and -s are each connected in accordance with the arrangement of the feeders and busbars as a differential measuring bridge for the individual selectively tripped busbar sections through auxiliary relays (see the Circuit Diagrams in the Appendix). Selective tripping is thus ensured.

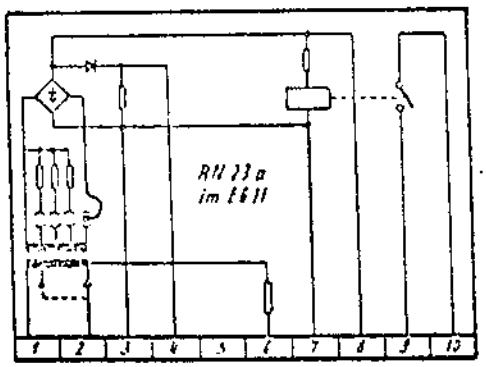
Each "Trip" control-signal circuit associated with a feeder is brought additionally through a starting contact of the main feeder protection system (e.g. distance relay), so that only the feeders carrying overcurrent are tripped when the busbar differential protection system responds. This ensures the highest possible safety against spurious tripping.

The current in the tripping circuit is supervised by the looped-in monitor R 1 AH 423a.

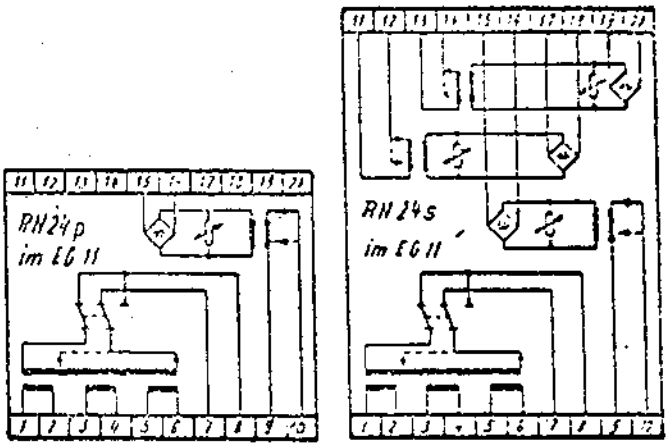
Equipment:

Differential relay RN 23a

Relay RN 23a incorporates a d.c. bridge with a moving-coil relay connected across the bridge. The pick-up value of this differential relay for three-phase faults can be adjusted from 1 to 2.5 times the rated current. The vectorial sum ΣI is fed to the a.c. input (terminals 1 and 2) of the RN 23a. The interposing c.t. whose primary is connected to terminals 1 - 2 of the relay has tappings on its secondary side for setting the stabilisation factor s, using four plugs on the front of the relay: s = 0.5 / 0.6 / 0.7 / 0.85.



Differential protection system RN 23a



Stabilisation supplementary unit RN 24 p and RN 24 s

Fig. 5

The rectifier in full-wave bridge circuit forms the scalar amount of the vectorial sum of currents for comparing it with the scalar sum of currents fed to terminals 3 and 4. The d.c. side comprises the balancing resistors and a diode which is introduced into the circuit of the stabilising side as voltage-dependent resistor in order to reduce the effect of the summation currents in the region of low current values so that the pick-up characteristic curves ensure a high sensitivity of the protection system in the region of the rated current (for the pick-up characteristic curve see the Appendix).

The NO contact of the RN 23a can operate an external tripping relay. Normally it controls the auxiliary relay A in the monitor R 1 AH 423a, which can be used to trip breakers directly. Make sure not to exceed the maximum switching capacity.

The tripping control signal can be multiplied so that one contact is available for each breaker of the plant to be protected. Auxiliary relays 7 PA 10 or RH 29, for instance, which are energized by relay A in R1 AH 423a serve this purpose.

