Westinghouse Electric Corporation
Relay-Instrument Division
Coral Springs, FL 33065

July, 1984
Supersedes RPD 41-181A1
dated February, 1974
Mailed to: E, D, C/41-400B

CM Relay in FT-31
Flexitest Case①

Type CM Phase Balance Current Relay

Ordering Information

- Name the part and give its style number.
- Give the complete nameplate reading.
- State method of shipment desired.
- Send all orders or correspondence to nearest sales office of the company.

CM Relay in FT-31 Flexitest Case①

Relay Complete				Style Number of Part		
Style Number	Tap Rating (Amps)	Frequency (Hertz)	I.C.S. or A.C.S. Rating (Amps)	Electromagnet Front	Electromagnet Rear	I.C.S. or A.C.S. Unit②
1963756	1-2-3	60	1.0	407C819G10	407C819G03	3491A30G23
290B960A09	1 Amp No Tap	60	.2-2	407C819G09	407C819G01	3491A37G18
290B960A10	1 Amp No Tap	50	.2-2	407C819G09	407C819G01	3491A37G18
290B960A11	1 Amp No Tap	25	.2-2	407C819G09	407C819G01	3491A37G18
290B960A21	1-2-3	60	.2-2	407C819G10	407C819G03	3491A34G30
290B960A22	1-2-3	50	.2-2	407C819G10	407C819G03	3491A34G30
290B960A24	1-2-3	60	.5	407C819G10	407C819G03	3491A30G24
290B960A25	1-2-3	60	.15	407C819G10	407C819G03	3491A30G17
290B960A26	1-2-3	25	.2-2	407C819G10	407C819G03	3491A34G30
290B960A27	1-2-3	60	1.0	407C819G10	407C819G03	3491A39G19
290B960A28	1-2-3	25	1.0	407C819G10	407C819G03	3491A39G19
290B960A29	1-2-3	60	.1	407C819G10	407C819G03	3491A30G24
Ⓣ 644B600A27	1 Amp No Tap	50	.2-2	407C819G13	407C819G07	3493A68G20
Ⓣ 718B600A23	1-2-3	60	.2-2	407C819G13	407C819G07	3493A68G12
Ⓣ 775B443A21	1-2-3	50	.2-2	407C819G13	407C819G07	3493A68G12

① For Flexitest Case Parts refer to RPD 41-076A1.
② For ICS and ACS Unit Parts refer to RPD 41-852A1.
Ⓣ Tropicalized.

Reference Number	Description of Part	Style Number
1	I.C.S. unit	See Table②
1	A.C.S. unit	See Table②
2	Stationary contact for I.C.S. unit – double trip only	183A860G02⑥
3	Stationary contact for I.C.S. and A.C.S. unit – double trip only	183A862G01⑤
4	Stationary contact for I.C.S. and A.C.S. unit	1732868③
5	Electromagnet	See Table③
6	Tap block	33B3100G02③⑤
7	Tap screw for tap block	1545282④⑤
8	Molded insulating block	183A408H01
9	Top bearing screw	52D6291G03③
10	Moving contact, spring and adjuster assembly	880A722G11③
11	Disc and shaft assembly	880A772G09③
12	Upper bearing	1210530③
13	Lower bearing	184A440G01③
14	Adjustable contact support assembly	407C057G01③
15	Contact on spring	183A654G01④
16	Set screw and plate	407C057G03④
17	Bottom bearing screw	3499A37G09③
18	Permanent magnet	1732780③
19	Resistor 500 ohms adjustable	1336158③⑥⑥
20	Potentiometer 500 ohms	762A790H01③⑤⑥
21	Nut to lock bottom bearing screw	203056③
22	Cardholder clip	182A798H01
23	Mounting and connection hardware	1876412

Note: Parts indented are included in the part under which they are indented.
③ Two (2) Used.
④ Four (4) Used.
⑤ Not Used in Styles 290B960A09, A10 and A11.
⑥ Used Only in Styles 290B960A09, A10 and A11.
⑦ Six (6) Used.
⑧ Not Used in Style 644B600A27.
⑨ Used Only in Style 644B600A27.

Printed in U.S.A.

Westinghouse Electric Corporation
Relay-Instrument Division: Newark Plant
Newark, N. J. 07101

