2-3

Sheet 1 of 2

DATA SHEET 3

VENDOR DOCUMENT STATUS SHEET

LOG NO. 2X3AE10-64 REVISION 2

DOCUMENT TITLE:

FOR INFORMATION ONLY

VENDOR Reliance Custom Controls

P.O. ______ DATE RECEIVED 4-21-89

DOCUMENT LEGIBLE? YES ✓ NO ____

READ AND DESTROY

IF NO IS CHECKED, THE RESPONSIBLE REVIEWER SHALL DETERMINE IF THE DOCUMENT CAN BE USED IN ITS PRESENT CONDITION. IF IT CAN, THE NORMAL REVIEW CONTINUES. IF IT CAN NOT, THE DOCUMENT MUST BE RETURNED TO DOCUMENT CONTROL FOR REJECTION BACK TO THE VENDOR.

ORIGINAL

DISCIPLINE REVIEW REQUIRED

- [ ] MAINTENANCE
- [ ] OPERATIONS
- [✓] ENGINEERING
- [ ] HEALTH PHYSICS
- [ ] CHEMISTRY
- [ ] OTHER ______

STATUS CODE

- [✓] 1 APPROVED FOR PLANT USE
- [ ] 2 REVISE AND RESUBMIT. VENDOR MAY PROCEED WITH MANUFACTURE SUBJECT TO THE INCORPORATION OF CHANGES INDICATED
- [ ] 3 REVISE AND RESUBMIT. MANUFACTURE MAY NOT PROCEED
- [ ] S SUPERSEDED BY ______
- [ ] V VOID

DCNs INCORPORATED: (IF APPLICABLE) ______

ENG - HD Stewart
NAME OF RESP. DEPT. AND REQUIRED SIGNATURE DATE: 5/3/89

ENGR SUPPORT John [illegible]
NAME OF RESP. DEPT. AND REQUIRED SIGNATURE DATE: 5/12/89

NAME OF RESP. DEPT. AND REQUIRED SIGNATURE DATE: ______

703445

9202190460 920116
PDR ADOCK 05000424
S PDR

Sheet 2 of 2

DATA SHEET 3

VENDOR DOCUMENT STATUS SHEET

(NORMS CROSS REFERENCE INPUT SHEET)

LOG NO. 2X3AE10-64 REVISION 2

EQUIPMENT TAG NUMBER(S)

2-1816-U3-012

SERIAL OR MODEL NUMBER(S)

SYSTEM NUMBER(S) 1816

ASEA

ASEA ELECTRIC
400 S. Prairie Avenue
Waukesha, WI 53186

Tel: 414/547-0121

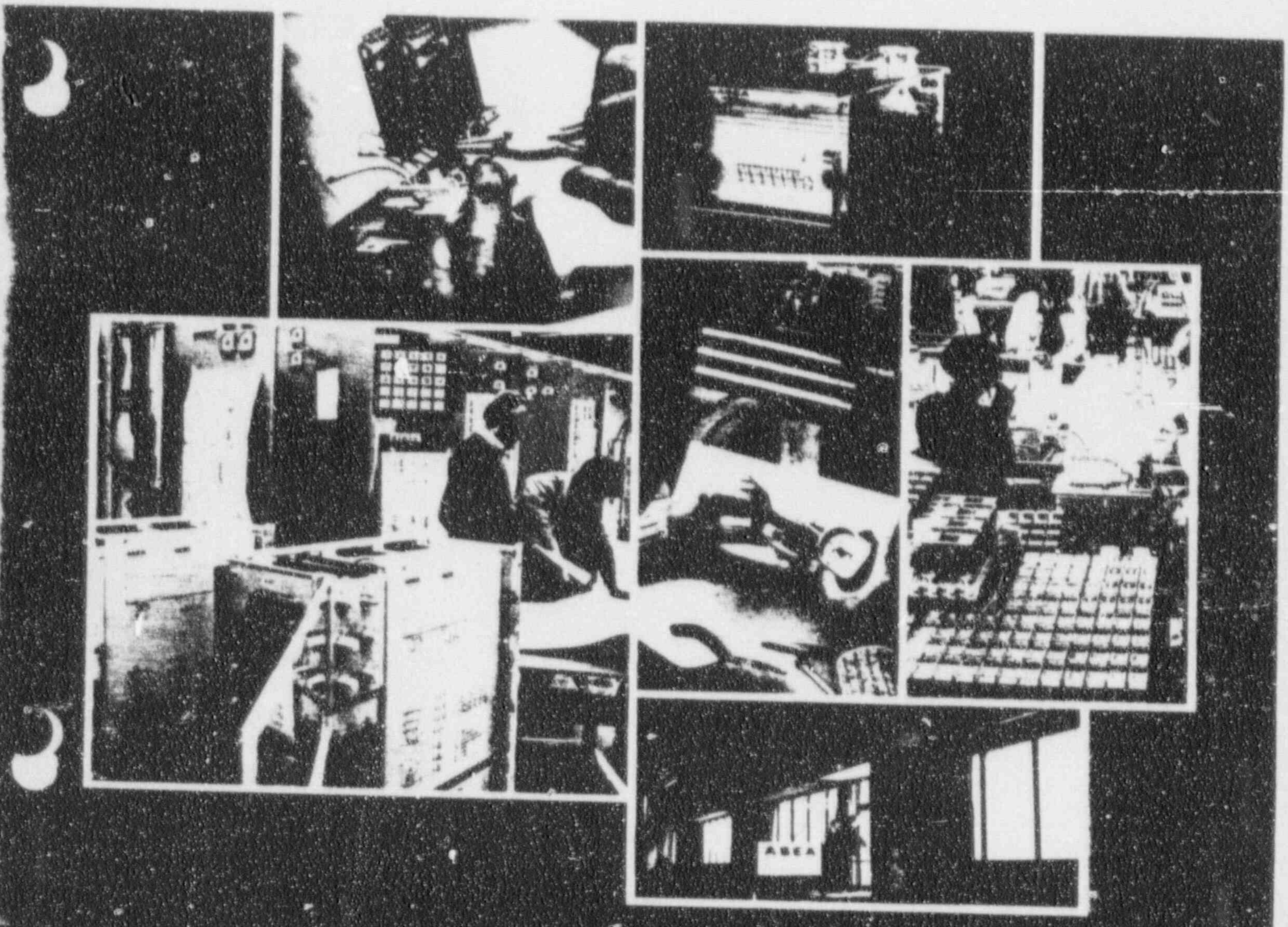
RELAYS

SOMETHING SPECIAL.

RADSE

Instruction Manual

Reliance Electric
Customer Reference: 307891
ASEA Electric Ref: 801-4357



ASEA

LIST of CONTENTS

RK 626 500-BA
5 inputs

High Speed Phase and Ground Protection for Multiple-Winding and Auto-Transformers

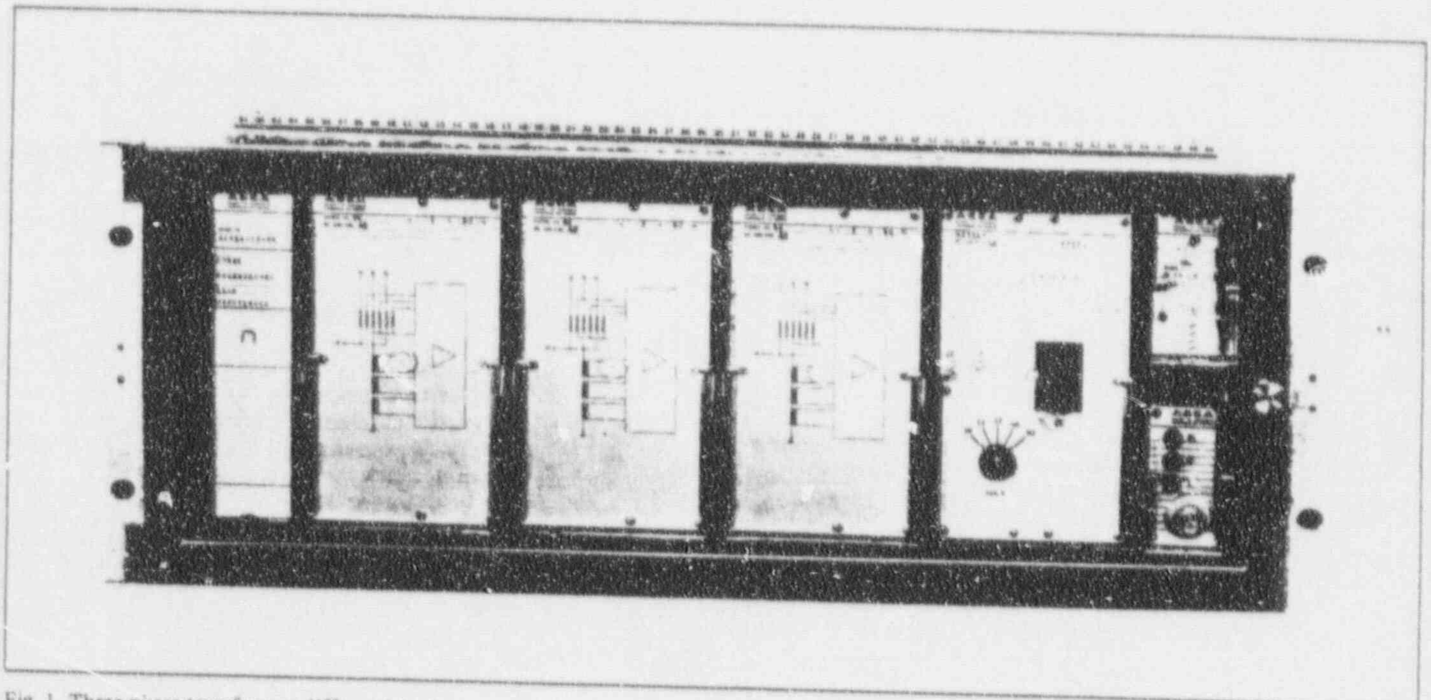


Fig. 1. Three-phase transformer differential relay, type RADSE, occupies one 4S (7" high) COMBIFLEX® equipment frame for mounting on a 19" equipment rack. Auxiliary CT's for ratio and phase matching are provided for separate mounting.

GENERAL

The DSE is a static, transformer differential relay with outstanding speed, sensitivity and security. Only one relay is required to protect the three phases of a transformer. There is no limitation in the application of the relay as to the number of transformer windings, or to the number of breakers which may be associated with any one transformer winding.

Solid state circuitry is used to create three separate restraints:

1. The variable percentage restraint circuitry provides both improved security to external faults and improved sensitivity to internal faults.
2. The 2nd harmonic restraint circuitry provides improved inrush suppression. It is derived from all three phases. It has a minimum effect on relay sensitivity to an internal fault if one occurs during the transformer energizing period.
3. A 5th harmonic restraint, also developed from all three phases, is used to prevent relay operation due to excess exciting currents during transformer overexcitation. The 5th harmonic is preferable to the 3rd for this function because the 3rd harmonic currents may circulate mostly in the transformer delta winding and not appear in the relay restraint circuit. The 5th harmonic is also to be preferred when considering possible current distortions due to CT saturation during an internal fault. Under such conditions tripping is desired and the 5th harmonic provides less restraint than the 3rd.

Device No. 87 T

ASEA

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

REFERENCE PUBLICATIONS

a. Sales Information	62–10 SI
b. Application Guide (This publication)	62–10 AG
c. Test Instruction (Includes commissioning and servicing)	62–10 TI
d. COMBIFLEX System	
Sales Information	92–10 SI
Application Guide	92–10 AG
e. COMBITEST System	
Sales Information	92–11 SI
Application Guide	92–11 AG
f. Accessories:	
Auxiliary Relays MS 1	21–16 SI
Lock-out Relays MVR 4	25–10 SI
Maintenance of Auxiliary Relays	–
g. Price Lists	

APPLICATIONS

The DSE is an instantaneous, 1/2–2 cycle, three phase differential relay with three separate percentage restraint input circuits per phase. Additional restraint input circuits, when required, are provided for by the use of RXTUC 4 three phase input-restraint units. These units have input circuits identical to the basic DSE relay. They mount in the COMBIFLEX 19" frame with the other DSE modular components. Typical applications are:

1. Two-winding transformer; auto-transformer
The basic three-winding relay, Figure 1, is used. The unused, third input is left open circuited. See wiring diagram Figure 7 (a). All of the described relay characteristics are applicable for this usage.

2. Three-winding transformer
The complete three input relay is used as shown in Figure 7 (b).

3. Auto-transformer
No special treatment is required. Wiring diagram, Figure 7 (b), for a wye-wye-delta connected transformer is applicable. This includes provisions for load on a tertiary winding. When there is no load, or when there is no tertiary winding, this input to the DSE is left unconnected, as with a two-winding transformer, Figure 7 (e).

4. Two-winding transformer with dual breakers on one winding
This would occur with a ring bus, double bus, or breaker and a half bus configuration. The complete three input relay is used without concern for matching any specific relay input circuit with any breaker location. See Figure 7 (c). Also note section on CT calculations, page 14.

5. Any transformer with four or more breakers
This configuration could result from a two-winding transformer with dual breakers on each winding, or from multiple-winding transformers, with or without additional breakers associated with any winding. The basic three phase input relay is used, plus as many additional TUC 4 three phase input restraint units as are required. There is no practical limit to the number of additional TUC 4 units, nor need they be assigned to any specific relay input source. Thus inputs from strong or weak sources need no special treatment. Figure 7 (d) is typical of this application. To provide the necessary test facilities a second RTXP 18 test switch is provided. The general arrangements for these basic relays are shown in Figure 3 (a).

6. Long transformer leads
The differential zone of the DSE can include appreciable lengths of transformer leads. Up to one-half mile of high voltage cable, or comparable capacitance, can be included within the differential zone. While the steady-state phasors would suggest no problem, system disturbances have been known to shock excite these configurations into high current oscillations at frequencies unrelated to the power system frequency. Adequate filtering is within the DSE to make it secure during these abnormalities without jeopardizing its 1/2–2 cycle operating time.

7. Long CT secondary leads
Current transformers may be located at an appreciable distance from the DSE relay location. When this requirement is overly severe, supplemental auxiliary current transformers may be installed at each end of the long CT leads to greatly reduce the effective CT burden. A 5/1 or even a 5/0.5 A auxiliary CT at the two ends can reduce the burden of a mile of secondary leads at standard 5 A input to 5 VA, including the required auxiliary CT's. The DSE will function correctly with such an arrangement of the secondary CT circuits.

8. Wye, delta and zig-zag configurations
The DSE is provided with separate auxiliary CT's for ratio and phase angle matching and containment of zero sequence current as required with certain power transformer configurations. Thus there are no restrictions on the type of connections used on the main CT's. Various CT and auxiliary CT arrangements are shown in Figure 9. When main CT's are connected in delta at the main CT location the equivalent burden the leads to the relay location is increased by a factor of two. Thus the comments in item 7 above may be applicable for even moderate distances.

9. Use of instantaneous unit
The DSE has an un-restrained instantaneous unit which is responsive to the total differential current, less any dc component. Its setting is selected with regard to the transformer inrush considerations only. It need not be coordinated with the setting of the restraint unit of the DSE because the restrained relay is not restrained by 3rd harmonics. Thirds are the predominant harmonic in the secondary current from a saturated CT. Hence, CT saturation has no effect on the DSE restraint unit during internal faults. The main purpose of the un-restrained instantaneous unit is to provide slightly faster and redundant operation for severe internal faults.

10. Use of sensitivity setting for minor faults
The relay sensitivity to internal faults can be set by means of a selector switch at 20, 25, 32, 40 or 50 percent of the relay rated current. The 20 percent setting, in particular, provides improved sensitivities for small windings on large, multiple-winding transformers. These small windings may be on separate bushings or they may be one of several parallel coils which constitute one main winding of the transformer. In either case the difficulty of making definite fault current calculations for turn to turn faults makes a differential relay setting as sensitive as feasible very desirable. The 20 percent sensitivity may also be desired where

large CT ratios are dictated by other system conditions such as the transformer breakers in a ring bus or with a breaker and a half configuration.

11. Use of variable restraint for external fault security
The variable percentage restraint characteristic of the DSE provides exceptional restraint for severe external faults. For example, an error of 40 percent in the effective turns ratio of one set of CT's can be tolerated by the DSE without improper trip out during an extreme external fault. When expressed in terms of the lesser of the fault currents to the relay, the restraint approaches 90 percent, even when the relay is set on the above illustrated 20 percent sensitivity. This characteristic makes the relay suitable for use with autotransformers or in a system configuration wherein one transformer winding is directly connected to two or more breakers. In either of these cases external faults may result in very large secondary currents because they are not limited by the usual 5–15 percent transformer impedance.

DESCRIPTION

The DSE is available in four standard versions, each with or without a phase operation indicator SG 1, and/or MVB 4 lockout relay. The versions are for three-, four-, five- and six-winding transformers respectively.

The basic three phase, three-winding DSE relay occupies 19 or 20 module seats of a 4S (7" high) COMBIFLEX equipment frame prewired and ready for mounting on a 19" equipment rack or on a switchboard with suitable cut outs made. The basic version with phase indicator is shown in Figure 2 together with the standard test plug handle RTXH 18. The multi restraint model layouts shown in Fig. 3 (a) illustrate the flexibility of the COMBIFLEX design. Any model can be simply expanded to more inputs or tripping outputs if future conditions should change. Fig. 3 (b) is one type of system configuration which may result from enlargements over the years.

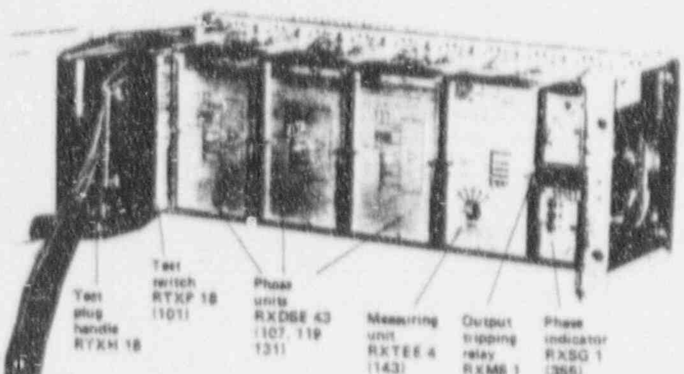


Fig. 2. Three-phase variable percentage differential relay with test plug handle inserted. The numbers within brackets denote seat location of the units.

The components are:

1. **Test switch, RTXP 18**
   In Figure 2 the switch has the test plug handle RTXH 18 inserted. This test facility permits complete testing of the relay from this one location without any additional, or coordinated actions. Load checks are made from this same device. Also, should it be necessary to block relay tripping, a trip-block plug RTXB inserts into the RTXP 18 without affecting the functioning parts of the relay. Figure 7 (a) to 7 (f) show how this test switch connects into the relay external wiring. Figure 8 shows how the plugs and other accessories are used with this switch.

2. **Phase units, RXDSE 43**
   Each of these plug-in units, one for each phase, occupies four seats in the COMBIFLEX frame. Each unit includes the circuitry for three inputs, namely, three sets of air-gapped transformers and three pairs of power diodes. In addition, the required variable percentage restraint circuitry and the harmonic restraint filters together with threshold detectors for each phase are located in these three DSE 43 units.
   Four short-circuiting devices type RTXK are inserted in each of the three terminal bases for the phase units. These devices short-circuit automatically the secondary circuits of the supplying line or auxiliary current transformers when any phase unit is removed.

3. **Measuring and output unit, RXTEE 4**
   This plug-in unit also occupies four seats. It includes the measuring circuits, sensitivity range selector switch, power supply regulating circuitry, dry-reed relay and operation indicator. The mechanical output target in this unit may be reset mechanically or by a remote push-button as shown in Figure 7 (a).

4. **Output tripping relay, RXMS 1**
   This one seat 3 ms relay is driven by the measuring unit. The relay has six output contacts, each capable of tripping a circuit-breaker. One contact is used for energizing the operation indicator in the measuring unit.

5. **Phase indicator, RXSG 1**
   The DSE can be furnished with this one seat indicator. It indicates which phase unit has operated independent of the output trip circuitry. When not specified, the seat is left vacant.

6. **Input-restraint units RXTUC 4 (not shown in Figure 2)**
   Additional input-restraint units, TUC 4, are used when more than three input-restraint circuits are required, as shown in Figure 4. This unit also occupies four seats. Each TUC 4 is a three phase unit inserted in a terminal base equipped with three short-circuiting devices. It includes three single-phase air-gap transformers plus three pairs of power diodes.

Each TUC 4 has three output circuits, one for each phase. These connect to the respective DSE 43 input-restraint units. These is no practical limit to the number of TUC 4's which can be added to the DSE relay. When TUC 4's are required, an additional test switch RTXP 18 is also needed. These additional components mount on an additional 4S apparatus frame identical to that used in the equipment frame for the basic relay. The relay then occupies an 8S (14" high) COMBIFLEX equipment frame. Various combinations are shown in Figure 3 (a). A typical system which would require six inputs is shown in Figure 3 (b).

7. **Lock-out relay, RXMVB 4**
Another option is a trip unit consisting of a third test switch and a lock-out relay RXMVB 4 shown at lower right of Figure 4. The MVB 4 is energized through the 3 ms MS 1 output tripping relay contacts. This trip unit occupies six seats.

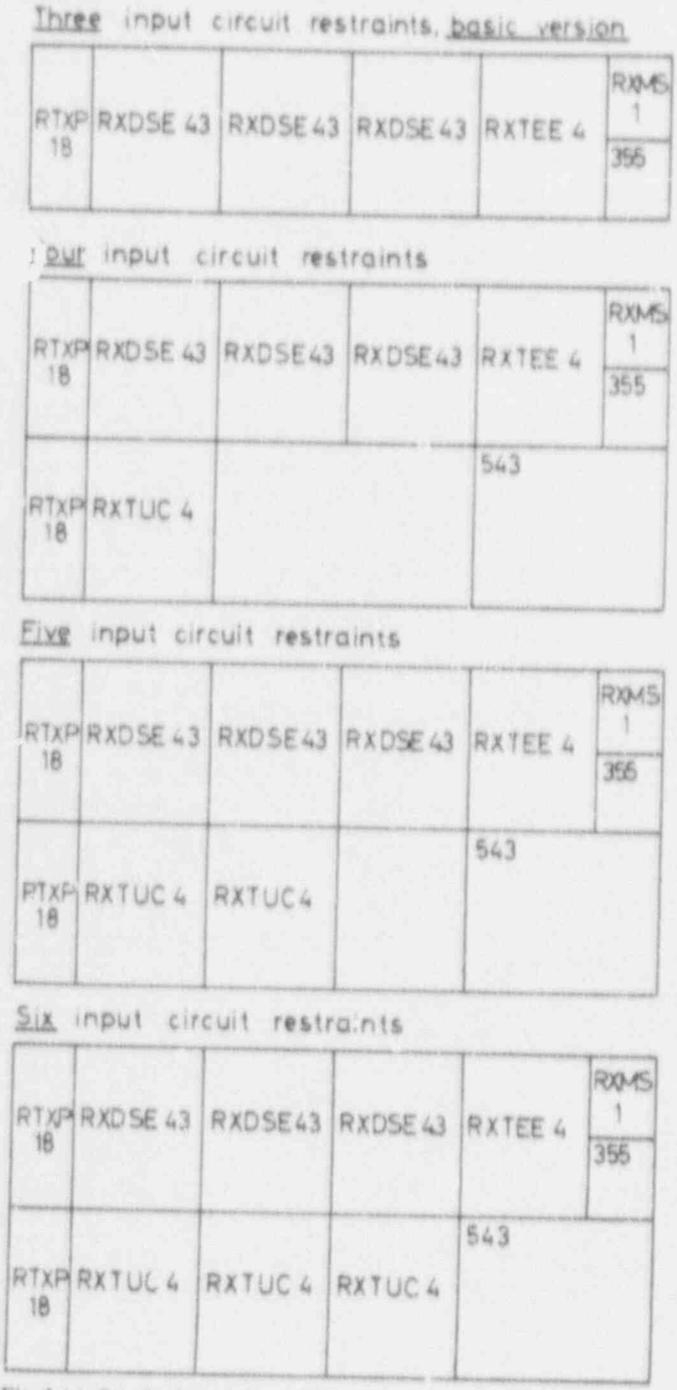


Fig. 3 (a). Standard versions of DSE.

Note 1: All versions can be delivered with phase indicator SG 1 or additional MS 1 on seat 355.

Note 2: All versions except the basic can be delivered with a third test switch and a lock-out relay MVB 4 on seat 543, see Figure 4.

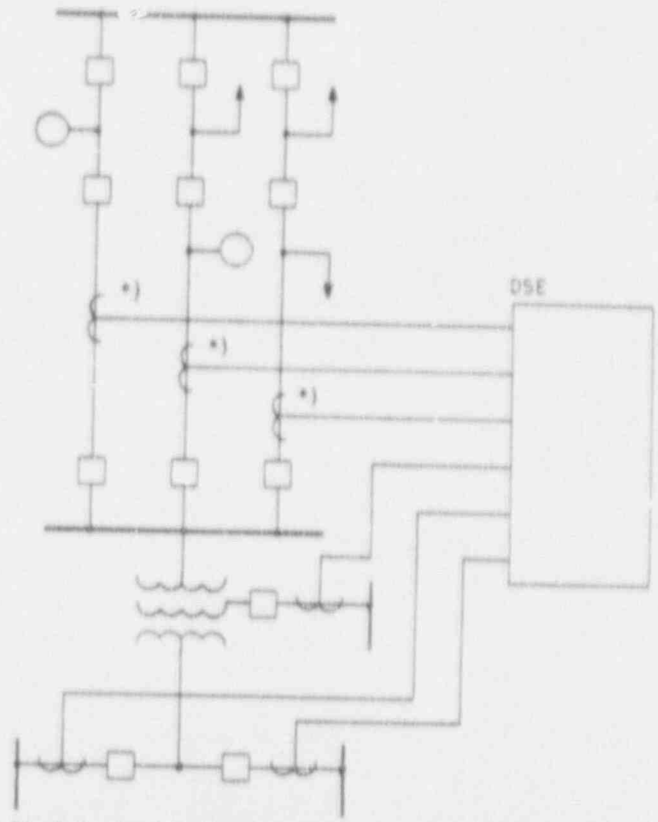


Fig. 3 (b). One line diagram showing an application of a six-input DSE transformer differential relay.

*) Note: Depending on system conditions two or more of these CT's may be summed up to one restraint input.

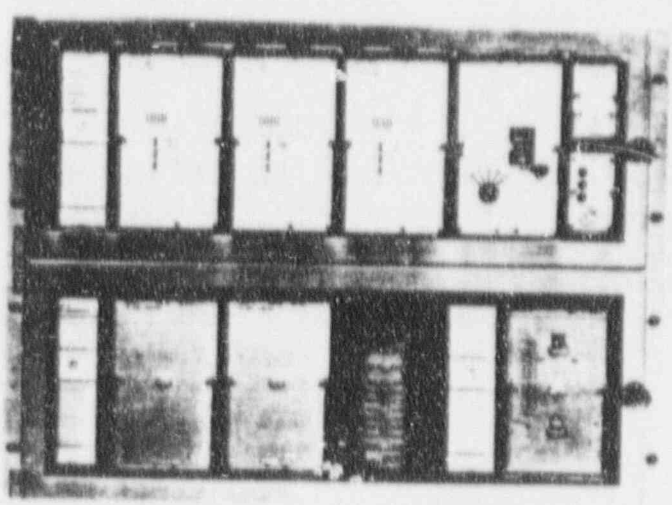


Fig. 4. Two additional input restraint unit TUC 4's (lower left) and lock-out relay MVB 4 (lower right) in a DSE with five input-restraints.

ASEA

Figure 5 is a rear view of the DSE showing the interconnected factory wiring between the individual modules. The relay is shipped with this wiring in place ready for the connection of the CT leads, battery and trip circuits. When additional input units are required, the relay is assembled and wired in a double sized equipment frame as shown in Figure 4. The full options of the COMBIFLEX modular approach can be used for specific application situations without affecting the relay characteristics. This includes specifying the relay modules in a RHGX 20 relay case for mounting on a switchboard.

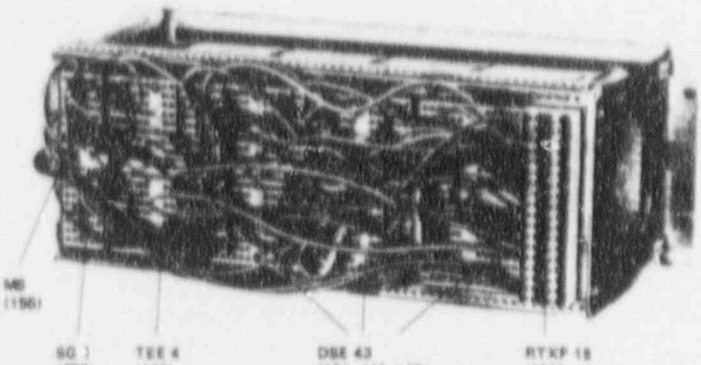


Fig. 5. Rear view of the basic DSE showing factory installed interconnected wiring between the modules.

Auxiliary ratio matching and phase shifting transformers are furnished for mounting separately. They are shown in Figure 6. See page 11 and appendix 1 for more information on the auxiliary CT's.

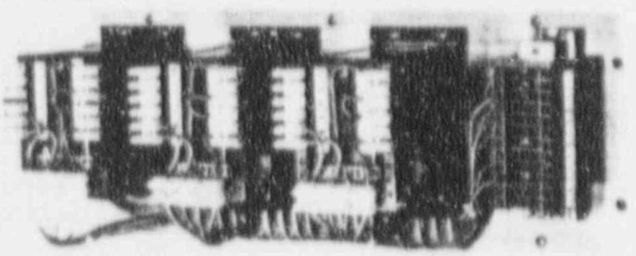


Fig. 6. Auxiliary CT set for one winding mounted on a 4S (7" high) 19" apparatus plate.

INSTALLATION REQUIREMENTS

The DSE relay has only nominal physical requirements for a successful installation. It is designed to mount in a standard 19" equipment frame. The complete basic version occupies 7" of rack space.

The individual modules are protected by securely fitted clear plastic covers. All terminals and connections of the COMBIFLEX system are silver plated, contact pressures are substantial, leads terminate in connectors which directly mate with the module terminals to which the interconnected wiring or the switchboard leads have been crimped. Corrosive atmosphere and high humidity should be avoided as a matter of general prudence.

Field Wiring

Field wiring is mostly terminated in the RTXP 18 test switch. Position No. 1 is at the top, position 18 at the bottom. The wires must be fitted with the ASEA COMBIFLEX terminal connectors for insertion into the respective positions. These connectors are designed electrically for a secure, low resistance contact. The mechanical design provides a secure capture. They are not removable without using the provided tool. This extractor, RTXD, is shipped with the relay.

Depending on the application, some external wiring may need to be connected directly to the relay terminals without going through the test switch. This is shown by the slashed lines in Figure 7. The same ASEA wire terminal connectors are used in all cases. The 20 A (larger) connector should be used for all current circuits and for all connections to the RTXP 18 test switch. It can accomodate up to No. 12 wire. The smaller, 10 A, connector should be used for all other connections. It can take up to No. 14 wire.

The location of each relay terminal can be determined from its number on the wiring diagrams, Figure 7 (a) to 7 (f). Figure 7 (g) shows the physical location of the wiring in Figure 7 (a) which connects directly to the relay modules without going through the test switch. Figure 7 (g) also illustrates the COMBIFLEX numbering system. The test system is described in more detail in Figure 8.

A typical DSE installation wiring diagram for two- and three-winding transformers is shown in Figure 7 (a) to 7 (c). A lock-out, No. 86 function, can be provided internally within the DSE relay. This may be done by electrically sealing in the MS 1 relay via the contact shown on the alarm function. Or an additional MVB 4 magnetic latch relay can be provided. When so specified the MVB 4 relay is wired into the system as shown in Figure 7 (f). Figure 7 (f) also shows the external wiring for five inputs. This might be a three-winding transformer where two of the windings have two breakers each. The same basic arrangement is used for four inputs as shown on Figure 7 (d). More than six inputs can be provided by simple addition of more TUC 4 modules.

Device 101 is the RTXP 18 test switch, shown in more detail in Figure 8. All wiring shown as full lines to the right of this in all of these diagrams is the interconnection wiring between the relay modules. The relay is normally provided with this wiring in place. At time of ordering, the proper dc voltage should be specified for the MS 1 tripping relay. The target electrical reset can be energized by a 48–60 or 110–250 V dc source separate from the main relay, if desired. For additional details on the COMBIFLEX system and the use of the RTXP 18 test switch refer to Publications 92–10 SI, 92–10 AG and 92–11 SI and 92–11 AG, respectively.

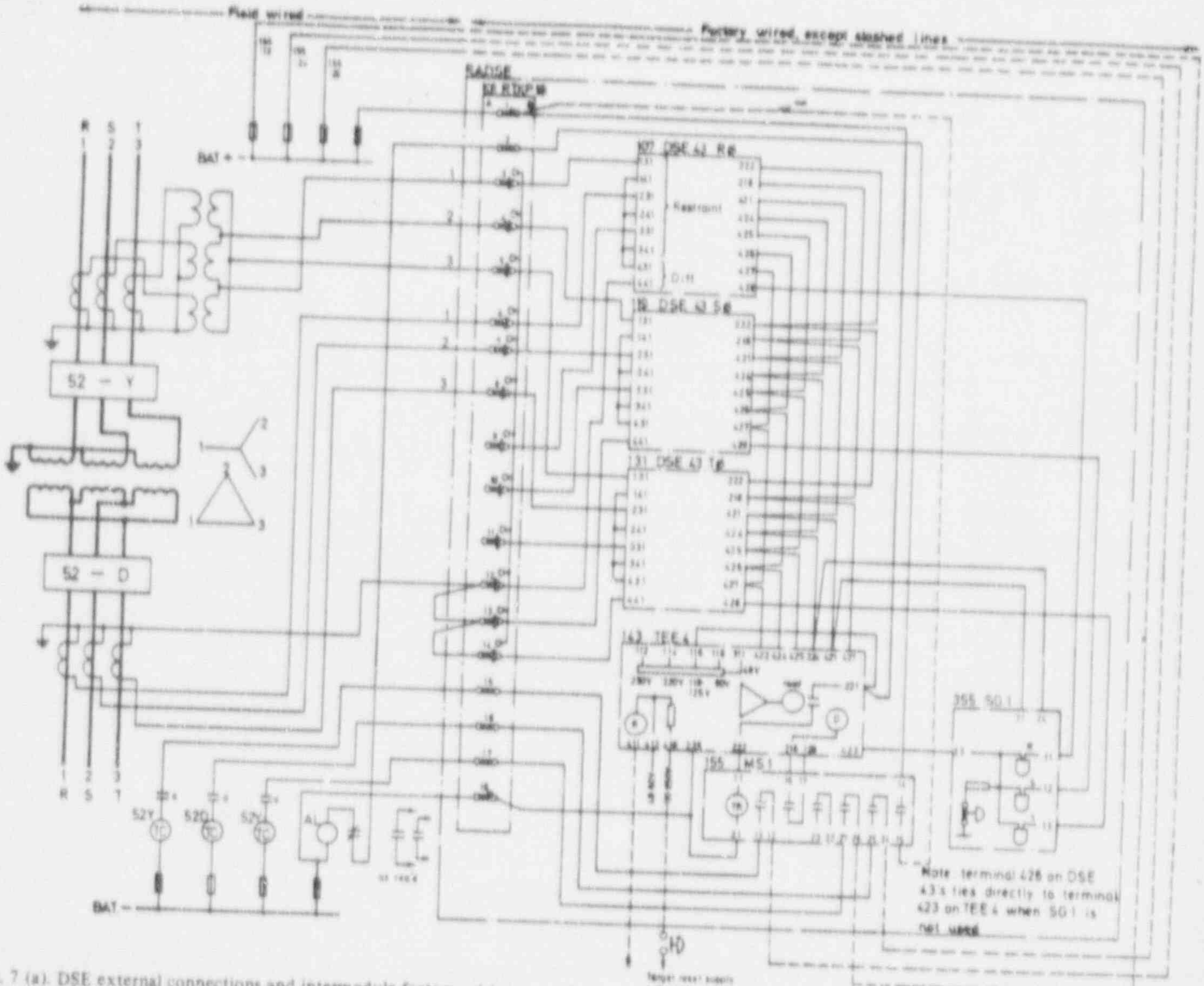


Fig. 7 (a). DSE external connections and intermodule factory wiring for protection of two-winding transformers. (Optional SG 1 phase indicator is also shown)

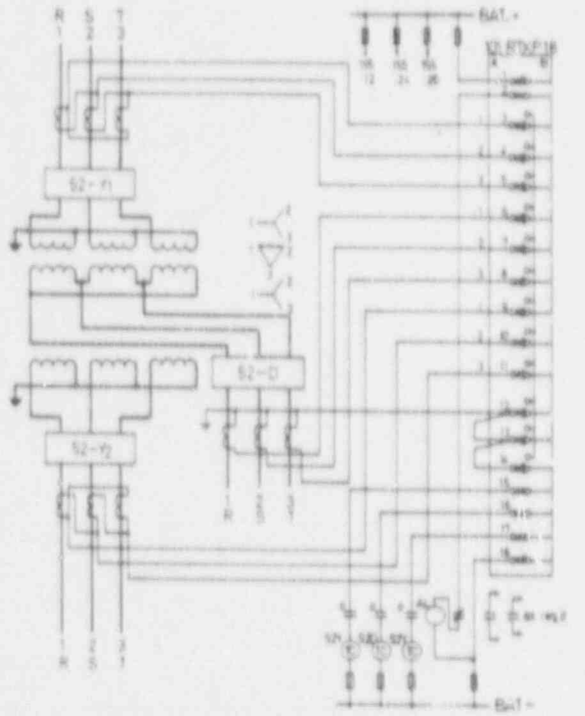


Fig. 7 (b). DSE external connections for protection of three-winding transformers. See Figure 7 (a) for additional field wiring within the DSE. (Add auxiliary CT's for ratio matching if required. This same connection is used for protection of autotransformers. (Delete 3rd DSE-input if there is no delta winding).

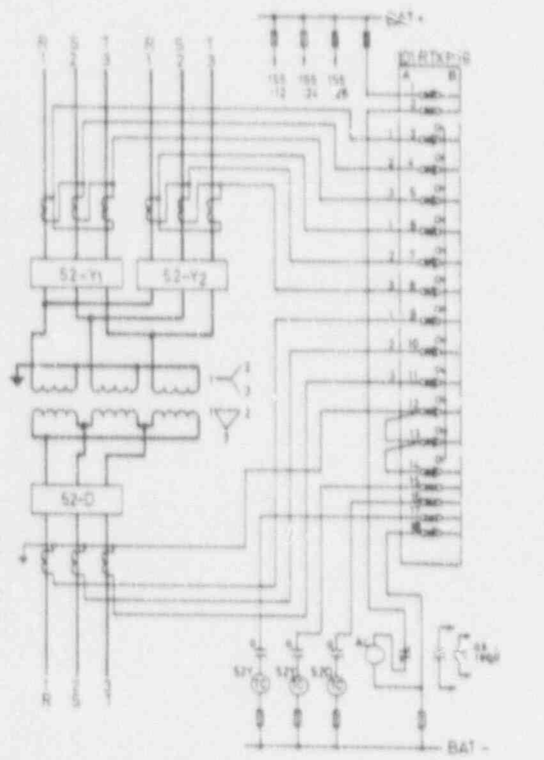


Fig. 7 (c). DSE external connections for protection of two-winding transformer with two breakers on one winding. See Figure 7 (a) for additional field wiring within the DSE.

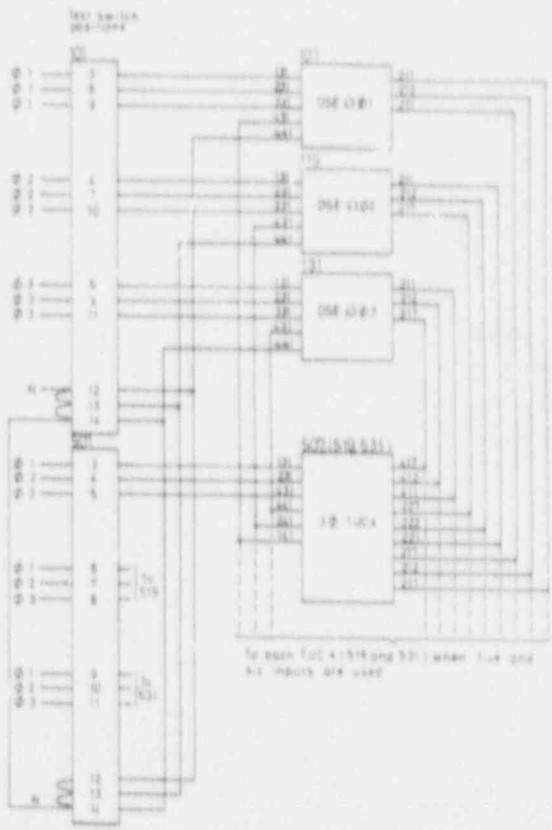


Fig. 7 (d). Factory wiring of TUC 4 to test switch and interconnections to DSE 43's (Typical of four-, five- or six inputs).

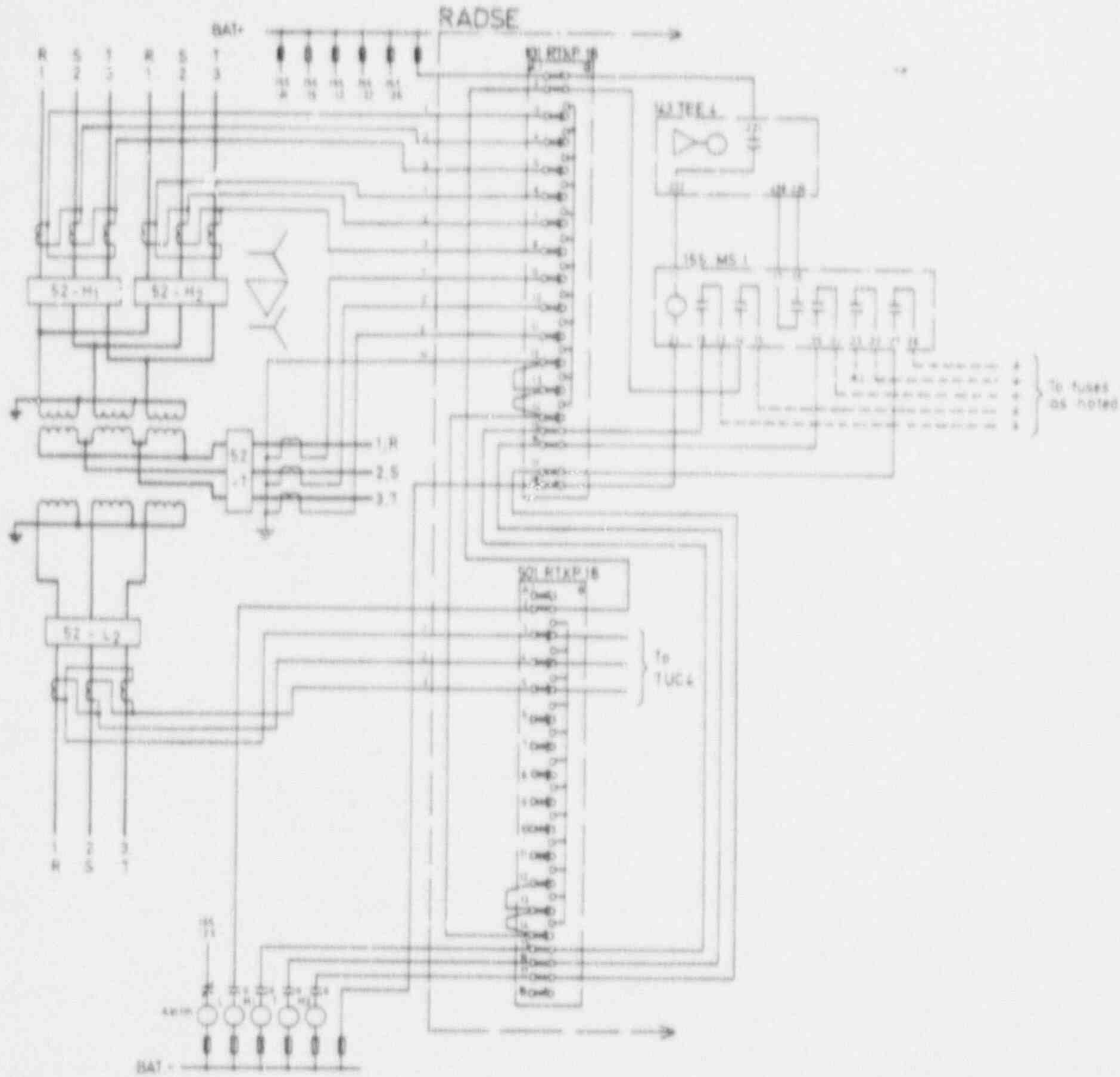


Fig. 7 (e). DSE external connections for protection of three-winding transformer with four circuit-breakers using one TUC 4.

ASEA

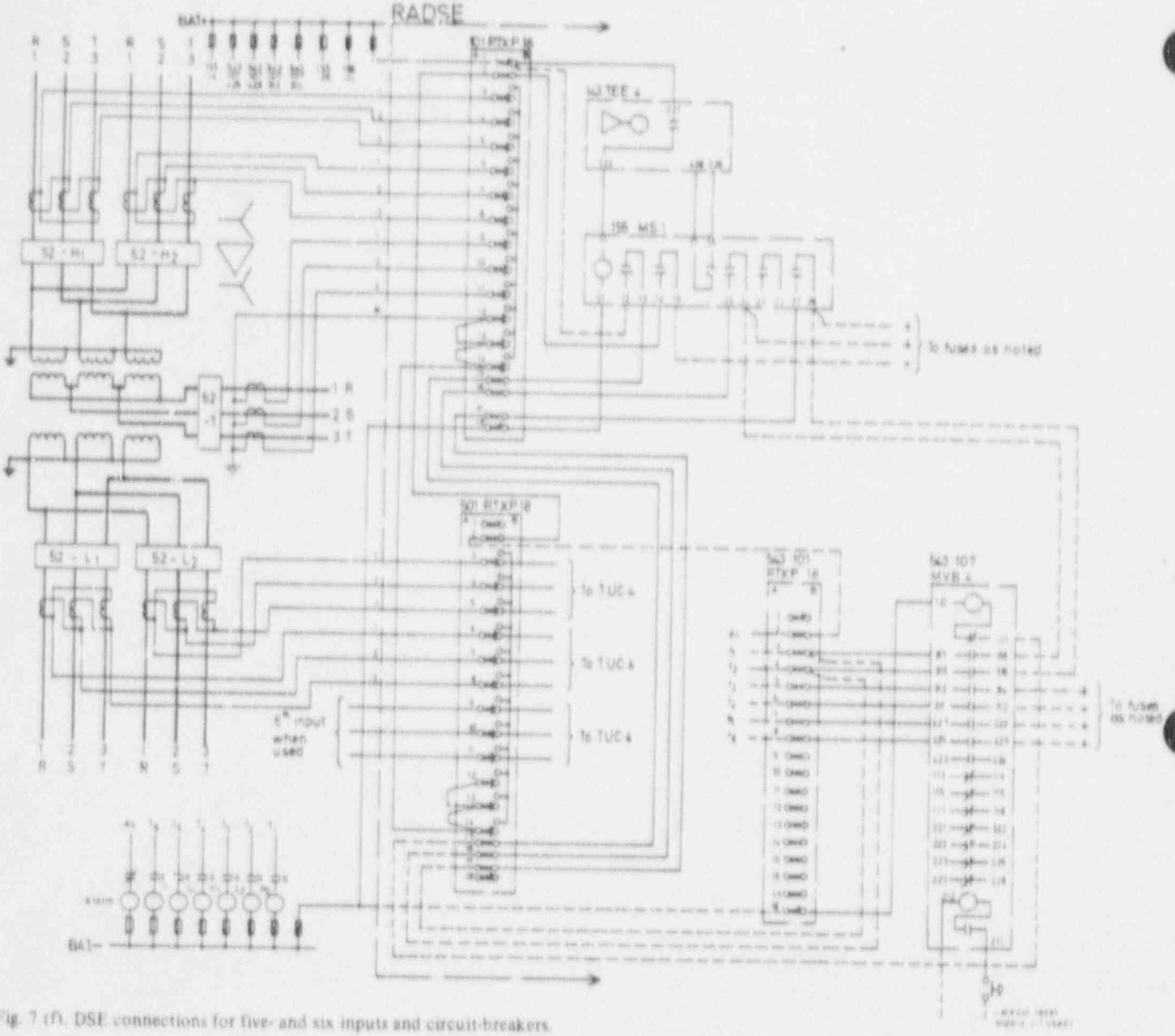
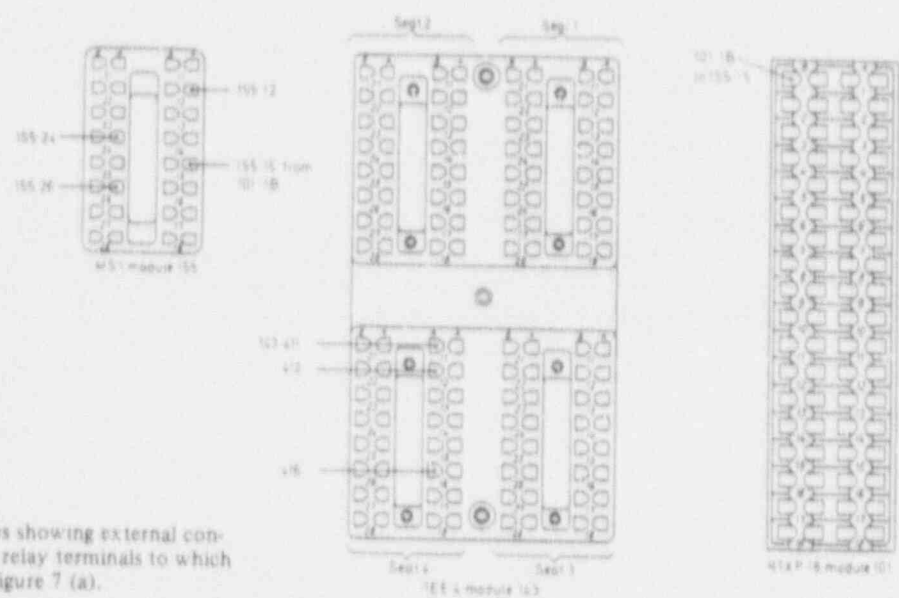


Fig. 7 (f). DSE connections for five- and six inputs and circuit-breakers.

