INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

Type HZ-3 Impedance Relay

CAUTION Before putting protective relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The type HZ-3 relay is a three unit non-directional, high-speed relay with impedance units of the balanced-beam type. The relay is used to supplement slow-speed relays on radial circuits. As applied to these circuits, the relay is used for phase fault protection over 80 to 90% of the line section, with the existing slow-speed relays protecting the remaining 20 to 10% and providing back-up protection.

CONSTRUCTION

The type HZ-3 relay contains three identical instantaneous impedance units, a contactor switch, and three operation indicators. The units are constructed as follows:

Impedance Unit

Construction details of this unit are shown in Fig. 1. A balanced beam is pulled downward on the contact end by a current coil and on the other end by two voltage coils. The fluxes of these two potential coils are shifted out of phase with respect to each other to produce a steady pull. A tap screw on the front of the unit permits changing the number of turns on the current coil, and a core screw on the bottom of the unit changes an air gap in the magnetic path. These two adjustments make it possible to set the units.

A rectangular silver contact is flexibly fastened on the forward end of the beam. As the beam trips, the contact bridges two silver stationary hemispherical contacts mounted on the free end of a short leaf spring. A small set screw determines the position of the leaf spring and provides means for adjusting the contact gap.

Contactor Switch

This is a small solenoid type d-c switch. A cylindrical plunger with a silver disc mounted on its lower end moves in the core of the solenoid. As the plunger travels upward the disc bridges three silver stationary contacts.

Operation Indicator

The operation indicator is a small solenoid coil connected in the trip circuit. When the coil is energized, a spring restrained armature releases the white target which falls by gravity to show the completion of the trip circuit. The high speed action of the indicator is obtained by fastening a weight through a leaf spring to the armature. The added inertia causes the armature to continue its motion after the coil has been short-circuited. The indicator is reset from outside the case by a push rod.

OPERATION

The relay measures the impedance of the line to which it is connected by measuring the ratio of the current and voltage supplied to it. The relay is connected to receive a current and voltage proportional to those existing on the high-tension line. With a fault in the zone of the relay, a given amount of current, I, will flow from the relay location to the fault. With zero voltage existing at the fault, the voltage at the relay must be equal to the drop in the line due to the current, I, or equal to IZ where Z is the impedance to neutral of the line from the relay to the point of fault. The ratio of the two values is $IZ/I = Z$. Thus, the ratio is constant for any value of current as the voltage on the relay is equal to the current times the line impedance. Therefore, if the impedance unit is adjusted by the core screw and taps on the current coil for a value of current such that the pull of the current coil is just equal to the potential restraint for a fault at 80 to 90% of the line section,

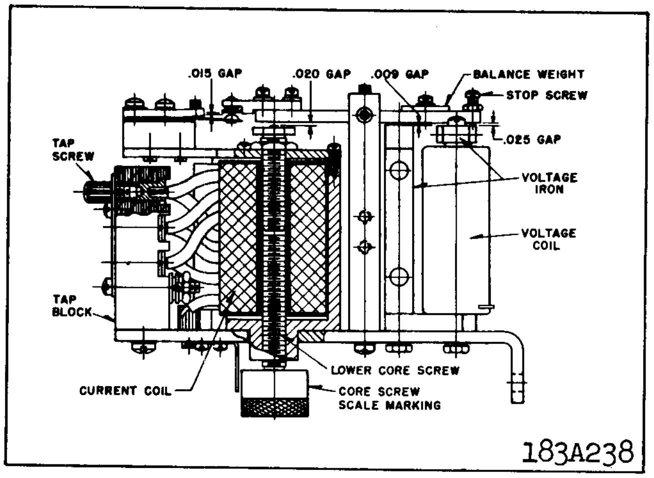

Fig. 1. Sectional View of the Impedance Units.

the beam will be balanced for a fault at that point for any value of current. Now, if the fault occurs beyond this balance point, the beam will not trip as the voltage pull is the greater because of a larger amount of impedance and correspondingly larger potential restraint than for which the beam is balanced.

The trip circuit consists of the three impedance unit contacts and the three operation indicator coils in parallel, and this combination in series with the contactor switch coil. When the relay contacts close, the coil is energized and its contacts short around the relay contacts, relieving them of the duty of carrying the breaker tripping current. These contacts remain closed until the trip circuit is opened by a breaker auxiliary switch. The operation indicators show a white target to indicate which of the three impedance unit contacts close to complete the trip circuit.

