OPERATION OF SCHEME
# INSTRUCTIONS

# WESTINGHOUSE TYPE HKB SINGLE POLE CARRIER RELAYING AND RECLOSING

## GENERAL

This scheme provides single pole tripping and reclosing for phase to ground faults, and three pole tripping and reclosing (optional) for phase faults including two line to ground faults. This is, for all internal phase A-to-ground faults, only the phase A pole of the circuit breakers of both ends of the protected line will be opened. In a like manner, only phase B pole will be operated for phase B-to-ground faults and only phase C pole for phase C-to-ground faults. For each of these faults the opened pole will be reclosed immediately at each end.

On any internal three-phase, phase-to-phase, or two-phase-to-ground fault all three poles of the circuit breaker will be opened. Immediate reclosing for these faults is optional, that is, three pole reclosing can be provided if desired or three pole reclosing can be blocked.

The back-up relays used to supplement the type HKB Single pole carrier relays provide a separate independent protective system. These back-up relays trip all three poles and may be directional overcurrent, directional impedance, etc. If the types HZ Impedance or HZM distance relays and instantaneous trip attachments are used, then a time delay relay is necessary to delay the instantaneous back-up relays from tripping all three poles until the carrier relays have had an opportunity to trip single pole.

## COMPONENTS OF COMPLETE EQUIPMENT

The relay components of the type HKB Single pole carrier system consists of the following:

- 1 Type HKB Carrier Relay and Auxiliaries
- 1 Type HQS Phase Selector Relay
- 1 Type HZM-3 Distance Relay
- 3 Type SGR-12 Reclosing Relays as Req.
- as Req. Type SG and MG Auxiliary Relays

This list does not include phase and ground back-up relays which provide an independent relay system.

## OPERATION

The schematic connections for a typical type HKB single pole system is shown in figs. 3 to 6. The type HKB relay itself operates in the same manner as described in I.L. 41-600.3. The common tripping contacts of this relay are supervised by the types HQS and HZM-3 relays as shown on in figure 4 under "Carrier Trip Circuits". These relays have the following operating characteristics:

The type HQS phase selector relay is connected to receiver negative sequence current from a three-phase negative sequence filter energized by the current transformers and the residual current from the neutral circuit of the current transformers. On all single line-to-ground faults, the zero sequence components of all three phases are essentially in phase with the negative sequence component of the faulted phase. This means on a phase-A-to-ground fault, for example, the phase A phase selector element will have contact closing torque while the phase B and C elements will have contact-opening torque, since the B and C components of negative sequence current are essentially 120° out of phase with the negative sequence component of the unfaulted phase.

On all double line-to-ground-faults, the three zero sequence components are essentially in phase with the negative sequence component of the unfaulted phase. For example, consider a phase B-C to-ground fault. In this case the phase A phase selector element will receive contact closing torque while the phase B and C elements will not, because the negative sequence components of these two phases are

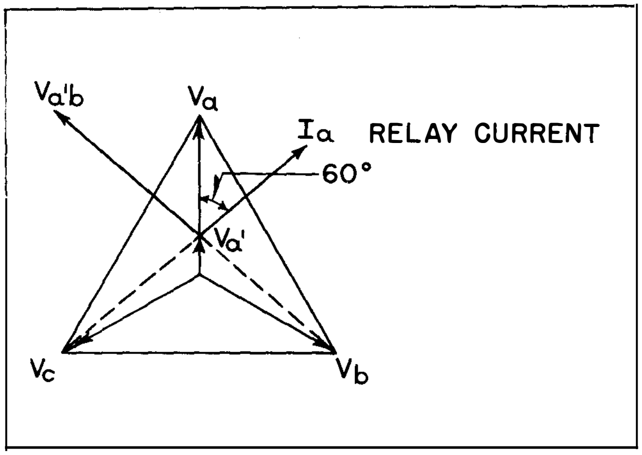



Fig 1—Vectors for Normal Balanced Conditions and for a Phase-A-to-Ground Fault.

essentially 120° out-of-phase with the respective zero sequence phase B and C components.

For phase faults not involving ground, the type HQS relay does not operate as the zero sequence currents are zero.