Feeder relay RN 24

This relay is available in three types:

RN 24 p	for single busbars
RN 24 r	for duplicate busbars
RN 24 s	for triplicate busbars

If there are more than three busbars, two relays have to be provided for each feeder and coupler connection.

The relay RN 24 incorporates a summation transformer which has a ratio of the primary windings of 2 : 1 : 3 and converts the three-phase current into a single-phase current which is about 100 mA at rated current of the c.t. This secondary current is passed through small interposing transformers.

The RN 24 p relay has one	interposing transformer,
the 24 r RN relay has two	interposing transformers, and
the 24 s RN relay has three	interposing transformers,

which, through auxiliary relays, are connected to or disconnected from one of the existing ring lines depending on the connection of the feeder concerned (see the circuit diagrams in the Appendix).

Rectifiers in a full-wave bridge circuit are introduced in the secondary side of the intermediate transformers. The rectifiers of these intermediate transformers of one protection zone are connected in parallel for the purpose of forming the scalar sum of the currents, and are connected to the d.c. side of the differential relay.

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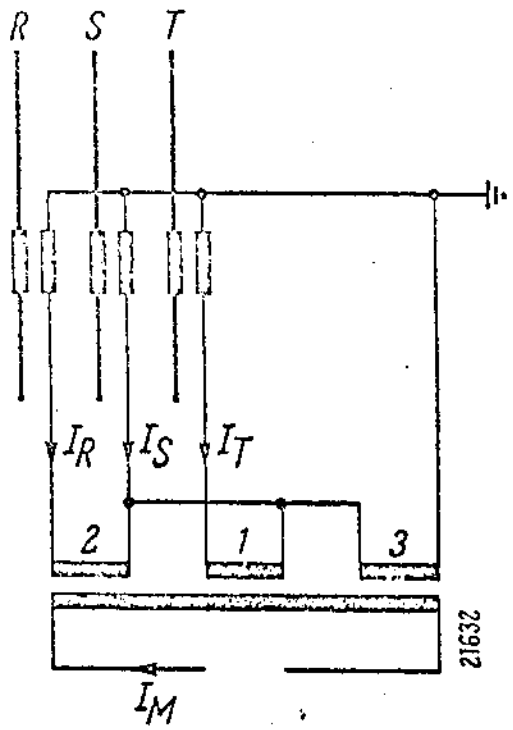


Fig. 6

Summation transformer in the RN 24 relay

Short circuit	Secondary current (ratio)	
R - S	2	times the fault current
S - T	1	
T - R	1	
R - S - T	$\sqrt{3}$	
R - O	5	
S - O	3	
T - O	4	

$$I_M = 2\ I_R + I_T + 3\ (I_R + I_S + I_T)$$

$$I_M = 5\ I_R + 3\ I_S + 4\ I_T$$

Connection:

The busbar protection relay is normally connected to three c.t.'s per busbar feeder. The current transformers shall have a core for 15 VA or more with a saturation factor larger than 10. The busbar differential protection system and the other relays can be connected to a common core. The current level of the secondary side of the c.t.'s must be the same for each busbar protection system.
If the transformation ratios of the main c.t.'s are different, type I o.5 D matching transformers have to provide for equal magnitude of the current.

The differential protection system RN 23a / 24 can be extended as required. It is particularly advantageous in this case that the number of pilot wires does not rise with the number of busbar feeders.

Monitor R1AH 423a:

To prevent operation when current transformers are inadvertently short-circuited or open on the secondary side, the current in the tripping line of the measuring circuit is continuously supervised.

This automatic supervision is effected by the supplementary unit R1 AH 423a which is part of the busbar differential protection system. This supplementary unit incorporates current relay RA 15 which is introduced in the tripping line in series with the winding of the differential relay RN 23a, and a tripping relay.

