Notes

The differential relay types D 2 se, D 21 se and D 22 se with auxiliary relay YD 22 are employed for the selective protection of generators and power transformers in A.C. networks.

General

The three-phase ratio differential relays of the series D 2..se with moving coil measuring elements are compensated inrush-proof relays suitable for the selective protection of generators and power transformers in A.C. networks. These relays are connected to the current transformers. They receive the secondary currents of the current transformers installed on both sides of the object being protected; these secondary currents are equal in magnitude and phase angle during normal service. They cover in an absolutely selective manner the following faults in the protected zone, i.e. in the zone enclosed by the current transformer sets supplying the relay:–

- two- and three-phase short circuits
- earth faults in transformers whose neutral point is earthed either directly or through a low resistance
- earth faults in generator stators with neutral solidly grounded or earthed through a low resistance
- inter-turn faults in transformers.

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Fig. 1
Three-phase inrush proof differential relay Type D 2 se

Type Designations

D 2 se Designed for generators

In the event of surges (e.g. during switching manoeuvres) the temporary dissimilar behaviour of current transformers may cause a transient difference in the secondary currents which are similar to the inrush currents of a power transformer while being switched in. It is, therefore, recommended to use inrush-proof relays for the differential protection of generators as well. Inter-turn faults in the generator windings are not detected since the currents flowing before and after the protected object are the same.

D 21 se Designed for two-winding power transformers and generator-transformer blocks in unit connection

The inter-turn faults of the transformer windings are also detected. In order to avoid non-selective tripping during switching in the transformer this relay has been stabilised against inrush currents.

D 22 se and YD 22 Designed for three-winding power transformers

The additional elements necessary for the third winding in the case of differential protection of a three-winding transformer as well as the common tripping contactor are mounted separately on a withdrawable frame in a relay casing of size I (type YD 22).

Special Features

- Three-phase relay with small dimensions
- Short tripping times independent of the auxiliary voltage within a chosen range
- Withdrawable active part with automatic shorting links at the current terminals
- High stability for heavy through fault currents
- High sensitivity for internal faults
- Unambiguous and stable tripping characteristic even in the case of asymmetrical faults due to the individual execution for each phase
- High stability of inrush-proof characteristic even with heavy switching currents
- Operation independent of the service conditions: Load, voltage, etc.

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- Tripping characteristic with two points of inflection; thereby practically independent of current transformer saturation
- Easy selection of auxiliary voltage range
- Small power consumption
- Plug-in type moving coil measuring elements
- Plug-in type element for different blocking characteristics in case of inrush currents
- Simple and functional settings
- Basic setting as well as pick-up ratio adjustable in steps
- Easy accessibility for testing also during service
- Easy accessibility of the active part for checking purposes even during service, thanks to the withdrawable execution.

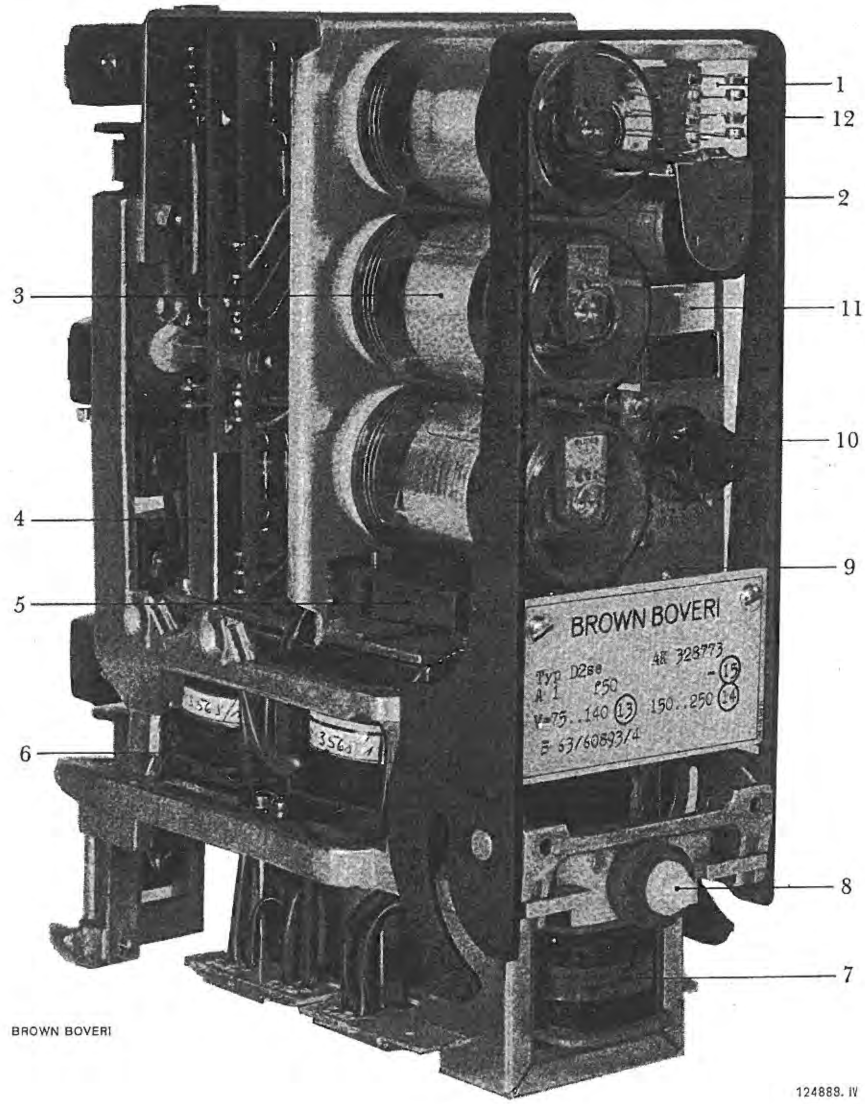

Fig. 2

Active part of a three-phase inrush-proof differential relay type D 2 se

Legend:

1 Contacts for tripping and signalling circuits
2 Common tripping contactor
3 Moving coil measuring element (interchangeable)
4 Differential current transformer W_Δ
5 Plug-in element (interchangeable)
6 Holding current transformer W_H
7 Blocking current transformer W_S
8 Signal resetting button
9 Setting screw for basic setting (see fig. 3, item 18)
10 Selector switch for pick-up ratio
11 Signalling device
12 Swing bracket

Construction

The relay consists chiefly of a current transformer and rectifier bridge combination per phase, three plug-in type moving coil measuring elements, a common tripping contactor with four potential-free closing contacts with large making capacity and a signalling device which can be reset from outside the casing.

Each phase has a separate measuring system. This ensures unambiguous tripping even in the case of asymmetrical faults.

When one or more moving coil measuring elements operate, the tripping contractor, as also the signal, are actuated. There are four contacts available for tripping and signalling circuits.

The signal is maintained by a D.C. circuit after the moving coil relay falls back and can be reset by a push-button. The resetting push-button can be operated from outside without opening the relay cover. The functioning of the measuring circuit and the tripping contactor is independent of resetting the signal.

