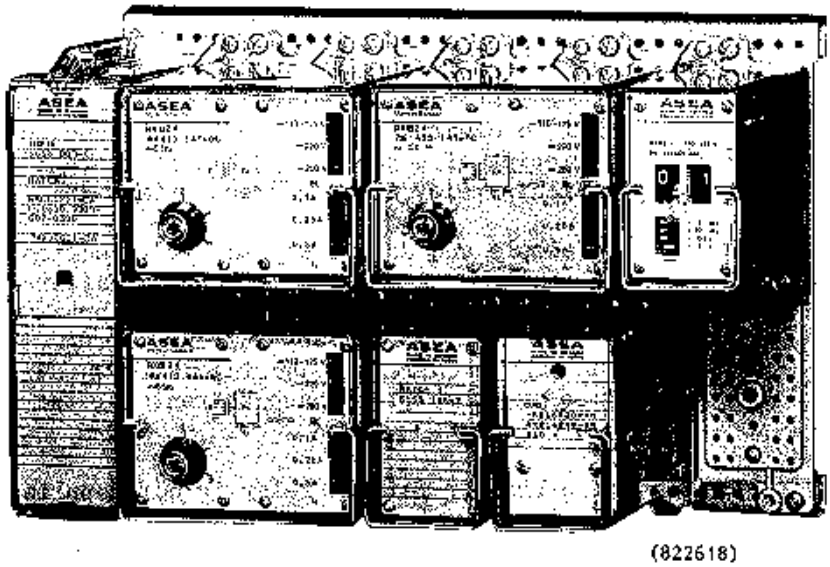
Breaker failure relay type RAICA

- Provides local back-up protection when a primary circuit breaker has failed to operate
- Initiates tripping of adjacent back-up breakers for disconnection of the fault, thus preventing power system instability
- Contains static current measuring units with short pick-up time and short resetting time
- Includes static time measuring units with excellent time measuring accuracy and very short overshoot time
- Operates correctly even with saturated current transformers
- Has no power consumption in the auxiliary voltage circuit during normal service



(822618)

Fig. 1: Breaker failure relay type RAICA with one time step.

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APPLICATION

The protective relays are required to rapidly initiate fault clearing by power circuit breakers when for example a short circuit occurs in the power system, consequently isolating the faulty section of the system.

It is then important that the power circuit breaker operates correctly, so that the fault clearing is done quickly. However, there is always a risk that the breaker will not succeed to interrupt the fault current and that the fault clearing time will be dependent on how fast the back-up protection schemes can initiate fault clearing.

Increasing power system complexity demands shorter and shorter fault clearing times, for example to maintain the stability of the power system. It is therefore often necessary to provide each circuit breaker with a local back-up protection scheme, comprising a breaker failure relay. If a power circuit breaker is unsuccessful to clear a fault, for example due to a stucked breaker pole, tripping of adjacent circuit breakers is provided by the breaker failure relay after a preset time.

Current measurement

A simple and secure way to verify correct operation of a power circuit breaker is to detect that after a certain time, which is sufficiently long for the circuit breaker to normally operate, there is no longer any current through the breaker. Type RAICA has three current measuring units which provide a possibility to measure the three phase currents or two phase currents and the zero sequence current.

The breaker failure relay is not supplied with auxiliary voltage during normal service. This feature results in no battery drain as the current measuring units are not continuously supplied from the auxiliary voltage source, so there will be zero power consumption. An additional advantage is also obtained. Possible contact disturbances are prevented if the relay is supplied with a distorted current close to the set value, since the d.c. power is only supplied during a fault for which the relay is initiated to operate.

Time measurement

The tripping impulse of the protective relay which starts the breaker failure relay is supplied via the contacts of the current measuring units to a time measuring unit. If the current through the power circuit breaker still is above the set value of the current measuring units after the set time, the breaker failure relay provides a tripping impulse to adjacent circuit breakers in the same station.

Type RAICA is available with one or two time steps, that is with one time measuring unit and with two time measuring units. The two step version provides added security for tight breaker failure margins. One step of the version with two time steps can be set short and be started by for example a three-phase short-circuit relay. This provides shorter tripping times for faults which can cause instability in the system. However, this must be compared with the risk when having decreased margins between the normal clearing time of the breaker and the set time of the time measuring unit.

Thus RAICA versions with two time steps can be used in applications when it is desired to differentiate between two different types of faults. For example, one time measuring unit is set short for three phase faults which are the least probable in occurance, but most severe to the stability of the system. The other time measuring unit is set longer to provide greater breaker failure margin, because all other types of faults are most probable but less critical than three-phase faults, and they have longer allowable clearing times.

The total clearing time of the breaker failure relay is shown in Fig. 3, illustrating a time co-ordination chart, see page 6.

Auxiliary relay for additional primary tripping impulse

The RAICA relay also includes an auxiliary relay which instantaneously seals in through the contacts of the current measuring units. Contacts of the auxiliary relay send a second trip signal via separate wires to the second trip coil of the primary circuit breaker to assure that it receives a tripping impulse. This feature would prevent tripping of the back-up circuit breakers if the normal tripping circuit has an interruption. Thus, only the primary circuit breaker would be tripped instead of the back-up circuit breakers. The phase current measuring units which were operated by load current would reset the time measuring unit after the auxiliary relay trips the primary circuit breaker.

Filter unit

A filter unit is provided to incorporate additional application features. The functions of the filter units are described on page 8.

Co-operation with bus protection

The RAICA versions are designed for bus protection applications. However, there is also a special space-reducing RAICA version available for applications together with bus differential relays, for example type RADSS. See pages 12 and 22.