CHARACTERISTICS

The relay is available in two impedance ranges: 0.6 to 6.0 ohms and 0.2 to 2.0 ohms. The difference in the two ranges is in the current coils of the impedance unit and the corresponding tap markings. The tap and scale markings are as follows:

0.6 to 6.0 Ohm Relay

Taps – 6.2, 9.4, 13.5, 20.8, 29.8, 45

Core Screw Marking – .8, .9, 1.0, 1.1, 1.2, 1.3, 1.4

0.2 to 2.0 Ohm Relay

Taps – 2, 3, 4, 6, 9, 13

Core Screw Marking – .8, .9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.6

SETTINGS

The type HZ-3 relay requires a setting for each of the three impedance units. The following nomenclature will be used:

Z = the line-to-neutral ohmic impedance of the protected line from the relay to the 80 or 90% balance point.

R_C = The current transformer ratio.

R_V = The potential transformer ratio.

T = The impedance unit current tap value.

S = The impedance unit current core screw value. The values appear as a series of dots on the drum of the lower core screw adjusting knob.

Since the impedance of the voltage circuit of the relay is the same at all times, the balance point of the unit is adjusted by changing the pull on the current coil. This is done by taps (T) on the current coil winding, and by the core screw (S) which varies the magnetic air gap for the current flux.

For phase fault protection using line-to-line voltage and delta current, or for ground fault protection using line-to-neutral voltage and star current, use the following formula to determine the relay setting:

$$TS = \frac{10Z\,R_C}{R_V} \qquad (1)$$

For phase fault protection using line-to-line voltage and star current, use:

$$TS = \frac{17.3Z\,R_C}{R_V} \qquad (2)$$

The tap, T, is obtained by dividing the TS product by S to give an available tap number. When changing taps, the extra tap screw should be screwed in the desired tap before removing the existing tap screw to prevent open circuiting the current transformers.

The numbers on the core screw appear in ascending order as the core screw is screwed into the core. In some cases, a question of doubt may arise whether the scale setting is correct, or is out by one full turn of the core screw. In such a case, the point may be verified by turning the core screw all the way in. Then back out the core screw until the highest scale marking just comes under the end of the pointer.

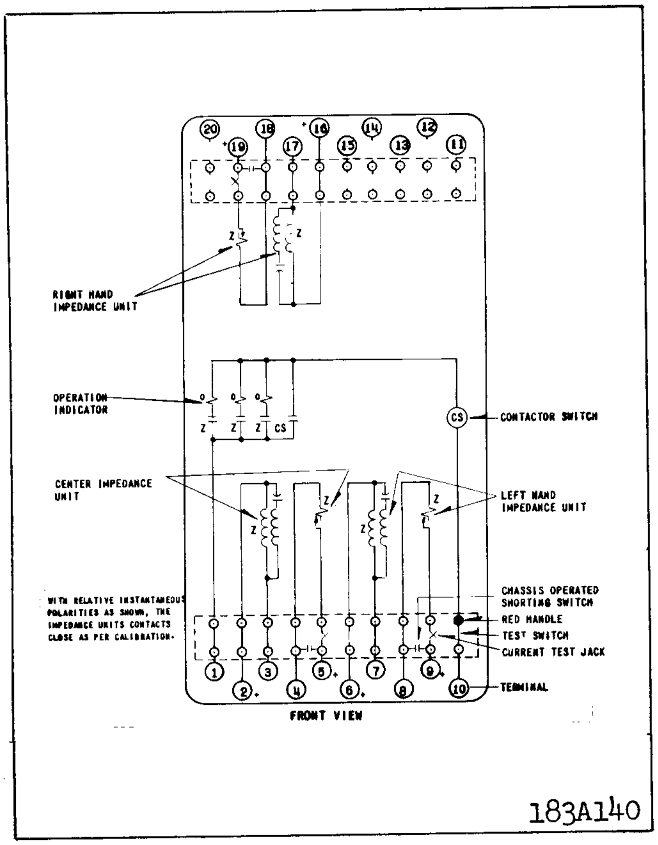

Fig. 2. Internal Schematic of the Type HZ-3 Relay in the Type FT32 Case.

This will occur in approximately one turn. To prevent such doubt it is recommended that the core screw setting be made by thus locating the highest scale marking and then continuing to back it off until the desired value appears exactly under the end of the pointer. Sufficiently accurate setting can be made by interpolating between the marked points when necessary.

The above formulas are based on the relay being used on a 60° line and are correct for lines of that angle. For lines other than 60° a slight error is introduced which may be as much as 8% and 6% on 40° and 80° lines, respectively. However, the formula relay setting can be corrected for lines other than 60° by using the curve of Fig. 5. The scale reading should be decreased so that the current to trip the beam at the line angle is equal to the current to trip on a 60° line.

The formulae settings are sufficiently accurate for most installations. Where it is desired to set the balance point more accurately the tap and scale values may be checked by applying to the relay the voltage, current, and phase angle conditions which will be impressed on it for a fault at the desired balance point. A slight change in the scale value from that calculated may be required.