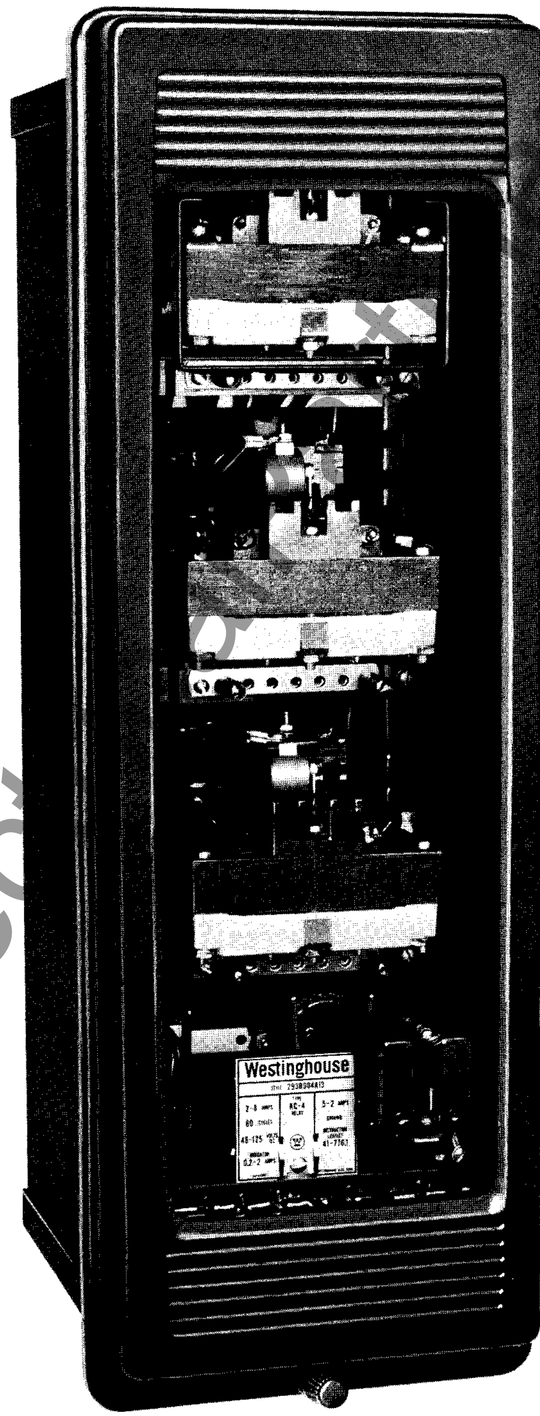
Descriptive Bulletin
41-170

May, 1977
Supersedes DB 41-170 dated May, 1971

Mailed to: E, D, C/2013/DB

For Phase and Ground Faults and
Breaker Failure Protection Schemes

Type KC-4 Current Detector Relay



The type KC-4 relay is a non-directional current or fault detector which operates for all phase and ground faults to supervise the tripping of other protective relays.

It is particularly suited for breaker-failure relaying schemes in which it supervises local back-up tripping, based on the presence or absence of current flow in the protected circuit breaker.

The relay can be applied where the phase units are to be operated indefinitely in the picked up position well below full load. Alternatively, where the relay is to be used as a fault detector (pickup above full load), the 98% or better dropout ratio of the phase and ground units is advantageous.

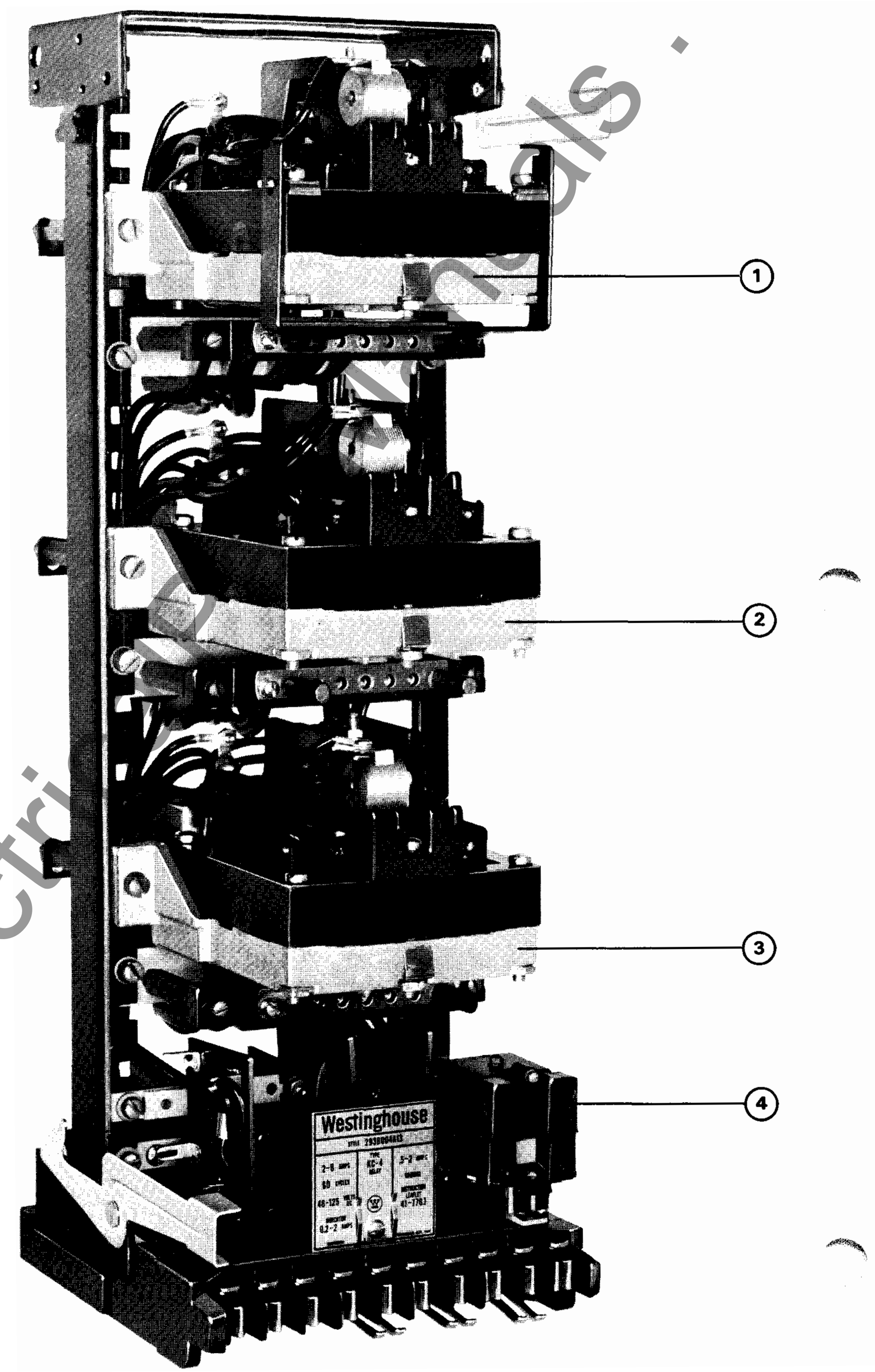
Specific benefits and techniques for breaker-failure detection using the KC-4 current detector relay are given in subsequent sections.

Construction

The KC-4 relay consists of two cylinder type phase instantaneous overcurrent operating units, one ground overcurrent unit, and an indicating Contactor Switch.

Each overcurrent unit operates to close its contact when current exceeds a specified value. The Indicating Contactor Switch, actuated by closure of one of the cylinder unit contacts, relieves the main contact of carrying the heavy trip current, and also displays a target which indicates operation of the relay. This target is reset by a push rod from outside the relay case.

(1) Phase Instantaneous Overcurrent Unit (I_A)
(2) Phase Instantaneous Overcurrent Unit (I_C)
(3) Ground Instantaneous Overcurrent Unit (I_0)
(4) Indicating Contactor Switch



Benefits of Breaker-Failure Protection

The failure of circuit breakers to interrupt fault current when called upon to trip by relays is a moderately frequent and extremely serious problem in electric power system operation. The example system of Figure 1 has been chosen to illustrate the advantages of local breaker-failure protection over the former practice of depending entirely on remote backup relaying.

