INSTRUCTIONS

MOR 3000

DIGITAL DIRECTIONAL OVERCURRENT PROTECTION, CONTROL AND MONITORING SYSTEM

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MOR3000

SYSTEM OF PROTECTION, CONTROL AND MONITORING FOR DISTRIBUTION LINES

1. DESCRIPTION

The MOR3000 is a microprocessor-based digital protection system that incorporates three-phase- and ground-directional overcurrent protection, and automatic reclosing designed for protection, control and monitoring of distribution lines.

Each MOR3000 is associated with a single line and acts as an independent directional overcurrent protection and reclosing system.

The MOR3000 is provided with a serial communication module that allows its use as an integral part of a complete protection and control system in substations or at higher levels (see Figure 3). The other components that form the system are:

a) TTI: Remote controller.
Personal PC computer with a modem.

b) CPR: Communication concentration unit.
Multiplexor and modem for connection to MOR systems associated with each substation line.

The MOR3000 incorporates the following functions:

- Inverse overcurrent function and definite time (four curves are included, one of these can be defined by the user), as well as instantaneous overcurrent protection for phases and ground.

- Phase-to-phase and phase-to-ground unbalanced-current protection.

- Five-shot programmable automatic recloser.

- Three-phase and ground current measurement.

- On-line monitoring of breaker status, including health and cumulative current.

- Event recorder with incorporated counter and timer with capacity for 255 events. The information stored includes date, time, current value and type of event (such as pickup of the protection function, tripping, reclose, change of breaker status etc.).

- Maximum current recorder with seven-day capacity

- Serial communication module for remote access to information, breaker control and programming of the relay, such as reclosing settings and system parameters. In addition, a keypad and display for local interface is provided. The various MOR models include the following standard interfaces:

20 mA current loop.

Fiber optic (glass or plastic) interface.

RS232C.

- Remote breaker control.

- Self checking and monitoring of the internal circuitry and input signals.

The protection and reclosing functions of the MOR3000 are independent of control and communication, to ensure highly reliable protection operation even in the case of failure of the remaining system components.

The MOR3000 is housed in a single case. The dimensions appear in Figure 9.

The MOR3000 has two trip-output contacts, two reclose-output contacts, one alarm and seven optional auxiliary contacts that are normally open. The customer may choose these seven contacts from the following list:

- TOC phase pickup.
- TOC ground pickup.
- TOC phase and/or ground pickup.
- TOC phase trip.
- TOC ground trip.
- TOC phase and/or ground trip.
- IOC phase trip.
- IOC ground trip.
- IOC phase and/or ground trip.
- Unbalanced-current trip.
- Reclose in process.
- Reclose blocked.
- Final Trip.

In addition, there is an internal clock without a battery that is precise to a hundredth of a second. Since there is no battery, it is necessary to set the time in the relay when it is put in service. Upon energization, the MOR3000 searches for the date and time of the last recorded event and begins to count time from that moment. If there is no recorded event the clock initializes itself with the default date and time (01/01/88, 00:00:00). Therefore, if the date and time are not properly set, all events will appear displaced in time, but the relative time between events will be correct.

2. APPLICATION

The MOR3000 is used for protection of feeders and lines in general where overcurrent and short-circuit protection is required, as well as automatic reclosure (the recloser may be activated or deactivated). The ability to record events, control and monitor makes the MOR3000 system especially appropriate for use in rural and un-manned substations, eliminating the necessity of sending personnel to the field to obtain information on fault conditions and return the circuit to service, thereby improving quality of service and maintenance. It can also be used for industrial installations where it is desirable to have centralized control of the MOR's and their associated breakers.

2.1 OVERCURRENT UNIT

The overtravel characteristic is practically insignificant (less than 30 milliseconds for the inverse-time unit, less than 10 milliseconds for the instantaneous unit). The reset time is less than 70 milliseconds and the pickup-to-dropout ratio is no less than 95%. These characteristics, together with the adjustable time delay of the instantaneous unit and the continuous pickup current setting, allow precise coordination and high-speed reclosure without compromising selectivity. The relay has four inverse-time curves available. If any application requires the use of special current characteristics in order to obtain improved coordination, the user can define the curve.

The inverse-time characteristic is generally used in applications in which the fault current magnitude depends on the generating capacity at the moment of the fault. Figure 4 represents the operating characteristic curve of the inverse-time unit.

The very inverse-time characteristic is generally used in applications where the fault current magnitude depends fundamentally upon the impedance of the system between the generation point and the location of the relay, and has very little or no relationship to the characteristics of the generating system. Figure 5 represents the operating characteristic of the very inverse-time overcurrent unit.

The extremely inverse-time unit is used principally in applications where there would be a high value of current at the moment the circuit is connected after having been out of service for a period of time (e.g. cold load). A typical example is the application on distribution circuits, since the extremely inverse characteristic is the one that approximates the fuse curves that are employed on these circuits. Figure 6 represents the operating characteristic for the extremely inverse-time overcurrent unit.

An example of the characteristic defined by the user is shown in Figure 7. This curve can be defined by the factory, or users can program their own curve. In order to program a new curve, a computer help program exists in which the user can graphically introduce a series of points. These points are then processed to convert them to data that can be identified by the MOR3000 and are input through the GEPC LINK program.

The instantaneous unit can also be programmed with time-delay. The operating time of the instantaneous unit when the time-delay is zero is given in Figure 8.

Operation of the inverse-time and instantaneous units can be blocked through an external signal, both for the phase and ground units.

2.2 RECLOSER

The multiple-shot recloser included in the MOR3000 is totally programmable. The number of reclosures can be selected in a specific cycle between zero (0) (out of service) and five (5).

The security (reset) time, is selectable between 1 and 10 minutes. This time is adjustable for initial security time as well as the security time between the reclosures. The initial security time count begins from manual closure of the breaker or from initialization of the relay (either upon connecting the relay to the supply, or after a change of setting). If a fault occurs during this initial security time it is considered permanent and the reclose cycle is terminated.

The protection functions can be programmed so they can trip, or not trip, the breaker in each of the following circumstances:

> During the security time following manual closure.

> After the security time has finished.

> After each one of the programmed reclose attempts.

The pause times before performing each reclose attempt are separately adjustable.

Each reclose attempt is initiated only if the protection function that produced the previous trip has been programmed such that it can initiate a specific reclose attempt. If it is not so programmed, the fault is considered permanent and the reclose cycle is ended.

This programming flexibility allows specific reclose cycles to be carried out; for example: a first instantaneous trip and a second time trip, and their associated reclosures, and then a third time overcurrent trip to permit downstream fuses to clear in order to keep the feeder in service.

The recloser can be externally blocked using a permanent signal to block the Reclose input; it can also be blocked and unblocked by command through the communication port.

An AC voltage input is included to permit the recloser to be disabled if voltage is not present at the substation bus.

3. CHARACTERISTICS

3.1 GENERAL CHARACTERISTICS

> - Accurate and reliable with low power consumption.

> - Rack mounted.

> - LED Ready indicator for "system in service".

> - Integral keypad and display.

> - High-reliability solid-state components.

> - Microprocessor system.

> - Self checking (self monitor)

3.2 TECHNICAL SPECIFICATIONS

Frequency:	50 or 60 Hz.
Rated input voltage for reclose permit:	V_n = 110 VAC phase-to-phase or 68 VAC phase-to-ground ±20%.
Rated current:	I_n = 1 or 5 A AC.
Auxiliary DC supply:	Two operating ranges: 48-125 VDC ±20%; 110-240 VDC ±20%

Thermal capacity:

Continuous:	2xI_n.
3 seconds:	50xI_n.
1 second:	100xI_n.

Temperature:

Operation:	−20 degrees C to +65 degrees C.
Storage:	−40 degrees C to +65 degrees C.

Relative Humidity: Up to 95% without condensing.

Communications:
- 20 mA current loop.

I > 12 mA "ON".
I < 2 mA "OFF".
Vmax with open-loop 60 VDC.
Vmax with closed-loop < 5 VDC.

- 1 mm plastic fiber optic.

Typical emitted power	−8dBm.
Receiver sensitivity	−39dBm.
Numerical aperture N.A.	=0.5.
Wavelength	660 nm (visible red).

- 100/140 glass fiber optic.

Typical emitted power	−14dBm.
Receiver sensitivity	−25dBm.
Numerical aperture N.A.	=0.3.
Wavelength	820 nm (infrared invisible).
Connector type	SMA.

Output trip contacts:

- Closing:	3000 W resistive for 0.2 seconds with 30 A and 300 VDC.
- Breaking:	50 W resistive with 2 A and 300 VDC maximum.
- Continuous:	5 A and 300 VDC maximum.

Auxiliary contacts:

- Closing:	5 A DC for 30 seconds and 250 VDC maximum.
- Breaking:	25 W inductive and 250 VDC maximum.
- Continuous:	3 A.

Standards:

- Insulation voltage test:	2 kV 50/60 Hz for one minute, per IEC 255-5.
- Impulse test:	5 kV peak, 1.2/50 microsecond, 0.5 J, per IEC 255-5.
- Interference test:	2.5 kV longitudinal, 1 kV transversal, class III, per IEC 255-22-1.

- Electrostatic discharge: Per IEC 255-22-2, class III.
- Radio interference: Per IEC 255-22-3, class III.
- Fast transient: Per IEC 801-4, class III.
- Interference test withstand: SWC per ANSI C37.90.1.

Accuracy:

- Operating value: 5%.
- Operating time: 5% or 0.030 second (whichever is greater).
- Error index, class E, per IEC 255-4
    for currents and operating time: class E-5.

Repeatability:

- Operating value: 1%.
- Operating time: 2% or 0.030 seconds (whichever is greater).

Burdens

Current Circuit	Frequency	VA @ 5A
ϕA, ϕB, ϕC, Ipol	@60 Hz	1.1
ϕA, ϕB, ϕC, Ipol	@50 Hz	0.85

		VA @ 1A
ϕA, ϕB, ϕC, Ipol	@60 Hz	0.04
ϕA, ϕB, ϕC, Ipol	@50 Hz	0.04

Voltage Circuits		VA @ 120 Vrms
ϕA, ϕB, ϕC	@60 Hz	0.25
ϕA, ϕB, ϕC	@50 Hz	0.27

DC Battery (power supply)	
Tripping Mode	11 W
Non-tripping mode	9 W

3.3 RANGES AND SETTING VALUES

The following indicates the ranges corresponding to standard models. It is possible to supply special models with other setting ranges on request.

Overcurrent function.

Current Transformer ratio: 0 to 4000 in steps of 1.
(independent for phase and ground)

Time overcurrent unit (TOC):   0.3 to 2.4 x In. or
0.2 to 1.6 x In. or
0.1 to 0.8 x In, in steps of 0.01 A.
Independent ranges for phase and ground units). A setting of zero disables this function.

Time delay (TOC):   Depends on the curve selected. See Figures 4, 5, 6 and 7.
(independent for phase and ground)

Instantaneous unit pickup: 1 to 160 times the minimum tap for the setting range of
(independent for phase and ground)   the time unit (depending on the setting value for this unit), in steps of 0.01 A. (Take note of the dependence between the units described in section 4.2). A setting of zero disables this function.

Time delay of instantaneous unit: (independent for phase and ground)	0.00 - 9.90 seconds, in steps of 0.01 seconds.
Phase-unbalance percentage:	5 to 25% in steps of 1% (At least one of the currents should exceed the minimum pickup current by 0.5 times the minimum tap range of the relay). A setting of zero disables this function.
Pickup of ground unbalance:	From 0.25 times the minimum tap of the setting range of the ground time-delay unit to the tap setting of the unit. A setting of zero disables this function.
Unbalance time-delay:	0.15 to 60.00 seconds in steps of 0.01 seconds.
Phase operating curve:	ANSI INVERSE, VERY INVERSE, EXTREMELY INVERSE and a user-definable curve/another that can be defined by the user.
Ground operating curve:	ANSI INVERSE, VERY INVERSE, EXTREMELY INVERSE and another that can be defined by the user.
Phase/ground directional control:	Enabled/disabled.
MOR identification:	Maximum 20 characters.
Number to identify the breaker associated with the M0R:	0 to 255.

Directional unit

The characteristic makes a ±90 degree angle with the maximum torque line, with an accuracy of ±2.5 degrees.

Phase directional unit:	Nominal polarization voltage:	120 V phase-to-phase (60 Hz), 110 V (50 Hz).
	Thermal continuous rating:	1.2 Vn.
	Characteristic angle:	45 degrees leading.
	Directional sensitivity:	minimum operation current 5 % In. minimum operating voltage 0.4 V.
	Operation time:	less than 20 ms for currents making an angle with the polarization voltage equal to the characteristic angle (for nominal polarization values of voltage and current).
Ground directional unit:	Nominal polarization voltage:	69 V phase-to-phase (60 Hz), 63 V (50 Hz).
	Thermal continuous rating:	3.6 Vn.
	Characteristic angle:	45 degrees lagging.
	Directional sensitivity:	minimum operation current 2 % In. minimum operating voltage 0.2 V.
	Operation time:	less than 20 ms for currents making an angle with the polarization voltage equal to the characteristic angle (for nominal polarization values of voltage and current).

Recloser function.

Number of reclosures: 0 to 5 (0 means that the recloser is out of service).

Number of repetitive trips: 1 to 30 in time window of one hour.

Operating elements enabled during
security time after a manual close: Phase IOC, phase TOC, ground IOC, ground TOC, and phase and ground unbalance. Enabled/disabled, each one independently except for unbalance, which is common for phase and ground.

Units that produce trips: Phase IOC, phase TOC, ground IOC, ground TOC and phase and ground unbalance. Enabled/disabled, each one independently except for unbalance, which is common between phase and ground.

Units that produce reclosure: Phase IOC, phase TOC, ground IOC, ground TOC and phase and ground unbalance. Enabled/disabled, each one independently except for unbalance, which is common between phase and ground.

Time-delays.

Maximum time for breaker opening: 0.1 to 1.0 second in steps of 0.01 second.

Maximum closing time of the breaker: 0.5 to 99.9 seconds, in steps of 0.1 second.

Lockout time (security time):   1.00 to 10.00 minutes in steps of 1 second.
Permit-reclosure time (VCA CTR. TIME)   1.00 to 10.00 minutes in steps of 1 second. Adjusting
(VAC Control Time):   this setting to zero disables the Permit Reclosure input and is treated as if a Permit Reclosure signal exists.

Reclose time (delay time):   0.2 to 99.9 seconds in steps of 0.1 second, independently programmable for each reclose attempt.

Breaker supervision: The limit value can be adjusted between 1 and $99999 \ kA^2$, and an accumulated current value between 0 and $99999 \ kA^2$.

3.4 EVENT RECORDER

(See Section 4.11)

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3.5 COMMUNICATIONS

Baud rate: 300, 600, 1200, 2400 or 4800 baud (See section 4.8).

Mode: Half duplex.

Communications Channel:
Remotely: 20 mA current loop (standard), fiber optic or RS232C interface (options).
Locally: keypad and display.

3.6 APPLICATION COMMANDS

(See user's manual for the MLINK program, GEK-90575.)

4. PRINCIPLES OF OPERATION

4.1 INPUTS

The current transformers for the protected circuit provide the secondary current that is applied to the input of the relay and is immediately reduced through internal current transformers. The secondary of the internal current transformers of the relay are connected to input resistances that produce a voltage that represents the input current to the relay.

This voltage passes through low-pass filters with a cutoff frequency of 50 or 60 Hz. (according to the model), before arriving at a multiplexor and digital-to-analog converter that performs the function of a variable gain and amplification stage. The output of this converter is rectified and goes to an analog-to-digital converter, in which the instantaneous current measurement is performed.

4.2 MEASUREMENT

An internal timer of the microprocessor generates an interruption every millisecond (50 Hz.) or each 0.833 milliseconds (60 Hz.), such that there are 20 interruptions per cycle. The interruptions are divided in groups of five, such that the first four are used to measure the phases and ground and the fifth is left free to execute the reclose program and event recorder. Therefore, four measurements are made for each phase in the cycle, separated by 5 milliseconds (50 Hz.) or 4.33 milliseconds (60 Hz.).

With these four instantaneous current measurements (I1, I2, I3, and I4), it is possible to calculate the RMS current with the formula:

$$I^2 \, RMS = \frac{I1^2 + I2^2 + I3^2 + I4^2}{4}$$

In order to improve the accuracy of obtaining these instantaneous currents, two measurements are performed, 50 microseconds apart. The first is done with a fixed gain and, depending on the value obtained, this gain is changed and a second measurement is obtained, which is the one actually used. In this way a wider dynamic range of the analog-to-digital converter is used, and therefore the accuracy is greater.

In order to obtain optimal advantage of the dynamic range of the converter, the tap ranges of the MOR3000 have been divided into three zones:

Zone	Independent for phase and ground
I	1K to 2K (inclusive)
II	2K (exclusive) to 4K (inclusive)
III	4K (exclusive) to 8K (inclusive)

Where K is the minimum tap of the setting range for the inverse-time unit.

According to the tap setting, a zone is selected and the gains that are used are different from those that would be used in another zone.

The operating value of the instantaneous unit can be adjusted between the minimum value of zone I (times 1) and 20 times the maximum value of the zone in which the relay is set. For example, for In = 5 A and the range of 0.2 to 1.6 x In, the zones would be 1 to 2, from 2.01 to 4, and from 4.01 to 8 A. If the inverse-time unit is set to 2.5 A we would find ourselves in zone II and therefore the instantaneous unit could be set between 1 x 1 = 1 A and 20 x 4 = 80 A.

If the inverse-time unit is set to 2 A, we would find that this value is included in zone I and therefore the instantaneous unit could be set between 1 x 1 = 1 A and 20 x 2 = 40 A.

NOTE: All of the absolute values of current that appear in this instruction book are given for a MOR3000 with a nominal current of In = 5 amperes for phases and In = 1 ampere for ground and a setting range of 0.2 to 1.6 x In.

4.3 DIRECTIONAL UNIT OPERATION

The purpose of the directional unit is to enable or disable the phase and ground overcurrent trips, each of them independently. The directional unit does not affect the unbalanced-current unit.

The MOR's directional unit consists of three independent phase units and a ground unit. As a general rule, phase and ground have a 45 degree characteristic; other angles can be provided upon request.

4.3.1 Phase Directional Units

The directional phase units measure the angle between the line current and the polarization voltage (which, for each phase, is the phase-to-phase voltage of the other two phases, obtained in the relay from the phase-to-ground voltages).

This measurement is performed by making the polarization voltage, Vp, lead the characteristic phase angle (see Figure 13); in this way we obtained Vp'.

After doing so we measure the phase angle between line current, IL, and Vp'.

If this angle is less than 90 degrees, then the line current and the polarization voltage are in the same side of the directional characteristic, so the trip is enabled. Figure 13 shows the operating principles of the phase directional units.

The operation of the phase directional unit is as follows. The input signals are converted into square waves through rectifier filters, the positive and negative transitions of the polarization voltage are made to lead by means of software the characteristic angle, obtaining Vp'.

After this, the transitions of IL and Vp' are time-measured. This time difference is digitally processed and compared with a reference corresponding to a 90 degree angle. If it is greater, then the trip is disabled, and if it is smaller the trip is enabled.

When line current or polarization voltage can not be measured in one phase, then the directional unit is not able to detect which direction the current is flowing; then the trip for that phase is disabled.

4.3.2 Ground Directional Unit

The ground directional unit can be polarized either by voltage or by current. If both polarizations inhibit the operation of the unit, then the trip is disabled. If at least one of the polarizations permits the operation of the unit, then the trip is enabled.

4.3.2.1 Voltage Polarization

The ground directional unit measures the phase angle between Io current and the polarization voltage Vp, in the same way as described before for the phase unit. Voltage Vp is made to lag the characteristic angle (see Figure 14), obtaining in this way Vp'.

After this we measure the phase angle between Io and Vp'. If this angle is less than 90 degrees, Io and Vp' are in the same side of the characteristic, so the voltage polarization inhibits the trip.

On the other hand, if this angle is greater than 90 degrees, Io and Vp' are in different sides of the characteristic and the voltage polarization permits the trip.

Figure 14 shows the operating principles of the ground directional unit with voltage polarization.

The polarization voltage in the MOR3000 is obtained by adding the three phase-to-ground voltage phasors inside the relay vectorially.

4.3.2.2 Current Polarization

The ground unit measures the phase delay between the operating current (Io) and the polarization current (Ip).

These two currents can only be in phase or 180 degrees out of phase. If they are in phase, the current polarization permits the trip. On the other hand, if the phase angle is 180 degrees, then the current polarization inhibits the trip.

If the current polarization of the ground directional unit is not used, then the two terminals must be short-circuited. Furthermore, either when the ground current can not be detected or when both polarizations (current and voltage) are removed, the ground-overcurrent unit trip is automatically disabled.

4.4 INVERSE-TIME UNIT

The current measurement obtained is compared independently for each phase and ground with the value that corresponds to the tap set by the user; if this value is exceeded, a Pickup "LED" lights in the display.

The minimum current value to produce an operation of the inverse-time measuring element is in no case less than the setting value (Is), nor greater than this value +10%.

$$1.0 \text{ Is} < \text{Imin} < 1.1 \text{ Is}$$

The dropout percentage is not less than 95% of the value that caused operation.