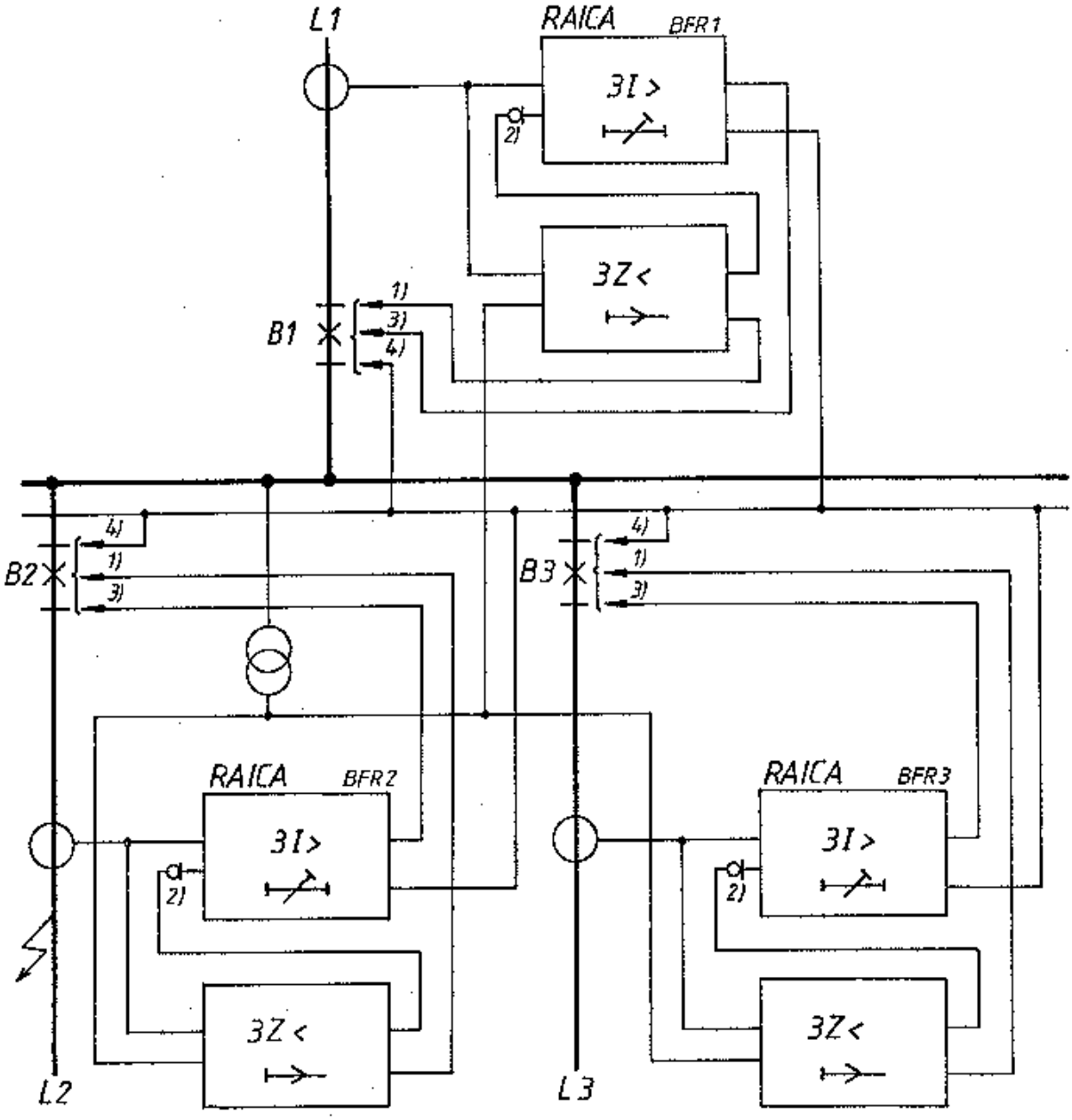

Fig. 2a: Example of application, single bus. If the power circuit breaker B2 does not clear a fault on line L2, the breaker failure relay BFR2 provides tripping of circuit breakers B1 and B3.

1) Primary tripping impulse from the distance relays.

2) The breaker failure relay type RAICA is started when the auxiliary voltage supply is switched in by the distance relay.

3) Type RAICA provides instantaneous tripping impulse to its "own" power circuit breaker.

4) Tripping of adjacent breakers after the set delay.

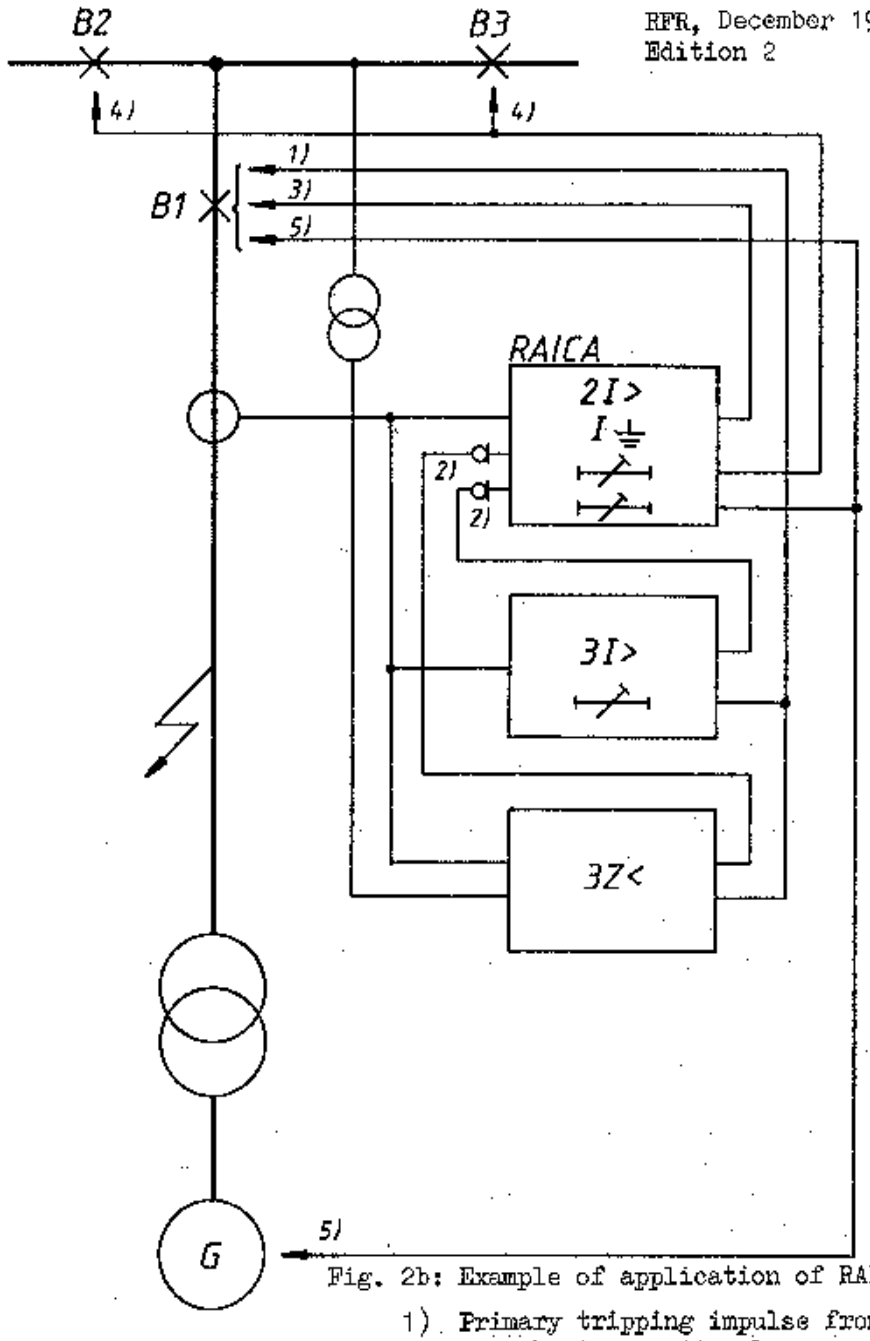

Fig. 2b: Example of application of RAICA with two time steps.

1) Primary tripping impulse from the three-phase distance and short-circuit relays.

2) The breaker failure relay type RAICA is started by the auxiliary voltage supply being switched in. The short time step is started by the overcurrent protection.

3) Type RAICA provides instantaneous tripping impulse to its "own" power circuit breaker.

4) Tripping of adjacent breakers after the set delay.

5) For certain types of faults, the short time step provides a rapid stop of the generator. Information on the type of fault will be provided from the overcurrent protection, see CIRCUIT DIAGRAMS on pages 20 and 21.

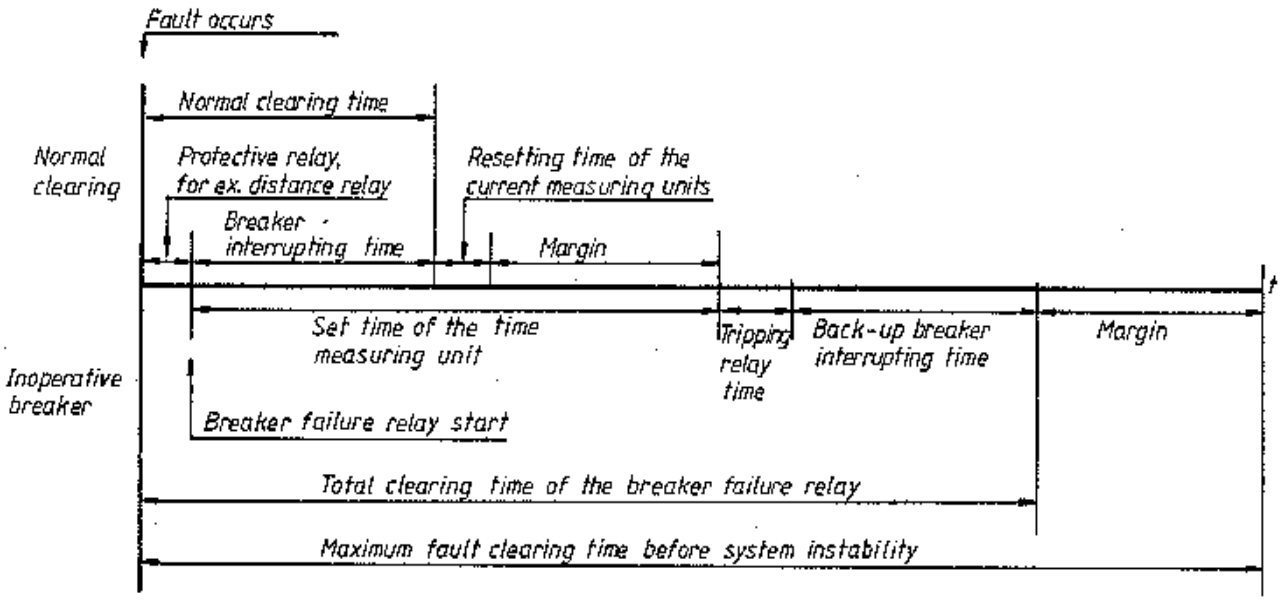

Fig. 3: Time co-ordination chart. Diagram for events with normal clearing (correct breaker operation) and with inoperative breaker.

