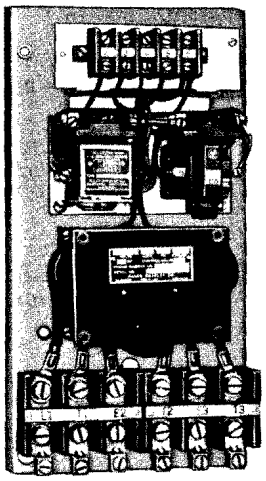
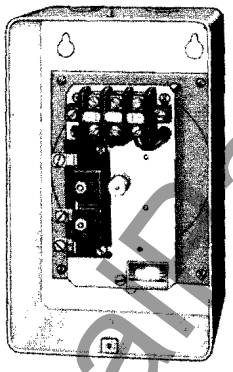
PHASE FAILURE AND PHASE REVERSAL RELAYS



Style F, Phase Failure Relay, Open Type construction.



Style R, Phase Reversal Relay, NEMA Type 1 enclosure.

DESCRIPTION

Bulletin 812 relays protect motors against hazards of open phase or reversed phase sequence conditions. These relays are available in three different styles: Style R, for phase reversal protection; Style F, for phase failure protection; and Style RF, which provides both phase reversal and phase failure protection.

These relays afford a high degree of protection, but only when properly utilized. With each application of a phase reversal or phase failure relay, it is mandatory to first determine that the intended application is within the capabilities of the Bulletin 812 device.

SPECIAL FEATURES

FACTORY-SET – Each Bulletin 812 relay is permanently set at the factory, and will function properly without further adjustment. Under no conditions should field adjustments be attempted. If the relay needs repairs, it should be returned to the factory.

FAIL-SAFE CIRCUITRY – Should a fault such as a loose connection develop within the relay, the relay is designed to drop out and remain dropped out until the fault has been eliminated.

STYLE F — PHASE FAILURE RELAY

APPLICATION – Phase failure in a three phase circuit may be caused by a blown fuse, an open connection or a broken line. If phase failure occurs when the motor is at a standstill, stator currents will rise to and remain at a very high value, but the motor will remain stationary. Since the windings are not properly ventilated while the motor is stationary, the heating produced by the high currents will very likely damage the windings.

If phase failure occurs while motor is running, the motor cannot be reversed or plugged, but will continue to run until intentionally stopped.

The Bulletin 812 Style F relay provides phase failure protection by opening the control circuit to the motor starter.

Typical applications include pumping, conveyors, machine tool slides and carriages, etc.

DESCRIPTION – Basically the relay consists of a static, current-sensitive network, which is connected in series with the line, and a switching relay connected in the coil circuit of the starter.

The sensing network continuously monitors the motor line currents. Should one phase open, the sensing network immediately detects it and causes the relay to open the starter coil circuit, thus disconnecting the motor from the line. A built-in delay of approximately ten cycles prevents nuisance dropouts caused by transient line fluctuations.

The Style F relay is available with coils for 120, 208/240, 480 or 600 volts, 60 Hertz operation. On systems operating above 600 volts, the relay can be applied by utilizing current and potential transformers. Relays are available for 50 Hertz applications. Refer to the Handy Catalog for additional information.

The Style F is supplied in four sizes, each one of which will accommodate motors having horsepowers in the ratio of 4:1. The four relay sizes cover motor full load currents from 1.5 amperes to 300 amperes. Current transformers can be used to extend the range.

As indicated by the range of operating currents, the Bulletin 812 phase failure relay will function under a wide variety of load conditions. In contrast to most other relays of this kind, it will trip instantly upon loss of a phase, regardless of whether the motor is under full, partial or no load.

The Style F phase failure relay can also handle high inrush currents. If a phase opens during the inrush period, the relay will instantly disconnect the motor from the line.