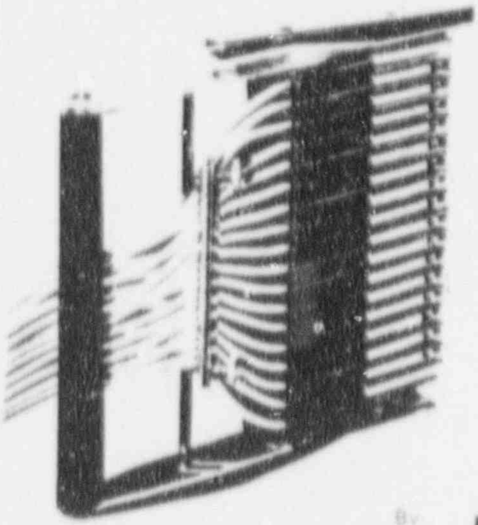


The module number is identified by the location of the top right corner of the relay seat. The 100 series in the location system represents the top of 4 mounting levels in a 4S equipment frame. When plug in modules are used however only levels 100 and 300 are used. See also Figure 17 and publication 92–10 AG.

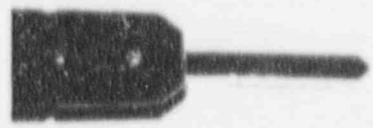
All external wires connect to A side of the test switch

Fig. 7 (g). Rear view of DSE modules showing external connections – physical locations of the relay terminals to which field wiring connects according to Figure 7 (a).

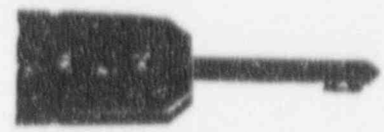
Test plug handle RTXH 18



Test plug handle includes

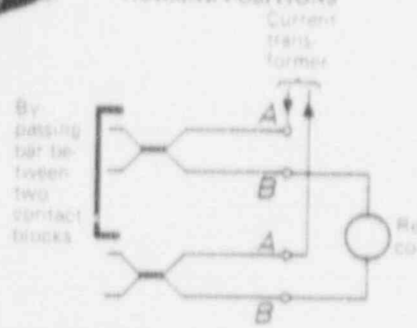


2 plug pins for + and − located at the top and bottom of the test plug handle. Used for supply of dc voltage to the test equipment. This pin does not open any contacts.

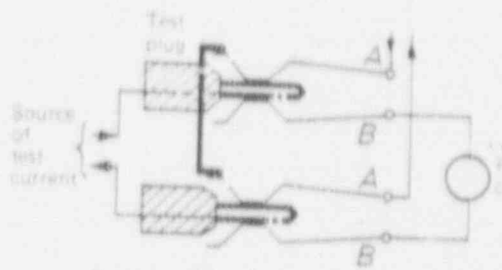


16 test plugs fitted in all remaining spaces in the test plug handle. These isolate both types of contacts i.e., those having a contact tip near the front of the test switch, intended for trip circuits, and those with a contact tip further inside, intended for current and voltage circuits.

NORMAL POSITIONS



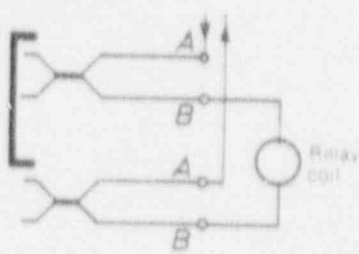
TEST POSITIONS

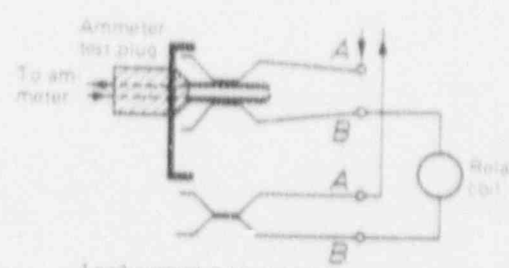


Current testing of relay (positions 3 to 14)

Loose plugs

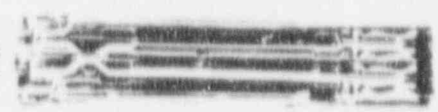
The ammeter test plug RTXM is used separately for service current measurement. It incorporates an overvoltage protection consisting of a gas tube. An arc occurs at approx. 300 V and short circuits the current if this is opened by mistake or if the plug is inserted in the test switch without an ammeter connected to the plug. A bimetal contact is heated up by the arc and takes over the short circuiting.



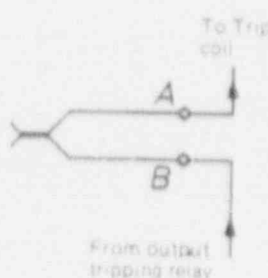


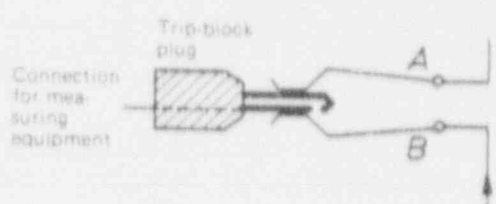
Load current measurement (positions 3 to 14)

Test switch contact for current circuits (positions 1, 3-14, 18)



The trip-block plug RTXB is short and is used separately for blocking trip circuits. It can also be used for measurement purposes in trip circuits. The plug is red to draw attention to the fact that blocking has been carried out. The door of the COMBIFLEX equipment frame can be closed while the plug remains inserted in the test switch.





Interruption or blocking of a dc circuit or for time measurement of trip pulses etc.

Test switch contact for trip circuits (positions 2, 15, 16, 17)

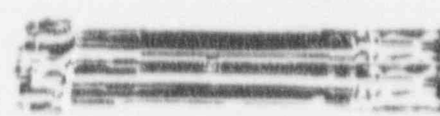


Fig. 8. Details of test plug handle, various test plugs, test switch contacts and method of use.

Other Installation Requirements

The type MS 1 output tripping relay has five output contacts in addition to the one used for the operation indicator. Each is capable of tripping a circuit-breaker. Four contacts are factory wired through the RTXP 18 test switch. There are no polarity or other restrictions on how there MS 1 contacts are utilized within their rating. The RTXP 18 test switch has a continuous rating of 20 A per contact. It can accomodate a total of four output trip circuits in the basic relay. When one or more TUC 4's input restraint units are used, an additional RTXP 18 test switch is provided with a total of 18 additional test circuits as shown in Figure 7 (d), (e) and (f). Electrical and mechanical details of the RTXP 18 test switch are shown in Figure 8.

Current Transformers

Type SLCE 12 multi-ratio current transformers are furnished for ratio and phase angle matching, one set for each of the specified inputs. These are mounted in sets of three on 4S (7" x 19") apparatus plates as shown in Figure 6, for installing in any convenient location. Appendix 1 provides complete mechanical details as well as information for selecting the desired turns ratios within ± 3 percent, and the ampere rating. Current transformer accuracy requirements are based on their performance during external faults, not internal. At high currents the DSE has a 0.65 slope. This allows over a 40 percent error in CT ratio before an undersired over-tripping would occur. Selection of CT's with 10 percent accuracy at maximum external fault current or at 20 times rating which ever is greater is suggested. This will allow adequate margins for possible CT saturation due to any dc component. When X/R ratios during external faults are over 75 severe CT saturation may not be preventable. In such cases symmetry in the affected CT secondary circuits and equal burdens will enchance the security of the system. These situations only occur with breaker and a half or other configurations where the power transformer size has little relation to the external fault current magnitudes.

For rated accuracy at 20 times rated current the 1 A model of the SLCE 12 can accept 2 Ω secondary lead burden or about 1000 feet of secondary wiring; the 5 A model can accept 0.1 Ω or about 50 feet of wiring between the CT's and the relay. Appendix 1 provides complete details on SLCE 12 capabilities.

When the DSE relay is to be located a significant distance from the main CT's, total CT burden can be reduced by locating the auxiliary CT's near to the main CT's. By using a DSE relay rated 1 A and converting to this current level with the auxiliary CT's, the burden of long CT leads can be greatly reduced with no ill affect on the overall relay performance. For exceptionally long CT leads, (over 1000 feet), an intermediate current level of 0.5 A is suggested. This may require a second set of SLCE 12 auxiliary CT's at the relay location to convert back to the rated 1 A value of the DSE if the full sensitivity of the relay is desired.

CT Connections

The determination of the turns ratio of the auxiliary CT's and the phasing connections is conventional. In general, prudence in transformer differential relay circuits suggests no additional devices connected into the differential CT circuits. However, from a burden viewpoint, the DSE burden is negligible and with suitable capability in the main CT's additional devices can be included in the DSE circuitry.

When additional burdens on the DSE CT's are a requirement, the flexibility of the separate ratio matching CT's can be further utilized. The main CT ratios and phase connections (wye or delta) can be selected to meet the requirements of the additional devices. The ultimate ratio and phase relations for the DSE can then be provided by the SLCE 12 auxiliary CT's.

The phase relations of the current circuits should be determined before the auxiliary CT ratios are calculated. There are three requirements for the auxiliary CT's.

1. Bring the currents from every source of a given phase into phase.
2. Bring the current magnitudes from every source into harmony.
3. Suppress the zero sequence (ground current) component to avoid improper operation on external faults.

Figure 9 shows the several methods of connecting the main and auxiliary CT's for reaching these objectives.

With the power transformer connected wye-delta, these objectives are most easily satisfied by connecting the main CT's inversely, that is in delta/wye respectively. A zig-zag winding of a power transformer will have a phase relation similar to a delta which usually requires wye connected CT's. But since the zig-zag neutral is usually grounded, the CT's on a zig-zag winding should be in delta or otherwise to suppress the zero sequence flow. Two such zero-sequence suppression arrangements are shown in Figure 9 (d) and (e).

The CT connections will have no effect on the harmonic restraint action of the DSE. This is because the rectified 2nd and 5th harmonics from each of the three phases are combined for a common harmonic restraint. Thus, the relative effect of these harmonics to the fundamental at the relay will be independent of the connections of the power transformer and the CT's. The 3rd harmonic is the one most affected by CT connections and this is not utilized for restraint in the DSE. Special CT connections are not required for the 5th harmonic overexcitation restraint.

Some power transformers, due to their construction, have "hidden" tertiary winding effects. This results in some of the currents, normally assumed to be flowing in the delta, to flow in fact in the transformer case and other mechanical parts of the transformers during severe external ground faults. Therefore, connection of main CT's inside the delta of main CT's inside the delta of a power transformer may not measure the total effective delta current. This connection is usually not recommended with the DSE. The 5th harmonic restraint characteristic of the DSE does not require this connection with its attendant complex calculations.

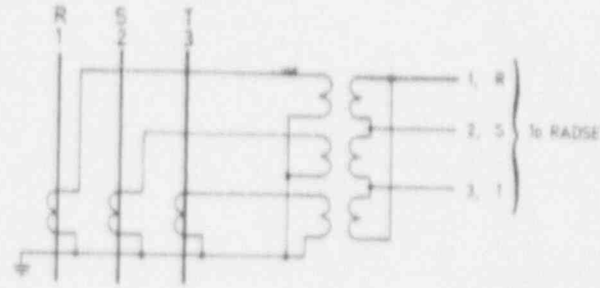


Fig. 9 (c). Auxiliary CT connections for wye-delta phasing with or without ratio matching requirements.

Note: Auxiliary CT delta should be made up with the same polarities and interphase wiring as the power transformer.

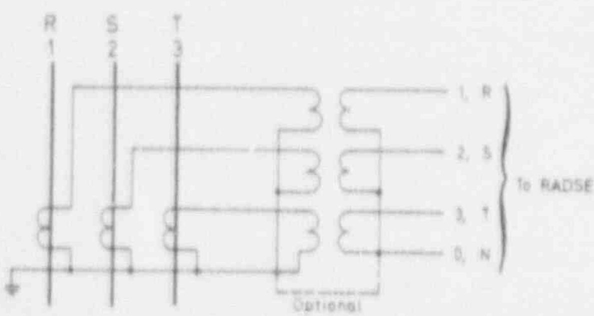


Fig. 9 (a). Auxiliary CT connections with wye connected main CT's for ratio matching only.

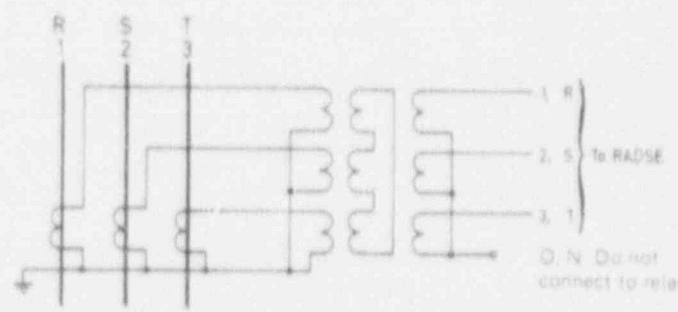


Fig. 9 (d). Auxiliary CT connections for zero sequence suppression when wye-delta phase shift is not acceptable.

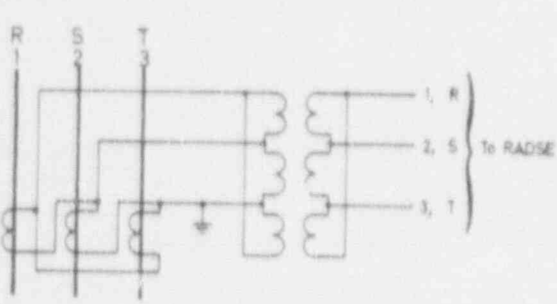


Fig. 9 (b). Auxiliary CT connections with delta connected main CT's for ratio matching only.

Note: Main CT delta should be made up with the same polarities and interphase wiring as the power transformer winding.

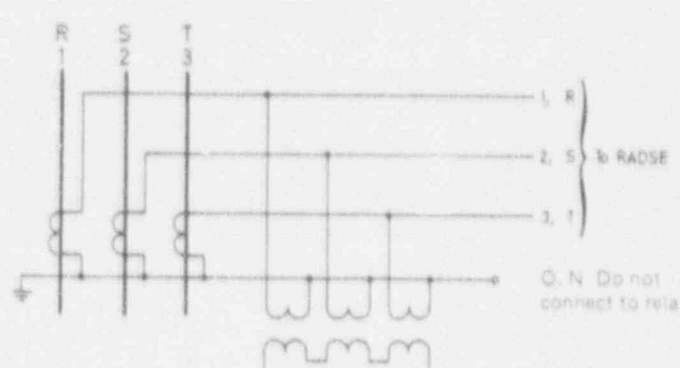


Fig. 9 (e). An alternative of Figure 9 (d) for zero sequence suppression when ratio matching is not needed.

CT Calculations

The following illustrated procedure will result in the proper sizes and ratios for the main and the auxiliary CT's.

1. State the problem by listing all voltages*), kVA ratings, overload requirements, line currents*), wye and delta windings, dual breakers, etc. For example: A 138/34.5/13.8 kV, delta-wye-wye power transformer with a rating of 100/60/60 MVA on the respective windings, see Figure 10 has a 135 percent overload requirement. The 34.5 kV winding will tie into the system with two breakers in a ring bus scheme. The exact voltage taps will be determined in the field, but it is judged they will be within 5 percent of the nominal values.

*) Note: These voltages and currents should be the selected tap values of the power transformer, not the system nominal voltages. In the case of tap changing under load transformers, it is customary to select the mid value of the operating range.

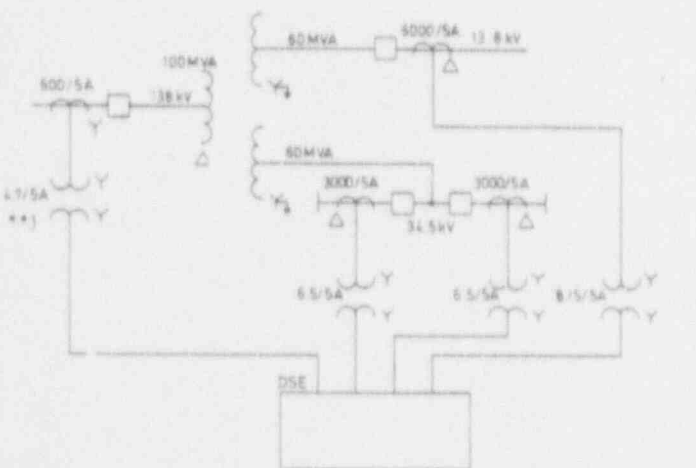


Fig 10. Example used in sample CT calculations.

**) Note: Auxiliary CT not generally needed, see item 2 below.

Determine the maximum line currents for each winding:

$$I_{line} = \frac{\text{kVA of winding}}{\sqrt{3} \times (\text{line-line kV})} \times \text{overload factor}$$

$$I_{138} = \frac{100.000}{\sqrt{3} \times 138} \times 1.35 = 418 \times 1.35 = 565 \text{ A}$$

$$I_{34.5} = \frac{60.000}{\sqrt{3} \times 34.5} \times 1.35 = 1001 \times 1.35 = 1360 \text{ A}$$

$$I_{13.8} = \frac{60.000}{\sqrt{3} \times 13.8} \times 1.35 = 2510 \times 1.35 = 3390 \text{ A}$$

2. Select an overall CT ratio for the largest kVA winding to yield about 5 A to the DSE.

$$\frac{565}{5} = 113/1 \text{ on 138 kV winding}$$

(But note, as in step 5, that the load flow through the two 34.5 kV breakers may be the maximum kVA value to which the system must be designed). Other requirements would probably suggest a main CT ratio of 120/1 or 600/5 A. No auxiliary CT would be needed with a ratio this near to desired value. However, assume exactly 5 A is desired at the relay.

auxiliary ratio =

$$\frac{113 \text{ (desired)}}{120 \text{ (main CT)}} = 0.942/1.0 \text{ or } 4.71/5 \text{ A}$$

From table 3 of appendix 1 the turns ratio of SLCE 12 for this input current should be 44/42.

3. Determine the overall CT ratios for the other two windings, these will be inversely proportional to the voltages (ignore the kVA):

$$34.5 \text{ kV ratio} = 113 \times \frac{138 \text{ kV}}{34.5 \text{ kV}} = 452/1$$

If 400/1 main CT ratio (2000/5) has been selected for other purposes, the auxiliary ratio becomes:

$$\frac{452 \text{ (desired)}}{400 \text{ (main CT)}} = 1.13/1 \text{ or } 5.65/5 \text{ A on 34.5 kV winding}$$

The turns ratio for the SLCE 12 would be 31/36, except for the delta considerations – see step 4.

Note: The dual 34.5 kV breakers do not normally affect this calculation, but see step 5.

$$13.8 \text{ kV ratio} = 113 \times \frac{138 \text{ kV}}{13.8 \text{ kV}} = 1130/1$$

If the main CT's have already been chosen to be 1200/1, (6000/5), the auxiliary ratio should be:

$$\frac{1130}{1200} = 0.942/1 \text{ or } 4.71/5 \text{ A on 13.8 kV winding}$$

The turns ratio for the SLCE 12 would be 44/42, except for step 4.

4. For those windings requiring delta connected CT's, increase the overall ratio by 1.73. It does not matter where the delta is made up, in the main CT's or in the auxiliaries, the overall ratio will be brought into harmony in the auxiliary CT's. In this example, both the 34.5 kV and the 13.8 kV will need delta CT's, so the auxiliary ratios become:

   1.73 x 5.65/5 = 9.76/5 A, or 22/42 turns on SLCE 12 for the 34 kV

   1.73 x 4.71/5 = 8.15/5 A, or 22/36 turns on SLCE 12 for the 13 kV.

5. Review other operating requirements for other CT needs. The two breakers on the 34.5 kV winding may have an additional requirement of being able to transfer power through the bus in addition to the transformer load. If this results in possible currents in excess of the 2000 A rating of the selected CT, then a higher rated main CT would be required. Assume a 3000 A capability may be needed and a 3000/5 or 600/1 main CT is selected. The auxiliary CT then becomes:

   $$\frac{452}{600}\ \frac{\text{(desired)}}{\text{(main CT)}} = .753/1 \text{ or } 3.77/5 \text{ A}$$

   And since this winding requires a delta CT connection, the selected auxiliary CT ratio would be

   1.73 x 3.77/5 = 6.5/5 A with SLCE 12 turns ratio of 31/40 for both sets of 34.5 kV CT's.

   Since the overall ratio has not been changed, the current to the DSE from these CT's during the 3000 A emergency through loading becomes:

   3000/452 = 6.64 A

   This is well within the rating of the DSE. However, the capability of the auxiliary CT's at this higher current level should also be checked. Also, if this requirement should have resulted in a relay current larger than desired, then this larger primary current should be used as the determining maximum kVA and the other ratios brought into agreement with it.

6. Determine if any of the auxiliary CT's can be eliminated. In this example the 138 kV auxiliaries are within 6 percent of a 1/1 ratio. Thus they could be eliminated with only a 6 percent reduction in relay current. The overall ratio becomes 120/1 on this largest winding and the other CT ratios would then be recomputed to maintain this overall ratio. However, since it was noted that operating experience may require a change in taps on the main CT, the auxiliary CT's would probably still be used to provide for future conditions.

7. Tabulate the burden on each set of CT's based on the final ratios as determined in step 6. For the illustration, assume (for the 34 kV CT's):

CT secondary winding: 2.5 milliohm per turn x 600 turns	= 1.5 Ω
Secondary leads: 500' (x 2 way) No. 9 wire 75°C	= 1.0 Ω
Auxiliary CT (2 VA burden rating at 5 A) x 2	= 0.16 Ω
DSE restraint burden (0.18 VA at 5 A x $(5/6.5)^2$ x 2)	= 0.01 Ω
Other burdens	– Ω
Total burden, as imposed on main 34 kV CT's	= 2.67 Ω

8. Calculate maximum secondary voltage on the main CT's, which could occur for a severe external fault; ignore possible asymmetry:

   $$E_{sec} = I_{sec} \times Z_{sec}$$

   Assume: 40,000 A (2,400 MVA) can flow through one of the 34 kV breakers for an external bus fault.
   CT secondary current = 40,000/600 = 66.7 A
   CT secondary voltage = 66.7 x 2.67 = 178 V
   Determine this for each set of CT's. If the auxiliary CT's are to be located a significant distance from the DSE relay, the capability of the SLCE 12 CT's should also be checked as shown in Append. 1. In this example, and allowing 0.1 Ω for the switchboard wiring from the SLCE's to the DSE, the SLCE's maintain their accuracy up to 125 A.

9. Specify CT secondary voltage accuracy class no less than this maximum voltage calculated in step 8, or a C 200 in this illustration. Additional margin is not necessary. For inrush considerations, the voltage accuracy class should be at least equal to the voltage developed at 20 times rated current or to the actual inrush current if known.

   Note: There is no need to make any CT calculations for internal faults. The relay will properly respond to internal faults up to 100 times rated current (500 A at the relay).

10. Where available CT's cannot provide the voltage needed in step 9, there are several options available.

    a) Install auxiliary CT's at the main CT's to reduce the current to a 1 A level and use a 1 A DSE relay. This solution greatly reduces lead burden.

ASEA

b) Use larger wire for the secondary leads to reduce the lead burden. This expense is usually not warranted in view of the other options noted.

c) Install auxiliary CT's at the main CT's to reduce the current level in the secondary wiring to 1/2 – 1 A range, with a compensating current step up adjustment in the auxiliary CT ratio at the relay. The one ohm lead burden in the illustration can be substantially eliminated by this method, but requires an additional set of CT's.

d) When auxiliary CT's are not needed for ratio correction or wye-delta phase shift, the burden can be reduced by selecting main CT ratios to yield only 2 – 3 A during maximum load conditions. This of course reduces the sensitivity of the relay, but the DSE has a minimum pickup setting as low as 20 percent of the 5 A (or 1 A) rating which may still yield a satisfactory sensitivity.

e) Connect main CT's to a higher ratio and compensate with a current step up ratio in the auxiliary CT's at the relay location. The lead burden will be reduced by the square of the increased CT ratio. In the illustration, doubling the main CT ratio will reduce the required secondary voltage to 72 percent. Note that the internal resistance of the CT increases with an increase in the number of secondary turns, thus reducing the net benefit gained from this solution.

BURDENS

The DSE is available as a 1 A or 5 A relay. The respective burdens at nominal rated current are:

1 A relay, 0.02 VA
5 A relay, 0.18 VA

In the differential circuit, at 20 percent rated current, the burdens are:

1 A relay, 0.01 VA
5 A relay, 0.02 VA

The relay burden is not affected by the minimum sensitivity adjustment.

Auxiliary current transformers are type SLCE 12 with an insertion loss of 1.0 to 2.8 VA depending on turns ratio at nominal rating. See Appendix 1 for specific data.

POWER CONSUMPTION

The DSE relay has the necessary components internally for operation at any dc control voltage, 48 V and above. The higher voltages require more power in view of the nearly constant current requirements of the internal voltage stabilizing circuits.

Approximate continuous dc power requirements at rated tap voltages:

48 V	3.0 W
60 V	3.5 W
110 V	5.0 W
125 V	6.5 W
220 V	9.0 W
250 V	10.0 W

The MS 1 output tripping relay requires an additional 7 W when it operates.

RATINGS

Input current circuits:

Frequency – 50 or 60 Hz

Nominal rating	Overload capability		
	Continuous	1 s	Instantaneous
DSE Relay			
1 A	10 A	100 A	180 A
5 A	20 A	250 A	500 A
SLCE 12 ratio matching CT's	2.5 times nominal rating	75 times nominal rating	

reconnectible rated current ratios:
0.65 – 2.60/1 A
2.55 – 9.60/1 A
2.85 – 9.70/5 A

Output contacts of type MS 1 relay:

Continuous	4 A
1 s	20 A
10 ms	100 A
Make and carry for 200 ms	30 A

DC auxiliary voltage:

Nominal relay tap values are 48, 60, 110, 125, 220, 250 V dc + 10 percent, – 20 percent (– 15 percent for 48 V version).

MS 1 output tripping relay is available in any one of these voltages, as specified.

Ambient temperatures:

– 25°C to + 55°C (–13°F to + 131°F), except if auxiliary voltage is 220 or 250 V, top temperature is reduced to + 40°C (104°F)

Dielectric and surge withstand:

Insulations tests:

current circuits, 2.5 kV, 50 Hz, 1 minute
all other circuits, 2 kV, 50 Hz, 1 minute

Impulse tests for all circuits:

5 kV, 1/50 μ sec., 0.5 joule

Surge withstand capability test:

2.5 kV, 1 MHz, decay time, 3–6 cycles, repeated each 2.5 ms for 2 s.

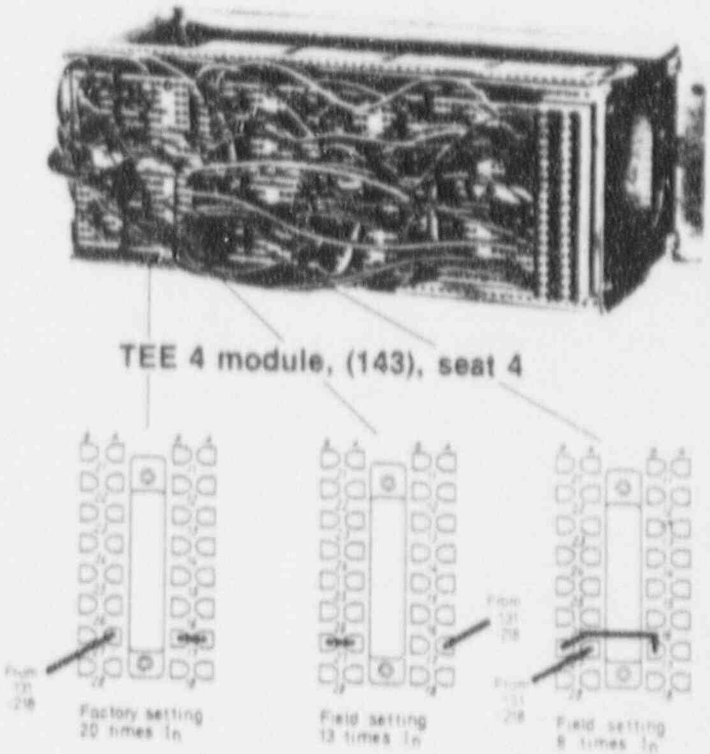


Fig. 11. Un-restrained instantaneous operating current setting adjustments by means of jumper positions at the rear of the TEE 4 module.

Auxiliary CT's type SLCE 12, taps available in 4–6 percent steps, as shown in Appendix 1.

From 0.65 A to 9.6 A primary to 1 secondary
From 2.85 A to 9.7 A primary to 5 A secondary

OPERATING SPECIFICATIONS

(See Section on Settings on page 22 for Setting Procedure Details)

Operating currents

Minimum operating current:

Settings of 20, 25, 32, 40 and 50 percent of the rated current of 1 A or 5 A

Un-restrained instantaneous unit operating current:

Tap settings of 8, 13 or 20 times the relay rating of 1 A or 5 A. See Figure 11 for method of making settings.

Operating time

Restraint unit:

At 3 times pickup current;	30 ms
At 10 times pickup current;	27 ms
Impulse time limit;	> 15 ms

Un-restrained unit:

At 2 times pickup current;	10–18 ms
Impulse time limit; approx.	3 ms

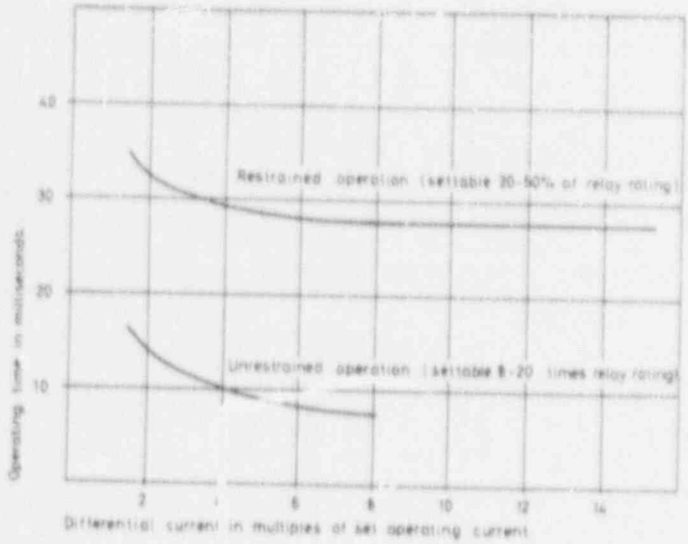


Fig. 12. Operating tim›-current characteristics for DSE relay.

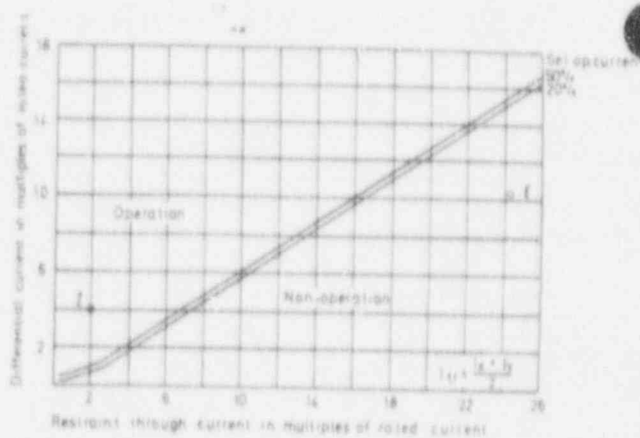


Fig. 13 (a). Through current restraining characteristic at larger current values. Minimum pickup setting of 20 and 50 percent of rated current. The through restraint current I_{tr} = the average of the maximum current I_x entering the protected zone and the maximum current I_y leaving the zone. See page 21 for points "I" and "E".

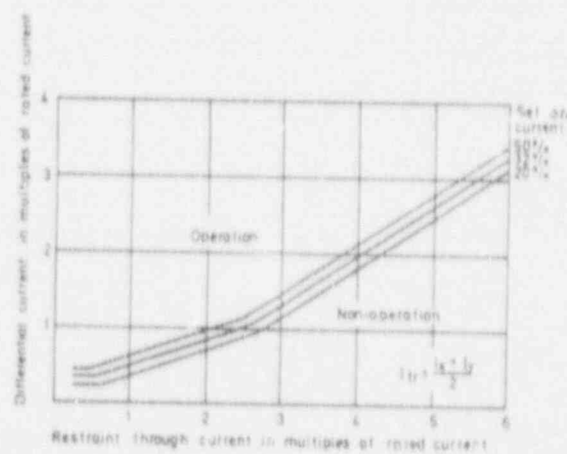


Fig. 13 (b). The low current region of Figure 13 (a).

Restraints

Percentage: Varia›le from 35 percent to 70 percent, d‹ pending on magnitude of through cu›ent and on minimum sensitivity setti›g, nonsettable. Figure 13 (a) and (b) sh‹w the relation between differential cu›rent and restraint current for relay operation. Figure 13 (c) shows this data presented as percent operating differential current vs through restraint current i.e. the percent slope characteristic. (See next section, THERY OF OPERATION, page 19 for method of describing restraint current).

2nd harmonic: 20 percent 2nd harmonic content in the differential current will prevent operation.

5th harmonic: 35 percent 5th harmonic content in the differential current will prevent operation.

Notes: (1) The 3rd harmonic contributes no harmonic restraint action. The 3rd harmonic current will contribute a small restraint due to the harmonic filter characteristic. However, this is offset by an operating voltage developed in the differential operate circuit by the 3rd harmonic.

(2) Frequencies above the 5th harmonic are filtered out of the operating circuit and have little effect on relay performance.

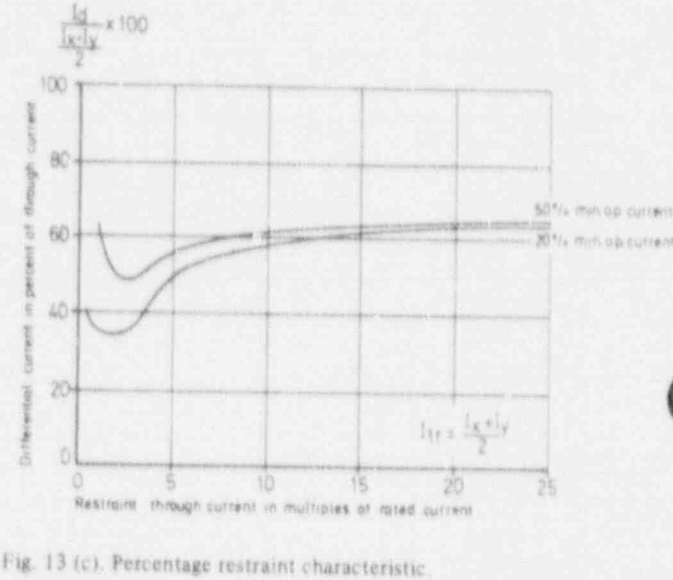


Fig. 13 (c). Percentage restraint characteristic.

Next page shows functional relations within DSE

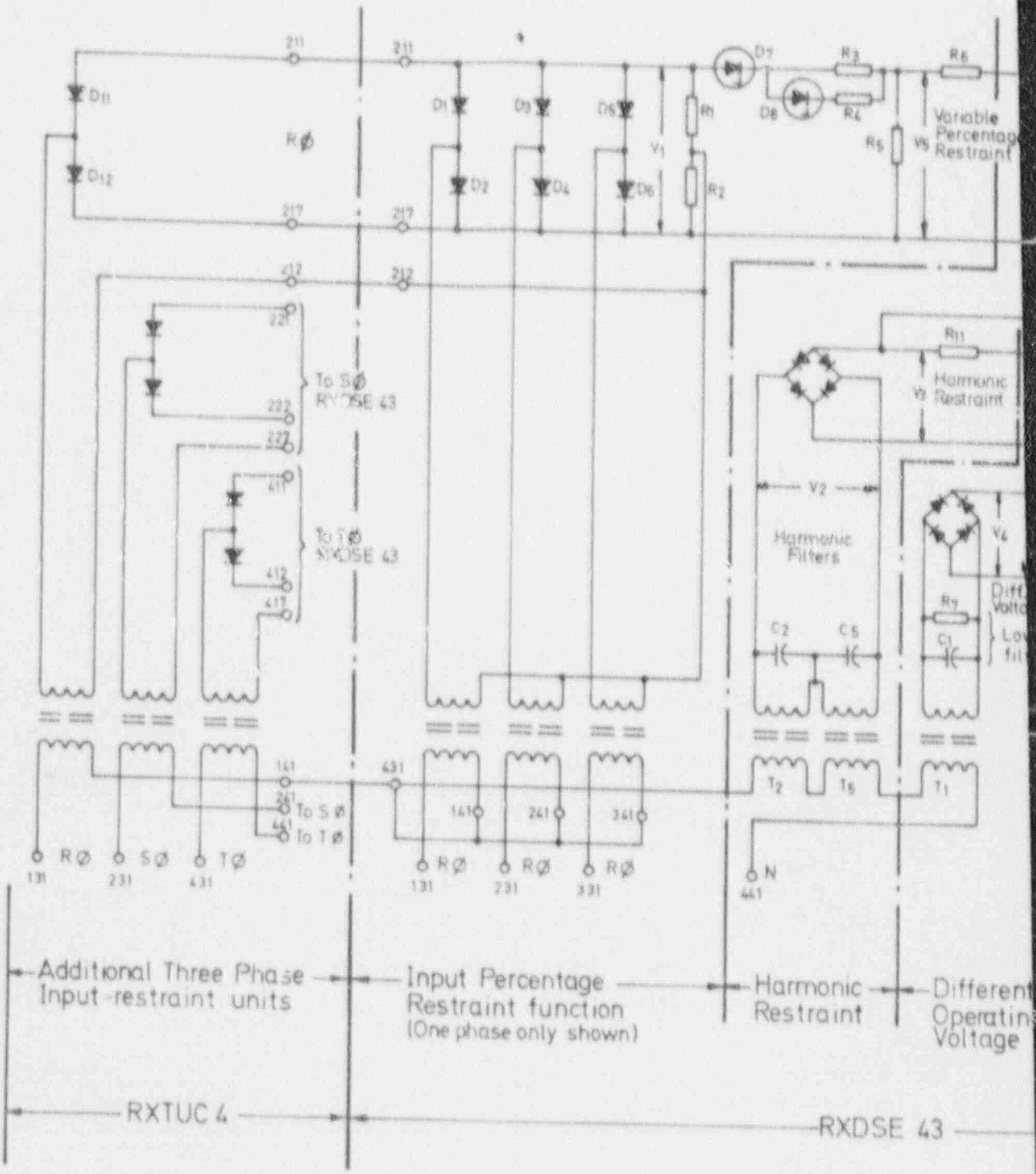
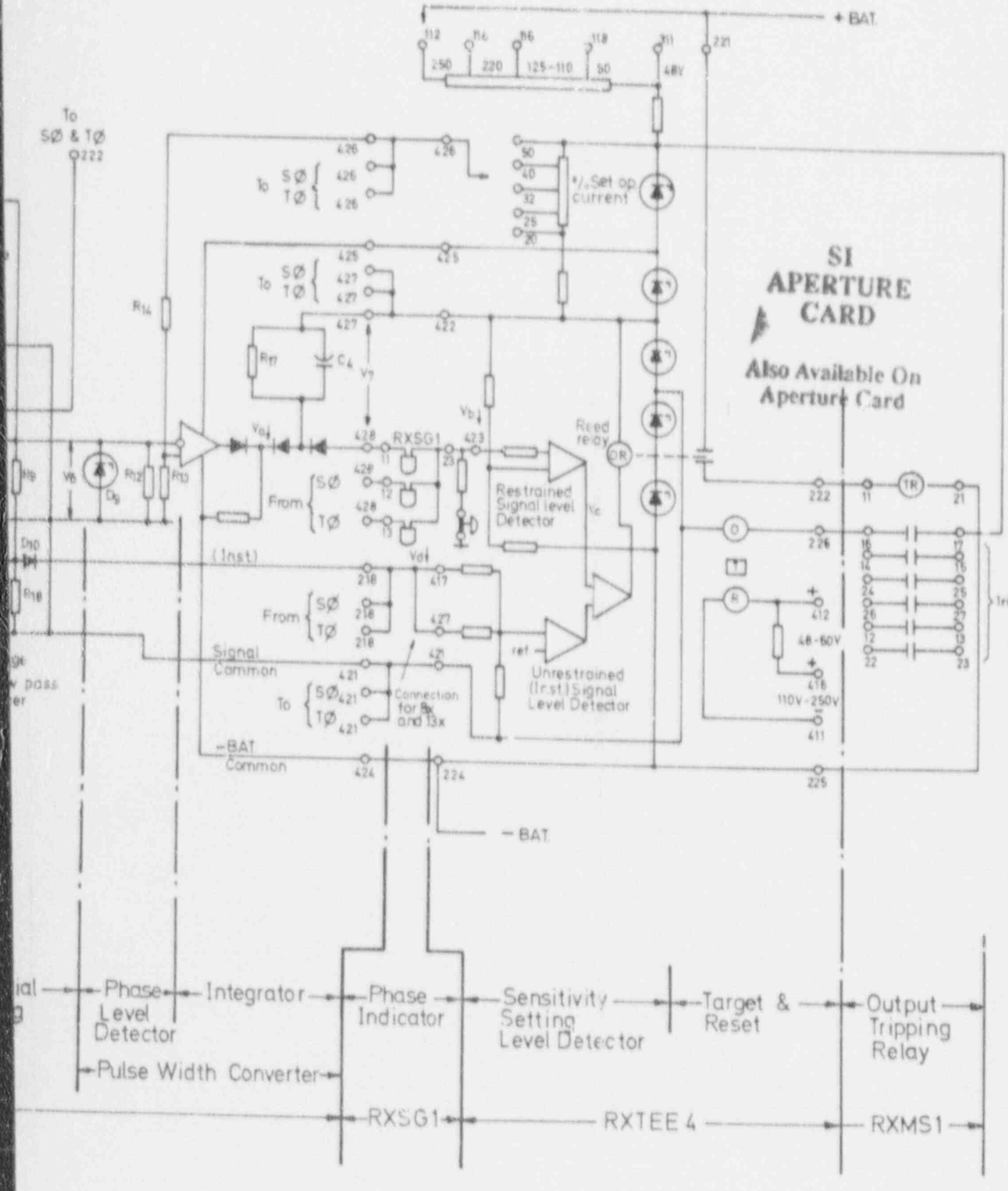


Fig. 14. Functional relations within DSE including supplemental input-restraint unit TUC 4.



9202190460-01

THEORY OF DSE OPERATION

There are ten interrelated functions within the DSE as shown in Figure 14.

1. Input circuitry

Air-gapped isolating transformers are used to convert each restraint current to a voltage. The dc component is thus also largely suppressed in the case of asymmetrical fault current. These are untapped, fixed ratio transformers in order to get the desired accuracy over the entire range of input currents.

These individual phase voltages are then each rectified with two power diodes, D_1 through D_6. Figure 14 shows the arrangement for one phase only. This input circuitry is identical in the TUC 4 three-phase supplemental input-restraint unit and in the main DSE relay, except for the manner of packaging the three phases as shown in Figure 14.

2. Percentage restraint circuitry

The rectified restraint voltages of each phase are applied in parallel to a center tapped resistor, R_1, R_2 as shown in Figure 14. When such dc voltages which have been derived from air-gapped isolating transformers are connected in parallel, the resulting voltage is equal to the largest applied voltage, and the lesser voltages have little effect on the resultant.

In addition, the use of R_1 and R_2 as two arms of the rectifier bridge provides a further valuable characteristic. In the conventional four diode bridge, the output has no sense of input polarity. But with a bridge composed of two diodes and two resistors, the dc output voltage becomes sensitive to the **relative polarity** of the applied ac voltages. If two applied ac voltages are of the same polarity (as during an internal fault), only the larger one will cause a current flow through R_1 on one half cycle and through R_2 on the other half cycle. But if two applied ac voltages are of opposite polarity (as during an external fault), one voltage will cause current to flow through R_1 and R_2 on alternate half cycles, as described, and at the same time the other voltage will cause currents to flow through R_2 and R_1 on the same half cycles. Thus the sum of the two applied voltages results when they are of opposite polarity, but only the maximum of the two results when they are of the same polarity.

Thus, this two-diode-two-resistor-type bridge, plus air-gapped current transformers results in a desirable type of restraint action. During an internal fault all of the lesser of the various input currents cause no restraint action. But on an external fault the restraint is increased to the sum of the largest of the input currents and the largest of the outgoing currents.

Another desirable feature of this circuit is that all currents sources other than these respective maximum ones, are isolated from the common restraint output resistors by virtue of their own rectifier diodes. Thus, additional input restraints via TUC 4 input unit can be added without practical limit, with minimum effect on the relay characteristic.

Mathematically, if I_x is the maximum (CT secondary) current into, and I_y the maximum current out of the protected transformer; in Figure 14, the restraint voltage, as developed by this circuit is:

$$V_1 = k\,(I_x + I_y)$$

where k is the proportionality between voltage and current of the entire circuit. For internal faults I_y will usually be zero (i.e. no current flowing out of the faulty power transformer). The actual restraint voltage is V_5. This is made non linear with respect to V_1 by means of zener diodes D_7 and D_8 and resistors R_3, R_4 and R_5. Thus more restraint voltage is developed proportionately at large input currents.

3. Differential circuitry

The differential current is derived in the conventional manner by summing all of the currents associated with each phase. This current is then used to develop the harmonic restraint as well as the operating voltages. Again air-gapped transformers are used to suppress the dc component in the operating voltage.

They are also used in the harmonic restraint circuitry and low pass filter to additionally provide the inductive branch of these L–C filters.

The total differential current is used to develop the differential voltage V_4. However, the high frequency components are suppressed in the low pass filter T_1, R_7 and C_1, before rectification in a conventional four diode bridge. This filter prevents relay operation from frequencies above 500 Hz.

4. Harmonic restraints

The 2^{nd} and 5^{th} harmonics are segregated by means of $T_2 - C_2$ and $T_5 - C_5$ respectively. These two harmonic voltages are totalled (V_2) before rectifying in a four diode bridge. The rectified harmonics from all three phases are brought together via terminals 222 and the resultant, V_3, used for restraint on each of the three phases. The net effect of this method of harmonic summation for restraint is to provide an improved restraint with minimum reduction in speed or sensitivity to internal faults.

5. Phase threshold circuitry. (Pulse width converter)

The rectified operating and restraint voltages are summed up in a resistor type summation circuit R_6, R_9, R_{11} and R_{12} as shown in Figure 14 as V_6. There is a substantial ac component in this summation because

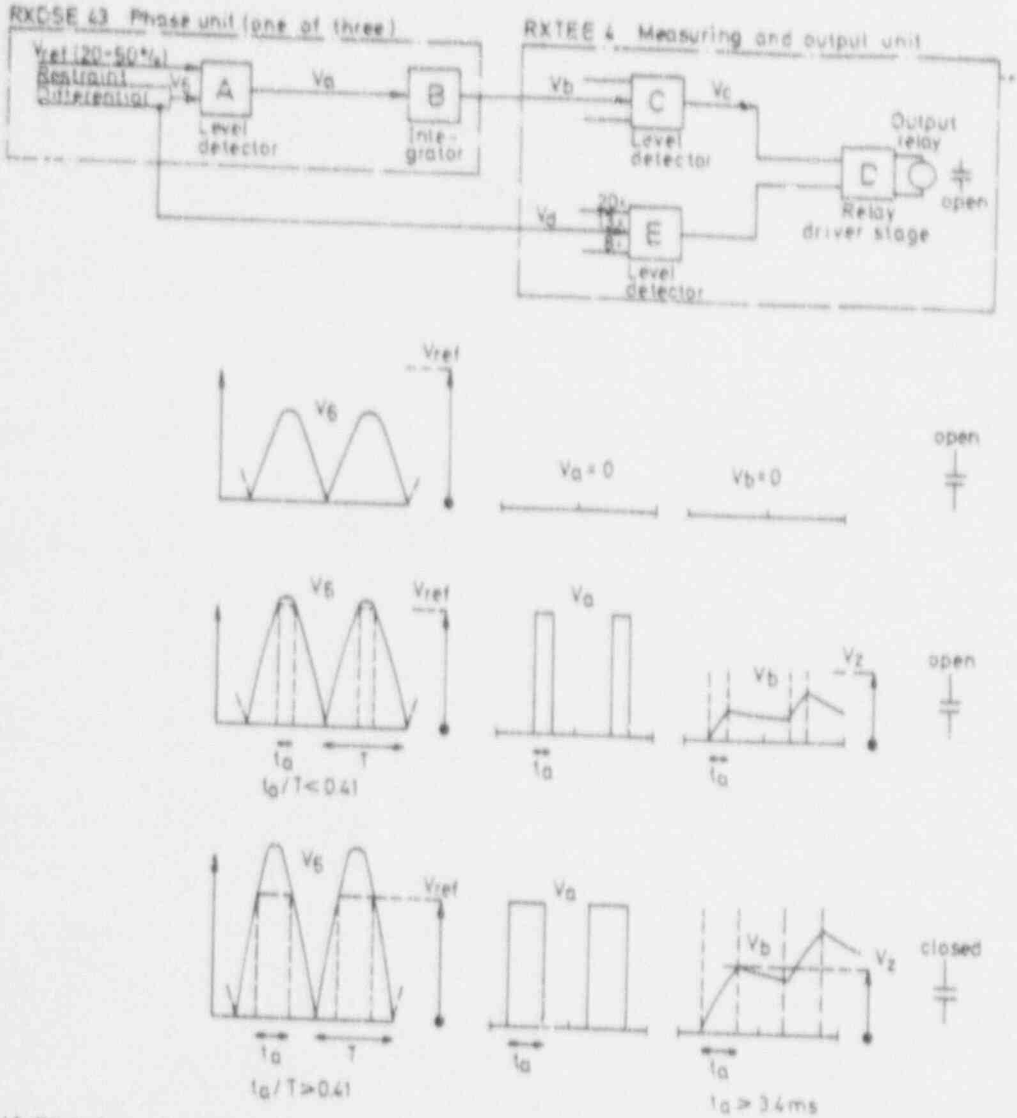


Fig. 15. Wave shapes and pulse width integrating action required to develop trip signals.

of very little filtering. This complex wave form is then compared to a dc reference developed by R_{13}, R_{14}. Any signal above the reference is converted in the operational amplifier circuit to a variable pulse width signal which is then integrated in C_4 and R_{17}.