In this diagram, the generating station high-voltage bus uses a breaker-and-a-half arrangement. Lines interconnect the station to systems S_1, S_2 and S_3.

Fault L is normally cleared by line relays tripping breakers 5, 6 and 9. Assume, however, that breaker 6 mechanism sticks so that current flow through breaker 6 is not interrupted. Under this condition, back-up protection must function. If remote back-up is relied upon, time delay relays must trip remote breakers 7 and 8. In addition, local generator feed through breaker 6 must be interrupted by tripping breaker 4.

However, if breaker-failure protection is incorporated in the system, the fault is cleared by the tripping of breaker 3. This action provides selective tripping, since as much of the system as possible was left intact. If breakers 4, 7 and 8 must trip, the local generator is lost and unnecessary separation of the generating station from power systems S_1 and S_2 would result. Also, the tapped load would be interrupted unnecessarily instead of being left tied to system S_2.

Remote back-up, in addition to not being selective, may not be sensitive enough because of the relatively small proportion of the total fault current flowing in any one line. For example, in Figure 1, there may be very little current flow in breakers 7 and 8 for fault L because of the large current contribution by the local machines at the generating station. Thus, it may be difficult, or impossible, at breakers 7 and 8 to detect adjacent line faults without depending upon sequential tripping. If the generator feed is interrupted for fault L, such as by tripping breaker 4, the current through breakers 7 and 8 may increase sufficiently for the relays to operate and trip breakers 7 and 8. By this time, however, the system is split into islands, and because of the long time delay required to clear the fault, portions of the system may be unstable.

Although breaker-failure protection offers many advantages, remote back-up cannot be completely eliminated from consideration. For example, assume that in Figure 1 breaker 3 fails for bus fault B. Breaker-failure protection will promptly trip breaker 2, but the fault is still fed by breaker 8. Likewise, if breaker 2 fails with a line fault at M, a remote breaker must trip to clear the fault. Breaker-failure protection trips breaker 3, but breaker 8 continues to feed the fault. Although breaker-failure protection does not complete the job in these examples, it does expeditiously trip the local breaker, making it easier for the remote relays to detect the fault.

In this last pair of examples, dependence on remote back-up can be further reduced by actually letting the breaker 3 failure protection circuit directly trip breaker 8. If the line from breaker 8 is protected by a blocking-type carrier scheme, breaker 3 failure relays can stop carrier transmission, allowing immediate tripping of remote pilot relays. Of course, this assumes that pilot relays at 8 respond to faults B and M regardless of other infeed sources. If this is not the case, a dedicated, direct transfer-trip channel can be provided to trip breaker 8 if either breaker 2 or breaker 3 fails. Note, however, that remote back-up protection should still be provided in case the transfer-trip channel fails, or in case of catastrophic malfunctions which result in total failure of local fault relays to even initiate breaker tripping (e.g., failure of potential supply or station battery).