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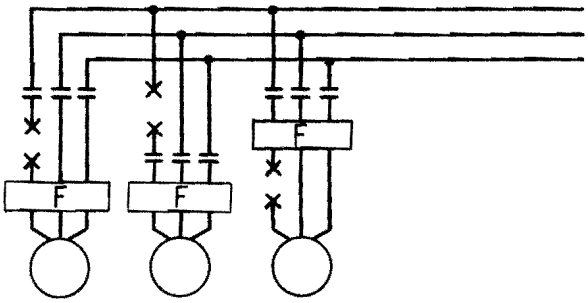
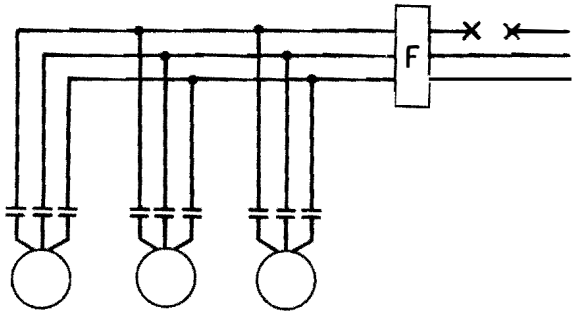


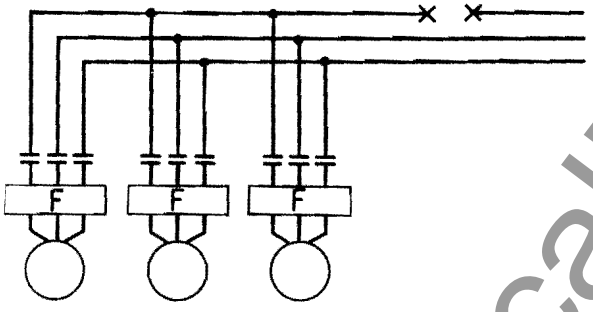
With the Style F relay, the motor is protected if the fault occurs in any of the places illustrated or if failure occurs at any other point within the single motor circuit. The motor is protected because the fault occurs within its own branch circuit.

Figure 1



These Motors have NO phase failure protection regardless of where the fault occurs.

Figure 2



These Motors may NOT be protected if a fault occurs as shown but are protected under circumstances shown in Figure 1.

Figure 3

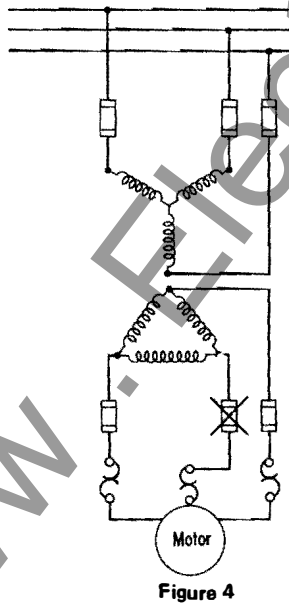


Figure 4

CAPABILITIES – The Style F relay will protect against the results of an open phase **in a single motor branch circuit** with magnetic starter control (See Figure 1).

LIMITATIONS – The Style F relay has the following limitations:

It will not provide system protection or multi-motor protection (See Figure 2 and 3).

(If one phase fails in a three phase system comprised of several pieces of rotating equipment, the results are quite unpredictable. After failure, the motors will continue to turn, some acting as generators to feed currents back into the open line; these currents, flowing through the phase failure relay appear no different than the original line current. If the system maintains a near balanced condition, the relay will detect no change and its contacts will remain closed.)

It will not operate under conditions of wide frequency variations; it cannot be used, for example, in the rotor circuit of wound rotor motors.

When used with manual starters with magnetic lock-in, or open circuit transition starters, protection is not given during starting.

It gives no protection when used with manual starters with mechanical lock-in.

This device must always be mounted in an upright position.

The ferrite cores used in the device will withstand normal treatment, but are brittle and the relay should not be dropped or mistreated.

Plugging or reversing capability lost due to phase failure cannot be restored by this device. Protection in such cases is limited to disconnecting the motor; therefore, its effectiveness depends on the time of occurrence of the phase failure.

No loads of any kind (including pilot lights) should be connected across coil PR of the DC relay. (See Figure 9 on Page 4.)

Contact M, in series with coil RC must always be a contact on the main motor starter, not on an auxiliary relay, which might close before the starter closes. (See Figure 11 on Page 4.)

FAULT HAZARDS – Consider one situation which contains many of the worst fault conditions (illustrated in Figure 4). Here not only is a single motor supplied by its own transformer, but the transformer is connected Y-Δ with ungrounded neutral; consequently, the motor may be subjected to any of several possible supply variations:

a. Accidental phase reversal on the secondary side of the transformer,

b. Accidental phase reversal on the primary side of the transformer,

c. Loss of a phase, as, for instance, the blowing of a secondary fuse,

d. Loss of a phase on the primary side for any reason.