6. Measurement circuitry

The integrated output pulses from each of the three, phase threshold-integrators are fed to a common measuring unit. When the width of the pulse to any phase threshold-integrator circuits exceeds 3.4 ms (out of 8.3 ms period), the biases on the transistor output amplifier are shifted to provide the desired trip output. At this threshold value several pulses will be required to bias the amplifier into a trip condition. Figure 14 illustrates the method by which this measurement is made. Figure 15 shows the wave shapes and the action of the various components in these circuits which determines if a trip condition exists.

7. Un-restrained trip circuitry

This is also an instantaneous function, with a signal as short as 3 ms capable of causing a trip output condition. This signal V_4, is derived from the differential current. It is taken from the rectified output of the differential voltage circuit through diode D_{10} prior to mixing with any of the restraint voltages. It is free of any dc component of the ac current due to asymmetry because of air-gapped input transformer T1.

A separate measuring circuit in the three-phase measuring unit determines if this signal is above the set value of 8, 13 or 20 times the relay rating. The desired setting is made by means of a COMBIFLEX wire jumper between terminals 417 and 427, as shown in Figure 11.

8. Minimum sensitivity circuitry

Within the three-phase measuring unit is a set of tapped resistors wired to a selector switch for the 20, 25, 32, 40 or 50 percent minimum pickup current setting. These resistors plus R_{13} and R_{14} set the bias on the operational amplifiers in the DSE 43 units. This sets the calibration of the individual phase threshold-integrators to the value marked on the selector switch.

9. Output circuitry

The output amplifier drives a 1 ms dry-reed relay. The reed relay energizes a 3 ms six contact, MS 1 output relay. Each contact is capable of tripping a breaker. Wiring functions are shown in Figure 14. The MS 1 relay contacts are all N.O. On special order double throw contacts can be provided. The MS 1 relay can be energized continuously. Thus the circuitry can seal in this relay so as to provide a self-contained lock-out function.

10. Ancillary functions

a. Target

One contact on the MS 1 output tripping relay energizes the coil 0 of an operation indicator, T. This is a mechanical and electrical reset device. It has no restrictions on the source of voltage for the reset function, R. As shown in Figure 14, a dropping resistor is included to allow resetting with any voltage from 48 to 250 V dc.

b. Phase indication

When specified, type SG 1 individual phase indicator unit is provided. This is a one seat device and locates in the available seat 355 in the basic COMBIFLEX DSE assembly. Electrically the targets are electronically controlled LED's located in the output of each phase threshold circuit as shown in Figure 14. The targets are reset by a front mounted push-button on SG 1.

c. The method of zener diode regulation of auxiliary voltages to correct value regardless of value of supply voltage between 48 and 250 V is also shown in Figure 14.

PERFORMANCE CHARACTERISTICS

The variable percentage restraint characteristics of the DSE is shown in Figures 13 (a) and (b). The abscissa is the average of the maximum current entering the protected zone and the maximum current leaving the zone. These are the two currents which develop the restraint within the relay. The average value of the current rather than the sum is used to provide a quantity whose value is comparable to the flow-through current during an external fault.

The ordinate of Figure 13 (a) and (b) is the usual operating current flowing in the differential circuit. The percentage slope plotted in Figure 13 (c), is the ratio of the ordinate to abscissa of Figure 13 (a).

This same set of characteristics is applicable for internal faults. Normally all currents would flow into such a fault. The correct value of restraint to use with these curves then becomes **one-half** of whichever current is the maximum infeed.

Note: It is apparent that the plotted slope of a differential relay is a function of the method of presenting the restraint data as well as the actual operating characteristic of the relay.

As shown in Figure 13 (c) the minimum pickup sensitivity, settable at 20, 25, 32, 40 and 50 percent of relay rating, has small effect on the percentage restraint at high current levels. The percentage restraint or slope shown in Figure 13 (c) will always exceed 35 percent of averaged restraint, regardless of sensitivity setting. It will exceed 50 percent above 3 1/2 to 6 times relay rated current.

The DSE fundamental frequency characteristic is further illustrated in Figure 13 (a) by points E and I. Point E is the plot of a heavy external fault as might occur in a ring bus or breaker and a half scheme with a through-fault current of 30 times CT ratings and a ratio error in one set of CT's of 35 percent. With such severe distortion, of course, the harmonic content of the secondary currents must also be considered. Point I is a small internal fault of four times transformer rating supplied from only one source.

Heavy load currents will have very little effect on the sensitivity of the DSE even to minor fault currents. These two currents, load and fault, will normally by nearly 90° out of phase to each other in at least one phase. The phase threshold measurement is made substantially on an instantaneous basis, since there is little filtering in the several rectified signal circuits. Thus the fault current measurement is made during the periods of the cycle when the load currents are at a minimum.

The 2nd and 5th harmonic restraint voltages for each phase are paralleled and the resultant used for harmonic restraint for each phase. This resultant will be proportional to the sum of the harmonic currents. These restraints are linear with respect to the operating current magnitude. A 2nd harmonic current in the differential operating circuit of any phase will block the operation of the relay if it exceeds 20 percent of the value of the fundamental differential current in any phase. Tests and analysis show that magnetizing inrush currents which are greater than the minimum pickup current of the DSE will contain more than 20 percent 2nd harmonic in at least one phase.

A 5th harmonic current in the differential operating circuit of any phase greater than 35 percent of the fundamental differential current in any phase will also block relay operation. Tests and analysis show that transformer exciting currents due to high voltage which are greater than the minimum pickup current of the DSE will contain sufficient 5th harmonic current to block relay operation. However, very large overexcitation currents can quickly cause transformer damage. Overvoltages of about 1.5 per unit will result in exciting currents approaching to the full load rating of the transformer. At these very high exciting currents, the percentage of 5th harmonic drops below the 35 percent restraint value of the DSE. Thus if the overvoltage is sufficient to seriously jeopardize the t transformer in a very short time, the DSE will operate to protect the transformer. Every transformer design will result in some differences in overvoltage excitation characteristics. But the basic mathematics of overexcitation currents shows that the 5th harmonic is larger than the amount required to block the DSE up to exciting currents about 70 % of transformer full load rating. And above this current, the percentage 5th harmonic becomes less and the relay will operate to prevent transformer damage. However, it is important that the DSE characteristic has been designed to prevent tripout on overexcitation and it should not be the sole protection if extremely large, damaging excitation currents are possible.

The operating time of the variable percentage, harmonic restraint relay is instantaneous as shown in Figure 12. The operating time of the un-restrained instantaneous unit is also shown in Figure 12. All characteristics are based on the ac component of the applied currents, since the DSE has air-gapped transformers which suppress the dc component.

The basic relay is a three-phase, three input restraint relay. The described performance is also applicable when the relay is used only with two three-phase inputs. Similarly, additional inputs in conjunction with TUC 4 three phase input modules will result in the same described relay performance.

All calibrations of the relay are accurate to 10 percent. The operating current of any relay will be within 10 percent of the values shown on the variable restraint characteristic of Figure 13. The performance is as stated up to 100 times relay rating of 5 A, or optionally 180 times the 1 A relay rating.

SETTING DETERMINATIONS

The 5 A nominal rated relay should normally be selected for use with 5 A rated CT secondaries. The overall CT ratios are then selected to provide about 5 A to the relay at normal loads as described under CT calculations. The relay (and SLCE 12's auxiliary CT's when used) is then capable of carrying any emergency loading up to the 12.5 A continuous secondary rating of the SLCE 12's (or the 20 A of the DSE).

Harmonic restraints

There are no setting adjustments required for neither the 2nd nor the 5th harmonic restraint current.

Sensitivity Setting

The setting for minimum current sensitivity (20, 25, 32, 40 or 50 percent of relay rating) should be selected based on estimated CT performance during small current conditions. As shown in Figure 13 (c) this setting is **not** a slope setting. It has minimal effect on the relay performance at high currents. It also has minimal effect on the **percentage** restraint action of the 2nd and 5th harmonics. Thus a sensitive setting will not hazard trip-outs due to magnetizing inrush.

The 20 percent sensitivity is suitable for CT turns ratio mismatch errors up to about 5 percent. When tap changing under load transformers are being protected, a minimum current sensitivity of about 15 percentage points greater than the worst turns ratio mismatch at the tap changer extreme should normally be selected.

These sensitivity guide lines are based on normal transformer load of 5 A in the 5 A relay. With breaker and a half, ring bus, or other similar schemes, high ratio CT's must generally be used because of possible through current flow which does not enter the transformer. This will result in a reduction in transformer differential relay sensitivity in terms of the transformer rating. However, auxiliary CT ratios can be used which will utilize the continuous overcurrent rating of the DSE up to 200 % so as to minimize this effect. The CT ratio selection procedure is given above in the section on **CT Calculations**.

Where accurate knowledge is available on the limitations of the CT characteristics, an increase in the sensitivity of the DSE may be possible. Application of the DSE with currents up to twice the relay rating is acceptable and results in a sensitivity, in terms of the actual circuit rating, of twice the markings on the relay.

Instantaneous Setting

The un-restrained, instantaneous relay setting is not functionally related to any other setting of the relay. Nor need its setting determination be based on the setting of the restrained unit or on CT characteristics. The relay is shipped with this unit set at 20 times relay rating. It can be reset to 8 or 13 times rating by means of shifting leads on the relay terminals as shown in Figure 11 and 14. This unit is not responsive to the dc component in an asymmetrical current. It is responsive to approximately the peak value of the ac component of the applied differential current and is calibrated in rms current for an equivalent sine wave. At high currents it will respond to a current pulse of only 3 ms, (as from a saturating CT). But it is unaffected by transient spikes of less than this time duration.

This function of the relay should be set above any anticipated inrush currents. The following table of suggested settings is based on experience with typical transformers

TABLE 1

Typical un-restrained relay settings based on full load current equal to nominal relay rating.

Transformer Connection	Transformer Size	When energized from: H.V. side	L.V. side
Y-Y	Less than 10 MVA	20 X	20 X
Y-Y	More than 10 MVA	13 X	13 X
Y-Delta (L.V.)	any	8 X	13 X

When additional TUC 4 input-restraint units are used there is no change in the setting procedures.

DC Voltage Taps

Taps for the dc voltage should conform to the available voltage, per Figure 14. The MS 1 output tripping relay should have the proper coil for the available voltage. The voltage taps and zener regulators of the TEE 4 are only for the electronic components.

TESTING

Acceptance Tests

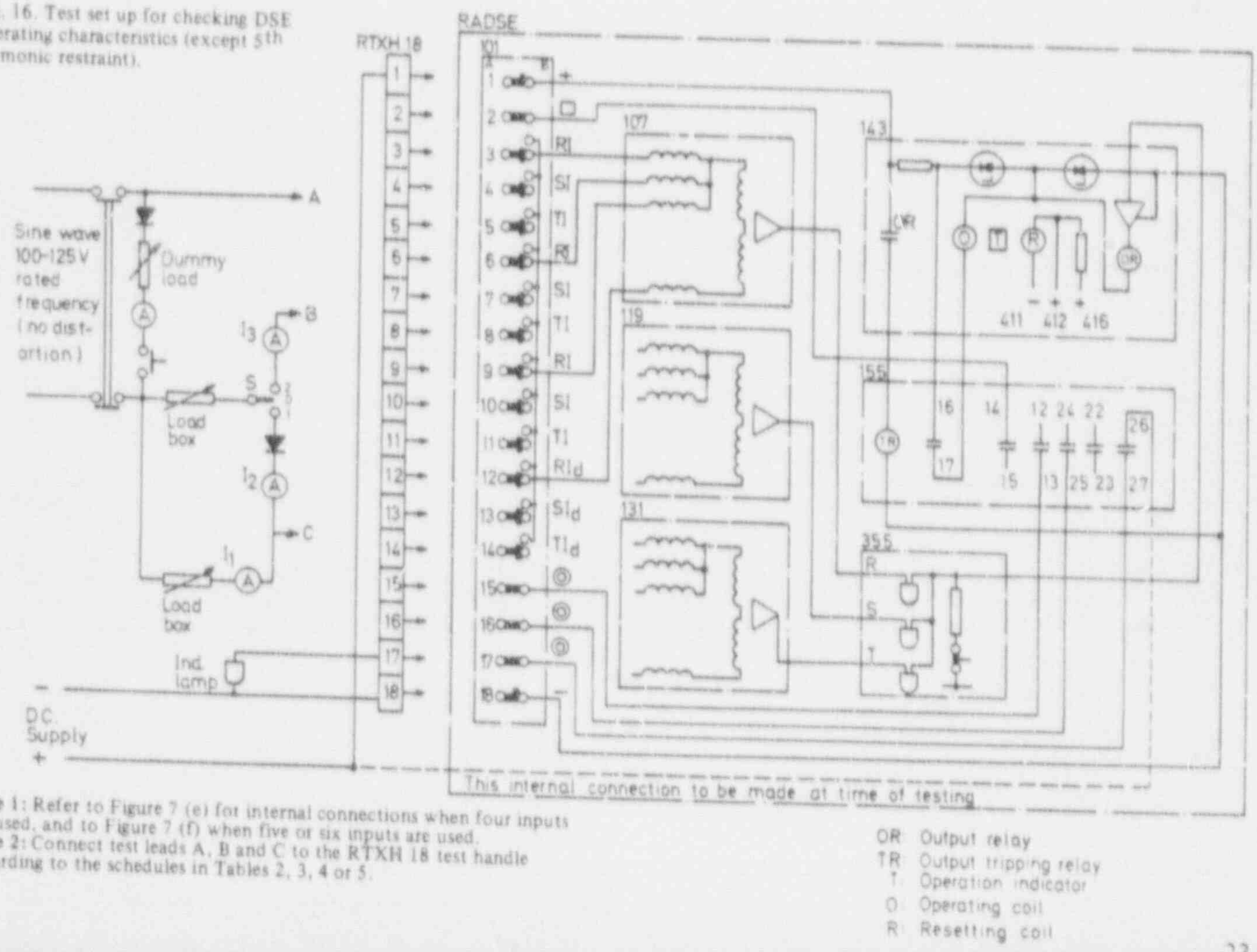
Check the name plate to assure that the relay model numbers, ratings and calibration ranges are as specified in the requisitions. Visually inspect the relay to assure that there has been no mechanical damage in shipment or storage. **Confirm that the dc voltage tap corresponds to the available voltage.**

The several operating characteristics for the three-winding relay can be individually checked with the conventional test circuit of Figure 16 by selecting the proper connections from Table 2 for each characteristic of interest.

When more than three inputs are required, additional restraint units, TUC 4, and a second test switch RTXP 18 are added to the relay as shown in Figures 3, 7 (d), (e) and (f). Note that in Figure 7 (e) the trip wiring is routed through two test switches so that insering the test plug in either opens all of the trip functions in the relay. The five and six input relays shown in Figure 7 (f) utilize three test switches for testing convenience. The testing schedules for these models are shown in table 3, 4 and 5.

The electrical connections to the relay should be made through the test handle properly inserted in

Fig. 16. Test set up for checking DSE operating characteristics (except 5th harmonic restraint).



Note 1: Refer to Figure 7 (e) for internal connections when four inputs are used, and to Figure 7 (f) when five or six inputs are used.
Note 2: Connect test leads A, B and C to the RTXH 18 test handle according to the schedules in Tables 2, 3, 4 or 5.

OR: Output relay
TR: Output tripping relay
T: Operation indicator
O: Operating coil
R: Resetting coil

the test switch. This will check the complete relay system including the output tripping relay. The details of these testing facilities are shown in Figure 8.

TABLE 2

To be used with Figure 16 and Figure 7 (a)

Test of basic DSE with three input-restraints

Test of	Phase	Connect lead A to terminal	Connect lead B to terminal	Connect lead C to terminal	Set switch S in position
Operating value	R	3 (6, 9)	–	12	0
	S	4 (7, 10,	–	13	0
	T	5 (8, 11)	–	14	0
2nd harmonic restraint	R	3 (6, 9)	–	12	1
	S	4 (7, 10)	–	13	1
	T	5 (8, 11)	–	14	1
Through-fault restraint	R	3	6	12	2
		3	9	12	2
	S	4	7	13	2
		4	10	13	2
	T	5	8	14	2
		5	11	14	2

Note: Connections shown to terminals within ( ) are optional for a more complete test of the relay input circuits.

TABLE 3

To be used with Figure 16 and Figures 7 (d) and (e)

Test of DSE with four input restraints (one TUC 4 and two test switches)

Test of	Phase	Connect lead A to terminal	Connect lead B to terminal	Connect lead C to terminal	Set switch S in position
Operating value	R	3 (6, 9, 3L)	–	12	0
	S	4 (7, 10, 4L)	–	13	0
	T	5 (8, 11, 5L)	–	14	0
2nd harmonic restraint	R	3 (6, 9, 3L)	–	12	1
	S	4 (7, 10, 4L)	–	13	1
	T	5 (8, 11, 5L)	–	14	1
Through-fault restraint	R	3	6	12	2
		9	3L	12	2
	S	4	7	13	2
		10	4L	13	2
	T	5	8	14	2
		11	5L	14	2

Note 1: Connections shown to terminals within ( ) are optional for a more complete test of the relay input circuits.

Note 2: L stands for terminals on the second test switch (501) in the lower left of the 8S equipment frame.

TABLE 4

To be used with Figure 16 and Figures 7 (d) and (f)

Test of DSE with five input restraints (two TUC 4's and two or three test switches)

Test of	Phase	Connect lead A to terminal	Connect lead B to terminal	Connect lead C to terminal	Set switch S in position
Operating value	R	3 (6, 9, 3L, 6L)	–	12	0
	S	4 (7, 10, 4L, 7L)	–	13	0
	T	5 (8, 11, 5L, 8L)	–	14	0
2nd harmonic restraint	R	3 (6, 9, 3L, 6L)	–	12	1
	S	4 (7, 10, 4L, 7L)	–	13	1
	T	5 (8, 11, 5L, 8L)	–	14	1
Through-fault restraint	R	3	6	12	2
		9	3L	12	2
		6L	3	12	2
	S	4	7	13	2
		10	4L	13	2
		7L	4	13	2
	T	5	8	14	2
		11	5L	14	2
		8L	5	14	2

Note 1: Connections shown to terminals within ( ) are optional for a more complete test of the relay input circuits.

Note 2: L stands for terminals on the second test switch (501) in the lower left of the 8S equipment frame.

TABLE 5

To be used with Figure 16 and Figures 7 (d) and (f)

Test of DSE with six input restraints (three TUC 4's and two or three test switches)

Test of	Phase	Connect lead A to terminal	Connect lead B to terminal	Connect lead C to terminal	Set switch S in position
Operating value	R	3 (6, 9, 3L, 6L, 9L)	–	12	0
	S	4 (7, 10, 4L, 7L, 10L)	–	13	0
	T	5 (8, 11, 5L, 8L, 11L)	–	14	0
2nd harmonic restraint	R	3 (6, 9, 3L, 6L, 9L)	–	12	1
	S	4 (7, 10, 4L, 7L, 10L)	–	13	1
	T	5 (8, 11, 5L, 8L, 11L)	–	14	1
Through-fault restraint	R	3	6	12	2
		9	3L	12	2
		6L	9L	12	2
	S	4	7	13	2
		10	4L	13	2
		7L	10L	13	2
	T	5	8	14	2
		11	5L	14	2
		8L	11L	14	2

Note 1: Connections shown to terminals within ( ) are optional for a more complete test of the relay input circuits.

Note 2: L stands for terminals on the second test switch (501) in the lower left of the 8S equipment frame.

Fundamental Frequency Tests

a. Minimum pickup currents
With the selector switch in the mid (0) position (Figure 16), the minimum pickup currents and the un-restrained operating currents can be determined. The value should be within 10 percent of the settings. To eliminate any ambiguity as to which unit is operating, the restrained unit can be temporarily disabled by opening the connection to terminal 143:423 of the TEE 4 measuring unit. See Figure 17 for the physical location of this terminal. The extractor type RTXD provided for this purpose should always be used. Never attempt to remove a lead without the extractor.

Note: The output relay will normally pulsate when the un-restrained circuit is tested. However, the time in the first picked-up position is long enough to trip a breaker when the relay is in service.

b. Restraint characteristics
With the selector switch (Figure 16) in position 2 the restraint characteristics can be determined. The operating values should be within 10 percent of the curves of Figure 13 (a) or (b). For convinience these values, with their accuracy limits, at an ambient temperature of 20–25°C, are tabulated in table 6.

Observe that the un-restrained unit has to be connected for an operating value higher than the highest value of I_1, in table 6.

This means that terminal 143:417 must not be connected to 143:427 as at the setting 8 times rated current.

TABLE 6

Variable Restraint Test Data at 32 % Min. Op. Current

Relay rated current	I_3 (A) Restraint	I_1 (A) Differential
1 A	0	0.29–0.35
	1.5	0.66–0.94
	3	1.6–2.2
	10	7.8–10.4
5 A	0	1.45–1.75
	7.5	3.3–4.7
	15	8.0–11
	50	39–52

Caution: This is a harmonic restraint relay and it is essential that good sine wave test current be used for all fundamental frequency testing requirements.

Harmonic Restraint Tests

The 2nd harmonic restraint characteristic can be checked with the circuit of Figure 16 by placing the selector switch to position 1. The single diode rectifier provides a current wave shape rich in 2nd harmonics in addition to the dc component. By adjusting the two load boxes, various proportions of 2nd harmonic to fundamental can be established.

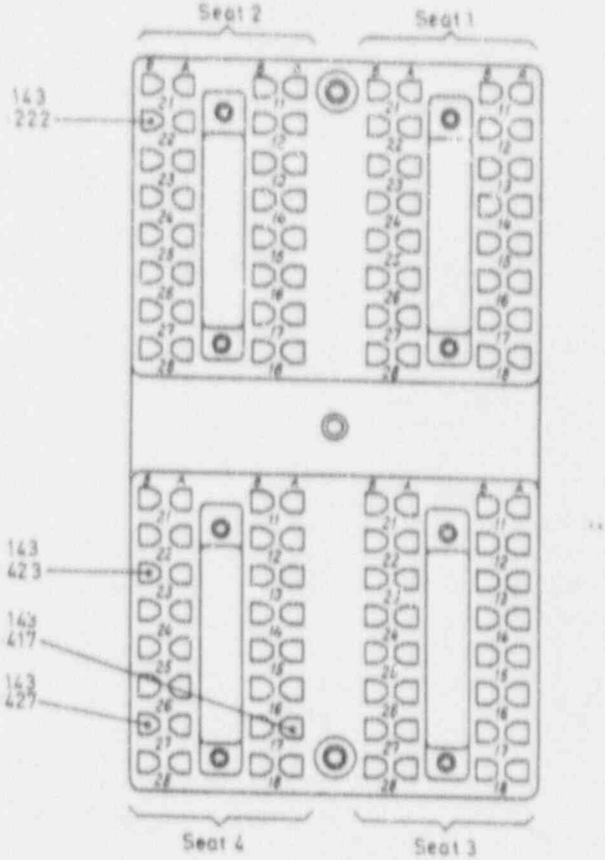


Fig. 17 (a). TEE 4 (143) measuring unit, rear view showing location of terminals used or opened during certain tests.

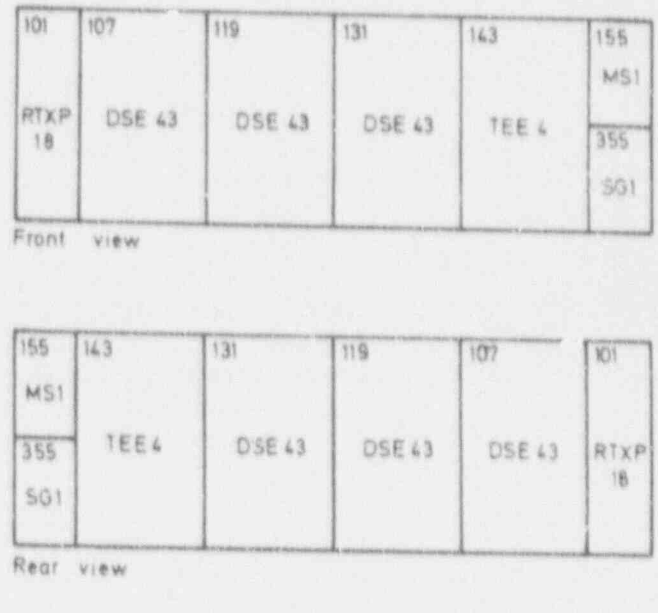


Fig. 17 (b). DSE, location and identification of modules.

Wave shape analysis shows that if the ac current I_1 is read on an ac ammeter and the dc current I_2 is read on a dc ammeter of moving coil type (neither of rectifier type) the following expression will be valid:

$$\text{percent 2}^{\text{nd}}\text{ harmonic} = \frac{0.47\ I_2}{1.11\ I_2 + I_1} \times 100$$

The 2nd harmonic restraint has a 20 percent nominal value. A convenient check point is to adjust the dc current to 4 A and with the minimum pick up setting at 32 percent, gradually increase the ac current until the relay operates. For the 18–25 percent factory calibration this should be at 3.1–6 A ac. The minimum pickup sensitivity setting has little effect on this 2nd harmonic restrain characteristic.

The dc component of the 2nd harmonic test current will not only flow in the relay (and cause no significant effect because of the air-gapped transformers), but it will also flow in the supply circuit. This may cause dc saturation in the supply transformer and result in fuse blowing. More importantly it may result in test voltage distortion which may affect the relay characteristics without the tester being aware of it other than by observing a relay with apparent lack of sensitivity. Should such be the case, one solution is to supply the rectifier circuit from a separate ac source. Another solution is to add a 2nd rectifier and dummy load to cancel the testing dc in the power source. This is also shown in the test circuit of Figure 16.

The 5th harmonic restraint action cannot be conveniently checked in the field. In the test lab, the use of a power oscillator adjusted to the 5th harmonic frequency is the most precise method of checking this characteristic. The relay will at three-phase be restrained with 5th harmonic of 35 percent or more of the fundamental.

Indicator Tests

Check that the indicator flag in the TEE 4 unit drops when the relay operates and that the indicator flag resets when 110–220 V dc is connected to terminals 416 (+) and 411 (–) in the TEE 4 unit.

Three-phase Tests

The complexity of three-phase testing is not usually warranted. If a three-phase, fundamental frequency test is made with a pure sine wave, the minimum pick-up current will be increased from the calibration value by a factor of 1.4 to 2.0. This is inherent in the relay design and is not adjustable.

Inter-phase Tests

To check for the inter-phase action of the harmonic restraint it will be necessary to inject the 2nd harmonic into one phase unit and the operating fundamental frequency into another.

To check the inter-action between S and R phase units proceed as follows:

1. Remove the test lead from ammeter I_2 to C, at C.
2. Connect this ammeter lead from I_2 to terminal 13, (S Ø)
3. Connect a jumper from terminal 4 to 3, (S Ø to R Ø)
4. Connect test lead A to terminal 3, (R Ø)
5. Connect test lead C to terminal 12, (R Ø)
6. Place switch *S* in position 1.
7. Adjust the d.c. current I_2 to 2 A (for a 5A relay) and with the minimum pick-up setting at 32 percent, gradually increase the a.c current I_1 until the relay operates. The fundamental current needed for operation will at this interphase test be proportionally higher than at the normal 2nd harmonic restraint test, as in this case, it does not flow any 2nd harmonic component in the operating circuit. The percentage 2nd harmonic is in this case equal to

   $$\frac{0.47\ I_2}{I_1} \times 100$$

   and will at this test normally be 2–6 percentage points lower than at the 2nd harmonic restraint test. Thus the 5 A-relay will operate for approx. 5–6 A.
8. Move test lead from 13 to 14 and jumper from 4 to 5 to check inter-action between TØ and RØ. To check the inter-action between TØ and SØ move the test lead A from terminal 3 (RØ) to 4 (SØ) and lead C from 12 (RØ) to 13 (SØ).

Note: This inter-phase harmonic relation does not involve the fundamental frequency restraints hence a total of three tests will completely check this feature regardless of the number of restraints.

Calibration

If any of the restraint characteristics appear to be off calibration, internal relay adjustments are not recommended.

However, before judging that a relay is off calibration confirm that the test current is a good sine wave. A small amount of 2nd or 5th harmonic in the test current can have a significant effect on the relay operating characteristics.

Functional in Service Check Out

Ratio checking of the current transformers and auxiliary transformers is conventional, as are the other functional tests such as circuit-breaker tripping and lockouts. In service load checks are most conveniently made with an ammeter and current test plug inserted in the respective current circuits at the RTXP 18 test switch. The location of the various currents on the test switch is shown in Figure 7. Good testing practice would include inserting the red trip blocking plug before taking any current readings. Note that with multi-restraint models which require two test switches, the residual phase currents have two contacts in **parallel**, see Figure 7 (d). Thus to measure the residual currents it is recommended to use two test plugs, one for each test switch. Connect the current test plugs in parallel to an ammeter. Insert the test plugs to the same position (12, 13 or 14) on the test switches. The ammeter then shows the total residual current. If, on the other hand, only onte test plug is available the residual current can be measured by insering the current test plug in one test switch and temporarily open the interconnection between the terminals 14, on the A side of the switches.

Routine Testing

Under normal conditions type DSE needs no special testing or maintenance. The covers of the plug-in modules should be fitted properly. Contacts in the output tripping relay or in the test switch which are burnt due to abuse should be carefully dressed with a diamond file or a very fine file. Emery cloth or similar abrasive materials are unsuitable for dressing relay contacts, as insulating grains from the abrasive material may be deposited on the contact surfaces, thereby causing mal-function and failures.

Routine electrical tests can conform in frequency to the users' established practice. Checking the pickup setting of the relay and timing it at a moderate multiple of pickup is usually adequate for the restrained unit. The un-restrained unit operation can be conformed by timing this unit about 150 percent of its pickup value. This time should be about 10–12 ms less than the restraint unit time when checked at a value just under the un-restrained pickup current. It is not recommended to routinely disconnect the wires on the TEE 4 unit to establish the complete individual performance of these two units.

Caution: The relay calibrations can only be checked accurately with pure sine wave currents because of the harmonic restraint nature of the relay characteristic.

Spare Parts

There is normally no need for stocking spare parts but this procedure also assures that a replaced relay is up to the original factory quality and calibration standards.

RECEIVING, HANDLING AND STORAGE

These relays are shipped in cartons designed to protect them from damage when not included as part of a cubicle or control panel. Upon receipt the relay should be inspected for physical damage.

It is recommended that the relay be replaced in its shipping carton after inspection for delivery to jobsite. Also the relay should preferably be left in its shipping carton until time for actual installation.

The relay is not critical as to humidity. But general prudence suggests that it be stored in a dry, moderate temperature environment.

DIMENSIONS

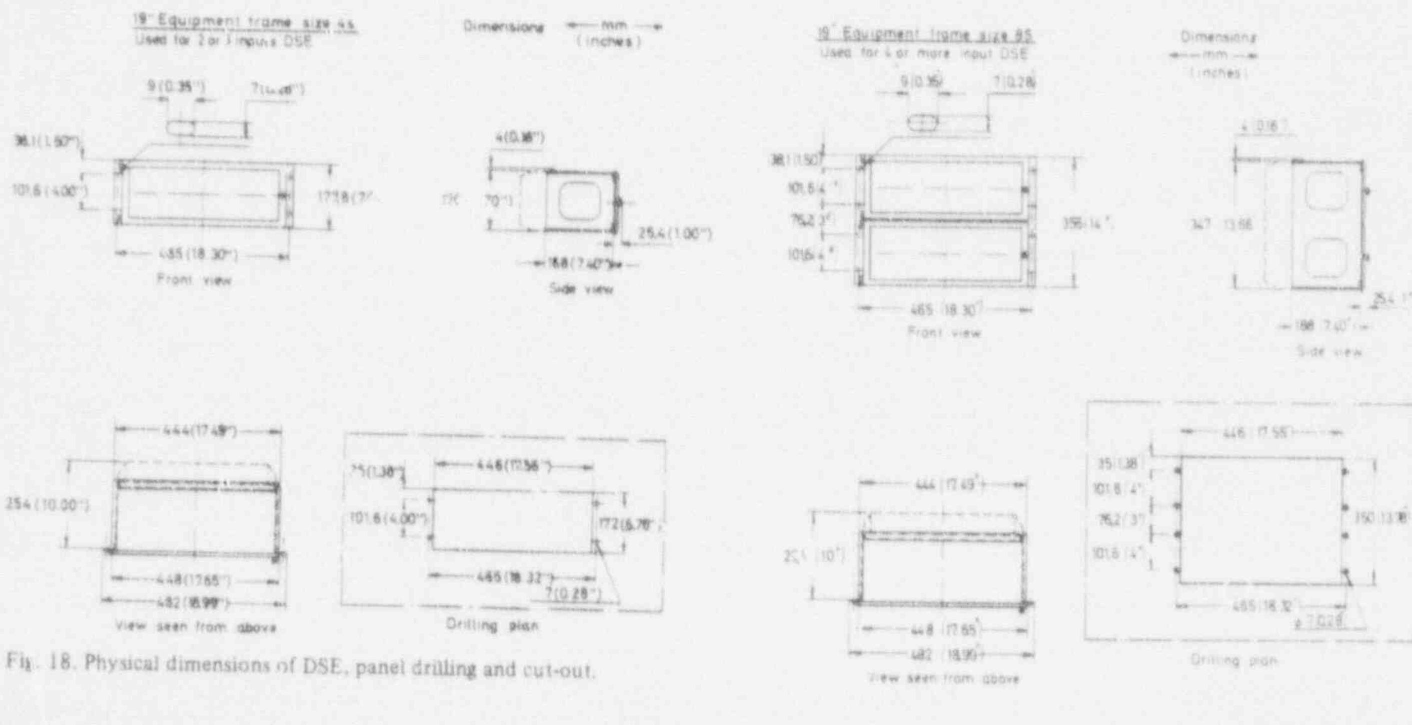


Fig. 18. Physical dimensions of DSE, panel drilling and cut-out.

APPENDIX 1

MULTI-TAPPED SINGLE PHASE AUXILIARY CURRENT TRANSFORMERS TYPE SLCE 12

These are reconnectible auxiliary current transformers intended for use with 1 A or 5 A transformer differential protection type RADSE. Three different transformers are available to provide current ratios from 0.65–2.60/1 A, 2.55–9.60/1 A and 2.85–9.7/5 A. Sufficient taps are provided for setting the secondary current with an accuracy of ± 3 percent of any desired value.

Design

The transformers are equipped with three secondary windings connected to a terminal block with six terminals marked 1 to 6, and with two primary windings with intermediate tap connected to another terminal block with six terminals marked 7 to 12. The transformers have also a third terminal block with their terminals marked P1 – P2, S1 – S2, to which the external connections should always be made.

Tables 1, 2 and 3 on pages 30, 31 and 32 show the most suitable internal connections (and turns ratio) to obtain a standard secondary current of 1 A or 5 A for the listed primary current. If the transformer is ordered with a certain ratio it will be delivered connected for this ratio.

These tables can also be used to determine turns ratios and connections when secondary currents less than 1 A or 5 A are desired by directly proportioning the values.

For example, if I_p = 3.6 A and it is desired that I_s = 4.5 A:

Choose the 5 A transformer with the same current ratio, i.e.

$$\frac{X}{5} = \frac{3.6}{4.5} \quad \text{gives } X = 4.0$$

Hence from table 3 choose SLCE 12 current transformer 4785 040-VS with a current ratio 4.0/5 A, and turns ratio 53/42.

These tables are also suitable for wye delta connected transformers.

For example if the incoming line current I_p = 1.31 A and it is desired to have delta secondaries yield I_s = 1 A line current:

$$\frac{X}{1} = \frac{1.31}{1/\sqrt{3}} \quad \text{gives } X = 2.26$$

Hence from table 1 choose SLCE 12 current transformer 4785 040-VP with a current ratio 2.26/1 A and turns ratio 70/162.

Load Burden

The maximum permissible resistance in the wires between the auxiliary current transformers and the differential relay depends on the relay burden and the maximum primary current for which good performance is desired. For a given total secondary burden the maximum primary current $I_{p\,max}$ for a 10 percent ratio error can be calculated according to the following formula:

$$I_{p\,max} = n \cdot I_n$$

where $n = \dfrac{a}{b + z}$

I_n = rated current of the auxiliary CT's
a = constant (ohms), given in table 1, 2 and 3. This depends on the design of the CT and the frequency of the current.
b = resistance of the secondary winding according to table 1, 2 and 3.
z = impedance of the burden (wires and the differential relay).

This formula is valid for symmetrical primary current. Asymmetrical currents will saturate the core at a lower current. Good CT application practice suggests that n, the saturation factor, should correspond to the maximum through-fault current.

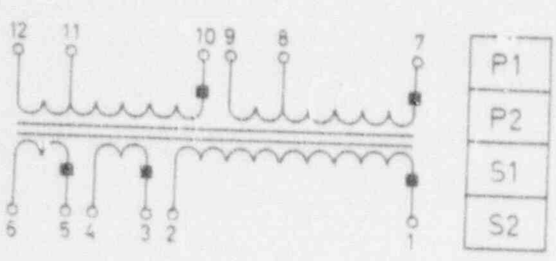


Fig. 1. Terminal markings for SLCE 12 auxiliary current transformer

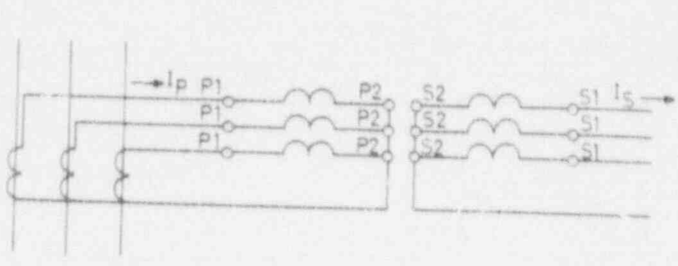


Fig. 2. Wiring diagram for three auxiliary current transformers connected wye-wye.

Ratings

Rated secondary current	1 A or 5 A
Rated current ratios	Reconnectible in 4–6 percent steps according to Tables 1–3 0.65–2.60 A/1 A 2.55–9.60 A/1 A 2.85–9.70 A/5 A
Rated frequency	60 Hz
Overload capacity	2.5 x rated current continuously 15 x rated current for 10 s 75 x rated current for 1 s
Burden (self consumption)	According to tables 1–3
Insulation test voltage	2500 V, 50 Hz
Maximum wire size to terminal block (P1-P2-S1-S2)	No 7 AWG (10.54 mm²)
Dimensions	According to Figure 3
Weight	3.6 kg (8 lbs)

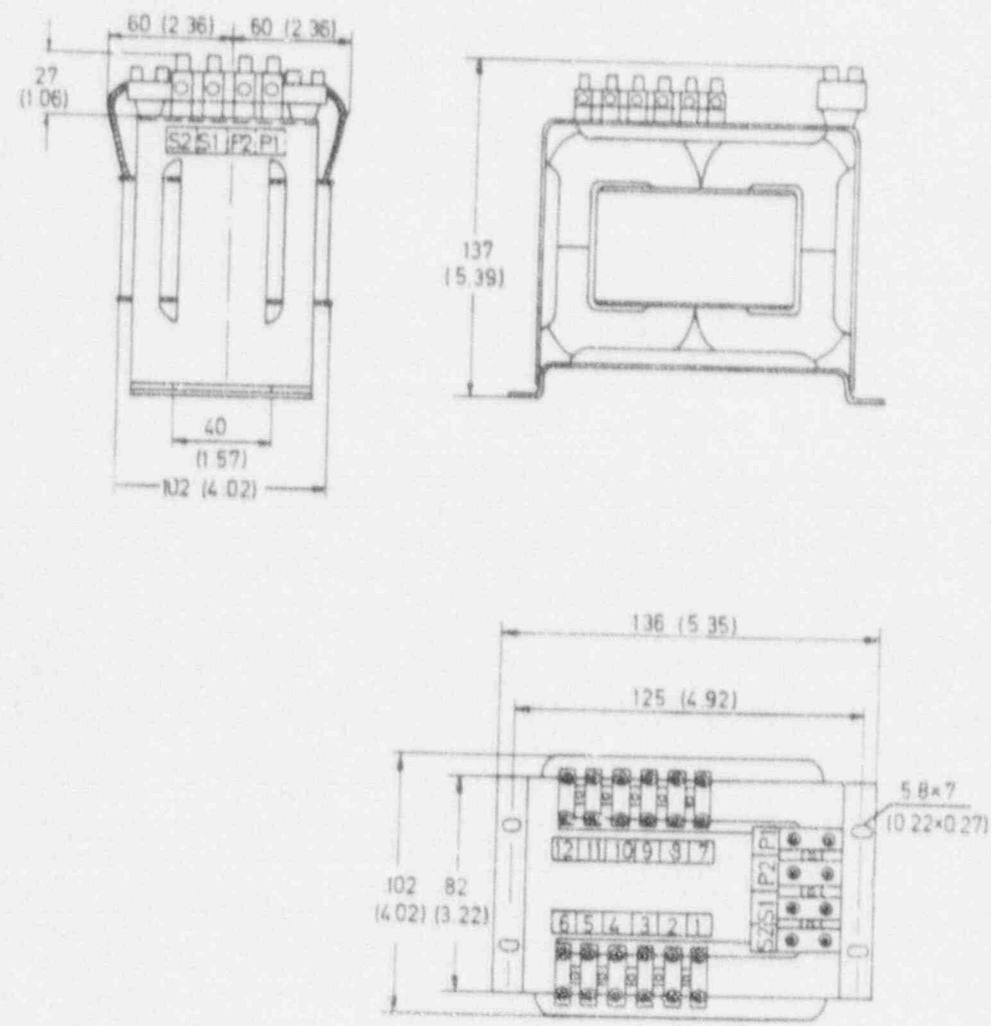


Fig. 3. Dimensions in mm (inch) for Auxiliary Current Transformer type SLCE 12.

TABLE 1: Connections for 1 A rated secondary

Transformer SLCE 12 for I_p = 0.65 – 2.60 A, I_s = 1 A
Ordering No. 4785 040-VP

Terminals	No. of turns	Resistance Ω
1–2	154	0.38
3–4	16	0.05
5–6	8	0.03
7–8	70	0.21
8–9	30	0.10
10–11	70	0.24
11–12	30	0.11

Primary current A	Turns ratio	Connections on primary side between terminals	Connections on secondary side between terminals	a [1] Ω	b Ω	Power consumption at I_s = 1 A VA
0.650–0.670	200/130	P1–7, 9–10, 12–P2	S1–1, 2–6, 4–5, 3–S2	56	0.47	1.0
0.671–0.710	200/138		S1–1, 2–4, 3–S2	60	0.44	1.0
0.711–0.750	200/146		S1–1, 2–6, 5–S2	63	0.42	1.0
0.751–0.790	200/154		S1–1, 2–S2	67	0.39	1.0
0.791–0.830	200/162		S1–1, 2–5, 6–S2	70	0.42	1.1
0.831–0.870	200/170		S1–1, 2–3, 4–S2	74	0.44	1.2
0.871–0.900	200/178		S1–1, 2–3, 4–5, 6–S2	77	0.47	1.2
0.901–0.930	170/154	P1–7, 9–10, 11–P2	S1–1, 2–S2	67	0.39	1.2
0.931–0.980	170/162		S1–1, 2–5, 6–S2	70	0.42	1.2
0.981–1.02	170/170		S1–1, 2–3, 4–S2	74	0.44	1.4
1.03–1.07	170/178		S1–1, 2–3, 4–5, 6–S2	77	0.47	1.4
1.08–1.12	140/154	P1–7, 8–10, 11–P2	S1–1, 2–S2	67	0.39	1.4
1.13–1.18	140/162		S1–1, 2–5, 6–S2	70	0.42	1.4
1.19–1.24	140/170		S1–1, 2–3, 4–S2	74	0.44	1.6
1.25–1.28	140/178		S1–1, 2–3, 4–5, 6–S2	77	0.47	1.6
1.29–1.34	100/130	P1–7, P1–10, 9–P2, 12–P2	S1–1, 2–6, 4–5, 3–S2	56	0.47	1.0
1.35–1.42	100/138		S1–1, 2–4, 3–S2	60	0.44	1.0
1.43–1.50	100/146		S1–1, 2–6, 5–S2	63	0.42	1.0
1.51–1.58	100/154		S1–1, 2–S2	67	0.39	1.0
1.59–1.66	100/162		S1–1, 2–5, 6–S2	70	0.42	1.2
1.67–1.74	100/170		S1–1, 2–3, 4–S2	74	0.44	1.2
1.75–1.81	100/178		S1–1, 2–3, 4–5, 6–S2	77	0.47	1.4
1.82–1.91	70/130	P1–7, P1–10, 8–P2, 11–P2	S1–1, 2–6, 4–5, 3–S2	56	0.47	1.2
1.92–2.01	70/138		S1–1, 2–4, 3–S2	60	0.44	1.2
2.02–2.14	70/146		S1–1, 2–6, 5–S2	63	0.42	1.2
2.15–2.25	70/154		S1–1, 2–S2	67	0.39	1.4
2.26–2.37	70/162		S1–1, 2–5, 6–S2	70	0.42	1.4
2.38–2.48	70/170		S1–1, 2–3, 4–S2	74	0.44	1.6
2.49–2.60	70/178		S1–1, 2–3, 4–5, 6–S2	77	0.47	1.6

1) The value is valid for 50 Hz. It is 20 % higher at 60 Hz.

TABLE 2: Connections for 1 A rated secondary

Transformer SLCE 12 for I_p = 2.55 – 9.60 A, I_s = 1 A
Ordering No. 4785 040-VR

Terminals	No. of turns	Resistance Ω
1–2	154	0.38
3–4	16	0.05
5–6	8	0.03
7–8	18	0.017
8–9	7	0.007
10–11	18	0.018
11–12	7	0.008

Primary current A	Turns ratio	Connections on primary side between terminals	Connections on secondary side between terminals	a [1] Ω	b Ω	Power consumption at I_s = 1 A VA
2.55–2.67	50/130	P1–7, 9–10, 12–P2	S1–1, 2–6, 4–5, 3–S2	56	0.47	1.2
2.68–2.84	50/138		S1–1, 2–4, 3–S2	60	0.44	1.2
2.85–3.00	50/146		S1–1, 2–6, 5–S2	63	0.42	1.2
3.01–3.16	50/154		S1–1, 2–S2	67	0.39	1.2
3.17–3.32	50/162		S1–1, 2–5, 6–S2	70	0.42	1.4
3.33–3.48	50/170		S1–1, 2–3, 4–S2	74	0.44	1.4
3.49–3.66	50/178		S1–1, 2–3, 4–5, 6–S2	77	0.47	1.6
3.67–3.86	43/162	P1–7, 9–10, 11–P2	S1–1, 2–5, 6–S2	70	0.42	1.4
3.87–4.04	43/170		S1–1, 2–3, 4–S2	74	0.44	1.6
4.05–4.21	43/178		S1–1, 2–3, 4–5, 6–S2	77	0.47	1.6
4.22–4.38	36/154	P1–7, 8–10, 11–P2	S1–1, 2–S2	67	0.39	1.6
4.39–4.61	36/162		S1–1, 2–5, 6–S2	70	0.42	1.6
4.62–4.83	36/170		S1–1, 2–3, 4–S2	74	0.44	1.8
4.84–5.07	36/178		S1–1, 2–3, 4–5, 6–S2	77	0.47	1.8
5.08–5.35	25/130	P1–7, P1–10, 9–P2, 12–P2	S1–1, 2–6, 4–5, 3–S2	56	0.47	1.2
5.36–5.67	25/138		S1–1, 2–4, 3–S2	60	0.44	1.2
5.68–5.99	25/146		S1–1, 2–6, 5–S2	63	0.42	1.4
6.00–6.31	25/154		S1–1, 2–S2	67	0.39	1.4
6.32–6.64	25/162		S1–1, 2–5, 6–S2	70	0.42	1.4
6.65–6.95	25/170		S1–1, 2–3, 4–S2	74	0.44	1.6
6.96–7.17	25/178		S1–1, 2–3, 4–5, 6–S2	77	0.47	1.8
7.18–7.44	18/130	P1–7, P1–10, 8–P2, 11–P2	S1–1, 2–6, 4–5, 3–S2	56	0.47	1.4
7.45–7.88	18/138		S1–1, 2–4, 3–S2	60	0.44	1.6
7.89–8.33	18/146		S1–1, 2–6, 5–S2	63	0.42	1.6
8.34–8.77	18/154		S1–1, 2–S2	67	0.39	1.8
8.78–9.21	18/162		S1–1, 2–5, 6–S2	70	0.42	1.8
9.22–9.60	18/170		S1–1, 2–3, 4–S2	74	0.44	2.0

1) The value is valid for 50 Hz. It is 20 % higher at 60 Hz.