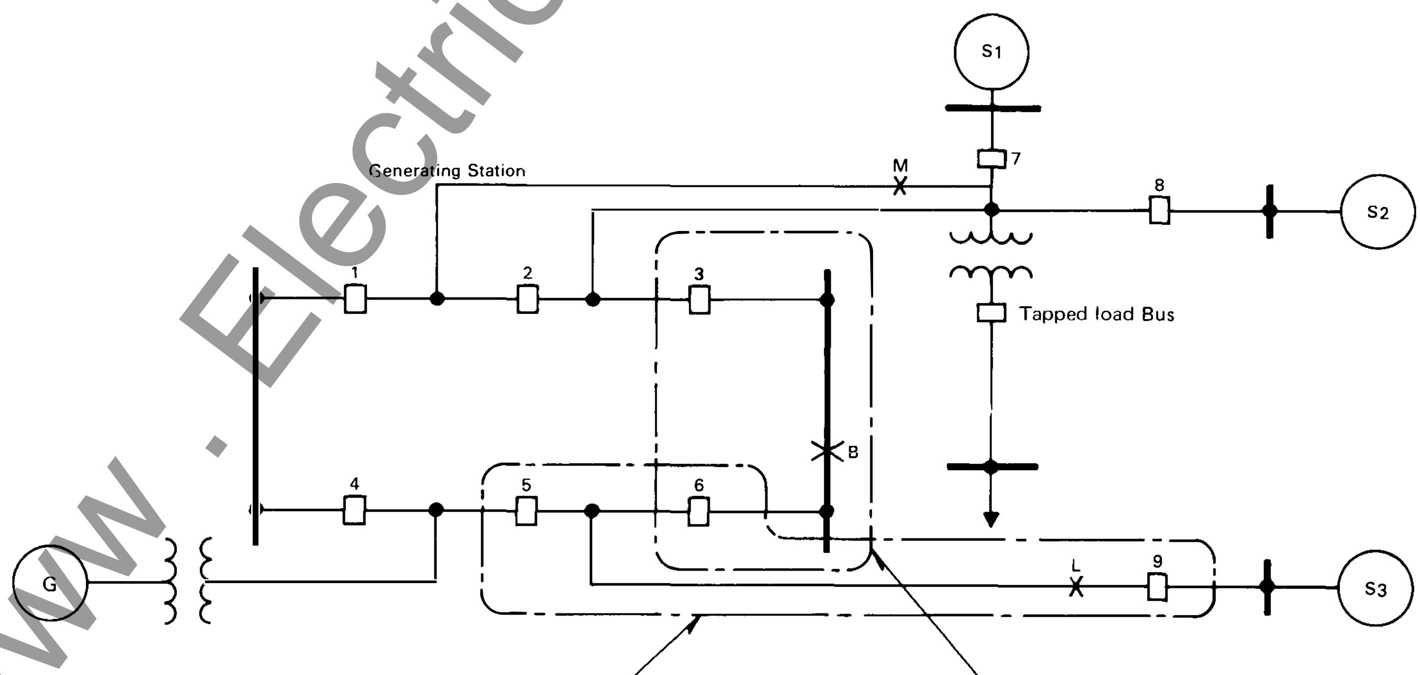


Fig.1

Operation of Breaker Failure Schemes

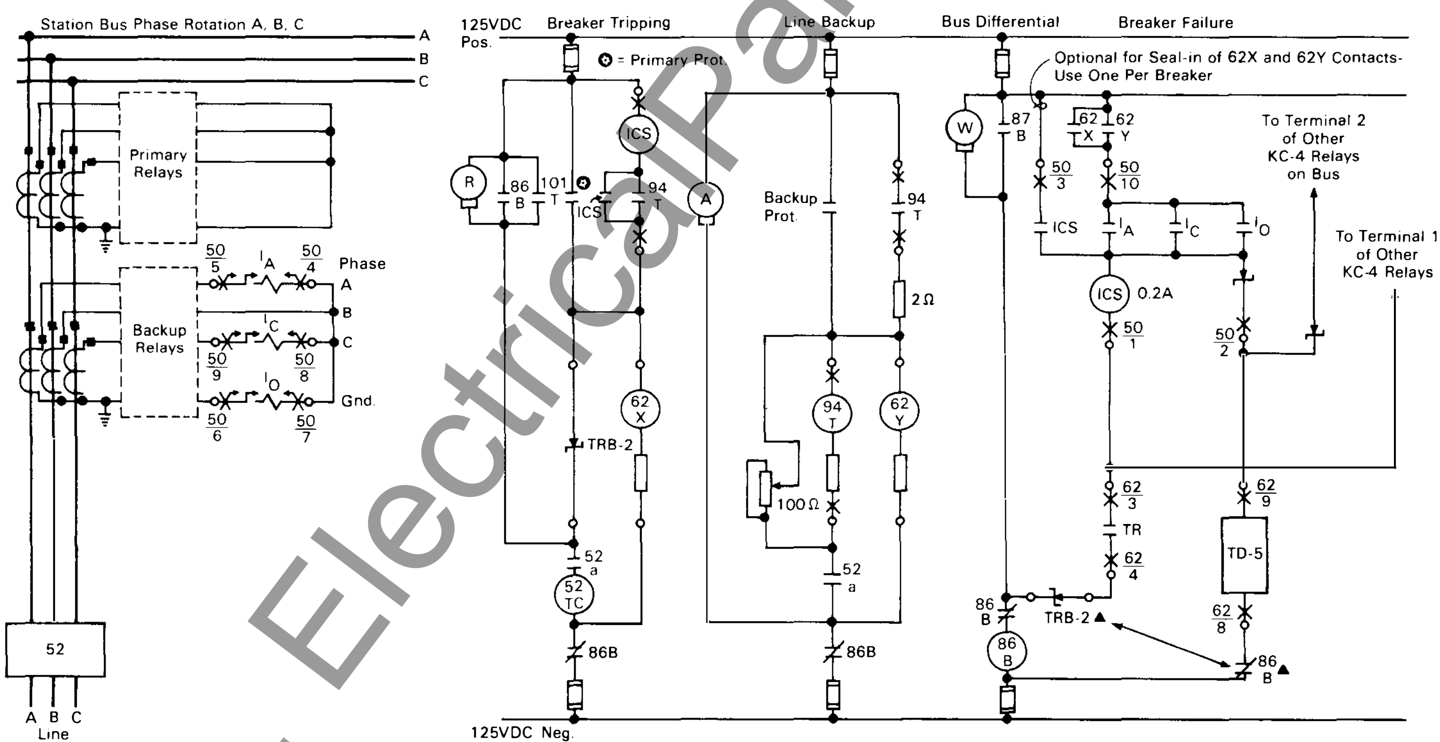
Single Bus/Single Breaker Arrangement
In a properly-functioning breaker, current flow should cease shortly after the trip circuit is energized. The time interval between trip-circuit energization and current flow cessation is the breaker-interrupting time. If interruption doesn't occur in about this much time, the breaker is assumed to have failed and the breaker-failure relaying should initiate tripping of adjacent and/or remote breakers to isolate the protected breaker. For the present bus arrangement, all the breakers on the bus must be tripped if any one of them fails. This is readily accomplished by having the breaker-failure protection circuits energize the bus-differential lockout auxiliary 86B.

Figure 2 shows the simplest breaker-failure scheme. Primary and back-up line relays connect to separate current transformers and separately-fused dc supplies so that a failure in either circuit will not disable all of the protection. When primary protection operates, it energizes auxiliary relay 62X and the breaker trip coil simultaneously. Similarly, back-up relays simultaneously energize tripping auxiliary 94T and auxiliary 62Y. 62X and 62Y are known as breaker-failure initiate (BFI) auxiliaries. The closure of contacts 62X and 62Y provide a signal in the breaker-failure scheme that breaker tripping has been initiated; they energize the TD-5 breaker-failure timer (62) through the KC-4 (50) contacts, which have already closed in response to the same fault which operated the line relays. If the breaker interrupts fault current as expected, the KC-4 drops out and the TD-5 is deenergized before it times out and no further action is taken. But if current flow continues beyond the expected time limit, the TD-5, delay expires and the output (TR) contact of the TD-5 energizes the 86B lockout auxiliary to strip the bus and block reclosing.

Note that, in Figure 2, each breaker has its own line protective relays, BFI auxiliaries and KC-4 current detector, but that all of these funnel into a single TD-5 timer. This is done for economy since the same tripping device, 86B, is energized regardless of which breaker fails. Targeting of the particular failed breaker is accomplished by the ICS in the asociated KC-4 in conjunction with the 62X and 62Y BFI contacts for that line.

The zener blocking diode inside each KC-4, connected to terminal 50-2, isolates the multiple trip circuits of the KC-4's so that only the desired target will drop.

Fig. 2 Single Bus / Single Breaker Arrangement Using KC-4 Relay and One Timer Per Bus



Device No.	Type	Function
...	TRB-2	Zener Tripping Unit
50	KC-4	Overcurrent Detector
50X	AR*	Overcurrent Aux. (Optional)
52	....	Power Circuit Breaker
62	TD-5	Breaker Failure Timer
62X	AR*	Breaker Failure Initiating Aux.
62Y	AR*	Breaker Failure Initiating Aux.