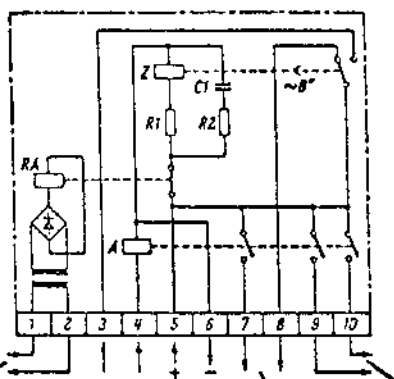


Fig. 7

Differential current path

Relay contact RN 23a

Alarm "Busbar protection system faulted"

Tripping signal

Monitor R 1 AH 423a for the busbar differential relay RN 23a
Interior circuit arrangement

The current relay is adjustable between 10 and 50 mA. Any equalizing current flowing through the tripping circuit as a result of, e.g. inadvertent short-circuiting or opening of pilot lines, causes the current relay to pick up as soon as the preset pick-up value is exceeded. The built-in time element is then operated with a drop-out delay of about 8 s. After this time has elapsed this timing element opens the tripping circuit and completes the circuit of the positive pole for the indicatio "Busbar protection system faulty".

Technical data	RN 23 a
Frequency	
normal	50 Hz
also available	any frequency between 40 and 60 Hz
Pick-up current range	1 to 2.5 times the rated current
Stabilisation factor	0.5 - 0.6 - 0.7 - 0.85
Operating time	approx. 20 to 40 ms, depending on the setting range and the fault current
Rated current in the measuring circuit	100 (or 373) mA +)
Contact	1 NO contact
Contact material	Gold
Switching capacity	
at 0.7 p.f. and more	5 W or 8 VA
maximum switching voltage	250 a.c. or d.c.
maximum switching current	0.2 A
Case	EG 11
Number of terminals	10
Conductor type:	Round conductor up to 6 mm^2
Test voltage	2 kV, 50 Hz
Specifications	VDE 0435
Weight approx.	3.4 kp

+) Normally supplied for 100 mA rated current in the measuring circuit. It can be reconnected to 373 mA (by soldering) for the purpose of co-operation with the previous types RN 23, RN 24 k, l, m and R 1 AH 423.

Technical data	RN 24 p RN 24 r RN 24 s
Frequency	
normal	40 - 60 Hz
Rated current in the	
main c.t. circuits	5A or 1A, depending on the type
measuring circuit	100 (or 373) mA +)
Current carrying capacity of the current circuits for 1 s	100 times the rated current
for 10s	30 times the rated current
continuously	2 times the rated current
Power capacity of the current circuits	2 to 5 VA at rated current
Case	EG 11
Number of terminals	20
Conductor type:	Round conductor up to 6 mm^2
Test voltage	2 kV, 50 Hz
Specifications	VDE 0435
Weight approx.	RN 24 p 5.5 kp
	RN 24 r 6.4 kp
	RN 24 s 8.4 kp

+) Normally supplied for 100 mA rated current in the measuring circuit. It can be reconnected to 373 mA (by soldering) for the purpose of co-operation with the previous types RN 23, RN 24 k, l, m and R 1 AH 423.

Technical data	R 1 AH 423 a	
Frequency,		
normal	50 Hz	
also available	any frequency between 40 and 60 Hz	
Pick-up current range	10 ... 50 (or 25 - 125) mA +)	
Operating time	approx. 25 ms (tripping)	
	approx. 8 s (alarm)	
Rated current in the measuring circuit	100 (or 373) mA +)	
Contact	3 NO contacts for tripping	1 NC contact for alarm
Contact material	Silver	Silver
Switching capacity		
at 0.7 p.f. and more	1000 W	20 W
maximum switching voltage	250V a.c. or d.c.	220V a.c. or d.c.
maximum switching current	5 A	1 A
Auxiliary d.c. voltage, normal	110 or 220 V	
also available	any voltage between 24 and 240 V	
Power capacity of the d.c. circuit continuously	approx. 2 mW	
during pick-up	approx. 2 to 5 W	
Case	EG 11	
Number of terminals	10	
Conductor type:	Round conductor up to 6 mm^2	
Test voltage	2 kV, 50 Hz	
Specifications	VDE 0435	
Weight approx.	3.2 kp	

+) Normally supplied for 100 mA rated current in the measuring circuit. It can be reconnected to 373 mA (by soldering) for the purpose of co-operation with the previous types RN 23, RN 24 k, l, m and R 1 AH 423.