ASEA

TABLE 3: Connections for 5 A rated secondary

Transformer SLCE 12 for I_p = 2.85 – 9.70 A, I_s = 5 A
Ordering No. 4785 040-VS

Terminals	No. of turns	Resistance Ω
1–2	42	0.031
3–4	4	0.004
5–6	2	0.003
7–8	22	0.020
8–9	9	0.009
10–11	22	0.023
11–12	9	0.010

Primary current A	Turns ratio	Connections on primary side between terminals	Connections on secondary side between terminals	a [1)] Ω	b Ω	Power consumption at I_s = 5 A VA
2.85–2.98	62/36	P1–7, 9–10, 12–P2	S1–1, 2–6, 4–5, 3–S2	3.1	0.046	1.8
2.99–3.14	62/38		S1–1, 2–4, 3–S2	3.3	0.041	1.8
3.15–3.30	62/40		S1–1, 2–6, 5–S2	3.5	0.040	1.8
3.31–3.46	62/42		S1–1, 2–S2	3.6	0.035	1.8
3.47–3.62	62/44		S1–1, 2–5, 6–S2	3.8	0.040	2.0
3.63–3.78	62/46		S1–1, 2–3, 4–S2	4.0	0.041	2.2
3.79–3.91	62/48		S1–1, 2–3, 4–5, 6–S2	4.2	0.046	2.4
3.92–4.05	53/42	P1–7, 9–10, 11–P2	S1–1, 2–S2	3.6	0.035	2.2
4.06–4.24	53/44		S1–1, 2–5, 6–S2	3.8	0.040	2.2
4.25–4.43	53/46		S1–1, 2–3, 4–S2	4.0	0.041	2.4
4.44–4.65	53/48		S1–1, 2–3, 4–5, 6–S2	4.2	0.046	2.6
4.66–4.87	44/42	P1–7, 8–10, 11–P2	S1–1, 2–S2	3.6	0.035	2.2
4.88–5.11	44/44		S1–1, 2–5, 6–S2	3.8	0.040	2.4
5.12–5.34	44/46		S1–1, 2–3, 4–S2	4.0	0.041	2.6
5.35–5.62	44/48		S1–1, 2–3, 4–5, 6–S2	4.2	0.046	2.8
5.63–5.96	31/36	P1–7, P1–10, 9–P2, 12–P2	S1–1, 2–6, 4–5, 3–S2	3.1	0.046	2.0
5.97–6.28	31/38		S1–1, 2–4, 3–S2	3.3	0.041	2.0
6.29–6.61	31/40		S1–1, 2–6, 5–S2	3.5	0.040	2.0
6.62–6.93	31/42		S1–1, 2–S2	3.6	0.035	2.0
6.94–7.25	31/44		S1–1, 2–5, 6–S2	3.8	0.040	2.2
7.26–7.57	31/46		S1–1, 2–3, 4–S2	4.0	0.041	2.2
7.58–7.95	31/48		S1–1, 2–3, 4–5, 6–S2	4.2	0.046	2.4
7.96–8.40	22/36	P1–7, P1–10, 8–P2, 11–P2	S1–1, 2–6, 4–5, 3–S2	3.1	0.046	2.2
8.41–8.85	22/38		S1–1, 2–4, 3–S2	3.3	0.041	2.2
8.86–9.31	22/40		S1–1, 2–6, 5–S2	3.5	0.040	2.4
9.32–9.70	22/42		S1–1, 2–S2	3.6	0.035	2.4

1) The value is valid for 50 Hz. It is 20 % higher at 60 Hz.

Printed in Sweden Västerås 4 1976 Västerås Kontorstryck 2000

Drawn by [redacted] | Sheet
Design checked by | Rev | Dept | Year Wk | Cont

Drawn by | Formula No [redacted] | Sheet
Design checked by | Rev | Dept | Year Wk | Cont

Beställare Customer

Anläggning Plant

Innehåll Contents — Blad Sheet

Module Location

List of Apparatus

101	107	119	131	143	155
					355
501	507	519	531		

Revision	Year Wk	Dept	Appd

ASEA

Apparatlista List of apparatus

Department	Year	Week	Drawing checked by	Drawn by
RT	1983	05		V. Gash

RADSE Transformer Differential Relay

RK 626 500 BA

This document must not be copied without our written permission, and the contents thereof must not be imparted to a third party nor be used for any unauthorized purpose. Contravention will be prosecuted. ASEA

Qty Ant	Item designation Postbeteckning 2	3	4	5	Article No Artikelnummer	Type data Beteckning data	Name of item Benämning	Locat Plats	Remark Anm
				101	RK 926 003-AM	RTXP 18	Test Switch		
				107	RK 626 430-AD	RXDSE	Phase Unit		
				119	|	|			
				131	|	|			
				143	RK 626 410-AC	RXTEE	Measuring Unit		
				155	RK 216 263-AP	RXMS 1	Auxiliary Relay		
				355	RK 276 110-AA	RXSG 1	Indicating Device		
				501	RK 926 003-AM	RTXP 18	Test Switch		
				507	RK 626 440-AB	RXTUC 4	Input Restraint Unit		
				519					
				531					

ASEA

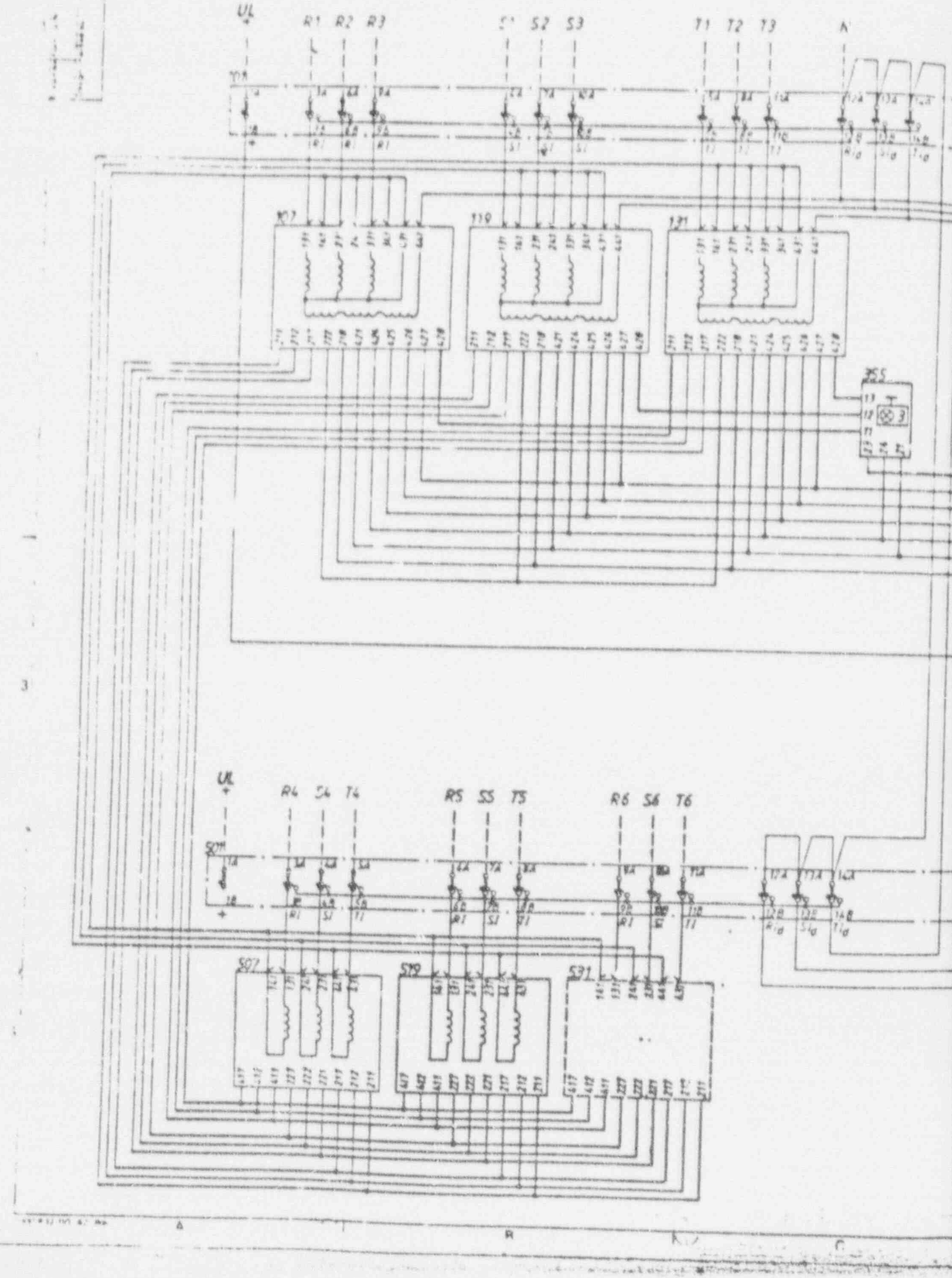
Department: RE | Year: 1983 | Week: 05 | Drawn by: V.Gash

Apparatlista List of apparatus

RADSE Transformer Differential Relay

RK 626 500 BA

Sheet 1


UL
R1 R2 R3
S2 S3
T1 T2 T3
107
119
131
155
UL
R4 S4 T4
R5 S5 T5
R6 S6 T6
507
519
531
A
B
C

Bildkort

ASEA

RADSE Differential relay
Differentialskydd

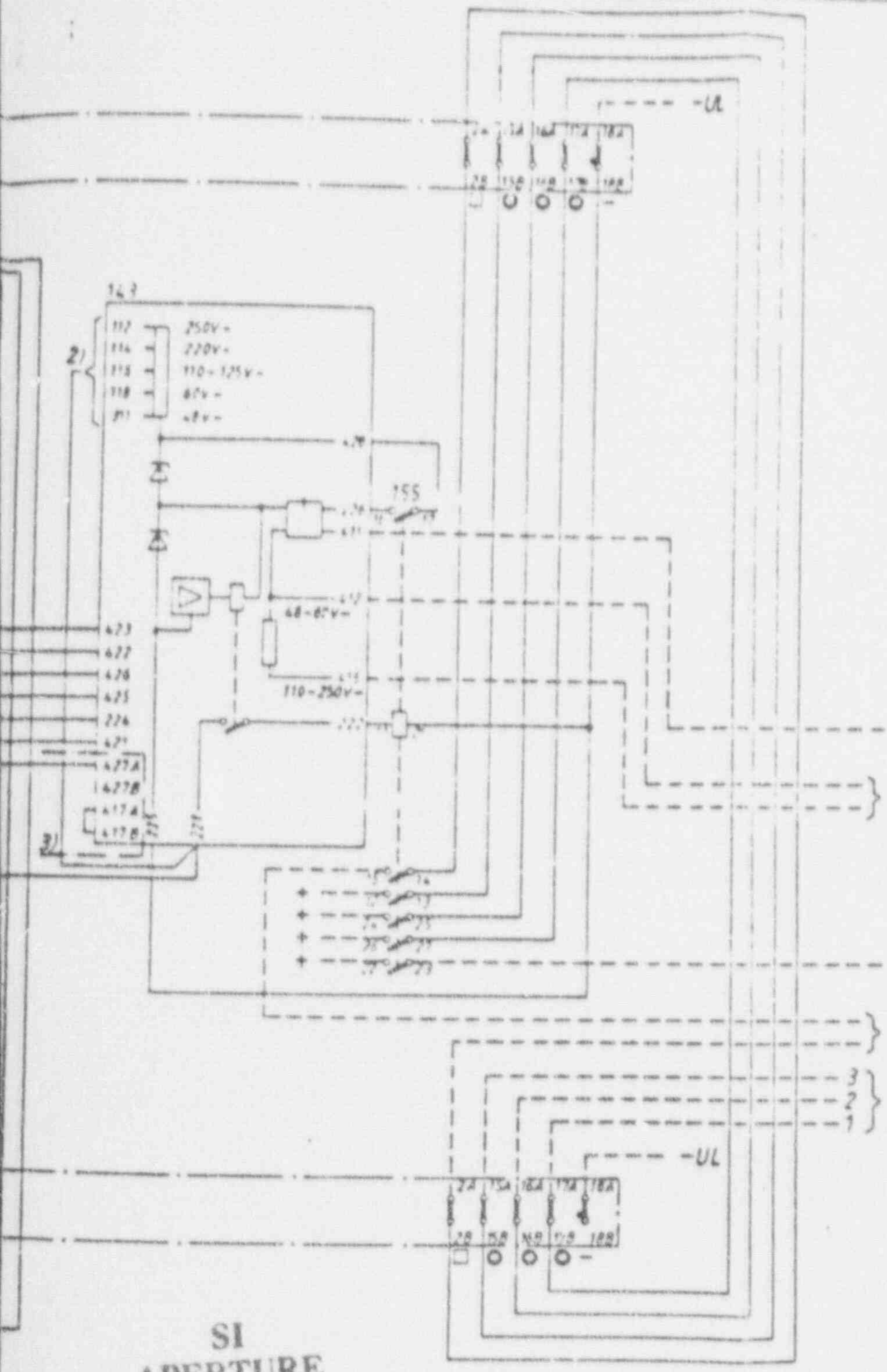
7454 338-BA

Ref RK 626 500-BA

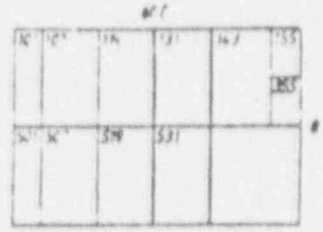
RKL | 7L | 12

T Johansson | Westesson | LC

3Id/I>



Transformer differential protective relay with five (six) input circuit restraints and phase indicator.
Transformatordifferentialskydd med fem (sex) stabiliserande ingångar och fasindikering

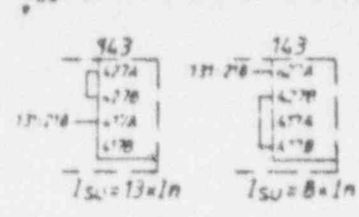


101 501	RTXP 18
107 119 131	RXDSE 43
143	RXTEE 4
155	RXMS 1
355	RXSG 1
507 519	RXTUC 4
531	RXTUC 4 1)

1) Only at six input circuit restraints
Endast vid sex stabiliserande ingångar

2) Connected to actual voltage at delivery
Vid leverans ansluten till aktuell spanning

3) Unrestrained instantaneous operating current setting $I_{SU} = 20 \times In$ from factory
Ostabiliserad momentan utlosn $I_{SU} = 20 \times In$ leveransutforande



SI APERTURE CARD

Also Available On Aperture Card

9202190460-02

5	UL info and L1 added			
4	Omritad, not 3) inf			LC

D F

GENERAL DOCUMENTS

Pos	Document Name	Drawing No.	Remarks
801	AC - elementary diagram	NY7454 0005-2	
802	DC - elementary diagram	NY7454 0005-3	
803	Wiring diagram	NY7454 0005-4	
804			
805			
806			
807			
809	Outline diagram	NY5283 0000-2	

Rev ind Revision		Appd	Year Week
Accepted by qual control	Accepted for prod by	Description: RADSE (6 Inputs and Signals)	
Design checked by: P. Carlsson	Drawn by: SW	Document Specification	
Drawing checked by: D.P. Sammon (DPSa)	Issued by Dept: UUS/RK, Year 83, Week 06	NY7454 0005-1	Rev ind; Sheet 1; Cont 2
ASEA			

UUS/RK 0101 sk; W-Erichsen; UUS/RK02 49; Sheet 1; Cont 2

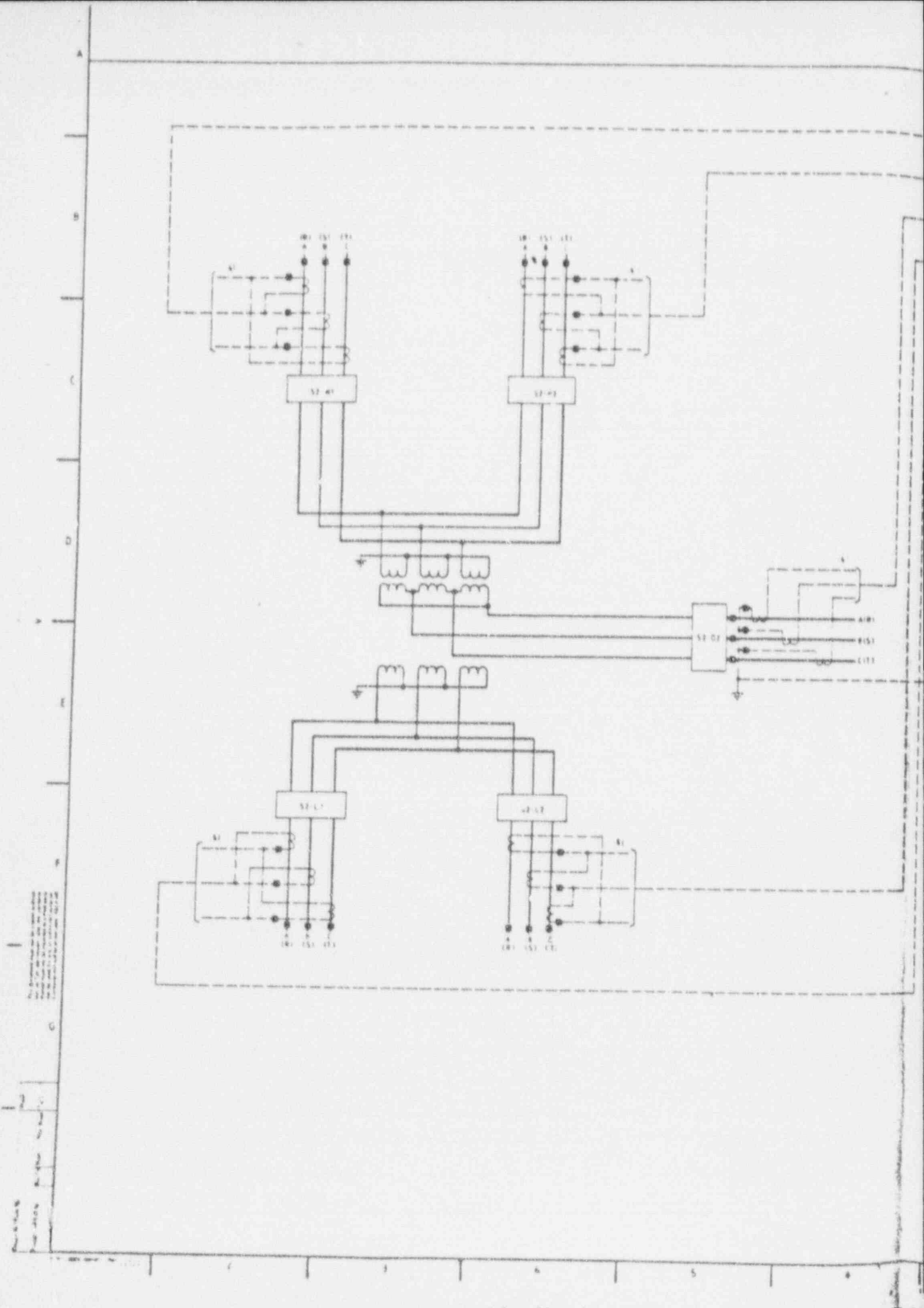
0917 5300 AA(A4) Rev

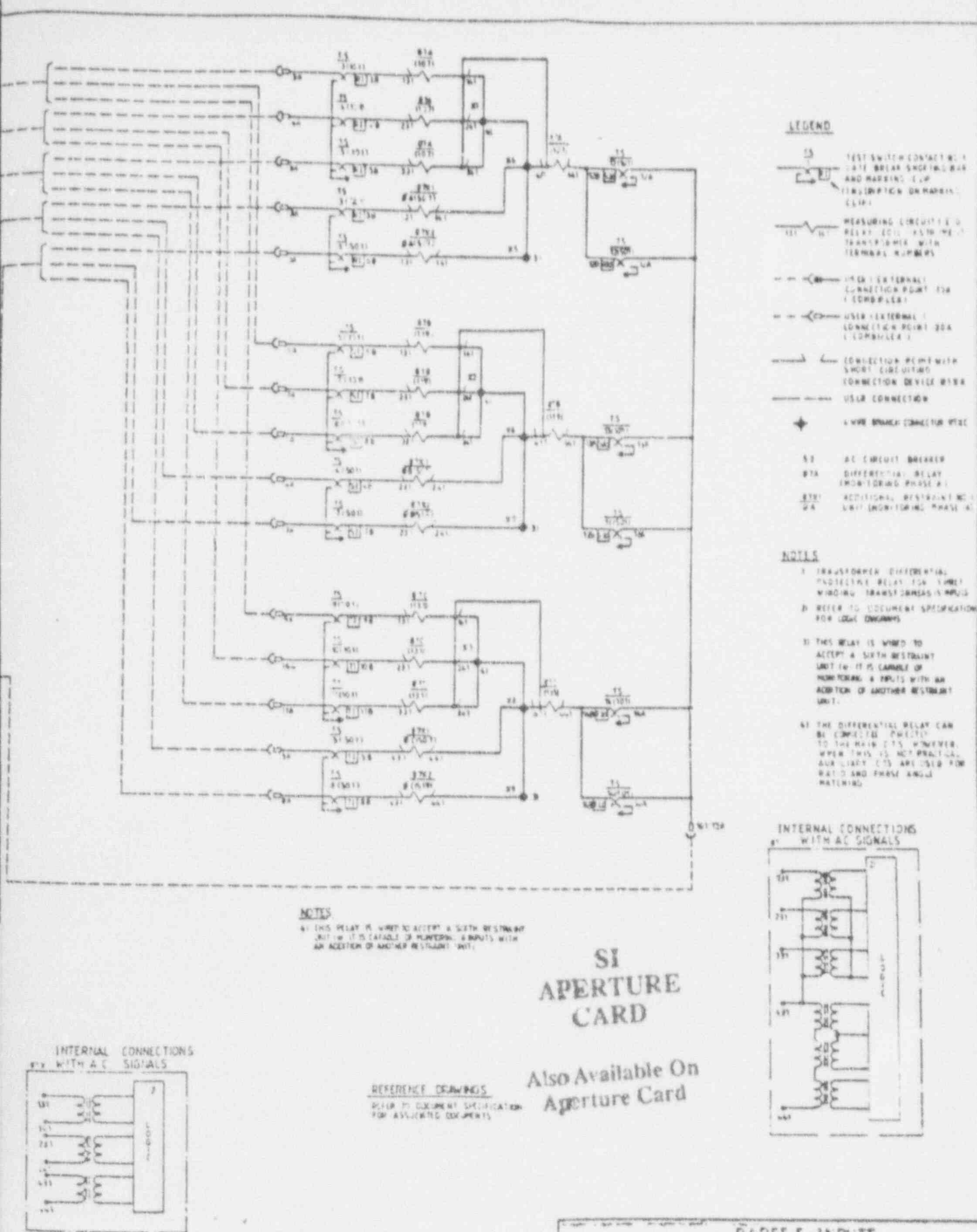
BLOCK, OVERALL AND UNIT LOGIC DIAGRAMS

POS	DOCUMENT NAME	DRAWING NO.	REMARK
810	BLOCK & OVERALL LOGIC DIAGRAM	NY 7454 0002-5	RADSE 4/5/6 INPUTS AND SIGNALS
811	UNIT LOGIC DIAGRAM	NY 7454 0013-3	RXDSE 43 PHASE UNIT
812		-4	RXTEE 4 MEASURING UNIT
813		-5	RXTUC 4 INPUT UNIT
814		NY 5634 0000-1	RXSG 1 INDICATOR UNIT

Rev ind Revision		Appd Year Week	
Accepted for qual control	Accepted for prod by	Description	RADSE (5 INPUTS AND SIGNALS)
Des/checked by W ERICHSEN	Drawn by SK		DOCUMENT SPECIFICATION
Drawing checked by T. EKMAN	Issued by Dept Year Week UUS/RK 83 27	NY 7454 0005-1	Rev ind Sheet 2
ASEA			Cont -

6917 5300 BA (A4) Rev





SI
APERTURE
CARD

Also Available On
Aperture Card

9202190460-03

P CARLSSON WRL	RADSE 5 INPUTS
	AC ELEMENTARY DIAGRAM
ASEA	NY 7454 0005-2

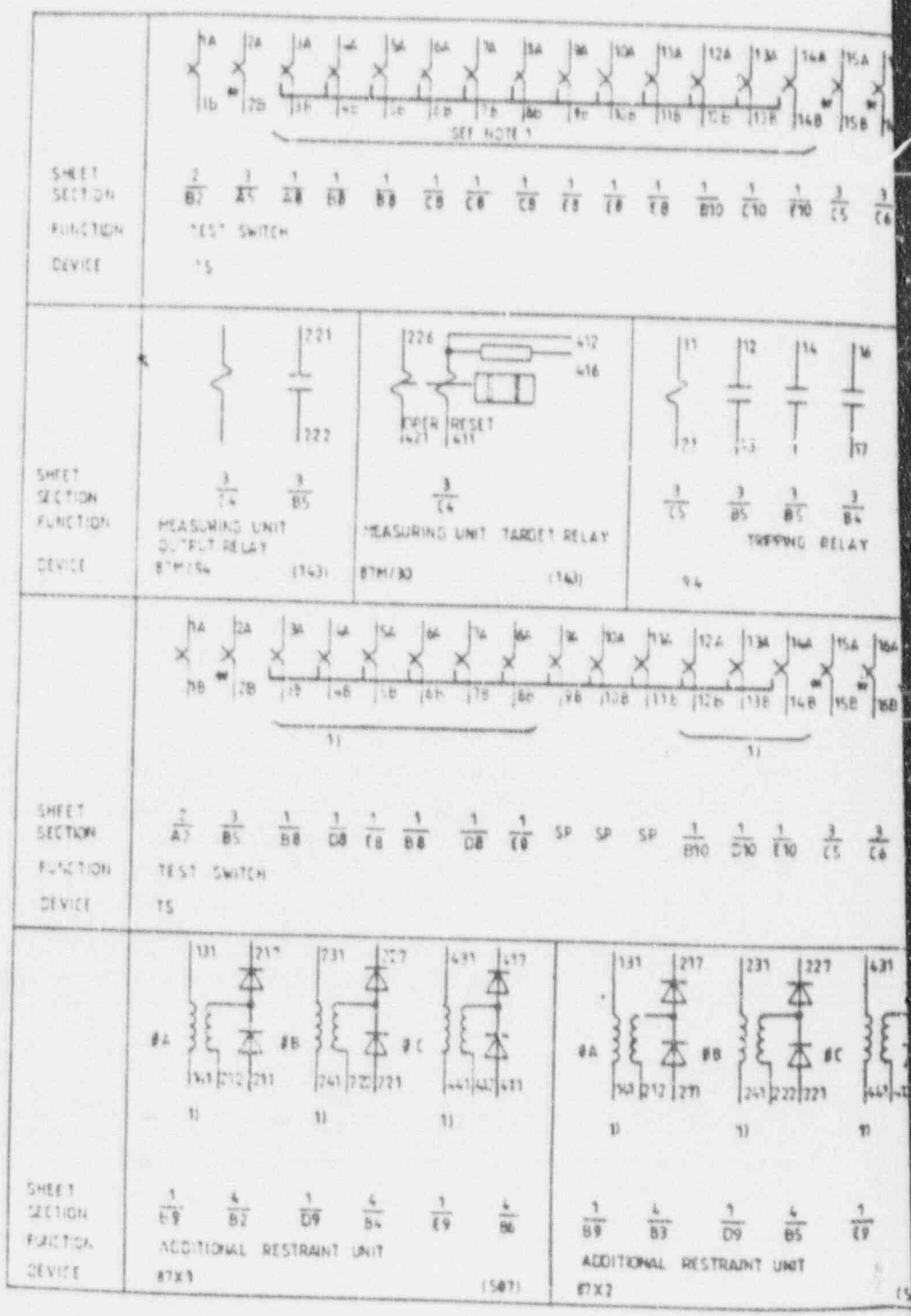
A

B

C

D

E



6911 5302 AA (A2)

2 3 4

LEGEND

TS — TEST SWITCH CONTACT NO. 1 (LATE BREAK) WITH MARKING CLIP

INSCRIPTION ON MARKING CLIP

TS — TEST SWITCH CONTACT NO. 2 (EARLY BREAK)

USER (EXTERNAL) CONNECTION POINT 10A (COMBIFLEX)

USER (EXTERNAL) CONNECTION POINT 20A (COMBIFLEX)

11 12 — RELAY COIL WITH TERMINAL NUMBERS

MECHANICAL TARGET WITH ELECTRICAL RESET

(101)	MODULE LOCATION
87H/30	TARGET RELAY
87A	DIFFERENTIAL RELAY (MONITORING PHASE (A)
87H	DIFFERENTIAL RELAY MEASURING UNIT
94	TRIPPING RELAY
87H/94	MEASURING UNIT OUTPUT RELAY
SP	SPARE (AVAILABLE BUT NOT USED)
	RED LED
87X1 ØA	ADDITIONAL INPUT RESTRAINT UNIT NO. 1 (MONITORING PHASE A)

NOTES

1) ELEMENTS ARE LOCATED ON THE A.C. ELEMENTARY AT THE SHEET AND SECTION COORDINATES INDICATED.

2) FACTORY WIRED ACCORDING TO ORDERED VOLTAGE.

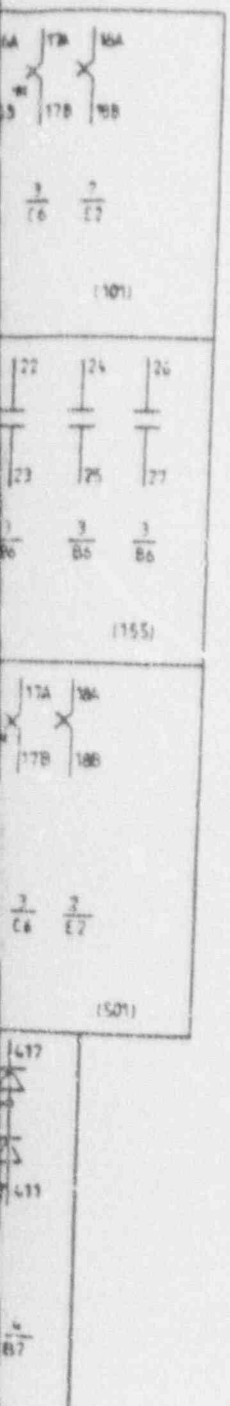
3) SETTABLE TO 20%, 30%, 40%, OR 50% OF MINIMUM PICK-UP.

4) REFER TO DOCUMENT SPECIFICATION FOR LOGIC DIAGRAMS.

5) THE UNRESTRAINED INSTANTANEOUS OPERATING CURRENT (Id) IS SET AT 20 x In A. THE FACTORY OTHER SETTINGS ARE AVAVAILABLE (SEE WIRING DIAGRAM)

6) RESETTING CAN BE ACCOMPLISHED USING ANY VOLTAGE IN THE RANGE OF 48-250 VDC

7) WHEN MONITORING MORE THAN 3 WINDINGS/TERMINALS ADDITIONAL RESTANT UNITS ARE NECESSARY (SEE PAGE 4)



SI APERTURE CARD

Also Available On Aperture Card

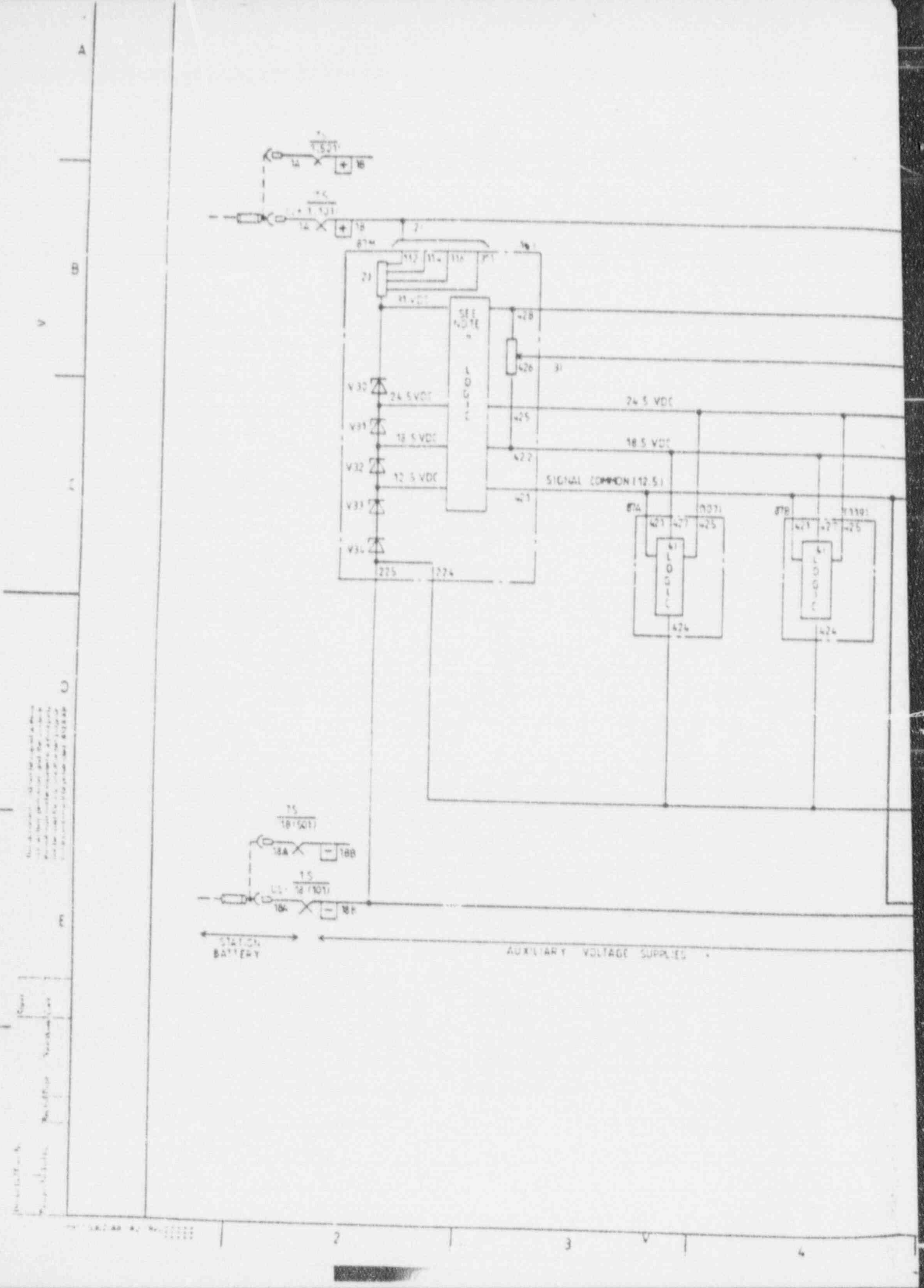
9202190460-04

REFERENCE DRAWINGS

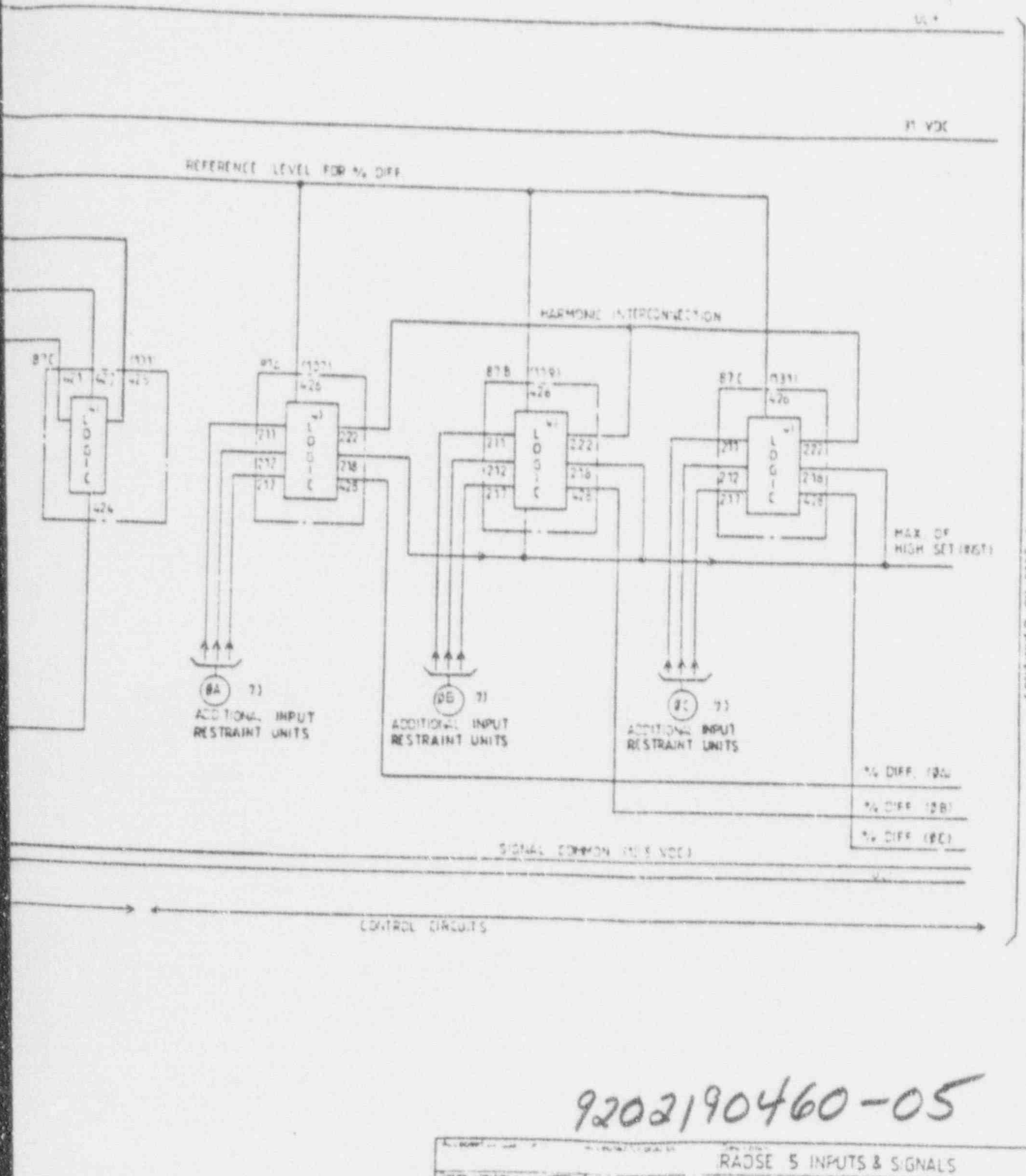
REFER TO DOCUMENT SPECIFICATION FOR ASSOCIATED DOCUMENTS

Designed: P. CARLSSON	Drawn: FCT
D. SAMMON	IUUS/RK 83 25
ASEA	
RADSE 5 INPUTS & SIGNALS	
D.C. ELEMENTARY DIAGRAM	
NY 7454 0005-3	Sheet 1 / 2

5 6 7 8

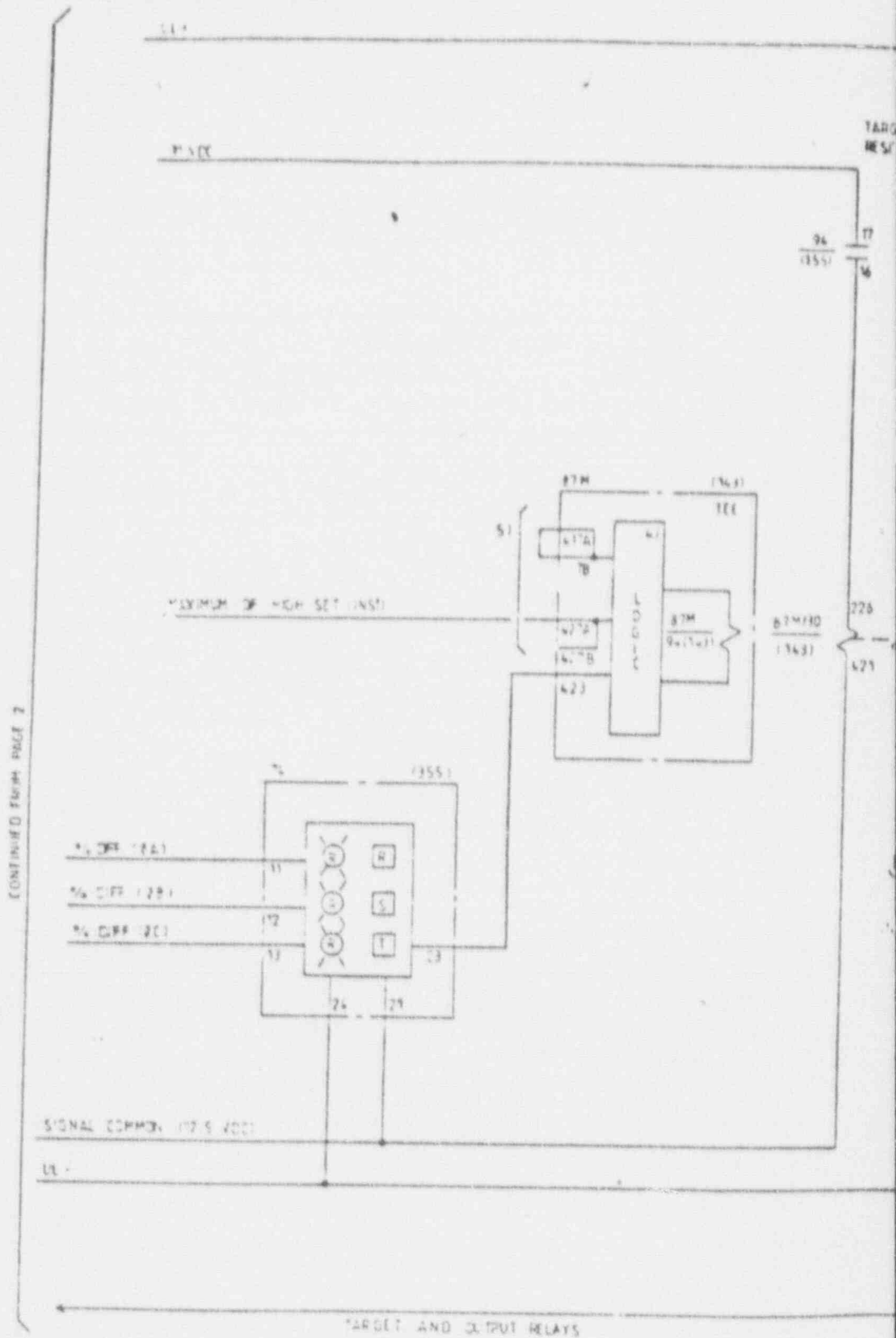


A
B
C
D
E
TS
14
16
18
21
SEE NOTE
LOGIC
428
426
425
422
421
24.5 VDC
18.5 VDC
12.5 VDC
V30
V31
V32
V33
V34
225
224
SIGNAL COMMON (12.5)
LOGIC
424
18A
18B
STATION BATTERY
AUXILIARY VOLTAGE SUPPLIES
2
3
4

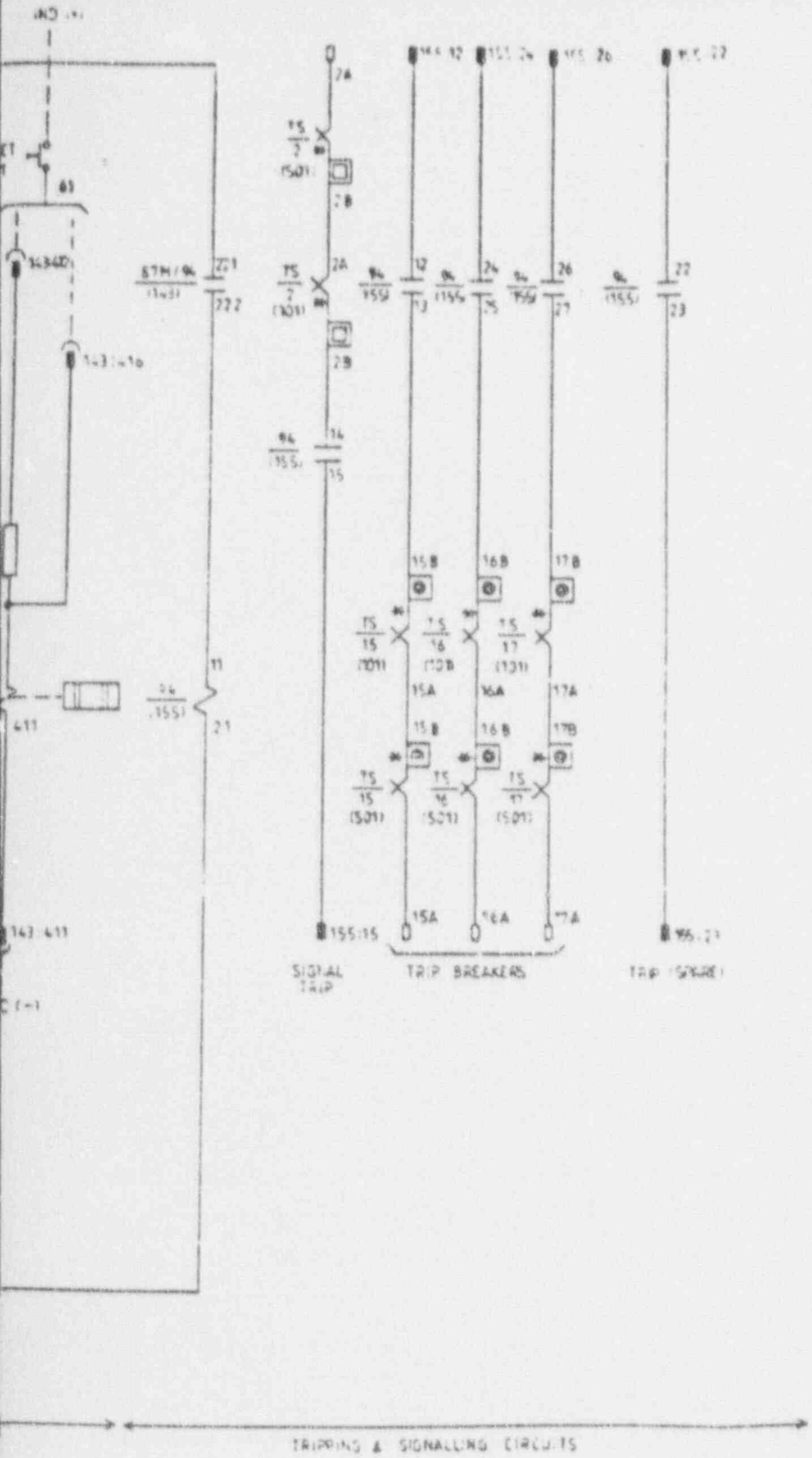


9202190460-05

		RADSE 5 INPUTS & SIGNALS
P. CARLSSON	FCT	D.C. ELEMENTARY DIAGRAM
D. SAMMON	UUS/RK 83 25	NY 7454 0005-3
ASEA		2 / 3

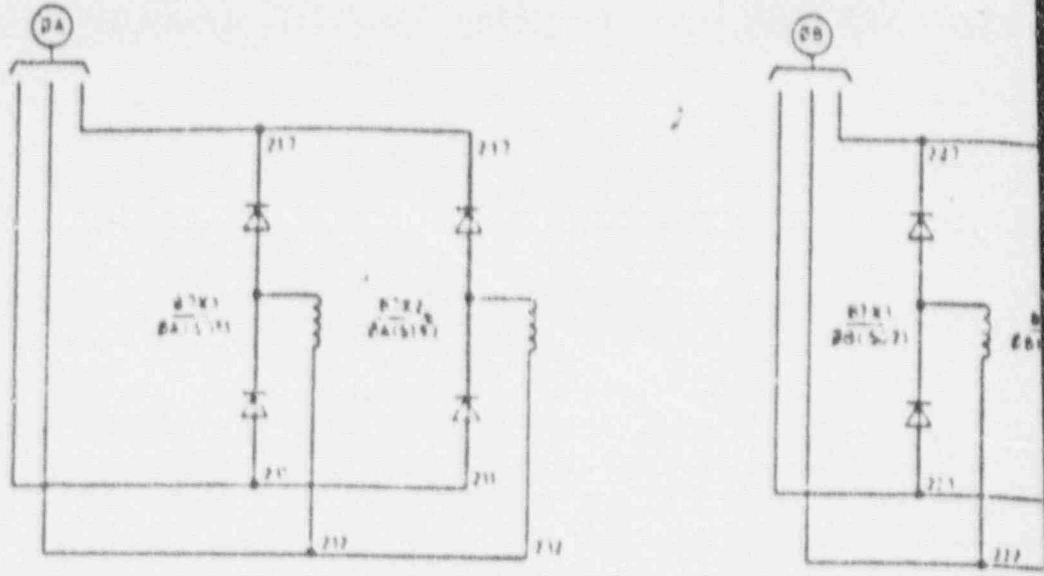


CONTINUED FROM PAGE 2
87M
(343)
LOGIC
(355)
R
S
T
TARGET AND OUTPUT RELAYS



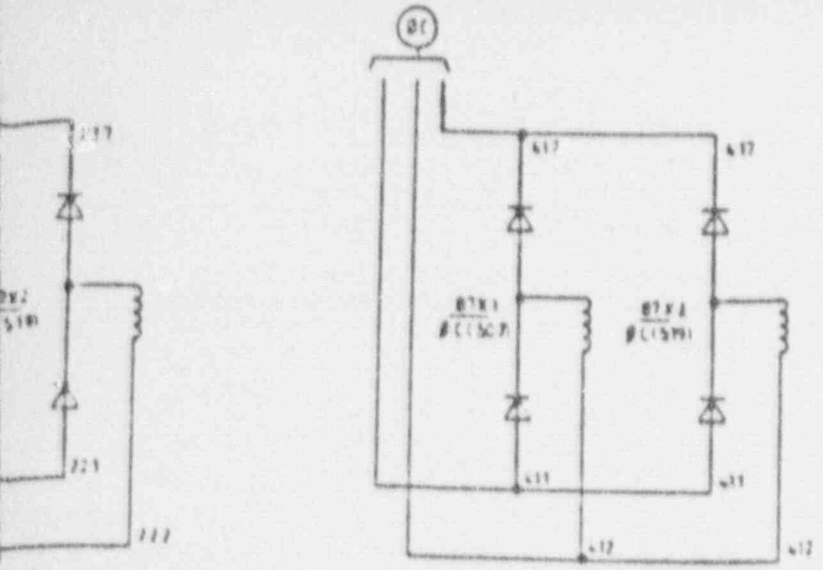
9202190460-06

		RADSE 5 INPUTS & SIGNALS
P. CARLSSON	FCT	D.C. ELEMENTARY DIAGRAM
D. SAMMON	UUS/RK 83 25	NY 7454 0005-3
ASEA		3 / 4



ADDI..ONAL RESTRAINT UNITS (87X) FOR MONITORI

(2 RX TUC UNITS (507,511) ADDITIO



NG 5 TERMINALS (INPUTS
SAL)

SI
APERTURE
CARD

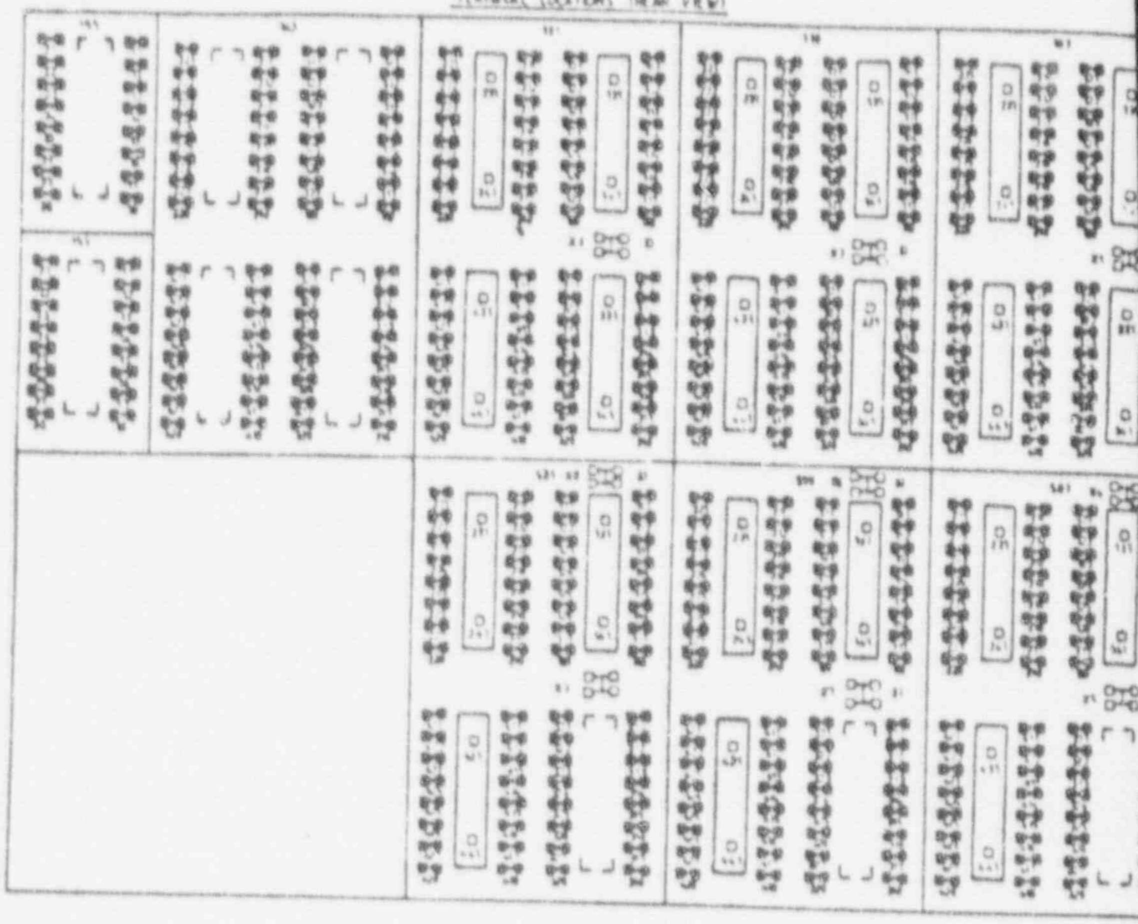
Also Available On
Aperture Card

9202190460-07

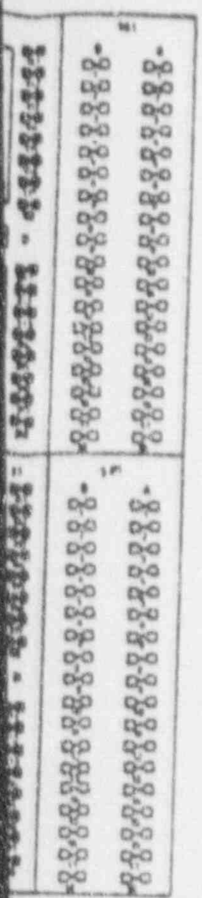
Accepted by	Accepted for	RADSE 5 INPUTS WITH SIGNALS
Design checked by P CARLSSON	Drawn by WRL	DC ELEMENTARY DIAGRAM
Drawing checked by D SAMMON	Issued by UUS/RK 83 07	NY 7454 0005-3
ASEA		

5 6

TERMINAL LOCATIONS (REAR VIEW)



INTERNAL CONNECTIONS



SI APERTURE CARD

Also Available On Aperture Card

EXTERNAL CONNECTIONS

AC INPUTS

[illegible]

DC AUXILIARY SUPPLIES

[illegible]

CONTROL INPUTS

[illegible]

TRIPPING AND SIGNALLING CONTACTS

NO CONTACTS

[illegible] TRIPPING CONTACTS (N.O.)