Device No.	Type	Function
86B	WL	Bus Diff. Lockout Aux.
87B	....	Bus Diff. Relay
94T	AR*	Tripping Aux.

* = High-Threshold Type (4MS Pickup)
▲ = With Supervising Light, use either 86B Contact or TRB-2 Blocking Zener but not both.

Figure 2 – 719B395
Sub 4

Figure 3 shows a more elaborate breaker-failure scheme for the same bus arrangement. The key differences are that (a) now a separate TD-5 timer is dedicated to each breaker, and (b) this scheme incorporates *BFI seal-in* which is provided by the TX auxiliary in the TD-5. The seal-in feature will be explained shortly.

Although using a separate timer for each breaker is more costly than the scheme of Figure 2, there are several performance advantages:

(1) For a fault which begins on one line and subsequently spreads to another (such as can occur on a double-circuit tower), the common timer in Figure 2 will be energized by the initial fault. However, even if the breaker clears the first line affected, the 62X and Y contacts and KC-4 of the second faulted line will keep the timer energized. The time delay may expire and the bus may be stripped before the second breaker clears the fault, even though no breaker failed.

(2) If the breakers on the bus have different interrupting times, a common timer must be set to accommodate the slowest breaker. Separate timers provide faster back-up clearing for faster breakers.

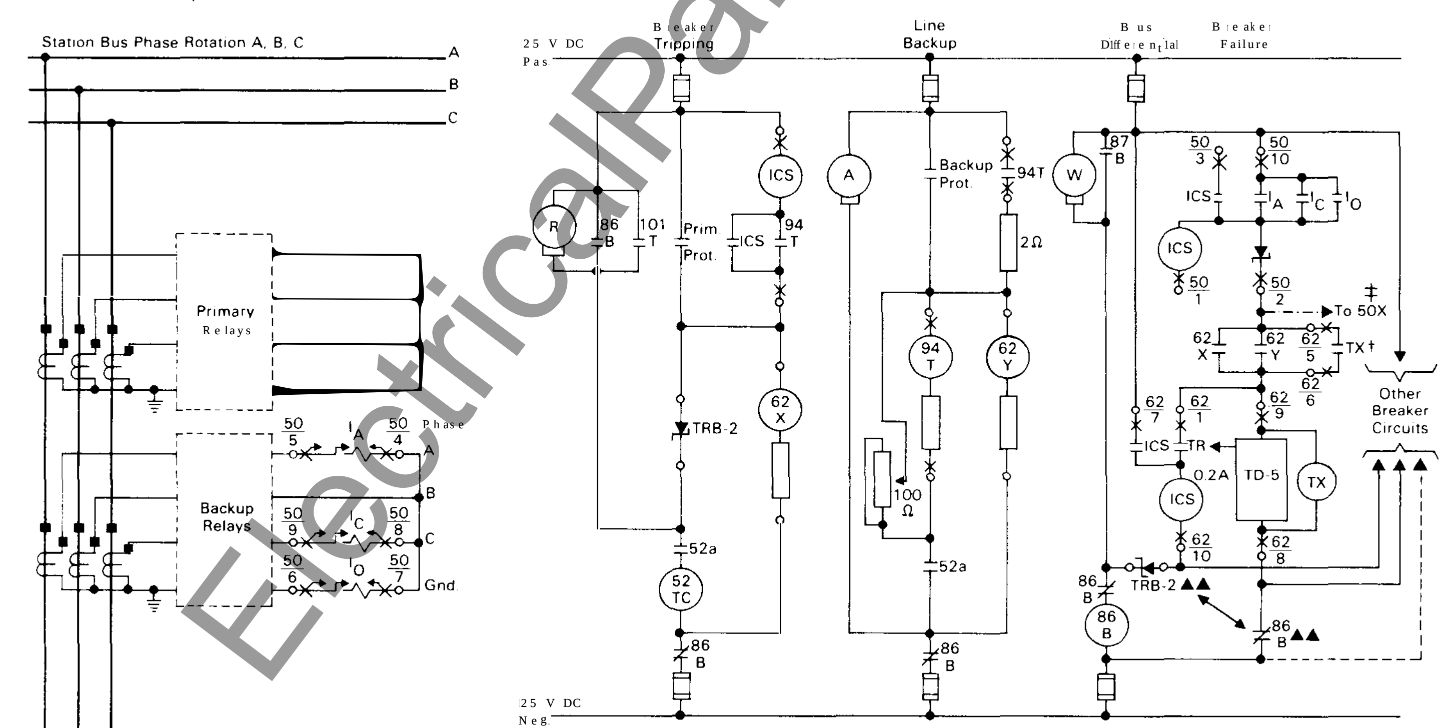
(3) With separate timers, the bus can be reconfigured without rewiring the breaker-failure circuits.

(4) If the user desires to initiate breaker-failure timing for *bus* faults, separate timers must be used, since the failure of any particular breaker for a bus fault requires transfer-tripping for that line only. An output unique to this breaker is needed to accomplish this.

(5) If BFI seal-in is needed as described below, it is easy to obtain with separate timers. With a single timer, auxiliary relays and blocking diodes must be added whose cost mitigates the timer savings.

The telephone relay coil TX in parallel with the TD-5 timer 62 is optionally used to *seal-in* 62X and 62Y contacts. When the KC-4 contacts and 62X and Y contacts are both closed, both the timer circuit and TX are energized; TX seals around 62X and Y so that only the opening of the KC-4 contacts can stop the timer. This may be needed when 62X and Y are energized by potential-polarized distance relays. If a close-in fault occurs so that the polarizing potential collapses completely, the distance relay will reset after stored energy in the polarizing circuit damps out (usually 15 to 30 ms). This will cause dropout of 62X or Y, even if the breaker has failed and the fault remains. The TX contact will keep the timer energized for this critical situation, allowing the breaker-failure scheme to function and strip the bus.