As an example of the formula setting, set the impedance units to protect a 60°, 110 kv., 60 cycle line, 75 miles long. The line-to-neutral impedance is .75 ohm per mile. The current transformer ratio is 400/5, and the potential transformer ratio is 1000/1. Each unit is to protect 90% of the line section or for a balance point .90 x 75 x .75 = 50.6 ohms away. Then

$$TS = \frac{10 \times 50.6 \times 80}{1000} = 40.5$$

Set tap = 29.8 and core screw = 1.36 on a 0.6 to 6.0 ohm relay. Since the relay is a three-phase relay, the settings for the second and third units will be duplicate of the first as above.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information refer to I.L. 41-076.

CONNECTIONS

Impedance Unit

The impedance to the balance point is measured from the point where the potential transformers are connected.

In some applications a power transformer bank forms part of the transmission line, and potential transformers are available only on the bus side of the bank. In this case the relays may be set thru the bank to protect the line only if the bank impedance is not too large as compared with the line impedance.

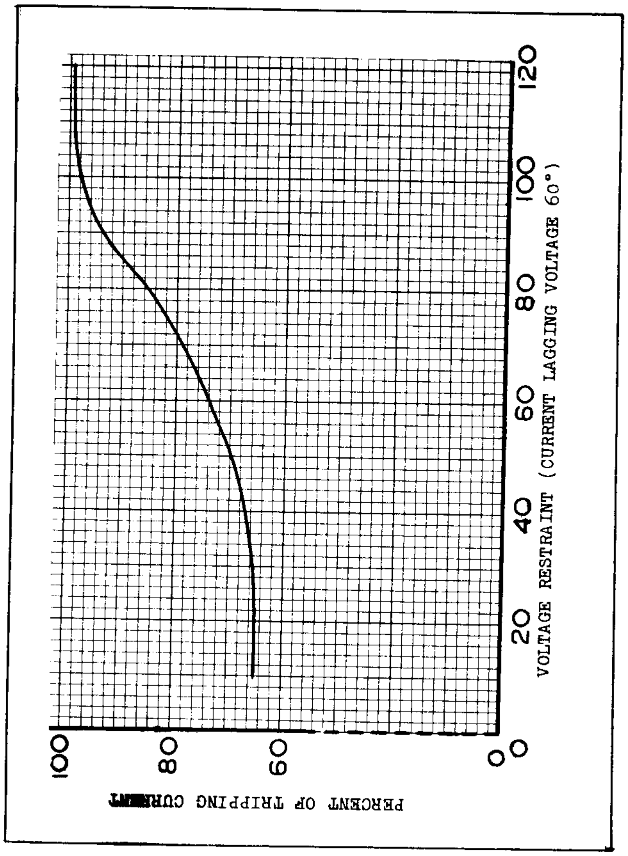

Fig. 4. Typical Reset Curves for all Three Units.

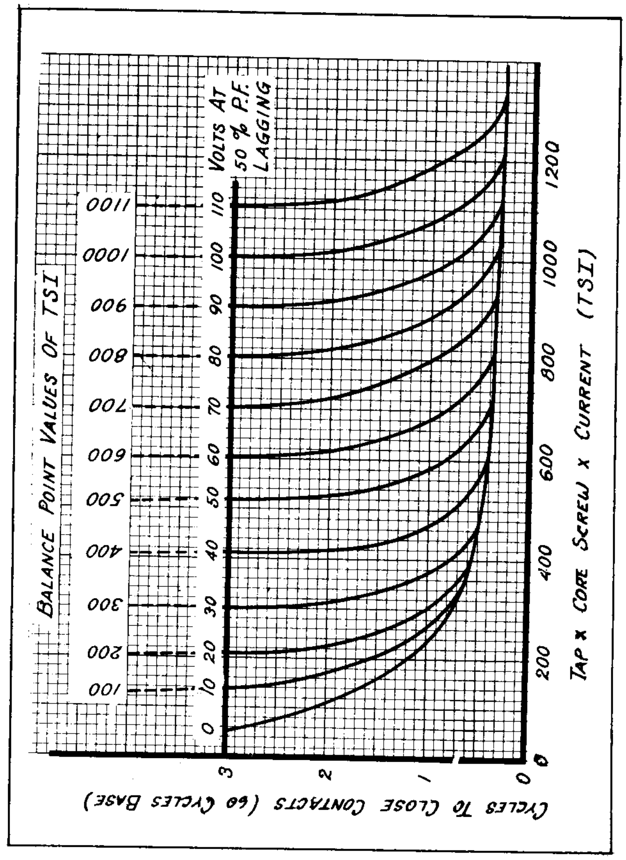

Fig. 6. Typical Time of Operation Curves for all Three Units.