Figure 9 shows the basic circuit of the static current sensitive network. C_1 and L, represent a resonant filter circuit which is tuned to the third harmonic of line frequency. The integrating circuit R_1 C_2 functions also as a dropout time delay for the DC sensing relay PR.

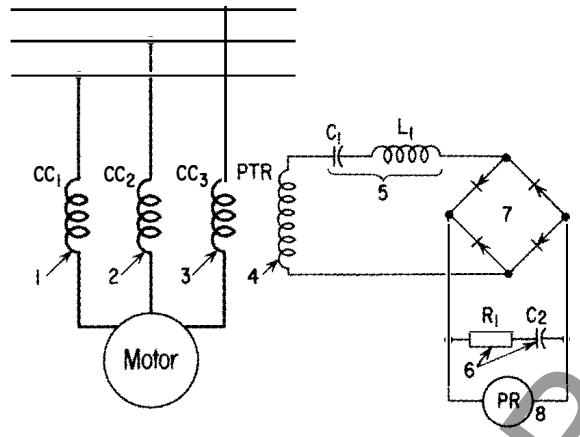
In Figure 10, the relay current is plotted as a function of motor current in per cent. This covers the three conditions just discussed.

The circuit is inherently fail-safe, since under normal conditions the relay is energized and interruption of its coil or any other circuit element will cause this relay to drop out. The motor starter, energized through a normally open contact of this relay, will also drop out.

The complete line diagram for the phase failure relay is shown in Figure 11. Here, PTR is the secondary voltage coil shown previously in Figure 5; PR is the coil of the D.C. sensing relay.

The function of the Bulletin 812 Style F is then as follows: Closing start button energizes the pickup circuit from Line 1, through the normally closed RC contact to the bridge rectifier, through resistor R_2 to Line 2. The output of the rectifier causes PR to pick up.

The normally open contact of PR then energizes the motor starter coil M, M picks up RC, which holds itself in by means of its own normally open contact. The normally closed contact of RC is now open and the pickup circuit of PR is interrupted. If the motor currents are equal and symmetrical, PTR will deliver a voltage sufficient to hold PR until the stop button is pressed, and the entire control circuit becomes de-energized. If a phase failure occurs, PTR does not deliver enough voltage to hold PR, and M is dropped out. Notice, however, that RC will stay closed until the stop button is actuated and the control circuit is therby reset.



1, 2, 3-Current Coils
4-Common Voltage Coil
5-Resonant Circuit
6-Time Delay Circuit
7-Rectifier
8-DC Relay Coil