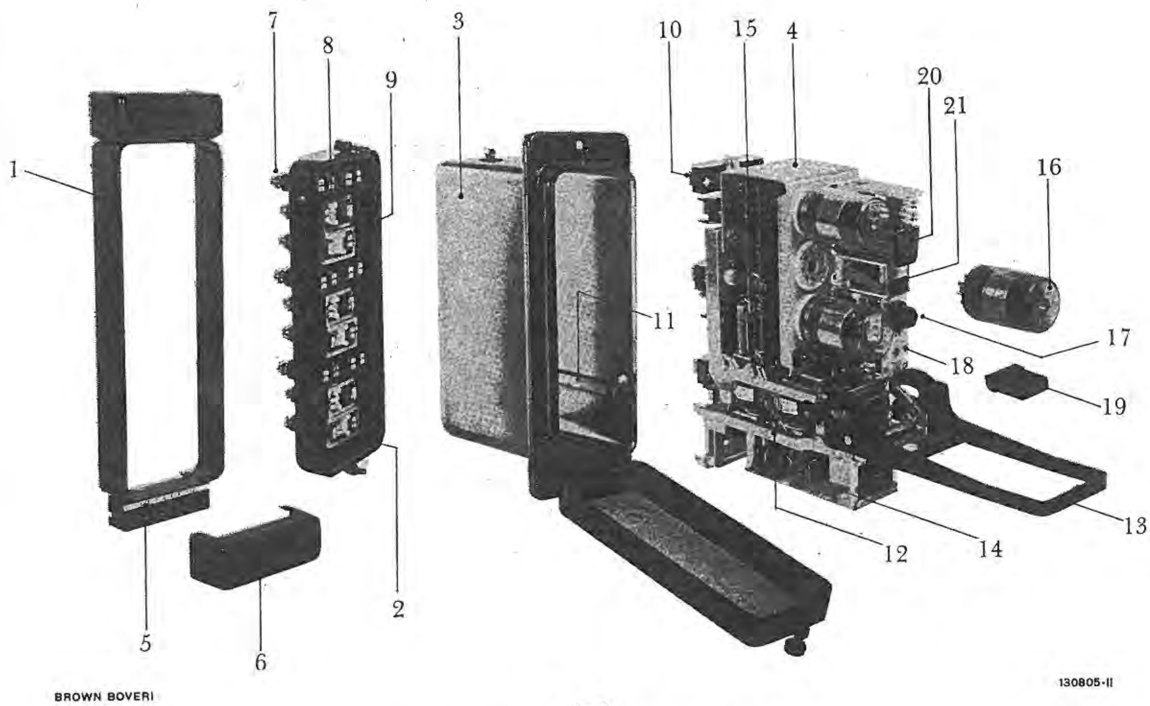

Fig. 3
Exploded view of differential relay type D 2 se

Legend:

1 Base frame
2 Rear wall of casing
3 Casing with cover
4 Active part
5 Terminals for front connection
6 Terminal cover
7 Rear connecting terminals
8 Stationary clips
9 Shorting links
10 Knife contacts
11 Guide rail
12 Guide
13 Bracket with slot
14 Auxiliary transformer sets
15 Print
16 Moving coil measuring element
17 Setting switch for pick-up ratio
18 Setting crew for basic setting
19 Plug-in element for in-rush-proof characteristic
20 Tripping contactor
21 Pick-up signal
Resetting button (see fig. 2, item 8)

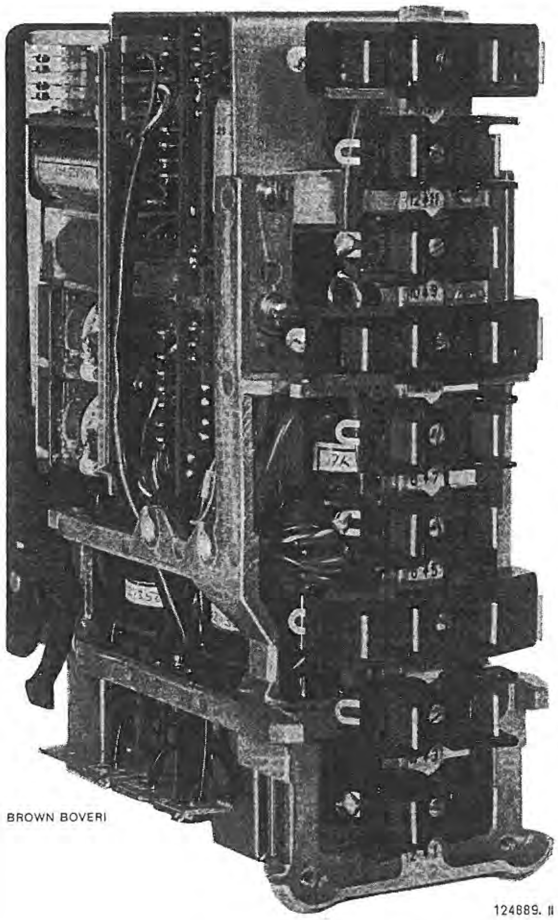

Fig. 4

Differential relay type D 2 se
Rear view of the active part with knife contacts

Casing

Withdrawability: The complete arrangement for all the three phases is mounted on a common withdrawable framework housed in a relay casing size I. For the protection of three-winding transformers the additional elements necessary for the third winding, as also the tripping contactor, are supplied in a second relay casing size I. The active part of this additional relay is also of the withdrawable type.

Thanks to the withdrawable construction of the relay, it can easily be withdrawn from its casing at any time, even when in service, for periodic inspection or for replacement. When the bracket is pulled downwards, as shown in figure 5, the relay will be disconnected from all the connecting leads. Simultaneously, the shorting links built in the casing short-circuit automatically the current terminals thereby eliminating any danger to the current transformers.

When the relay is re-inserted in its casing, the knife contacts of the active part engage the stationary clips provided in the casing. The spring action of these clips ensures a good and trouble-free contact at all times.

Withdrawing the active part: After resetting the signal and opening the cover of the casing the bracket which is normally vertical can be lowered. By the action of two fixed lugs inside the case engaging in the curved slots of the drawout bracket, the relay is forced slightly forward. The chassis is now held in the guide rails in the casing by its guides on each side of the die-cast frame.

When the drawout bracket is in the lowered position, the relay is isolated from the connecting leads (figure 6). The settings of the relay can be changed in this position.

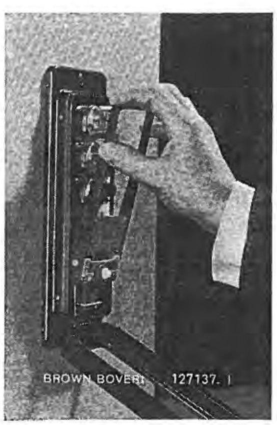

Fig. 5

Fig. 6

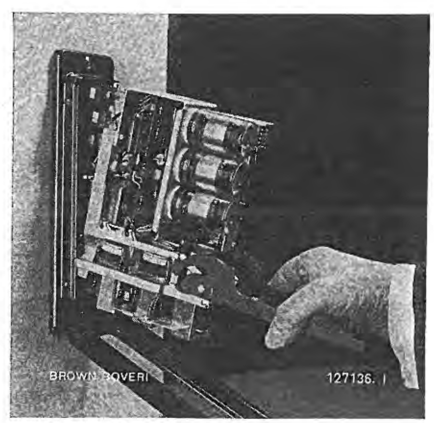

Fig. 7

Withdrawal of active part

Now using the bracket as a handle the active part of the relay can now be withdrawn from its case (figure 7) and can be replaced by a spare unit if it is desired to keep the protection effective during checking.

The casing has a fixing frame which can be shifted allowing the relay to be flush- or surface-mounted. The terminals are normally at the rear. For switchboards more than 17 mm thick it can be equipped with extra long terminals for surface mounting (for a wall thickness of maximum 40 mm). For surface mounting with front connection an additional adapter frame with terminal block is supplied (see figure 3, item 1).