Once a trip is produced, the optional auxiliary relay closes (time-delayed for phases or for ground) during the time that the Trip relay is closed.

The MOR3000 has four inverse-time operating curves available: ANSI INVERSE, VERY INVERSE, EXTREMELY INVERSE, and another that can be defined by the user. Within each family, the curves are defined by a coefficient (time dial) from 1 (upper curve) to 0.05 (lower curve). In the event the user does not wish to define a new curve in the MOR3000, a curve is provided by the factory, as shown in Figure 7.

It is possible to disable the inverse-time unit for phases or ground by setting the corresponding tap to zero. Please refer to the procedure in the user manual for the GEPCLINK program.

4.5 INSTANTANEOUS UNIT

The instantaneous unit follows two operating criteria:

- The unit operates if the instantaneous current measured is greater than double the effective current set by the user.

- The unit operates if the effective current measured is greater than the effective current set by the user.

In either case, a Pickup "LED" located in the display is "lit", and a timer programmable by the user is started. When this timer times out, the relay trips and an optional auxiliary relay closes during the time the Trip relay is closed (phase or ground instantaneous).

The minimum current to produce an operation of the instantaneous unit is never less than 95% of the set value (Is), nor less than this value +5%.

$$0.95 \text{ Is} < \text{Imin} < 1.05 \text{ Is}$$

The dropout-to-pickup ratio is not less than 95%.

The trip level is user-adjustable independently for phases and ground. Also, the timer can be programmed, again independently for phases and ground, between 0.0 and 9.9 seconds.

To prevent the instantaneous unit from acting sooner than the directional unit, and thus tripping before it can be blocked, if the delay time is set to 0 or any value lower than 20 msec, the delay time will actually be 20 msec.

It is possible to disable the instantaneous unit by setting the trip value to zero. Please refer to the procedure in the program manual for GEPCLINK.

4.6 UNBALANCED CURRENT

4.6.1 Phase

This unit compares the RMS current between the three phases, and if the difference between them is greater than a certain percentage established by the user, the unit picks up and the "LED" indicator lights up in the display.

If the difference between the phases continues for a user-adjustable time, the relay trips, and at the same time an auxiliary relay (optional) closes, corresponding to the unbalanced-current unit.

The percentage can be adjusted between 5% and 25%. If the user wishes to disable this function, a value of zero can be introduced as a setting. The operating times are programmable between 0.15 and 60 seconds.

In order to produce an operation, it is necessary that at least one of the phases be greater than 50% of the minimum tap. The minimum operating values are between 85% and 115% of the settings. The dropout ratio is not less than 80% of pickup.

This unit is disabled when the inverse-time unit picks up, and returns to operation when the inverse unit drops out.

4.6.2 Ground

This unit compares the RMS ground current with a value established by the user, and when the value is exceeded, a Pickup "LED" lights in the display , indicating that the unit has picked up. If this current level continues for a user- programmable-time, the relay trips, and at the same time an auxiliary relay (optional) closes, corresponding to the unbalanced-current unit.

The pickup current can be adjusted between 0.25 times the minimum tap range of the inverse-time unit, and the ground setting of this unit, since this function disables the unbalanced-ground-current unit.

If the user wishes to disable this function, it should be set to zero. The operation time is the same as that for the unbalanced-phase-current unit (0.15 to 60 seconds).

The minimum operating values fall between 85% and 115% of the settings. The dropout-to-pickup ratio is no less than 80%.

4.7 AUTOMATIC RECLOSER UNIT

4.7.1 Recloser Program

The recloser unit allows up to five (5) reclose attempts. The number of attempts is programmable between 0 and 5, where the value of 0 indicates the recloser unit is out of service.

For each attempt of the cycle, the pause time between trip and reclose can be independently programmed. This time (DELAY) can be set between 0.2 and 99.9 seconds. The lockout time, also called security time, (LOCKOUT TIME) can also be programmed between 1 and 10 minutes before the function returns to reset conditions.

In order to initiate the cycle, it is necessary that the breaker-status signal indicate that the breaker is closed and that a "Trip" command exists, emanating from the protection units. It is also necessary that there be no "Block reclose" command.

Once the Breaker Closed signal and Trip signal disappear, the (optional) auxiliary relay that indicates "reclose in progress" will close if there is no blocking signal. It is necessary that external AC voltage of 110 to 220 V be present at the Permit Reclosure input before the pause time begins to count down. If this voltage is not present, the relay waits a user-adjustable time, between 1 and 10 minutes (VCA CTR. TIME - VAC Control Time). If at the end of this time voltage still has not appeared, the auxiliary Reclose in Progress relay opens and stays open until a manual close. It is possible to disable the Permit Reclosure input by setting the permit-reclosure time to zero (VCA CTR. TIME).

If the permit-reclosure voltage is already present, or appears during the VCA CTR. TIME, the pause-time counter is started for the corresponding reclose within the cycle. When this time expires, a "Reclose" command is given and the Reclose in Progress auxiliary relay opens. At this moment, the MOR3000 starts the lockout-time counter and if another trip appears before this count is completed, the same sequence is repeated for the following reclose in the cycle. If a trip is not produced, a new cycle is initiated.

If the reclosure is the last one programmed for the cycle and a trip is produced during the lockout time of the MOR3000, the Final Trip auxiliary relay closes and the relay does not reclose again. This auxiliary relay opens when the next manual close occurs.

Following the manual close, the lockout time (security time) counter is always started, and if a trip appears before the counter counts down, the Final Trip auxiliary relay closes without producing reclosure. This also occurs if a fault arises that is of a type not allowed during the initial lockout time, and it remains after that time has expired.

4.7.2 Cancellation of the Reclose Cycle, Blocking

The reclose cycle is cancelled in the following cases:

- Any time after a "Reclose" command has been issued, when the time expires (MAX CLOSING TIME, adjustable between 0.5 and 99.9 seconds) without the Breaker Closed signal being detected, the "Reclose" command is deactivated and a new cycle is initiated awaiting a manual close.

- A command to connect or disconnect is detected, which has not been given by the MOR3000. In this case the reclose cycle is initialized.

- When the recloser is blocked.

There are various types of blocks:

- Local block. Local block is when a DC voltage (value depending on the model) is applied at the input of the MOR3000 corresponding to "recloser blocked". When this voltage is removed, the block is eliminated and the lockout timer is started. If a fault occurs during this block, the relay will give the Final Trip signal.

- Remote block. Remote block is produced when a "Block" command is sent, through the communication channel or through the keypad. When the unblocking command is sent, remote block is eliminated and the initial security time is ignored. If during this block a fault appears, the relay gives the Final Trip signal.

- Block due to failure to open. This is produced when, after a trip, the Breaker Open indicating signal does not appear, or when the fault is not eliminated during a programmable time between 0.1 and 1 second. This block is eliminated when a manual close is produced.

- Block due to repetitive trips. In order to avoid excessive wear on breakers in special cases, for example during a storm, in which the breaker could be tripping and closing continuously, a one hour window has been created during which trips are recorded. The window moves in such way that it is always counting the trips during the preceding 60 minutes. If the number of trips is greater than the value defined by the user, between 1 and 30, the recloser is blocked and the Final Trip signal is given. This block is eliminated by a manual close.

All of the previously mentioned recloser blocks are reflected in the Recloser Blocked "LED", which is in the display of the MOR3000.

The loss of AC voltage on the Permit Reclosure input can be considered as a special case of blocked reclosure.

4.7.3 Settings, Enabling and Disabling Reclosures, and Trips

The MOR3000 offers the possibility of disabling trips and reclosures that are not desired.

After a manual close, the lockout time (Security Time) always starts counting down. During this time, trips produced by different protection units can be enabled or disabled. The trips that can be set are those produced by the inverse-time unit (for phases and ground independently), those produced by the instantaneous unit (for phases and ground independently), and those produced by the unbalanced-current unit (common for phases and ground). When a trip is produced during the lockout time, there is no reclosure and the recloser goes to a state of "reclose cycle cancelled".

After the lockout time is over, the relay enters its normal operating mode and here the trips can be enabled or disabled independently from the way they have been programmed for the lockout time.

When trip conditions are produced, two situations can arise:

- That type of trip is enabled, therefore the MOR3000 trips and begins to execute the actions necessary to reclose, if it is set to reclose;

- That type of trip is disabled. In this case it does not trip, and it continues waiting for one of the enabled protection units to trip.

If the relay has tripped and proceeds to the reclose mode, other settings come into play. These settings enable or disable reclosure, according to the protection unit that has tripped. For example, a setting can be made whereby the relay does not reclose for trips due to unbalanced-current, but will reclose when another protection unit trips the relay.

If there are reclosures programmed and a trip occurs, two situations can give rise to reclose conditions:

- The reclosure associated with the protection unit that has tripped is disabled. In this case the optional Final Trip relay closes and no reclosure occurs;

- The reclosure is enabled, in which case the optional Reclosure in Progress relay closes and the reclose process is initiated.

If the breaker has reclosed, it is possible to program the relay such that trips are permitted for the following reclosure. Following this process, the last reclosure is reached, and it is possible to program, independently for each reclosure during the cycle, which units, which "permit trips", and which "permit reclosures", are enabled/disabled, depending on which protection unit caused the trip. For example, if one wants to allow tripping initially for whichever protection unit operates, but after the first reclosure one wants to limit tripping to the inverse-time unit, the unbalanced-current unit and instantaneous unit trips can be disabled after the first reclosure.

When the recloser is out of service (the number of reclosures is set to zero), the relay acts as if the lockout time were infinite; the relay pays attention only to trips that are enabled for this lockout time. This can also occur when the reclose is simply blocked.

4.8 COMMUNICATIONS

The MOR3000 is provided with a serial half-duplex communication module that can be utilized as an integral part of a complete protection and control system in substations.

Up to 255 MOR's can be connected with a communication concentrator, CPR, which through its modem is connected to a modem-equipped PC-compatible personal computer. In this manner, the MOR's can be controlled remotely. The MOR can be connected through a 20 mA. current loop, through fiber optics (crystal or plastic), or through RS232.

The MOR3000 has two means of communications:

- Remote.
- Local. Communication is possible through the keypad and display located on the front of the relay. Please refer to section 4.18 below for instructions on the keypad and display.

The MOR3000 depends on serial communications only for its relations with the outside world; the relay can be set or information can be requested in this remote mode. However, if for any reason communication is cut, the MOR continues protecting the line, and storing data in its memory in order to send it when the communication link is re-established.

4.9 CHANGING SETTINGS

The MOR3000 allows a complete block of settings to be changed, or only specific settings.

If, for any reason, values are introduced that are outside the limits of the relay, it does not accept the command to change the setting, and continues working with the previous settings until settings within the limits have been entered.

During a change of settings, the MOR3000 makes sure that the settings are within limits and that they have been loaded correctly in memory, and it initializes a series of values, etc. While it is doing this the relay is not protecting the line for a certain time. To reduce this time, two tables of settings have been created, one active (with the actual settings) and the other inactive.

When the command is given to change settings, these are compared with the limits and are loaded in the inactive table, and correct loading is verified. During this time the relay continues to use the active table. Once the process of loading has been completed, the tables are interchanged from active to inactive and vice-versa. In this manner, protection is only lost for a short period of time during the initialization of the new settings. The time without protection is never greater than 150 milliseconds.

In order to avoid a loss of settings when there is a power supply failure, these settings are stored in nonvolatile memory, EEPROM.

If one wishes to leave the MOR out of service, it is sufficient to introduce a zero value for the transformer ratio, for each phase and ground. In this state, no protection function can be performed, only communication and self checking. If a zero is placed in the transformer ratio for one unit, such as the ground unit, only that unit remains out of service, both time-delay and instantaneous.

In the event the relay is started with a new EEPROM memory without settings, the relay automatically detects this and immediately loads the transformer ratios to a zero value, disabling tripping and reclosure, since values might exist in the EEPROM that would cause a trip. In order to place the MOR in service, through the communications module, the protection settings should be loaded first, then the recloser settings, and finally the transformer ratios should be loaded.

When the relay is out of service because the transformer ratios have been set to zero, the MOR sends a signal to the remote terminal, and locally the Pickup "LED" located in the display flashes indefinitely at intervals of one (1) second.

4.10 TRIP ENABLE

In order to avoid placing a relay in service with the trip functions inadvertently disabled, the MOR acts in the following manner, based on the possible causes for the relay being disabled:

- If the transformer ratios are zero: a signal tells the remote communications that the relay is out of service, and the Pickup "LED" in the display flashes at intervals of one (1) second.

- If the external blocking inputs are active for phase or ground directional functions: a signal is sent to communications.

- If all trips are disabled during the security time: a signal is sent to communications.

The first case arises when the MOR3000 is powered up and the EEPROM is new and has not been set, or when the transformer ratios are set directly to zero in order to leave the relay out of service. In this case the relay should not function.

The second case might be deliberately set, therefore it only gives indication.

The third case can occur at the same time as the first case, when new settings are introduced and the appropriate transformer ratios are set and neither the recloser setting nor the trip enable has yet been introduced (since these trip enable settings are made along with the recloser settings).

4.11 EVENT RECORDER

The MOR has an internal event recorder available, in which all actions produced by the relay are recorded.

Each event is composed of the day, month, hour, minute, second and hundredths of a second, the status of the breaker, the status of the recloser (in service, blocked or out of service), the type of event (changes of breaker status, pickups, trips, reclosures, commands, etc.), and the phase and ground currents at the time of the event.

The event recorder is formed from a loop of up to 255 events, in such a way that when the loop is full, new events overwrite the first events that had been recorded. To avoid such overwriting, after having requested all of the events from the MOR3000, they can be erased to leave space for the next event. Events can be requested by date; when this option is used, events can not be erased, but only overwritten.

So that they are not lost in the case of power-supply failure, the events are registered in nonvolatile EEPROM memory.

The types of events that are recorded are the following:

- Change of breaker status. Information on the breaker status to allow the user to determine if there has been an opening or closing of the breaker
- Pickup of the phase overcurrent unit
- Phase instantaneous pickup
- Ground time-overcurrent pickup
- Ground instantaneous pickup
- Phase unbalanced-current pickup
- Ground unbalanced-current pickup
- Phase time-overcurrent trip
- Phase instantaneous trip
- Ground time-overcurrent trip
- Ground instantaneous trip
- Phase unbalanced-current trip
- Ground unbalanced-current trip
- Reclose command
- External open command
- External close command
- Open command failure
- Close command failure
- Repetitive trip block
- Local external block
- Remote external block

- Local external unblock
- Remote external unblock
- Change of settings
- Program initiation. This is produced when the MOR3000 is powered up, or when failure of the power supply causes the relay to power up again
- End of the fault. This is produced after the recloser has completed its lockout time and the new cycle is initiated. It is treated as if the recloser has performed successfully. If it has not been successful, an "end of fault" event does not appear and the optional Final Trip relay closes
- Current present with the breaker open
- Blocking input disabled
- Permit Reclosure input disabled
- Breaker Status input disabled
- Phase-directional input disabled
- Ground-directional input disabled
- Change in the event mask/filter for the event recorder. This indicates that there has been a change in the mask/filter that determines that certain events will, or will not, be registered
- Change in the curve defined by the user
- Time synchronization
- Loss of power supply in the ADC (analog-to-digital converter)
- Power supply re-established in the ADC
- Directional unit in service
- Directional unit out of service
- Blocking due to the directional unit
- Unblocking due to the directional unit.

Owing to the fact that certain events might not be of interest in certain cases, the event recorder has an event mask/filter through which the unit can be programmed to determine which events will be recorded. Please refer to the procedure in the user manual for the GEPCLINK program.

Through the GEPCLINK program, the event record can be stored in a file and used later as an input data file for application programs performed by the user.

4.12 CURRENT HISTORY

The MOR3000 has a peak-demand recorder that permits monitoring the load of the protected line.

Each minute, the current passing through phase A is measured. From the measurements that are made over a period of one hour, the largest that does not exceed the tap settings is always saved. This avoids possible false peaks during abnormal conditions.

The demand register has the ability to save data for one week, again in the form of a loop; when it is full, new information automatically overwrites the old information. Demand data is stored in volatile RAM memory; therefore if there is a power-supply failure the data is lost.

If the clock in the MOR3000 is not set, the recorder saves current values for each hour but those values will show starting from the date and time of the last event recorded; if there has been no event recorded, time is measured from the default date and time (01/01/88, 00:00:00).

Through the GEPCLINK program, the current history can be stored in a file and later used as a data input file for application programs to be performed by the user.

4.13 CHANGE IN BREAKER STATUS

The MOR3000 allows the breaker to be opened or closed remotely. When an order is sent to change the status of the breaker, followed by a confirmation of that command, the MOR compares the command with the breaker status, and if for example it is commanded to open but is already open, it returns a signal of a successful opening but does not execute the command, and the event recorder only records the opening order (not a change of status).

If on the other hand it receives an "Open" command and is currently closed, it orders the breaker to open and waits one second for the breaker to change status. If during this time the breaker changes from closed to open, the "Open" command is immediately removed, the Successful Opening signal is returned and both the command and the breaker opening are recorded in the event recorder. If after one second the change is not detected, the "Open" command is removed and the Failure to Open signal is returned. When the "Close" command is sent and the breaker is open, the same procedure is followed.

4.14 STATUS OF THE MOR3000

Upon request for the status of the MOR3000, general information on the status of the breaker, the recloser, possible blocks, and the status of communications is provided. In addition, a series of messages that advise of errors or special conditions are also provided:

- Out of service. This indicates that the transformer ratios are zero and that the MOR has not completed initial checks. The Ready LED on the front of the relay also indicates this condition when the relay has not passed through this check (lit when in service and out when out of service). When it is a result of the transformer ratio, the Ready LED lights and the Pickup "LED" located in the display flashes at intervals of one second, waiting for the ratio to be introduced.

- Clock missing. This indicates that the time has not been set. In this case the current history and event recorder will appear with an erroneous date and time. This indication disappears when the time is set.

- Measurement in a dangerous zone. Indicates that the MOR3000 has detected that the supply voltage for its digital-to-analog converter and analog-to-digital converter has decayed, although it is still in a zone in which it can ensure that the measurement is correct. If the voltage recovers, the signal disappears.

- Trips disabled. Indicates that all of the trips during the lockout (security) time are disabled. This message is eliminated when any of the trips is enabled.

- Current with the breaker open. Indicates that current has been detected through the line despite the fact that an indication is reaching the relay that the breaker is open. (It is quite possible that the failure is in the connection to the breaker that provides the breaker-status input). This is eliminated when the relay detects the Breaker Closed signal.

- EEPROM error. Indicates that an error has been detected in the EEPROM that does not affect the setting zone and therefore the relay can continue to function.

- Input disabled. Indicates that there is an input failure and therefore the relay has been disabled. The event recorder indicates which of the inputs has failed.

- Mask screen missing. Indicates that an error has been detected in the mask screen (filter that is able to limit the types of events to be recorded), and therefore all events will be recorded.

- Directional error. Indicates there is an error in the directional circuit board. In this case if you set the directional unit out of service, power down the relay and then power it up again; the MOR will act as a non-directional unit.

- User curve missing. Indicates that a time-curve defined by user has been programmed and that in the verification check of the curve an error has been detected, or that no curve has been defined by the user. By default, the relay will act according to the curve defined in the factory (see Figure 7).

- The breaker needs maintenance. Indicates that the breaker associated with the MOR has exceeded the limit set for kA^2 (number of openings, and the current squared during those openings, that have been accumulated in the MOR3000's breaker-supervision function).

- Configuration lost. Indicates that the MOR3000 has lost the communication configuration: unit number, baud rate, etc. Since in this case it is not possible to communicate with the unit remotely, the alarm is only visible locally, on the MOR display.

4.15 SELF-CHECK AND ERROR ROUTINES

When the MOR3000 detects a critical failure of one of its components, it immediately gives a Critical Failure error message, disables the trip and recloser, and changes the transformer ratio to zero to avoid undesirable trips. In this case the relay is left in a program loop from which it cannot exit until the error is removed and the supply voltage is re-established. To indicate this locally, the Ready LED goes out on the front of the relay, as well as the Pickup "LED" and the Recloser Blocked "LED" lights in the display.

This situation can only occur when the MOR3000 detects the failure of the RAM, EPROM or EEPROM, or when the supply to the measurement converter has dropped such that correct measurement cannot be ensured.

The first thing that the MOR3000 does when it is powered up is a complete check of RAM and EPROM. If any error is detected, the relay passes over to a Fatal Error state.

Once this memory-check stage is passed without errors, the settings zone of the EEPROM is checked and in the event of any error in the settings, it only loads those settings that impede tripping and reclosing, leaving the rest as they were, awaiting new settings. Once these new settings have been introduced, the relay is checked to see if they can be loaded correctly in EEPROM. If they cannot, a Fatal Error signal is given.

Once the relay is functioning, partial checks of RAM, EPROM and EEPROM are performed during the time in which the relay is free from its protection and communication functions. If any error arises, the relay passes to the Fatal Error state.