[illegible] TRIPPING CONTACTS (N.O.)

[illegible] TRIPPING CONTACTS (N.O.)

[illegible] SIGNAL DIFFERENTIAL RELAY OPERATION (N.O.)

TRAIL CONTACTS

[illegible] TRIPPING CONTACTS (N.O.)

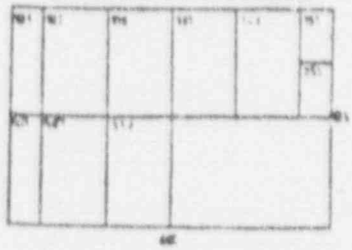
TABLE 1

[illegible]	From	To
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

TABLE 2

[illegible]	[illegible]		[illegible]	
	From	To	From	To
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

MODULE LOCATIONS (FRONT VIEW)



MODULE	TYPE	DESCRIPTION
[illegible]	[illegible]	[illegible]

LEGEND

[illegible]

NOTES

1 - TERMINAL NUMBERS SHOWN ON THE LAYOUT ARE THE COMPLETE TERMINAL NUMBERS AND MAY NOT NECESSARILY APPEAR PHYSICALLY ON THE REAR OF THE RELAY TERMINAL BASE.

2) THE UNRESTRAINED INSTANTANEOUS OPERATING CURRENT IS SET AT THE FACTORY FOR [illegible]. HOWEVER, OTHER MULTIPLES OF PICK-UP CAN BE OBTAINED (SEE TABLE 2 FOR WIRING CONNECTIONS).

3) RTXC BRANCH CONNECTORS ARE MOUNTED FREELY AND SUSPENDED BY LEADS.

4) RELAYS ARE WIRED FOR RATED VOLTAGE ON DELIVERY. SEE TABLE 1 FOR WIRING CONNECTIONS.

5) BOTH 5 INPUT RESTRAINT AND 6 INPUT RESTRAINT VERSIONS ARE WIRED IDENTICALLY (ie. WIRED FOR SIX INPUT RESTRAINTS). IN THE 5 INPUT RESTRAINT VERSION HOWEVER, THE SIXTH RESTRAINT UNIT IS OMITTED.

6 - TOOLS NECESSARY FOR INSTALLATION:

- EXTRACTOR TOOL RTXD: [illegible]
- CRIMPING PLIERS: [illegible] (16A SOCKET) / [illegible] (20A SOCKET)

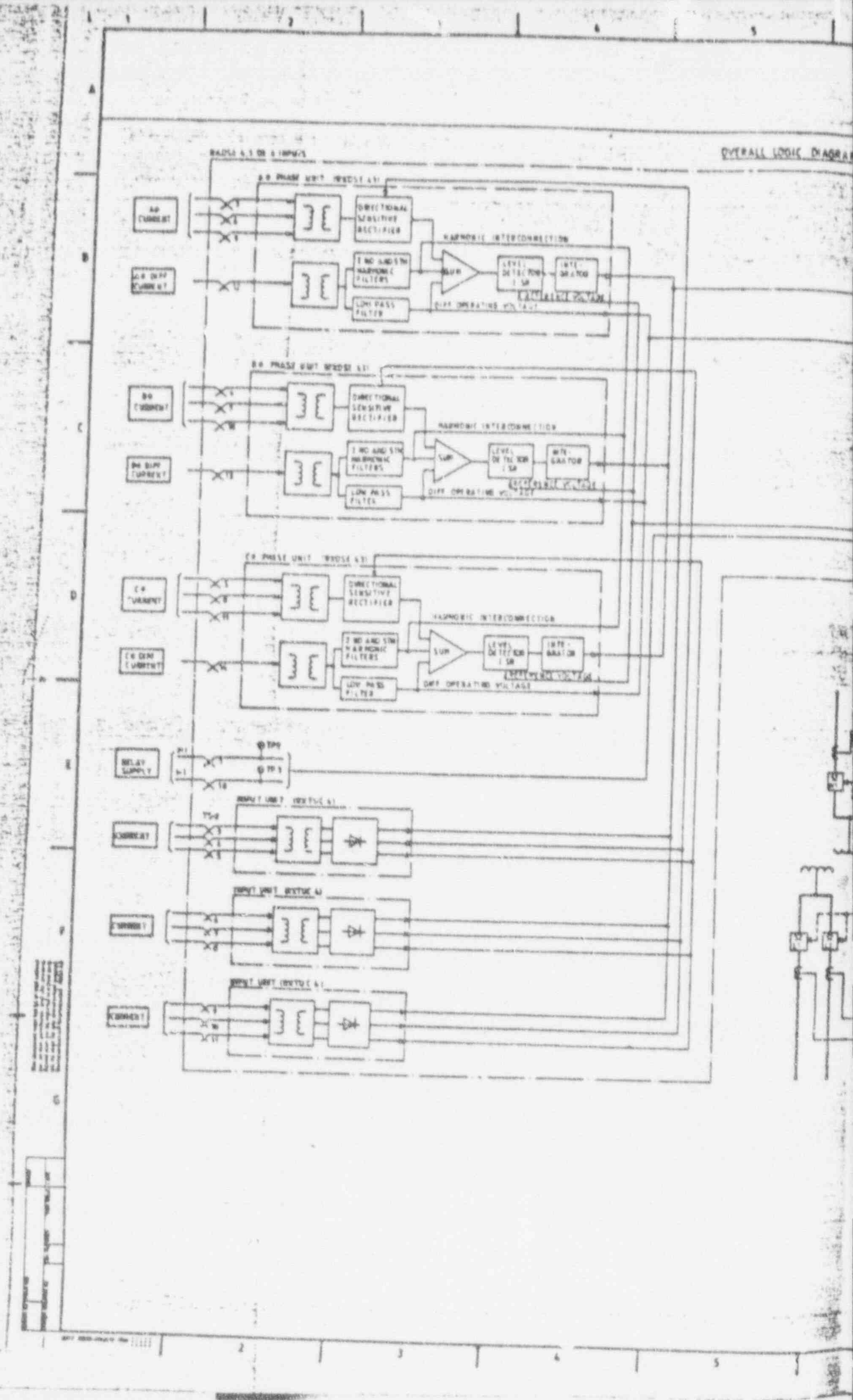
7 - FOR 20A COMBIFLEX SOCKETS, THE MAXIMUM AND MINIMUM ALLOWABLE WIRE SIZES ARE [illegible] AWG AND 14 AWG RESPECTIVELY. FOR 10A COMBIFLEX SOCKETS, THE MAXIMUM AND MINIMUM ALLOWABLE WIRE SIZES ARE 14 AWG AND [illegible] AWG RESPECTIVELY.

REFERENCE DRAWINGS

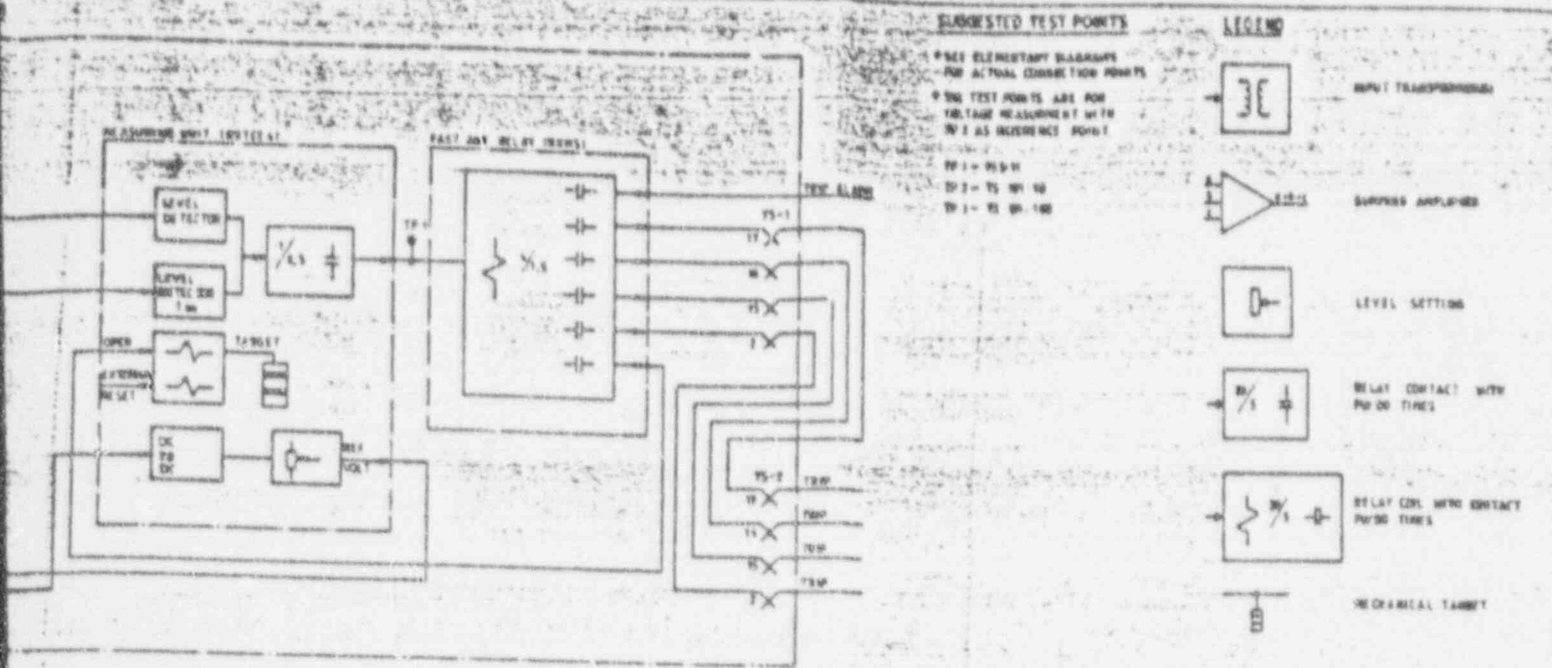
REFER TO DOCUMENT SPECIFICATION FOR ASSOCIATED DOCUMENTS

9202190460-08

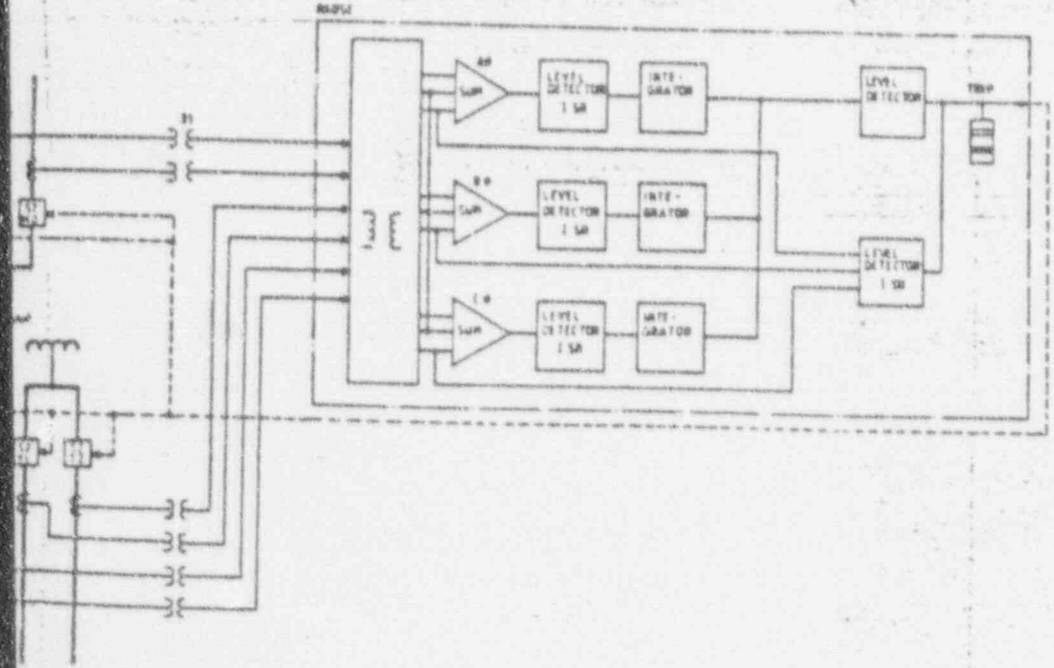
P CARLSSON FCT	RADSE (5 INPUTS & SIGNALS)
D SAMMON USS/RK 83 [illegible]	WIRING DIAGRAM
ASEA	NY 7454 0005-4



OVERALL LOGIC DIAGRA
DIRECTIONAL SENSITIVE RECTIFIER
HARMONIC INTERCONNECTION
SUM
LEVEL DETECTOR
LOW PASS FILTER
DIFF OPERATING VOLTAGE
RELAY SUPPLY
CURRENT



BLOCK DIAGRAM



1) THIS INPUT UNIT IS NOT MOUNTED IN VERSION WITH 4 INPUTS

2) THIS INPUT UNIT IS NOT MOUNTED IN VERSION WITH 4 AND 5 INPUTS

3) INTERPOSING CTs NOT GENERALLY NEEDED. ONLY WHEN RATIO OR PHASE ANGLE HAS TO BE MATCHED

SI APERTURE CARD

Also Available On Aperture Card

REFERENCE DRAWINGS

REFER TO DOCUMENT SPECIFICATION FOR ASSOCIATED [illegible]

9202190460-09

TRANSFORMER DIFFERENTIAL RELAY WITH 4,5 OR 6 INPUTS

		RADSE DIFFERENTIAL RELAY
W.ERICKSEN	MBI	BLOCK AND LOGIC DIAGRAM
C-H CARVALL	LLJ/SARK 83 32	
ASEA		NY 7454 0003 -5

ASEA

Mounting and connection hardware

B03-9302E

Page 1
June 30, 1982
Data subject to change without notice

COMBIFLEX modular system

The COMBIFLEX[1] system compactly combines plug-in apparatus and other components to form complete systems for protection, control and supervision in power plants, substations, industries, etc.

The COMBIFLEX system fulfills the requirements for substation protection and control equipment with regard to insulation resistance, temperature rise, current-carrying capacity, and surge-withstand capability. The system permits easy and rapid installation, service, and expansion of both simple and complex systems.

Fig. 14, page 6–7, shows how the plug-in apparatus, terminal bases, and connection hardware are combined and installed in either support cases for surface mounting, cases for flush- or semi-flush panel mounting, or equipment frames for standard 19" rack, cubicle or panel mounting. Table 1, page 5 and 8, serves as a quick reference for ordering mounting and connection hardware. Figures 1–13 illustrate some features of the COMBIFLEX system.

Modules are plugged in and then fastened by screws to terminal bases. Terminal bases can be mounted in a variety of ways. For standard 19" rack or cubicle mounting, equipment frames are used (see Fig. 1). The terminal bases mount either directly to an apparatus frame, or to apparatus bars. The apparatus frame is included in one version of equipment frame for direct mounting of the terminal bases. When terminal bases are already mounted on apparatus bars (such as for relay assemblies), the apparatus bars are mounted onto a support frame included with a different version of equipment frame. The equipment frame is then installed in a standard 19" rack or cubicle. COMBIFLEX also includes provisions for installing terminal bases mounted on apparatus bars into 4 different size cases, see Fig. 2. The cases mount into panels and are compatible with other panel-mounted equipment.

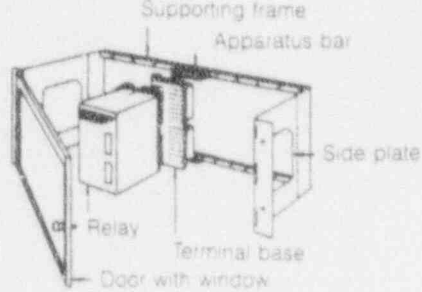


Fig. 1 Equipment frame

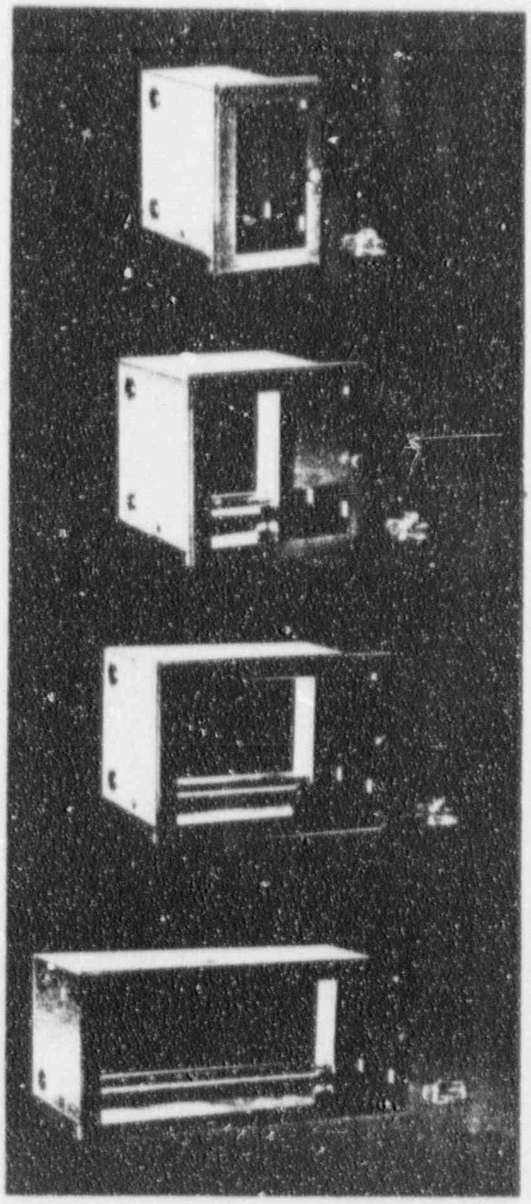


Fig. 2 Cases

COMBIFLEX modular system (contin'd)

Figure 3 illustrates the most generally used module sizes. Other components which conform to the same basic modular sizes bolt directly to the apparatus bars. One such component is the RTXP 18 test switch, shown as the left module in Fig. 4. Fig. 4 illustrates a typical relay assembly consisting of a test switch, plug-in modules and terminal bases mounted on a pair of apparatus bars.

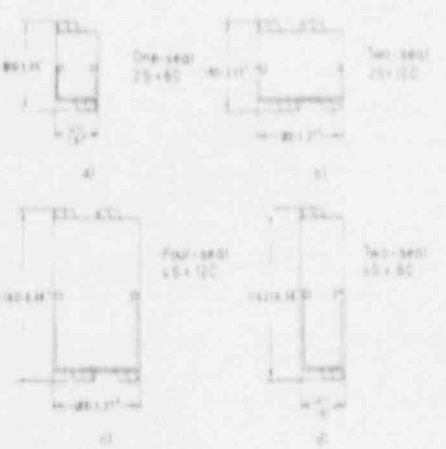


Fig. 3 Modular sizes

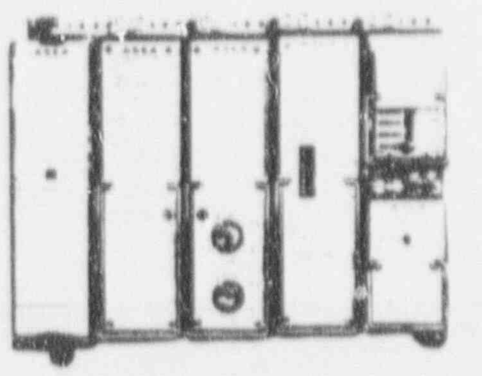


Fig. 4 Relay assembly

Fig. 5 illustrates terminal bases (two seat high RX 2H and four seat RX 4). For front connected surface-mounting applications RXZ 21 and RXZ 41 panel bases are used. RX 2 and RX 4 terminal bases are included in the RXZ 21 and RXZ 41.

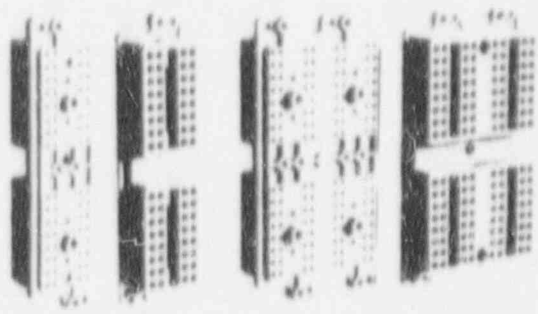


Fig. 5 Terminal bases

Fig. 6 illustrates two relays mounted on a front-connected RXZ 41 panel base. For relay assemblies, the RX 2H and RX 4 terminal bases are fastened to apparatus bars of the required length. The basic vertical spacing of the apparatus bars is 4S (7"). The apparatus bars can then be mounted to a support frame designed for cases or 19" rack-mounting equipment frames.

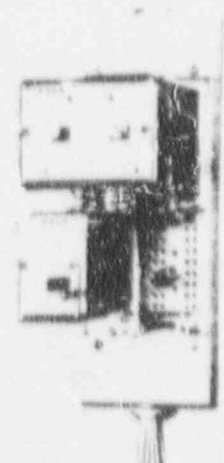


Fig. 6 Front-connected panel base, use without a panel cutout

A total of 20 seats (i.e. RX 4 terminal bases, or one RX 2H, four RX 4 terminal bases, and one test switch) can be installed in a standard 4S equipment frame. When more seats are desired they can be provided in additional 4S frames. Thus an entire cubicle can be built up with the basic size units. When more than 20 seats are required for an integrated set of functions, an 8S or 12S equipment frame can be provided. Thus up to 60 seats can be factory wired and delivered as a single 21" unit. This permits complete relay terminals to be packaged in one prewired assembly.

When the modules are to be mounted on a panel, the apparatus bars are mounted in the appropriate size RHGX case containing the support frame. Fig. 2 shows the four different sizes and Fig. 14 the additional collar used when semi-flush mounting is desired. In addition, terminal bases can be directly panel-mounted and rear-connected with a suitable cutout provided.

Connections between plug-in apparatus are made with socket-equipped plug-in leads. Electrical connections are made directly from the male terminal pin of the module to the female terminal socket crimped to the socket lead. Fig. 8 shows this connection feature. Each pair of terminal pins connects to a single circuit within the module. This permits the paralleling of circuits without the use of an additional terminal block. Even with this dual connection, 16 separate 10 A circuits can be brought out from a one seat relay module. All voltage, coil, and contact circuits are made with terminal pins and sockets (as used in the relay module shown in Fig. 7). These are all rated 10 A continuous, 150 A for 1 s. The current circuit and test switch terminals are rated 20 A continuous, 350 A for 1 s. Contact resistance is less than 5 milli-ohms for each rating.

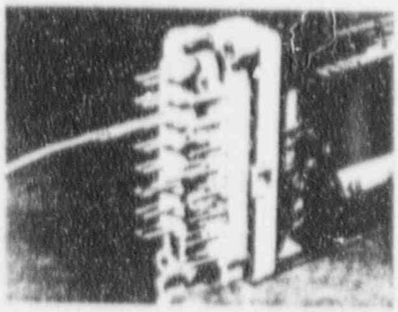


Fig. 7. Electrical connections are made directly to relay without intervening connection in base.

The socket lead attaches to the terminal base as follows: the terminal socket which is crimped to the lead has a retaining collar, and the terminal base has a retaining clip; once mated they cannot be separated without the use of a clip-spreading tool (extractor RTXD). These details are shown in Figs. 8a, b, and c.

The retaining clip is located a sufficient distance inside the terminal base so that when a socket lead is properly seated there are no exposed live parts. Figs. 8c and d also show the way in which the extractor tool is used.

a)

b)

c)

d)

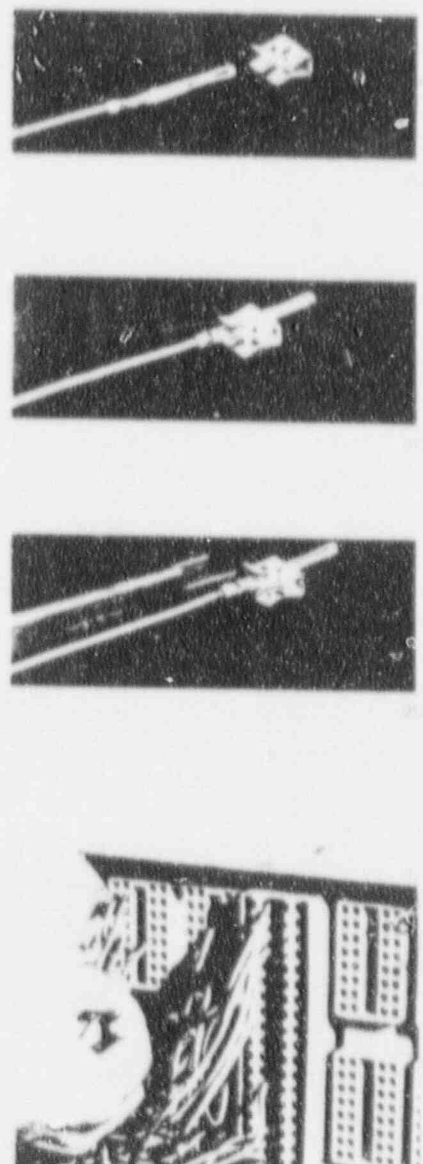


Fig. 8. Lead retention clip details and view of rear of terminal base.

COMBIFLEX accessories

The COMBIFLEX system provides a complete line of connection components and accessories, some of which are shown in Figs. 9–13. The accessories shown in Fig. 9 each mount in a component pocket in the terminal base. (Fig 8d shows this pocket between two vertical rows of connection holes).

Fig. 9. Accessories which mount in a component pocket in rear of terminal base.

Each terminal base which accepts ac current circuits is equipped with type RTXK short-circuiting connectors (see Fig. 10). These are spring-loaded, silvered contact assemblies which are normally kept in an open position by a guide pin on the module plate. When the module is withdrawn from the terminal base, these contacts short the current circuits before the module terminal pins separate from their associated terminal sockets in the terminal base.

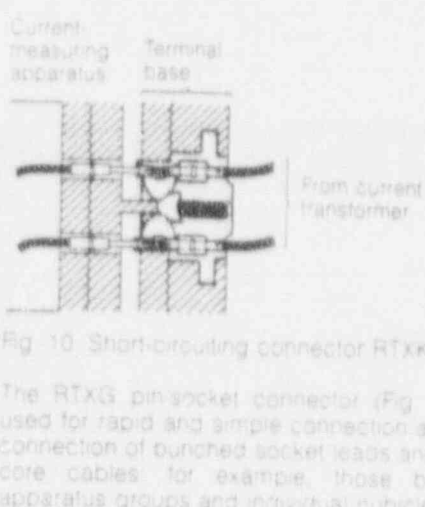


Fig. 10. Short-circuiting connector RTXK.

The RTXG pin-socket connector (Fig. 11) is used for rapid and simple connection and disconnection of bunched socket leads and multi-core cables, for example, those between apparatus groups and individual cubicles.

The RTXC branch connector (shown in Fig. 12) is used both for branch connection of socket leads and to increase the number of connections that can be made to a terminal on the module base. The space-saving RTXC cross connectors (shown in Fig. 13) are available with blocks of 20, 40, 60, 80 and 100 branch connectors. In approximately the same panel space occupied by the conventional 12 point screw-down terminal block, the RTXC 100 cross connector provides 100 electrically isolated connection points, each point having the capacity for the connection of up to four external leads.

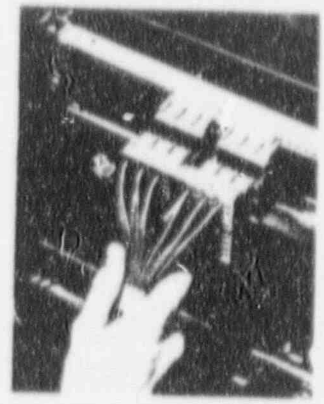


Fig. 11. Pin/socket connector RTXG.

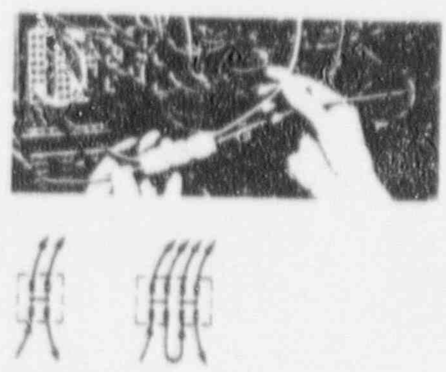


Fig. 12. Branch connector RTXC. One connector can accommodate 1 incoming and 3 outgoing leads, two connectors 1 incoming and 5 outgoing, etc.

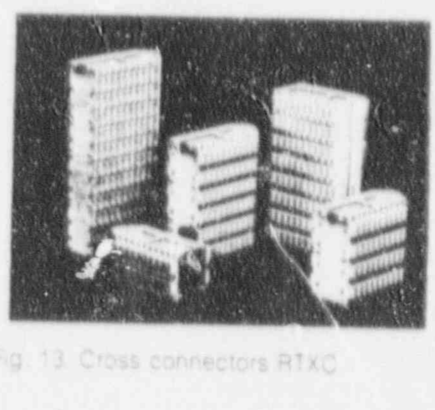


Fig. 13. Cross connectors RTXC.

Table 1. Ordering table: Mounting and connection hardware (cont'd on page 6)

	Seats	Qty/Type	Ordering no	Seats	Qty/Type	Ordering no
Surface-mounted terminal base rear-connect						
Available mounting seats per terminal base	2			2		
Terminal base		1/RX 2	RK 924 0001		1/RX 2H	RK 924 0004
Surface-mounted panel base front-connect						
Available mounting seats per panel base	2			4		
Panel base (includes terminal base)		1/RXZ 21	RK 928 008-AB		1/RXZ 41	RK 928 009-AB
Flush panel-mounted case						
Available mounting seats per case	4			8		
Case		1/RHGX 4	RK 927 001-AA		1/RHGX 8	RK 927 002-AA
Apparatus bars (set of 2)		1/12 C	SK 142 016-K		1/24 C	SK 142 016-G
Terminal base		1/RX 4	RK 924 0002		2/RX 4	RK 924 0002
Flush panel-mounted case with test switch						
Available mounting seats per case	2			6		
Case		1/RHGX 4	RK 927 0[illegible]-AA		1/RHGX 8	RK 927 002-AA
Apparatus bars (set of 2)		1/12 C	SK 142 016-K		1/24 C	SK 142 016-G
Terminal base		1/RX 2H	RK 924 0004		1/RX 2H	RK 924 0004
Terminal base					1/RX 4	RK 924 0002
Test switch		1/RTXP 18	(See B03-9510E for ordering no.)		1/RTXP 18	(See B03-9510E for ordering no.)
Semi-flush panel-mounted case (option)						
Spacer frame - (add to flush mounted case)		1/12 C	RK 927 005-AA		1/24 C	RK 927 006-AA
19" rack-mounted equipment frame						
Available mounting seats per equipment frame	20			40		
Equipment frame (door with window)		1/4 F	SK 142 010-G		1/8 S	SK 142 010-H
Apparatus bars (set of 2)		1/60 C	SK 142 016-A		2/60 C	SK 142 016-A
Terminal base		5/RX 4	RK 924 0002		10/RX 4	RK 924 0002
19" rack-mounted equipment frame with test switch						
Available mounting seats per equipment frame	18			38		
Equipment frame (door with window)		1/4 S	SK 142 010-G		1/8 S	SK 142 010-H
Apparatus bars (set of 2)		1/60 C	SK 142 016-A		2/60 C	SK 142 016-A
Terminal base		1/RX 2H	RK 924 0004		1/RX 2H	RK 924 0004
Terminal base		4/RX 4	RK 924 0002		9/RX 4	RK 924 0002
Test switch		1/RTXP 18	(See B03-9510E for ordering no.)		1/RTXP 18	(See B03-9510E for ordering no.)
Other components						
Terminal sockets (set of 100) 10 A		1/-	RK 924 0010			
20 A		1/-	RK 924 0020			
Crimping pliers						
10 A red handle		1/-	RK 924 009-AA			
20 A blue handle		1/-	RK 924 009-AB			
Stripping pliers		1/-	RK 924 034-AA			
Extractor type RTXD		1/-	RK 924 0055			
Branch connector (gray) 10 A		1/RTXC 1	RK 924 004-AB			
(transp.) 20 A		1/RTXC 1	RK 924 004-BB			

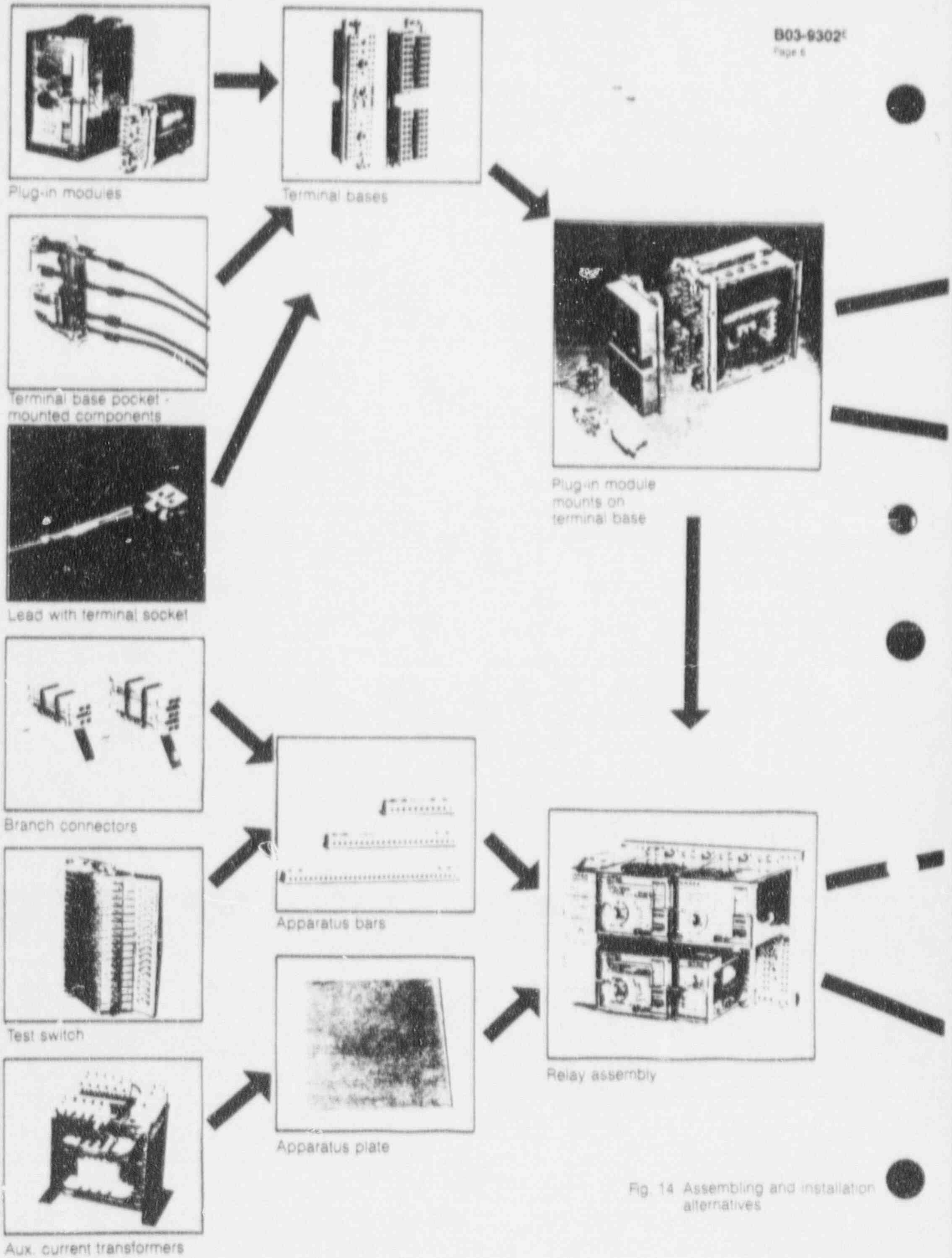
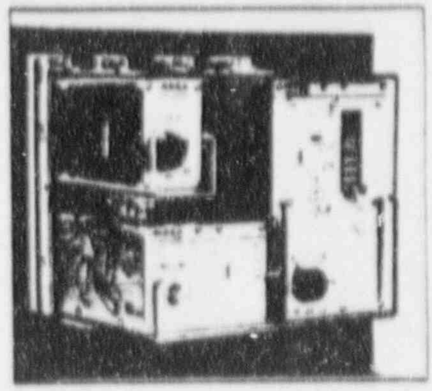
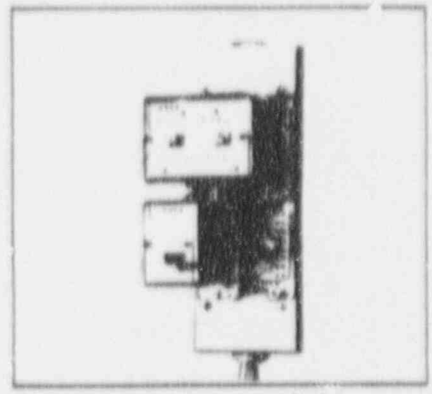


Fig. 14 Assembling and installation alternatives



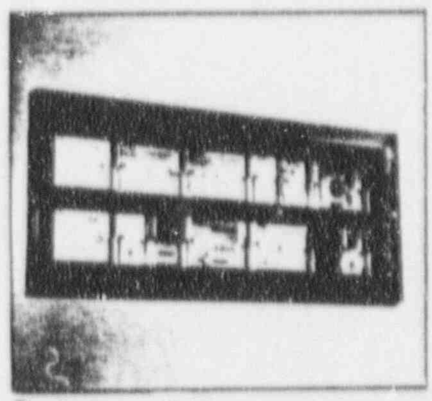
Surface - mounted terminal base
Rear connect

Support case
Panel base

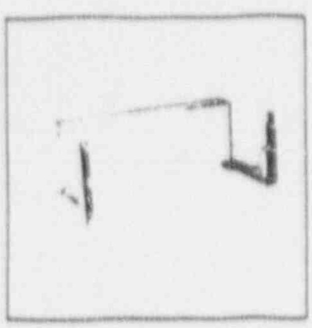


Surface - mounted panel base
Front connect

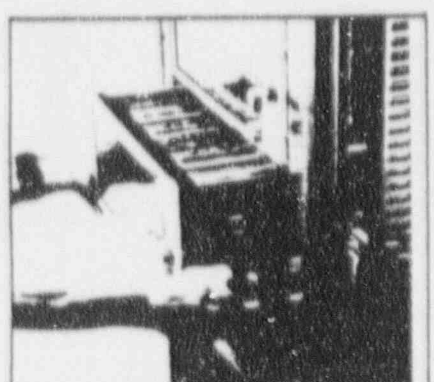
Case



Flush- or semiflush
mounted case



19" Equipment frame



19" rack or VSG cubicle mounted
or flush-mounted 19" equipment frame

Table 1 Cont'd from page 5

	Seats	Qty/Type	Ordering no	Seats	Qty/Type	Ordering no
Surface-mounted terminal base rear-connect						
Available mounting seats per terminal base	4					
Terminal base		1/RX 4	RK 924 0002			
Flush panel-mounted case						
Available mounting seats per case	12			20		
Case		1/RHGX 12	RK 927 003-AA		1/RHGX 20	RK 927 004-AA
Apparatus bars (set of 2)		1/36 C	SK 142 016-E		1/60 C	SK 142 016-A
Terminal base		3/RX 4	RK 924 0002		5/RX 4	RK 924 0002
Flush panel-mounted case with test switch						
Available mounting seats per case	10			18		
Case		1/RHGX 12	RK 927 003-AA		1/RHGX 20	RK 927 004-AA
Apparatus bars (set of 2)		1/36 C	SK 142 016-E		1/60 C	SK 142 016-A
Terminal base		1/RX 2H	RK 924 0004		1/RX 2H	RK 924 0004
Terminal base		2/RX 4	RK 924 0002		4/RX 4	RK 924 0002
Test switch		1/RTXP 18	(See B03-9510E for ordering no.)		1/RTXP 18	(See B03-9510E for ordering no.)
Semi-flush panel-mounted case (option)						
Spacer frame - (add to flush mounted case)		1/36 C	RK 927 007-AA		1/60 C	RK 927 008-AA
19" rack-mounted equipment frame						
Available mounting seats per equipment frame	60					
Equipment frame (door with window)		1/12 S	SK 142 010-K			
Apparatus bars (set of 2)		3/60 C	SK 142 016-A			
Terminal base		15/RX 4	RK 924 0002			
19" rack-mounted equipment frame with test switch						
Available mounting seats per equipment frame	58					
Equipment frame (door with window)		1/12 S	SK 142 010-K			
Apparatus bars (set of 2)		3/60 C	SK 142 016-A			
Terminal base		1/RX 2H	RK 924 0004			
Terminal base		14/RX 4	RK 924 0002			
Test switch		1/RTXP 18	(See B03-9510E for ordering no.)			

ASEA

Item and terminal designations for relay equipment

B03-9381E

Page 1

May 1982

Data subject to change without notice

Introduction

To be able to locate a relay unit in a protective relay, the unit is identified with a unique item designation. Furthermore, the electrical connection requires that each connection point has a unique terminal designation. These designations are used on circuit diagrams, terminal diagrams and elsewhere.

A circuit diagram for a protective relay shows the units of which the protective relay is built up, the internal wiring between the units and the external connection of the relay. The terminal diagram shows in a simplified way the functioning of the protective relay and the external connection of the relay.

The item designations are based on a coordinate system of S and C modules and the terminal designations are based on the size of the unit. S is the height module and C is the width module. The S-module (44.45 mm, 1.75 in), derived from the 19" standard, is the vertical distance between the groups of holes in the fixing bars of cubicles. The C-module (7 mm, 0.28 in) is the horizontal distance between the fixing holes in apparatus bars. See also B03-9382E.

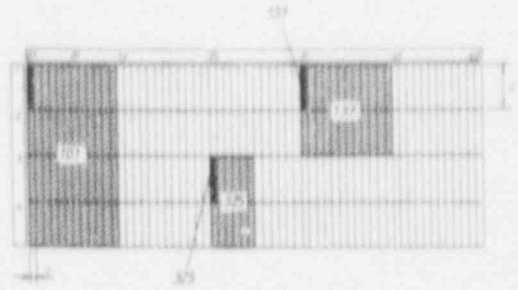
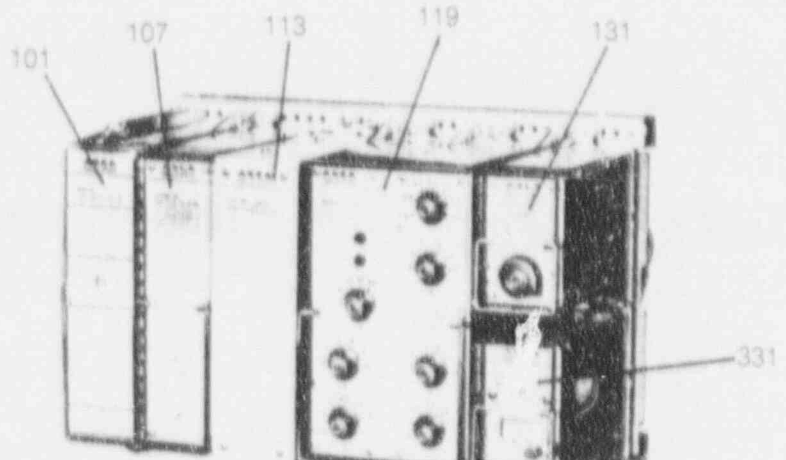


Fig. 1. The S and C modules form a coordinate system. Note that the item designations of each unit is the combination of S and C modules covered by that unit's upper left corner, e.g. 101 and 325.

Illustration of item and terminal designations

The left unit of the protective relay in fig. 2 has the item designation 101, where the first figure stands for the S-module position and the next two for the C-module position. The next unit, 107, has the same S-module position but has added 6C to its C-module position. Unit 331 has added 2S and 24C to its module position.



(790176)

Fig. 2. Item designations for relay units.

A complete terminal designation for the protective relay shown in fig. 2 consists of e.g. the item designation 101 and the terminal designation 14A. This terminal, 101:14A, is encircled in the terminal diagram, fig. 3 and in the connection guide, fig. 4.