The type HZM-3 relay is connected to receive star current and the delta voltage which leads this current. With this connection and by proper setting, the relay can be made to operate on phase faults only. For close-in line to ground faults, the star current and the leading delta voltage are approximately 120° apart as shown in Figure 1.

This figure shows $V_a$, $V_b$, $V_c$ for normal conditions. When a phase a line-to-ground fault occurs, $V_a$ collapses to $V_a$, and the fault current $I_a$ lags this voltage by the system angle shown 60° in the figure. The delta voltage $V_{ab}$ is reduced slightly and now leads the relay current by approximately 120°.

On an R and X impedance diagram as shown in Figure 2, the type HZM-3 relay sees ground faults in the shaded area in the second quadiant. By off setting and shifting the ohm circle so that the relay response in the region of 90 to 180° lag is very limited, the relay can be made inoperative on ground faults.

It should be remembered that the scalar impedance seen by the distance relay is inherently higher for ground faults than for

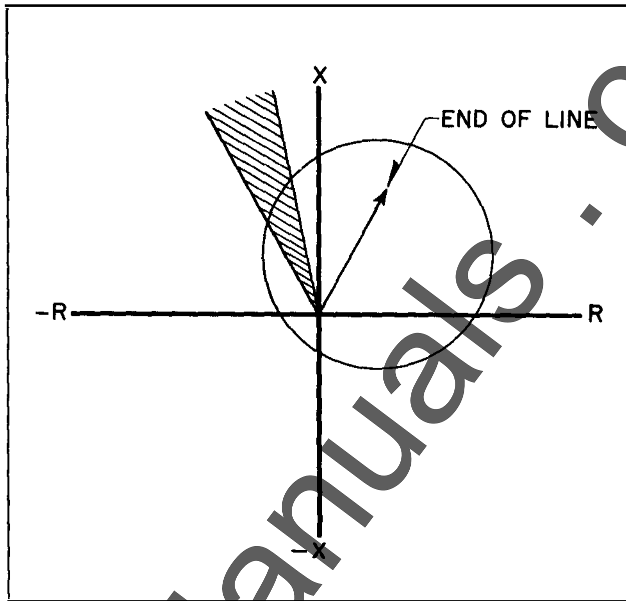



Fig. 2—Operating Characteristics of the Type HZM-3 Relay on Single-Line-to-Ground Faults plotted on an R-X Diagram.

phase faults. On phase faults the delta relay voltage is almost completely collapsed as compared to a collapse of not more than 57% for ground faults. Thus for heavy close-in ground faults the impedance seen by the relay will be outside the relay setting.

The three poles of the breaker are tripped as follows for the various faults. For internal single line-to-ground the type HKB and HQS relays operate to trip only the faulted phase. In other words for phase A to ground faults, the HKB relay contacts R close, and the type HQS phase selector relay contacts $S_A$ close to trip phase A pole. For a phase B-to-ground fault, contact R and $S_B$ close to trip phase B pole, and for a phase-C-to-ground fault, contacts R and $S_C$ close to trip phase C pole. For these faults contacts $Z_A$, $A_B$, and $Z_C$ of the type HZM-3 relay should not operate.

For any internal three-phase, phase-to-phase, or two-phase to-ground fault contact R and one or more of the type HZM-3 relay contacts $Z_A$, $Z_B$, or $Z_C$ close and energize CS1 and CS2 contactor switches. These in turn trip all three poles of the breaker. On two phase-to-ground faults the phase selector contact associated with the unfaulted phase will operate and initiate tripping of this phase, but simultaneously CS1 and CS2 will also trip this phase as well as the other two.

The back-up relays either phase or ground trip all three poles of the breaker for all types of faults within their range. These relays energize the type MG relay (designated MGT) which in turn trips the three phase poles. The instantaneous elements of the back-up relays are connected thru the type TG-1 Time Delay relay. This relay has a time setting of 5 to 15 cycles after which it energized MGT coil to trip all three poles. This time delay provides an opportunity for the carrier relays to trip one pole if the fault is single line to ground. When carrier single pole relaying is out of service, a contact on the type W carrier switch shorts out this time delay relay.