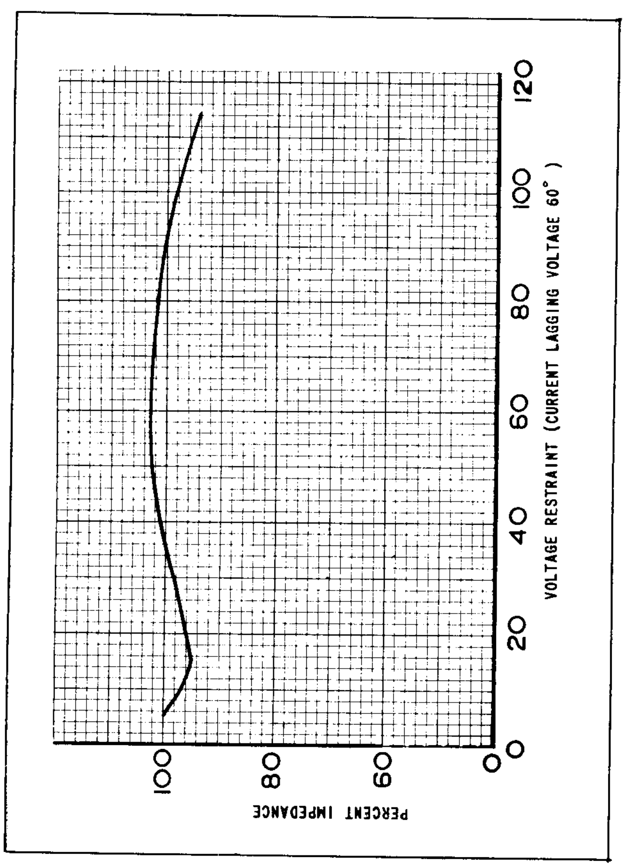

Fig. 3. Typical Impedance Curves for all Three Units.

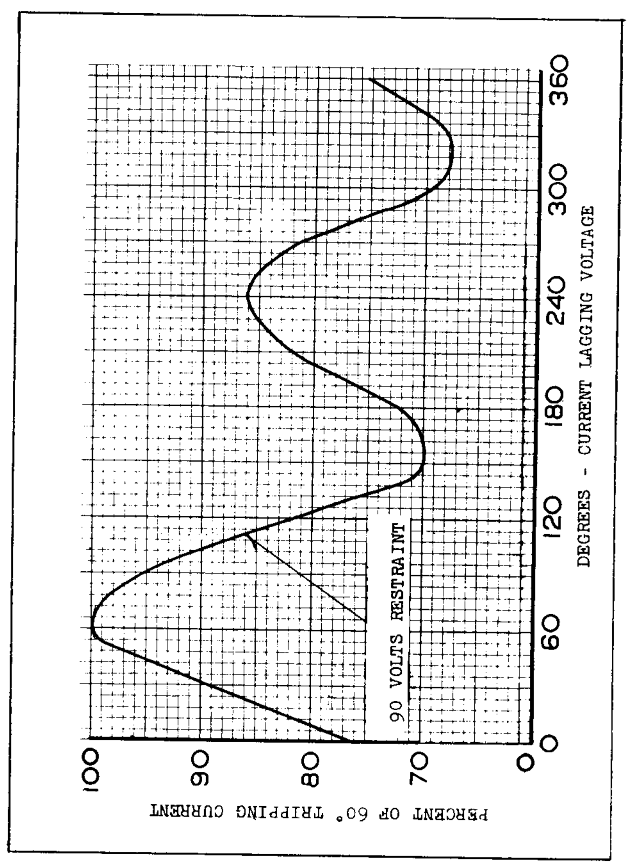

Fig. 5. Typical Phase Angle Curve for all Three Units.

If the bank impedance is too large in comparison with the line impedance, the 80 or 90% setting of the impedance element may cover only a very small percentage of the transmission line or in some cases not cover any of the line section. In order to use the potential transformers on the bus side of the bank under this condition, Type KX compensators are used and the impedance measured from the line side of the bank to the balance point. The type KX compensators (I.L. 41-861) operate from the current transformers and provide voltage compensation equivalent to the drop in the power bank.

The above discussion assumes that power is fed thru the bank to faults on the line. Where a power transformer connects to a high tension transmission line and does not supply power to a line fault, low-tension potential transformers may be used without compensation. Then, the impedance to the balance point is measured from the point where the potential transformers connect to the protected line.