Principle of Measurement and Operation

The differential relay connected to the current transformers on either side of the protected object compares the incoming and outgoing currents by means of a differential circuit.

If the differential current exceeds a certain percentage of the current flowing through the protected object, a fault is indicated and the relay trips.

With differential currents upwards of $0{\cdot}5 \times I_n$ the operation of the relay is dependent not only upon an absolute value of the differential current, but also upon the ratio of differential- to through-current. Thus the relay is compensated.

Two-winding transformers: The principle of measurement and operation can be followed from the figures 8 and 9. During normal service the currents I_1 and I_2 in the primary winding of the holding transformer are practically equal in magnitude and phase angle displacement. Hence it follows that the differential current $I_\Delta = I_1 - I_2 \simeq 0$; the measuring element, a highly sensitive moving coil relay, will not be actuated. In the case of a fault within the protected zone there is a differential current while, on the other hand, the holding current is small in magnitude. The measuring element will be actuated and the relay trips. In case of faults outside the zone of protection no tripping occurs through the differential current caused by current transformer saturation and asymmetry since the holding current has a large magnitude.

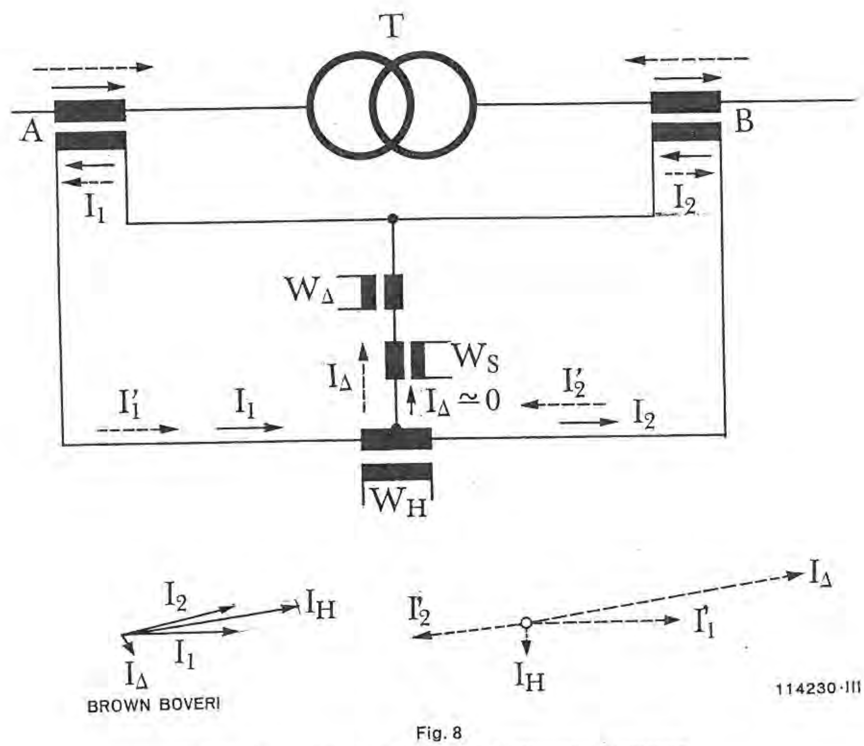

Fig. 8

Current flow and vector diagrams of differential protection for a two-winding transformer

Legend:

T	Protected transformer
A, B	Main current transformers
W_H	Holding current transformer
W_s	Blocking transformer for stabilisation circuit
W_Δ	Differential current transformer
——→ I_1, I_2	Currents during normal service
– – –→ I'_1, I'_2	Currents during a fault inside the protected zone
I_Δ	Differential current
I_H	Holding current

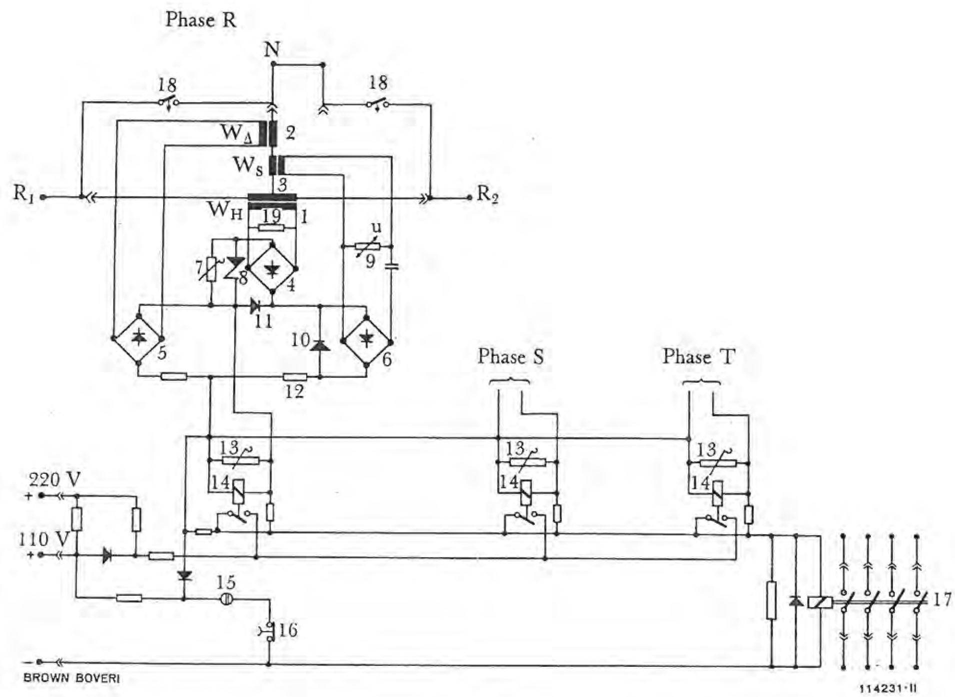

Fig. 9
Principle diagram of three-phase differential relay type D 2...se

Legend:

1 Holding current transformer W_H
2 Tripping current transformer W_Δ
3 Blocking transformer W_s (Air gap transformer)
4 Holding current rectifier bridge
5 Blocking current rectifier bridge
7 Resistance for pick-up ratio setting
8 'Zener' Diode
9 Voltage dependent resistance
10 Blocking current limiting diodes
11 Diodes
12 Plug-in blocking element
13 Resistance for basic setting
14 Moving coil relay
15 Signal element
16 Signal resetting button
17 Tripping contactor
18 Automatic shorting links
19 Restraining circuit resistance
R_1, R_2 Input terminals of the phase R
N Star point of current transformer sets

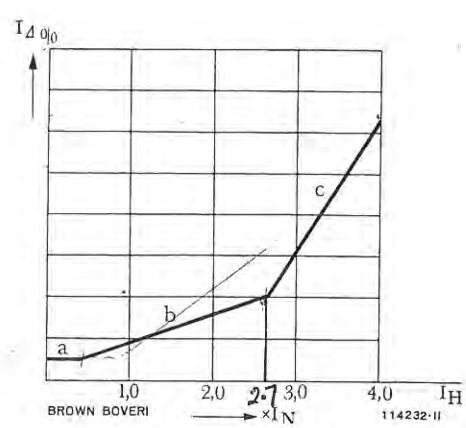

Fig. 10
Tripping characteristic of differential relay

The tripping characteristic (figure 10, 16) runs horizontal up to about $0{\cdot}5 \times I_n$ (part a) i.e. in this region it is independent of the holding current thus ensuring high sensitivity of operation even when the transformer is on no-load or only lightly loaded. This pick-up value corresponds to the so-called basic setting g% defined as the minimum differential current expressed as a percentage of rated current at which the relay operates when there is no holding current. This magnitude can be set by means of a setting screw (see fig. 2, item 9) and must be chosen so as to be higher than the maximum magnetising current which can occur at the highest possible voltage.