DESIGN AND MODE OF OPERATION

The breaker failure relay type RAICA comprises a test switch, plug-in units, terminal bases, and mounting accessories type COMBIFLEX®. The test switch and the terminal bases are screwed to two apparatus bars. The plug-in units are screwed to the terminal bases and all wiring between the components of the relay are done at the rear of the terminal bases.

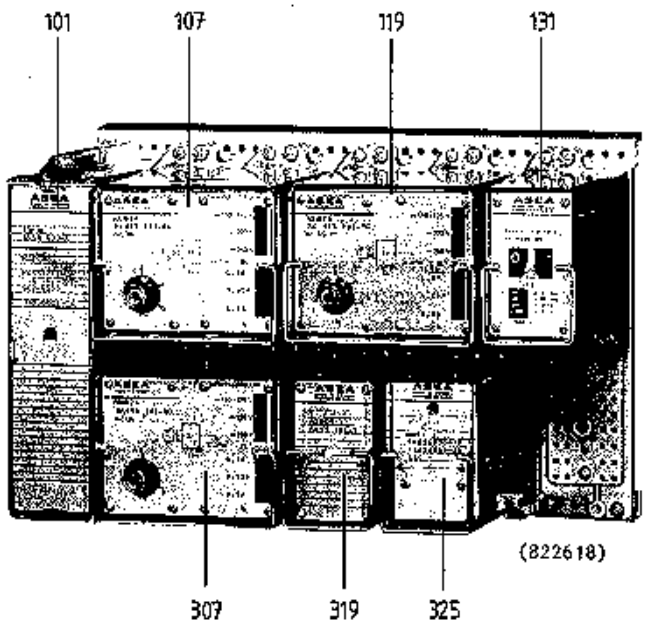

Fig. 4: Basic design of type RAICA. The digits underlined in the text below denote the physical position of the various units of the relay.

Basic breaker failure relay units

101 Test switch type RTXP 18 has most of the input and output wires connected to its rear 20 A terminals with wires fitted with COMBIFLEX® sockets. Additional connections are done directly on the terminal bases.

A complete secondary testing can be performed with the two components of the testing system COMBITEST, the test switch RTXP 18 and the test plug handle type RTXH 18. When the test plug handle is inserted in the test switch, the tripping and signal circuits are first opened and then the current transformer circuits are short circuited. Access is then provided to the current and tripping circuits of the relay, and the breaker failure relay is then ready for testing.

The tripping circuits can be blocked with trip-block plug type RTXB (red colour) and operating currents can be measured with an ammeter test plug type RTXM. The breaker failure relay can be totally blocked, that is disconnection of the auxiliary supply, tripping, measuring, and signal circuits, with a block plug handle type RTXF 18.

107 119 307 Static current measuring unit type RXIB 24 with its main characteristics, the short resetting time, ≤ 12 ms, and the short and consistent pick-up time, 4-5 ms, see the diagram in Fig. 6.

The resetting time of type RXIB 24 is not influenced by a possible d.c. offset in the secondary circuit of the current transformer when a short-circuit current with a d.c. component is interrupted. This is an important and necessary characteristic of protective relays of this type.

131 The static time measuring unit type RXKE 1 has several features. Those are short overshoot time, short resetting and recovery times plus accurate time measurement. These RXKE 1 qualities are especially suitable for breaker failure relay applications. The delay of the breaker failure relay is set on the time measuring unit, and the time should be equal to the sum of the operating time of the primary breaker, the resetting time of the current units and a safety margin. See Fig. 3.

319 Plug-in unit type RXTCB 1 contains filter and impulse storing circuits for three functions:

1 Contact disturbances of the tripping relay is prevented which otherwise could be caused by contact disturbances of the current measuring units when there for example are saturated current transformers. A diode in the unit RXTCB 1 is connected between a series resistor and the coil of type RXMS 1 which then is picked up continuously for a 1 ms pulse each half period (50-60 Hz).

2 The impulse storing circuit prolongs the impulse to the time measuring unit. Thus, incorrect time measurement is prevented, should there be contact disturbances of the current measuring units due to saturation of the current transformers.

The overshoot time and the resetting time of the time measuring unit is not influenced by the circuitry of this additional plug-in component. The recovery time of the time measuring unit before operation will be approximately 10 ms longer than normal, but the recovery time during and after operation will not be changed.

3 Unnecessary tripping via the tripping relay is prevented, should an earth fault occur in the auxiliary voltage supply circuit. If the current measuring units are set below load current, they should otherwise pick up. The breaker failure relay should then seal in and initiate tripping. An impulse storing circuit has been included to prevent this unnecessary tripping. The impulse storing circuit with a parallel connected discharge resistor is connected betw terminal 13B of the test switch (start) and terminal (minus). A diode is connected in series to avoid prolo tion of the resetting time of the breaker failure relay.

325 Auxiliary relay type RXMS 1 provides a rapid (pick-up time 3.5 ms) second tripping impulse to the "own" circuit breaker and it provides simultaneously a seal-in of the auxiliary voltage supply to the RAICA through the contacts of the current measuring units.

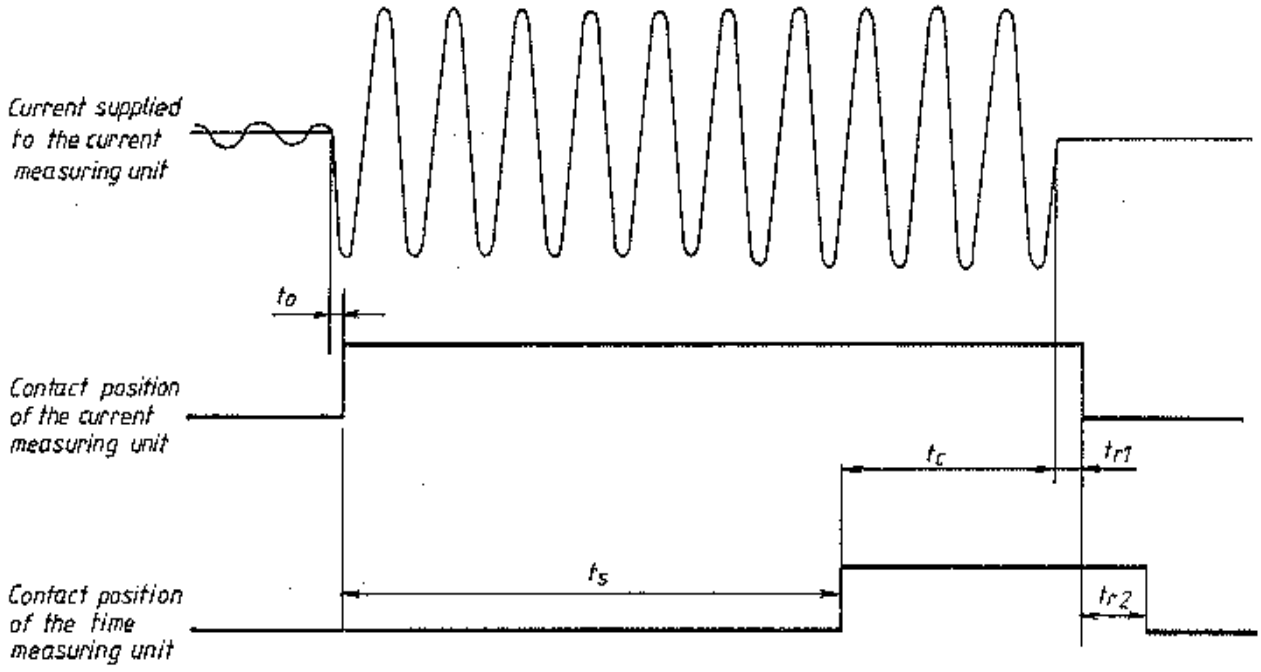

Fig. 5a: Example of a diagram for operation WITHOUT saturation of the current transformers. The time measuring unit operates in a normal way also WITHOUT IMPULSE STORING CIRCUITS.