The conventional star connection of current transformers is not as satisfactory as the delta connection where accurate distance relay protection is desired. With this connection, the balance point of the impedance unit shifts about 15% depending upon whether a phase-to-phase, a three phase or a double ground fault is involved. That is, if the balance point were adjusted at 80% for a three phase fault, then for a double ground fault the shift may be more or less than plus or minus 15% of the 80% setting, depending upon the relative magnitudes of the positive, negative and zero sequence impedance of the system from the source of power to the fault. This error can be entirely eliminated by making use of the vector difference between the line currents, (i.e. delta currents) for actuating the relay.

The most common method is to connect the main current transformers in star and use a set of auxiliary 5/5 ratio transformers to supply delta currents to impedance unit, as shown in Fig. 8. These auxiliary transformers need not be of very large volt-ampere capacity, as they supply only the impedance unit coils which are of very low burden.

Trip Circuit

The contactor switch operates on a minimum of 1.0 ampere, but the trip circuit should draw at least 4 or 5 amperes in order to reduce the time of the operation of the switch to a minimum and provide more positive operation. If the relay is used to trip an auxiliary multi-contact relay, provision should be made for loading down the trip circuit with a resistor in parallel with the operating coils of the auxiliary relay. Also, since the total trip circuit resistance in the relay is approximately 1.0 ohms, care must be taken to see that the breaker trip coil will receive enough current when low voltage control is used.

The main contacts on the impedance units will safely close 30 amperes at 250 volts d-c, and the switch contacts will safely carry this current long enough to trip the breaker.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer. If the adjustments have been changed, the relay taken apart for repairs, or if it is desired to check the adjustments at regular maintenance periods, the instructions below should be followed.

All contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

Impedance Unit

Refer to Fig. 1. Adjust the stop screw on the rear of the beam to give a clearance of .025 inch between the beam and the voltage iron circuit. With the beam in the reset position, i.e., with the stop screw against the stop, adjust the vertical gap for .009 inch between the adjustable iron and the beam. Also, with the beam in the same position adjust the gap between the front end of the beam and the stop in the upper core screw to .020 inch. The above values for the air gaps may be obtained by means of feeler gauges. It should be borne in mind, however, that the values given represent normal, or average values. The actual gaps on any particular relay may vary a few thousandths from these values.

The beam should be balanced as follows. Connect the relay with polarities as shown in the test diagram.

CAUTION: The relay voltage should be of good wave form. The combination of a phase shifter and autotransformer may give an output voltage of poor wave form if the magnetizing current of the autotransformer is high in proportion to the impedance of the phase shifter used. In case of doubt, check the output voltage wave form with an oscilloscope.

With any tap and scale setting, check the impedance measured by the relay with 35 volts potential restraint. Apply 5 volts restraint and adjust the balance weight on the beam until the beam just trips with 1/7 of the current required to trip with 35 volts restraint. In calibrating the first unit, the same current should be passed thru the second unit in the reverse direction thus simulating a phase-to-phase fault. In this way the small amount of electrical interference between units is calibrated out. Similarly, the third unit current coil should be energized in the reverse direction when calibrating the second unit, and the first unit current coil should be energized in the reverse direction when calibrating the third unit. In the factory adjustment, this is done at T = 20.8 and S = 1.4 for the 0.6 to 6.0 ohm relay, and at T = 13, S = 1.6 for the 0.2 to 2.0 ohm relay.

The stationary contacts should be adjusted to give .015 inch clearance between them and the silver bridge on the beam when the beam is in the reset position. The bridge should be made to touch both contacts simultaneously, and deflect the contact springs at least .010 inch before the beam strikes the bronze stop on the core screw.

It is difficult to adjust accurately the contacts by eye. A good method consists in first adjusting one of the contacts to the correct gap and then applying just sufficient current to trip the beam against a restraint of about 5 volts. While the beam is in this position, that is, lightly pressing on the one contact, the other contact should be slowly adjusted upward by means of the set screw until it just touches the silver bridge without lifting it off the other contact. The trip circuit should be energized so that the lighting of a lamp or the tripping of an auxiliary relay will show when both contacts are made.

Contactor Switch

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core of 1/64" when the switch is picked up. This can be done by turning the relay up-side-down or by disconnecting the switch and turning it up-side-down. Then screw up the core screw until the moving core starts rotating. Now, back off the core screw until the moving core stops rotating. This indicates the point where the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/32" by means of the two small nuts on either side of the Micarta disc. The switch should pick up at 1 ampere d-c. Test for sticking after 30 amperes d-c have been passes through the coil.

Operation Indicator

Adjust the indicator to operate at 1.0 ampere d-c gradually applied. Test for sticking after 30 amperes d-c is passed thru the coil. Adjustments may be made by loosening the two screws on the under side of the assembly, and moving the bracket forward or backward. Also, the amount of over-hand of the armature on the latch may be adjusted by means of the small screw bearing on the flat spring carrying the inertia weight. The best adjustment will usually be found when this screw just touches the flat spring with the armature in the reset position. If the two helical springs which reset the armature are replaced with new springs, they should be weakened slightly by stretching just beyond their elastic limit.