In the current range from approx. 0·5 to approx. $2{\cdot}7 \times I_n$ the tripping characteristic (part b) corresponds to a fixed ratio between the differential current (I_Δ) and holding current (I_H); this ratio, designated as pick-up ratio v%, can be selected through a switch in the relay (see fig. 2, item 10). Thus the difference in the two currents applied to the relay which result from changes in the position of the tap changer switch and different current transformer characteristics are compensated. In this way an optimum functioning of the relay far beyond the overload region is achieved.

With currents higher than $2{\cdot}7 \times I_n$ the tripping characteristic (part c) runs considerably steeper upwards, i.e. the current required for tripping relative to the holding current will be higher. On the one hand this is permissible, since there is only a small holding current available during heavy short circuits in the power transformer and thus tripping is assured. On the other hand, such a characteristic is necessary in case of through faults so that no tripping occurs despite large magnitudes of differential current produced by possible current transformer saturation.

Three-winding transformers: Additional elements are necessary for the protection of three-winding transformers. A correct differential measurement under all possible service conditions is ensured only when a separate holding current circuit for the third winding is provided. The summation of the holding current from the third winding is undertaken on the D.C. side so that sufficient holding current is available during short-circuits in the network connected to the third winding.

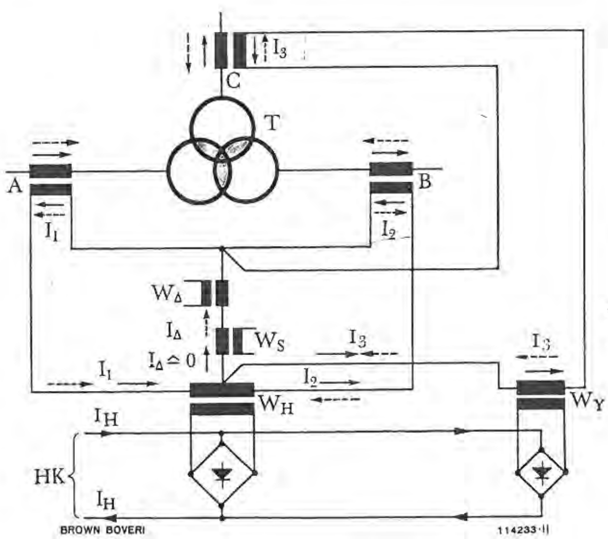

Fig. 11
Principle of measurement of differential protection for a three-winding transformer

Legend:

T	Transformer protected
A, B, C	Main current transformers
W_H	Holding current transformer
W_Y	Additional holding current transformer
W_S	Blocking transformer for stabilisation circuit
W_Δ	Differential current transformer
——→ I_1, I_2, I_3	Currents during normal service
- - -→ I_1, I_2, I_3	Currents during fault inside the protected zone
I_Δ	Differential current
I_H	Holding current
H_K	Holding circuit (see fig. 9)

The additional elements necessary as well as the common tripping contactor are, on account of accommodation difficulties, mounted separately in a separate casing size I; the active part of this additional relay can also be withdrawn from its casing. The main relay thus changed has the type designation D 22 while that for the additional relay is YD 22.

Tripping Contactor: The common tripping contactor is a fast-acting, small contactor with four make contacts with large making capacity. The contactor is insensitive to changes in the magnitude of the auxiliary voltage. The tripping time of the relay does not change within the chosen range of 75–140 V (respectively 150–250 V) D.C.

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Fig. 12

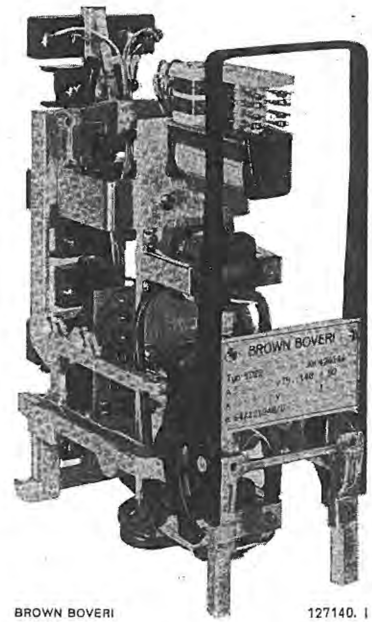

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Fig. 13

Auxiliary relay type YD 22 for three-winding transformers
Left: Front view
Right: Withdrawable active part

In this context it has to be observed that it is not possible to convert the relay type D 21 se for the protection of a three-winding transformer even if the additional relay type YD 22 were to be ordered at a later date.

Signalling: For signalisation the relay is equipped with an electrically-operated signalling element with flag indicator. When one or more moving coil relays pick up the signal element 15 (see fig. 9) will be actuated and sealed in electrically.

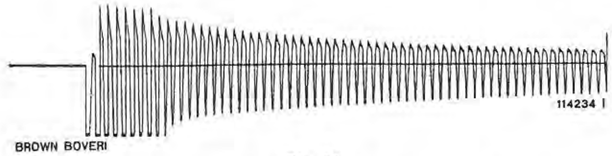


Fig. 14
Oscillogram of inrush current of a transformer

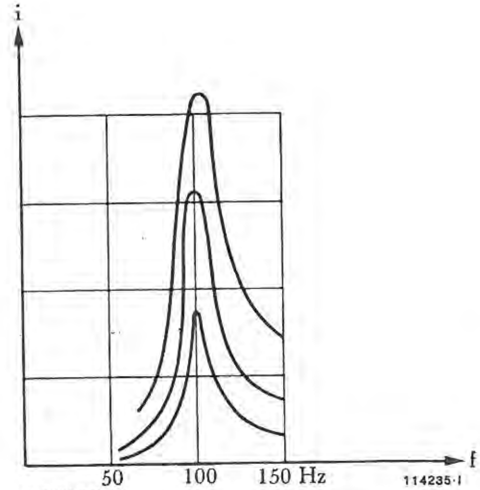


Fig. 15
Frequency characteristic of the blocking filter

Resetting can be done by means of a push-button which interrupts the holding circuit.

Inrush-proof characteristic: When a power transformer is switched-in a transient current surge is produced which diminishes finally to the magnetising current of the transformer. This surge occurs only on the switching side and hence appears as a difference current to the relay. Differential currents of similar wave form resulting from the momentary dissimiliar behaviour of the current transformers can also occur in the case of generator differential protection during surges of large magnitude; however these are of a shorter duration.

The oscillogram in figure 14 shows the inrush current surge with severe distortion produced at the time when a power transformer is switched in.

The analysis of these curves reveals a large proportion of second harmonic component. This second harmonic component of the differential current is made use of for stabilising the relay against inrush current surges in that this component, after resonance amplification and rectification, is applied to the moving coil relay in the blocking direction. The resonance amplification is done through a filter built in the secondary circuit of the blocking current transformer W_S. The frequency characteristics of the filter are shown in figure 15.

Since this blocking is effective only in the case of second harmonic which is characteristic of the switching inrush current surges of power transformers the relay distinguishes positively between inrush current surge and a short circuit in the object protected.

The voltage drop caused by the resonance amplified secondary current is limited by a chain of diodes 10 (fig. 9) connected parallel to the rectifier group and the series resistance 12 (fig. 9) in the moving coil relay circuit.