A telephone type relay designated X3 in the type HQS relay is used to prevent the unfaulted trip circuits from being energized momentarily by the transient response of the type HQS element, when the fault current disappears. The break contact of X3 is connected in each of the three phase-selector trip paths. The X3 contact opens in about 3-4 cycles and closes instantaneously. This contact does not open up the trip coil current on the faulted phase since this has been sealed in previously.

The X3 relay as well as the types JD and SGG relays are energized either by the type HKB relay trip circuit thru the contactor switch or when any one or two poles only are open.

The SGG relay shorts out the coils of the ground back-up relay type CWC or CWP. This is necessary only if the relay is set sensitively with a short time and might operate before the opened phase is reclosed. The type JD timing relay limits the time which the line can be operated with one or two phases open and thus serves a back-up ground relay.

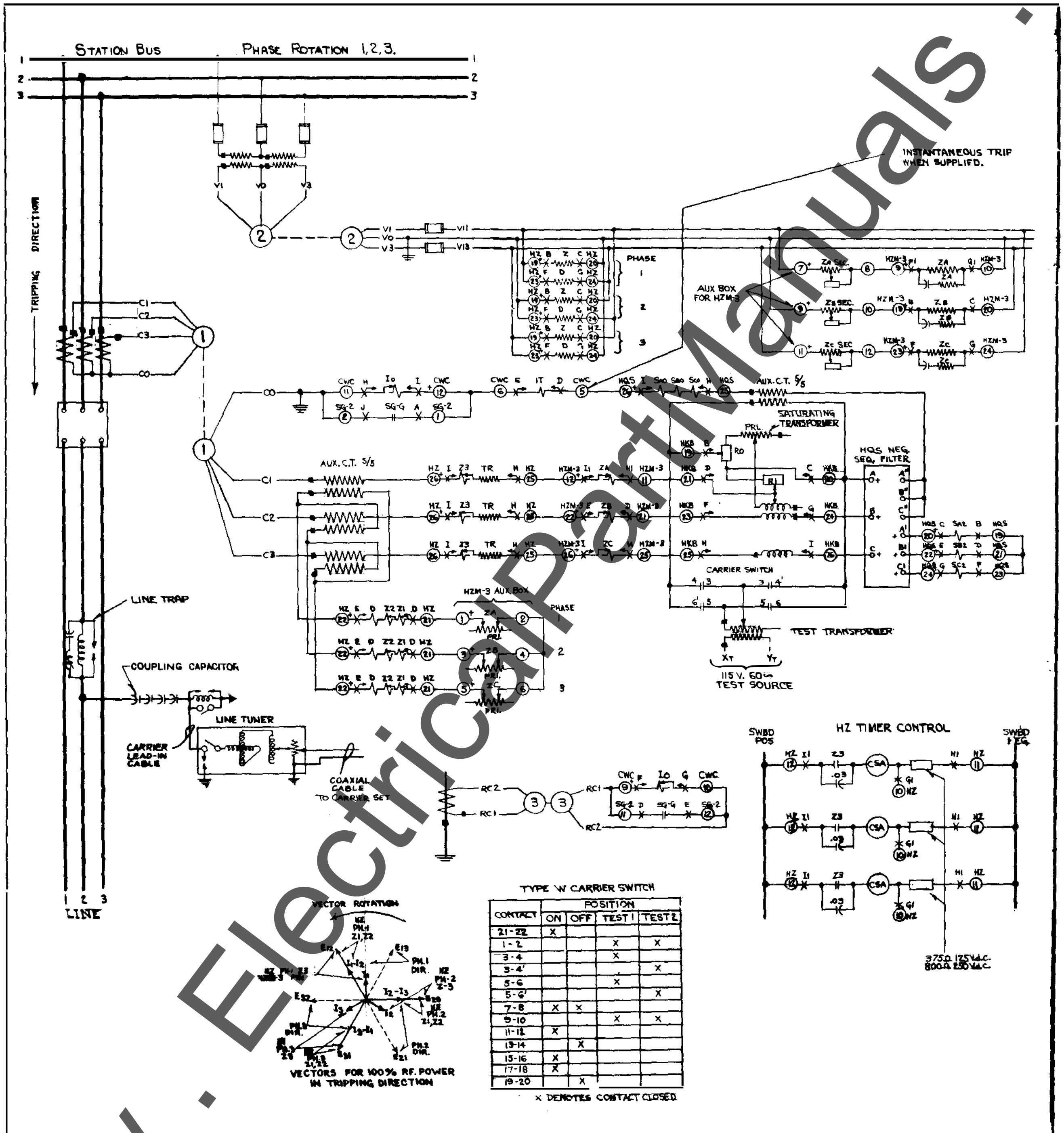
The operation of the carrier control circuits are the same as in the standard carrier scheme.