Another cause of fatal error is a failure in measurement. In order to detect the possible existence of a failure, each of the voltage supplies to the converter is read every five (5) milliseconds. In addition to verifying the operation of the multiplexor in this operation, the rectifier, converter, and microprocessor port that selects the phases are also verified. As soon as they are measured, the voltages are verified 1) for correctness, 2) for being within limits, or 3) for being incorrect. The second case gives rise to indication of what is occurring, and the third case gives rise to a "recoverable fatal error". This is a special error because it allows communication, and disappears if the supply voltages to the converters recover. A Failure message would be left in the event recorder, as well as another for the recovery.

The MOR3000 has a WATCHDOG supervision program.

The status of the breaker is checked continuously and, if it is open, the MOR verifies whether current is flowing. In the event that current is flowing, an error indication appears.

If any input is damaged and the MOR3000 reads that this input is changing value more than a certain number of times in a second, it decides that this input should be disabled, leaving it in a pre-determined state (see list bellow). In this case it gives a signal that one of the inputs has been disabled and the event recorder indicates which one. The state in which the disabled inputs are left are:

-	Breaker	Closed
-	Recloser blocked	Blocked
-	Reclose permit	Not permitted
-	Phase directional	Phase directional disabled
-	Ground directional	Ground directional disabled

4.16 USER CURVE

The MOR has the capability to accept a curve defined by the user. In order to use this function, a program, CRVCALC, is included in the GEPCLINK program. With this program, a new curve can be created and assigned a number. Later, with the GEPCLINK program, the new curve is loaded in the MOR (see the operating manual for GEPCLINK).

4.17 BREAKER SUPERVISION

Breakers have an operating life that depends on how many times the breaker has opened and what current was flowing through the breaker at the time of the opening. The MOR monitors associated breaker openings in order to provide an indication of the need for breaker maintenance.

Each time the MOR detects the breaker opening it records the maximum phase current. When an opening is produced and the current does not exceed nominal current, nominal current is taken as reference. The MOR calculates current squared and adds this to values accumulated from previous openings.

The MOR allows the user to set a limit to this summation (accumulation) and when that limit is reached, it gives an indication that the breaker needs maintenance. The settings allow the user to set the value of the summation either for a new breaker, or for situations where the MOR is used on a breaker that has undergone opening prior to installation of the MOR.

4.18 KEYPAD AND DISPLAY

The MOR includes a 20-key keypad and a liquid-crystal display of 32 characters, divided into two lines of 16 characters each. These two elements allow the user to access almost all the protection functions, with the exception of those cited later (see 4.18.5). The keypad of the MOR can be seen in the figure below:
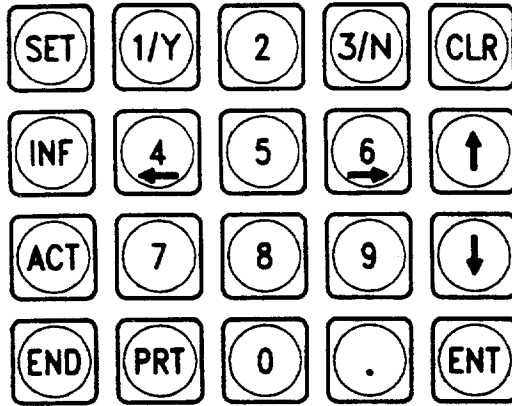
Figure 1 (0286A5570) MOR3000 Keypad

The keypad program employs menus to access the various options, which have been divided into three overall categories, each of which is accessed through a distinct key on the keypad. The categories are:

Information: provides information on the status of the relay, alarms, current, breaker status, etc. This is accessed through the INF key.

Actions: opening and closing the breaker, blocking and unblocking the recloser. These are accessed through the ACT key.

Settings: viewing and modifying settings. These are accessed through the SET key.

In the steady state, the MOR shows the following message on the display:

```
    MOR
GENERAL  ELECTRIC
```
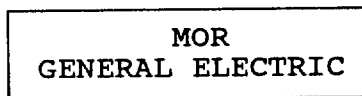
From this point one of the three categories previously mentioned is selected. Within a given category you can not select another category. To select a different category one should return to the steady-state message (by pressing CLR) and press the key corresponding to the new category.

Movement within the category is achieved through the ENT, CLR, and UP/DOWN ARROW keys. The use of these keys is as follows:

ENT: To accept the option that appears on the display at the moment. It is equivalent to descending a level in a menu tree.

CLR: Abandon the option that is on the display at the moment. This is equivalent of ascending a level in a menu tree.

UP/DOWN ARROWS: Change the option. This is equivalent to moving within a menu. When the desired option appears on the display it is selected with ENT.

The use of these keys can be seen in detail under the description of the different categories.

4.18.1 Information Category

This category provides information on the status of the MOR. In order to access this information, the INF key is pressed when the MOR is showing the steady-state message. Upon entering the INFORMATION menu, the first item of this menu appears on the display and can be seen as follows:

```
┌─────────────────────────┐
│                         │
│         MODEL           │
│                         │
└─────────────────────────┘
```

This is an indication that the first item in the INFORMATION menu is the model number of the relay. By pressing the UP and DOWN keys, the other items of the INFORMATION menu appear on the display. When the desired element is on the display, the ENT key provides the associated information.

For example, if one wishes to see the model number, pushing ENT will produce a message on the display similar to the one below:

```
┌─────────────────────────┐
│     MOR3000D000G00       │
│         60 Hz            │
└─────────────────────────┘
```

On the upper line, the model number of the relay appears, and the lower line shows the frequency of the model. In order to return to the menu, the CLR key is pressed and the previous display reappears:

```
┌─────────────────────────┐
│                         │
│         MODEL           │
│                         │
└─────────────────────────┘
```

Once here, one can select another element from the menu through the UP and DOWN ARROW keys, or again press CLR and return to the steady-state message:

```
┌─────────────────────────┐
│        (*)  MOR          │
│    GENERAL  ELECTRIC     │
└─────────────────────────┘
```

The significance of the asterisk is explained later in section 4.18.8, **Interaction of the Keypad with Remote Communications**. For now it is enough to know that the presence or absence of the asterisk does not affect the operation of the keypad.

When changing items within a given menu, pressing the UP ARROW key is considered as advancing an item and pressing the DOWN ARROW key is considered as descending an item. The order in which the items are cited in this manual corresponds to that which results from repeatedly pressing the UP ARROW key.

All of the MOR menus are circular; that is to say, by pressing the UP ARROW when the last item is on the display, the display passes to the first item, and pressing the DOWN ARROW when the first item is on the display passes to the final item.

In addition to the model number, the INFORMATION menu is composed of the following items:

CURRENTS: Shows the current circulating at that moment through the line, continuously updated. If this option is selected, the following display will appear:

```
A=10.45 B=10.45
C=101.4 N= 3.14
```

Representation of the current is as follows:

      Between 0 and 99.99 A, two decimal places are shown.
      Between 100 and 999.9 A, one decimal place is shown.
      Between 1000 and 9999 A, no decimal.
      10000 A or greater, not represented.

STATUS OF RELAY: Shows the status of the protection. If this option is selected, the upper line that appears on the display indicates whether the relay is in service or out of service and the lower line shows (ALARMS) when there is any active alarm. When this message appears, the UP and DOWN ARROW keys allow one to move from alarm to alarm, examining which alarms are active.

Only the active alarms appear on the display, therefore the size of this menu is variable. It is not possible to say how many alarms are active at a given moment without running through the complete menu. At any point in this menu one can press CLR to return to the INFORMATION menu.

Given that the alarms disappear when their original cause is no longer present, it is possible that an alarm will have disappeared while (ALARMS) is still on the display. In this case the program will still show the alarm that was present when the user had pressed the UP ARROW key, or it may return to the Status display if appropriate. Thus, the message (ALARMS) can appear and disappear when the Status display has been selected.

The "in service" or "out of service" status is independent of the alarm status.

The alarm messages are as follows:

CONFIGURATION LOST
ACCUMUL. BREAKER OVER LIMIT

INPUTS DISABLED
NON-FATAL ERROR IN EEPROM
CURRENT WITH OPEN BREAKER
TRIP DISABLED
MEASURING IN A DANGEROUS ZONE
CLOCK STOPPED
DIRECTIONAL FAILURE
NO EVENT MASK
NO USER CURVE

The first one means that the configuration of the MOR has been lost. See section 4.18.7 for a complete description. See section 4.14 for a detailed description of the significance of the rest of the alarms and the relay status.

For example, let us look at the situation where we power up the MOR and the directional unit fails. The alarm messages in this case would be CLOCK STOPPED and DIRECTIONAL FAILURE. Let us suppose that from the Relay Status display one repeatedly presses the UP ARROW key.

We start from the INFORMATION menu:

```
STATUS OF RELAY      ENT      RELAY IN SERVICE  ↑
                                  (ALARMS)

CLOCK STOPPED    ↑   DIRECTIONAL    ↑   RELAY IN SERVICE
                       FAILURE               (ALARMS)
```
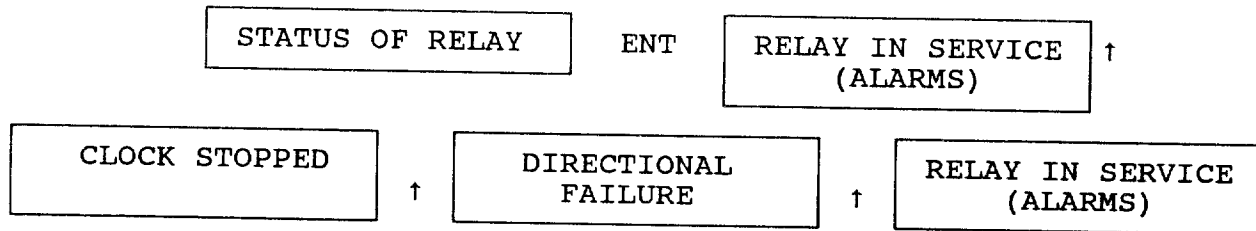
If the directional unit returns to correct operation with the DIRECTIONAL FAILURE message on the display, this message will disappear and the RELAY IN SERVICE (ALARMS) will reappear. That is to say, the display would return to the same place where it would have been if the UP ARROW key had been pressed. The message (ALARMS) indicates that the CLOCK STOPPED continues to be active.

If the message (ALARMS), does not appear, the UP and DOWN ARROW keys have no effect on the Relay Status display; CLR will need to be pressed to return to the INF menu.

STATUS OF BREAKER: Shows the status of the breaker and the digital inputs. If this option is selected the following display might appear:

```
         CLOSED
   REC BLK GDI PDI
```
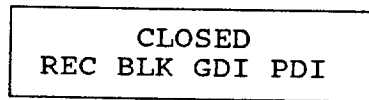
Breaker status appears on the upper line. In the lower line the digital inputs are coded as follows:

REC: Reclose permitted.
BLK: Local block.
GDI: Ground directional unit.
PDI: Phase directional unit.

The message corresponding to a digital input appears when this input is active, and does not appear when it is inactive. For instance, when the Permit Reclosure input was the only one active, we would see the following:

```
+----------------------------------+
|              CLOSED              |
| REC                              |
+----------------------------------+
```

STATUS OF RECLOSER : Shows the status of the recloser. If this option is selected, a display similar to the following might appear:

```
+----------------------------------+
|           IN  SERVICE            |
|            (BLOCKED)             |
+----------------------------------+
```

The message (BLOCKED) will appear only if a block is present. The following display is the one for blocks, and is accessed through the UP and DOWN ARROW keys:

```
+----------------------------------+
| LOCAL   REM    OPEN E            |
| SUC.TRIP     NO-PERM             |
+----------------------------------+
```

The blocks are:

LOCAL: Local block.
REM: Blocked through remote command.
OPEN E: Blocked through opening error.
SUC.TRIP: Blocked by successive trips.
NO-PERM: Blocked by absence of permit-reclosure (VCA CTR. TIME)(VAC Control Time)

The message corresponding to a block appears when that block is active and does not appear when the block is inactive. So if at a given moment the recloser were blocked by a remote command we would see the following:

```
+----------------------------------+
|              REM                 |
|                                  |
+----------------------------------+
```

The CLR key returns us to the INFORMATION menu from whichever display we are in.

Any number of blocks can be active at the same time. If none were active, the message (BLOCKED) would not appear in the Recloser Status display and in the Blocks display one would read:

```
+----------------------------------+
|           NOT  BLOCKED           |
|                                  |
+----------------------------------+
```

The message "In Service" or "Out of Service" is independent of whether or not there are blocks present. See section 4.7 for a detailed description of the operation of the recloser.

DIRECTIONAL: Gives information about the directional unit. If this option is selected, we can choose between three submenus:

STATUS OF DIRECTIONAL
TRIPPING PERMISSIONS
ANGLES

Let us examine them one by one.

STATUS OF DIRECTIONAL: If this option is selected, in the upper line will appear whether the unit is IN SERVICE or OUT OF SERVICE. This message shows the status of the directional unit; if it is out of service, that means a failure has occurred.

The lower line shows the message PERMIT or PROHIBIT; this is the status of PHASE/GROUND DIRECTIONAL setting. If it is PERMIT (enabled), the MOR will work as a directional relay; on the other hand, if it is PROHIBIT (disabled) the MOR will disregard the directional unit and work as a non-directional relay.

TRIPPING PERMISSIONS: In this display four simulated LED's are shown, indicating whether tripping is enabled or not (for each phase and for ground). A solid block represents a lit LED, and that means tripping for that unit is enabled. A blank border represents an unlit LED, and that means tripping for that unit is disabled.

The display below would appear when tripping is enabled for the three phases, and disabled for the ground.

```
┌─────────────────────┐
│ PA : ■   PC : ■      │
│ PB : ■   PN : □      │
└─────────────────────┘
```
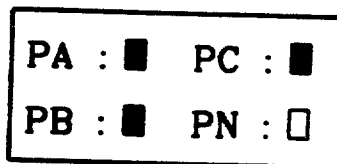
Figure 2 (0286A5570) MOR Display with Simulated LEDs Showing Tripping Permissions

ANGLES: This display shows, for each phase and ground, the angle between the line current and the corresponding phase-to-ground voltage. If one of the phases or the ground is not active (that is to say there is either no current flowing, or no polarizing voltage), instead of the angle's value, asterisks would appear.

A positive angle means that current leads voltage, and a negative one means the opposite.

As an example, let us view the display of a three-phase balanced system. In this system there are neither ground voltage nor ground current, so that unit is not active. Note that voltages and currents are in phase.

```
┌─────────────────────┐
│ A:  0.0   B:  0.0    │
│ C:  0.0   N:******   │
└─────────────────────┘
```
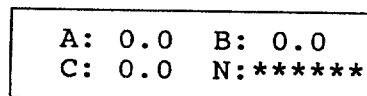
DATE AND TIME: Shows the date and time of the relay. If this option is selected, the following display will appear:

```
  01-OCT-91
  12:43:05
```

The date and time are continuously updated. The CLR key returns us to the INFORMATION menu.

EVENTS: Shows the events. If this option is selected, the 50 most recent events are extracted from memory and shown on the display. During the extraction process, the following display is visible:

```
  PROCESSING
EVENT        (NN)
```

where NN is the number of events extracted. When all of the events have been uploaded, the most recent event appears.

The UP ARROW key advances through the older events, while the DOWN ARROW key advances to the more recent events. Events are available in a loop, so pressing the DOWN ARROW key when the most recent event is in view will move to the oldest event, and if the UP ARROW key is pressed when the oldest event is in view, the most recent event comes into view.

Although only the 50 most recent events are shown on the local display, all 255 are extracted from memory. (Events 51-255 can be viewed only on the computer screen or sequence-of-events printout).)

The display for a given event is as follows:

day and month   hour, minute, seconds and hundredths of second

```
01OCT 12:47:4026
R.UNB.EXT.REMOTE
```

event name
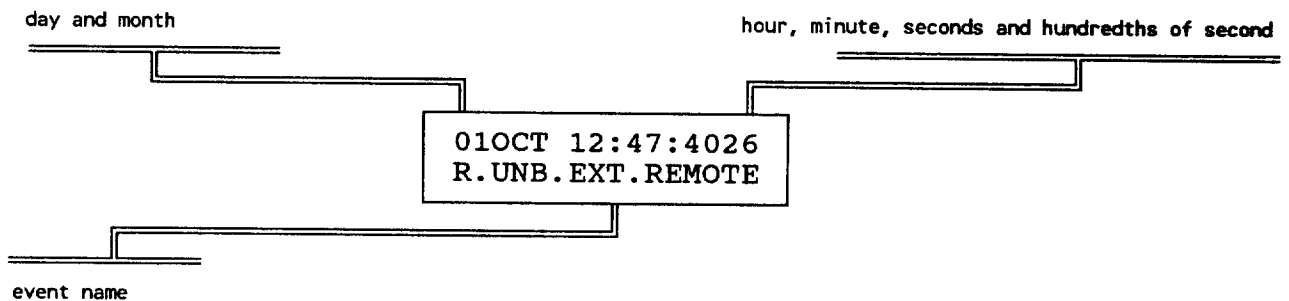
When information is desired about the event that appears on the display, pressing ENT passes to the current display and shows the current that was flowing through the line when the event occurred. If ENT is pressed again, the status of the breaker and recloser when the event occurred will appear on the display.

The CLR key returns to the Event display, from which one can select another event with the UP and DOWN ARROW keys. Pressing CLR from the Event display returns us to the INFORMATION menu. Once we leave the INFORMATION menu, all of the event information disappears and must be reloaded if one wishes to return to this option. This keeps events up to date.

For the previous event, the two additional displays would be:

```
                           CLR                            CLR
  ┌─────────────────┐     <--   ┌─────────────────┐     <--   ┌─────────────────┐
  │ 01OCT 12:47:4026│           │ A= 0.00 B= 0.00 │           │    B:OPEN       │
  │ R.BLK.EXT.REMOTE│           │ C= 0.00 G= 0.00 │           │ R:OUT OF SERVICE│
  └─────────────────┘    -->    └─────────────────┘    -->    └─────────────────┘
                          ENT                            ENT
```
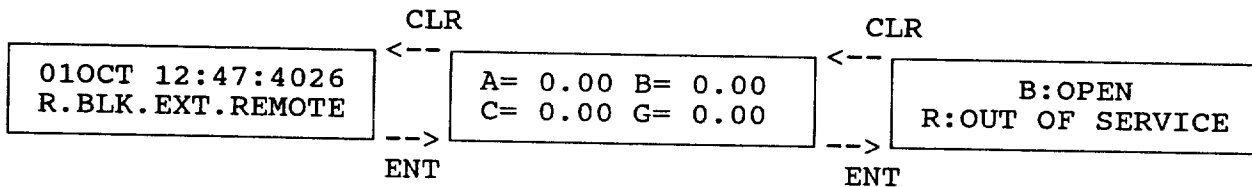
The possible events, grouped by subjects, are:

Protection units:

PU TOC PHASE:	Pickup of the phase time-overcurrent unit
PU IOC PHASE:	Pickup of the phase instantaneous unit
PU TOC GROUND:	Pickup of the ground time-overcurrent unit
PU IOC GROUND:	Pickup of the ground instantaneous unit
PU PHASE UNBAL:	Pickup of the phase unbalance unit
PU GROUND UNBAL:	Pickup of the ground unbalance unit
TRIP TOC PHASE:	Trip of the phase time-overcurrent unit
TRIP IOC PHASE:	Trip of the phase instantaneous unit
TRIP TOC GROUND:	Trip of the ground time-overcurrent unit
TRIP IOC GROUND:	Trip of the ground instantaneous unit
TRIP PH UNBAL:	Trip of the phase unbalance unit
TRIP GRN UNBAL:	Trip of the ground unbalance unit

Breaker operations:

BREAKER CHANGE:	Change of breaker status
EXT. OPEN COMM.:	External open command
EXT. CLOSE COMM.:	External close command
52 FAIL TO CLOSE:	Failure of the close command
52 FAIL TO OPEN:	Failure of the open command

Reclosure:

RECLOS. COMMAND:	Reclose command
R.BLK. REP.FAULT:	Block due to repetitive trips
R.BLK.EXT. LOCAL:	Local external block
R.BLK.EXT.REMOTE:	Remote external block
R.UNB.EXT. LOCAL:	Local external unblock
R.UNB.EXT. REMOTE:	Remote external unblock
END OF FAULT:	End of the fault

Digital inputs disabled:

DISAB.BLCK INPUT:	"Block reclose" disabled
DISAB.VCA INPUT:	"Permit reclose" (VAC) disabled
DISAB. 52 INPUT:	"Breaker status" disabled
DISAB.PH.D.INPUT:	"Phase directional" disabled
DISAB. N.D.INPUT:	"Ground directional" disabled

Miscellaneous:

SETTINGS CHANGED:	Change of settings
PROGRAM START:	Initiation of the program
CURR.WITH 52 OPEN:	Current with the breaker open
EV. MASK CHANGED:	Change of the event filter
USER CURVE CHANGE:	Change of the user curve
PROGRAM RESET:	Program reset
TIME/DATE SET:	Date and time synchronization
DIR.O. OF SERVICE:	Directional unit out of service
DIREC.IN SERVICE:	Directional unit recovered
BLOCKED BY DIREC:	Block due to directional supervision
UNBLCK. BY DIREC:	Unblock due to directional permission
ADC V. FAILURE:	Failure of the reference voltage (Analog-to-Digital converter)
ADC V. CORRECT:	Reference voltage recovered
COMM. TO LOCAL:	Communications in local mode
COMM. TO REMOTE:	Communications in remote mode.