t_o = operating time of type RXIB 24 ≈ 4 ms
t_s = set delay of type RXKE 1 (150 ms)
t_c = operating time of the power circuit breaker (60 ms)
t_{r1} = resetting time of type RXIB 24 (≈ 10 ms)
t_{r2} = resetting time of type RXKE 1 (≈ 20 ms)

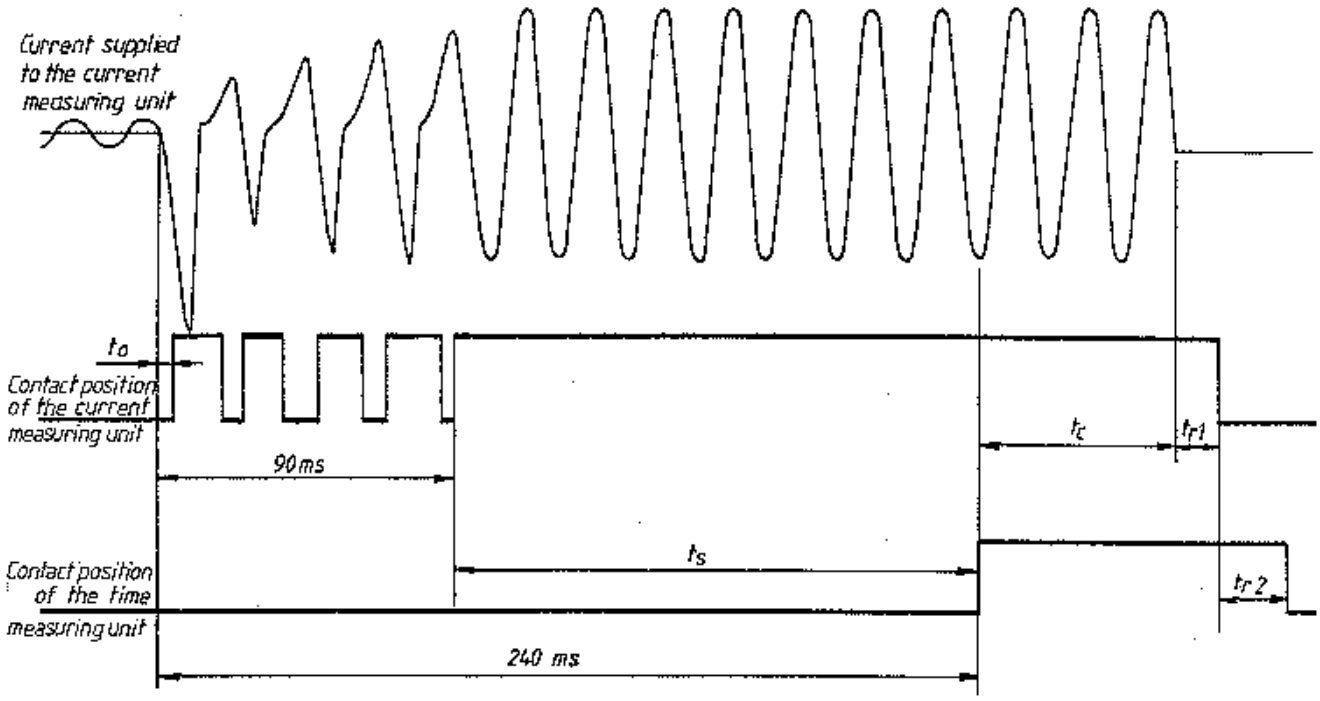

Fig. 5b: Example of a diagram for operation WITH saturation of the current transformers. The operation of the time measuring unit is delayed approximately 90 ms WITHOUT IMPULSE STORING CIRUITS according to the example in the diagram.

t_o = operating time of type RXIB 24
t_s = set delay of type RXKE 1
t_c = operating time of the power circuit breaker
t_{r1} = resetting time of type RXIB 24
t_{r2} = resetting time of type RXKE 1

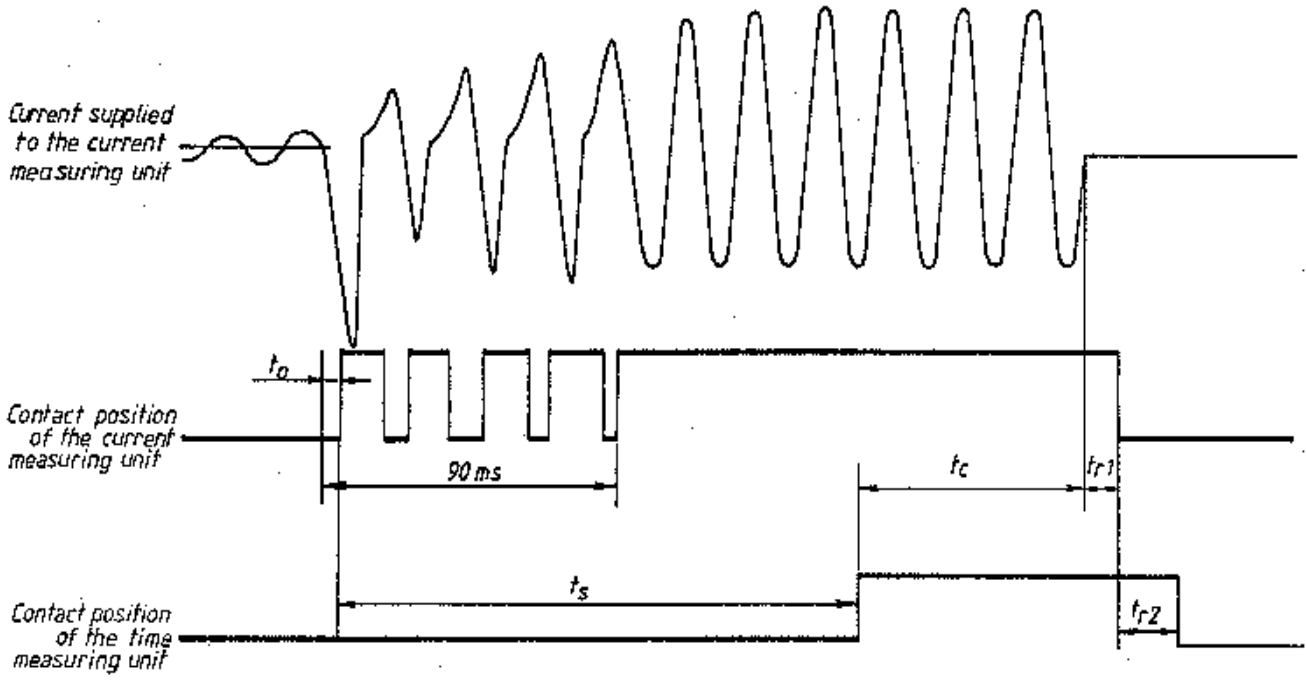

Fig. 5c: Example of a diagram for operation WITH saturated current transformers. Correct time measurement is obtained WITH IMPULSE STORING CIRCUITS.

t_o = operating time of type RXIB 24
t_s = set delay of type RXKE 1
t_c = operating time of the power circuit breaker
t_{r1} = resetting time of type RXIB 24
t_{r2} = resetting time of type RXKE 1

Signal relay

A signal relay type RXSF 1 is included in two versions of the breaker failure relay. Indication is obtained for instantaneous tripping and for tripping on the individual time steps. Type RXSF 1 includes one or two flag relays which are manually reset.