Calibration of Impedance Units

The current required to operate the impedance units against any given voltage is obtained from the equation:

$$TS = \frac{10\,E}{I} \qquad (3)$$

where T is the current tap and S is the setting of the calibrated core screw, E and I are the voltage and current respectively applied to the relay. Thus, if the setting is T = 20.8, S = 1.4 and the voltage is 35 volts, then the current required at 60° lagging is:

$$I = \frac{10\,E}{TS} = \frac{10 \times 35}{20.8 \times 1.4} = 12 \text{ amperes}$$

When checking the calibration, it is essential that the polarity as shown in the internal schematic be used, otherwise an error will be introduced.

The variation of tripping current for a given voltage as the phase angle between current and voltage is varied as shown in Fig. 5. To make sure that the relay is operating at 60° lag and not 240°, the current leads can be reversed and the beam should operate on a smaller current if the connections were originally correct.

The general shape of the impedance curve for different ohm settings is shown in Fig. 3. These curves are obtained by tripping the beam against different voltages for a constant T and S setting and then plotting the ratio E/I in percent of the 35 volt calibrating impedance against the voltage. The lower voltage points (5 to 15 volts) are considerably affected by the mechanical balance of the beam, while the higher points are but little influenced.

Accurate time tests on the instantaneous unit can only be taken with the aid of an oscillograph or high-speed timer. The time of operation in cycles (60 cycle per second basis) of the impedance element for various balance points is given in Fig. 6. By using these curves the operating speed can be determined for any value of the current or voltage applied to the unit.

CAUTION: Make certain that the stops on the rear and front of the beam are absolutely clean, otherwise the impedance at which the beam trips may be effected, particularly at low voltages. The stop can be easily cleaned by drawing a piece of clean white paper between the beam and the stop while the beam is firmly pressed down.

Also, when checking the impedance unit at low voltage, observe the tripping of the beam instead of an indication in the trip circuit. This will prevent an error in the contact adjustment which might otherwise affect the beam calibration.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

ENERGY REQUIREMENTS

The 60 cycle burden of the various circuits of this relay are as follows:

POTENTIAL CIRCUITS AT 120 VOLTS

Circuit	V.A.	P.F. Angle
Impedance Unit (each)	2.2	20° lag

CURRENT CIRCUITS

	Tap	Amps	V.A.	P.F. Angle
Impedance Unit	45	8.66	6	42°
	13.5	8.66	1.3	22°
Auxiliary Star-Delta C.T. S#879127 5Y/8.66Δ See I.L. 41-486		5	3.5	10°