Fig. 3 Single Bus/Single Breaker Arrangement Using KC-4 Relay and One Timer Per Breaker



52

A B C
Line

Figure 3 – 1427C95
Sub 8

Device No.	Type	Function
...	TRB-2	Zener Tripping Unit
50	KC-4	Overcurrent Detector
50X	AR▲	Overcurrent Aux. (Optional)
52	....	Power Circuit Breaker
62	TD-5	Breaker Failure Timer
62X	AR▲	Breaker Failure Initiating Aux.
62Y	AR▲	Breaker Failure Initiating Aux.

Device No.	Type	Function
86B	WL	Bus Diff. Lockout Aux.
87B	....	Bus Diff. Relay
94T	AR▲	Tripping Aux.

▲ = High-Threshold Type (4MS Pickup)
▲▲ = With Supervising Light, use either 86B Contact or TRB-2 Blocking Zener but not both
† = Optional for Seal-in of 62X and 62Y Contacts.
‡ = Optional for Contact Multiplication of KC-4 Overcurrent Detector.

Breaker-and-a-Half Arrangement
Figure 4 shows breaker-failure protection circuits for a breaker-and-a-half bus arrangement, with one timer for each breaker. Each of the two buses can be protected with a single timer if desired – refer to KC-4 relay instruction leaflet IL 41-776.1 for the scheme.

The basic functioning of the scheme of Figure 4 is the same as for the single-bus/single-breaker case – the differences are in the initiating and tripping functions.

First, consider the breaker 1 failure detection circuit as an example for a breaker adjacent to a bus. Breaker-failure timing is initiated not only for faults on line A, but on bus L as well. Auxiliary relay 62Z-L in the bus L clearing circuit provides for breakers 1, 4 and others on bus L whenever a bus fault occurs and bus differential relay 87B-L operates.

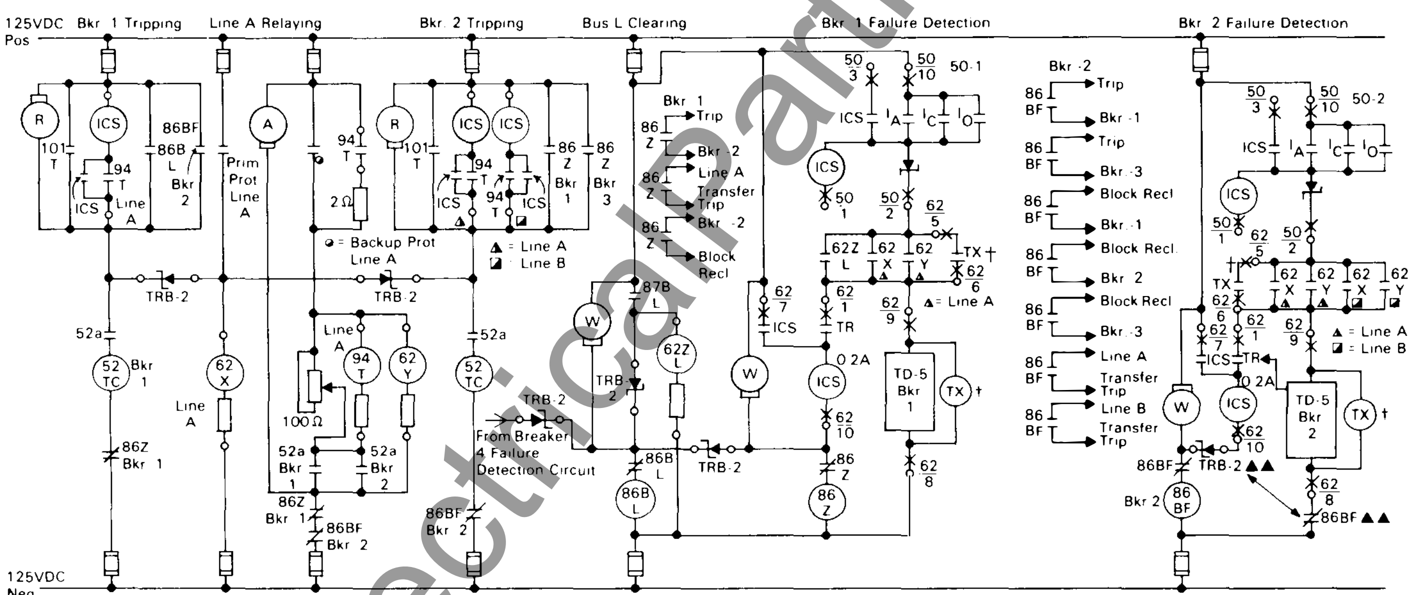
For a bus fault on L and a failure of breaker 1, the timer 62 will energize lockout switch 86Z directly, which will in turn cause tripping and reclose blocking of breaker 2 and transfer tripping of breakers at the remote end of line A. The timer 62 also energizes lockout switch 86B-L through a TRB-2 blocking diode; this is not detrimental but is redundant since 86B-L was already tripped by the bus relay 87B-L.

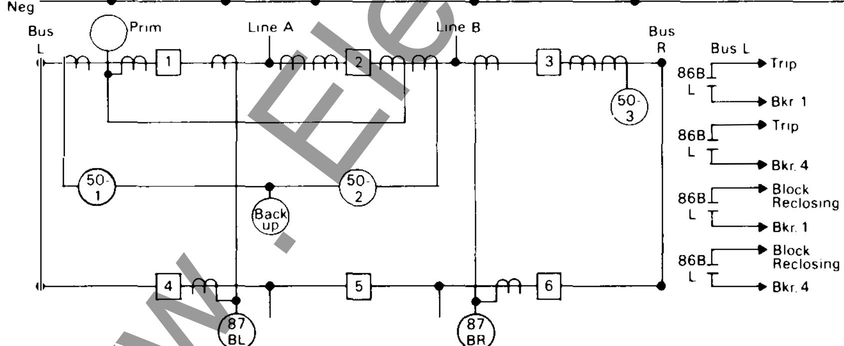
Now consider a fault on line A and a failure of breaker 1. BFI is provided by 62X and Y. The timer 62 will energize 86Z and 86B-L through TRB-2 as just described. In this case, however, breaker 2 and remote-breaker tripping were already accomplished by line relays, so these actions are redundant. However, the blocking of reclosing for breaker 2 and reclose blocking at the remote terminal via the transfer-trip signal, are now provided. Also, 86B-L now strips bus L to isolate the failed breaker 1.