The MOR considers commands as remote when they are not originated in the protection units. For example, a "Block reclosure" command can be produced through the keypad, through the communications line, or by a Block Reclosure input. The latter would be local (originated in the substation) and the first two cases would be considered remote (originated by the user; the MOR does not distinguish between commands entered through the keypad or entered through the communications line).

4.18.2 Actions Category

This group allows operation of the breaker from the keypad, as well as blocking and unblocking the recloser. To access this category the ACT key is pressed when the MOR is showing the steady state message (successively pressing the CLR key will return the display to that point). Upon entering the ACTION menu, the first menu item appears on the display, as follows:

```
+-------------------+
|       OPEN        |
|     BREAKER       |
+-------------------+
```

This indicates that the first item of the ACTION menu is the opening of the breaker. Pressing the UP and DOWN ARROW keys causes the rest of the ACTION menu items to appear on the display. When the desired action appears on the display, the ENT key selects that menu item.

In order to avoid non-desired actions, the keypad program requires confirmation for all of these actions. In order to confirm, one presses the key 1/Y and then ENT. To abort the operation, one presses 3/N and then ENT. Pressing CLR before the confirmation request is equivalent to 3/N and ENT.

If the command is confirmed, the result of the action appears on the display. This message is accepted by either ENT or CLR and the action menu returns.

For example this would be the process to open the breaker from the ACTION menu:

```
┌─────────────────┐         ┌─────────────────┐         ┌─────────────────┐
│     OPEN        │         │    CONFIRM      │         │    CONFIRM      │
│    BREAKER      │  ENT    │     (Y/N)       │  1/Y    │     (Y/N)       │  END
└─────────────────┘         └─────────────────┘         └─────────────────┘
```

```
                    ┌─────────────────┐ ENT    ┌─────────────────┐
          ENT       │    OPENING      │        │     OPEN        │
                    │   SUCCESSFUL    │ CLR    │    BREAKER      │
                    └─────────────────┘        └─────────────────┘
```
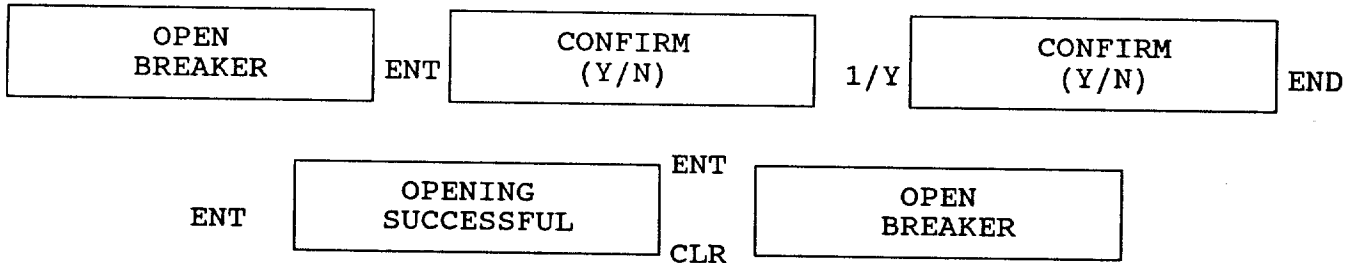
If the breaker had not opened, the result would have been:

```
                    ┌─────────────────┐
                    │    OPENING      │
                    │  UNSUCCESSFUL   │
                    └─────────────────┘
```
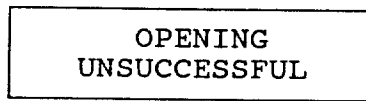
The actions are:

OPEN BREAKER
CLOSE BREAKER
BLOCK RECLOSER
UNBLOCK RECLOSER

Please note that the "Unblock recloser" command affects only the remote (user-originated) block, and not other (MOR-originated) blocks that might be active. In the same way, the "Block recloser" command activates only the remote (user-originated) block.

4.18.3 Settings Category

This category allows one to see and modify the settings of the MOR. It is accessed by pressing the SET key when the MOR is showing the steady state message. If this is done, the following message appears on the display:

```
                    ┌─────────────────┐
                    │     READ        │
                    │   SETTINGS      │
                    └─────────────────┘
```

Pressing the UP or DOWN ARROW keys, one passes to the message:

```
                    ┌─────────────────┐
                    │    MODIFY       │
                    │   SETTINGS      │
                    └─────────────────┘
```

We shall first look at the READ SETTINGS sections.

In order to look at this section, ENT is pressed when the message READ SETTINGS appears on the display. The following display then appears:

```
┌─────────────────────┐
│      GENERAL        │
│      SETTINGS       │
└─────────────────────┘
```

By pressing the UP and DOWN ARROW keys we move through the menu. The possibilities that are offered are:

GENERAL SETTINGS
PROTECTION SETTINGS
RECLOSER SETTINGS

We shall look at them one by one.

4.18.3.1 General Settings

If we select to view the GENERAL SETTINGS option, something similar to this display will appear:

```
┌─────────────────────┐
│   PHASE CT RATIO    │
│         1           │
└─────────────────────┘
```

The lower line shows the value of the phase current-transformer ratio. Repeatedly pressing the UP ARROW key, we pass through all of the general settings. We shall look at them in detail:

PHASE CT. RATIO 1	GROUND CT. RATIO 1
PH/GRN DIRECT. DISABLED	REPETIT. FAULTS 1
MAX. OPEN.TIME 0.50 S	MAX.CLOSING TIME 1.00 S
LIMIT 99999 kA^2	ACCUMULATED 0 kA^2
IDENTIF.:	BREAKER NUMBER 1

Values of the settings appear on the lower line, together with the unit of measure where appropriate. The name of the setting under consideration appears on the upper line. The displays can be reviewed in reverse order from that shown, by pressing the DOWN ARROW key.

The settings of this group are:

Phase transformer ratio: No unit of measure
Ground transformer ratio: No unit of measure
Directional status
Number of repetitive trips: No unit of measure
Maximum opening time: Seconds
Maximum closing time: Seconds
Accumulated current limit: kA^2 (kI^2)
Accumulated current counter: kA^2
Unit ID Number: Text
Breaker number: Non-dimensional

4.18.3.2 Protection Settings

The protection settings section has a presentation identical to that for the general settings: The name of the setting appears on the upper line and the value of the setting appears in the lower line. The settings that make up the protection group are the following:

Phase instantaneous pickup value: Amperes
Phase instantaneous time-delay: Seconds
Phase time-overcurrent pickup value: Amperes
Phase curve time index: Non-dimensional
Phase curve type
Ground instantaneous pickup value: Amperes
Ground instantaneous time-delay: Seconds
Ground time-overcurrent pickup value: Amperes
Ground curve time index: Non-dimensional
Ground curve type
Ground unbalanced-current: Amperes
Unbalance unit time delay: Seconds
Phase unbalance percent: %.

4.18.3.3 Recloser Settings

The recloser settings control the behavior of the recloser unit of the MOR. To clarify the meaning of the settings it is helpful to take a look at the whole reclose cycle at the same time.

```
Manual
Close    1T      1R    2T      2R    3T      3R    4T      4R    5T      5R    FT
     ___      __      __      __      __      __      __      __      __      __
    |   |    |  |    |  |    |  |    |  |    |  |    |  |    |  |    |  |    |  |
 ___|S.T| 1P |  | 1  |2P|  2 |3P|  3 |4P|  4 |5P|  5 |  |____
```
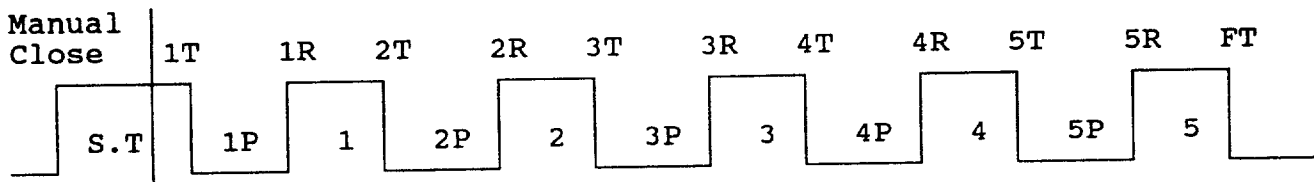
A reclose cycle begins, for example, with the manual close of the breaker. The lockout time (security time) follows this closure; if a trip is produced during this time, the reclose cycle does not start.

In each cycle (the digits by themselves in the lower line of the diagram identify the cycles) there can be up to five (5) reclosure attempts. Each attempt has three (3) phases:

> Trip: an order is given to open the breaker.
> Pause: delay time before the reclose attempt.
> Reclose: an order is given to close the breaker.

At the completion of the 5 reclose attempts, there is a trip called "Final Trip", after which no more reclosure commands are produced and the relay goes to the Lockout state.

If we take, for example, the first attempt, to define it completely we need to program the following:

a) Units that have permission to trip.
b) Duration of the pause.
c) Units that have permission to reclose.

Refer to section 4.7 for a detailed description of the operation of the recloser and the meaning of the settings.

To associate the settings of the reclosure diagram of the previous page, which are those that appear in the GEPCLINK program for the MOR, the MOR display shows the units with permission to trip (the descending line) with a T, and the units with permission to reclose (the ascending line) are represented with an R.

If we select the "read reclosure settings" option, the following display appears:

```
┌─────────────────────┐
│   LOCKOUT TIME      │
│   1:00 min          │
└─────────────────────┘
```

This setting is the duration of the lockout time (security time). Pressing the UP ARROW key causes the following to appear:

```
┌─────────────────────┐
│ T-PI PT NI NT UB    │
│ S-NO YS NO NO NO    │
└─────────────────────┘
```

This display shows those units that have trip permission during the security time. On the left appear the letters T and S (for Time and Security), separated by "-" from the rest of the display. In the upper line the protection units appear with the following code:

> **PI:** Phase IOC.
> **PT:** Phase TOC.
> **NI:** Ground IOC.
> **NT:** Ground TOC.
> **UB:** Unbalance.

In the lower line, below each unit, appears yes (**YS**) or no (**NO**) to indicate which unit has permission to **trip** during the lockout time.

If we continue to push the UP ARROW key, the display that appears shows the number of reclose attempts and the delay time for each one.

By continuing, we pass to the information for the first **reclose** attempt. Each attempt consists of three displays: Trip display, Pause display and Reclose display. In the case of the first attempt, these displays would be:

```
┌─────────────────────┐   ┌─────────────────────┐   ┌─────────────────────┐
│ 1-PI PT NI NT UB    │   │ DELAY ATTEMP 1      │   │ 1-PI PT NI NT UB    │
│ T-NO NO YS YS YS    │   │      30.00 s        │   │ R-YS YS YS YS YS    │
└─────────────────────┘   └─────────────────────┘   └─────────────────────┘
```

Successively passing through the five reclose attempts brings one to the Final Trip display:

```
┌─────────────────────┐
│ F-PI PT NI NT UB    │
│ T-NO NO YS YS YS    │
└─────────────────────┘
```

Keep in mind that the letters "T" and "R" represent the descending line (trip) and rising line (reclose), respectively, which correspond to those that appear on the GEPCLINK screen.

The recloser settings are:

Duration of the lockout time: min:sec.
Units permitted to trip during the lockout time
Number of reclose attempts
Reclose permit pause (VAC control time): min:sec.
Attempt 1: trip permits
Attempt 1: delay
Attempt 1: reclose permits
Attempt 2: trip permits
Attempt 2: delay
Attempt 2: reclose permits
Attempt 3: trip permits
Attempt 3: delay
Attempt 3: reclose permits
Attempt 4: trip permits
Attempt 4: delay
Attempt 4: reclose permits
Attempt 5: trip permits
Attempt 5: delay
Attempt 5: reclose permits
Final Trip: trip permits.

4.18.4 Change of Settings

If we select the option MODIFY SETTINGS, from the SETTINGS menu, the following options are offered:

> MODIFY GENERAL SETTINGS
> MODIFY PROTECTION SETTINGS
> MODIFY RECLOSER SETTINGS

We shall look at them one by one.

4.18.4.1 Modification of General Settings

If this option is selected, the following display appears:

```
┌─────────────────────────┐
│   PHASE CT RATIO        │
│   1        ------       │
└─────────────────────────┘
```

The upper line of the display shows the name of the setting under consideration. In the lower line to the left is the present value of the setting, which in this case is 1. To the right is the field for the new value, represented by a dotted line, indicating that this setting has not been changed.

If we wish to change the phase CT ratio to 15, we would push the "1/Y" and "5" keys; the display would change successively as follows:

```
┌─────────────────────────┐   ┌─────────────────────────┐
│  PHASE CT. RATIO        │   │  PHASE CT. RATIO        │
│  1          1----       │   │  1          15---       │
└─────────────────────────┘   └─────────────────────────┘
```

In order to accept this value, we push ENT and the dotted line disappears, indicating that the setting has been accepted:

```
┌─────────────────────────┐
│   PHASE CT RATIO        │
│   1             15      │
└─────────────────────────┘
```

If we had pressed CLR in place of ENT, the editing of the setting would have been canceled, and we would have returned to the original display:

```
┌─────────────────────────┐
│   PHASE CT RATIO        │
│   1         1----       │
└─────────────────────────┘
```

The CLR key cancels the modification in process, but not the results of previous modifications. Let us suppose that we had accepted, by pressing ENT, the value of 15; if we then decided to change it to 10, the sequence would be as follows:

```
┌─────────────────────────┐      ┌─────────────────────────┐      ┌─────────────────────────┐
│  PHASE CT. RATIO        │  1   │  PHASE CT. RATIO        │  0   │  PHASE CT. RATIO        │
│  1           15         │  →   │  1          1----       │  →   │  1          10---       │
└─────────────────────────┘      └─────────────────────────┘      └─────────────────────────┘
```

If we now decide to cancel the modification and we press CLR, we would return to the previous value:

```
┌─────────────────────────┐
│    PHASE  CT  RATIO     │
│   1                 15  │
└─────────────────────────┘
```

The relay's setting editor has the ability to filter certain mistakes in the input before sending them to the protection unit. For example, the CT ratio should be a whole number, so the editor would not admit a decimal point in the setting; neither in this case can more than five digits be introduced or accepted.

Let us leave the setting for the phase CT ratio with the new value of 15, and press the UP ARROW key to go to the following setting, which is the ground CT ratio. We change it in the same way we did for the phases. Pressing the UP ARROW passes us to the next setting, which is the directional operation:

```
┌─────────────────────────┐
│    PH/GRN  DIRECT       │
│   PROHIB        ──────  │
└─────────────────────────┘
```

Directional operation is in this case disabled (prohibited). The settings can only be disabled or enabled; the modification is made through the keys 1/Y (in order to enable) and 3/N (to disable). If we wish to enable the directional operation, we press 1/Y and will see the following:

```
┌─────────────────────────┐
│    PH/GRN  DIRECT       │
│   PROHIB       permit   │
└─────────────────────────┘
```

The modified value appears in lower case to indicate that it has still not been accepted. If we wish to accept it, we press ENT, and the display changes to:

```
┌─────────────────────────┐
│    PH/GRN  DIRECT       │
│   PROHIB       PERMIT   │
└─────────────────────────┘
```

We could also have pressed CLR if we wished to cancel the modification.

Pressing the UP ARROW again takes us to the next general setting, which is the number of repetitive trips. We would see a display as follows:

```
┌─────────────────────────┐
│   REPETIT.  FAULTS      │
│   1            ──────   │
└─────────────────────────┘
```

Let us suppose we want to program 300 repetitive trips. We introduce the number 300 and ENT. On the display the following message appears:

```
┌─────────────────────────┐
│       NUMBER  TOO        │
│          BIG            │
│                         │
└─────────────────────────┘
```

This message tells us that the value 300 is not admissible for the number of repetitive trips. In the same way, the editor would not have allowed us in this case to introduce more than three digits. Pressing CLR erases the error message and we return to the setting. Let us change the value of the setting to 200 and press ENT. Once the setting is accepted, we continue to the next one with the UP ARROW key.

The next general setting is the maximum opening time of the breaker. We will see a display similar to this:

```
┌─────────────────────────┐
│  MAX.  OPEN.  TIME       │
│  0.50          ──────    │
│                         │
└─────────────────────────┘
```

This setting has a value in seconds, with two places beyond the decimal. This type of MOR setting has a general range that goes from 0.00 to 255.99, independent of the range of each particular setting; the editor will not allow more than three digits to be introduced before the decimal point, nor more than two digits after. If the value introduced were greater than 255.99, the message "NUMBER TOO BIG" would appear.

Let us select a value of 5.00 seconds for the setting and go on to the next one.

```
┌─────────────────────────┐
│  MAX  CLOSING  TIME      │
│  1.00          ──────    │
│                         │
└─────────────────────────┘
```

Let us suppose we are satisfied with the setting and do not want to modify it. In this case we would go on to next one. Pressing the UP ARROW key would produce the following:

```
┌─────────────────────────┐
│         LIMIT           │
│  99999         ──────    │
│                         │
└─────────────────────────┘
```

which is the setting of the limit of the accumulated number of openings for breaker supervision. We change it to 50000.

The next setting is the accumulated-current counter:

```
┌─────────────────────────┐
│      ACCUMULATED        │
│  0             ──────    │
│                         │
└─────────────────────────┘
```

which we would leave unchanged (unless the breaker already has a history of openings since it was last serviced, in which case its kI² accumulation should be entered here).

Pressing the UP ARROW key again brings us to the display:

```
BREAKER NUMBER
1              ------
```

For this relay we will select a breaker number of 5.

These are all of the general settings that can be modified. If we repeatedly press the UP ARROW key or the DOWN ARROW key we can review all of the settings of this group:

```
PHASE CT. RATIO
1            15
```
```
GROUND CT. RATIO
1             15
```
```
DIRECTIONAL
PROHIBITED PERMIT
```

```
REPETIT. FAULTS
1           200
```
```
MAX. OPEN. TIME
0.50        5.00
```
```
MAX. CLOSING TIME
1.00        ------
```

```
    LIMIT
99999      50000
```
```
ACCUMULATED
0          ------
```
```
BREAKER NUMBER
1              5
```

Once we consider the group of new GENERAL SETTINGS to be as we want them, we proceed to change the settings in the relay. To do this, press the END key, and the following message appears on the display:

```
MODIFY SETTINGS?
    (Y/N)
```

If we respond NO, we return to the Change of Settings display where we were previously, with all the original settings intact. If we respond YES, the settings are sent to the protection unit. In this case we would obtain the following response:

```
SETTINGS ERROR
```

This message indicates that some of the settings have been rejected by the protection unit. To determine which, we press ENT or CLR; the error message disappears, returning us to the setting editor. Now, in each setting a code appears, indicating whether the setting has been accepted or rejected. The GENERAL SETTINGS group would be seen as follows:

```
PHASE CT. RATIO
1        A > 15
```
```
GROUND CT. RATIO
1          A > 15
```
```
PH/GRN DIRECT
PROHIB A>  PERMIT
```

```
REPETIT. FAULTS
1        R > 200
```
```
MAX. OPEN. TIME
0.50    R > 5.00
```
```
MAX. CLOSING TIME
1.00        ------
```

```
    LIMIT
99999    A> 50000
```
```
ACCUMULATED
0          ------
```
```
BREAKER NUMBER
1            A> 5
```

Settings marked with A> have been accepted, and those marked with R> have been rejected. Those that have not been modified do not have any mark.

In order to resolve the problem, we have to give values to the rejected settings that are within the limits for each setting. The complete range of all the settings is shown in section 3.3.

Let us suppose that we give the Number of Repetitive Faults setting the value 5, and to the Maximum Opening Time the value 1.00. When we press the END key to confirm the change, we would obtain the message:

```
SETTINGS  CHANGED
```

This message indicates that the settings have been accepted and that the protection is reinitialized. If we accept the message by pressing ENT or CLR, we will return to the MODIFY SETTINGS menu:

```
MODIFY  SETTINGS
     GENERAL
```

If, instead of pressing END after correcting the settings, we had pressed CLR, the message would have been:

```
QUIT?
(Y/N)
```

If we respond YES, all of the settings introduced would be lost and we would return to the MODIFY SETTINGS menu; if we respond NO, we return to the change-of-settings display in which we were previously.

Confirmation request for the END and CLR keys only appear if a setting has been modified. If no setting has been modified, both the CLR key and the END key return us to the MODIFY SETTINGS menu without affecting the protection.

4.18.4.2 Modification of Protection Settings

The modification of protection settings is done in the same way as the modification of general settings. The input of data is also identical, except in the Phase Curve setting and in the Ground Curve setting. In these, one is allowed to select between four curves by pressing the 0, 1, 2 or 3 keys. The selected curve appears in lower case until it is accepted by pressing ENT. The text that appears on the display is:

```
Key 0 -- User Curve        : USER
Key 1 -- Extremely Inverse : EX. INVERSE
Key 2 -- Very Inverse      : VERY INVERSE
Key 3 -- Inverse           : INVERSE
```

A peculiarity of the Phase Time Index and Ground Time Index settings is that the editor will reject all values greater than 1.00, given that the time index of the inverse-time curve should be between 0.05 and 1.00. Quantities less than 0.05 would also be rejected with the message NUMBER TOO SMALL.