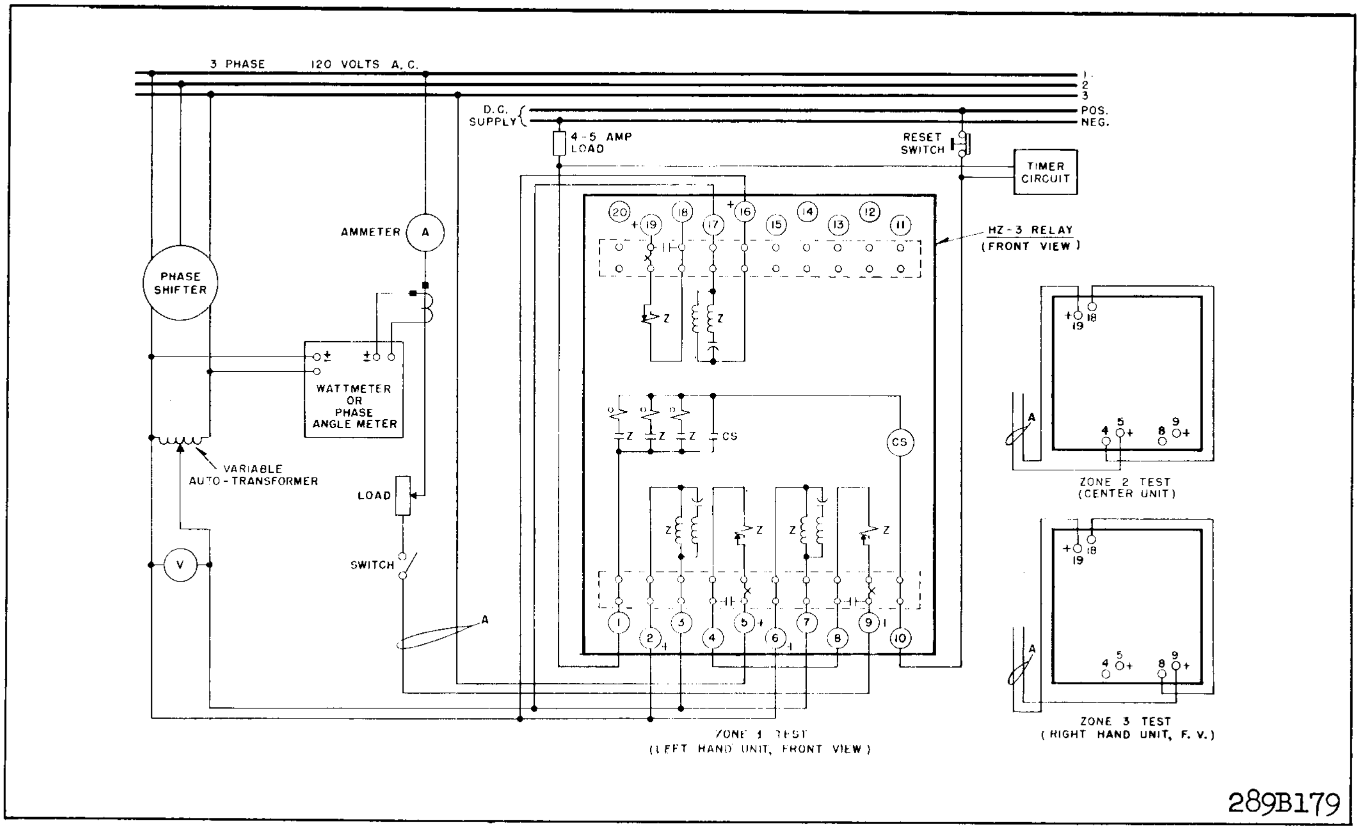

Fig. 7. Diagram of Test Connections for the Type HZ-3 Relay.