By using different plug-in elements e_1, e_2 and e_3 (item 12, fig. 9) the blocking effect can be changed according to necessity. Thus the stability against inrush current surges can be increased in extreme cases. It results in an insignificant delay in the operating time. The blocking current is diverted through the diode 11 (see fig. 9) so that it has not to flow through the pick-up ration setting resistance 7 (fig. 9) and the holding current rectifier group 4 (fig. 9); thus the blocking effect is independent of the pick-up ratio set in the relay.

The frequency variations normally expected during service (approximately 3%) have no influence on the operation of the relay with respect to the correct blocking during switching-in the transformer to be protected.

The inrush-proof relay can be delivered for a rated frequency of 50 or 60 c/s. Other frequencies on demand.

Testing arrangement: In general our differential protection system is equipped with a separate testing switch by which the preparedness of the protection can be checked at any time during service. The relay is then energised from an auxiliary source, phase by phase, which actuates the relay. During testing the tripping contacts are switched over to signal lamps. Apart from this the active part of the relay can be taken out of its casing during service and checked in the laboratory.

Setting

Basic setting: The basic setting can be chosen in steps as follows:

Type D 2 se	for generators	10–25%
Type D 21 se	for two-winding transformers and generator-transformer blocks	20–50%
Type D 22 se	for three-winding transformers	20–50%

The basic setting shall in all cases be chosen sufficiently high to ensure that the magnetising currents corresponding to the highest service voltages in the case of power transformers do not lead to non-selective tripping. In the case of generators it shall be chosen so as to compensate the small asymmetries in the currents on the two sides of the protected object.

Pick-up ratio: The pick-up ratio can be chosen in steps as follows:

Type D 2 se	for generators	5–25%
Type D 21 se and Type D 22 se	for power transformers	10–50%

This pick-up ratio is valid only for the range $I_H \approx 0{\cdot}5$–$2{\cdot}7 \times I_n$.

The pick-up ratio shall be chosen large enough to ensure that the differential currents experienced in normal service which result from the dissimilar transformation ratios of the current transformers, the transformer regulating tappings, etc. do not cause non-selective tripping.

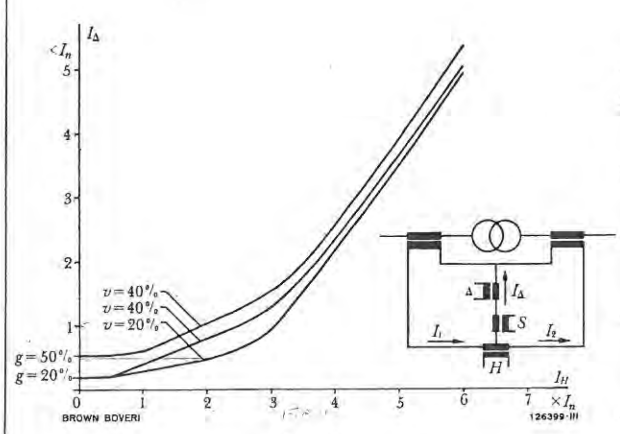


Fig. 16
Pick-up characteristic

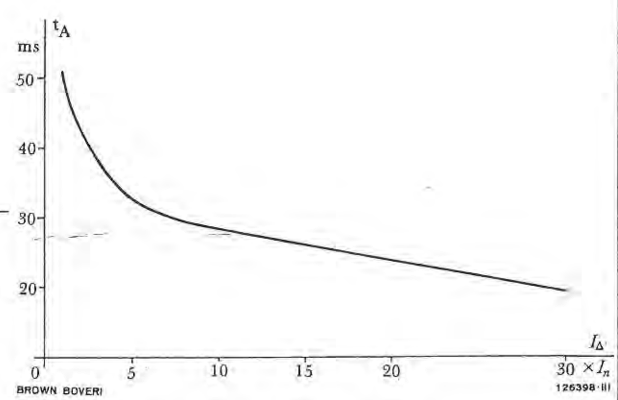


Fig. 17
Tripping characteristic

Legend:

t_A	Tripping time in ms	v	Pick-up ratio
I_n	Relay rated current in Amps.	Δ	Differential (tripping) circuit
I_H	Holding current	H	Holding circuit
ΔI	Differential current	S	Blocking circuit
g	Basic setting		

Accessories

Intermediate Current Transformers:

The vector group of the transformer to be protected has to be simulated on the secondary side by the corresponding connections of the secondary winding of the main current transformers, or better still by the use of intermediate current transformers in the relay circuit.

The intermediate current transformers serve to:

1. Compensate the phase displacement between the currents on the primary and secondary sides of the protected transformer caused by the vector group.
2. Ensure that currents of the same magnitude and phase angle displacement are applied to the relay when both the transformer windings are equally loaded. The currents flowing into the relay when the transformer-winding is fully loaded should be at least $0{\cdot}7 \times I_N$.
3. Filter out the zero sequence currents in the case of transformers with earthed neutral or autotransformers.

In case only one set of current transformer ratios has to be considered for the differential protection or if in the event of a future change in the ratios such changes are effected simultaneously and in the same proportion on both sides, the intermediate transformers type R 1,1 – according to the price list AB 110a – are normally used. If, however, such is not the case, these asymmetries have to be compensated with the help of taps on the intermediate transformers. Under these circumstances the intermediate transformer Type S 1,1 or T 1,1 (according to price list AB 110a) will be used.

Hence we recommend that all possible main current transformer ratios, which have to be considered for the differential protection, be indicated in the questionnaire (see pages pages 16 and 17).

Requirements of the main Current Transformers

The main current transformers must fulfil the conditions of accuracy class S 10 at 120% of the actual burden connected, or should have an overcurrent factor of minimum 10 at 140% of the actual burden connected.

- Actual load connected (refered to the current transformer rated current): connecting leads, intermediate current transformers type R 1,1 (approx. 3 VA), differential relay and other apparatus connected.
- Class S 10: in the range $0{\cdot}33 \ldots 10 \times I_n$, ratio error less than $\pm$ 5%, phase angle error less than $\pm$ 300 mins.
- Overcurrent factor n: Multiple of the rated current at which the transformation ratio error of the current transformer operating at its rated load attains 10%.
- The extremely short operating time necessitates additional care in the choice of the current transformer supplying the relay. In view of the transients in the network and the possible current asymmetries associated with these, it is recommended to avoid the use of current transformers whose transformation ratios are based on widely different capacities. For example, in the case of protection of a generator-transformer block with a third winding for the auxiliary supply, the transformation ratio of the differential protection core of the main current transformer in the auxiliary branch should be based on the generator capacity.

  In case of important deviations from this condition we should be consulted as to the advisability of use at the same time giving us the technical data of the current transformers proposed to be used.

Material Required

The complete differential protection consists of different apparatus depending upon the object protected and circuits employed. These are listed in the table below. Total weights and prices may be obtained by adding the individual weights and prices given in the appropriate price lists. Mounting panels, connecting leads, etc. are not included.