Tripping circuits

The tripping impulse from the breaker failure relay (terminals 101:16B and 101:17B of the test switch) to the primary circuit breaker should be routed separately to the second trip coil. The breaker failure can consist of interruption of the ordinary tripping circuit and if this circuit also is used for the breaker failure relay, the extra tripping impulse will be ineffective.

Co-operation with bus protection (diagram on page 22)

A version of type RAICA according to circuit diagram 7429 0005-AA, see CIRCUIT DIAGRAMS, is intended for co-operation with a bus differential relay, for example type RADSS. The filter unit type RXTCB 1 is not included in this version. The space requirement of the breaker failure relay is in this case only 30C width modules and then two breaker failure relays can be mounted in the same equipment frame (size 4S). The contacts of the current measuring units are included in the tripping circuit. It is therefore necessary to take into consideration the contact data for type RXIB 24 in such applications.

A diode has been connected in parallel with the tripping relays type RXMS 1 to prevent contact disturbances. The tripping relay resetting time with this diode included is approximately 10 ms.

The version does not include any impulse storing circuit for the time measuring unit and no protection for accidental earth faults in the auxiliary voltage supply circuit.

Tripping of single pole power circuit breakers

Type RAICA with Catalogue No's RK 651 211-AA, -CA, and RK 651 213-AA, -CA, and RK 651 216-AA can be used for single pole tripping if the current measuring units are set ABOVE the largest load current.

At single pole tripping, type RAICA must be supplemented with a relay logic that selects the proper breaker coil to be tripped on the first time step.

TECHNICAL DATA

Rated frequency	50 or 60 Hz
Auxiliary voltage U_n	36, 48, 55, 110, 125, 220, and 250 V d.c.
Permissible variation of the auxiliary voltage	-20 to +10 % of U_n
Permissible ambient temperature range	-25 to +55 °C

Insulation test voltage	2.5 kV, 50 Hz for the current circuit 2.0 kV, 50 Hz for other circuits
Impulse test	5 kV, 1.2/50 µs, 0.5 joule (Ws) (according to IEC Publ. 255-4, Appendix E)
High frequency disturbance test	Common mode voltage 2.5 kV, 1 MHz Transverse mode voltage 1 kV, 1 MHz (According to IEC Publ. 255-4, Appendix E)

Data for the current measuring unit type RXIB 24
See Information RK 413-301 E for complete data.

Operating value	Steplessly settable between 1 and 3 times the scale factor I_s
Scale factor I_s	Reconnectible between 1, 2.5, and 5 mA or 10, 25, and 50 mA or 0.1, 0.25, and 0.5 A or 0.2, 0.5, and 1 A or 1, 2.5, and 5 A or 6, 15 and 30 A
Resetting ratio	≥87 %
Operating time	See Fig. 6
Resetting time	See Fig. 6
Overload capacity continuous (max. 20 A)	30 x lowest setting
1 second (max. 350 A)	500 x lowest setting
Power consumption in measuring circuit Scale factor:	
0.25 mA-0.25 A	7 mVA
10 mA-0.5 A	9 mVA
1 A	18 mVA
2.5 A	55 mVA
5 A	150 mVA
6 A	0.7 VA
15 A	2.1 VA
30 A	5 VA

Contact data:

Maximum voltage between lines	250 V d.c. or a.c.
Continuous current carrying capacity	2 A
Making capacity	2 A
Breaking capacity	
a.c., P.F. $\geq$ 0.1	
at max. 250 V	0.6 A
d.c., L/R $\leq$ 40 ms	
at max. 55 V	0.4 A
110 V	0.2 A
125 V	0.15 A
220 V	0.1 A

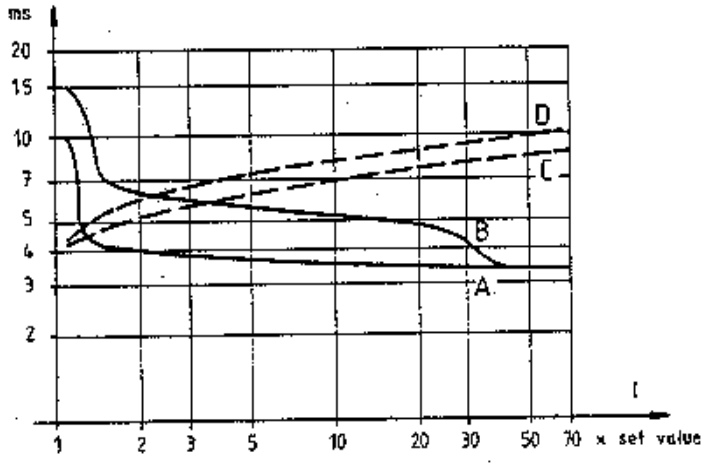

Fig. 6: Operating and resetting times as functions of the supplied current.

A = Operate times for currents with no dc component
B = Operate times for currents with fully developed dc component
C = Reset times at 60 Hz
D = Reset times at 50 Hz

Data for the time measuring unit type RXKE 1
See Catalogue RK 33-12 E for complete data.

Time-lag scales	20 ms-99 s
Auxiliary voltage dependence	0.01 % of set time + 3 ms per % voltage change
Impule margin time	< 2.5 ms

Contact data for tripping and signal circuits:

	RXMS 1 (Trip)	RXSF 1 (Signal)	RXKE 1 (Timer)
Maximum voltage between the lines a.c./d.c.	300/250 V	300/250 V	250/250 V
Current carrying capacity			
Continuously	4 A	5 A	5 A
During 1 s	20 A	50 A	15 A
Capacity to make and conduct, inductive load and L/R ≥ 10 ms			
During 200 ms	30 A	30 A	30 A
During 1 s	10 A	10 A	10 A
Breaking capacity at d.c., L/R ≤ 40 ms, single contacts			
48 V	1.2 A	1.5 A	1.0 A
55 V	0.8 A	1 A	0.8 A
110 V	0.3 A	0.4 A	0.4 A
125 V	0.25 A	0.3 A	0.3 A
220 V	0.15 A	0.2 A	0.2 A
250 V	0.12 A	0.15 A	0.15 A

SETTINGS

Current measuring units

The current measuring units should be set to obtain secure operation for the smallest short-circuit current which can be obtained.

If the application also includes measurement of the current in the neutral, this relay unit is set as sensitive as possible with consideration taken to the relay data and to the highest possible zero sequence current.

The operating values of the current measuring units are possible to set steplessly 1-3 times the scale constant with the aid of a knob in the front. The knob is accessible through a hole in the cover of the unit. The hole is normally blanked off with a removable plastic plug. By unplugging the unit from the terminal base and removing the cover, the scale constant can be changed by moving a screw connection on the right-hand side of the unit. Each unit has thus three scale ranges. In the same way, the relay unit can be reconnected for different auxiliary voltages. Correct connections are done according to the data stated in the order, when the RAICA relay is delivered.

Time measuring unit

Set the time measuring unit on position 131 (325) at a delay equal to the breaker time plus the resetting time of the current measuring units plus a safety margin.

Example:

The distance relay provides at a short-circuit a tripping impulse to the breaker after approximately 20 ms. The breaker generally needs approximately 60 ms to interrupt the fault current. The current measuring unit type RXIB 24 has a 10 ms resetting time. The safety margin has been chosen to 70 ms. The time measuring unit should then be set on 60 + 10 + 70 = 140 ms.

Total fault clearing time = 20 ms (tripping time of the primary protective relay) + 140 ms (type RAICA delay) + 3.5 ms (type RAICA tripping relay) + 60 ms (back-up breaker tripping time) ≈ 225 ms.

The setting of the short-time time measuring unit on position 137 or 331 cannot generally be stated, it must be defined from case to case. It should be remembered that this time measuring unit should always be started via an external condition from for example an overcurrent relay contact, see CIRCUIT DIAGRAMS, Figures 10 and 11.