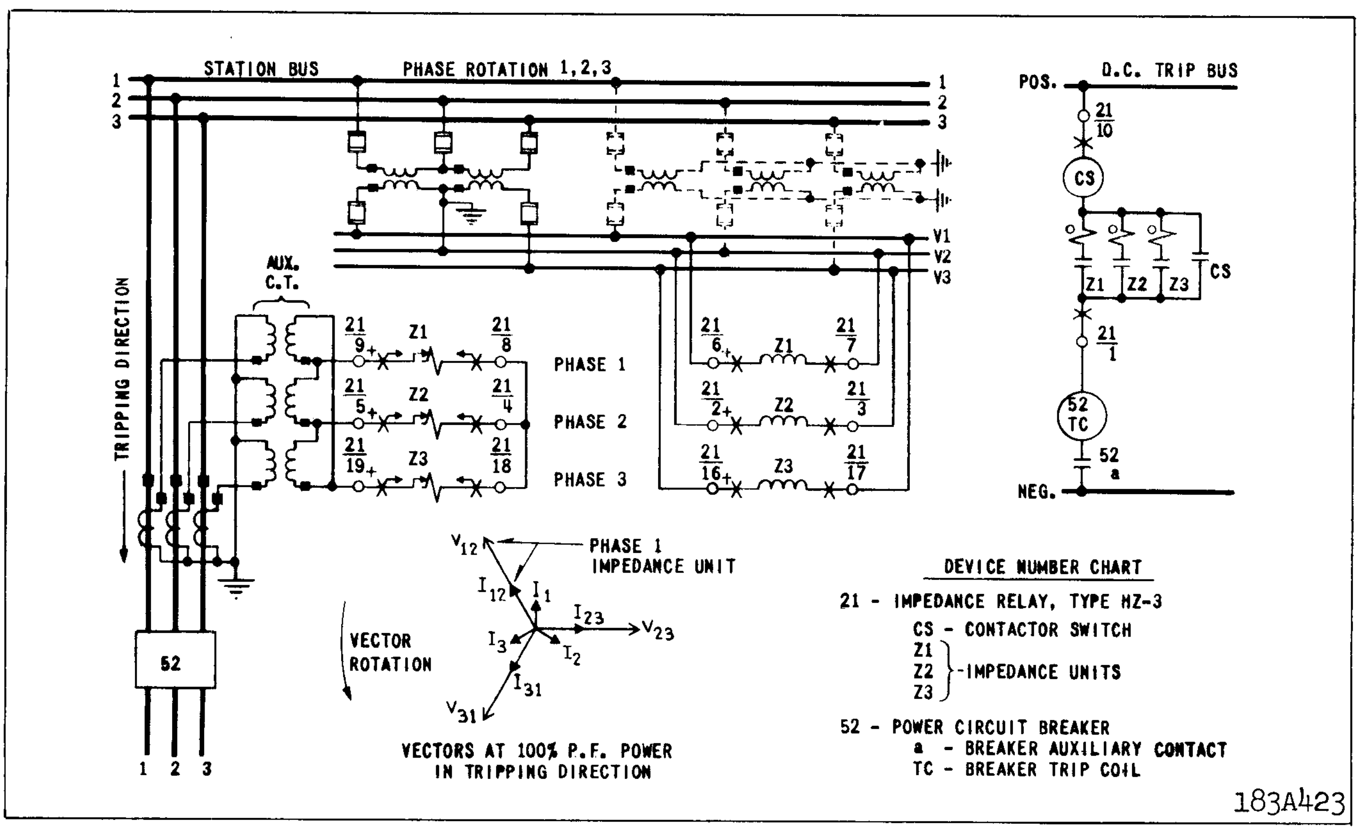

Fig. 8. External Schematic of Type HZ-3 Relay for Phase Protection.

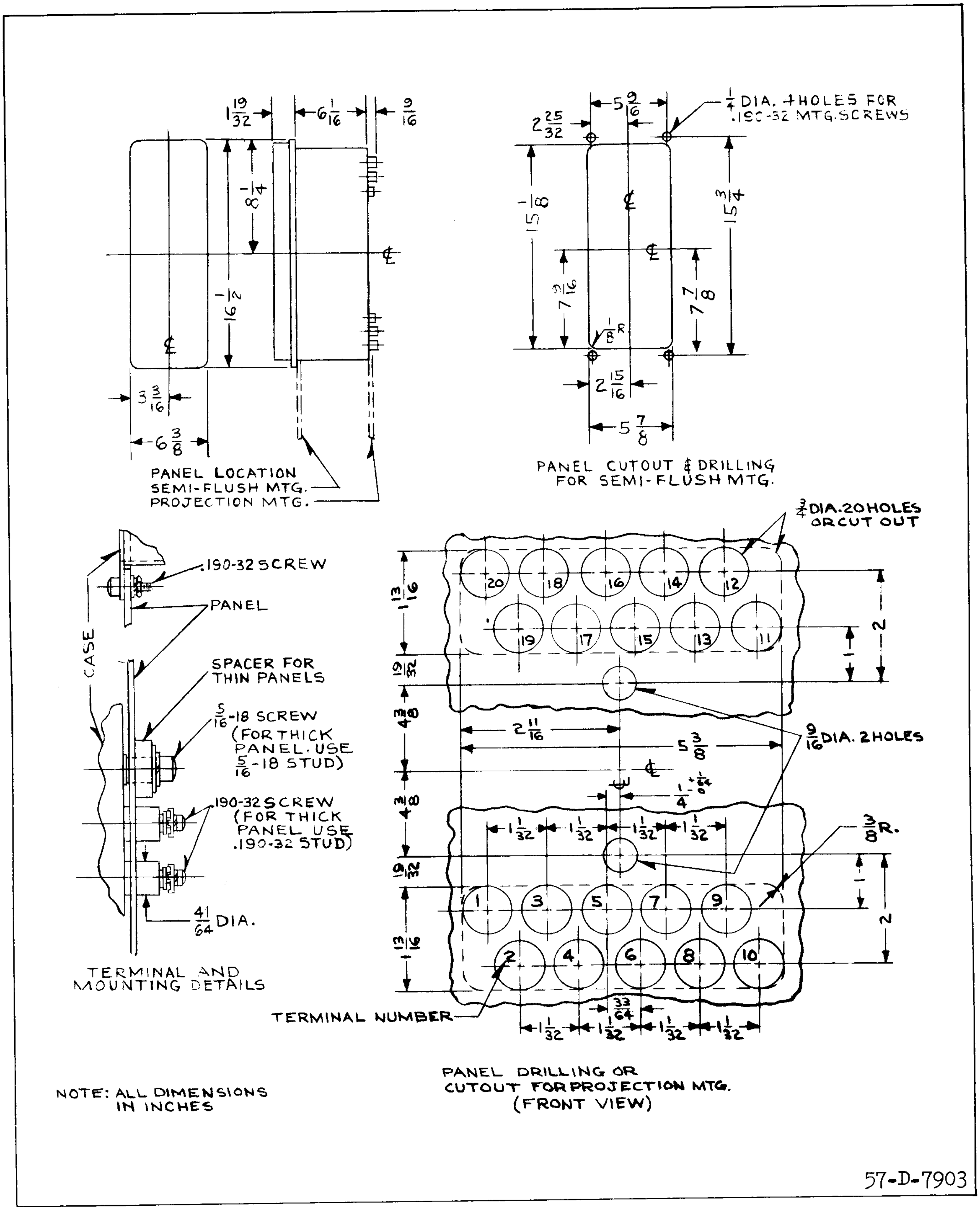

Fig. 9. Outline and Drilling Plan of the Type HZ-3 Relay in the Type FT32 Case.

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