Designation of apparatus	Page or price list No.	Differential protection for: for three-phase generator	two-winding Transformers: 3 Intermediate transformers per power transformer	two-winding Transformers: 6 Intermediate transformers per power transformer	three-winding Transformers: 6 Intermediate transformers per power transformer	three-winding Transformers: 9 Intermediate transformers per power transformer
Differential relay type D 2 se	Page 19	1	–	–	–	–
Differential relay type D 21 se	Page 19	–	1	1	–	–
Differential relay combination types D 22 se + YD 22	Page 19	–	–	–	1	1
Intermediate transformer type R 1,1	AB 110a	–	3	6	6	9
Test Arrangement						
Single-phase test transformer . . . /20 V ①	T 302a	1	1	1	1	1
Test switch type QV 12	AB 502	1	1	1	1	1
Test resistance type TDv ②	MA 342a	1	1	1	1	1
Signal lamps	AB 514	4	4	4	4	4

① Primary voltage to be chosen according to the low voltage available

② For relays with rated current 1 A type TDv 50; for relays with rated current 5 A type TDv 100

Ordering Instructions

In order to avoid time consuming correspondence and queries the order should include the following information:

Designation	Example for the protection of a two-winding transformer
1. Quantity	1
2. Brown Boveri designation	Three-phase differential relay
3. Type	D 21 se
4. Type of current and frequency	Alternating current 50 c/s
5. Rated current	5 A
6. Pick-up ratio	10...25%
7. Basic setting	20...50%
8. Auxiliary source ① Type of auxiliary source Voltage	 D.C. 110 V
9. Details of casing design and arrangement of terminals (see dimension drawings page 22)	Casing for flush-mounting with terminals at the rear
10. Special instruction for installation (e.g. panel thickness if larger than 17 mm)	—
11. Special execution	—

① When this information is not contained in the order the relays will be delivered suitable for an auxiliary D.C. voltage range from 75–140 V which can be changed to 150–250 V.

Remarks: It is recommended to include the application proposed as well as the technical data of the object to be protected and the main current transformers so that recommendations for the proper circuitry to be chosen, setting of the relay, etc. can be made. For this purpose there are questionnaires available which should be filled in and sent with the order:

For two-winding transformers: No. E 4–02–52 (see page 16)

For three-winding transormers: No. E 4–02–53 (see page 17)

Questionnaire

Differential protection of two-winding transformers

Client .... Your letter of .... Order No. .... item ....

Installation .... Your order No. .... Tender No. ....

Power Transformer

Vector diagram

Single- / Multi-phase unit ①   Frequency   c/s

		High voltage	Low voltage
Transformer capacity single- / multi- phase ①	kVA		
Rated line voltage (no load)	kV		
Range of regulation ±	kV ① or %		
Connection ②	—		
Short-circuit voltage	%		
based on	kVA		
Main Current Transformers (Relay core)			
Chosen service ratio	A/A		
Ratios to be considered for future use ③	A/A		
Connection ④	—		
Rated capacity	VA		
Accuracy class	—		
Overcurrent factor n	—		
Connected burden of main current transformers (at rated current) intermediate current transformers	VA		
connecting leads	VA		
loads other than differential relay	VA		
Auxiliary voltage for actuating the tripping contactor (D.C.)	V		

Important remarks

Requirements to be fulfilled by the main current transformers:

The main current transformers must fulfil the conditions of accuracy class S 10 at 120% of the actual load connected or should have an overcurrent factor of minimum 10 at 140% of the actual burden connected (class S 10: in the range 0·33...10× I_N ratio error less than ± 5% phase angle error less than ± 300 min).

- Actual load connected (referred to the current transformer rated current): connecting leads + intermediate current transformers (Type R 1,1: approx. 3 VA) + differential relay (I_N = 1 A: 0·1 VA I_N = 5 A: 0·3 VA) + other connected apparatus.
- The small intermediate current transformers have to be mounted in close proximity to (maximum a few meters) the relay. Bigger intermediate transformers have a smaller power consumption.

① Cross out what is not applicable

② Indicate whether the star point has been brought out and / or grounded

③ Give only those ratios which have to be considered for compensation with the aid of taps on intermediate current transformers

④ To be indicated only if the usual star connection is not used

Questionnaire

Differential protection of three-winding transformers

Client .... Your letter of .... Order No. .... item ....

Installations .... Your order No. .... Tender No. ....

Power Transformer

Vector diagram

Single- / Multi-phase unit ① Frequency c/s

		High voltage	Medium voltage	Low voltage
Transformer capacity single- / multi- phase ①	kVA			
Rated line voltage (no load)	kV			
Range of regulation ±	kV ① or %			
Connection ②	—			
Short-circuit voltage	%	HV/MV	MV/LV	HV/LV
based on	kVA			
Main Current Transformers (Relay core)				
Chosen service ratio	A/A			
Ratios to be considered for future use ③	A/A			
Connection ④	—			
Rated capacity	VA			
Accuracy class	—			
Overcurrent factor n	—			
Connected burden of main current transformers (at rated current) intermediate current transformers	VA			
connecting leads	VA			
loads other than differential relay	VA			
Auxiliary voltage for actuating the tripping contactor (D.C.)	V			

Important remarks

Requirements to be fulfilled by the main current transformers:

The main current transformers must fulfil the conditions of accuracy class S 10 at 120% of the actual load connected or should have an overcurrent factor of minimum 10 at 140% of the actual burden connected (class S 10: in the range 0·33...10× I_N ratio error less than ± 5% phase angle error less than ± 300 min).

- Actual load connected (referred to the current transformer rated current): connecting leads + intermediate current transformers (Type R 1,1: approx. 3 VA) + differential relay (I_N = 1 A: 0·1 VA I_N = 5 A: 0·3 VA) + other connected apparatus.
- The small intermediate current transformers have to be mounted in close proximity to (maximum a few meters) the relay. Bigger intermediate transformers have a smaller power consumption.

① Cross out what is not applicable

② Indicate whether the star point has been brought out and / or grounded

③ Give only those ratios which have to be considered for compensation with the aid of taps on intermediate current transformers

④ To be indicated only if the usual star connection is not used

Technical Data

Description	Differential relay type D 2 se for the protection of generators		Differential relay type D21 se for the protection of two-winding transformers		Differential relay type D22se + type YD22 for the protection of three-winding transformers	
Rated current ①	1 or 5 A		1 or 5 A		1 or 5 A	
Rated frequency ①	50 or 60 c/s		50 or 60 c/s		50 or 60 c/s	
Basic setting 'g'	10...25%		20...50%		20...50%	
Pick-up ratio 'v'	5...25%		10...50%		10...50%	
Auxiliary D.C. voltage range	75...140 V can be changed to 150...250 V or 20...36 V can be switched to 40...60 V		75...140 V can be changed to 150...250 V or 20...36 V can be switched to 40...60 V		75...140 V can be changed to 150...250 V or 20...36 V can be switched to 40...60 V	
Tripping characteristic	with 2 points of inflexion		with 2 points of inflexion		with 2 points of inflexion	
Tripping time	app. 20...50 ms		app. 20...50 ms		app. 20...50 ms	
Inrush-proof stability I_{peak}/I_n	5 for plug-in element e_1		10 or 15 for plug-in element e_2 or e_3 ②		10 or 15 for plug-in element e_2 or e_3 ②	
Power consumption	$I_n = 1$ A	$I_n = 5$ A	$I_n = 1$ A	$I_n = 5$ A	$I_n = 1$ A	$I_n = 5$ A
– during normal service conditions	app. 0.03 VA	app. 0.1 VA	app. 0.03 VA	app. 0.1 VA	app. 0.03 VA	app. 0.1 VA
– under short-circuit conditions	app. 0.1 VA	app. 0.3 VA	app. 0.1 VA	app. 0.3 VA	app. 0.1 VA	app. 0.3 VA
Dynamic limiting current	$200 \times I_n$ peak		$200 \times I_n$ peak		$200 \times I_n$ peak	
Short-time current rating						
during 1 s	$65 \times I_n$		$65 \times I_n$		$65 \times I_n$	
during 2 s	$40 \times I_n$		$40 \times I_n$		$40 \times I_n$	
during 5 s	$30 \times I_n$		$30 \times I_n$		$30 \times I_n$	
permanent overload	$2 \times I_n$		$2 \times I_n$		$2 \times I_n$	

Technical data of the built-in small contactor and the signalling element

Making capacity of the contact of the tripping contactor	10 A at 220 V	10 A at 220 V	10 A at 220 V
Test voltage at 50 or 60 c/s	2000 V during 1 min.	2000 V during 1 min.	2000 V during 1 min.
Power consumption of the small contactor	app. 3 W	app. 3 W	app. 3 W

① Other values on request
② Normal execution is e_2

Requirements to be fulfilled by the main current transformers:

The main current transformers shall fulfil the conditions of accuracy class S 10 at 120% of the actual load connected or should have an overcurrent factor of minimum 10 at 140% of the actual burden connected.