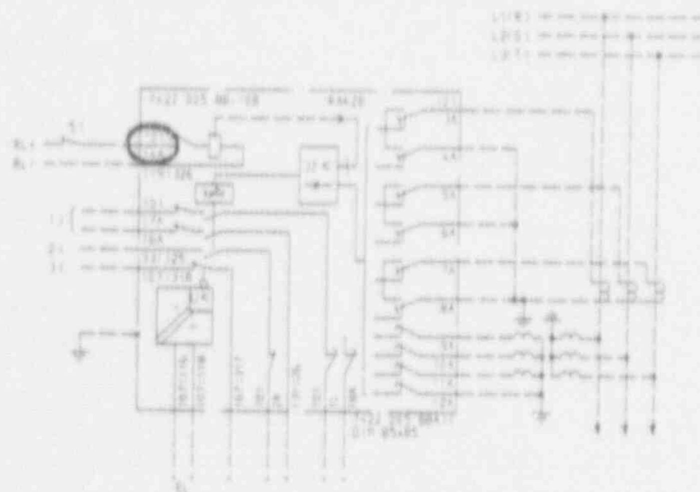


Fig. 3 Terminal diagram

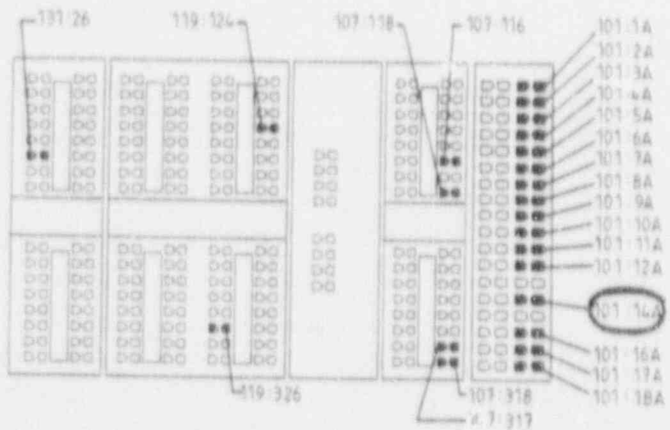


Fig. 4 Connection guide for external connections according to the terminal diagram (rear view).

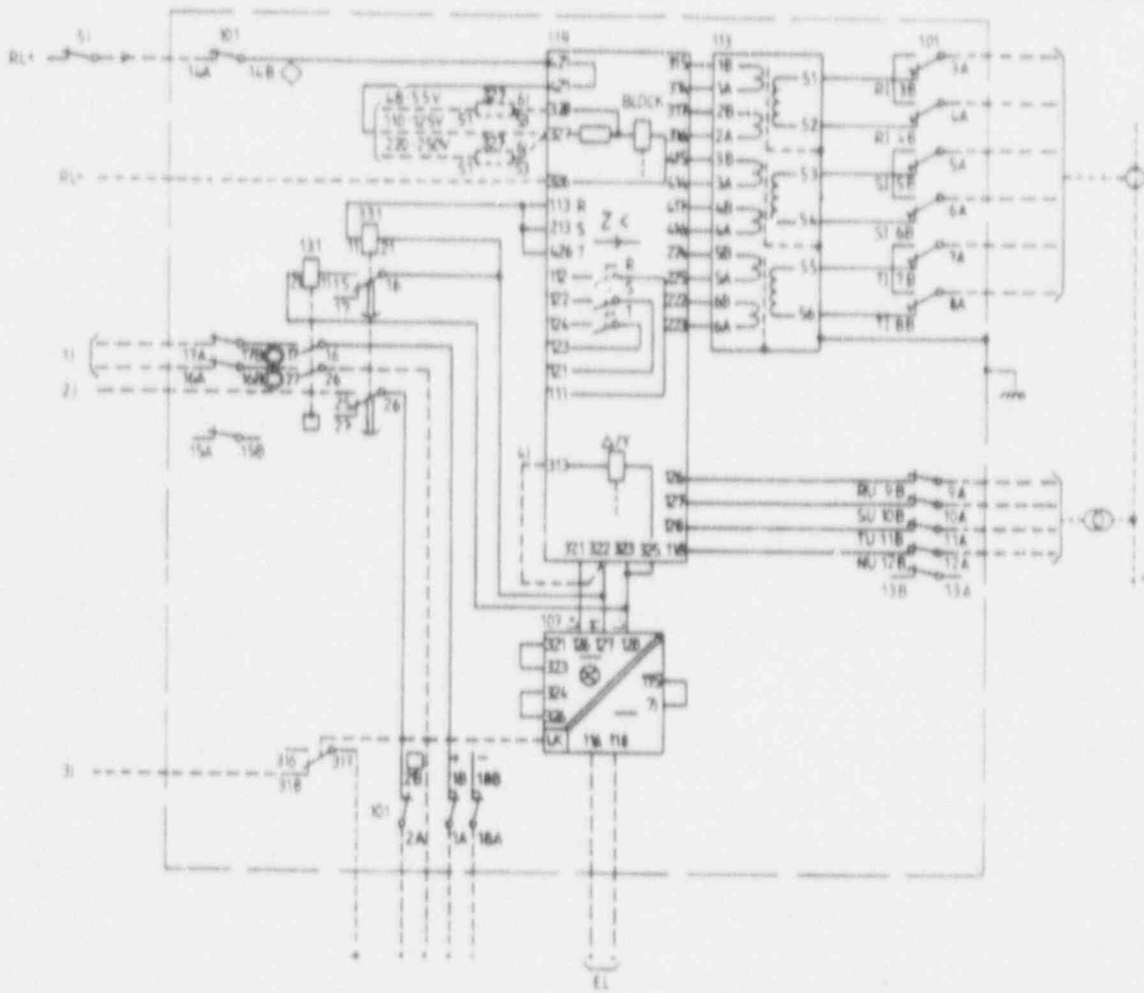


Fig. 5 Circuit diagram

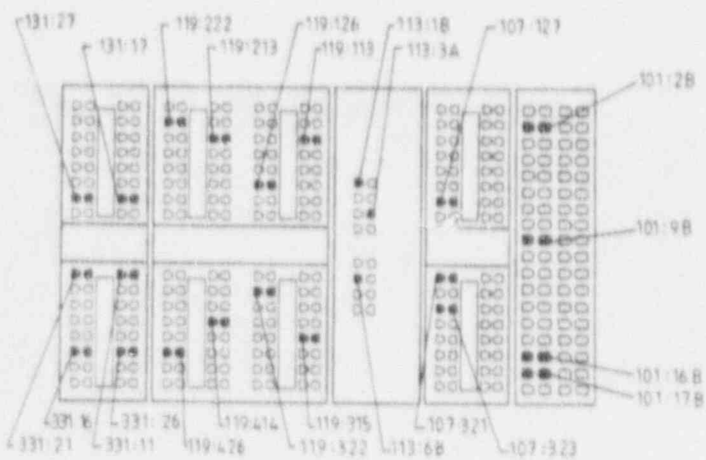


Fig. 6 Some of the terminals used in the internal connections in fig. 5 (rear view)

Terminal bases are marked with figures and letters according to fig. 7. The terminal designation for a relay unit depends on the size of the mounted unit, not on the terminal base. One and the same terminal, 21, see fig. 8, in an RX 4 terminal base can get four different terminal designations depending on the size of the mounted relay unit.

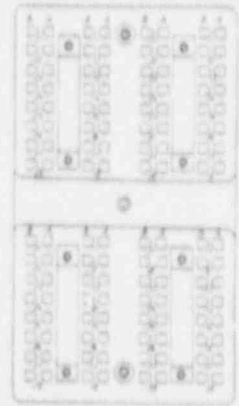


Fig. 7 Terminal base seen from the rear

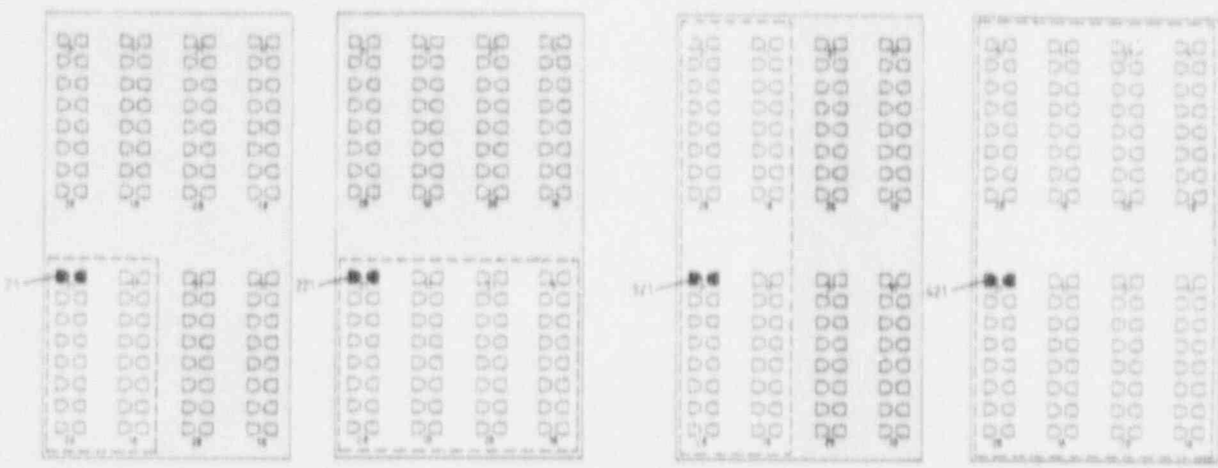
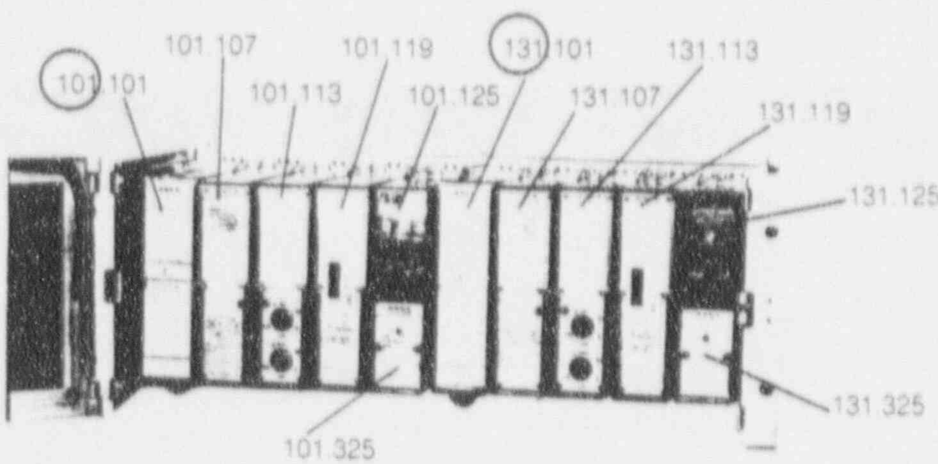


Fig. 8 Terminal designation for different relay units mounted on the same terminal bases



(830245)

Fig. 9 Two of the same protective relays, the encircled 101 and 131, mounted in an equipment frame

The terminal designation for one terminal in the left unit of the left protective relay will be 101.101:14A. The same terminal in the right protective relay has the terminal designation 131.101:14A as this relay has added 30 C-modules to its position 131.

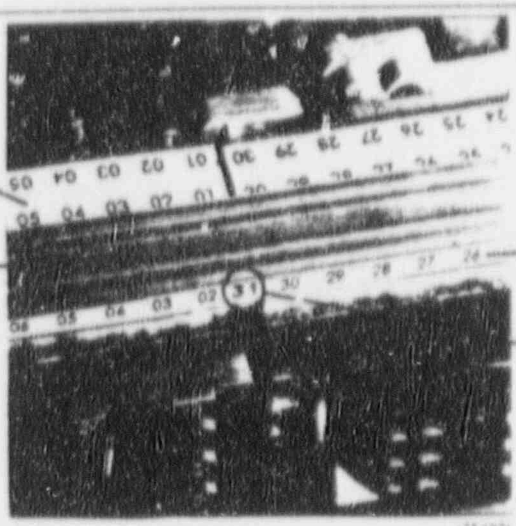


Fig. 10 C-module markings

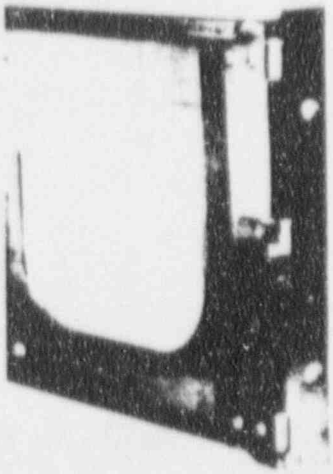


Fig. 11 Vertical S-module marking tape

A relay cubicle consists of several equipment frames and apparatus plates. To be able to identify one equipment frame the cubicle is devided in mounting planes, see fig. 12. Placed in a cubicle fig. 13, the equipment frame has got an identifaction plate at the right side of the frame. In the item designation D5, D9 etc the letter stands for the mounting plane and the figure for the S-module level.

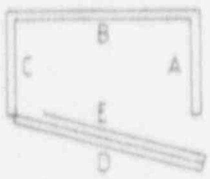


Fig. 12 Mounting planes in a relay cubicle

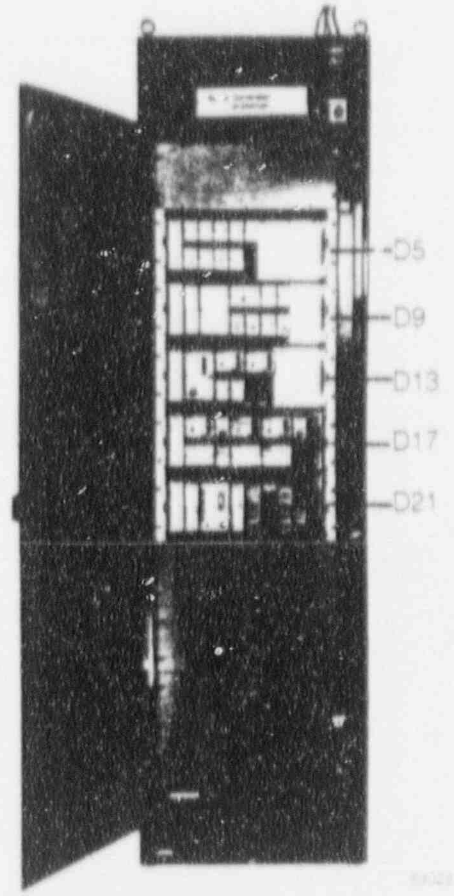


Fig. 13 Equipment frames in a relay cubicle

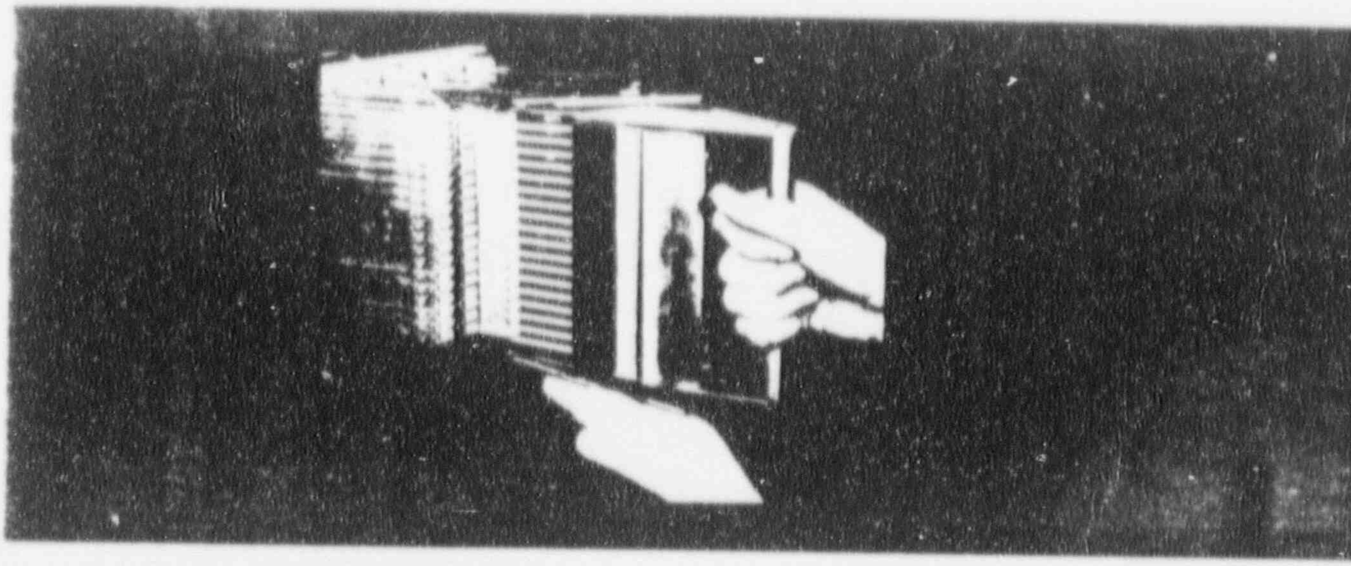
Reference

Buyers Guide	No
Marking strips and labels	B03-9380E
Dimensions	B03-9382E

ASEA

Test system COMBITEST

B03-9510



Abstract

- Fail-safe sequence disconnecting trip circuits when the test-plug handle is inserted
- Latching feature so that when the test-plug handle is withdrawn the relay stabilizes in its reset position before the trip circuits are restored
- Complete isolation of secondary instrument transformer circuits
- Trip-block plug which decommissions a trip circuit without interrupting other circuits, allows the trip output to be monitored, and also provides visual indication of a decommissioned trip circuit
- Block-plug handle which disconnects all circuits routed through the test switch
- Ammeter test plug with built-in automatic shorting device in case of inadvertent opening of a CT circuit
- Auxiliary station power supply made available for operating test equipment
- Extension bases which facilitate measurement and adjustment of plug-in module circuits

Application

The COMBITEST system for testing relays is built up around the RTXP 18 test switch which is used with all protective relays constructed in the COMBIFLEX modular system. Spare positions in the test switch can be used for other testing needs not directly associated with the COMBIFLEX relays, such as for switchboard ammeters or voltmeters.

The test switch may be used independently of the COMBIFLEX system, where testing relays or instruments would otherwise require disconnecting instrument transformer secondary or control circuit wiring. It may also be used to advantage in testing other complete relay systems, even when each individual relay has its own test switch.

When the test-plug handle is inserted into the test switch, preparations for testing are automatically carried out in the proper sequence, i.e. blocking of tripping circuits, short circuiting of CT's, opening of voltage circuits, making relay terminals available for secondary injection.

The free ends of the test-plug handle leads may be connected to any type of test equipment or instrument.

When a number of protective relays of the same type are tested, the test-plug handle need be moved only from the test switch of one relay to the test switch of the other, without altering previously made connections. If different types of relays are to be tested, it is a simple matter to change the connections on the test-plug handle and the relay testing set.

Design

The COMBITEST system comprises a test switch, a test-plug handle, test leads, a trip-block plug, an ammeter test plug and a block-plug handle.

Test switch
The test switch RTXP 18, which consists of a transparent plastic housing containing a maximum of 18 contact units, occupies the space of two seats in the COMBIFLEX system with dimensions of 4S (7" high) and 6C (1.7" wide). It mounts rigidly to the COMBIFLEX apparatus bars or any suitable panel cutout. It does not plug into the standard COMBIFLEX relay terminal base. It is fitted with 20 A COMBIFLEX terminals.

The RTXP 18 test switch, available in 13 standard contact arrangements (see Ordering table), contains 2 basic contact types: 1 for trip circuits is designed to open first when the test-plug handle is inserted and close last when the handle is removed, the other type is used for all other circuit functions, current, voltage and auxiliary power. Each test circuit contains 2 similar, adjacent contact units, with the exception of the dc supply voltage (where positive is position 1 and negative is position 18). An additional shorting bar mounted within portions of the test switch provides the necessary short-circuiting of the current transformer circuits when a test-plug handle is inserted. Leads from measuring transformers, trip circuits and relays are connected to the rear of the test switch.

The contact blocks are numbered consecutively on the left-hand side with marking clips 1 – 18, from top to bottom. Similar marking clips are arranged on the right-hand side of the contact block for the function marking. As standard the contact block for + is placed at the top and the contact block for - at the bottom of the housing, and the unused space is occupied by dummies of the same shape as the contact blocks. The contact blocks have guiding slots fitting the guides of the test pins, to prevent incorrect insertion of the test-plug handle.

The front of the test switch is a door with a face plate having space for test device and the protective relay data. Space is also provided for text specified by the customer. On the back of the face plate there is a symbol showing the type and location of the contacts and bypassing bars used in the test switch. With the door open, marking piece symbols indicating the significance of each test switch contact are visible. The available contact arrangement and marking piece symbols are shown in the ordering table.

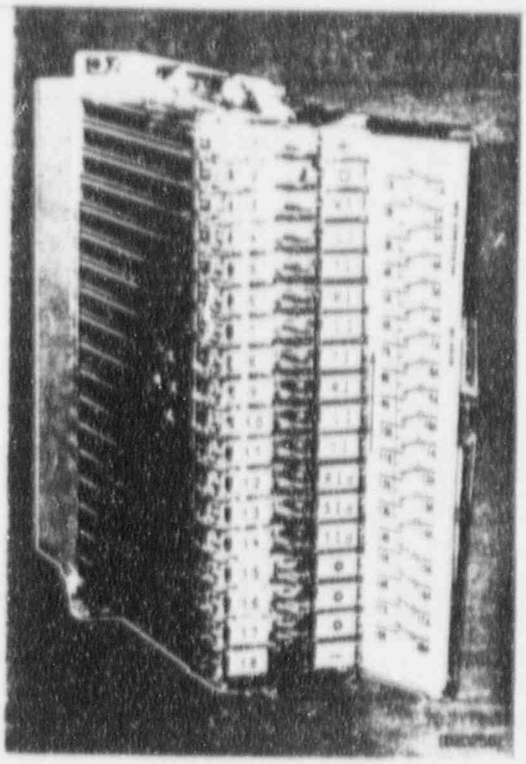


Fig. 1. Test switch

Test plug handle

The test-plug handle RTXH 18, which is made of a grayish-blue plastic, has 18 plugs and 18 banana-plug sockets for use with 4 mm banana plugs. Test leads are used to connect between the banana-plug sockets on test-plug handle and the relay testing set. Plugs 1 and 18 are for + and − dc auxiliary voltage and maintain circuit continuity when inserted into the test switch, and the other 16 plugs are test plugs which disconnect the relay and connect it to the test leads. To prevent unwarranted tripping when the handle is withdrawn, 2 latches on the handle secure it in the half drawn-out position. In this position, all voltages and currents are restored to the relay and any reenergizing transients are given a chance to decay before the trip circuits are restored. When the latches are released, the handle can be completely withdrawn from the test switch, restoring the trip circuits to the relay.

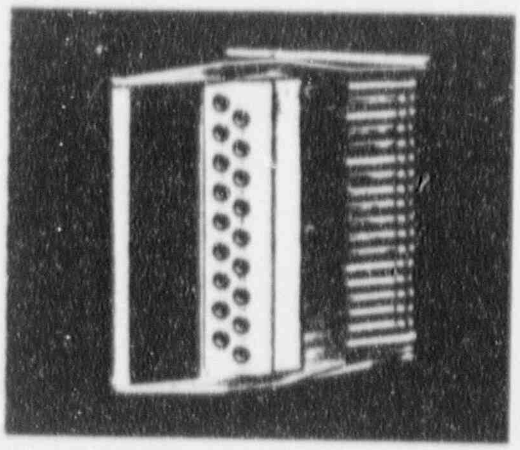


Fig. 2 Test-plug handle

Test leads

Red and black test leads are available; these leads are 2.5 m long with a cross section of 2.5 mm^2 and with 4 mm banana plugs at each end.

Trip-block plug

The trip-block plug RTXB is a short red plug which can open a trip-type contact only. It cannot cause any switching action if it is inadvertently plugged into a wrong position. It can also be used for measurement purposes in trip circuits. The plug is red to draw attention to the fact that blocking has been carried out. The door of the COMBIFLEX equipment frame can be closed while the plug remains inserted in the test switch.

Ammeter test plug

The ammeter test plug RTXM is thinner than the other plugs so that when inserted into a current position it connects the meter in series with the circuit, but does not open the switch far enough to cause the current shorting bars to be contacted. This plug is equipped with a gas tube and a thermal element to provide overvoltage protection and limit any overvoltage to about 300 V in case of an inadvertent opening of the CT. At approx. 300 V an arc occurs which provides a current path and heats up a thermally activated bi-metallic contact. This contact then provides a solid short-circuiting path. The overvoltage protection can withstand a continuous current of 15 A.

The plug has 1 black and 1 red lead, 2.5 m in length with a 2.5 mm^2 cross-section. The free ends are fitted with banana-type 4 mm plugs. The plug is to be inserted with the red lead connected to the relay side.

Block-plug handle

The block-plug handle RTXF 18 consists of 18 test plugs clipped together. This device blocks the complete relay by disconnecting all circuits routed through the test switch including the dc power supply. When the block-plug handle is inserted, the door of a COMBIFLEX equipment frame can be closed.

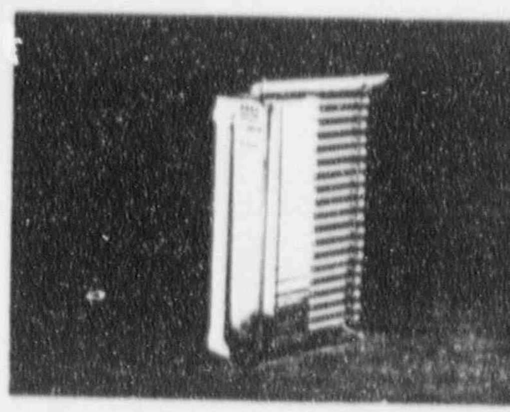
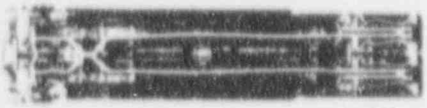


Fig. 3 Block-plug handle

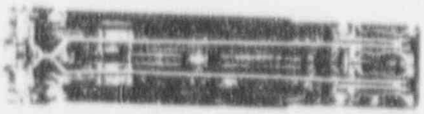
Design (cont'd)

Test switch includes



36844

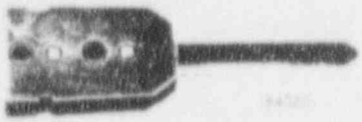
Contacts for current circuits



36844

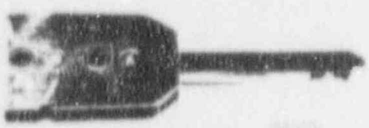
Contacts for trip circuits

Test-plug handle includes



34520

DC supply plug
2 plugs for + and − dc auxiliary voltage supply to the test equipment



34520

Test plug
16 test plugs which disconnect the relay and connect it to the test leads

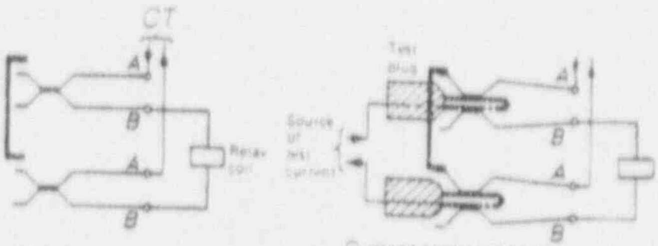
Loose plugs

34520

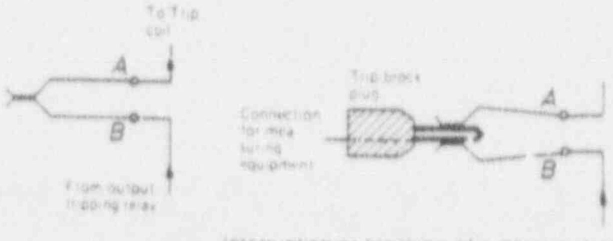
Trip-block plug
The trip-block plug RTXB is short and is used separately for blocking trip circuits. It can also be used for measurement purposes in trip circuits

Ammeter test plug
The ammeter test plug RTXM is used separately for service current measurement. It incorporates an over-voltage protection

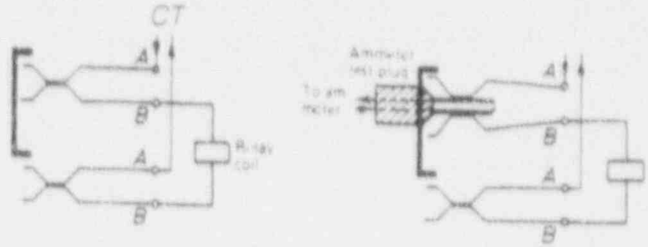
NORMAL POSITION | TEST POSITION



Current testing of relay



Interruption or blocking of a dc circuit or for time measurement of trip pulses etc



Load current measurement

Fig. 4 Methods of use, plugs and contacts

Extension bases

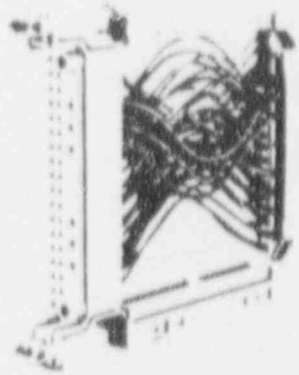
The extension bases consist of a plug-in plate and a terminal base between which are connected leads with combination pin-sockets

(76813)

RX 1

(76812)

RX 2H



RXY

Extension base	RX 1	RX 2H	RXY
Suitable for terminal base type	RX 1 RX 2 RX 2H RX 4	RX 2H RX 2H RX 4	RXY
Moduler dimension	2S 6C	4S 6C	4S 4C

Technical data

Test voltage	2.5 kV
Highest system voltage	600 V dc, 500 V ac
Current-carrying capacity	
continuous	20 A
for 1 second	350 A

Short-circuiting connector
Short-circuiting connectors type RTXK are supplied with ac current relay modules. The connector is fastened to the terminal base of the relay module with screws and allows the module to be withdrawn from its terminal base without the secondary circuit of the CT being opened. In this way, individual relay modules can be changed, tested, or adjusted separately. See Mounting and connection B03-9301E for details.

Note: Before an undercurrent relay, which is normally energized, is withdrawn, the trip circuit must first be blocked, either directly by removing the output relay or by inserting an RTXB trip-block plug into the test switch.

To order

When ordering the test switch, specify:

- Type: RTXP 18
- Quantity
- Ordering no.
- Function designation symbol on the marking pieces and the quantity, location and ordering no. of each one of these
- Wording on the lower half of the face plate

Ordering example:

Test switch RTXP 18 RK 926 003-AS	
6 unmarked marking pieces on position 9–12, 14, 15	RK 926 0201
1 + on position 1	0202
1 − on position 18	0203
2 RI on position 3–4	0204
2 SI on position 5–6	0205
2 TI on position 7–8	0206
2 □ on position 2, 13	0265
2 ⑤ on position 16–17	0266

When ordering other test parts, specify:

- Description
- Quantity
- Ordering no.

Mounting and connection:

- See B03-9301E

To order (cont'd)

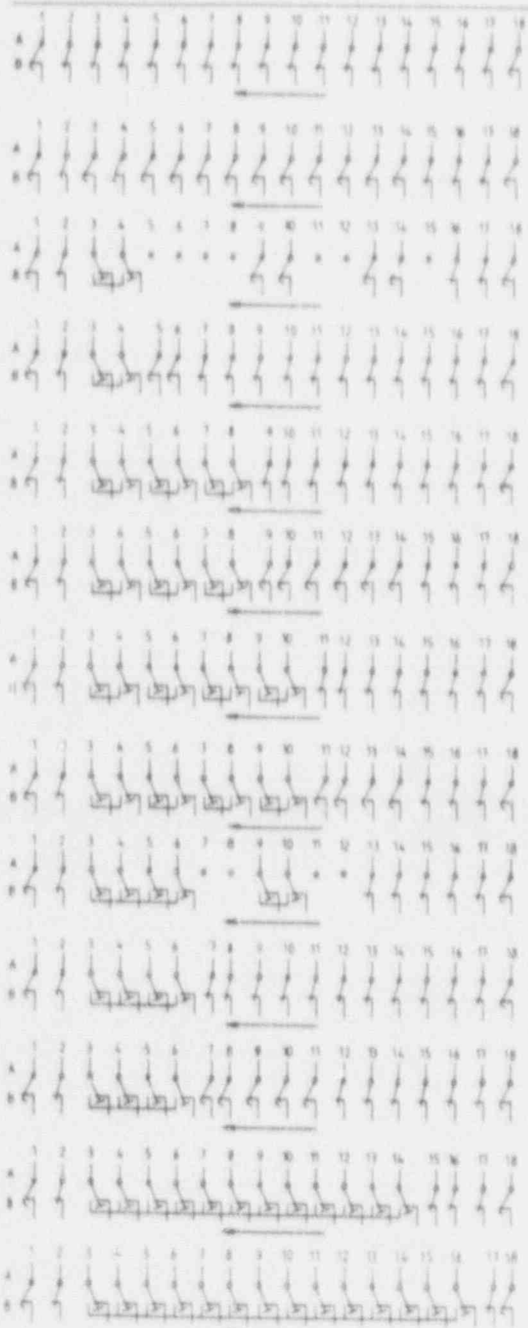
Test switch RTXP 18

Contact functions

Blocking of trip circuit

Short-circuiting of current circuit

Opening of voltage circuit

Symbol	Ordering no
	RK 926 003-AN
	-AR
	-AC
	-AP
	-BG
	-AS
	-BF
	-AD
	-AX
	-AV
	-AH
	-AM
	-BH

Marking piece for function designation symbols (visible when test switch door is opened)

Symbol	Significance	Ordering no.
Unmarked		RK 926 0201
+	Positive terminal	0202
−	Negative terminal	0203
+ ~	Positive terminal or ac voltage	0260
− ~	Negative terminal or ac voltage	0261
~	ac voltage	0271
RI	Phase current	0204
SI	in each	0205
TI	respective phase	0206
NI	Neutral current	0208
I	Current	0210
I_d	Differential current	0219
RI_d	Differential current	0220
SI_d	in each	0221
TI_d	respective phase	0222
RU	Voltages in	0223
SU	three-phase	0224
TU	systems	0225
NU	with neutral	0227
U	Voltage	0229
U_1	Voltages in	0230
U_2	different stages	0231
U_3	or levels	0232
□	Various, e.g. signal + outgoing blocking	0265
⊗	Tripping	0266
○	Closing	0267
↑*	Raise	0268
↓*	Lower	0269
☼	Influence of external factors e.g., blocking or deblocking	0270

Test-plug handle RTXH 18	RK 926 011-AB
Leads for test-plug handle	
Black	RK 926 013-AD
Red	RK 926 013-AC
Trip-block plug RTXB	RK 926 005-AC
Ammeter test plug RTXM	RK 926 006-AA
Block-plug handle RTXF 18	RK 926 007-AB

Extension bases with terminal base

RX 1	RK 924 035-AA
RX 2H	RK 924 035-AB
RXY	RK 924 0215

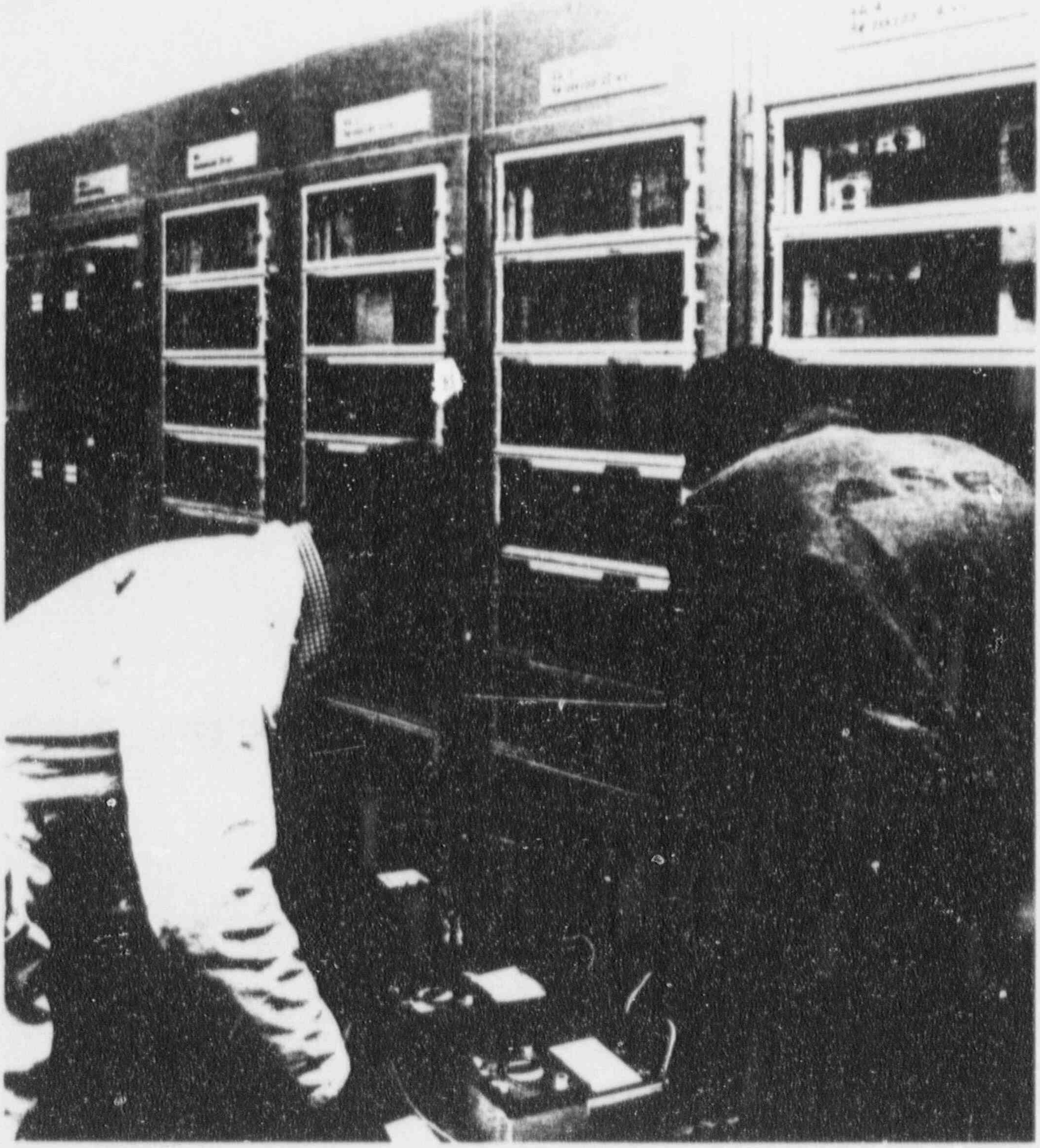
Reference

Buyer's Guide	No
Tools	B03-9550E
Mounting and connection	B03-9301E

Information RK 926-100 E
Edition 2 April 1980
File RK 00-90 E Section 9

ASEA
Relay Division

INSTALLATION, TESTING AND MAINTENANCE OF RELAYS



(771172)

ASEA

LIST OF CONTENTS

LIST OF ILLUSTRATIONS RK 926-100 E

GENERAL

This information deals with handling and maintenance testing of relay units and protective relays composed by the most common types of ASEA auxiliary, time-lag, current, voltage and directional relays. Testing of other types of more complex protective relays and protection schemes are described in separate testing and commissioning instructions.

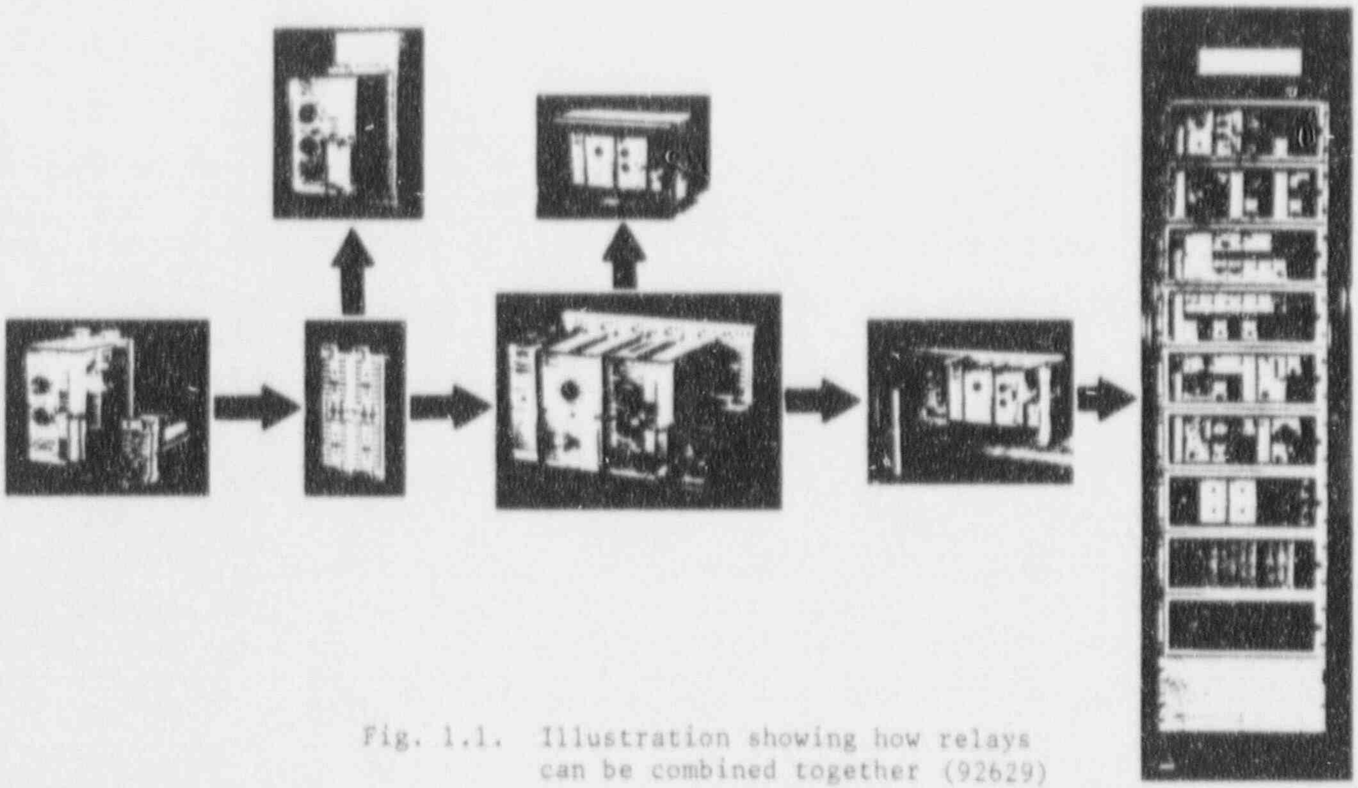


Fig. 1.1. Illustration showing how relays can be combined together (92629)

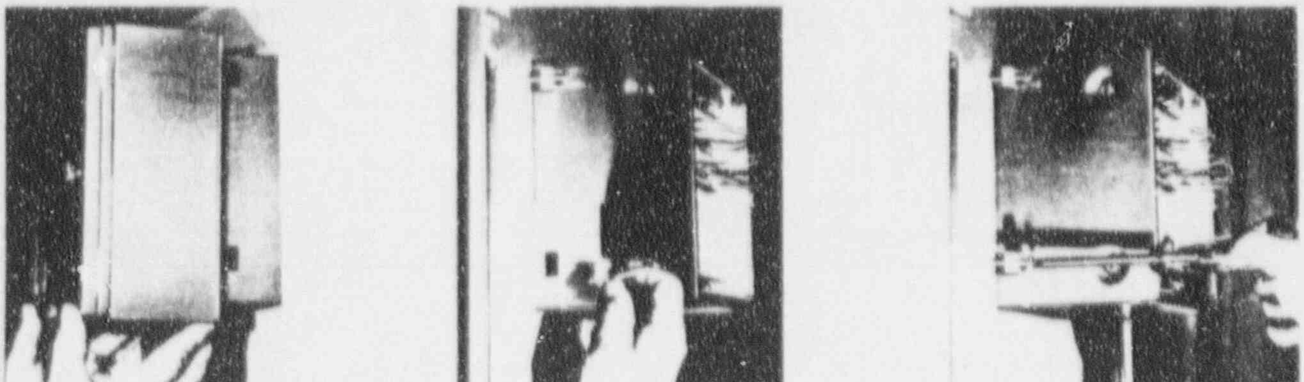


Fig. 1.2. Installation of a RHGX case in a panel (790900, 790898, 790899)

INSTALLATION

Receiving, handling and storage

Upon receipt the relay should be inspected for any physical damage. It is recommended that the relay is kept in its shipping carton until it is installed. The place where the relay is stored should be dry and free from dust and should have normal room temperature.

Humidity protection

When a relay cubicle is located a longer period of time in an unheated control room with a relatively high humidity, for example in a new installation, and without being taken into service, the cubicle should be equipped with a heater which is connected in immediately. When the relays are in service, sufficient heat is generated in the cubicle by the relays.

Mounting

The relays are normally installed in apparatus cubicles with equipment frames. Fig. 2 and 3 show how an equipment frame is mounted and attached with four screws d .ivered with the equipment frame.

Fig. 2. Mounting of an equipment frame in a cubicle. (94540)

Fig. 3. Attaching an equipment frame to a cubicle by screws. (94538)

When a protective relay is installed in an equipment frame, it is attached from the rear by threading screws, type B6 x 9.5 (No. 2124 2011-279), see Fig. 4.1.

The screw is to be inserted through a hole in the support frame anu fastened in the apparatus bar of the protected relay.

The number of screws n and their positioning is determined by the width C and illustrated in Fig. 4.2. Sufficient number of screws are delivered with the protective relay.

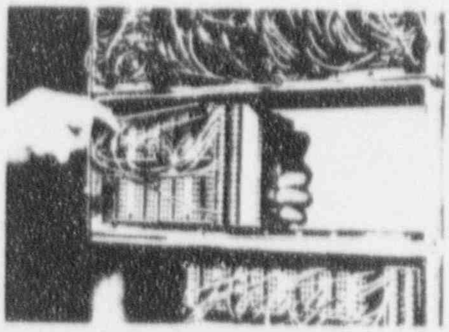


Fig. 4.1. Attaching a protective relay in an equipment frame (94531)

Fig. 4.2. Pattern for the positioning of the rews

Plug-in relays are inserted in a terminal base and attached by screws. The terminal base is screwed on apparatus bars, see Fig. 5 and 6.

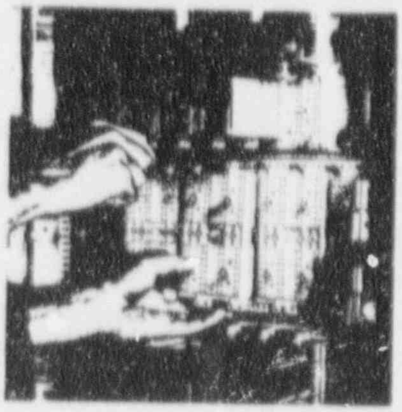


Fig. 5. Mounting of a terminal base. (94535)

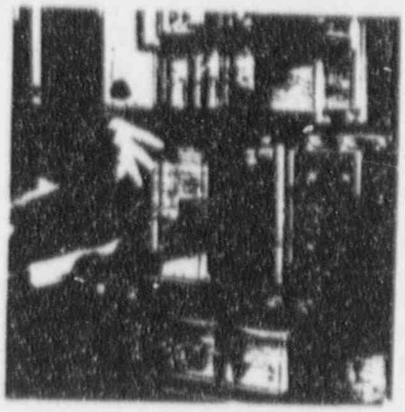


Fig. 6. Attaching a plug-in relay to a terminal base. (94541)

Single relays Fig. 7.1 may also be inserted in a panel base type RXZ 21 or RXZ 41. These bases have space for terminal blocks for screw connection of single-core leads Fig. 7.2. The panel base is to be mounted on a wall or a panel.

The connections between the socket terminals and the screw terminals are made with leads equipped with sockets on one end and stripped on the other end

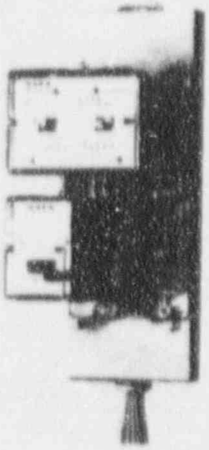


Fig. 7.1 Plug-in relays in a panel base type RXZ 41. (99176)

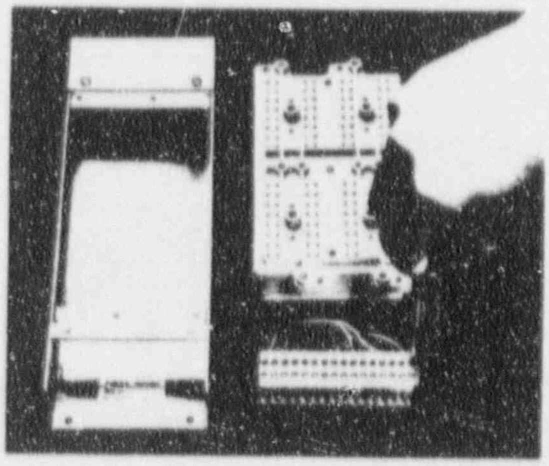
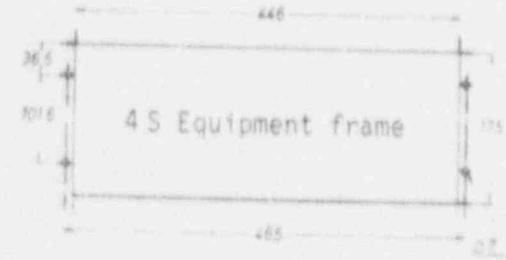
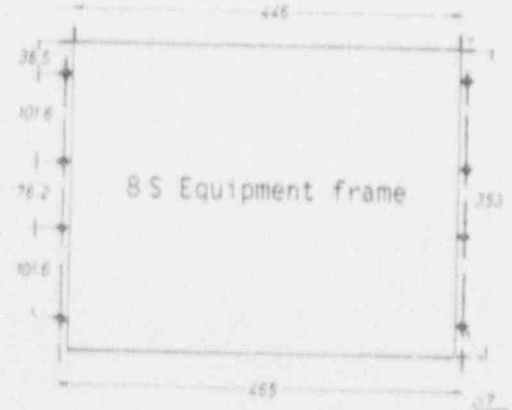


Fig. 7.2 Connecting leads in a panel base type RXZ 41 for front screw connection. (99586)

The leads are obtainable in the lengths 100 mm and 180 mm as standard and ordered from cat. RK 92-10 E.