Automatic immediate reclosing is provided thru high speed breaker switches after one pole of the breaker is opened, but if all three poles open immediate reclosure may or may not be permitted depending upon system conditions. The reclosing scheme is shown on in figure 5, and operates as follows: For a phase A-to-ground fault which trips phase A pole, the high speed breaker switch 52bb, will close to immediately reclose this pole. The breaker auxiliary closing relay closes its contact 52X to energize 79X-0 coil. This is the operating coil of the toggle element in the type SGR-12 reclosing relay. Contact 79X in the closing circuit is thus opened to prevent further reclosing of pole A. Another contact on the toggle element, 79X, is closed to energize the reset motor (79M) of the type SGR-12 relay when the breaker pole closes as indicated by the closing of 52a. If the breaker stays closed the motor contact 79M closes after a suitable delay to energize the toggle relay reset coil 79X-0. This coil resets the two 79X contacts which in turn de-energizes the timing motor and resets the closing circuit for a subsequent trip.

A similar sequence of operations will take place for the other breaker poles when they are opened by operation of the protected relays. It is to be noted that the manual control switch and the back-up relays all energize a master tripping relay MGT. Make contacts on MGT operate the toggle element 79X-0 of the type SGR-12 recloser to lock out and block reclosure until after the breaker poles are manually reclosed. Reclosing is also blocked when carrier is out of service by the type W carrier switch. If instantaneous reclosing is to be prevented for internal phase faults tripped by carrier, then another type MG relay is required. This relay is energized by CS1 contactor switch of the type HZM-3 relay. This type MG relay will trip all three breaker poles and energize 79X to lock out and block recloser of all three breaker poles.

The manual closing switch, 101-C, operates a master closing relay designated MG-C1. The contacts of this relay energize the closing circuit of each of the three poles.

In the above discussion it was assumed that the breaker poles remained closed after the first reclosure indicating that the fault was not permanent. If the arc restrikes or the fault is solid, then the protective relays will operate to retrip the breaker poles again. This time one or more of the 79X reclosing contacts of the type SGR-12 recloser will be open from the first reclosure so that reclosure is locked out on these poles. When the poles are open, a breaker b switch 52b, is closed to energize relay SGF through the closed contact 79X. The contacts of SGF operate the MGT relay to trip all poles. Thus the second tripout results in tripping and locking out reclosure of all three breaker poles. This b switch which energizes the SGF relay must be set so that it never closes on a




| CONTACT | POSITION | | | |
|---|---|---|---|---|
| | ON | OFF | TEST 1 | TEST 2 |
| 21-22 | X | | | |
| 1-2 | | | X | X |
| 3-4 | | | X | |
| 3-4' | | | | X |
| 5-6 | | | X | |
| 5-6' | | | | X |
| 7-8 | X | X | | |
| 9-10 | | | X | X |
| 11-12 | X | | | |
| 13-14 | | X | | |
| 15-16 | X | | | |
| 17-18 | X | | | |
| 19-20 | | X | | |

X DENOTES CONTACT CLOSED

Fig. 3—Typical Carrier Control and Alarm Circuits for the Type HKB Single Pole Carrier Relaying Scheme.

high-speed open-close cycle. In other words, when the tripping and closing mechanisms of the breaker are energized approximately simultaneously, the breaker contacts are not fully opened but are parted sufficiently to extinguish the arc. Correspondingly, the breaker auxiliary switch is not completely operated.