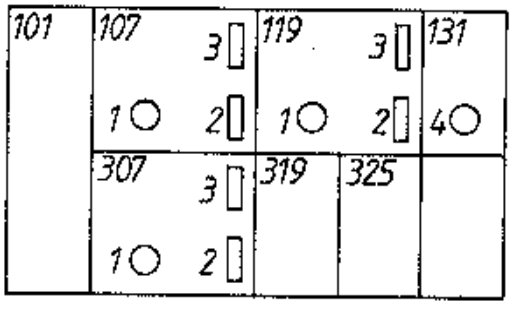

Fig. 7: Picture showing the setting possibilities (for the basic version) according to circuit diagram 7429 0001-AA.

1 Operating value for current
2 Selection of scale constant. Loosen the fastening screws and pull out the current measuring unit from the terminal base and remove the protective cover. Then change the screw connection to the desired position.
3 Alteration for different auxiliary voltages is done by changing screw connections in the same manner as 2.
4 Setting of the delay.

INSTALLATION

If the breaker failure relay is not included in a delivery of a protection equipment in a cubicle, it will be delivered in a package so designed as to prevent damage during normal conditions of transportation. On receipt, the protective relay should always be inspected for external damage. Following this examination, the unit should be replaced in its packing until it is to be installed. It should be stored in a dry location.

The protective relay, which is delivered with its integral units mounted on apparatus bars, is intended to be mounted on a supporting frame in a 19" equipment frame, which is then installed in an apparatus cubicle. The protective relay can also be screwed into an RHGX case. Equipment frames and cases are described in Catalogue RK 92-10 E and can be ordered using the information in Catalogue SK 14-1 E.

All internal connections (full lines in the diagrams) are made on delivery and therefore only external connections remain to be made.

MAINTENANCE

Under normal conditions, type RAICA requires no special maintenance. The covers should be mounted correctly in place and the setting holes in the covers blanked off with the removable. plastic plugs. Burnt contacts can, in exceptional cases, be dressed carefully with a diamond file or an extremely fine file.

Emery cloth or similar products must not be used as insulating grains of the abrasive may remain on the contact surfaces and cause failure. Under normal service conditions and non-corrosive atmosphere, routine testing is recommended each or every other year.

When inserting or removing relays and other units, as when resetting, reconnection, etc., care must be taken to prevent unnecessary operation. Normally, the protective relay should be disconnected in such cases, but it is often sufficient to block the tripping circuit with a type RTXB trip-block plug, which is inserted in the test switch.

When handling the units of the breaker failure relay, it is advisable to always improve security by blocking the tripping circuits in the test switch.

CIRCUIT DIAGRAMS Catalogue No. RK 651 211-AA.

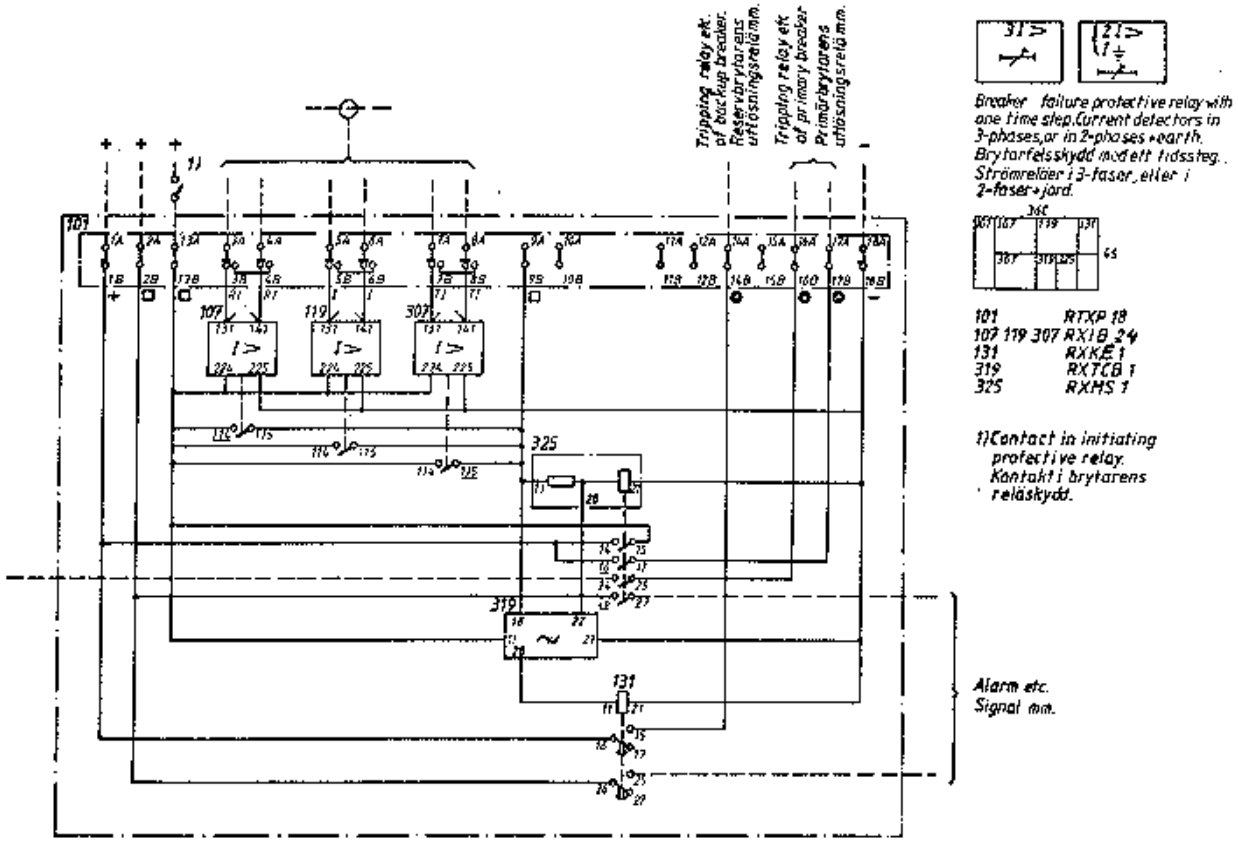

Fig. 8: Circuit diagram 7429 0001-AA. Basic version, one time step. See also Fig. 13 on page 22.

Catalogue No. RK 651 211-CA.