Associated drawings: 3 TS 137 S S 30397;3v TS137S S 30544
4 TS 137 S K 32088 / 89 / 90 / 91

Sammelschienendifferentialschutz RN23a/24p,r,s

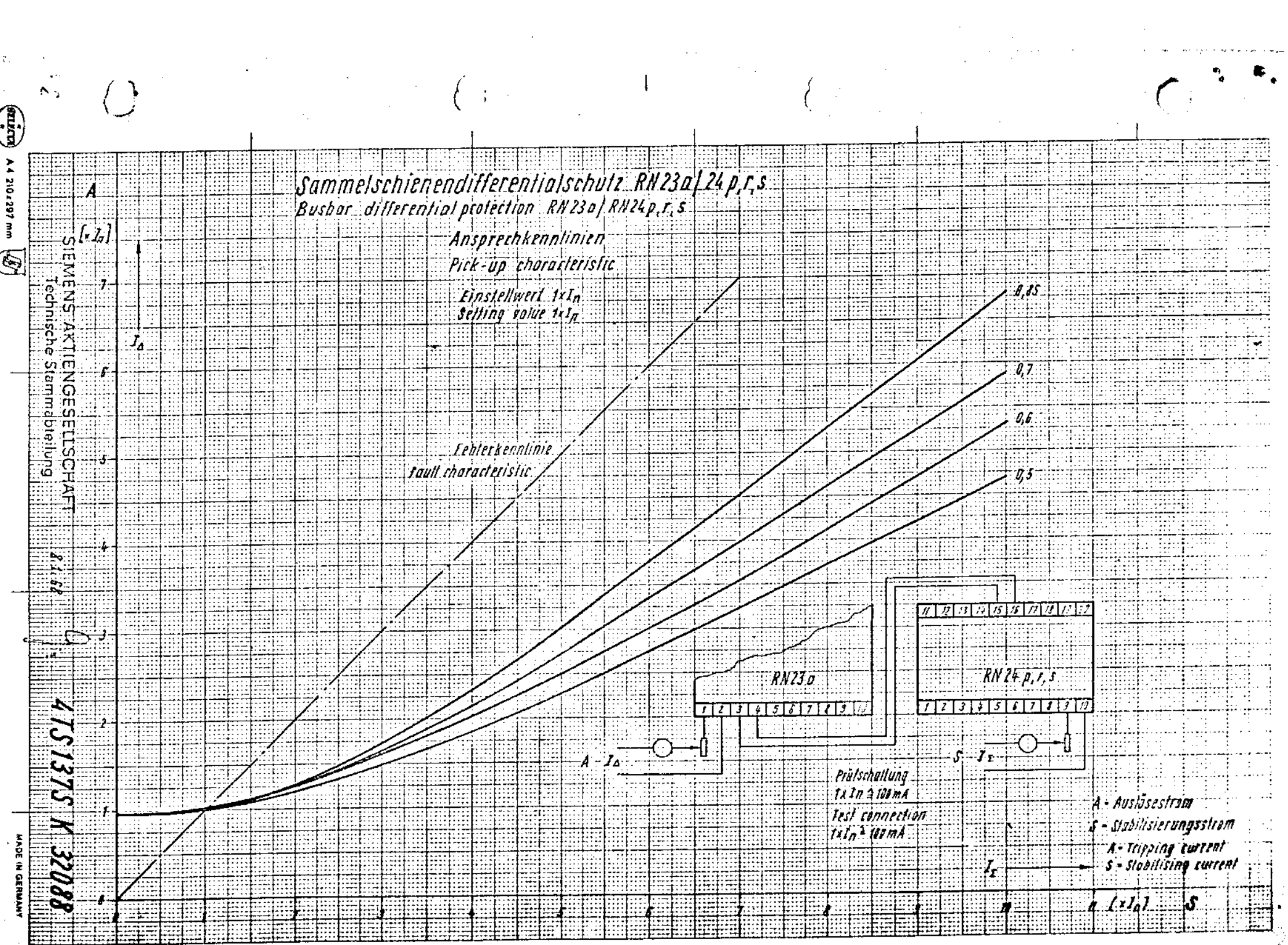
Busbar differential protection RN23a/RN24p,r,s