4.18.4.3 Modification of Recloser Settings

When we select the Modify Recloser Settings option from the menu, the first display we encounter is the following:

```
┌──────────────────────────┐
│      LOCKOUT  TIME        │
│  1.00            ──────   │
└──────────────────────────┘
```

This display deals with setting the Lockout Time duration, and is expressed in minutes:seconds. The editor will treat it as decimal, except that when the "." (decimal) key is pressed, the mark ":" (colon) will appear, and numbers greater than 59 are not allowed in the second field. If a larger number were introduced, the following error message would appear:

```
┌──────────────────────────┐
│      59  SECONDS          │
│        MAXIMUM            │
└──────────────────────────┘
```

The next setting is for permitted trips during the lockout time. The Permit Reclosure displays have a special editor. We shall look at how we would alter the permits in this setting.

We start from the Permit display. One enters to edit by pressing one of the 1/Y, 3/N, 4/<- or 6/→ keys. The enable upon which one is acting at any time appears in lower case letters. With the 1/Y and 3/N keys we enable or disable those which we wish, and by pressing ENT the changes are accepted (or by pressing CLR they are rejected) and all permits are returned as upper case. Look, for example, at how we would disable phase and ground instantaneous trips during the lockout time, assuming that all these units are enabled prior to the change:

```
┌──────────────────────────┐
│   T-PI  PT  NI  NT  UB    │
│   S-YS  YS  YS  YS  YS    │
└──────────────────────────┘
```

If 1/Y or 3/N is pressed upon entering the display, without moving the cursor, the selected unit is the first one on the left, that is to say, phase instantaneous. We press 3/N in order to disable it:

```
┌──────────────────────────┐
│   T-PI  PT  NI  NT  UB    │
│   S-no  YS  YS  YS  YS    │
└──────────────────────────┘
```

Now we move the cursor until it is located on the next unit we wish to modify: ground instantaneous. To select it we press the 6/→ two times:

```
┌─────────────────────┐       ┌─────────────────────┐       ┌─────────────────────┐
│ T-PI PT NI NT UB    │  6/→  │ T-PI PT NI NT UB    │  6/→  │ T-PI PT NI NT UB    │
│ S-no YS YS YS YS    │       │ S-NO ys YS YS YS    │       │ S-NO YS ys YS YS    │
└─────────────────────┘       └─────────────────────┘       └─────────────────────┘
```

Once the unit we wish to block is selected we press the 3/N key:

```
T-PI PT NI NT UB
S-NO YS no YS YS
```

And finally we press ENT to accept:

```
T*PI PT NI NT UB
S*NO YS NO YS YS
```

The asterisk replaces the dash to indicate that the display has been modified.

The recloser settings that do not correspond to enable commands are modified in the ways described in the previous sections.

4.18.5 Settings Not Accessible Through the Keypad

Some settings have been excluded from the keypad, due to their incompatibility with the display keypad system. The following are involved:

Date and time: can be seen but cannot be modified. To avoid the loss of synchronism of the relay in the substation, the date and time can only be changed through a remote command.

Unit ID: can be seen but not modified. Given that the MOR only has a numeric keypad available, modification of the unit ID needs to be done by a remote command through an alphabetical keyboard.

Event mask: cannot be seen or modified. Owing to the large quantity of information that the event mask involves, it can only be seen and modified through remote (computer) commands.

Events sequence by date: this possibility also is accessible only from the remote controller.

4.18.6 Operation with a single key

The MOR allows a simplified mode of operation, through the utilization of the ENT key. This mode allows access to diverse information about the relay without the need to remove the cover to access the entire keypad.

The key used for this mode is the ENT. In order to access the simplified mode, the relay should be in the steady state, with the display reading:

```
       MOR
GENERAL ELECTRIC
```

Then, by pressing the ENT key we will see the following display appear:

```
A:  0.00   B:  0.00
C:  0.00   N:  0.00
```

In which the currents that are flowing in the line are shown, constantly updated. This display is exactly equivalent to the one we obtain by selecting CURRENT in the INFORMATION menu.

If the ENT key is pressed again, the following display will appear:

```
RELAY  IN  SERVICE
```

This display shows the status of the relay, whether in service or out of service. The display does not show the alarms. In order to see the ALARMS message and any alarm that might be present, it is necessary to use the full keypad to select STATUS OF RELAY from the INFORMATION menu.

If we press ENT again we will see:

```
RECLOSER
IN  SERVICE
```

This display shows the status of the recloser, whether in service or out of service. The display does not show the blocking messages. In order to view the blocking messages and the blocks that might be present, it is necessary to use the full keypad to select RECLOSER STATUS from the INFORMATION menu.

Pressing ENT once again brings us to the following display:

```
☐      PICK  UP

█   REC.  BLOCKED
```

This display shows the simulated LEDs for the protection Pickup and recloser-blocked units. A blank border represents an unlit LED. A solid block represents a lit LED. In the case illustrated above, none of the protection would be picked up, and the recloser would be blocked.

If we press ENT again, we go to the Manual Block/Unblock Reclose display, which is described in detail below (4.18.6.1).
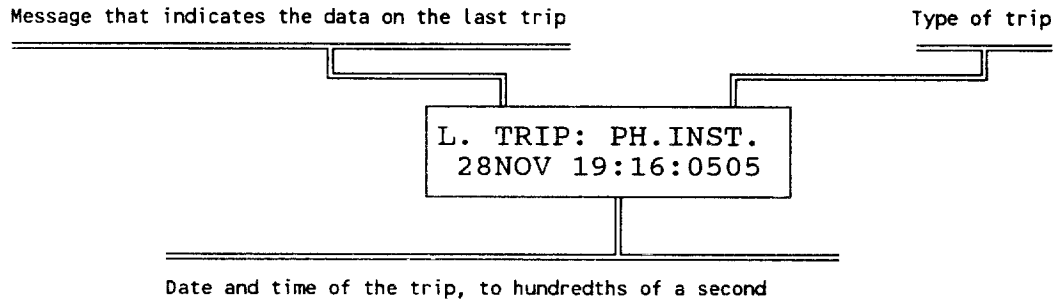
By pressing ENT one more time, we go to the display with information on the last trip. The MOR stores data in memory from the last trip that occurred, as well as the number of reclosures that have taken place during relay operation.

Information on the last trip is stored in RAM memory, therefore it can be lost if the relay loses its power supply. The number of reclosures is stored in EEPROM memory and that information is maintained when the power supply is lost. The user can erase information on the last trip and the number of reclosures.

If there were no information on the last trip in memory, the following display would appear:

```
NO RECORDED
TRIP DATA
```

If there were data stored, the display would be similar to this:

```
Message that indicates the data on the last trip          Type of trip



            L. TRIP: PH.INST.
            28NOV 19:16:0505



        Date and time of the trip, to hundredths of a second
```

Another display follows this one, which is accessed by pressing ENT, and in which the currents at the moment of the trip are shown. For example, for this trip it would be:

```
A: 1.00   B:13.04
C: 1.00   N: 0.00
```

If there is no information recorded for the last trip, the Current display does not appear.

The following display is the one for the number-of-reclosures counter:

```
N. RECLOSURES
      0
```

In this example no reclosure has occurred.

Pressing ENT one more time returns us to the steady-state message:

```
         MOR
GENERAL ELECTRIC
```

If one wishes to erase information on the last trip, it should be done when the display shows the reclosures counter. At that point, one presses and holds down the ENT key until the RESET message appears on the display. When the key is released, the display returns to the steady-state message.

4.18.6.1 Manual Blocking/Unblocking of the Recloser.

The MOR allows blocking and unblocking of the recloser through the simplified operation, following the display with the Pickup and Rec.Blocked simulated LEDs. This block corresponds to the REMOTE EXTERNAL BLOCK, and therefore is registered in the event recorder. It is similar to the one obtained by accessing the menu with the ACT key, with the difference that it is not affected by the reclose operation permission set through the keypad (see section 4.18.7). Blocking and unblocking the recloser through the simplified operation is always possible (as long as the relay has been configured to permit remote recloser operation - see 4.18.7 **Configuration Unit**).

Depending on the state in which the REMOTE EXTERNAL BLOCK is found, either of the following messages could appear on the MOR display:

```
+-------------------+
|   KEEP  PRESSED   |
|   TO  BLOCK       |
+-------------------+
```

if external block is not active

```
+-------------------+
|   KEEP  PRESSED   |
|   TO  UNBLOCK     |
+-------------------+
```

if external block is active

In the first case, if the ENT key is pressed for a few seconds, the following message is obtained:

In the second case we would obtain the message:

```
+-------------------+
|      BLOCKED      |
+-------------------+
```

```
+-------------------+
|     UNBLOCKED     |
+-------------------+
```

this message will stay on the display as long as we keep the key down, and the REMOTE EXTERNAL BLOCKED is active.

and the REMOTE EXTERNAL BLOCKED would remain inactive.

Since this block is the same as the one produced from the remote controller, it is important to have disabled the remote recloser operation (see **Remote Permissions** in section 4.18.7) in order to avoid simultaneous access from the computer.

The message that appears in this function depends exclusively on the REMOTE EXTERNAL BLOCK, and not on any other block that might be active. Therefore it is possible that an "Unblock" command might not unblock the recloser, because other (relay-originated) blocks were active. In order to know for sure whether the recloser is blocked or unblocked, use the full keypad to obtain the "LED"s display on the Recloser Status function from the INF menu.

If one does not want to change the recloser status, press the ENT key without holding it, in order to pass to the next menu item (for last-trip information).

4.18.7 Configuration Unit

The MOR has a configuration unit that can only be accessed through the keypad. The object is to select the form in which the MOR interacts with the outside world. The elements of the configuration unit are:

Unit number: Relay identifier
Baud rate of the serial communications
Stop bits for serial communications
Permission for local breaker operation (keypad)
Permission for local recloser operation (keypad)
Permission to change settings locally (keypad)
Permission for remote breaker operation
Permission for remote recloser operation
Permission to change settings remotely
Language selection.

One enters the configuration unit from the steady-state message by introducing a four-figure numerical code through the keypad, after which the ENT key is pressed. If the code is correct, the configuration unit is accessed; if the code is incorrect, the display returns to the steady-state message. The code is unique for the MOR relay, since it is not meant to be a password, but merely a simple security measure to avoid accidental manipulation of the configuration.

The code is 7169, which has been selected to correspond to the ASCII code for the initials GE.

We see how one would enter the configuration unit from the steady-state message:

MOR GENERAL ELECTRIC	7	*	1	**

6	***	9	****	ENT	1	UNIT NUMBER ----
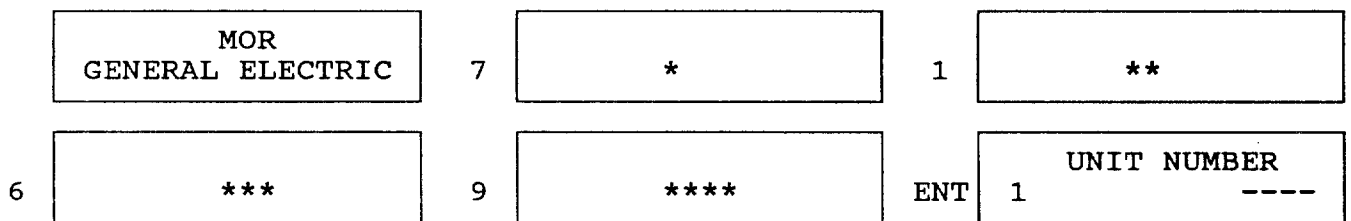
Modification of this permission is made in the same way as any other change of settings. Once modified, press END to confirm the setting change, or CLR to cancel the change.

We are going to see in detail each one of the configuration possibilities for the MOR.

Unit number:

Each MOR is identified by a unit number or address that serves to identify the messages directed to the relay through the remote communication line. This number can be any number between 1 and 255, inclusive. If one tries to program the number 0, the following message would be obtained:

```
VALUE OUT
OF LIMITS
```

In the configuration unit the settings are compared at the moment they are modified, therefore they would not be rejected when execution of the change was ordered.

Baud Rate:

This is the baud rate that the MOR uses in its serial communications via remote controller. The possible baud rates are 300, 600, 1200, 2400 and 4800 baud.

Stop bits:

The number of stop bits that are added to each byte transmitted by the serial line.

The MOR always transmits in 8 bits without parity; the number of stop bits and the baud rate can be changed by the customer in this unit.

Keypad permissions:

The MOR can prohibit access through the keypad for certain critical functions. These functions are:

    Breaker operation: Opening and closing.
    Recloser operation: Blocking and unblocking.
    Setting changes.

Each one of these permissions can be set independently.

When one of these options is prohibited, the corresponding menu does not appear on the display. Suppose that breaker operation through the keypad is prohibited, and recloser operation and setting changes are permitted; upon pressing the ACT key one time, the normal display:

```
+---------------------+
|        OPEN         |
|       BREAKER       |
+---------------------+
```

would instead be:

```
+---------------------+
|        BLOCK        |
|      RECLOSER       |
+---------------------+
```

The displays OPEN BREAKER and CLOSE BREAKER would disappear from the menu. If the operation of the recloser were also prohibited, pressing the ACT key would not produce any effect.

If change of settings is prohibited through the keypad, then the SETTINGS menu will only have the Read Settings option.

Remote permissions:

The MOR can prohibit remote (computer) access to certain critical functions. These functions are:

    Breaker operation: Opening and closing.
    Recloser operation: Blocking and unblocking.
    Settings changes.

Each one of these permissions can be set independently.

If the command corresponding to a function that is not permitted arrives through the remote controller, the error message "ACCESS DENIED" would appear. Since these permissions are only accessible through the keypad, this method allows a limitation of the commands that can be executed through remote control.

The remote permission for change of settings includes the modification of the curve by the user.

Language:

The MOR can show messages in two languages: Spanish and English. In order to program the desired language, the number corresponding to the selection needs to be set. The numbers are:

    Spanish : 0
    English : 1

Activation of the configuration unit changes is performed in the same way as any other group of settings, by pressing END and confirming the command. The configuration change takes effect immediately.

The configuration is stored in permanent memory of the EEPROM type. In the improbable event that this memory were to deteriorate, the relay would lose its configuration. If this were to occur, the default configuration would be loaded and the alarm CONFIGURATION LOST would appear in the Status of Relay section, and remote communications would be disabled. The alarm disappears and the remote communications are reactivated when the user modifies the configuration unit at the relay, via the keypad.

The default configuration is the following:

    Unit number: 255
    Baud rate : 4800
    Stop bits :   1
    All permissions disabled.
    Language   : English.

If one enters the configuration unit and does not modify any setting, the CONFIGURATION LOST alarm will not be eliminated.

4.18.8 Interaction of the Keypad with Remote Communications

In the MOR, the keypad has priority over remote communications. When the keypad is active, all messages that arrive specifically directed at the unit are returned with the error message "BUSY".

The keypad becomes active when any of the SET, INF or ACT keys are pressed, or if the ENT key is pressed for simplified operation, or one of the numerical keys is pressed to enter the configuration unit. If, at the moment of pressing the key, remote communications were active, the following message would appear:
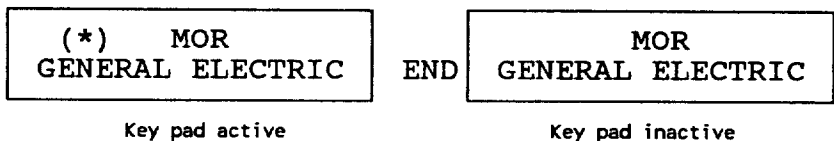
```
┌─────────────────────┐
│  BREAKING  REMOTE   │
│   PLEASE  WAIT      │
└─────────────────────┘
```

Which would remain for the time it takes to interrupt the remote communication. In order to assure the integrity of transmission, the MOR cannot interrupt communication while a message is being transmitted. Therefore, the above message can either remain on the display for an appreciable time if the baud rate is low (on the order of 300-600 baud), or will practically be invisible for higher baud rates (2400 baud).

If the parameters for the unit number or communication baud rate are modified, they take effect as soon as the changes are confirmed. The same will occur for remote operation permits.

Once remote communication is cut, the MOR operates normally. The keypad remains active until the operator inactivates it (by pressing the END key while the MOR is showing the steady-state message).

The asterisk symbol that appears on the display indicates that the keypad is still active and therefore remote communications are disabled. The symbol disappears once the keypad is inactivated:

```
┌──────────────────────┐        ┌──────────────────────┐
│ (*)    MOR           │        │        MOR           │
│ GENERAL  ELECTRIC    │  END   │ GENERAL  ELECTRIC    │
└──────────────────────┘        └──────────────────────┘
```
Key pad active   Key pad inactive

In simplified operation the keypad is deactivated automatically upon returning to the steady-state message.

If at any time the full-keypad operation lasts for more than 2'11" (2 minutes, 11 seconds) without a key being pressed, the MOR will return to the steady-state message and the keypad will be deactivated. However, if one is at any point in the simplified operation, the keypad does not deactivate, although priority is given to the communication port. Thus the keypad would continue indefinitely in the state in which it was left, but the moment any message was received through the communication port, the keypad would become inactive and would return to the steady-state message.

5. CONSTRUCTION

5.1 CASE

The case of the MOR3000 is sheet metal. The general dimensions are shown in Figure 9.

The front cover is a plastic material shaped to the front of the case in such a way as to press on a gasket situated around the edge of the relay, which produces a hermetic seal that impedes the entrance of dust.

5.2 INTERNAL AND EXTERNAL CONNECTIONS

The connections of the external cables are made through five terminal blocks mounted on the rear of the case. Each terminal block contains 12 screw-type terminals 3 mm. in diameter.

All of the current inputs are made through terminal blocks, on the same rear plate. Each block has the necessary capacity to withstand the secondary current from the current transformers. The internal input current conductors are thicker than the rest of the internal connection cables. They have been designed in such a way as to obtain the shortest possible length in order to minimize the resistive burden on the current transformers.

The connections are made on pressure-type terminals. The input current cables are grouped together in the same bundle, separated from the other cable bundles in order to minimize the coupling effects of the magnetic fields associated with the input current on the other internal conductors for weaker signals.

5.3 IDENTIFICATION

The complete relay model is indicated on the name plate.

Terminal blocks are identified by a letter situated on the rear plate. There are five terminal blocks and each has its unique code (from A to E) in order to avoid confusion when connecting the external cables.

On each terminal block, the connection screws (1 to 12) are marked by engraved numbers.

5.4 EXTERNAL SIGNALS

The MOR3000 has one LED on the front of the relay. During normal operation the LED is green, changing to red if a failure is detected.

6. ACCEPTANCE, HANDLING AND STORAGE

The relays are supplied to the customer in special packing that protects them, especially during transportation, so long as this is done under normal conditions.

Immediately upon receiving the relay, the customer should check for any sign that the relay has suffered damage during transport. If it becomes evident that the relay has been damaged due to rough handling, the freight company should be notified immediately in writing, with copy to the manufacturer.

In order to unpack the relay, it is necessary to take normal precautions, and to take care not to lose the screws that are supplied inside the packing.

If the relay is not going to be installed immediately, it should be stored in its original packaging in a dry place, free from dust.

It's important to verify that the name plate inscription coincides with the characteristics of the purchase order.

7. ACCEPTANCE TESTS

It is recommended that once the relay is received, a visual inspection be performed immediately and the tests that are described below be performed to make sure that the relay has not suffered any damage during transport and that the calibration performed at the factory has not been disturbed.

These tests can be performed as installation tests or acceptance tests, according to the user's practice. Since most users have different procedures for installation and acceptance tests, this section indicates all of the tests that can be performed on these relays.

NOTE: All the absolute values of current that appear in this instruction book are given for a MOR3000 with a nominal current In = 5 amperes for phase and In = 1 ampere for ground, and a setting range of 0.2 to 1.6 x In.

7.1 VISUAL INSPECTION

If not already done at the time of receipt, verify that the model indicated in the name plate corresponds to the information reflected in the purchased order. Unpack the relay and verify that none of the parts are broken and that there is no sign that the relay has suffered damage during transport.

7.2 ELECTRICAL TESTS

General Considerations Regarding the Supply Source

All devices that function with alternating current are influenced by the frequency. Given that a non-sinusoidal waveform is the result of a fundamental frequency wave plus a series of harmonics of this fundamental wave, one can deduce that devices (relays) that function with alternating current are influenced by the applied waveforms.

In order to test correctly relays that function with alternating current, it is important to use a sinusoidal current and or voltage waveform. The purity of the sine wave (absence of harmonics) cannot be expressed in a specific form for a given relay. Nonetheless, any relay that incorporates time-synchronizing circuits, R-L and R-C or nonlinear elements (such as inverse time-overcurrent relays) can be affected by non-sinusoidal waveforms.

In the same way, relays that have a DC power supply should be tested with DC and not with rectified AC, since in the event that the supply is not properly isolated it is possible that relay operation would not be correct due to voltage drop in the power supply.

These relays respond to the current waveform in a different way than most AC ammeters. If the supply source used for this test contains high amplitude harmonics, the response of an ammeter and that of the relay will be different.

The relay has been calibrated in the factory utilizing a 50 or 60 Hz sine wave with minimum harmonic content. When tests are performed on the relay, a supply source should be used whose waveform does not contain harmonics.