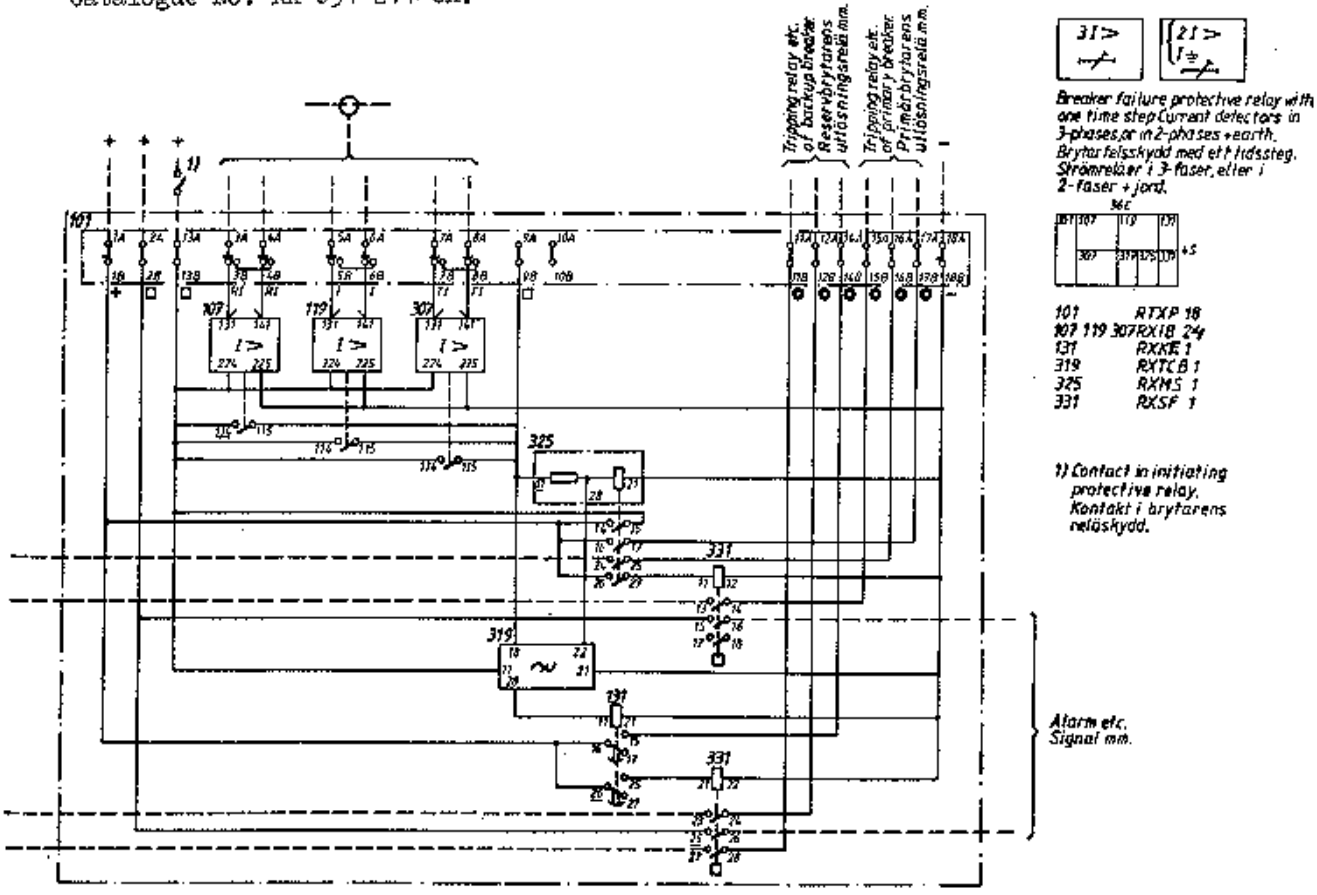

Fig. 9: Circuit diagram 7429 0001-CA. One time step. Signal relay type RXSF 1 (331) is included. See also Fig. 13 on page 22.

Catalogue No. RK 651 213-AA.

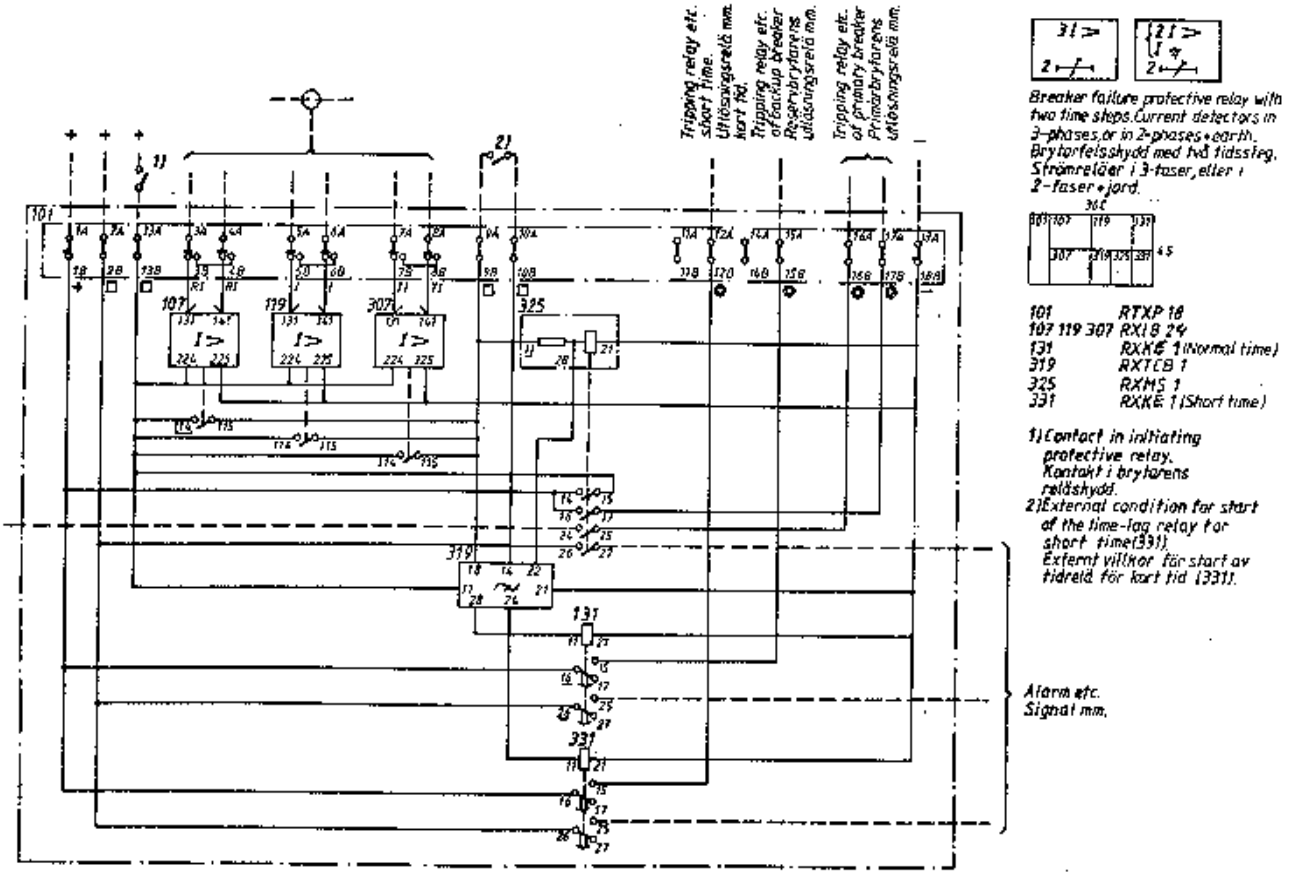

Fig. 10: Circuit diagram 7429 0003-AA. Two time steps are included (131, 331). See also Fig. 14 on page 23.

Catalogue No. RK 651 213-CA.

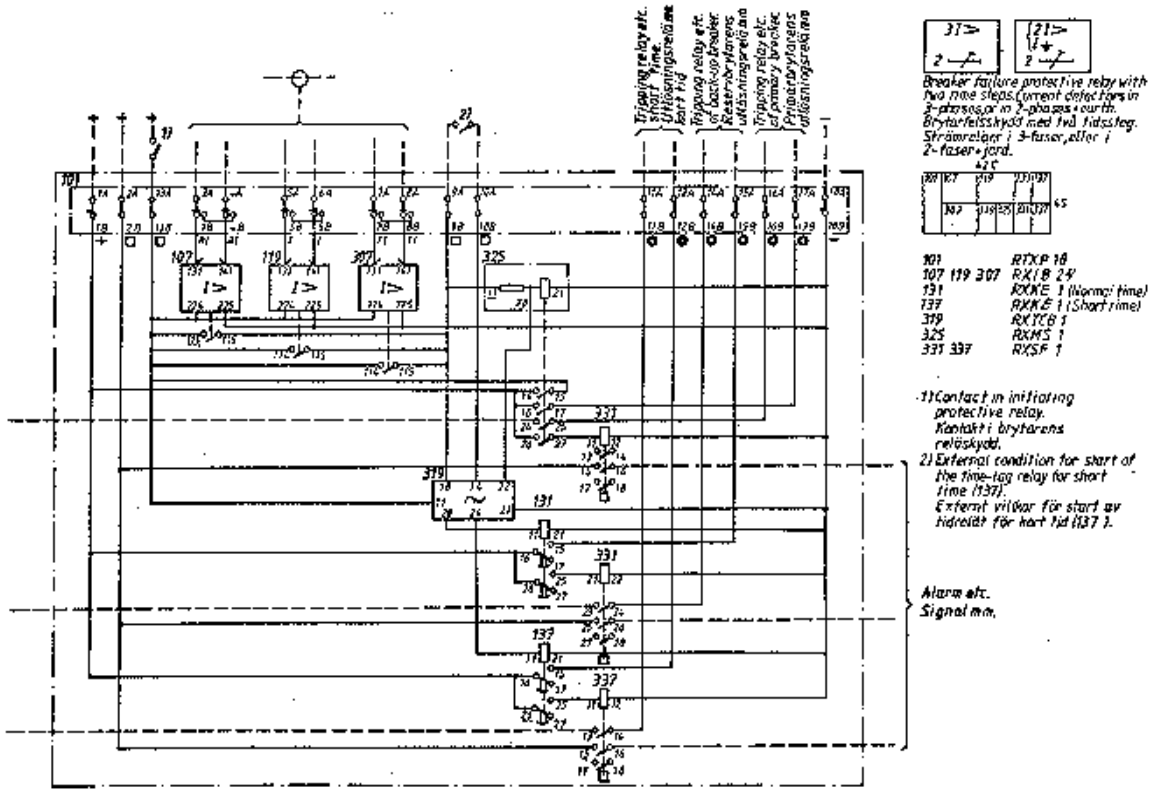

Fig. 11: Circuit diagram 7429 0003-CA. Two time steps (131, 137) and two signal relays (331, 337) are included. See also Fig. 14 on page 23.