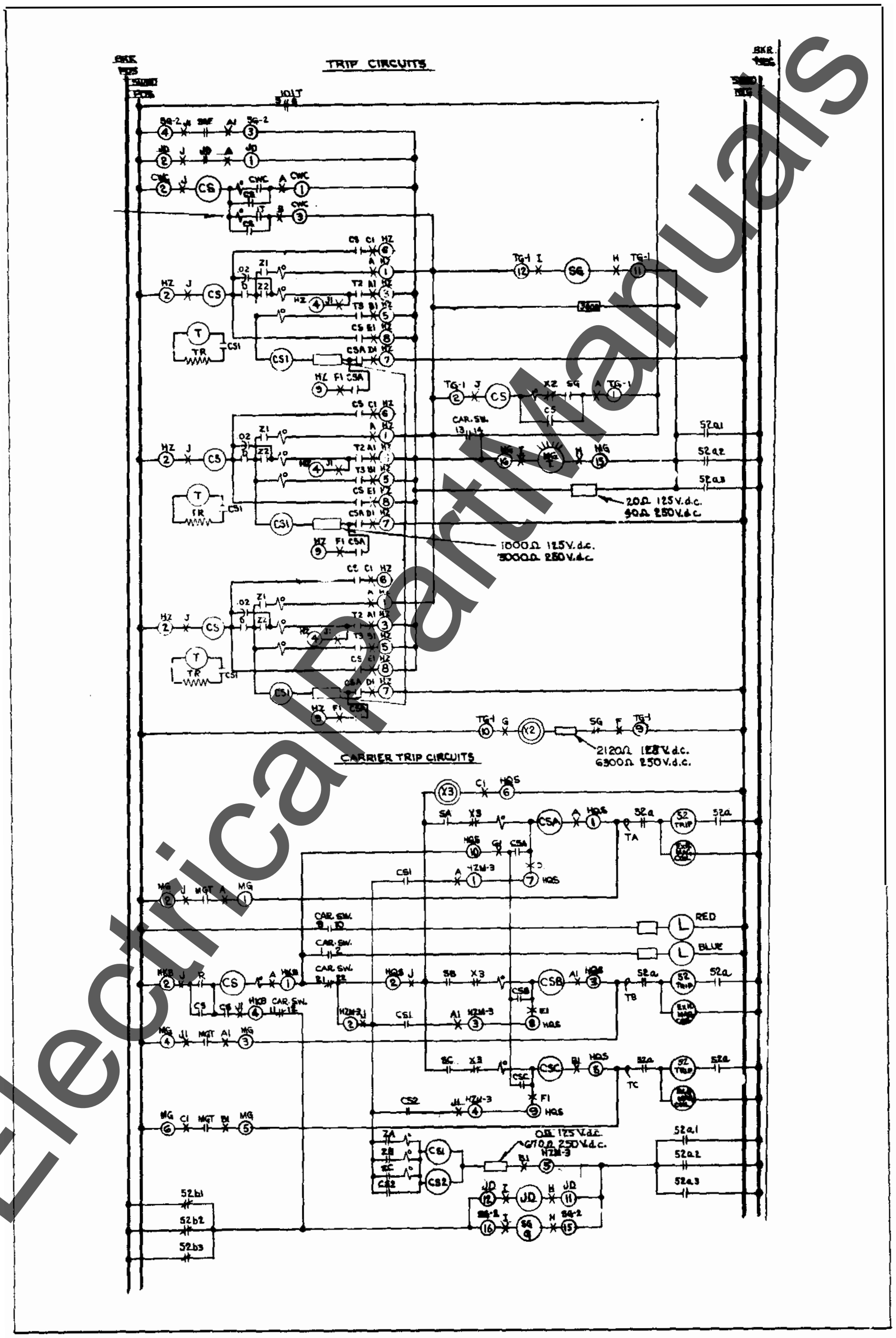



Fig. 4—Typical Reclosing Circuits for the Type HKB Single Pole Carrier Relaying Scheme.