The ammeters used to perform pickup-current tests on the relay, and the timers used to perform operating tests on the relays, should be calibrated, and their accuracy should be better than that of the relay. The supply source used in the test should stay stable, particularly in the level close to the pickup current of the test, as well as throughout the time in which the relay operates according to the curve that is being tested.

It is important to point out that the accuracy of the test depends on the power supply source and the calibration of the instruments used. Functional tests performed with inadequate supplies and instruments would only be useful to verify that the relay operates correctly; therefore the characteristics would be verified only in an approximate way.

7.2.1 Directional Unit

7.2.1.1 Phase Directional Unit

To perform the phase directional unit tests, we need to set the Phase Ground Directional setting to "PERMITTED" and disable the unbalanced-current trip.

In order to test phase A it is necessary to have the Vbc phase-to-phase polarization voltage; that is why we apply the following voltages and currents:

Ia = 5 A
Vb = 69 V, 60 Hz (63 V, 50 Hz) lagging 120 degrees from Ia
Vc = 69 V, 60 Hz (63 V, 50 Hz) lagging 240 degrees from Ia

See Figure 12 for the external connection diagram.

Set the overcurrent unit of phase A as follows:

Instantaneous unit:	-Set value 3 A. -Time-delay 0.
Time unit:	-Disabled.

Apply voltage and current to the relay; use a phase shifter to make currents lead voltage, and verify that the relay trips for the following values:

Characteristic angle	Phase meter readings (±2.5 degrees)
45 degrees	From 0 to 45 degrees and from 225 to 360 degrees

Repeat the same test for the other two phases, with the following values:

Phase B: Ib = 5 A.
     Va = 69 V, 60 Hz (63 V, 50 Hz) lagging 120 degrees from Ib.
     Vc = 69 V, 60 Hz (63 V, 50 Hz) lagging 240 degrees from Ic.
Phase C: Ic = 5 A.
     Va = 69 V, 60 Hz (63 V, 50 Hz) lagging 120 degrees from Ic.
     Vb = 69 V, 60 Hz (63 V, 50 Hz) lagging 240 degrees from Ic.

7.2.1.2 Ground Directional Unit

To perform the ground directional unit tests, we need to set the Phase Ground Directional setting to "PERMITTED" and disable the unbalanced-current trip.

Current Polarization

Apply to the ground current circuit a current of the same value as the relay's ground nominal current, and also apply 5A in the polarization circuit (see Figure 12, external connections diagram). In this way both currents are in phase.

Set the ground overcurrent unit in the following way:

Instantaneous unit:	-Set value 0.5 A. -Time-delay 0.
Time unit:	-Disabled.

Apply current to both circuits. Verify that the relay trips; now switch the terminals of the current polarization, producing an angle of 180 degrees.

Apply current again to both circuits and verify that the relay does **not** trip.

Voltage Polarization

Apply voltage and current to the ground circuits (see Figure 12), using a phase shifter to obtain the phase angle required. Apply 69 V, 60 Hz (or 63 V, 50 Hz) and a current of the same value as the relay's nominal ground current.

Set the ground overcurrent unit in the following way:

Instantaneous unit:	-Set value 0.5 A. -Time-delay 0.
Time unit:	-Disabled.

Using a phase shifter, verify that the relay operates for the following values:

Characteristic angle	Phase meter readings (±2.5 degrees)
45 degrees	From 45 to 225 degrees

7.2.2 Inverse-Time Unit

7.2.2.1 Verification of the Pickup Tap Calibration

- Connect the relay as indicated in Figure 10. In order to apply current to the relay, use a source of 120 V, 60 Hz (or 110 V, 50 Hz) with a variable resistance in series, or a current source.

- Set the relay to any tap and disable the instantaneous unit, the directional unit and the unbalanced-current unit by introducing a zero in the instantaneous setting, another one in the unbalance setting, and selecting PROHIBITED for the Phase Ground Directional setting.

Apply current to the relay and verify that the Pickup "LED" in the display lights between 100 and 110% of the tap setting, and that the Trip relay closes.

With the output contact of the relay closed, lower the current applied, verifying that, at a current value between 95 and 105% of the tap, the output relay resets and the Pickup "LED" goes out.

NOTE: If the breaker-status input to the relay is disconnected, or connected incorrectly, it is possible that the Blocked Reclosure "LED" in the display will light, since the relay interprets that the breaker has not responded after the trip, and therefore blocks reclosure.

7.2.2.2 Verification of Operating Time

With the relay connected as indicated in the previous section, set the inverse-time unit at the minimum tap and set the corresponding curve to 0.5.

Successively apply current of 2, 5 and 10 times the minimum tap, verifying that the operating time is within the margin indicated in Table 1, 2, 3 or 4, as appropriate.

TABLE 1. ANSI INVERSE Relay Characteristic

Times Minimum Tap	Applied Current (A)	Operating Times for Curve (IT = 0.5) in seconds
2	2	4.14 - 5.32
5	5	1.89 - 2.19
10	10	1.36 - 1.50

TABLE 2. VERY INVERSE Relay Characteristic

Times Minimum Tap	Applied Current (A)	Operating Times for Curve (IT = 0.5) in seconds
2	2	7.03 - 9.04
5	5	1.89 - 2.19
10	10	0.88 - 0.98

TABLE 3. EXTREMELY INVERSE Relay Characteristic

Times Minimum Tap	Applied Current (A)	Operating Times for Curve (IT = 0.5) in seconds
2	2	14.03 - 18.04
5	5	1.89 - 2.19
10	10	0.50 - 0.55

TABLE 4. USER DEFINED Relay Characteristic
(factory-defined default curve)

Times Minimum Tap	Applied Current (A)	Operating Times for Curve (IT = 0.5) in seconds
2	2	5.59 - 7.19
5	5	1.89 - 2.19
10	10	1.08 - 1.20

Set the relay to the minimum tap and verify that when a current of 5 times tap setting is applied, the operating time is within the margin indicated in Table 5.

TABLE 5. OPERATING TIME MARGIN

Curve	Time in seconds ANSI inv. - Very inverse Extremely inverse - User
I.TIME = 1.00	3.76 - 4.37
I.TIME = 0.70	2.64 - 3.07
I.TIME = 0.30	1.15 - 1.34
I.TIME = 0.10	0.41 - 0.48

7.2.3 Instantaneous Unit

7.2.3.1 Verification of Pickup

- Connect the relay as indicated in Figure 10. In order to apply current to the relay, use a source of 120V, 60Hz (or 110V, 50 Hz) with a variable resistance in series, or a current source.

- Set the instantaneous unit of the relay to 1 Ampere and disable the inverse-time unit by changing the tap setting to zero. Similarly, disable the unbalanced-current unit and also the directional unit by selecting PROHIBITED for the Phase/Ground Directional setting. Set the delay time of the instantaneous unit to zero seconds.

  Apply current to the relay and verify that the Pickup "LED" in the display of the relay lights, and that the Trip relay closes when the current is between 0.95 and 1.05 amperes.

  With the trip contact of the relay closed, reduce the applied current, verifying that between 95 and 100% of the pickup value, the Trip relay resets and the Pickup "LED" goes out.

NOTE: If the breaker-status input to the relay is open or not correctly connected, it is possible that the Blocked Reclosure "LED" in the display will light, since the relay interprets that the breaker has not responded to the trip, and therefore blocks reclosure.

7.2.3.2 Verification of the Operating Time

  With the relay connected as indicated in the previous section, apply current of 5 Amperes, verifying that the operating time is less than 0.025 seconds.

  Set the delay time of the instantaneous unit. Verify that the operating time is the sum of the delay time you set plus the pickup time.

7.2.4 Unbalanced Current

7.2.4.1 Phases

Connect the relay as shown in Figure 10. Disable the inverse-time, directional and instantaneous units. Set the phase unbalance to the percent desired, as well as the delay time. Apply current and verify that between 0.5 and 0.6 Amperes (minimum pickup value for the phase unbalanced-current unit) the Pickup "LED" in the display lights. Maintaining the same current, verify that upon completion of the programmed time, the trip contact closes.

With the Trip relay closed, slowly lower the current until the Pickup "LED" goes out and the Trip relay resets. It should occur at a current between 0.48 and 0.56 Amperes.

Applying to the relay another two current inputs similar to the current already applied above, apply 1 Ampere to each of the three phases. Increase the current for one of the phases and verify that the Pickup "LED" lights between 85 and 115% of the expected value, according to the programmed percentage. Upon completion of the programmed time, the Trip relay should close. Lower the current and verify that the Pickup "LED" goes out and the Trip relay resets at current between 80% and 100% of the value that produced pickup.

7.2.4.2 Ground

Connect the relay as indicated in Figure 10. Set the ground unbalance and delay time to the desired values. Disable the inverse-time and the instantaneous units.

Increase the ground current and verify that the Pickup "LED" lights between 85% and 115% of the expected value as programmed. Upon completion of the program time, the Trip relay should close. Lower the current and verify that the Pickup "LED" goes out and that the Trip relay resets, at current between 80% and 100% of the value that produced pickup.

7.2.5 Reclosure

Connect the relay as shown in Figure 11. In order to simulate the breaker, we can use a latching relay in such a way that when the Trip relay closes, voltage is supplied to the active coil, closing a contact in the circuit between terminals E3 and E4.

In this way the relay interprets that the breaker has opened. When the Recloser relay closes, voltage is applied to the other coil and opens the circuit. Then the relay interprets that the breaker has closed.

7.2.5.1 Verification of Reclosure Cycle

The recloser can be placed out of service by changing the number of reclosures to zero (0). When this has been done, verify that no reclosure is produced by applying trip current.

Set the number of reclosures to one (1), the reclose pause time to five (5) seconds, and set all of the trips and reclosures as "enabled". Set the lockout time to one minute and the inverse unit to 1 Ampere, at the same time disabling the directional, instantaneous and unbalanced-current units. Set the repetitive trips to 30. Manually open and close the breaker (notice that the closed contact indicates breaker open, and the open contact indicates breaker closed). After waiting a minute for the security time to pass, apply current greater than 1 Ampere in order to verify that the relay recloses between 4.95 and 5.05 seconds. In this manner the time from trip to reclose can be measured.

The number of reclosures can be changed in order to verify that the relay follows the program cycle. In order to measure times (DELAY) for intermediate reclosures, apply a current of 1.2 Amperes and reset the timer after each reclosure.

7.2.5.2 Manual Close

Repeat the previous test, applying enough current to trip the relay before the completion of the minute corresponding to the lockout time, and verify that the relay does not reclose.

7.2.5.3 Verification of Blocks

Apply VDC between terminals E3 and E6, verifying that the Reclosure Blocked "LED" lights in the display. Upon removing DC voltage, the "LED" should go out. Repeat the previous step after waiting for the lockout time and apply the voltage before the trip, or during the reclose delay time (DELAY), and verify that no reclosure is produced.

Remove the previous voltage and give a remote "Block" command. In this case the Recloser Blocked "LED" in the display lights, and upon repeating the previous test a reclose is not produced. If a remote "Unblock" command is given, the "LED" should go out.

Set the number of reclosures to five (5) and the number of repetitive trips to three (3). After opening and closing the breaker, wait for the security time and apply current. Verify that after the third trip the Recloser Blocked "LED" in the display lights, and that no reclosure is produced. Manually close the breaker, and verify that the Recloser Blocked "LED" goes out.

With the breaker closed, loosen terminal C5 and set the opening time (MAX. OPENING TIME) to one (1) second. Apply current and verify that, approximately one (1) second after the Trip relay closes, the Recloser Blocked "LED" in the display lights. Maintaining current, reconnect terminal C5, and verify that the relay opens the breaker but does not produce a reclosure. Manually close the breaker and verify that the Recloser Blocked "LED" goes out.

7.2.5.4 Verification of the Reclosure Permit

Set the permit-reclosure time (VCA CTR. TIME)(VAC Control Time) to 1 minute and repeat the test described in Section 7.2.5.1, but with terminal E1 disconnected and with a reclose time of 30 seconds. Verify that the relay does not reclose. Repeat, connecting the terminal when 50 seconds have passed after the trip. Verify that 30 seconds after applying voltage to E1, the relay recloses. Repeat once more, but connecting the terminal after one (1) minute. Verify that in this case the relay does not reclose.

Set the permit-reclosure time (VCA CTR. TIME) to zero in order to disable the "permit", and repeat the previous test. Verify that the relay always recloses, independent of whether there is permission or not.

7.2.5.5 Verification of Trip and Reclose Enabled

With the number of reclosures set greater than zero, set the inverse-time unit to 2 amperes and the instantaneous to 1 ampere. Disable the instantaneous trip and the unbalanced-current trip for trips after the security time. Apply current after the security time has passed and verify that the Pickup "LED" lights in the display when the current is approximately 1 ampere, but no trip occurs. Increase the current above 2 amperes and verify that a trip occurs after the passage of time delay corresponding to the inverse-time unit. Afterwards the relay will reclose according to the number of reclosures set. After the first reclose it will trip to the instantaneous unit since for the subsequent trips it has not been disabled. Verify with the event recorder that it has actually tripped, the first time due to an inverse-time unit, and the other time due to an instantaneous unit trip.

Enable the instantaneous trip and disable the first instantaneous reclose, and repeat the previous test. Verify that a trip occurs due to the instantaneous unit and the MOR does not reclose. Disable the instantaneous unit by entering a zero in the setting, and repeat the test. In this case it will trip due to an inverse-time unit trip, and therefore it can reclose.

NOTE: As a result of the repetitive trips it is possible that the recloser might become blocked during a test. Manually close the breaker in order to eliminate any block, and set the number of repetitive trips to the maximum.

8. INSTALLATION

8.1 INTRODUCTION

The place where the relay is to be installed should be clean, dry, and free from dust or vibration, and well lit in order to facilitate inspection and test.

The relay should be mounted on a vertical surface. Figure 9 represents the mounting dimensions for cutting and drilling.

The external connections scheme is reflected in Figure 12.

8.2 GROUND CONNECTION FOR OVERVOLTAGE SUPPRESSION

Terminal B1 of the relay should be connected to ground in order for the disturbance-suppression circuit included in the relay to function correctly. This connection should be multiwire of 2.5 mm. cross section (14 AWG) and the shortest possible length in order to assure maximum protection (preferably 25 cm./10 inches or less).

8.3 TESTS

Since most users utilize different procedures for installation tests, the **ACCEPTANCE TESTS** section includes all the necessary tests that can be performed as installation tests according to the user's practice. The tests below are considered minimum:

- Tests of the inverse-time unit.

  Set the relay to the pickup tap desired. Apply current to the relay and verify that it operates between 1 and 1.1 times the set value.

  The **ACCEPTANCE TESTS** section includes detailed descriptions of the pickup current test for the inverse-time unit.

  Set the relay to the desired time curve. Verify the operating time by applying a current of 5 times the pickup tap value. Verify the operating time again by applying current 2 and 10 times the pickup tap value. The **ACCEPTANCE TESTS** section includes detailed information on the operation-time test for the inverse-time unit.

- Instantaneous Unit tests.

  Set the instantaneous unit of the relay to the desired value and refer to the **ACCEPTANCE TESTS** section for pickup and operating time verification tests.

- Phase directional unit tests.

  Refer to the **ACCEPTANCE TESTS** section.

- <u>Ground directional unit tests</u>.

  Refer to the **ACCEPTANCE TESTS** section.

- <u>Unbalanced-current tests</u>.

  Set the unbalanced-current unit of the relay to the desired value and refer to the ACCEPTANCE TESTS section for pickup and operating time verification tests (7.2.3.1 7.2.3.2).

- <u>Recloser tests</u>.

  Refer to the **ACCEPTANCE TESTS** section.

All the tests described in the **INSTALLATION** section should be performed at the time the relay is installed.

If for any reason any specific test in the **ACCEPTANCE TESTS** section has not been performed already, it is recommended that it be performed at the time of installation.

9. PERIODIC MAINTENANCE AND TESTS

Given the primary importance of protective relays in the operation of any installation, it is recommended that a periodic program of maintenance and tests be followed. Since the interval between periodic testing varies for different types of relays, and types of installations, as well as the experience of the user with periodic testing, it is recommended that the points described in the **INSTALLATION** section be verified at an interval of from 1 to 2 years.