Protective relays and other sets of apparatus can, instead of being mounted on 19" racks in apparatus cubicles, also be installed on a panel, either directly on the panel or in equipment frames or in relay cases type RHGX, which then are attached to the panel by screws. The mounting procedure is the same as described above. The necessary cutouts and panel drilling are done according to Fig. 8, 9 or 10. By using fixed distance of 56 mm between the holes in Fig. 9, future modifications are facilitated during the installation. By removing the peace of sheet metal between the cutouts for two RHGX 4 cases, an RHGX 12 case will fit in the new larger hole.





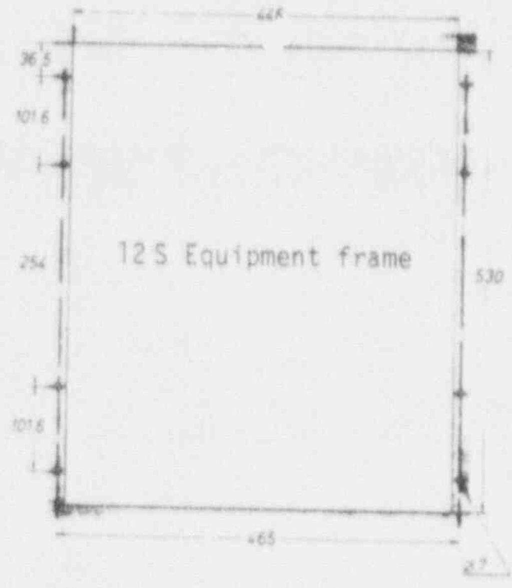


Fig. 8. Cutouts and drilling plans for panel-mounted equipment frames (dimensions in mm)

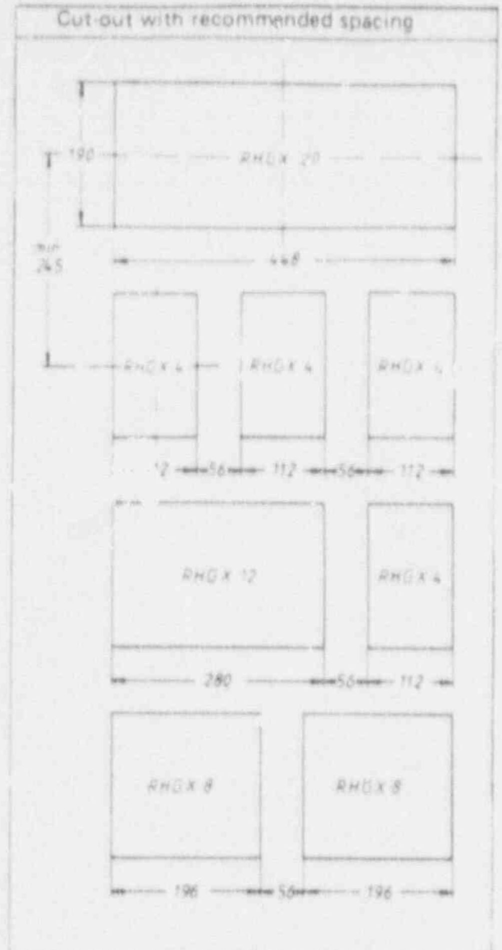


Fig. 9. Cutouts for relay cases in a panel
(dimensions in mm)

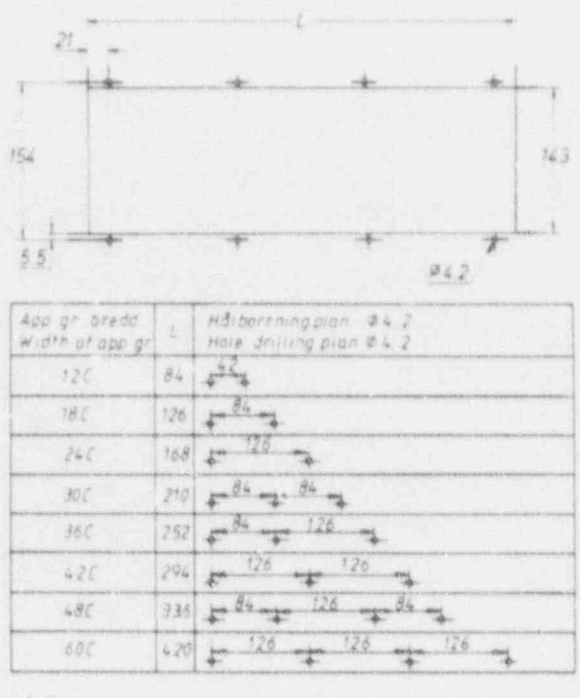


Fig. 10. Cutouts and drilling plans for protective relays on apparatus bars for mounting directly on a panel (dimensions in mm).

Electrical connection

The connections are made with socket-equipped leads. The leads should be pushed into the terminal holes until a "click" can be heard confirming that the locking clip in the terminal base locks the lead in correct position. No screws or soldering is required for the connection. If a lead should be removed, a special extractor type RTXD according to Fig. 11 should be used.

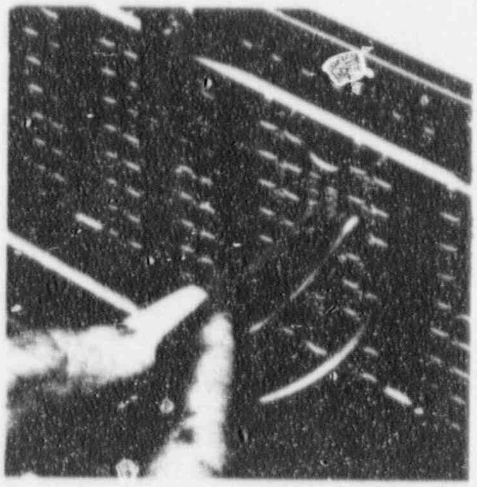


Fig. 11. Removal of a socket-equipped lead using an extractor type RTXD.

Catalogue RK 92-10 E describes the principle for the connections. The catalogue also lists ordering data and Cat. No.'s for ready-made socket-equipped leads of different lengths and versions. It is also possible to attach terminal sockets to leads with a special contact crimping tool. Fig. 12 and 13 illustrate how a lead is stripped and how a terminal socket is crimped on the lead. The tools used are included in the tool-box which is described on page 30.

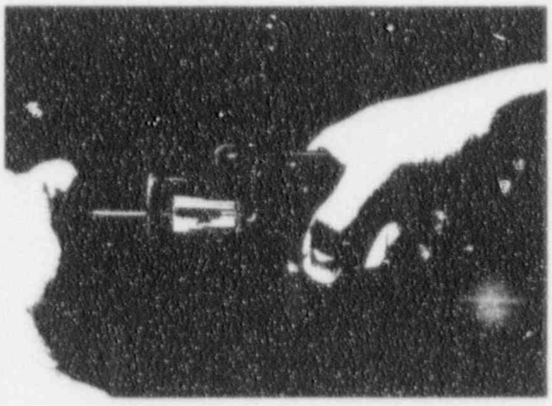


Fig. 12. Stripping a lead. (91816)

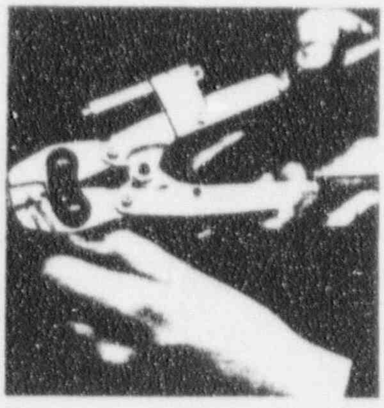


Fig. 13. Contact crimping of a terminal socket on a lead. (95977)

Short-circuiting connector

A short-circuiting connector type RTXK is always delivered together with measuring ac relays and the supply to such relays must always be done over the short-circuiting connector. The connector is mounted at the rear of the terminal base according to Fig. 14.

Fig. 14. Mounting of short-circuiting connector RTXK. (94536)

Shunt connector

Measuring relays for current supplied from a shunt are connected in over a connector type RTXI as short-circuiting of the supply circuit is not desired when the plug-in relay is withdrawn from its terminal base. This shunt connector is mounted in the terminal base in the same way as shown in Fig. 14. Fig. 15 and 16 illustrate the difference between the two connectors.

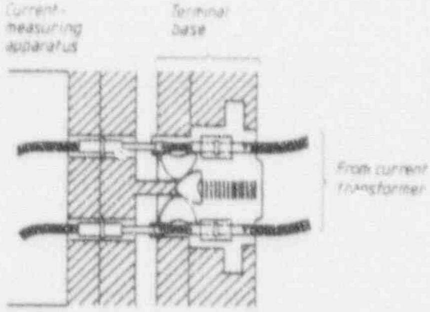


Fig. 15. Connection over short-circuiting connector RTXK.

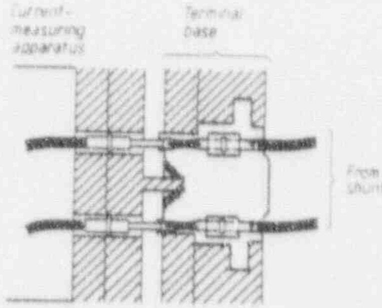


Fig. 16. Connection over shunt connector RTXI.

Indicating flag, locking strip

Certain protective relays are, when delivered, equipped with some or all indicating flags blocked. The indicating flags that should be blocked, are illustrated by the symbols in the circuit diagram of the protective relay, see Fig. 17.

Symbol for blocked flag

Symbol for flag without blocking. The indicating flag is reset manually

Fig. 17. Circuit diagram symbols for indicating flags.

When a current relay type RXIG 2 or a voltage relay type RXEG 2 is used as a minimum relay, the flag should always be blocked. The flag-locking strip is removed or mounted according to Fig. 18.

When mounting the flag-locking strip, its top end (A) is inserted in the second indicating hole from the bottom of the flag holder and i pushed upwards until the other end (B) of the strip is snapping into the lowest indicator hole.

When removing the strip, its bent part (C) is pulled and then the strip is pushed downwards.

Fig. 18. Removal and mounting of an indicating flag-locking strip.

MAINTENANCE TESTS

General

Before a relay or a protective relay is delivered from ASEA, it has, in the manufacturing process, been subjected to several careful tests. All types of relays and their integral components have been subjected to extensive laboratory testing during the development and design work. Prior to series production of a specific relay, it is typetested according to national and international standards. Each individual relay is in normal production individually tested and calibrated and checks are done so that its function and data correspond to specified characteristics and technical data. A protective relay composed by various plug-in modules is functionally tested through its test switch before delivery. Protective relays installed in an apparatus cubicle are checked in various ways before shipment.

Maintenance tests - why?

There are great demands on protective relays with regard to performance, operating time, etc. Therefore, it is necessary to, at regular intervals, perform maintenance testing. Maintenance testing is a secondary test where the following checks are done:

- o if the protective relay operates at set operating value
- o if releasing and blocking functions are in order
- o if alarm and indication are obtained

Maintenance tests - how often?

How often the tests should be performed depend on several factors, for example the importance of installation, environment conditions, simple or complex equipment, static or electromechanical relays. Normally, protective relays are maintenance tested each or every other year.

Maintenance tests - how?

If the protective relays are equipped with test switches of type RTXP 18, they can be tested without any hazard to the equipment in service. However, please do observe that the protective relay cannot operate in its normal manner during the time the test is performed. Should a fault occur, a backup protective relay will operate instead. If the protected object can be taken out of service during the testing, this disadvantage can be avoided and it is then possible to test the complete circuit with all associated apparatus.

Test reports

It is important to keep accurate equipment reports, test reports, and relay setting reports to be able to:

- o compare with preceding tests if there has been any change of the operation of the protective relay
- o observe how long time has passed since last testing and plan when the next testing should take place
- o see if the protective relay has changed, for example if some relay units have been exchanged
- o to see when and how the setting of the protective relay has changed

After larger service disturbances, those reports are valuable when analysis of the disturbances should be done.

Inspection

Before a protective relay is tested, it should be inspected. It is then recommended to check if the protective relay or the relay units have any visible faults, if there are deposits or contaminations inside the cover, or if there are any burnt contacts. If necessary, dust should be removed from the covers. If the covers are to be removed, dust removal must be done in advance so that stirred up dust will not fall down into the relays.

Connections for test

Before a protective relay is tested, the tripping circuit should be blocked, current and voltage circuit should be opened and the protective relay should be isolated from other equipment in the installation. This must be done in a sequential order without any interference of the operation of other protective relays and equipment in the installation. The necessary internal reconnections of the circuits for the testing are in ASEA protective relays performed when the test-plug handle is inserted in the test switch. See Fig. 19. When this is done, all in- and outputs of the protective relay are available for connection to the test equipment.

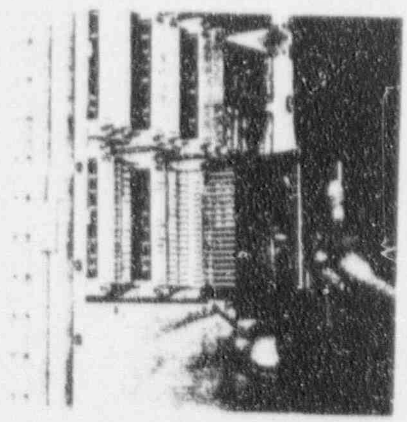


Fig. 19. Insertion of test-plug handle type RTXH 18 in test switch RTXP 18. (89393)

The relays should be tested in their normal working positions, that means plug-in relays inserted in their terminal bases and with their covers fitted. The test-plug handle should first be connected to the test equipment. Instructions on how the connection should be done can be seen from the circuit diagram for the protective relay and from the function markings on the contact units in the test switch.

The connections are then checked and the current and voltage sources are regulated down to zero and the test equipment is switched in to its supply. The test-plug handle is then inserted in the test switch and the test can start. When testing static relays, the auxiliary voltage should have been connected to the protective relay at least ten minutes before th measurements start.

If for example several three-phase overcurrent relays should be tested, it is recommended that a switch with the positions O-R-O-S-O-T is connected between the test-plug handle and the test equipment. This should be done in such a way that when the switch is in position R, current is supplied to the protective relay through the handle plugs 3-4, in position S through 5-6 and in position T through 7-8. The switch facilitates the testing since one phase after another can be tested in the protective relay without any changes of the connections. After testing one protective relay, the test-plug handle is just moved to the next protective relay of the same type and the testing can immediately start again. No reconnections are necessary.

All-or-nothing relays

These relays pick up, sometimes after a possible delay, when they are connected in to the rated voltage and drop out, after a possible delay, when the voltage is interrupted.

Auxiliary relays and time-lag relays for voltage are when delivered, adjusted to operate securely down to 80 % of the rated voltage indicated on the rating plate even if the relay has regular service temperature. The relays can withstand continuous supply up to 110 % of rated voltage. If the rated voltage is indicated with a range, for example 110-125 V, the operating range 80-110 % is applicable to each voltage within that range.

Auxiliary relays for current supply should pick up for the current indicated on the rating plate.

A regular operational check is recommended also for auxiliary relays and time-lag relays already in service. The check can generally be simple. Auxiliary relays are checked that they pick up when connected in to 80 % of the rated voltage and drop out when the voltage is interrupted (at ac) or by slowly regulating the voltage down to zero (at dc).

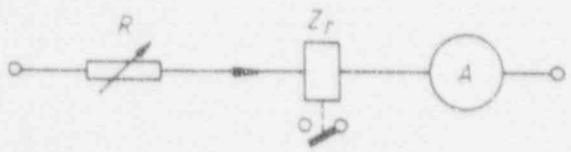
The voltage is momentarily connected in and momentarily interrupted for time-lag relays and the operating time is checked.

In installations where the voltage limits are critical, a more accurate check is advisable and it should be investigated that the pickup and dropout values do not diviate too much from the values of new relays.

DC relays and ac relays supplied over rectifiers have a somewhat higher pickup value when warmed up during regular service due to the increase of resistance of the coil. Directly supplied ac relays have insignificantly changed values when warmed up during regular service. The dropout value should be larger than 5 % of rated voltage. If it is considerably lower, there is a danger that the relay will be sticking in the near future (the relay will remain in its pickedup position due to remanence although the voltage has been interrupted). In addition, tests should be carried out on ac relays by interrupting the voltage instantaneously since the risk for remanence sticking is greater than when the voltage is slowly reduced.

Measuring relays

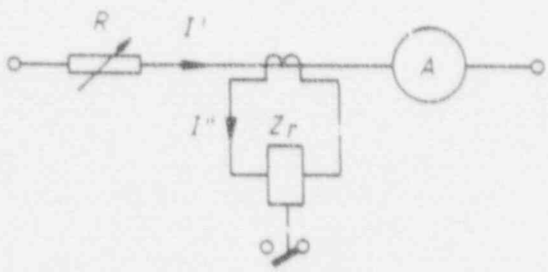
CURRENT RELAYS should be supplied over a large series resistor (at least 10 times the impedance of the relay). See Fig. 20.



$R > 10\,Z_r$

Fig. 20. Supply of a current relay.

If a high current is required, a current transformer can be used as illustrated in Fig. 21. The permissible burden of the current transformer must not be exceeded.



$R > 10\left(\frac{I''}{I'}\right)^2 Z_r$

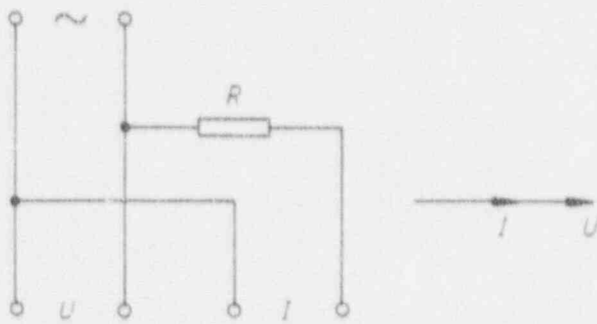
Fig. 21. Supply of a current relay via a current transformer.

Electromechanical relays often have a temperature dependence. The supply should therefore be regulated up to the pickup value and down to the dropout value within a shorter period of time than 10 s. The movement of the relay should be checked that it is distinct and that its operation is not slowed up in any mid-position, for example when a contact is making or breaking.

VOLTAGE RELAYS should be supplied from a variac or a low resistance potentiometer. Check on the voltmeter if the voltage is influenced by the pickup action. If the voltage does not correspond to the increase of the variac, the voltage source is not sufficiently strong.

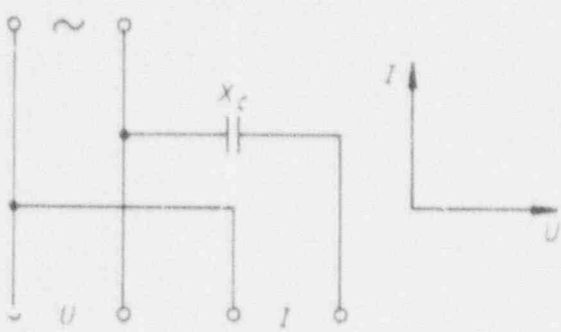
DIRECTIONAL RELAYS have an operating value that must be tested with a certain phase angle between current and voltage. The phase angle should be approximately as large as the characteristic angle of the relay. However, a diviation of $\pm$ 20° can be tolerated since the measuring error only will be 6 % (cos 20° = 0.94). If an angle error is compensated, it is possible to tolerate even larger diviations. That means that all types of single-phase power directional relays can be tested with a simple test set without phase shifters.

The phase angle 0° is obtained by connecting the current circuit via a series resistor to the voltage that supplies the voltage circuit. See Fig. 22. The phase angle 90° is obtained by connecting the current circuit via a capacitor to the voltage that supplies the voltage circuit. See Fig. 23. Certain other phase angles can be obtained by connecting the current and the voltage circuits in different ways in a symmetrical three-phase system. See Fig. 24.



The current is approximately in phase with the voltage (phase angle 0° between current and voltage) if the resistanc R is 10 times larger than the impedance of the current coil.

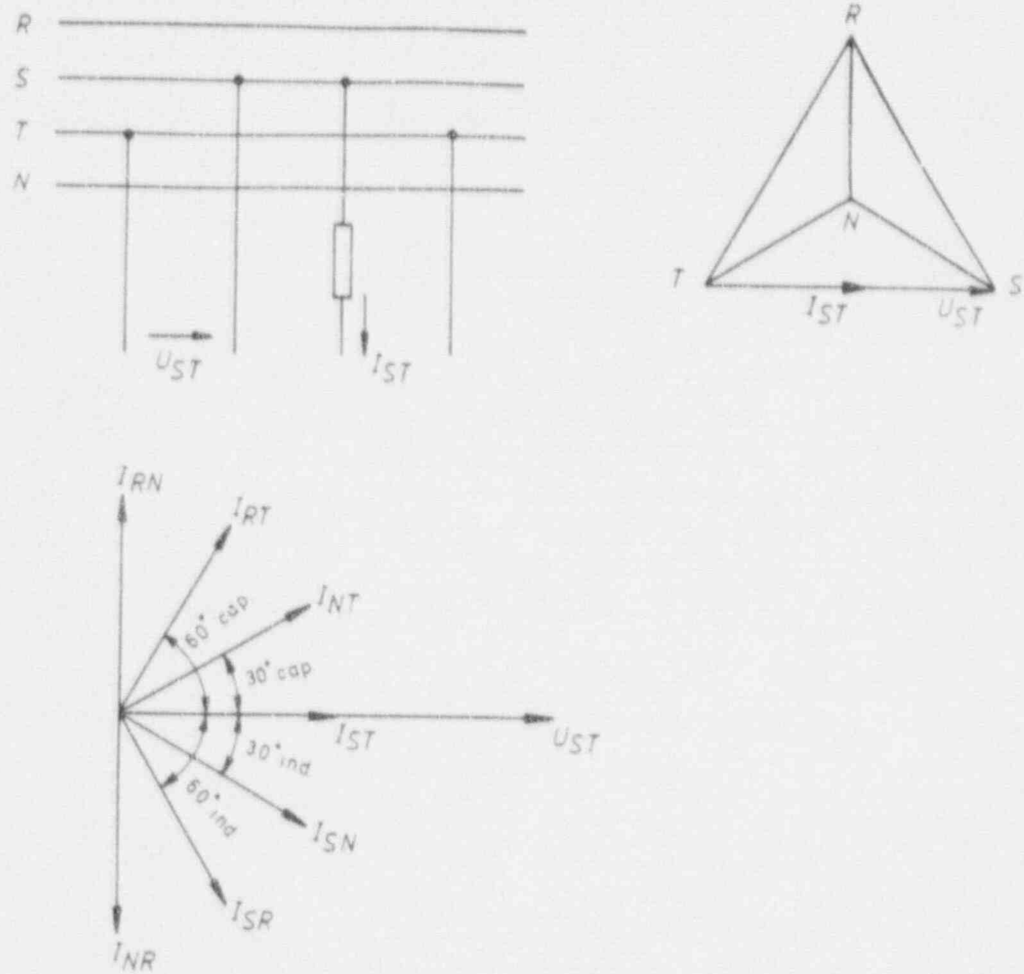
Fig. 22. Connection to a single-phase circuit to obtain 0° phase shift.



The current leads the voltage with approximately 90° if the reactance $X_C = \frac{10^6}{2\pi f \times C}$ ohms is 10 times larger than the impedance of the current coil (C = the capacitance in uF)

Fig. 23. Connection to single-phase circuit to obtain 90° phase shift.

ASEA



Phase angle	With the voltage circuit connected to U_{ST}, the current cirucit is connected to
90° capacitive	R - N
60° capacitive	R - T
30° capacitive	N - T
0°	S - T
30° inductive	S - N
60° inductive	S - R
90° inductive	N - R

Note 1. It is presupposed that the three-phase system is symmetrical even with the load connected. This can be checked by for example measuring the three voltages between lines.

Fig. 24. Connection to a three-phase system to obtain different phase angles between current and voltage.

REGULATING RELAYS should often operate for very small current changes. Therefore, it is usually necessary to use a constant voltage source to be able to check those current changes. It is also necessary to check that the constant voltage source supplies an alternating voltage which has a good curve form. These relays MUST be tested in service-warm condition with the cover fitted.

Operating times

Operating times can be checked in different ways depending on how long operating times are required to be measured. A stop watch is generally used for checking long times, longer than 1 minute. An electrically operated watch with a synchronous motor or of spring type is used for shorter times.

When operating time checks are made with the relay testing set type TURE, AEGs "Sekundenmesser" is usually used. It is started and stopped by relays included in the testing set TURE. When there are times shorter than approximately 100 ms, special time recorders should be used. It is then necessary to take into consideration the operating times of possibly used automatic euqipment for starting and stopping.

Relays with inverse time lag are checked at 2-3 points, suitably 2, 4 and 10 times set current. Relays with independent time lag are checked with a current which is twice the set value.

If the relay has an instantaneous function, this function should be checked at the set value. The test must be done rapidly to prevent that the relay and the testing equipment will be overheated.

Time-lag and auxiliary relays to be checked with regard to operating times, should be supplied with rated voltage. Overcurrent relays are suitably supplied with three times the set operating value, but overvoltage relays are supplied with 1.3 times set operating value. The time for undercurrent and undervoltage relays are measured at instantaneous decrease of the actuating quantity to zero.

Thermal relays with a large time constant, should be checked at a constant ambient temperature and the current should be very carefully maintained constant. As a rule, this is often very difficult to obtain when checks are made at site in an installation, therefore small deviations in the operating times ususally are obtained.

Measurement of service currents

After a check it is recommended to measure the service currents and service voltages that the protective relay obtains. The red trip-block plug type RTXB should first be used to block all tripping circuits. The current measuring plug RTXM, Fig. 25, with built-in overvoltage protection, is connected to an ammeter and is inserted in the test switch. The plug can easily be moved between the different phases and different service currents can rapidly be read.

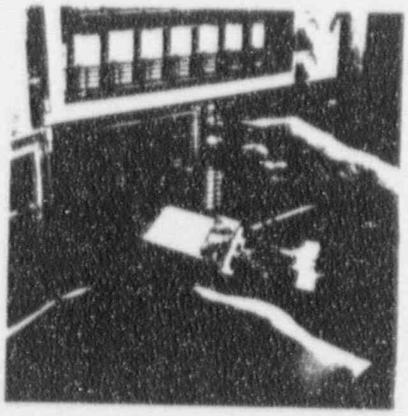


Fig. 25. Measurement of service current. (94537)

The zero-sequence current to earth-fault protective relays should be measured. The current amounts normally to just a few milliamperes so it is possible to see if the current circuit is "alive".

The neutral-point voltage to an earth-fault relay is checked with a voltmeter. The tips of the test leads are put directly against the contacts in the appropriate contact units of the test switch. The voltage is normally 0.1 to 1 V. However, voltage can be considerably higher due to harmonics if current convertors are connected to the network.

Check of the tripping circuit

When the protective relay is given an operational check, a tripping pulse is obtained on the contact No. 17 of the test switch. It is possible to check that contact 17 really is closed when the test-plug handle has been removed by using a voltmeter and measure between contact 1 and the right side of contact 17. The measurement is then done through the tripping magnet of the circuit breaker and therefore the complete tripping circuit is checked. Please observe that the test system does not have its built-in security during this test. If the instrument should be set on Amp instead of Volts, the circuit breaker naturally is tripped, therefore, greatest care is necessary.

Example on a periodic maintenance test of a protective relay

The example below describes how a three-phase delayed overcurrent relay is tested. See Fig. 26.

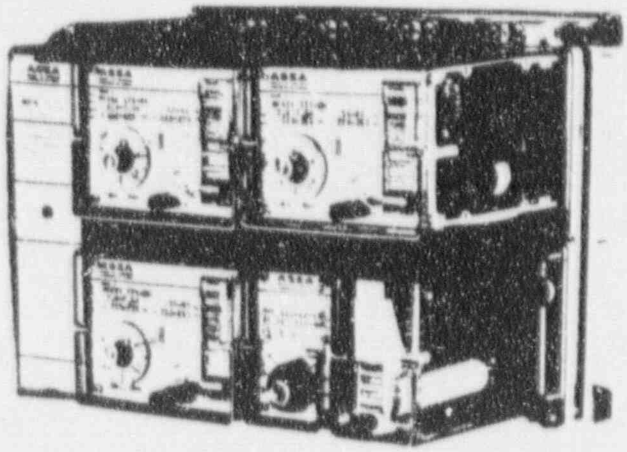


Fig. 26. Three-phase delayed overcurrent relay. (95403)

Begin by inspecting the relay. Check if the relay has any visible physical damages. The cover holes for the setting knobs should be fitted with plastic plugs. The settings should be checked for the different scale knobs that they correspond to the relay report. See Fig. 27.

Relay Data				Scale				Setting				Testing Data: Operating value							Time measurement				Remarks
Protected object / Protective relay	Current transf.	Ø	Relay type	Voltage Volts	Current Amp	Time Sec	Inst trip Times set value	Voltage Volts	Current Amp	Time Sec	Inst trip Times set value	Start current Amp	Pick up Volts	Pick up Amp	Drop out Volts	Drop out Amp	%	Inst trip	Time set value	Recorded time Sec	Time set value	Recorded time Sec	
3-phase		R	RXIG		1-3				2					2.02		1.96	97						
delayed over-		S	RXIG		1-3				2					2.00		1.96	98						
current		T	RXIG		1-3				2					2.00		1.94	97						
relay			RXKB			0.1-3				1.5										1.5			

Fig. 27. Example of a maintenance test report.

Then the testing equipment is connected according to Fig. 28. Check on the circuit diagram for the protective relay and on the terminal markings on the test switch to which terminals on the test-plug handle the different test leads should be connected.

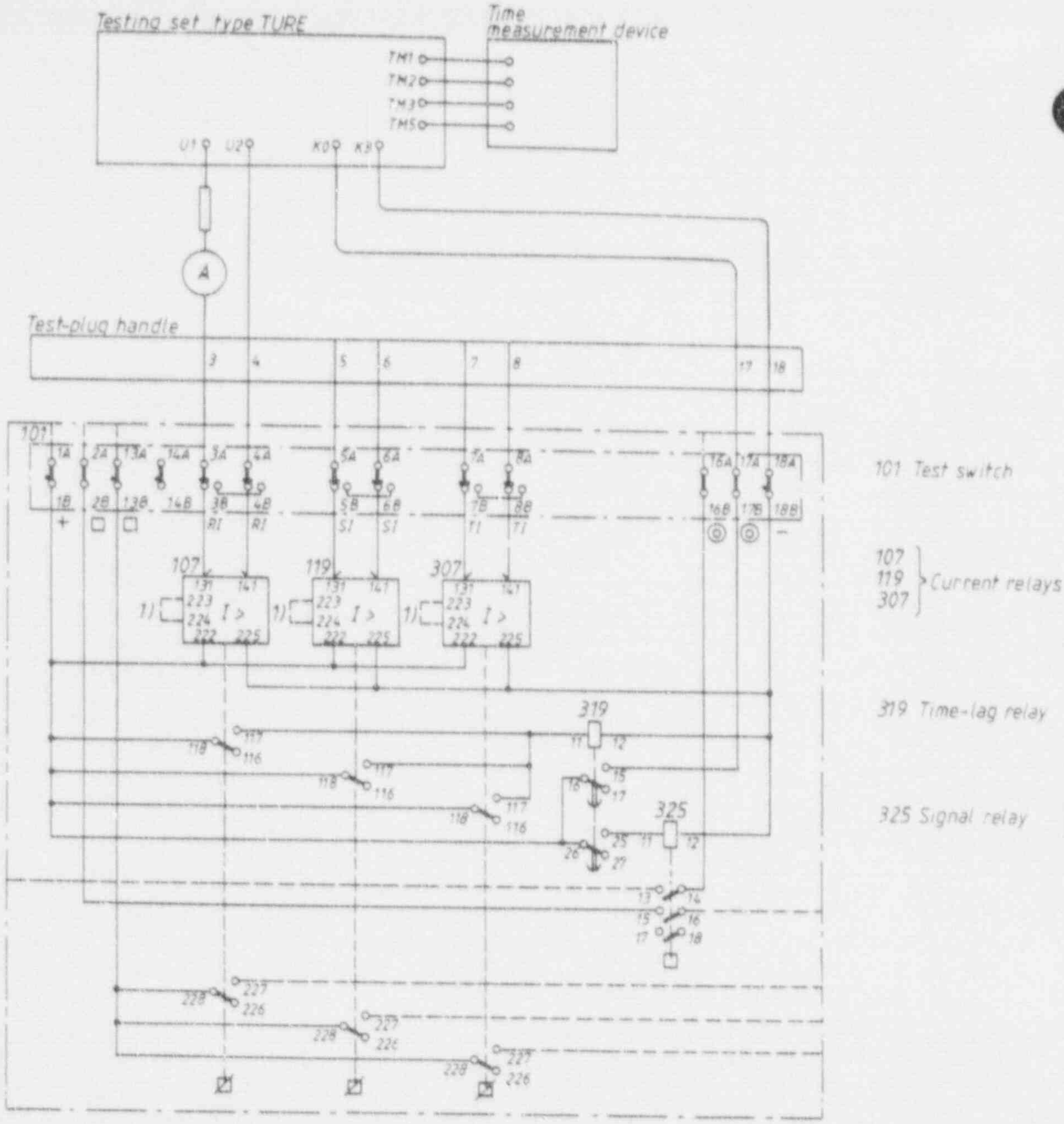


Fig. 28. Connections for testing.

Then turn down the knob for the current regulation to zero. Insert the test-plug handle in the test switch and close the main breaker of the testing set. First the operating values of the three current relays should be tested. Press the ON-button and increase slowly the current until the relay picks up. Then decrease the current until the relay drops out and record the operating value as well as the resetting value. Repeat the check once more to check if it is not too large a dispersion of the value and then write the result in the relay report.

The test is then repeated for the two other current relays after that the test leads in the test-plug handle terminals 3 and 4 has been moved to terminals 5 and 6, and 7 and 8, respectively. To make the check easier, it is possible to connect in a switch between the testing set and the test-plug handle which is described in the section "Connection for tests" above.

The operating time should then be checked. Turn up the current to the protective relay to approximately 3 times the operating value and then interrupt the current with the OFF push button. Check that the time-measurement device is in its zero position and that the switch d on the testing set TURE is in position M. When the ON push button is pressed, a relay in TURE starts the time-measurement device and at the same time the current relay picks up and starts the time-lag relay. When the time-lag relay picks up, a signal is supplied via terminal 17 in the test switch to a relay in TURE which stops the time-measurement device. The signal relay picks up simultaneously and indicates that a tripping pulse has been obtained. Read the time on the time-measurement device and check if the indicating flag of the signal relay has dropped. Repeat the test once more and write the result in the test report. The operating time is necessary to check just for one of the current relays since it is the same time-lag relay for all three current relays. When the operating time has been measured, the test is over. Put the TURE main switch in the OFF position, remove the test-plug handle and reset the indication.

Testing of separate relays

A special testing base is available for testing of separate relays. It consists of two parallel connected terminal bases. The relay to be checked is inserted in one of the bases and the currents and voltages required for the test are connected to the other terminal base, see Fig. 29. The testing leads to be used should be equipped with COMBIFLEX®-pins in one end. The toolbox for connections and testing, which is described on page 30, contains such leads.

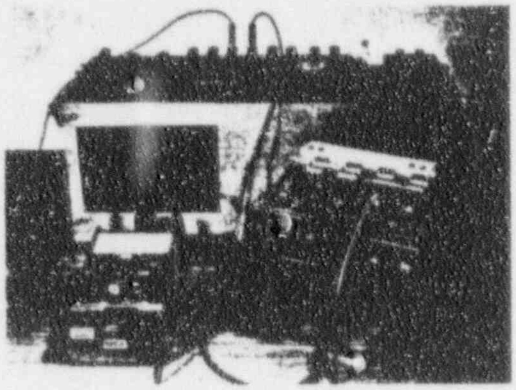


Fig. 29. Testing of a relay. (94532)

TESTING EQUIPMENT

Instruments

The instruments used should be of good accuracy class and they should have been tested at regular intervals. The so-called universal instruments are normally used. Such instruments usually have a built-in rectifier. Please note: Should harmonics be present, a moving coil instrument should be used.

The highest possible current scale, which gives a readable value, should as a rule be used, especially when measuring low currents, since the internal resistance of the instrument increases very much at low scale ranges. If an unnecessarily low scale is used, the current conditions in the circuit can be changed so much that the measured values are useless. To judge if the measured value can be relied upon during a test of sensitive protective relays, it is necessary to judge if the internal resistance of the instrument influences the measured value. Data about the internal resistance of the instrument at different scales can be obtained by the manufacturer of the instrument. Other resistances of the circuit are calculated or estimated with the aid of the power consumption of the relay and the current scale. The additional resistance

$Z_r = \frac{VA}{i_r^2}$, where VA is the volt-ampere consumption of the relay

and i_r is the lowest settable value on the current scale. If the impedance of the instrument is just 10-15 % of Z_r, no serious measurement faults are caused.

AEGs "Sekundenmesser" type S1 is recommended to be used as a time-measurement device. It is graduated with scale marks of 1/100 s. However, there are other makes available with the corresponding graduation and accuracy as well as electronic time-measurement devices.

Apparatus for connection checks

When checking the connection of a protective relay with static relay units, such apparatus that can cause harmful overvoltages are not allowed to be used as these voltages can destroy the electronic components in the relay. There are harmless apparatus for connection checks available on the market.

Static relays are not allowed to be impulse tested or insulation tested with for example a megger. The relays should be disconnected if cables and other connections should be insulation tested.

Relay testing sets

ASEA produces several types of relay testing sets. The choice of suitable test sets depends first on which type of tests should be performed, secondly which type of relay or protection scheme should be tested.

All available testing sets are described in separate Informations according to the list below:

Information	Typ	Application area
RK 90-101 E	TURE	Secondary testing of relay units and protective relays
RK 90-102 E	TURB	Secondary testing of distance relays
RK 90-103 E	TURG 1000	Primary testing of current transformers and relays connected to the CT's
RK 90-104 E	TURF	Testing of frequency relays
RK 915-300 E	TURH	Secondary testing of distance relays and other types of relays

MAINTENANCE

General

Since almost all ASEA protective relays contain just static relay units, except auxiliary relays, no special maintenance is required for the relays. It should be checked that all relays are equipped with their covers and the holes for the setting knobs are fitted with plastic plugs.

Polishing of contacts

Should burnt contacts be observed when inspecting the relays, a diamond file or an extremely fine file can be used to polish the contacts. Emery cloth or similar products must not be used as insulating grains of abrasive may be deposited on the contact surfaces and cause failure.

Tools

A toolbox is available for connection work and testing, see Fig. 30. The box contains for example screwdrivers, stripping tool, contact crimping tools, and certain parts of the testing system COMBITEST. The box is described in Catalogue RK 92-10 E.

For overhaul and adjustment of relays, a toolroll is available. The toolroll is described in Catalogue RK 91-1 E.

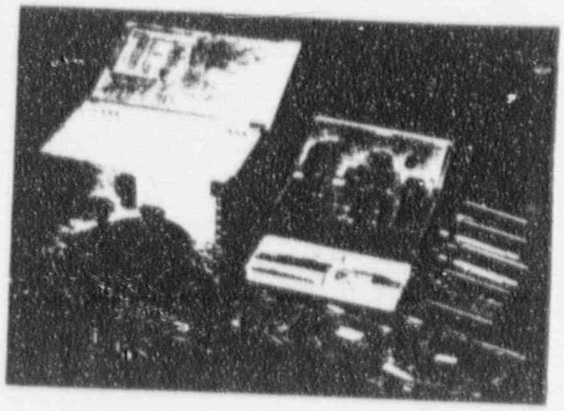


Fig. 30. Toolbox for connection work and testing. (91813)

REFERENCE PUBLICATIONS

Spare parts of type COMBIFLEX®	RK 92-10 E
Testing system COMBITEST	RK 92-11 E
Relay testing set TURE	RK 90-101 E
Relay testing set TURB	RK 90-102 E
Relay testing set TURG 1000	RK 90-103 E
Relay testing set TURF	RK 90-104 E
Relay testing set TURH	RK 915-300 E
Toolroll	RK 91-1 E

ASEA
Relay Division
S-721 83 VÄSTERAS, Sweden
Tel. + 46 21 10 00 00

Reg 560,740

ASEA

High Speed Phase and Ground Protection for Multiple-Winding and Auto Transformers

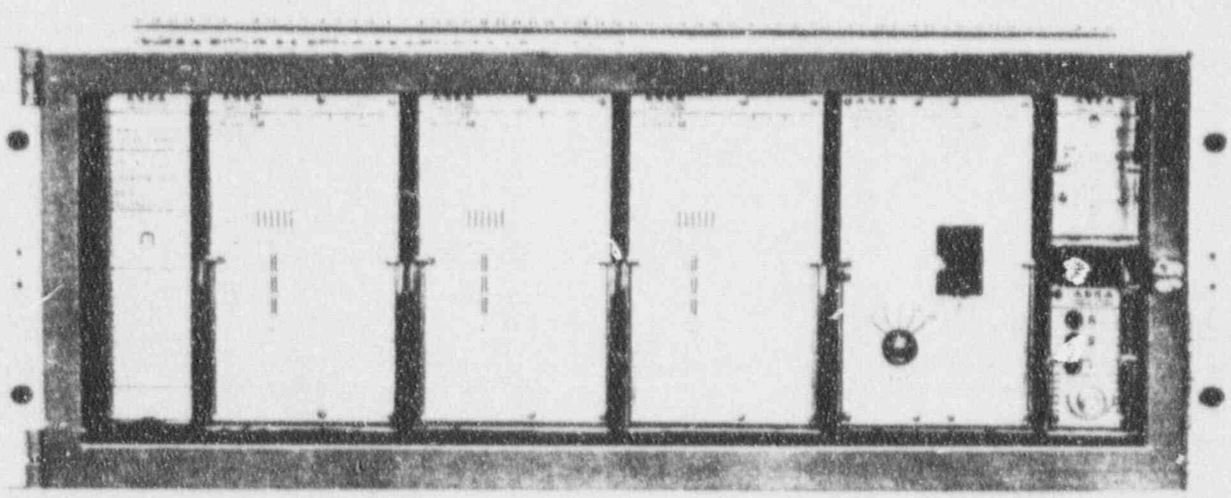


Fig. 25. Three phase transformer differential relay type RADSE

INTRODUCTION

The purpose of these Test Instructions is to augment the information in the Application Guide on acceptance and routine testing of the DSE. Generally the information in the AG is adequate for checking the performance of the DSE relay. The following instructions will deal with other aspects of startup testing and also provide more details on the individual components of the relay. These instructions are based on the user being familiar with the testing information in the AG and on the availability of the AG for reference to drawings and details provided in that publication. (Note: Figures numbered below 25 and Tables numbered below 10 are in the Application Guide, those figures numbered 25 and above and Tables 10 and above are in this Test Instructions.) These instructions contain adequate detail for servicing these relays. However, for those interested in a more complete explanation of the COMBIFLEX system and the method of marking, they can refer to Reference publications.

Reference Publications

a. Sales Information	62-10 SI
b. Application Guide	62-10 AG
c. Test Instruction (This publication)	62-10 TI
d. COMBIFLEX System	
Sales Information	92-10 SI
Application Guide	92-10 AG
e. COMBITEST System	
Sales Information	92-11 SI
Application Guide	92-11 AG
f. Accessories:	
(1) Auxiliary Relays RXMS 1	21-16 SI
Lock-out Relays RXMVB 4	25-10 SI

® Reg. trade mark

ASEA

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Changes from superseded edition

Over

Changes from superseded edition

Page 3. **STARTUP TESTING**, point 4a, new text: "4-8 kV showering arc test"

5. Item 9, first paragraph, new text: "Note that .... the rated value"

7. New paragraph: "Versions without .... measuring unit"

10. Table 14: revised values

11. Table 15: revised head and values

13. Item b: revised text

14. Table 6: revised values

2nd harmonic restraints: revised formula

15. **Inter-phase tests**, Item 7: revised text.

TEST INSTRUMENTS AND THEIR USE

The relay has been tested and calibrated using sine wave currents plus specific values of harmonics. The meters used for calibration are rms (not rectifier) type for ac measurements and true dc, moving coil, (averaging) type for dc measurements. It is essential that similar type meters be used in the field if reliable, consistent, results are to be attained.

When the rectified dc method is used as the source of 2nd harmonic, the formula given in the AG for calculating the amount of 2nd harmonic is based on reading the dc with a true dc ammeter (of moving coil type) as well as reading the ac with a true rms type ac meter. When a separate 2nd harmonic (or 5th harmonic) generator is used to supply the harmonic restraint current, its magnitude should also be measured with a true rms meter, accurate at that frequency.

DC voltages should be read with a 10,000 ohms per volt dc voltmeter with a true dc characteristic.

When insulation measurements are to be made it is prudent to use as low a voltage as feasible for the desired results. The relay has been production tested with voltages up to 2.5 kV, but such test voltages are **not** recommended for field testing. Any measurements made on the inter-module wiring should be at a voltage not to exceed that normally expected on that wire and from a high impedance source of at least 10,000 ohm/volt. In general, measurements on inter-module wiring beyond those given in the trouble shooting section are not recommended. Many of these circuits terminate in diodes and transistors. The results of measurements made on these circuits are the consequences of the test equipment characteristics as much as on the status of the circuit itself, and hence are meaningless and are not recommended.

STARTUP TESTING

There are no unusual requirements for commissioning a set of DSE transformer differential relays. However, in view of the several interrelated components, the following is offered as a guide.

1 General inspection: Inspect all name plates for proper ratings of equipment. Confirm the proper taps on main CT's and auxiliary CT's and correct voltage taps.

2 Current circuits connections:

a) Primary current injection: where CT ratios are low enough, using a low voltage source, apply a reasonable current in the primary circuit of each main CT. By means of an ammeter inserted into the various secondary circuits confirm the current wiring and ratios of each main and auxiliary CT.

b) Secondary current injection: As an alternate to the primary current test, insert current at each main CT secondary terminal in parallel with CT secondary.

c) These current tests do not check phasing or polarity of the CT's. Phasing checks are usually deferred until load checking. Polarity checks can be made with the dc "kick-test". Connect a dc voltmeter of a moving coil (not rectifier) type to the secondary of the CT, with the meter + on the polarity mark. Momentarily connect across the primary winding a dc voltage of 1 1/2 to 6 volts from a dry battery. With the battery positive to the CT primary polarity mark, the meter should kick up scale when battery is connected. It should go negative when battery is disconnected.

3 Inspect other wiring and compare with drawings provided with the transformers and relay for obvious errors or omissions. Depending on individual practices, circuit continuity can be checked with ohmmeter or by other methods. Any of these methods are suitable to check the proper functioning of the test switch and associated plugs for proper opening or shorting as indicated on the drawings.

4 Insulation tests: The DSE is production tested to 2–2.5 kV. In the field the current circuits are usually meggered to earth with 500 V max. This test can also be used to confirm that there is only a single protective ground on each current circuit. Confirm that each ground connection is restored correctly before proceeding to test another circuit. DC circuits are usually checked for grounds with a lower test voltage to avoid inadvertent damage to other equipment.

a) The DSE has been type tested with a 5 kV impulse, a 2.5 kV SWC test and a 4-8 kV showering arc test in addition to the noted dielectric tests. These type tests are usually not repeated in the field.

5 Trip circuit continuity tests: Manually operate the MS 1 output tripping relay by inserting a pin or small screw driver through the available opening in the cover. Confirm that the RTXP 18 test switch trip circuits are wired according to the appropriate diagram. Use the red trip-block plug RTXB (AG Fig. 8) to open the respective trip circuits in the RTXP 18 switch.

a) The MS 1 output relay may be electrically operated by applying the rated dc + voltage to terminal 143:222 on the rear of the TEE 4 module. (See Fig. 17a for physical location).

b) Using the RTXH 18 test plug handle inject current into the various DSE inputs (see AG Fig. 7, TI Fig. 27, or appropriate drawing for test switch detail) and observe that the MS 1 output relay picks up and that the operation indicator in the TEE 4 functions. If the SG 1 phase indicator is provided the respective phase indication should also occur.

c) These two tests provide a complete check of the tripping capability of the relay system. However, if it is a testing requirement that an overall tripping test be made in one test, i.e., current into relay to breaker tripping, a modification of the above procedure will be required. Remove the RTXH 18 test plug handle. To block the tripping of one or more breakers insert the red RTXB trip-block plug in the respective test switch positions. Prepare two leads each with a 20 A. COMBIFLEX female terminal crimped to one end. Connect these leads from a source of test current (preferably an ungrounded source) to the respective positions on the B (left) side of the rear of the RTXP 18 test switch. (See Fig. 7 in AG for the proper test switch positions). If there is also load current in the relay, the injected test current required to cause relay operation may not relate to any calibration value. However, since the overall tripping operation is still conformed as occuring just at a relay pickup, the purpose of the test is satisfied fully.

6 Set the relay: Refer to AG, Testing Section, for procedures for confirming the characteristics of the relay. There are only two settings to be made: (a) the minimum pickup current is set by means of the selector switch on the face of the TEE 4 measuring unit: (b) the unrestrained instantaneous unit is set by means of the jumpers on the rear of the TEE 4 unit as shown in Fig. 11 of the AG.