Now, refer to the breaker 2 failure detection circuit. BFI is provided by 62X and Y contacts for lines A and B, since a fault on either initiates tripping of breaker 2. If breaker 2 fails and the timer 62 delay expires, lockout switch 86BF is energized. Contacts of 86BF trip breakers 1 and 3, block reclosing on all 3 breakers, and transfer-trip lines A and B. Some of these actions are redundant – for example, a line A fault does not require re-tripping of breaker 1. But as for breaker 1 circuits described above, none of these redundant actions are detrimental.

The TX relay is shown providing optional seal-in of BFI contacts as described for the single-bus/single-breaker case above.

Fig 4 Breaker Failure Relaying Using KC-4 Relay and One Timer Per Breaker-Breaker and a Half Station





Device No.	Type	Description	Req'd No.
....	TRB-2	Zener Tripping Unit	3/Bay + 1
50	KC-4	Overcurrent Detector	1/Bkr.
52	....	Power Circuit Brkr.	3/Bay
62	TD-5	Breaker Failure Timer W/TX	1/Bkr.
62X	AR▲	B.F. Initiate Aux.-Pri	1/Line
62Y	AR▲	B.F. Initiate Aux.-Backup	1/Line
62Z	AR▲	B.F. Initiate Aux.-Bus	1/Bus
86B	WL	Bus Diff. Lockout Aux.	1/Bay
86BF	WL	B.F. Lockout Aux.	1/Bay
86Z	WL	B.F. Lockout Aux.	2/Bay
87B	....	Bus Diff. Relay	1/Bus
94T	AR▲	Tripping Aux.	1/Line

▲ = High-Threshold Type (4MS Pickup)
▲▲ = With Supervising Light, use either 86B Contact or TRB-2 Blocking Zener but not both.
† = Optional for Seal-in of 62X and 62Y Contacts.

Figure 4 - 1428C18
Sub 4

Ring Bus Arrangement

Figure 5 shows line and breaker-failure protection circuits for a ring bus. The symmetry of the bus permits a simple circuit for the latter function. Using breaker 2 as an example, BFI is provided by 62X and 62Y contacts from lines A and B, since a fault on either line initiates breaker 2 tripping. If the time delay expires, the lockout switch 86BF trips adjacent breakers 1 and 3; blocks reclosing of breakers 1, 2 and 3; and transfer-trips both line A and B. As in the breaker-and-a-half scheme, redundant actions are allowed since they cause no difficulties and result in the simplest scheme. Also, remember that transfer-tripping of the remote end of the faulted line isn't really redundant since it performs the important additional function of blocking reclosing at the remote terminal.

Characteristics

Current Ranges

Phase and ground overcurrent units are available in the following current ranges:

Current Range	Taps					
0.5-2 amps	0.5	0.75	1.0	1.25	1.5	2
1-4 amps	1.0	1.5	2.0	2.5	3.0	4.0
2-8 amps	2	3	4	5	∂	8
4-16 amps	4	∂	8	10	12	1∂

The tap value is the minimum current required to just close the overcurrent relay contacts. Pickup and dropout time curves for the phase overcurrent units are shown in Figure 6.

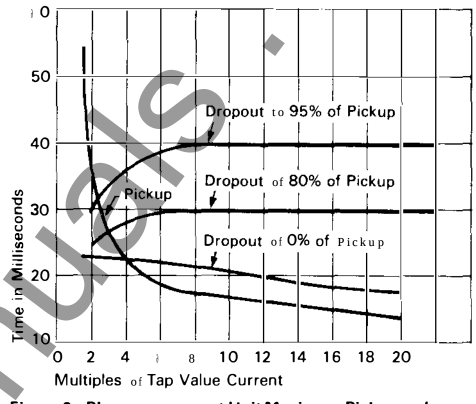


Figure 6 – Phase overcurrent Unit Maximum Pickup and Dropout Time

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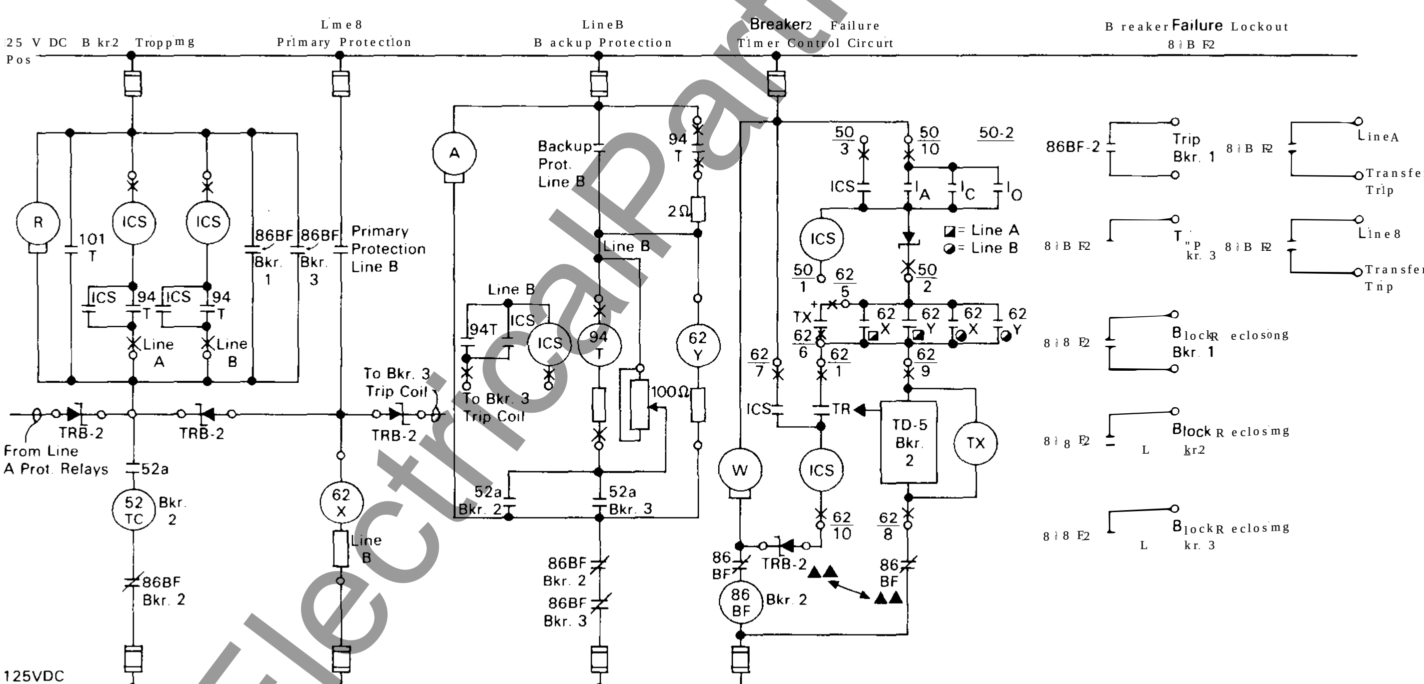
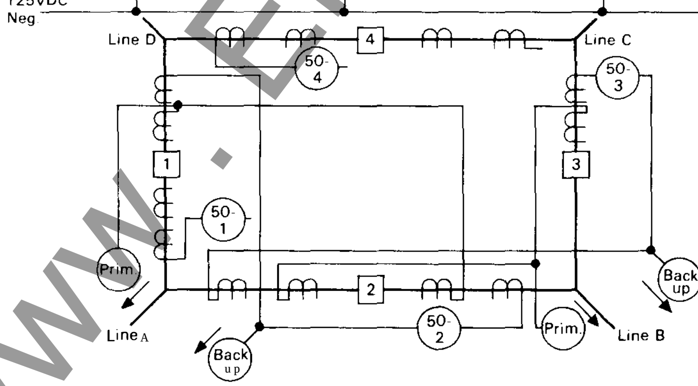
Fig. 5 Breaker Failure Relaying for a Ring Bus