- Actual load connected (referred to current transformers rated current): connecting leads + intermediate transformers (type R 1,1: app. 3 VA) + differential relay + other connected apparatus.
- The small intermediate current transformers have to be mounted in close proximity to (maximum a few meters) the relay. Bigger intermediate transformers have a smaller power consumption.
- Class S 10: in the range $0{\cdot}33\ldots10 \times I_n$: ratio error less than ± 5%, phase angle error less than ± 300 min.

Weights and Prices

For three-phase withdrawable-type differential relays in casing size I for flush- well as surface-mounting, terminals at the rear

Type	Use	Rated current A	PL-No.	Weight per piece ca. kg	Price per piece
D 2 se	for generators	1	AB 309 001	5.2	
		5	AB 309 002		
		2	AB 309 003		
		others	AB 309 009		
D 21 se	for two-winding power transformers and generator-trafo. block	1	AB 309 011	5.2	
		5	AB 309 012		
		2	AB 309 013		
		others	AB 309 019		
Combination D 22 se + YD 22	for three-winding power transformers	1	AB 309 021	8.4	
		5	AB 309 022		
		2	AB 309 023		
		others	AB 309 029		

Special Execution and Individual Elements

PL-No.	Designation		Suitable for type	Additional Weight ca. kg	Additional Price
AB 309 901	Relay in casing for surface mounting Terminals at the front (normal casing with additional U-frame)		D 2 se	0.5	
			D 21 se		
			D 22 se ① + YD 22	1.0	
AB 309 101	Plug-in element delivered separately	e 1	D 2 se	0.02	
AB 309 102		e 2	D 21 se		
AB 309 103		e 3	D 22 se		
AB 309 951	Moving coil measuring relay type E 51-1 D		D 2 se	0.25	
			D 21 se		
			D 22 se		
AB 309 911	Casing without active part (without U-frame)		D 2 se	2.2	
			D 21 se		
			D 22 se		
			YD 22		

① For the combination D 22 se + YD 22 two U-frames are required

Differential Relay Type D 2. . . se

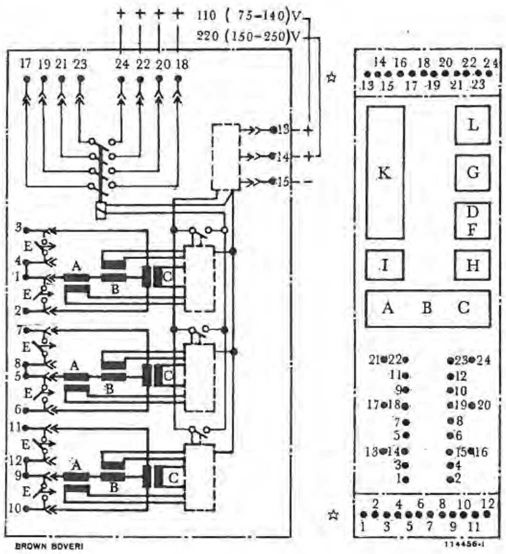


Fig. 1
Differential relay type D 2 se resp. D 21 se
Internal connections and front view

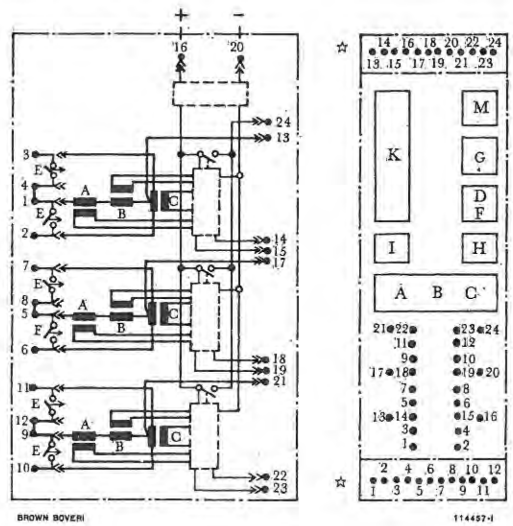


Fig. 2
Differential relay type D 22 se
Internal connections and front view

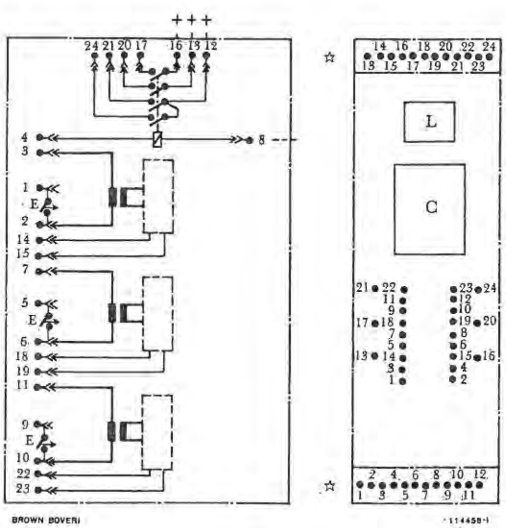


Fig. 3
Differential relay type YD 22
Internal connections and front view

Legend:

- A Tripping current transformer W_{Δ}
- B Blocking current transformer W_s
- C Holding current transformer W_H
- D Selector switch for pick-up ratio v%
- E Shorting links
- F Selector screw g%
- G Signalling device
- H Push button
- I Plug-in element
- K Moving coil relay type E 5 1-1 D
- L Tripping contactor
- M Voltage selector plug (only for relay type D 22 se)

* Terminals for front connection: will be delivered only when ordered specially. Terminals with the same designation are connected.