Figure 9 — Basic Circuit

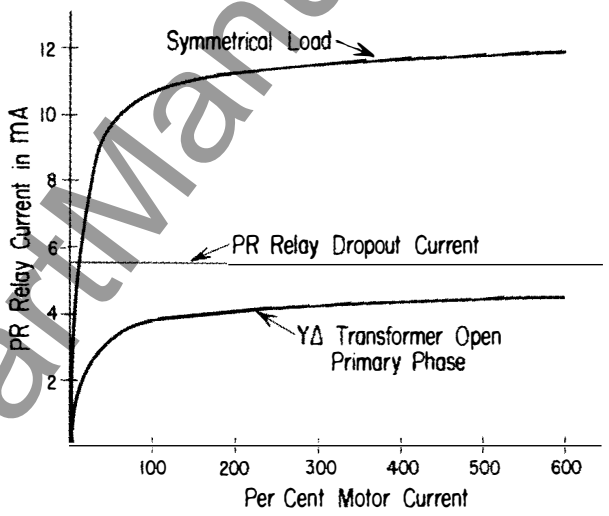


Figure 10 — Current at PR Relay Coil

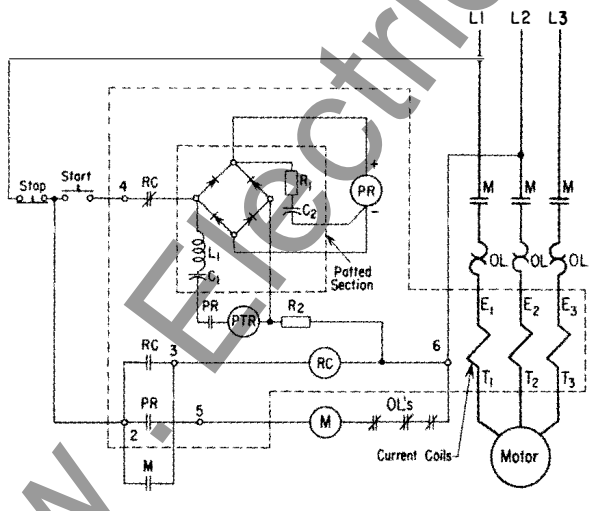


Figure 11
Style F Phase Failure Relay connected to a Bulletin 709 automatic full voltage starter. Circuit shown has three wire control.

STYLE R — PHASE REVERSAL RELAY

Phase reversal or incorrect phase sequence in a three phase circuit exists after connections for two of the three lines have been transposed. As a result of unwanted phase reversal, the motor or motors in the circuit rotate in the wrong direction. This frequently causes damage to connected machinery and the materials being handled, and endangers nearby personnel.

The Bulletin 812 Style R relay provides much-needed protection by inhibiting motor operation.

DESCRIPTION — The basic components of the Bulletin 812 Style R phase reversal relay are a set of shunt coils, a pivoted copper disc and a snap action switch with a set of NO-NC contacts. The coils are connected to the three phase supply on the line side of the starter, while the contacts of the snap action switch are in series with the starter's coil.

The relay is energized and responsive to phase sequence conditions whenever the supply's main disconnecting means is closed. The coils in the relay are arranged so that currents flowing through them produce a

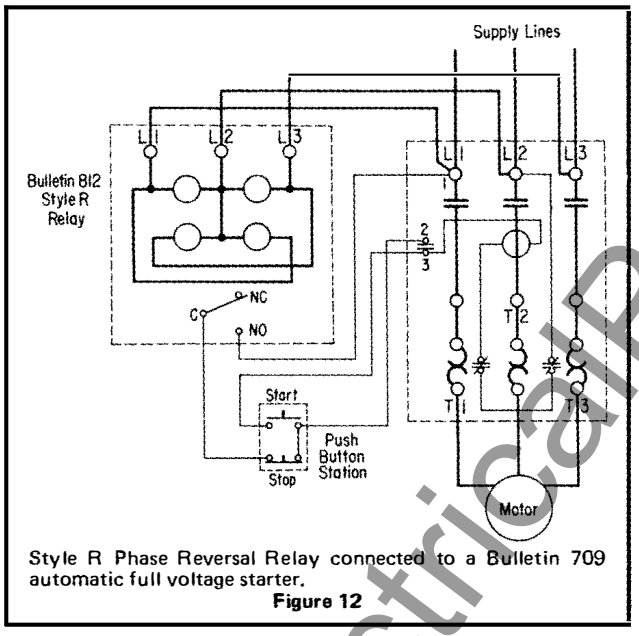
rotating magnetic field. This field induces eddy currents in the copper disc; the induced currents, in conjunction with the rotating magnetic field, produce a torque which causes the disc to rotate to its switch actuating position.

If the phase sequence is correct when the relay is energized, the disc rotates clockwise to the "On" position, closing the NO contact, which completes the starters coil circuit.

If phase sequence is incorrect, the magnetic field set up by the relay coils will rotate in a counter-clockwise direction and produce a torque on the disc in that direction. Since the disc must rotate in a clockwise direction to close the NO contact, the latter will remain open, and the starter will not pick up. A mechanical stop prevents the disc from rotating in a counter-clockwise direction from the "Off" or normal position.

Should a phase reversal occur while the motor is running, the disc will immediately be turned back to the "Off" position, opening the NO contact. This disrupts the starter's coil circuit and disconnects the motor from the line.

The complete line diagram for the phase reversal relay is shown in Figure 12.



Style R Phase Reversal Relay connected to a Bulletin 709 automatic full voltage starter.

Figure 12

The switch's NC contact can be connected so that it will energize a pilot light, contactor or other emergency device when a phase reversal occurs. If the application calls for additional auxiliary contacts, a second snap action switch can be provided as an accessory.