Ansprechkennlinien

Pick-up characteristic

Einstellwert $1 \times I_n$

Setting value $1 \times I_n$



SIEMENS AKTIENGESELLSCHAFT
Technische Stammabteilung

4 TS 1375 K 32088

A4 210x297 mm

MADE IN GERMANY

SIEMENS

A4 210 x 297 mm

Sammelschinendifferentialschutz RN 23a/24 p,r,s

Busbar differential protection RN 23a/RN 24 p,r,s

Ansprechkennlinien
Pick-up characteristic

Einstellwert $1 \times I_n$
Setting value $1 \times I_n$

Fehlerkennlinie
fault characteristic

0,85

0,7

0,6

0,5

A
$[\times I_n]$

I_Δ

150

100

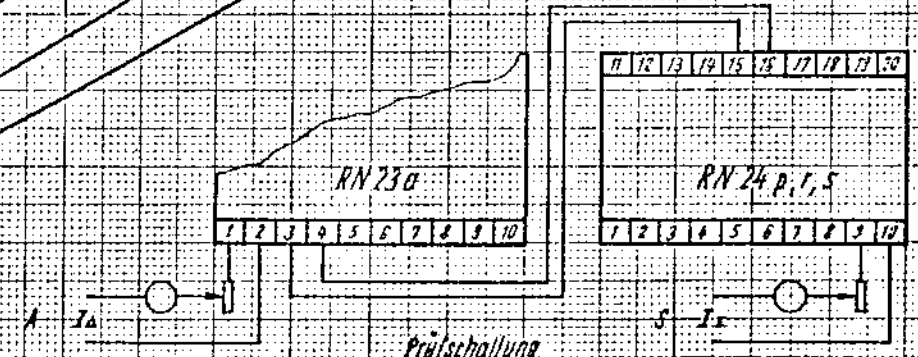
50

0

I_S

$[\times I_n]$

S



Prüfschaltung
$1 \times In \triangleq 100 mA$
Test connection
$1 \times I_n \triangleq 100 mA$

A = Auslösestrom
S = Stabilisierungsstrom
A = Tripping current
S = Stabilising current