TELEPHONE LINE

MULTIPLEXOR

MOR 1   MOR 2   MOR 3   MOR N
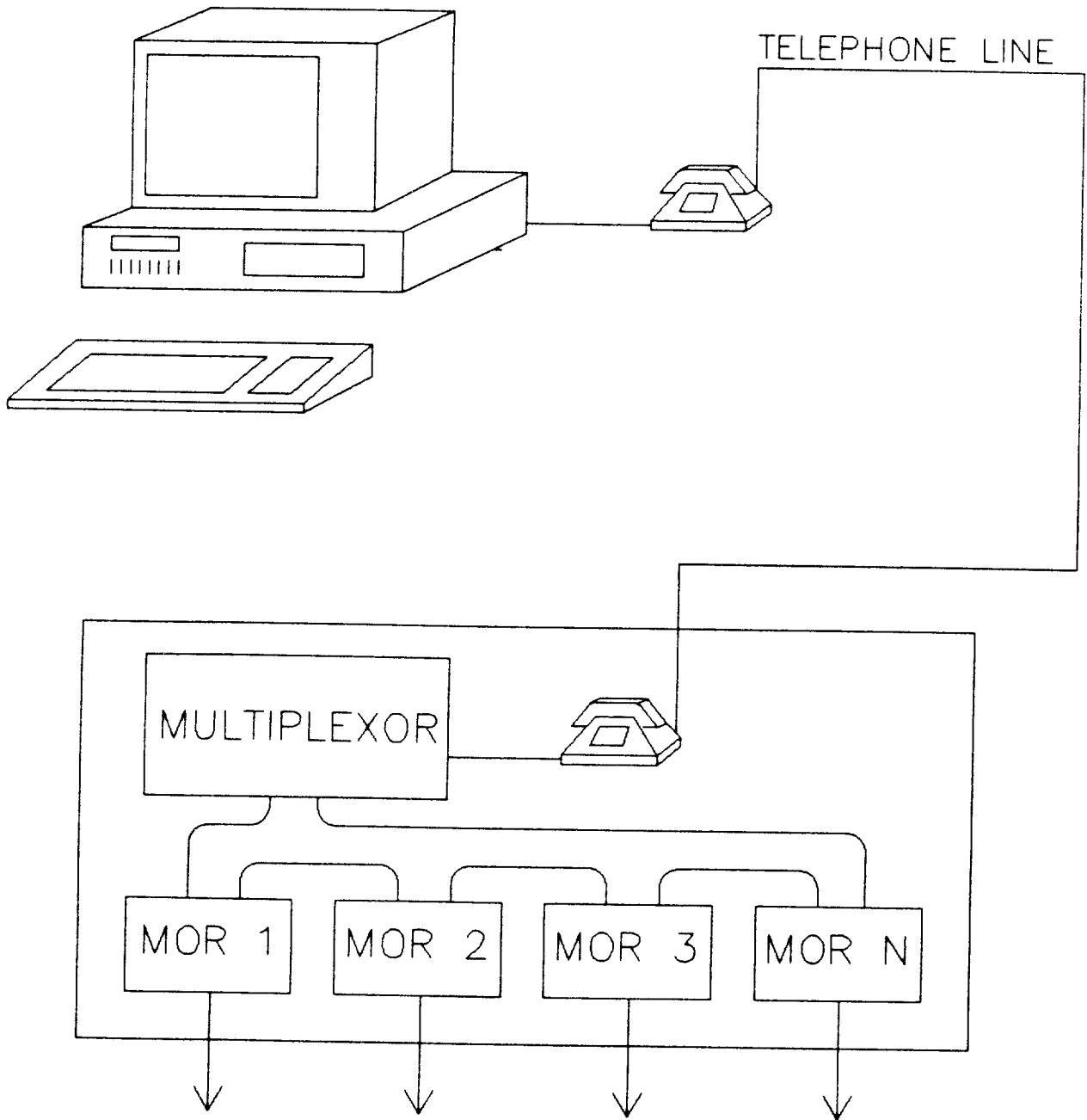
Figure 3 (0246A5397 [2]) System Diagram
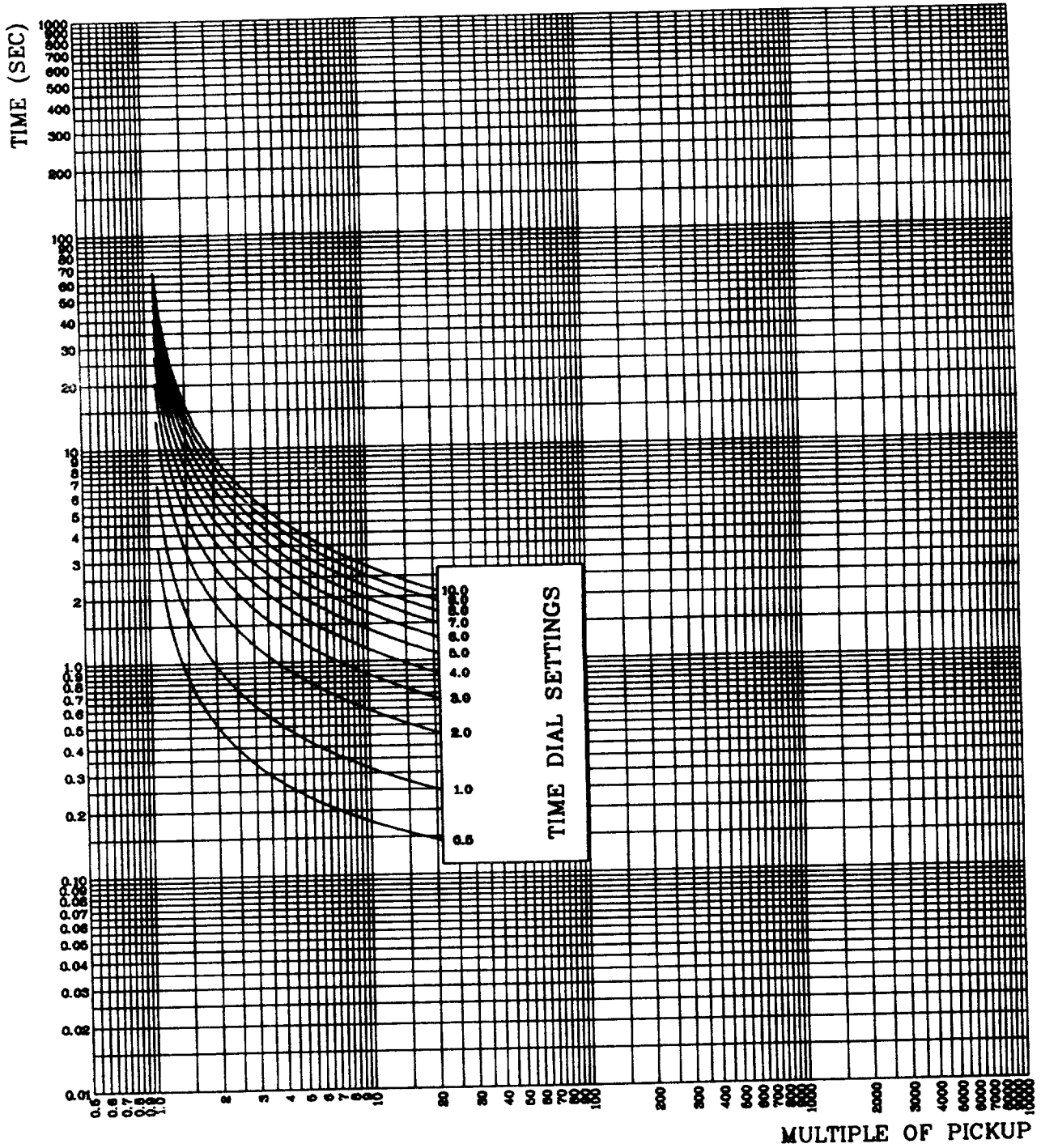
Figure 4 (0286A5398 [1] Inverse-Time Vs. Current Characteristic
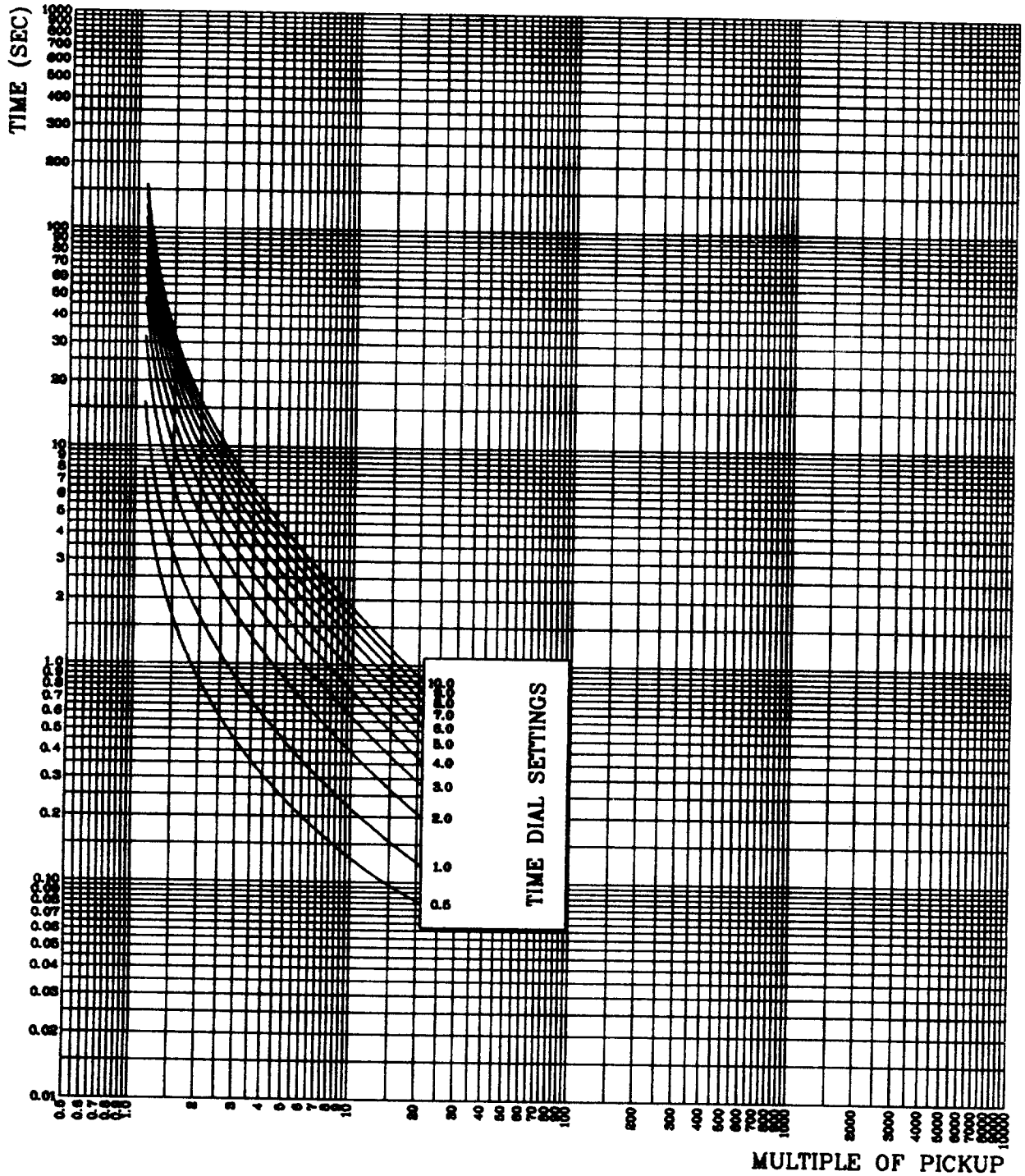
Figure 5 (0286A5399 [1]) Very Inverse-Time Vs. Current Characteristic
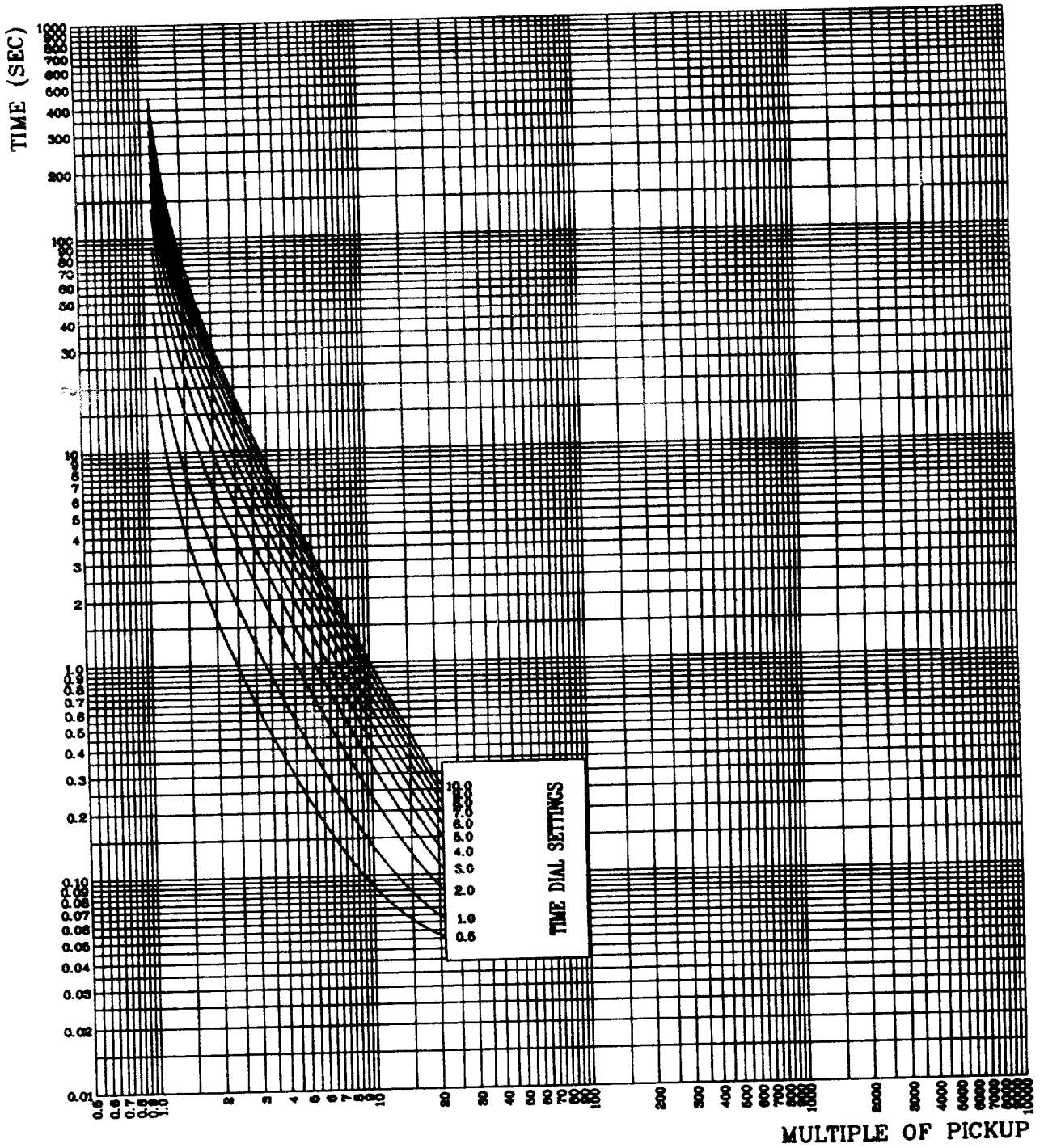
Figure 6 (0286A5400 [1]) Extremely Inverse-Time Vs. Current Characteristic
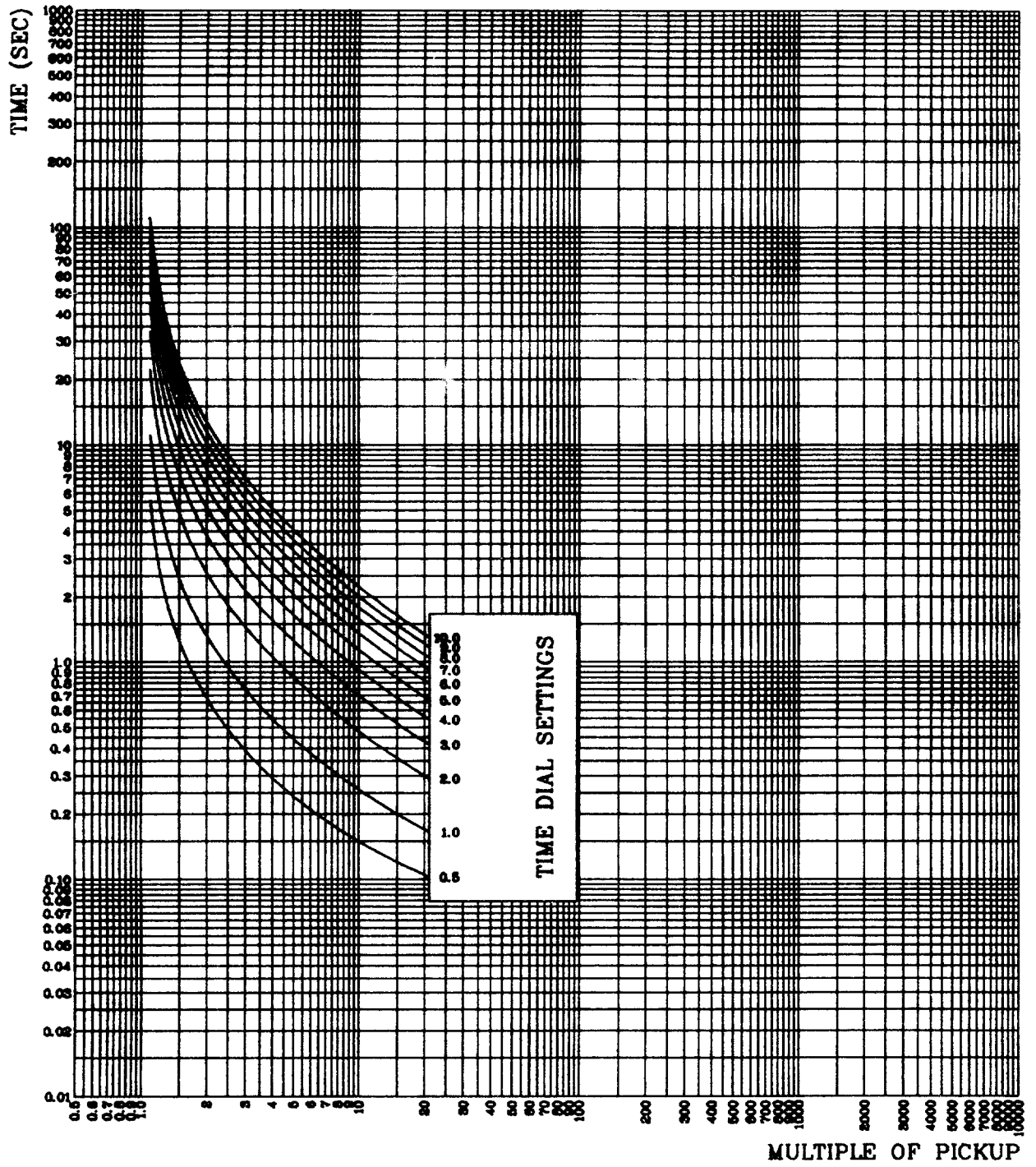
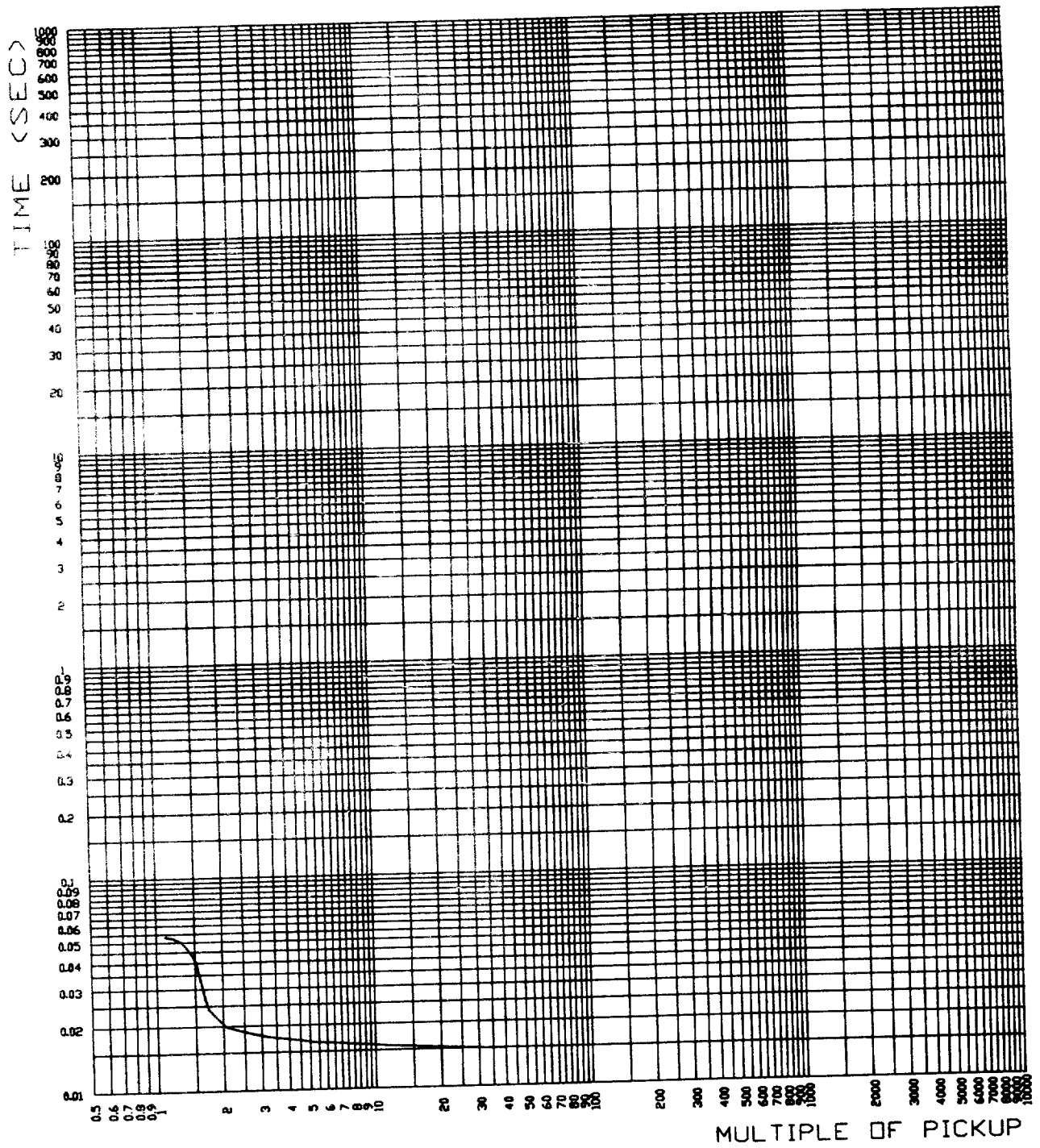Figure 7 (0286A5401 [1]) Time Vs. Current Characteristic