Device No.	Type	Function	No. Req'd
. . .	TRB-2	Zener Tripping Unit	1/Line
50	KC-4	Overcurrent Detector	1/Bkr.
52	. . . .	Power Circuit Breaker	1/Line
∂2	TD-5	Breaker Failure Timer	1/Bkr.
∂2 X	AR .	Bkr. Fail. Initiating Aux.	1/Line
∂2 Y	AR▲	Bkr. Fail. Initiating Aux.	1/Line
8∂8	WL	Bkr. Fail. Lockout Aux.	1/Bkr.
94T	AR .	Tripping Aux.	1/Line

▲ = High Threshold Type (4MS Pickup)
. . = With Supervising Light, use either 8∂8 Contact or TRB-2 Blocking Zener but not both.
† = Optional for Seal-in of ∂2 X and ∂2 Y Contacts.

Figure 5 – 408C554
Sub 9

Indicating Contactor Switch

Trip Circuit Constants

0.2 amp tap: 6.5 ohms dc resistance
2.0 amp tap: 0.15 ohms dc resistance

Relay Settings

Pickup Current

Select proper tap on tap plate. For settings between tap rating, adjust spiral spring on moving element assembly as described in Instruction Leaflet 41-776.1

Indicating Contactor Switch (ICS)

Select proper tap (0.2 or 2.0 amperes), as required.

Current Ratings

Phase and Ground Overcurrent Units

Range	Continuous Amperes Rating:	One-Second Amperes Rating:
0.5-2	5	100
1 -4	8	140
2 -8	8	140
4 -16	10	200

Further Information

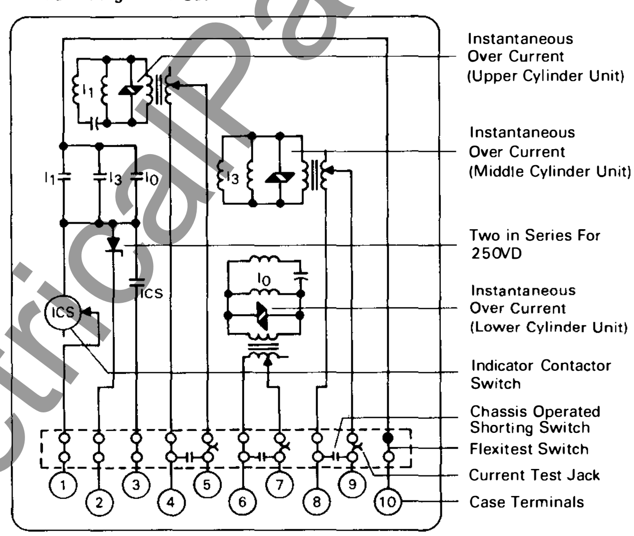
Standard Ratings, Ordering Information: TD 41-020
Prices: Price List 41-020
Dimensions (FT-41 Case):
Descriptive Bulletin 41-075, IL 41-076
Instructions: Instruction Leaflet 41-776.1
Other Protective Relays: Selector Guide 41-000A and B.

Energy Requirements

Phase and Overcurrent Units – 60 Hertz

Current	Tap	At Tap Value Volt-Amperes	At Tap Value Power Factor Angle	At 5 Amps Volt-Amperes	At 5 Amps Power Factor Angle
	.5	.37	39	24	46
	.75	.38	36	13	37
0.5-2	1	.39	35	8.5	34
	1.25	.41	34	6.0	32
	1.5	.43	32	4.6	31
	2	.45	30	2.9	28
	1	.41	36	9.0	36
	1.5	.44	32	5.0	32
1- 4	2	.47	30	3.0	29
	2.5	.50	28	2.1	27
	3	.53	26	1.5	26
	4	.59	24	0.93	24
	2	1.1	49	6.5	48
	3	1.2	43	3.3	42
2- 8	4	1.3	38	2.1	37
	5	1.4	35	1.4	35
	6	1.5	33	1.1	33
	8	1.8	29	0.7	29
	4	1.5	51	2.4	51
	6	1.7	45	1.2	45
4-16	8	1.8	40	0.7	40
	9	1.9	38	0.6	38
	12	2.2	34	0.37	34
	16	2.5	30	0.24	31

Internal Wiring FT-41 Case



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Sub. 2

Westinghouse Electric Corporation
Relay-Instrument Division:
Newark Plant, Newark, N. J. 07101

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