4 TS 1375 K 32089

MADE IN GERMANY

SIEMENS AKTIENGESELLSCHAFT
Technische Stammableitung

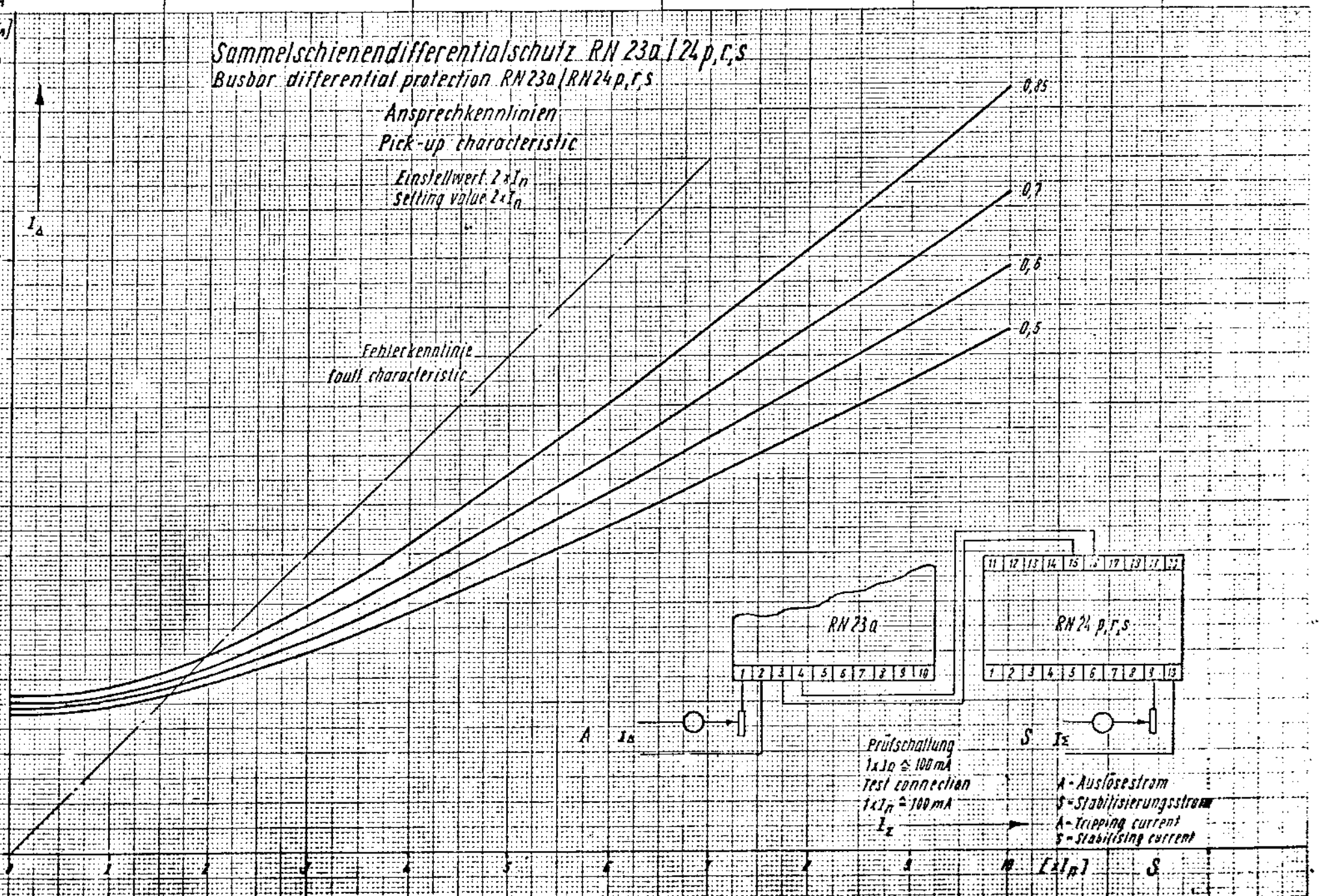
Sammelschienendifferentialschutz RN 23a / 24 p,r,s

Busbar differential protection RN 23a / RN 24 p,r,s

Ansprechkennlinien

Pick-up characteristic

Einstellwert $2 \times I_n$
Setting value $2 \times I_n$



4 7S137.5 K 32090

A 4 210 x 297 mm

MADE IN GERMANY

SIEMENS AKTIENGESELLSCHAFT
Technische Stammabteilung

8.7.68

4TS 137.5 K 32091

A 4 210x297 mm

MADE IN GERMANY

Sammelschienendifferentialschutz RN 23a/24p,r,s

Busbar differential protection RN 23a/RN 24p,r,s

Ansprechkennlinien

Pick-up characteristic

Einstellwert $2 \times I_n$

Selling value $2 \times I_n$