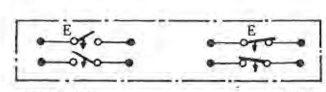
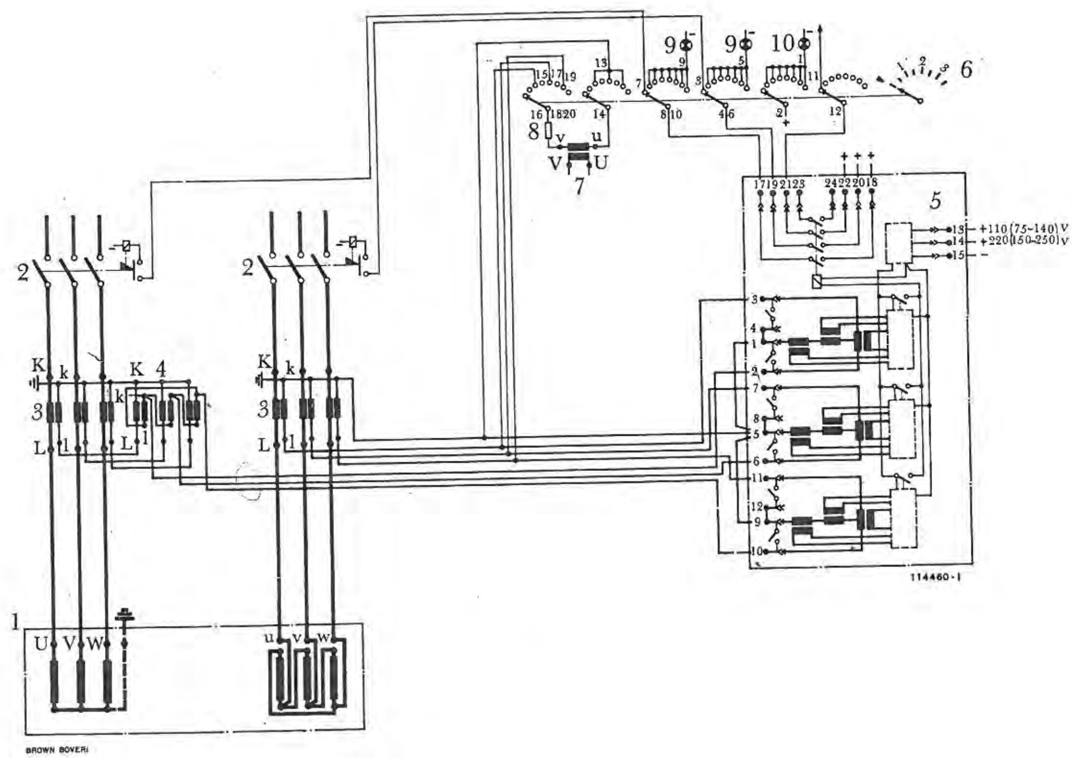


Fig. 4 Relais inserted

Fig. 4a Relais withdrawn

Differential Relay Type D 21 se



Typical connection diagram
Differential protection of a two-winding transformer with testing device

Legend:

1 Transformer
2 Circuit breaker
3 Current transformer
4 Auxiliary (intermediate) current transformer
5 Differential relay type D 21 se
6 Test switch type QV 12
7 Testing transformer .../20 V
8 Test resistance
9 Lamp "Trip"
10 Lamp "Test"

Withdrawable

Differential Relay Type D 2

in Casing Size 1

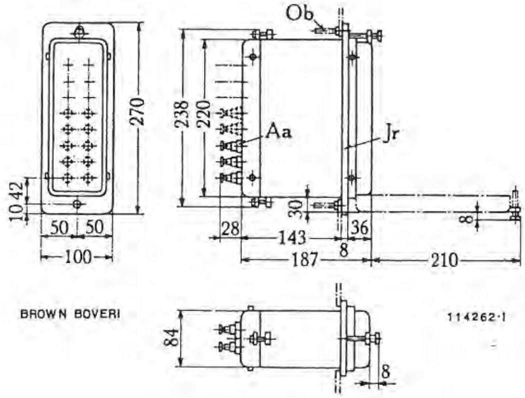


Fig. 1

Flush mounting with rear terminals

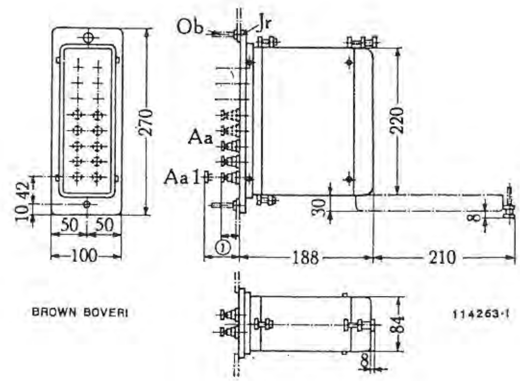


Fig. 2

Surface mounting with rear terminals

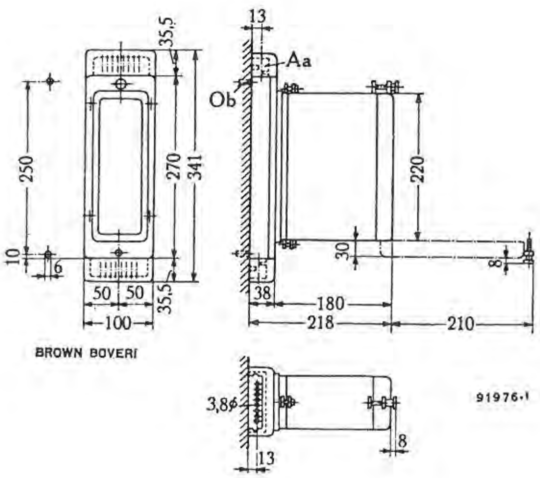


Fig. 3

Surface mounting with terminals for front connection
with additional mounting frame

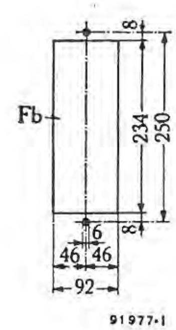


Fig. 4

Opening in relay panel for relays in fig. 1 and 2

Legend:

Aa and Aa 1	Terminals, number and arrangement according to circuit diagram
F_b	Opening in the panel
J_r	Mounting frame
O_b	Fixing screw M 5

① 27 mm for panels up to 17 mm thick
50 mm for panels up to max. 40 mm thick

Dimensions in millimeters (binding)

Conversion Table.

The **Metric System** is used throughout the price lists.
For conversion to **British Units** the following table may be employed.

Unit	To convert		Multiply by
Lengths	millimetres	to inches	0.0394
	„	„ feet	0.0033
	metres	„ „	3.28
Areas	sq. millimetres	to sq. inches	0.0015
	sq. centimetres	„ sq. „	0.155
	sq. metres	„ sq. feet	10.764
Volumes	cu. centimetres	to cu. inches	0.061
	litres	„ gallons	0.220
	„	„ cu. feet	0.035
	cu. metres	„ „ „	35.32
	„ „	„ gallons	220.0
	„ „	„ shipping tons	0.883
Weights	kilograms	to pounds	2.205
	„	„ hundredweights	0.0197
	„	„ tons (of 2240 lbs.)	0.000984
Area per H.P.	sq. metres per metric H.P.	to sq. feet per British H.P.	10.913
Volume per unit weight	cu. metres per kilogram	to cu. feet per pound	16.019
Weight per unit length	kilograms per metre	to lbs. per foot	0.672
Weight per „ volume	„ „ cu. metre	„ „ „ cu. foot	0.0624
Weight per H.P.	„ „ metric H.P.	„ „ „ British H.P.	2.235
Pressures	kilograms per sq. cm (approx. atmospheres)	to lbs. per sq. inch	14.223
	centimetres of mercury	„ „ „ „ „	0.1903
	„ „ water	„ „ „ „ „	0.014
	kilograms per sq. metre	„ „ „ „ foot	0.205
Energy and Power	kilogram metres	to foot pounds	7.233
	metric electric H.P. (736 watts)	„ British H.P. (746 watts)	0.986
	metric thermal units	„ British thermal units	3.968
	1 calorie = 427 kgm or 1 kg of water raised from 4° to 5° C	1 B.T.U. = 778 ft. lbs. or 1 lb. of water raised from 60° to 61° F	
Speed	metres per sec.	to ft. per sec.	3.28
	kilometres per hour	„ miles per hour	0.621
Temperature	in degrees Centigrade	to degrees Fahrenheit	9/5 then add 32
Temperature rise	Centigrade degrees	to Fahrenheit degrees	9/5
Flywheel effect	WD^2	to lb. ft²	24000 approx.
	W = weight of revolving parts in metric tons		
	D^2 = square of twice the radius of gyration in metres		