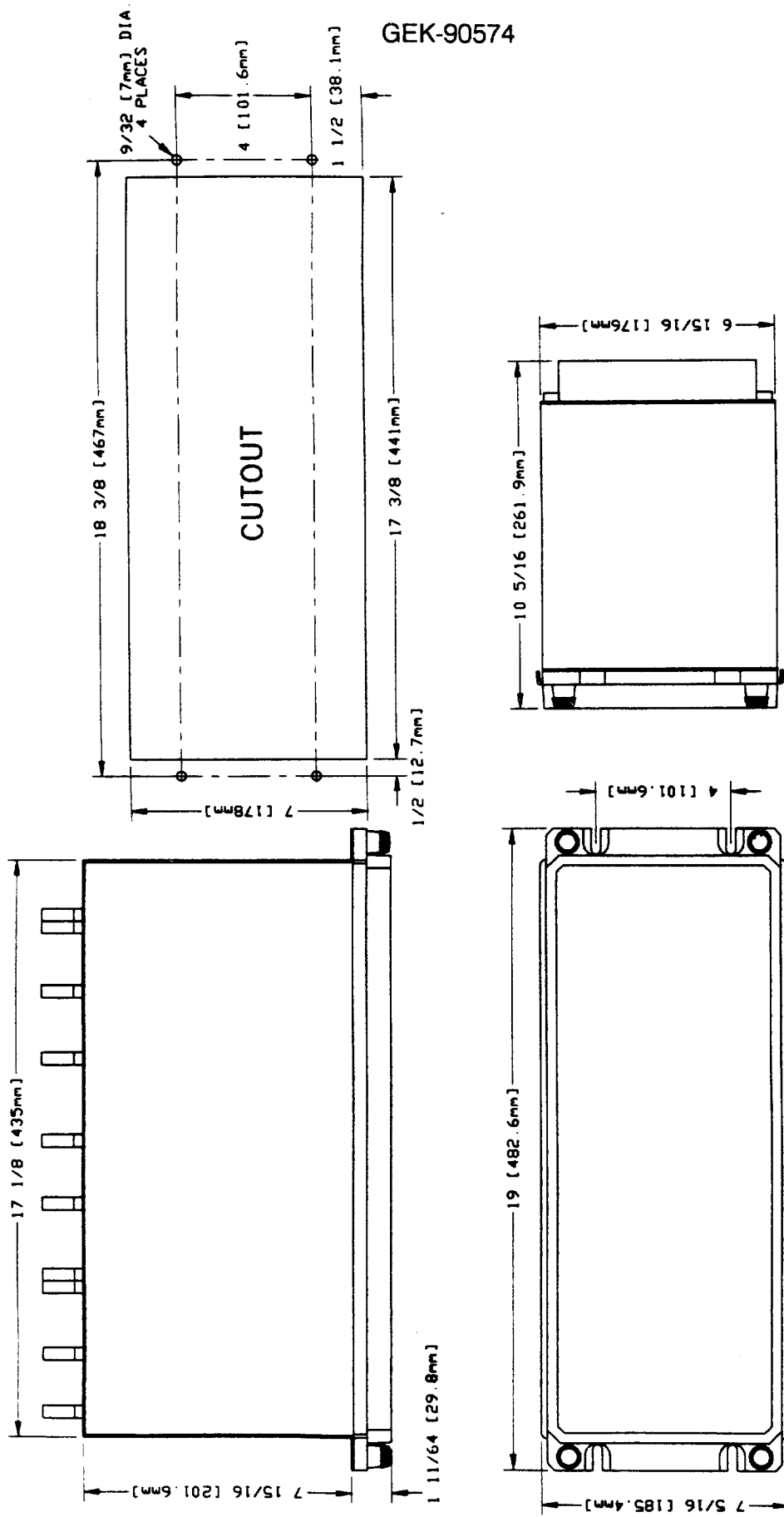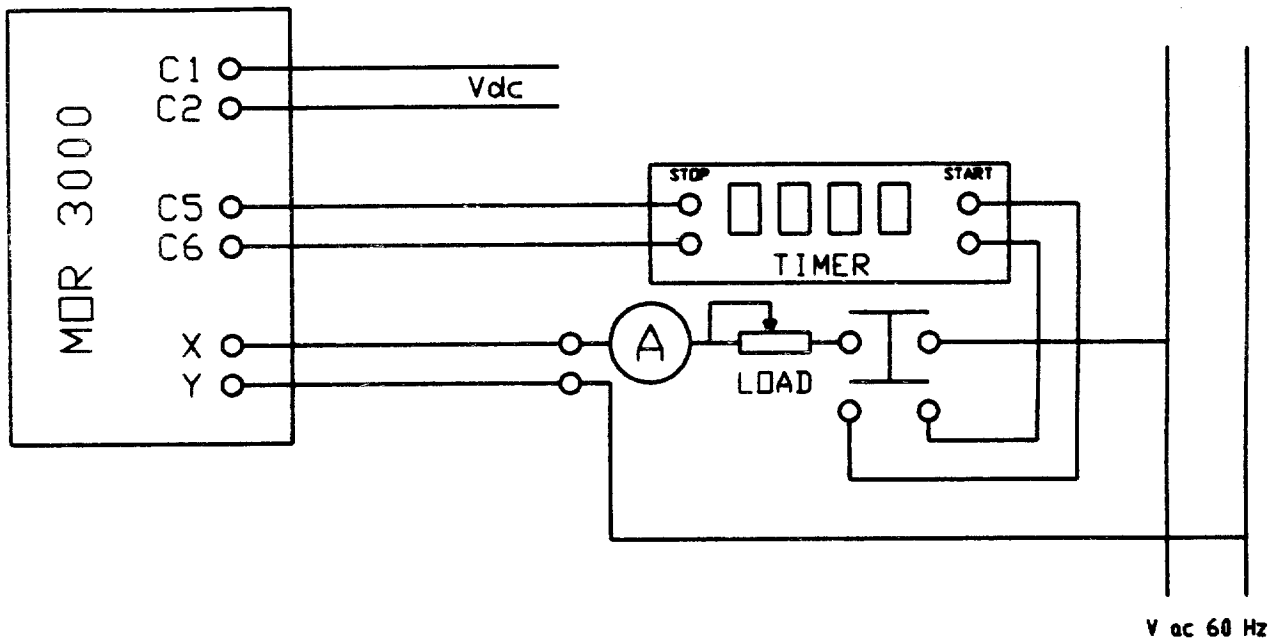Figure 8 (0286A5402 [1]) Instantaneous Unit Characteristic

CUTOUT

Figure 9 (0226B6086) Outline and Panel Drilling

	X	Y
PH1	B11	B12
PH2	B9	B10
PH3	B7	B8
GRN	B5	B6

Figure 10 (0286A5569) Test Circuit for Tripping Functions
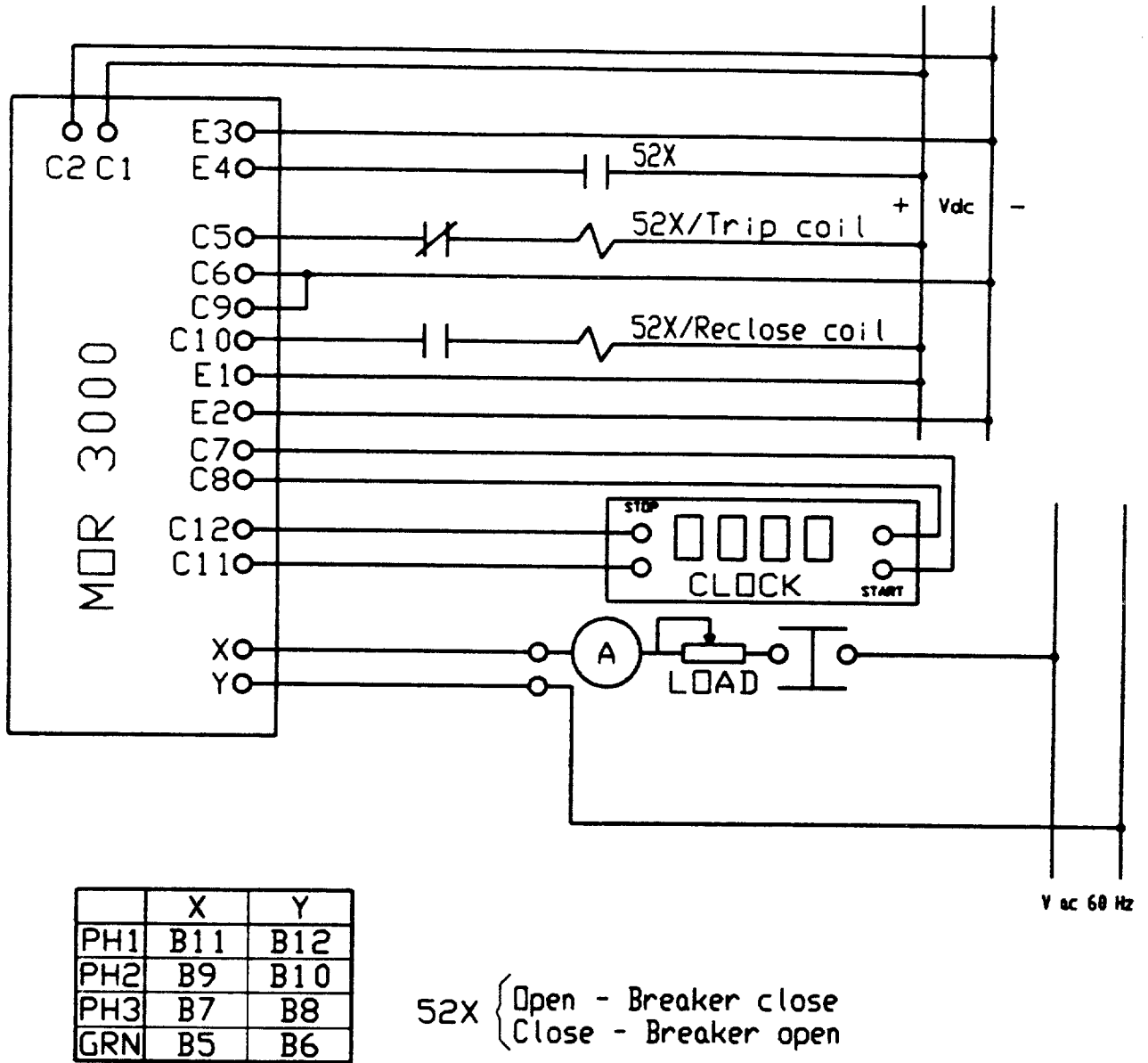
Figure 11 (0286A5568) Test Circuit for Recloser Functions
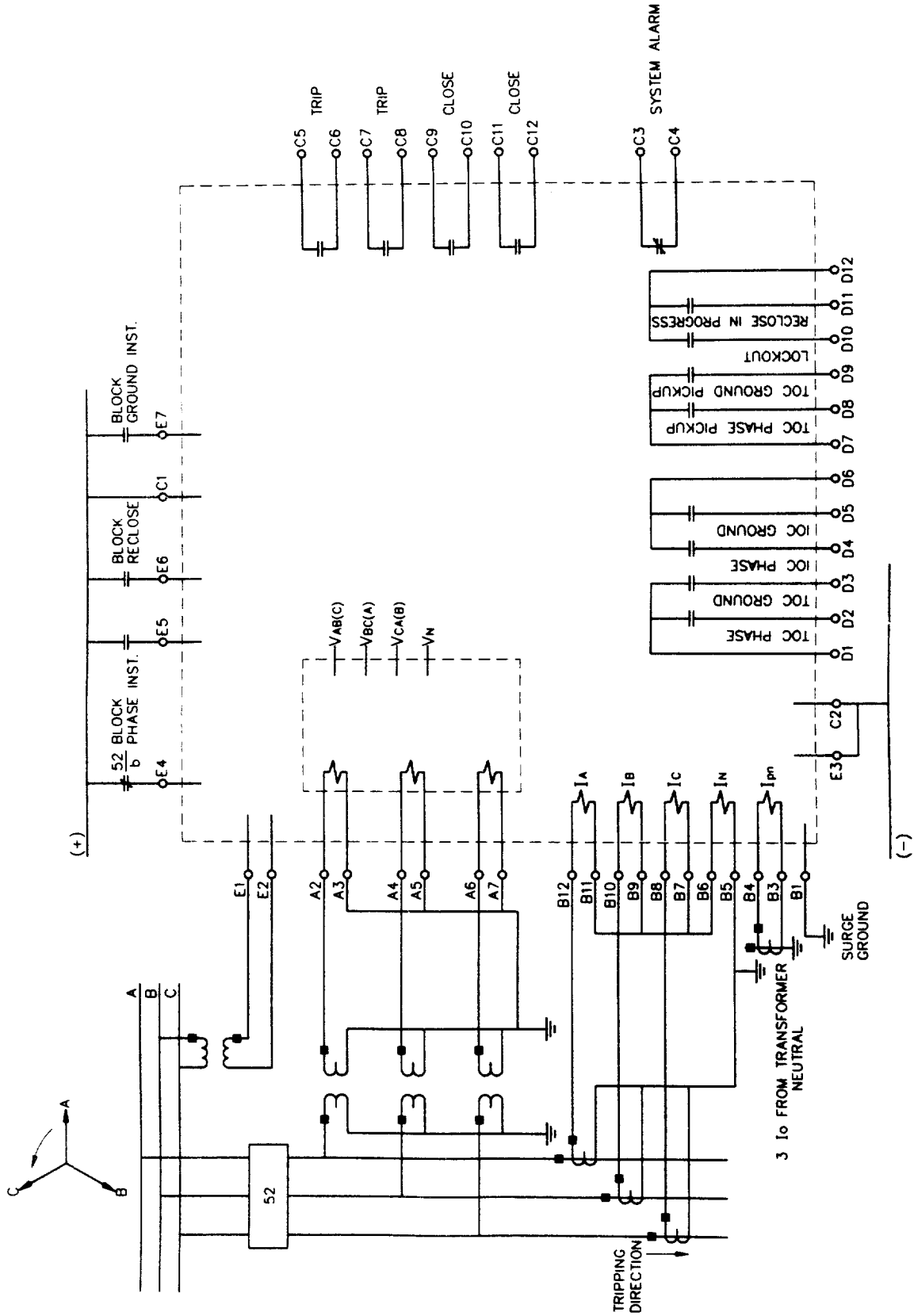
Figure 12 (0226B6041) External Connections
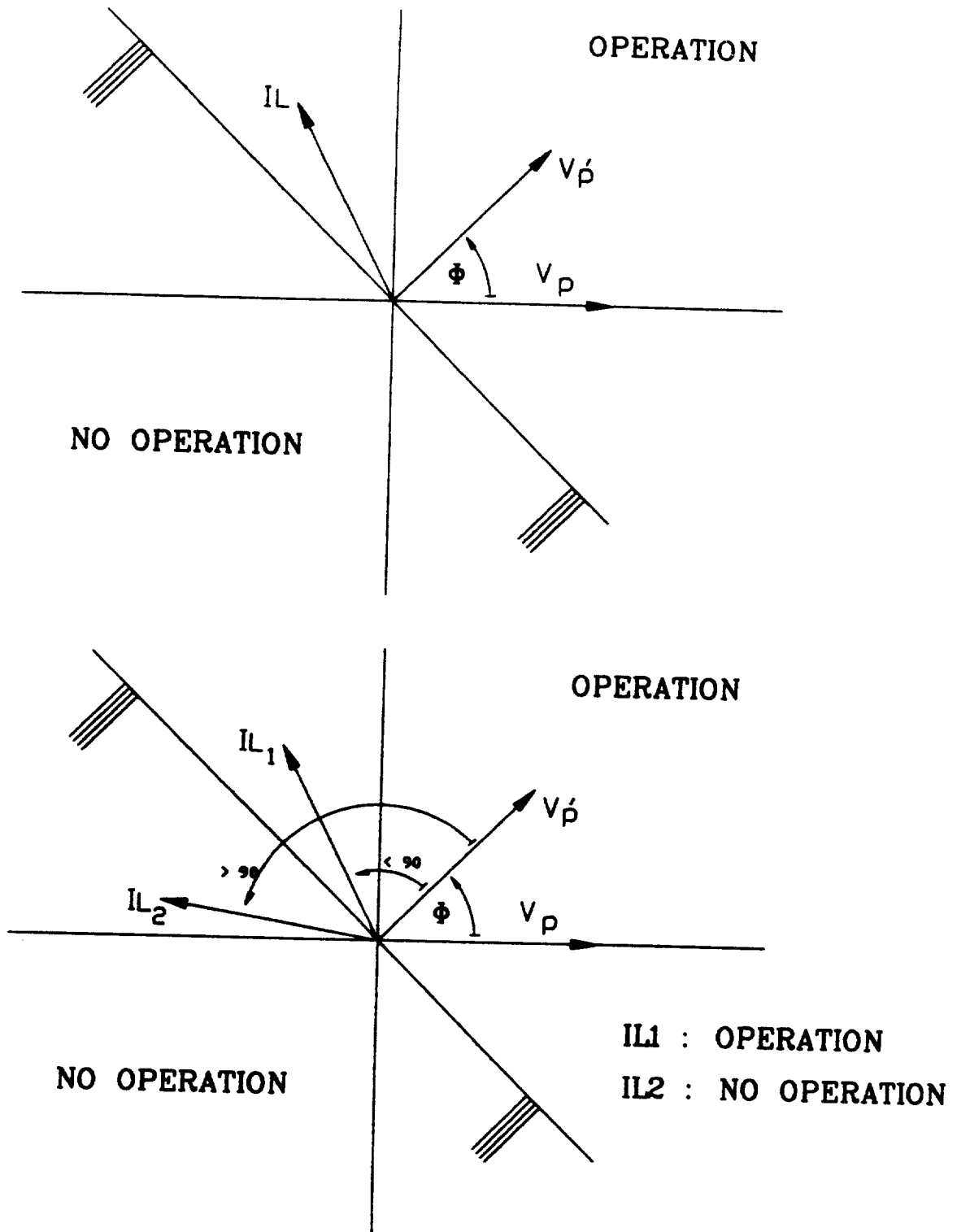
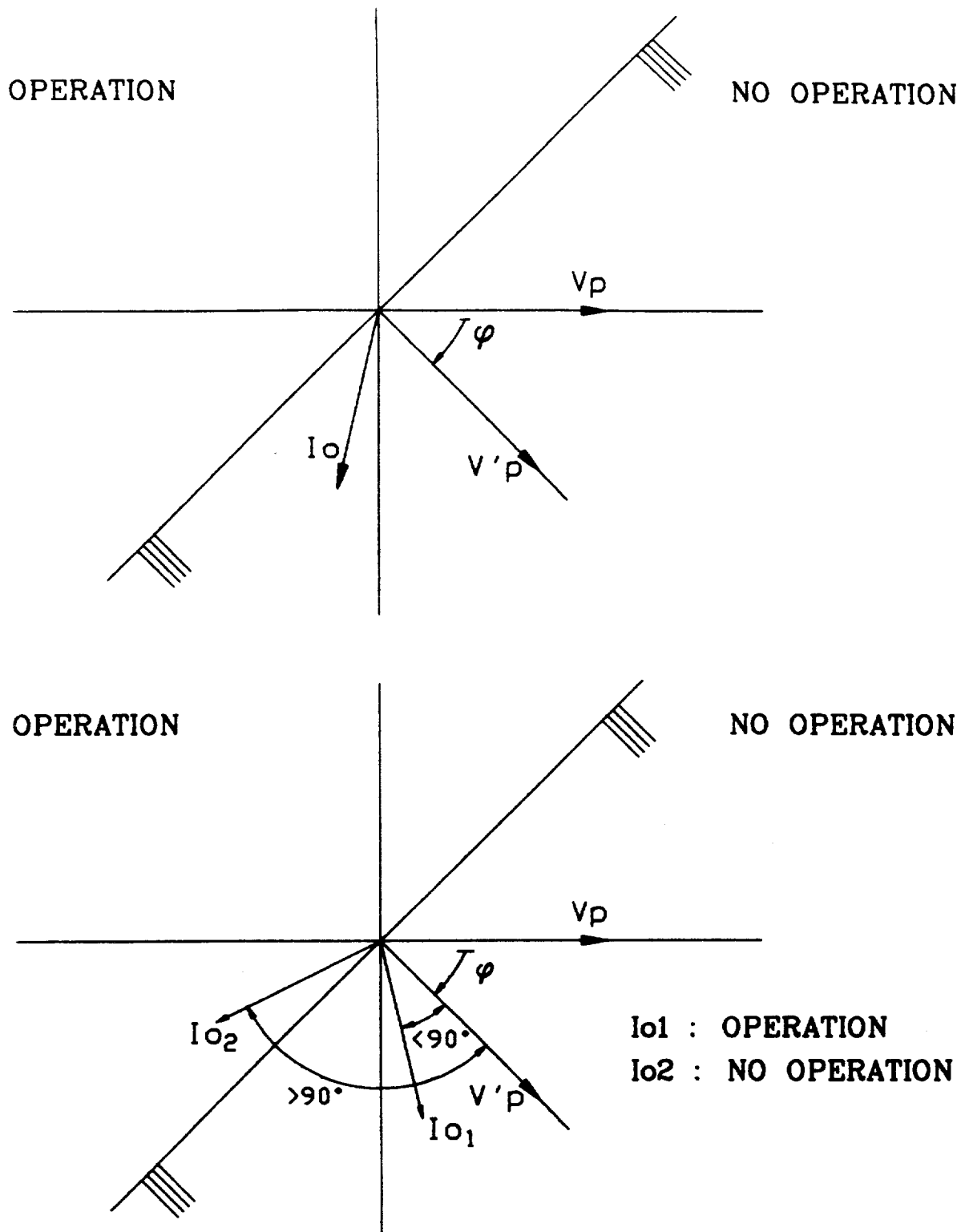Figure 13 (0286A5565) Phase Directional Unit Characteristic

OPERATION

NO OPERATION

Vp

φ

Io

V'p

OPERATION

NO OPERATION

Vp

φ
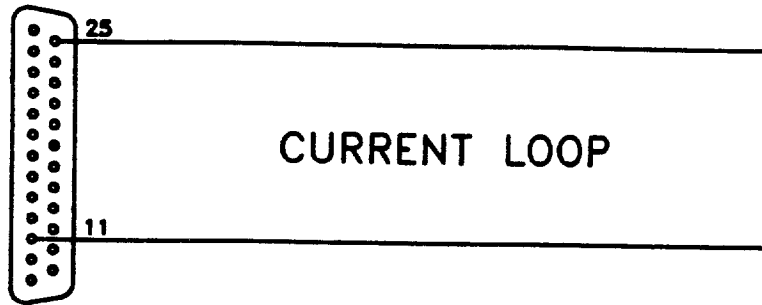
Io2

<90°

>90°

V'p

Io1

Io1 : OPERATION

Io2 : NO OPERATION

Figure 14 (0286A5566) Ground Directional Unit Characteristic

MALE DB25 CONNECTOR
(BOARD SIDE)

25

CURRENT LOOP

11

MALE DB25 CONNECTOR
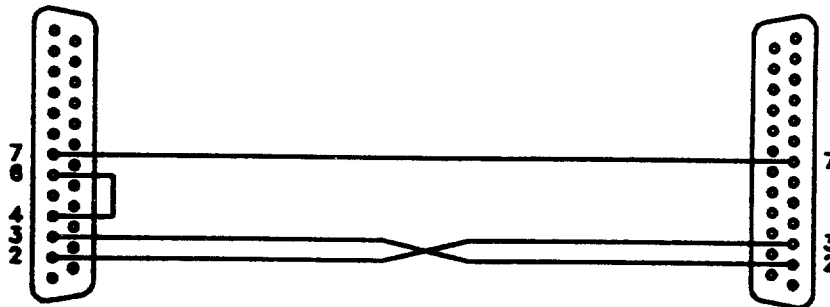(BOARD SIDE)

FEMALE DB25 CONNECTOR
(COMPUTER SIDE)

7
6

4
3
2

7

3
2

Figure 15 (0286A5567) Communication Links

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