The Style R relay is designed primarily for phase reversal protection, but it also provides limited phase failure protection. Should a phase open while the motor is at a standstill, the relay is designed to open the starter's coil circuit and thus prevent the motor from starting. However, if the phase failure occurs while the motor is running, the relay will not disconnect the motor at once, but will open the starter coil circuit as soon as the motor has been stopped after it has completed its intended cycle of operation. This feature is particularly valuable in elevator service, where, upon loss of a phase, the car will not suddenly stop between floors but will continue to the next stop and there be rendered inoperative.

The Style R relay can be furnished with coils for 120, 208/240, 480 or 600 volts, 60 Hertz operation and for 110, 220, 380/440 or 550 volts, 50 Hertz operation. The Style R relay can also be utilized in circuits having a potential higher than 600 volts by incorporating an appropriate three-phase step-down transformer.

APPLICATION – In general, the Style R relay should be used on all 3 phase devices where **unexpected** reversal could cause danger to personnel or damage to equipment or goods in process, and in those situations where limited phase failure protection is desired (see explanation above).

Typical applications include elevators, cranes, hoists, compressors, pumps, separately excited MG sets, ventilators, grinders - lathes, etc.

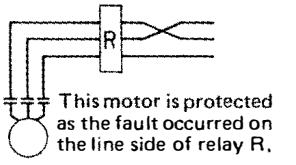
CAPABILITIES – The Style R relay provides phase reversal protection for an individual motor or an entire system, whenever a reversal occurs on the line side of the Style R relay.

It provides **limited phase failure protection** when used with magnetic motor starters, in that **the starter will not operate if the failure occurs during a shutdown period.** The motor will continue to run in a single phase condition if failure occurs during running, but can not be restarted if once stopped.

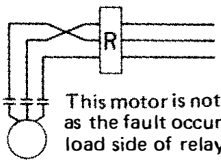
LIMITATIONS – It detects phase reversal only on the line side of the relay (see diagrams below).

On manual starters with magnetic lock-in, reversal protection is provided only during the running period, there is no protection during the start period. There is no phase failure protection on this type of starter, and all protection is eliminated if the operator holds the handle in the run position.

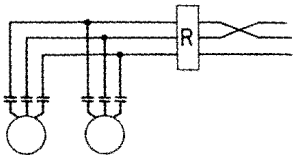
No protection can be provided for motors when manual starters with mechanical hold-in are used.



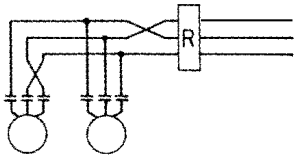
This motor is protected as the fault occurred on the line side of relay R.



This motor is not protected as the fault occurred on the load side of relay R.



Motors are protected if fault occurs here.



Motors not protected from these faults.

STYLE RF — PHASE REVERSAL AND FAILURE RELAY

The Bulletin 812 Style RF relay provides protection against both phase reversal and phase failure. This relay simply consists of a Style R phase reversal unit and a Style F phase failure unit mounted in a single enclosure. The two component units have the same capabilities, limitations and features as the individual Style R and F relays described in preceding sections; this must be borne in mind when applying Bulletin 812 Style RF relay.

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The consequence of a phase reversal will be a change in the direction of rotation of the machine with possible mechanical damage to the connected drive or bodily injury to workmen. The results of an undetected phase failure are not so easily predicted, since they depend, to a great extent, upon the associated motor control and, unfortunately, upon which line is lost in the case of primary phase failure. For example, if the motor in question forms a part of a drive which is expected to reverse periodically under the direction of limit switches, any loss of phase on either side of the transformer will result in malfunctioning. This is true since a three-phase motor continues to run on single phase, acting as a phase balancer but is completely insensitive to a reversal of phase sequence while so operating. If the loss of phase occurs on the transformer secondary, the rise in line current (to about $\sqrt{3}$ X the normal 3 phase current) will eventually trip the overload relays, but this may not occur in time to avoid the mechanical complications mentioned above.

OPERATION – The Bulletin 812 Style F phase relay consists, as shown in Figure 5, of three identical current transformers, whose primary coils are in series with the motor, or other load, to be protected. The three magnetic cores of square loop material are so dimensioned that the minimum current of the lowest horsepower motor for a given size will produce sufficient magnetomotive force for saturation of the core at about 30 electrical degrees. Each primary coil surrounds one leg of each core, whereas the remaining legs are surrounded by one common secondary coil, although magnetically separated. Each flux induces in the common voltage coil a voltage, the half-cycle-time-integral of which is essentially constant.