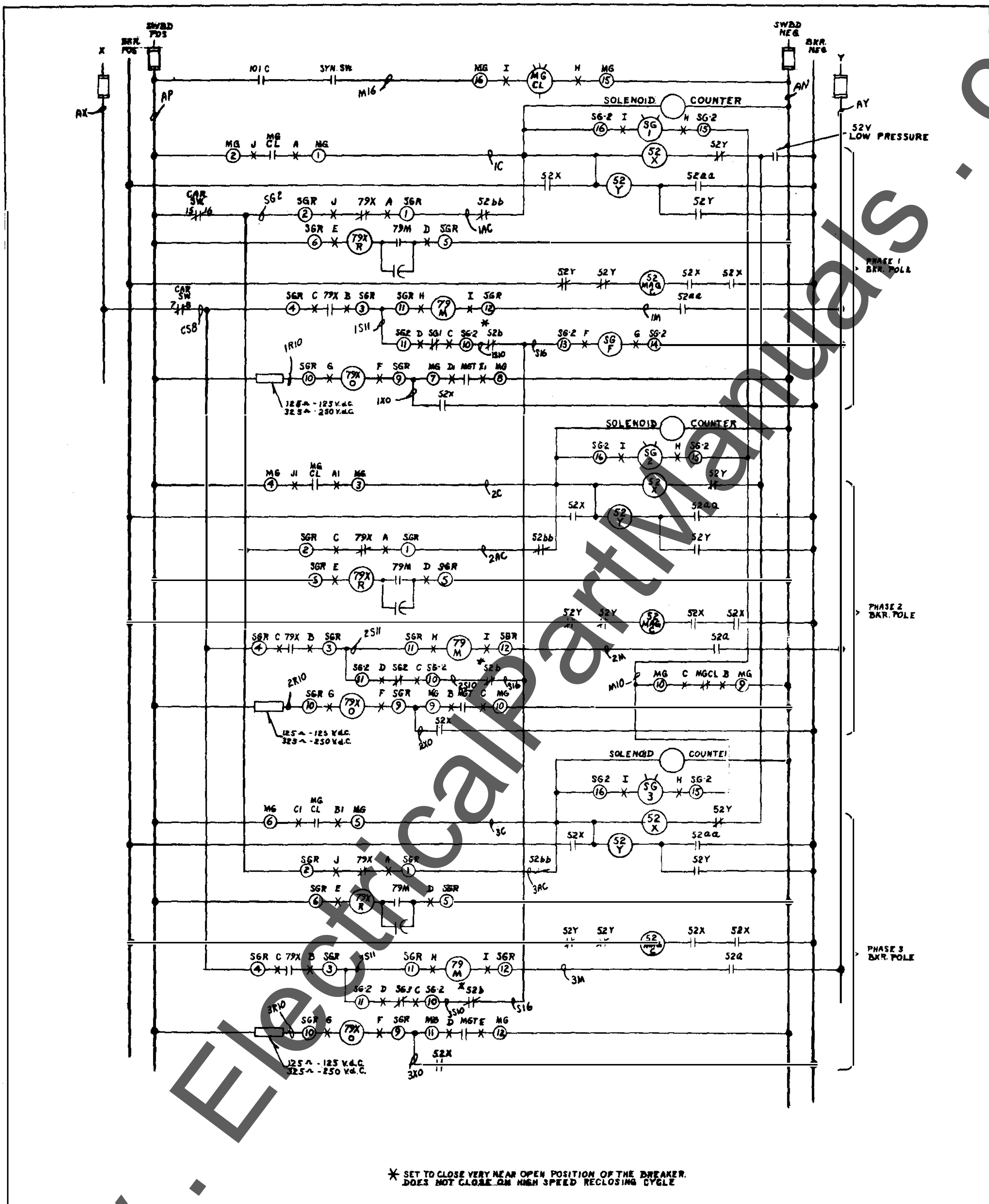
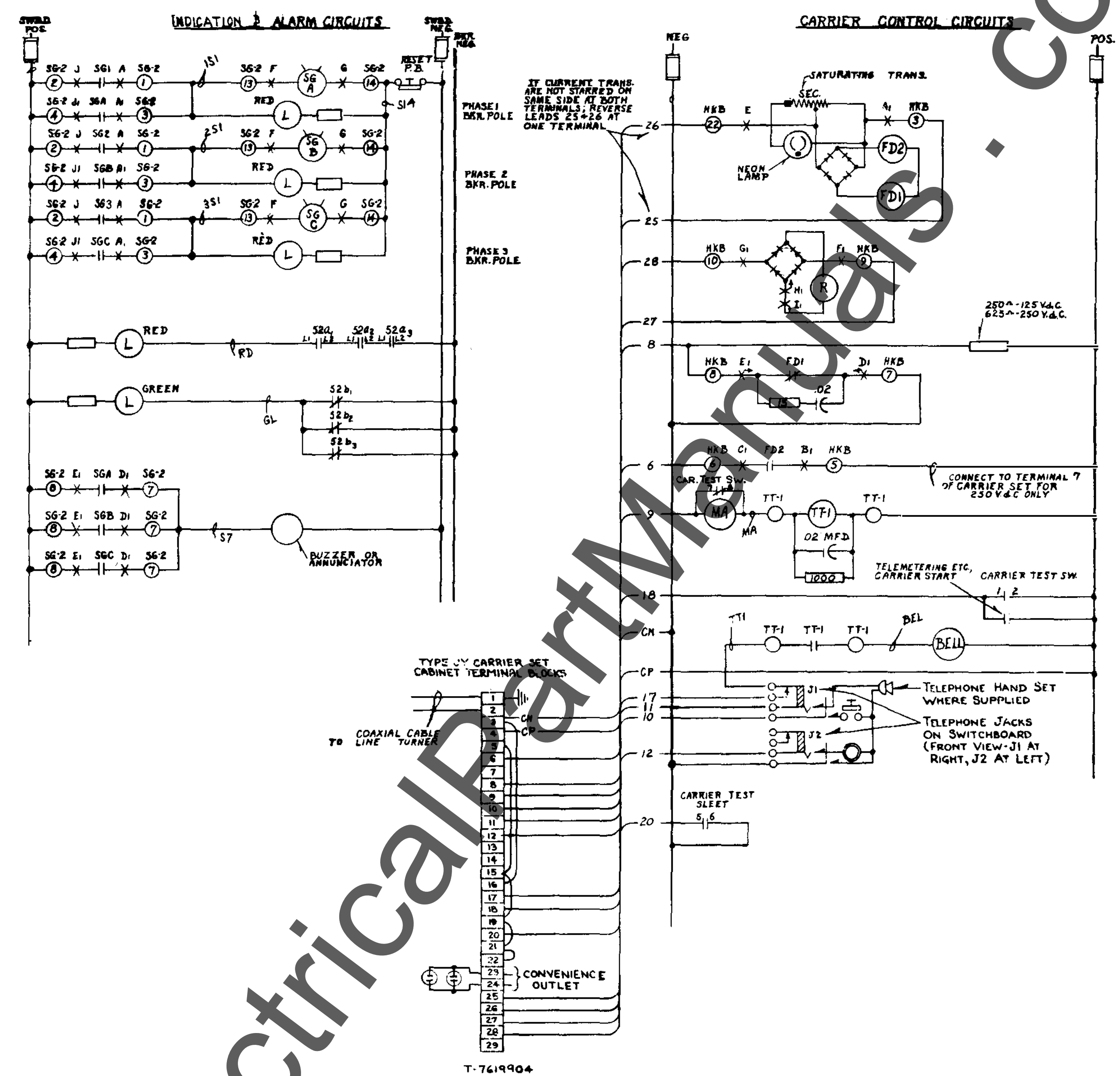



Fig. 5—Typical Reclosing Circuits for the Type HKB Single Pole Carrier Relaying Scheme.




CARRIER TEST SWITCH

| CONTACT | POSITION OFF | POSITION CARRIER TEST | POSITION SLEET TEST |
|---|---|---|---|
| 1-2 | | X | |
| 3-4 | | X | |
| 5-6 | | | X |
| 7-8 | X | | |

X DENOTES CONTACT CLOSED

Fig. 6—Typical Carrier Control and Alarm Circuits for the Type HKB Single Pole Carrier Relaying Scheme.

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