7 Initial energizing of transformers: This should not be done until after the relay is set and after the trip circuits are known to be functioning. With the test switch normal so the relay can trip, energize the associated transformer from the least critical source. If the relay operates, locate the fault or the inadequacy in the relay system before proceeding. If no fault is found, a wiring error should be suspected if the relay had been previously set correctly. The most likely cause would be a significant error in a CT ratio such as to cause the unrestrained unit to trip on excessive CT secondary current. Minor ratio errors or incorrect phasing of auxiliary CT's should not cause this type of incorrect tripping upon energizing without load.

a) To minimize the frustrations from such a situation it is usual to take oscillographic records of the initial energizations of large transformers. When this is not practical, the energizing source may be selected so as to minimize the possibility of a severe inrush causing a improperly installed relay to operate. Inrush is minimized by:

(a) Energizing the higher voltage winding.
(b) Energizing from the weakest source.
(c) Energizing a delta connected winding.

Seldom can all of these conditions be satisfied. Their relative merits for reducing inrush are about in the order listed. A maladjusted circuit breaker should be suspected if no other cause is located. If feasible, inrush can be minimized on the initial energizing by temporarily reconnecting the main transformer taps to include more turns on the winding to be energized.

b) Occasionally it may be desirable to initially energize a transformer from a separate, lower voltage test source. This can eliminate most inrush considerations. But it creates a hazard if a fault should exist in the transformer, there may be insufficient current to operate the protective relays and extensive internal damage might result.

8 Load checks: Load checks are most conveniently made with at least a 30 % load on the respective CT's. When this is not feasible, care should be used to make allowance for CT performance at low currents when evaluating results. Also the effect of the high burdens of low current ammeters must be allowed for. The various currents are measured by using an ammeter connected to the RTXM test plug inserted in the RTXP 18 test switch. Refer to detail drawings for the proper location of the various currents on the test switch. It is customary to insert red, trip-block plug into the RTXP 18 test switch to avoid inadvertent tripping while load checking. But this practice must be weighed against the hazard of a new piece of equipment faulting without primary protection in service.

a) Note that with multirestraint models which require two test switches, the neutral differential phase currents have two contacts in parallel, see Fig. 7(d). Thus to measure the differential currents it is recommended to use two test plugs, one for each test switch. Connect the test plugs in parallel to an ammeter. Insert the test plugs to the same position (12, 13 or 14) on the test switches. The ammeter then shows the total differential current. If, on the other hand, only one test plug is available the differential current can be measured by inserting the test plug in the test switch 101 and, on the A side of the switch, temporarily open the connection to terminal 14 on the test switch 501.

b) Load Tap Changer transformers are usually checked out on a mid-tap position. But frequently the taps are deliberately run off normal to develop a "circulating current" with another transformer for improved metering accuracy. The results are then converted to a neutral position by inversely proportioning the currents to the respective tap voltages.

c) When there are three or more windings, or sources, they are usually checked out in pairs, but this is not a requirement.

9 Wiring errors: When the differential current of any phase is more than a few percent of the input currents there is either a wiring error, such as a phase shift error in the auxiliary CT's or a ratio error somewhere in the system. Note that the magnetizing current in the power transformer can cause a higher percentage of differential current if the load current is lower than the rated value. The following are some of the more likely errors.

a) Same, small differential current in each phase – a wrong set of CT ratios or primary and secondary of auxiliary CT's interchanged, or LTC off calculated tap.

b) Differential currents higher than any of the restraint currents – reversed auxiliary CT ratio (or combination of c and d below).

c) Differential currents about equal to restraint currents – the delta of auxiliary CT's probably made up in reverse sequence from the main power transformer.

d) Differential currents $\sqrt{3}$ times restraint (on a two winding load test) – a "roll" in the phasing of one set of currents. On multiple winding transformers there could be more than one such error.

e) Unequal differential currents in the three phases – some type of asymmetrical wiring error. If there is current in two phases only and zero differential in one phase, probably an interchange of two phases from one source.

f) No current in a differential circuit – this should not be assumed to mean correct wiring, there may be a short circuit or an open circuit in the differential circuit. To test for one of these conditions observe the differential current when one of the restraints is removed from the relay. This can be accomplished as follows:

With the trips blocked and ammeter plug with meter connected inserted into the differential circuit, connect the A side (black lead) of a second ammeter plug to the same A side of the differential ammeter plug. Insert this second plug into one of the input circuits. The differential ammeter should now read the current which was thus bypassed from the relay. Be sure to make the connection between the two plugs before inserting the second plug to avoid an open CT condition.

10 Repetive energizing of the transformer to prove no maloperation is not recommended. When proof of performance is a requirement it is recommended that an oscillograph be used to record actual current wave shapes, thus minimizing the number of inrush tests which must be made.

11 Staged fault tests: This technique of proving no wiring errors or malfunctioning relays is the perogative of the user. It is not necessary from a relay commissioning viewpoint.

12 Placing in service: After all temporary startup facilities have been removed it is good practice, when feasible, to initiate a tripping from the DSE relay to confirm that the protection has been returned to working order, including targets, which should of course then be reset.

13 When one or more TUC 4 input-restraint modules are used, two RTXP 18 test switches are utilized as shown in Fig. 7 AG. However, to fully interlock the decommissioning of the tripping with the insertion of a test plug handle into either test switch certain dc circuit complexities have been introduced. Also as noted in item 8 above, the differential currents are parallelled in the two test switches at positions 12, 13 and 14. Thus, refer to proper drawing for the specific installation detail before load checking.

AUXILIARY CURRENT TRANSFORMERS

The various methods of connecting auxiliary CT'S to provide the desired phase shift and zero sequence performance are given in AG Fig. 9. Appendix of the DSE AG provides complete information on the SLCE 12 auxiliary CT turns ratios and winding development. The kneepoint voltage of these auxiliary CT's is 0.41 volt per turn. This can be used to confirm the general adequacy of the CT application, escpecially if there are any appreciable lead lengths between the auxiliary CT's and a 5 A rated relay.

RELAY ACCEPTANCE TESTS

The acceptance test procedures given in the AG will confirm all of the operating parameters of the DSE except 5th harmonic restraint. (This in treated in a separate section of this TI). Other tests which one may wish to make initially might include: (Refer to AG Fig. 16 and 7 for proper terminals for the various tests).

1. Operating time of the MS 1 tripping relay and any other tripping or lockout relays.
2. Operating sensitivity of tripping relays, and targets and target reset. Note: The phase operation indicators are all electronic and their threshold cannot be conveniently checked.
3. Influence of level of dc on performance of relay: To check for low dc voltage, connect a 5 KΩ 5 W rheostat between the 125 V and 220 V dc taps on the TEE 4 measuring unit (for a 125 V supply). Move the 125 V battery supply lead to the 220 V tap. Measure the voltage on the 125 V tap and adjust the rheostat for 100 V.

   This is the – 20 % specification for proper performance of the relay. Make such performance tests as desired. Remove rheostat, return battery to proper 125 V tap and recheck relay for proper performance. (A comparable procedure may be used for other supply voltages). To check performance on high dc voltage, increase battery charger input to raise voltage to 140 V overcharge condition (on 125 V system). Test relay to extent desired.
4. Simultaneous tripping of all breakers: This is more of a test of battery capacity and fusing practises than of relay performance since each trip circuit is routed through a separate relay contact. Also, all test switch positions are used below their conservative ratings.
5. Dielectric Tests: Each relay is production tested to the specifications given in the AG under ratings, i.e. 2.5 kV, 50 Hz – 1 minute for the current circuit, 2 kV for all other circuits. Field testing to 75 percent of this value is permitted by applicable standards.
6. SWC Test: The relay has been type tested with the standard 2.5 kV 1 MHz signal with a 3–6 cycles decay time. There are no applicable standards for a SWC field test.
7. DC interrupt test: General prudence suggests that no relay be left connected for tripping when the dc auxiliary voltage is interrupted or restored. However, the DSE is secure against such maloperation and it may be tested to confirm this without damage to the relay.
8. Other tests at time of acceptance or commissioning: For those wishing to establish bench marks for future reference in case of trouble, see section on Voltage Measurements for suggestions.

PERIODIC TESTING

Periodic routine testing can conform to the users established practices. There are no unusual requirements. Suggestions as to typical practices are given in the AG.

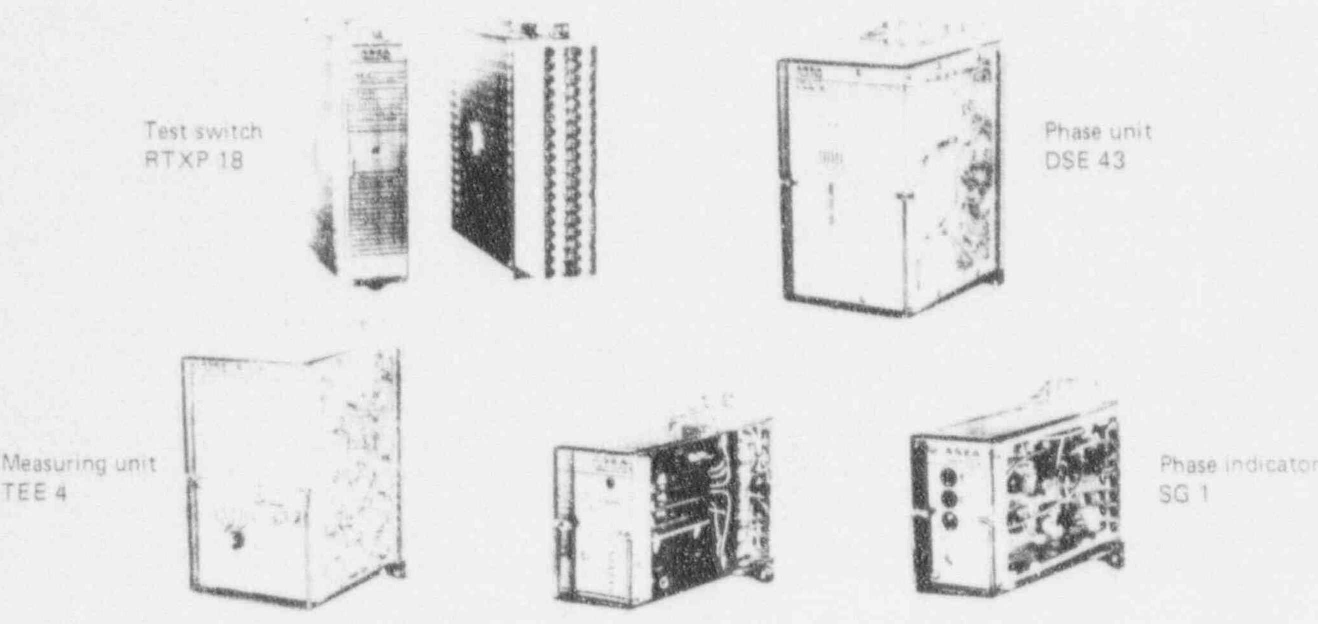


Fig. 26. DSE units

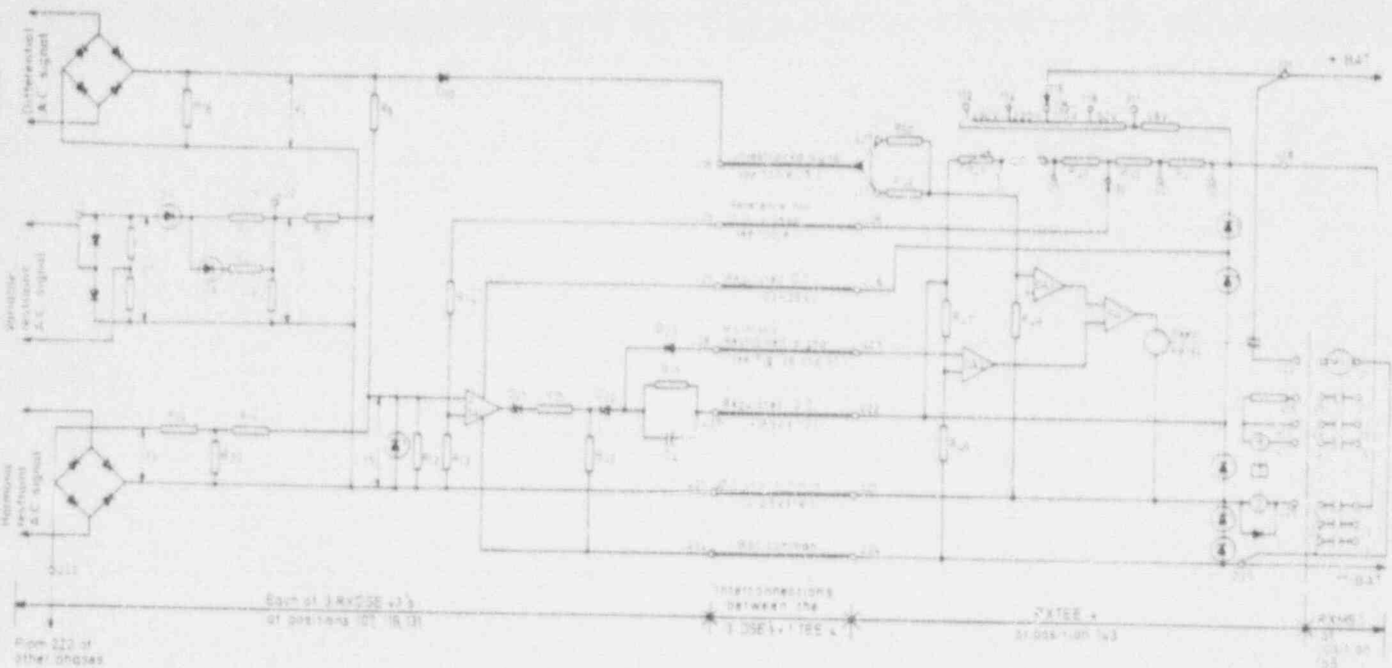


Fig. 27. D.C. interconnections between units of DSE
(Internal relay details are only shown functionally.)

DESCRIPTIVE PHYSICAL DETAIL

The AG provides in the first 6 illustrations and related text a physical description of each unit which makes up a DSE relay and the way the relay is assembled in the COMBIFLEX equipment frame. The AG also describes the relay on a functional basis with AG Fig. 14 showing in which unit each major function is located. Figures 26–32 herein show additional detail of each unit. **Note:** It is **not** the intent that this detail be used to facilitate **internal** repairs to any unit. The purpose is to make the functional relations shown in AG Fig. 14 more meaningful and to make trouble shooting **between** units more readily accomplished.

WIRING INTERCONNECTIONS BETWEEN MODULES

Fig. 27 shows the functional purpose of each of the interconnections between the DSE 43's and the TEE 4 measuring module. This enlarges on the information given in Fig. 7 and relates the overall operating details of Fig. 14 to the actual wiring.

Fig. 28 shows the connections to the SG 1, individual phase target module when this optional component is used. Note that these targets are operated only by the restrained signal. However, they will function when the instantaneous, unrestrained unit causes the tripping, because the function of this second tripping circuit is only to accellerate the operating speed of the relay. The restraint unit will always function a few milliseconds after the instantaneous unit.

Versions without the indicator RXSG 1 has a component block type RTXE with three built-in resistors mounted on the rear of the measuring unit.

When more than three inputs are used, a TUC 4 input module is added for each additional input. The connections between the RTXP 18 test switch and the DSE 43's and TUC 4's are shown in Figure 7. More detail is shown of these interconnections in Fig. 29. The TUC 4's are **three phase** units. The DSE 43's are **single phase** units with three inputs per phase. Thus each TUC 4 connects to all three DSE 43's.

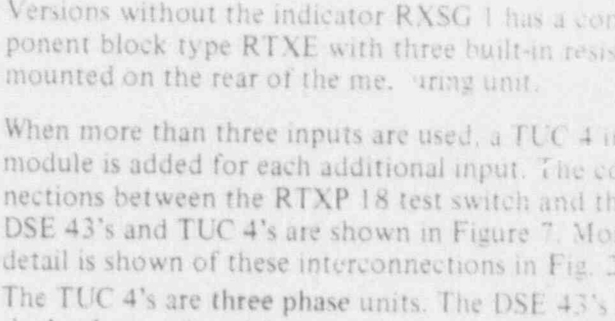


Fig. 28. DC interconnections to phase indicator SG 1.

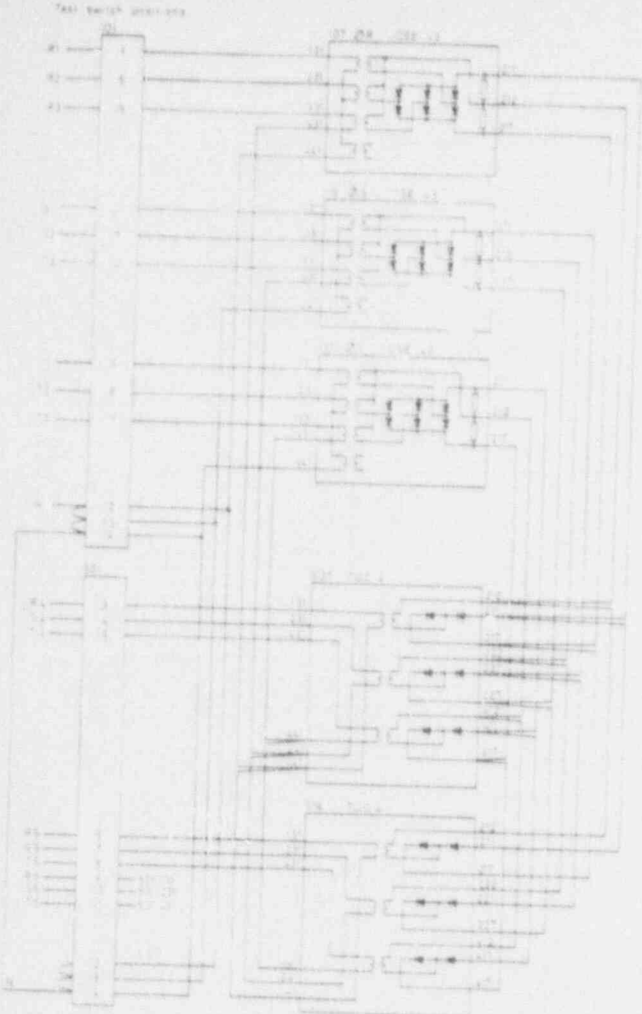


Fig. 29. Interconnections between DSE 43's and TUC 4's

VOLTAGE MEASUREMENTS

Auxiliary, reference and signal voltages may be measured and logged for future reference using a 10 kΩ per volt dc voltmeter. (See section on Test Instruments and Their Use Before Proceeding). This is not a necessary part of the commissioning procedures, nor is it necessary for future trouble shooting since the values given in this Instruction are adequate for locating any possible malfunction. The relay should be energized for three to five minutes before measurements are taken to allow for minor warm up drift of regulating circuits. This is not a restriction on placing the relay in service, it is only a procedure for assuring that an accurate set of bench mark readings are secured.

Auxiliary voltages

Apply 250 V between TEE 4 terminals 225 (–) and 112 (+) and confirm that voltages are according to Table 10.

If 250 V is not available apply the highest available connected to the proper voltage tap as given in Fig. 27. All voltages below this value should conform to Table 10.

Note: This test voltage may be applied to the RTXP 18 test switch at positions 18 (–) and 1 (+); however, be certain the TEE 4 voltage connection is on the correct tap before energizing.

TABLE 10

TEE 4 Positive DC Voltages Referenced to Terminal 224

Terminal	(+) Voltage
112	250
114	210 – 225
116	100 – 110
118	47 – 55
311	37 – 43
428	29 – 33 *
425	23 – 26 *
422	17.5 – 19.5 *
421	11.5 – 13.5 *

* These are zener stabilized voltages; as such their consistency once measured will be better than shown in the Table.

Connect the normal auxiliary supply voltage to proper terminals and reconfirm all pertinent voltages in Table 10. Increase the battery voltage to the rated overcharge value. All regulated voltages i.e., those at terminal 428 and below should be within the maximum values given in Table 10.

Minimum pickup reference voltages

With rated auxiliary voltage applied to the relay, the minimum pickup reference voltage on terminal 143:426 with respect to signal common, terminal 143:421 should be according to Table 11. The burden of the DSE 43's should be in place, i.e. no wiring disconnected.

TABLE 11

Minimum Pickup Reference Voltage, TEE 4 Terminal 143:426 with respect to Signal Common, Terminal 143:421

Min. Pickup Setting Percent	Voltage (+ volts)
20	7.6 – 8.6
25	9.3 – 10.4
32	11.5 – 12.8
40	14.2 – 15.8
50	17.5 – 19.5

TABLE 12. Test point values for RADSE

Testing of unit	Checking of		Current 1)		Test terminals	Typical voltage values 2)	
			Connect to RTXP 18 at seat 101 –terminal	Value times I_n		50 Hz relay	60 Hz relay
DSE 43 at seat 107	Diff. voltage	V4	3 and 12	1	+ 218, – 421	6.5 – 8.5	7.5 – 9.5
				3		23 – 29	25 – 32
	Percentage restraint	V1	3 and 12	1	+ 421, – 211	1.8 – 2.6	2.2 – 3.2
				3		7 – 8.5	8.5 – 10.5
	Variable percentage restraint	V5	3 and 12	1	+ 421, – 422	0	0
				3		1 – 2	1 – 2
	Harmonic restraint	V3	3 and 12	1	+ 421, – 222	5 – 7	6 – 8
				3		19 – 23	22 – 27
	Output voltage	V7	3 and 12	1	+ 427, – 428	6 – 7	6 – 7
				3		6 – 8	6 – 8
DSE 43 at seat 119	Same as above		4 and 13		Same as above	Same as above	
DSE 43 at seat 131	Same as above		5 and 14		Same as above	Same as above	
TEE 4 at seat 143	Stabilization of aux. voltage		–	0	+ 428, – 224	29 – 33	
	+ 12 V supply		–	0	+ 425, – 421	11.5 – 13.5	
	– 12 V supply		–	0	+ 421, – 224	11.5 – 13.5	
	Minimum pickup reference voltage		–	0	+ 426, – 421	11.3 – 13.0	
	Voltage to indicator		5 and 14	1	+ 226, – 421	17.5 – 20	
	Voltage to output relay		5 and 14	1	+ 222, – 225	Equal to connected battery voltage	

1) Sine wave of rated frequency.
2) Measured with a voltmeter of moving-coil type, highohmic ($\geq 10\ k\Omega/V$) with rated auxiliary voltage connected to terminals 1 (+) and 18 (–) on RTXP 18 test switch at seat 101. Minimum current pickup selector switch set at 32 percent.

Differential Current to Voltage: Transfer Constant

The differential operating circuit can be checked by applying ac current to the relay and observing the positive dc signal voltage on the unrestrained instantaneous signal wire on terminal 218 on the DSE 43 with respect to the signal common, terminal 421. This is voltage V4 in Table 12. Table 12 includes other data for the complete checking of the DSE 43's and the TEE 4.

Restraint Current to Voltage: Transfer Characteristic

The restraint current functions through a rectifier and a non-linear circuit so as to provide the variable restraint characteristic. A determination of the functioning of the rectification separate from the basic nonlinear network is possible by measuring the negative voltage on terminals 211 and 422 with respect to 421 of the DSE 43's. These values are shown as V1 and V5 in Table 12.

Harmonic Current to Voltage: Transfer Characteristics

The 2nd and 5th harmonic current restraints are mixed together from each phase after rectification. These harmonic filters are designed with broad characteristics so that there is a definite amount of fundamental signal passed through. This fact can be used to test these filters with fundamental frequency current so as to establish dc voltage bench marks for these circuits. Table 12 shows the restraint voltage, V3, on terminal 222 referred to 421 to be expected for rated fundamental frequency ac inputs to terminals on the test switch.

Integrated Output Voltage

The performance of the phase level detectors and output integrating circuitry can be checked by measuring the DSE output voltage across terminals 427 and 428. The expected values are shown as V7 in Table 12.

TABLE 13 Test point values for TUC 4

Testing of unit	Checking of	Current: Connect to RTXP 18 at seat 501 – terminal	Value times I_n	Test terminals	Typical voltage values: 50 Hz relay	60 Hz relay
TUC 4 at seat 507	Percent restraint voltage V1	3 and 12	1 3	+ 217, – 211	1.8 – 2.6 7 – 8.5	2.2 – 3.2 8.5 – 10.5
		4 and 12	1 3	+ 227, – 221	Same as above	Same as above
		5 and 12	1 3	+ 417, – 411	"	"
TUC 4 at seat 519	Percent restraint voltage V1	6 and 12	1 3	+ 217, – 211	"	"
		7 and 12	1 3	+ 227, – 221	"	"
		8 and 12	1 3	+ 417, – 411	"	"
TUC 4 at seat 531	Percent restraint voltage V1	9 and 12	1 3	+ 217, – 211	"	"
		10 and 12	1 3	+ 227, – 221	"	"
		11 and 12	1 3	+ 417, – 411	"	"

TEE 4 CALIBRATION CHECKS

The signals from the DSE 43's which activate the TEE4 measuring circuits can be simulated with dc voltages to confirm the performance of the TEE 4 separate from the DSE 43 units. Note: As described previously, the actual signals are unfiltered rectified waves, modified by an integrating circuit with unequal charge and discharge time constants. Thus one should not expect to find a direct relationship between the dc signals from the DSE 43's as measured and the performance of the TEE 4 as determined from the following dc signal tests. However, for developing bench marks, these are good tests and observations for confirming the proper performance of the relay.

Restrained Signal Level Detector

A negative going signal from the quiescent state on the TEE 4 signal terminal 423, will cause relay operation. With no ac into the relay the voltage on 423 should be 6 – 7 V negative with respect to 422. To establish a more negative signal, so as to cause operation, Fig. 30 shows how to do this by connecting a potentiometer between 224 and 422 with the slider going to 423. Monitor the output contacts of the reed relay by means of a small indicating lamp. Resistor values are not critical. The relay should operate per Table 14.

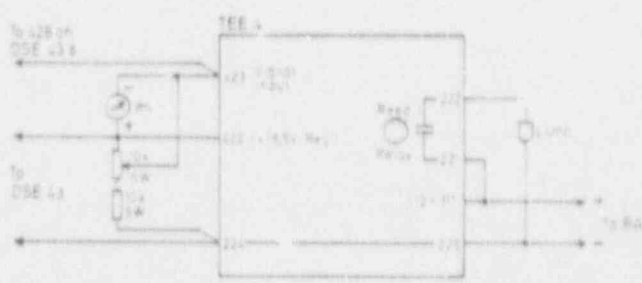


Fig. 30. D.C. signal simulation for checking calibration of restrained signal level detector in TEE 4.

TABLE 14

DC Calibration Check of TEE 4 Restrained Signal Pickup and Dropout negative Voltages on terminal 143:423 with respect to 143:422

Pickup	(6.0–6.7) V plus the percentage deviation of voltage on 422 from the 18.5 V nominal value (Note: The observed voltage will drop about 0.2 V when the relay operates due to designed circuit interaction)
Dropout	(2–4) V

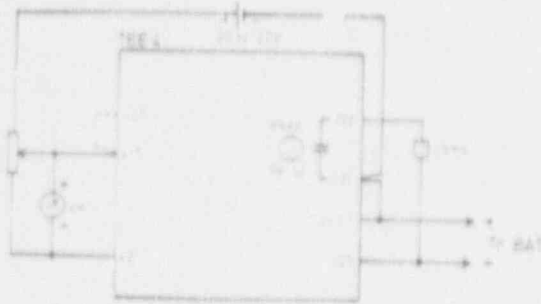


Fig. 31. D.C. signal simulation for checking calibration of unrestrained, instantaneous signal level detector.

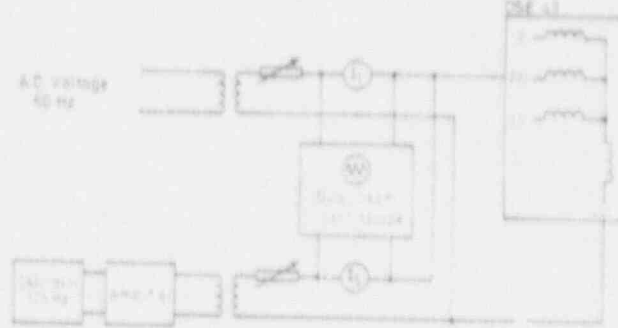


Fig. 32. Testing circuit and procedures for 5th harmonic restraint.

Unrestrained Signal Level Detector

A positive going signal from the quiescent state on the TEE 4 signal terminals 417 or 427 will cause relay operation. With no ac current into the relay the voltage on 417 and 427 should be a small positive value with respect to 421. To establish a more positive signal so as to cause relay operation, connect a variable resistor between terminals 143:417 and 143:221 of the TEE 4. Details are shown in Fig. 31. The relay should operate per Table 15.

Note: Add a 20 – 120 V dry battery in series as needed with the adjustable resistor if voltage on 143:221 is insufficient to develop adequate bias on 417/418.

TABLE 15

DC Calibration Check of TEE 4 Unrestrained Signal. Pickup and Dropout positive Voltages on terminal 143:417/427 with respect to 143:421

Setting		8 x 1)	13 x 2)	20 x 3)
Pickup,	60 Hz	80–100	140–170	215–265
	50 Hz	80–100	135–165	210–260
Dropout		Just below pickup		

1) 8 x setting is with connections to both 417 and 427
2) 13 x setting is with connections only to 417
3) 20 x setting is with connections only to 427
(See Fig. 11 in AG)

Output Relay, Target and Phase Indicator

The MS 1 output relay should be energized with whatever auxiliary voltage is connected to terminal 221 when the TEE 4 reed relay operates. To check its pickup margin connect a 10 KΩ variable resistor between TEE 4 terminals 143:221–222 and observe the voltage across terminals 155:11–12 of the MS 1 (or 143:222–225 of the TEE 4) when the MS 1 operates. The MS 1 operating time can also be checked by shorting across 143:221–222 to energize the relay at full voltage.

The target in the TEE 4 is energized through an MS 1 output relay contact from a regulated dc supply within the TEE 4. To check for its margin of operation connect a 10 KΩ variable resistor between TEE 4 terminals 143:226 and 428 and observe the voltage across the target coil when it operates by measuring across 143:226–421. The electrical reset can be similarly checked by suitable energizing across terminals 143:411–412 or 416.

The individual phase indicators when used, can be checked with the circuit shown in Fig. 30. However in place of connecting the test voltage and voltmeter on terminal 143:423 of the TEE 4, they are connected onto terminal 428 of each of the DSE 43 phase units in turn. They should turn on at a voltage shown in the Table 14 for the restrained signal operating threshold.

OVERALL PERFORMANCE TESTS

The acceptance tests outlined in the AG pages 23 to 27 form the basis of the overall performance tests. For convenience Fig. 16 and 17(a) and Tables 2, 3, 4, 5 and 6 showing details of connections to be made for various tests are repeated here.

TABLE 2

To be used with Figur[illegible] Figure 7 (a)

Test of basic DSE with three input-restraints

Test of	Phase	Connect lead A to terminal	Connect lead B to terminal	Connect lead C to terminal	Set switch S in position
Operating value	R	3 (6, 9)	–	12	0
	S	4 (7, 10)	–	13	0
	T	5 (8, 11)	–	14	0
2nd harmonic restraint	R	3 (6, 9)	–	12	1
	S	4 (7, 10)	–	13	1
	T	5 (8, 11)	–	14	1
Through-fault restraint	R	3	6	12	2
		3	9	12	2
	S	4	7	13	2
		4	10	13	2
	T	5	8	14	2
		5	11	14	2

Note: Connections shown to terminals within ( ) are optional for a more complete test of the relay input circuits.

TABLE 3

To be used with Figure 16 and Figures 7 (d) and (e)

Test of DSE with four input restraints (one TUC 4 and two test switches)

Test of	Phase	Connect lead A to terminal	Connect lead B to terminal	Connect lead C to terminal	Set switch S in position
Operating value	R	3 (6, 9, 3L)	–	12	0
	S	4 (7, 10, 4L)	–	13	0
	T	5 (8, 11, 5L)	–	14	0
2nd harmonic restraint	R	3 (6, 9, 3L)	–	12	1
	S	4 (7, 10, 4L)	–	13	1
	T	5 (8, 11, 5L)	–	14	1
Though-fault restraint	R	3	6	12	2
		9	3L	12	2
	S	4	7	13	2
		10	4L	13	2
	T	5	8	14	2
		11	5L	14	2

Note 1: Connections shown to terminals within ( ) are optional for a more complete test of the relay input circuits.

Note 2: L stands for terminals on the second test switch (501) in the lower left of the 8S equipment frame.

TABLE 4

To be used with Figure 16 and Figures 7 (d) and (f)

Test of DSE with five input restraints (two TUC 4's and two or three test switches)

Test of	Phase	Connect lead A to terminal	Connect lead B to terminal	Connect lead C to terminal	Set switch S in position
Operating value	R	3 (6, 9, 3L, 6L)	–	12	0
	S	4 (7, 10, 4L, 7L)	–	13	0
	T	5 (8, 11, 5L, 8L)	–	14	0
2nd harmonic restraint	R	3 (6, 9, 3L, 6L)	–	12	1
	S	4 (7, 10, 4L, 7L)	–	13	1
	T	5 (8, 11, 5L, 8L)	–	14	1
Through-fault restraint	R	3	6	12	2
		9	3L	12	2
		6L	3	12	2
	S	4	7	13	2
		10	4L	13	2
		7L	4	13	2
	T	5	8	14	2
		11	5L	14	2
		8L	5	14	2

Note 1: Connections shown to terminals within ( ) are optional for a more complete test of the relay input circuits.

Note 2: L stands for terminals on the second test switch (501) in the lower left of the 8S equipment frame.

TABLE 5

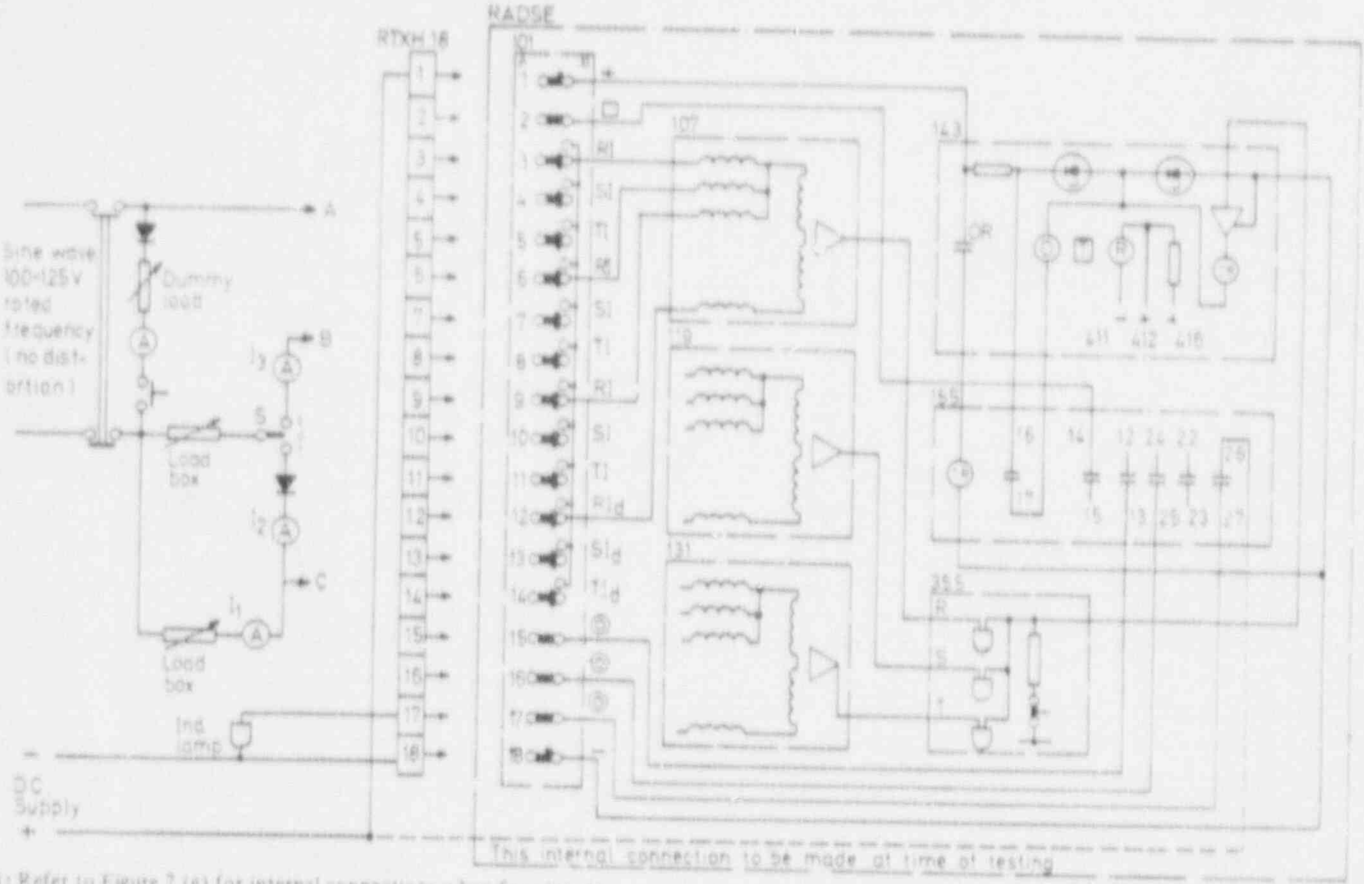
To be used with Figure 16 and Figures 7 (d) and (f)

Test of DSE with six input restraints (three TUC 4's and two or three test switches)

Test of	Phase	Connect lead A to terminal	Connect lead B to terminal	Connect lead C to terminal	Set switch S in position
Operating value	R	3 (6, 9, 3L, 6L, 9L)	–	12	0
	S	4 (7, 10, 4L, 7L, 10L)	–	13	0
	T	5 (8, 11, 5L, 8L, 11L)	–	14	0
2nd harmonic restraint	R	3 (6, 9, 3L, 6L, 9L)	–	12	1
	S	4 (7, 10, 4L, 7L, 10L)	–	13	1
	T	5 (8, 11, 5L, 8L, 11L)	–	14	1
Through-fault restraint	R	3	6	12	2
		9	3L	12	2
		6L	9L	12	2
	S	4	7	13	2
		10	4L	13	2
		7L	10L	13	2
	T	5	8	14	2
		11	5L	14	2
		8L	11L	14	2

Note 1: Connections shown to terminals within ( ) are optional for a more complete test of the relay input circuits.

Note 2: L stands for terminals on the second test switch (501) in the lower left of the 8S equipment frame.



Note 1: Refer to Figure 7 (e) for internal connections when four inputs are used, and to Figure 7 (f) when five or six inputs are used.
Note 2. Connect test leads A, B and C to the RTXH 18 test handle according to the schedules in Tables 2, 3, 4 or 5.

OR Output relay
TR Output tripping relay
T Operation indicator
O Operating coil
R Resetting coil

Fig. 16. Test set up for checking DSE operating characteristics (except 5th harmonic restraint).

Fundamental Frequency Tests

a. Minimum pickup currents
With the selector switch in the mid (0) position (Figure 16), the minimum pickup currents and the un-restrained operating currents can be determined. The settings should be within 10 percent of the calibrated value. To eliminate any ambiguity as to which unit is operating, the restrained unit can be temporarily disabled by opening the connection to terminal 143:423 of the TEE 4 measuring unit. See Figure 17 for the physical location of this terminal. The extractor type RTXD provided for this purpose should always be used. Never attempt to remove a lead without the extractor.

Note: The output relay will normally pulsate when the unrestrained circuit is tested. However, the time in the first picked up position is long enough to trip a breaker when the relay is in service.

b. Restraint characteristics
With the selector switch (Figure 16) in position 2 the restraint characteristics can be determined. The operating values should be within 10 percent of the curves of Figure 13 (a) or (b). For convinience these values, with their accuracy limits, at an ambient temperature of 20 - 25°C, are tabulated in table 6.

Observe that the un-restrained unit has to be connected for an operating value higher than the highest value of I_1, in table 6.

This means that terminal 143:417 must not be connected to 143:427 as at the setting 8 times rated current.

TABLE 6

Variable Restraint Test Data at 32 % Min. Op. Current

Relay rated current	I_5 (A) Restraint	I_1 (A) Differential
1 A	0	0.29–0.35
	1.5	0.66–0.94
	3	1.6–2.2
	10	7.8–10.4
5 A	0	1.45–1.75
	7.5	3.3–4.7
	15	8.0–11
	50	39–52

Caution: This is a harmonic restraint relay and it is essential that good sine wave test current be used for all fundamental frequency testing requirements.

2nd Harmonic Restraint Tests

The 2nd harmonic restraint characteristic can be checked with the circuit of Figure 16 by placing the selector switch to position 1. The single diode rectifier provides a current wave shape rich in 2nd harmonics in addition to the dc component. By adjusting the two load boxes, various proportions of 2nd harmonic to fundamental can be established. Wave shape analysis shows that if the ac current I_1 is read on an ac ammeter and the dc current I_2 is read on a dc ammeter of moving coil type (neither of rectifier type):

$$\text{percent 2nd harmonic} = \frac{0.47\, I_2}{1.11\, I_2 + I_1} \times 100$$

The 2nd harmonic restraint has a 20 percent nominal value. A convenient check point is to adjust the dc current to 4 A and with the minimum pick up setting at 32 percent, gradually increase the ac current until the relay operates. For the 18–25 percent factory calibration this should be at 3.1–6 A ac. The minimum pickup sensitivity setting has little effect on this 2nd harmonic restraint characteristic.

The dc component of the 2nd harmonic test current will flow not only in the relay (and cause no significant effect because of the air-gapped transformers), but it will also flow in the supply circuit. This may cause dc saturation in the supply transformer and result in fuse blowing. More importantly it may result in test voltage distortion which may affect the relay characteristics without the tester being aware of it other than by observing a relay with apparent lack of sensitivity. Should such be the case, one solution is to supply the rectifier circuit from a separate ac source. Another solution is to add a 2nd rectifier and dummy load to cancel the testing dc in the power source. This is also shown in the test circuit of Figure 16.

5th Harmonic Restraint Tests

A different test setup is needed to check the 5th harmonic restraint. A separate sine wave generator (usually an oscillator and power amplifier) are needed to provide the harmonic current. The test setup is shown in Fig. 32. Note that the fundamental and harmonic current sources are in parallel. Thus the current adjusting resistors serve the additional purpose of isolating the two sources from each other.

It is important that the 5th harmonic frequency not be exact. If it is made exact, it will beat with the residual harmonics in the fundamental and cause erratic operation of the relay. However, with a 5 Hz difference, the beat does not influence the relay operation, nor should any fundamental leakage into the oscillator cause frequency instability. Also if there is any harmonic in the fundamental it will be fully masked by the local oscillator. (An interfering signal of say 10 percent will cause only a percent effect on the rms value of the resulting wave).

The ammeter for measuring the harmonic current must of course be suitable for the frequency involved. The dual beam oscilloscope is an excellent method for confirming that the two signals are not interfering with each other; and of equal importance, that the ammeters are in fact properly indicating the respective currents.

The relay should not operate when I_5 at single phase tests is more than 35–45 percent of I_1. The relay should be set on the 32 percent minimum operating current tap to duplicate the factory calibration. A convenient method to check this is to apply 1.5 A of 5th harmonic (for a 5 A rated relay) and to then increase I_1 until the relay operates, which should be at 3.3 A, + 1 A – 0 A. The formula is:

$$I_1 \text{ operate} = \frac{I_5}{0.45} \text{ to } \frac{I_5}{0.35}$$

Indicator Tests

Check that the indicator flag in the TEE 4 unit drops when the relay operates and that the indicator flag resets when 110–220 V dc is connected to terminals 416 (+) and 411 (–) in the TEE 4 unit.

Three-phase Tests

The complexity of three-phase testing is not usually warranted. If a three-phase, fundamental frequency test is made with a pure sine wave, the minimum pickup current will be increased from the calibration value by a factor of 1.4 to 2.0. This is inherent in the relay design and is not adjustable.

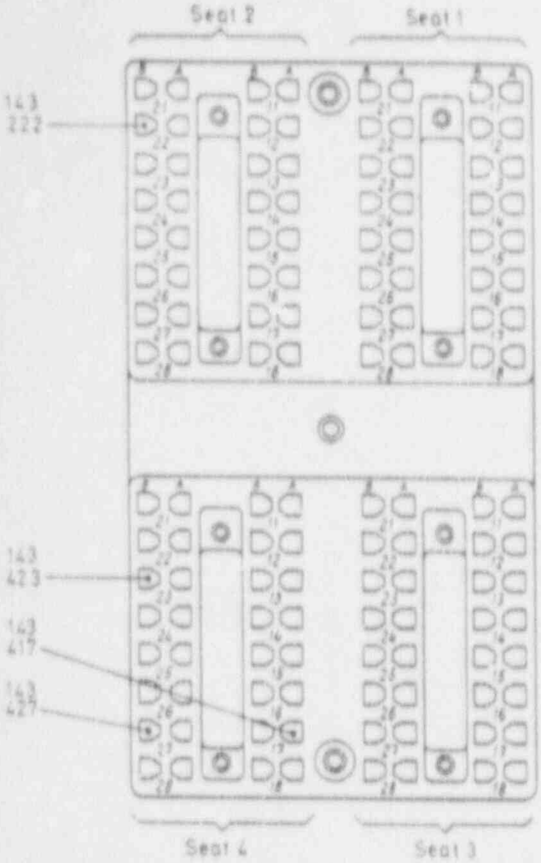


Fig. 17 (a). TEE 4 (143) measuring unit, rear view showing location of terminals used or opened during certain tests.

Inter-phase Tests

To check for the inter-phase action of the harmonic restraint it will be necessary to inject the 2nd harmonic into one phase unit and the operating fundamental frequency into another.

To check the inter-action between S and R phase units proceed as follows:

1. Remove the test lead from ammeter I_2 to C, at C.
2. Connect this ammeter lead from I_2 to terminal 13, (S O)
3. Connect a jumper from terminal 4 to 3, (S O to R O)
4. Connect test lead A to terminal 3, (R O)
5. Connect test lead C to terminal 12, (R O)
6. Place switch S in position 1.
7. Adjust the d.c. current I_2 to s A (for a 5A relay) and with the minimum pick-up setting at 32 percent, gradually increase the a.c. current I_1 until the relay operates. The fundamental current needed for operation will at this interphase test be proportionally hi...er than at the normal 2nd harmonic restraint test, as in this case, it does not flow any 2nd harmonic component in the operating circuit. The percentage 2nd harmonic is in this case equal to

$$\frac{0.47\, I_2}{I_1} \times 100$$

and will at this test normally be 2–6 percentage points lower than at the 2nd harmonic restra...t test. Thus the 5 A-relay will operate for approx. 5–6 A.

8. Move test lead from 13 to 14 and jumper from 4 to 5 to check inter-action between TO and RO. To check the inter-action between TO and SO move the test lead A from terminal 3 (RO) to 4 (SO) and lead C from 12 (RO) to 13 (SO).

Note: This inter-phase harmonic relation does not involve the fundamental frequency restraints hence a total of three tests will completely check this feature regardless of the number of restraints.

CALIBRATION

If any of the restraint characteristics appear to be off calibration, internal relay adjustments are not recommended.

However, before judging that a relay is off calibration confirm that the test current is a good sine wave. A small amount of harmonics in the test current can be a significant effect on the relay operating characteristics.

When a DSE 43 or TEE 4 module is found outside of the noted range of performance, it is recommended to replace the unit and return the defective unit to the factory. The reason for this policy is that recalibration could mask a partial failure of some other component and result in the SWC or the overall performance being at variance with published characteristics. This policy also assures against inadvertent maladjustment of a relay due to nonsinusoidal test currents.

When a module is replaced with one known to be in good working condition, it is not necessary to repeat all of the calibration checks. Obviously it is good practice to make sufficient tests to assure that all of the wiring has been properly replaced.

SERVICING ELECTROMECHANICAL MODULES

The electromechanical modules may be serviced by referring to the manuals on the specific components:

Reed Relays	RK 21–10 E
Operation Indicator	RK 27–12 E
MS 1 Output Tripping Relay	RK 21–10 E
COMBITEST Test System	92–11 AG

The reed relay contact assembly can be replaced without disturbing the actuating coil.

The operation indicator in the TEE 4 unit is similar to the four units assembled as an RXSP 1.

The SG 1 individual phase targets are 100 percent static. If a malfunction develops, replace the entire module and return defective module to factory.

Note: If the SG 1 is removed, full operation of the relay will continue if the 3 DSE 43 terminals 107, 119 and 131:428 are jumpered directly to the TEE 4 terminal 143:423. This will maintain the phase trip circuit signal continuity.

TROUBLE SHOOTING

The cause of suspected maloperation can be identified by checking the various voltages as given in the previous sections on voltage measurements and TEE 4 calibration checks. A defective unit can also be located by evaluating the basic test data. For example, if all three phases are off calibration the trouble is in the common TEE 4, or a ground on one of the output circuits of a DSE 43 which is interacting into each of the three phase units. If only one DSE 43 phase unit is off calibration, the trouble is most likely in that unit. Similarly, the relative calibrations between the restrained and unrestrained functions can be a clue as to source of trouble.

When any interconnection wiring between units is lifted while searching for the malfunction, a minor change can be expected in the various voltages with some reaction on actual calibrations. These effects should not be confused with the effect of an actual defective component.

Similar modules may be interchanged and modules replaced with new modules without causing the overall relay calibrations to exceed the specified limits. This suggests module substitutions as an effective method of trouble shooting. However, this should not be undertaken before confirming that all voltages are within range on the inter-modules wiring shown in Fig. 27.

ACCESSORIES AND SPARE PARTS

1 RTXH 18 Test plug handle and test leads

2 Ammeter test plugs RTXM
Trip block plugs RTXB
See 92-11 SI

An adequate spare parts list consists of:

1 RXDSE 43

1 RXTEE 4

1 RXMS 1

Printed in Sweden Västerås 1.1977 Västerås Kontorstryck 1000