Under three phase symmetrical load conditions we get, as shown in Figure 6, two voltage pulses in opposite direction per cycle for each phase, which add up to an output waveform of basically three times line frequency. In Figure 7 (one motor line interrupted), fluxes are obtained in exactly opposite phase positions and consequently, the induced voltage is zero. In Figure 8 (one primary line of Y-Δ transformer is open), the combined fluxes result in a voltage having an average value approximately 1/3 of that developed under three phase symmetrical conditions.

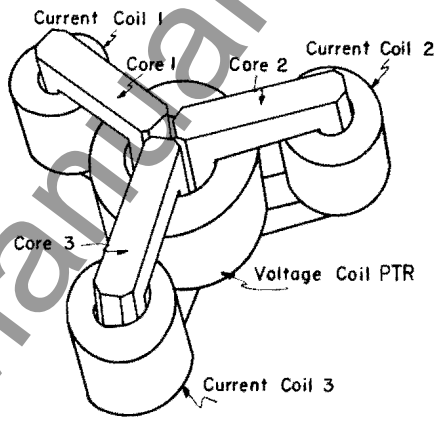

Figure 5

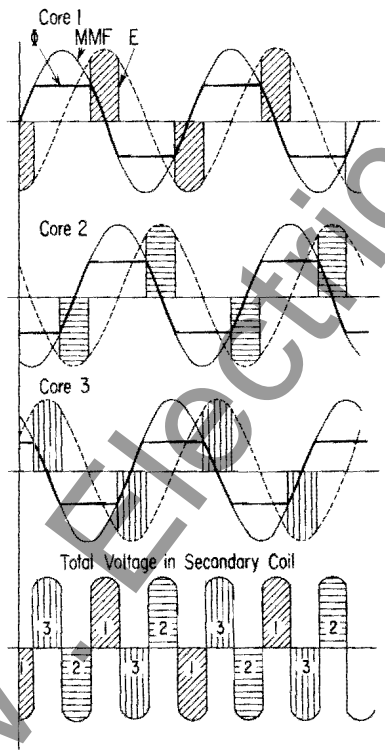

Figure 6
Symmetrical Load Conditions

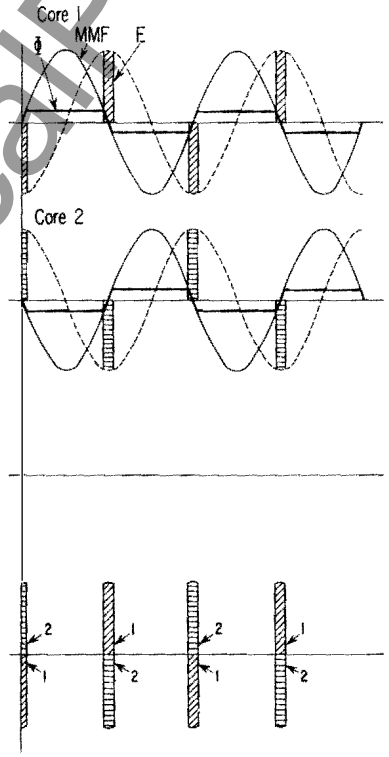

Figure 7
One Motor Line Interrupted

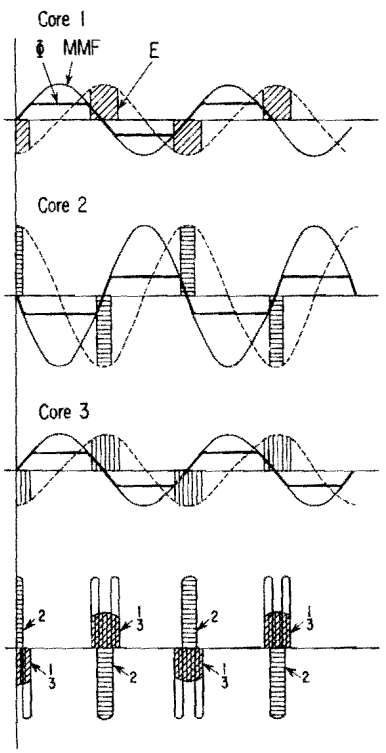

Figure 8
One Transformer Primary Phase Open