Catalogue No. RK 651 216-AA.

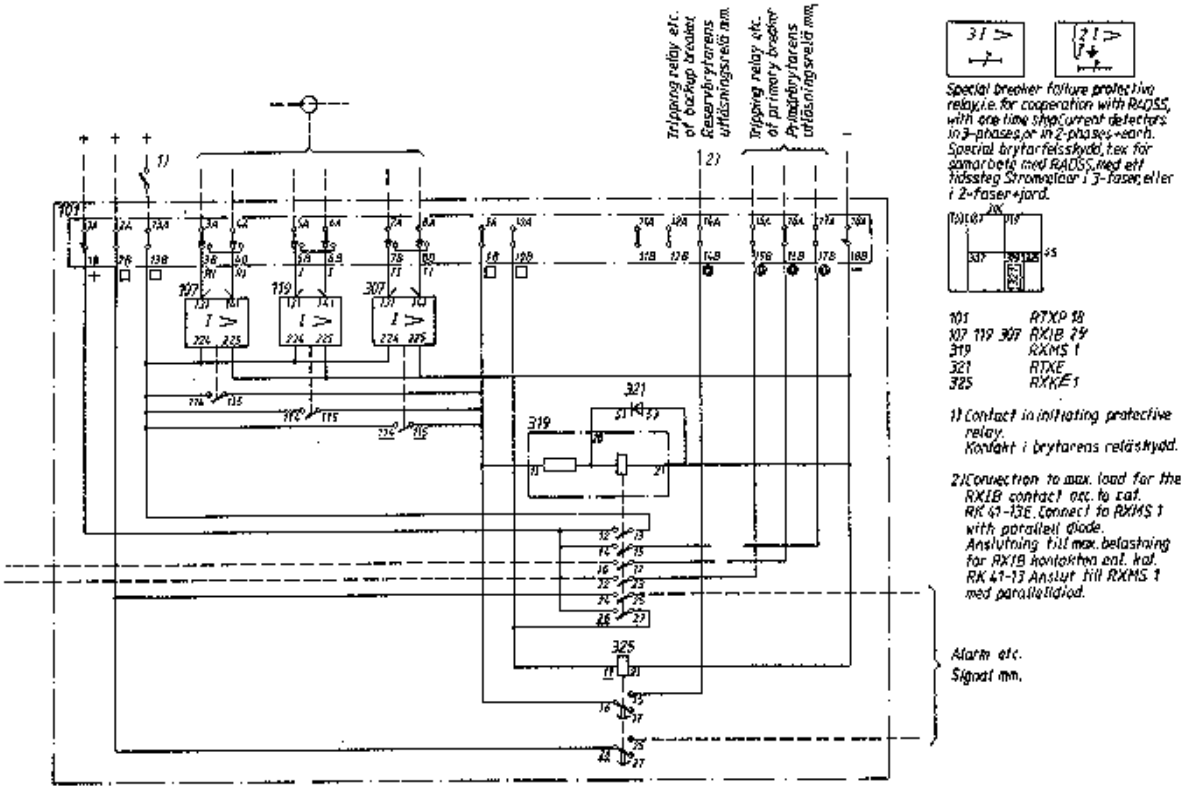

Fig. 12: Circuit diagram 7429 0005-AA. Version for co-operation with bus differential relay, one time step.

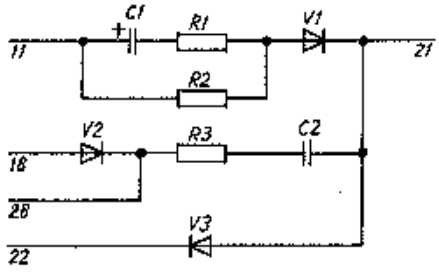

Fig. 13: Circuit diagram for type RXTCB 1 included in type RAICA according to Catalogue No. RK 651 211-AA (Fig. 8) and -CA (Fig. 9).

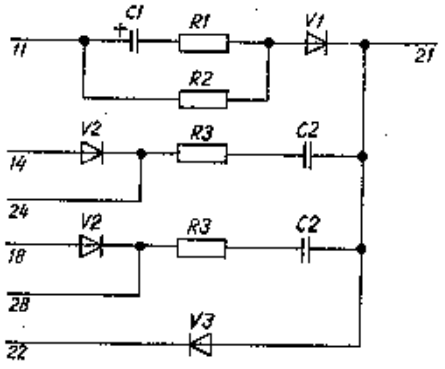

Fig. 14: Circuit diagram for type RXTCB 1 of type RAICA according to Catalogue No. RK 651 213-AA (Fig. 10) and -CA (Fig. 11).

DIMENSIONS

The height and the width of the breaker failure relays are shown in the diagrams with the aid of height and width modules. Example: 4S 36C, where the height module S = 44.45 mm, and the width module C = 7 mm. The maximum width space in an equipment frame is 60C. The depth of the protective relays, including space for connections, is approximately 200 mm. Detailed instructions for the COMBIFLEX® modular system are to be found in Catalogue RK 92-10 E.

ORDERING

When ordering state: The Cat. No. type designation, frequency, scale ranges, auxiliary voltage, and any required wording on the legend plate of the test switch. Current scale, time scale, and auxiliary voltage are chosen with the aid of the tables listed in the section TECHNICAL DATA. Mounting accessories as well as connection leads equipped with COMBIFLEX® sockets are ordered from Catalogue RK 92-10 E. Equipment frames and cases are orderd from Catalogue SK 14-1 E.

When ordering, state the desired scale constants as certain constants overlap each other.

Catalogue No.

Three-phase breaker failure relay type RAICA.

Time step	Signal relay RXSF 1	Circuit diagram No.	Catalogue No.	Space requirement	Weight kg
1		7429 0001-AA	RK 651 211-AA	4S 36C	4.9
1	1	-CA	211-CA	4S 36C	5.0
2		0003-AA	213-AA	4S 36C	5.2
2	2	-CA	213-CA	4S 42C	6.2
1		0005-AA	216-AA	4S 30C	4.5

Ordering example

- RK 651 213-AA
- RAICA
- Rated frequency 50 Hz
- Auxiliary voltage 110 V d.c.
- Scale constants, relay units 107 and 307:
  0.2, 0.5, and 1 A
  Scale constants, relay unit 119:
  0.1, 0.25, and 0.5 A
- Time-lag scale, relay unit 131: 60-600 ms
  , relay unit 331: 30-300 ms
- Wording on the legend plate: BFR 400

N.B.! If relay units of the same type should have different scales, they are separated by the item designation (for example 107).

REFERENCE PUBLICATIONS

Signal relay type RXSF	Catalogue RK 27-10 E
Overcurrent relay type RXIB 24	Information RK 413-301 E
Time-lag relay type RXKE 1	Catalogue RK 33-12 E
COMBIFLEX® modular system	Catalogue RK 92-10 E
Installation, testing, and maintenance of protective relays	Information RK 926-100 E
Cubicles, equipment frames, and cases	Catalogue SK 14-1 E
Index of printed matter	Information RK 000-100 (E)

Index of circuit diagram No's and Catalogue No's

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