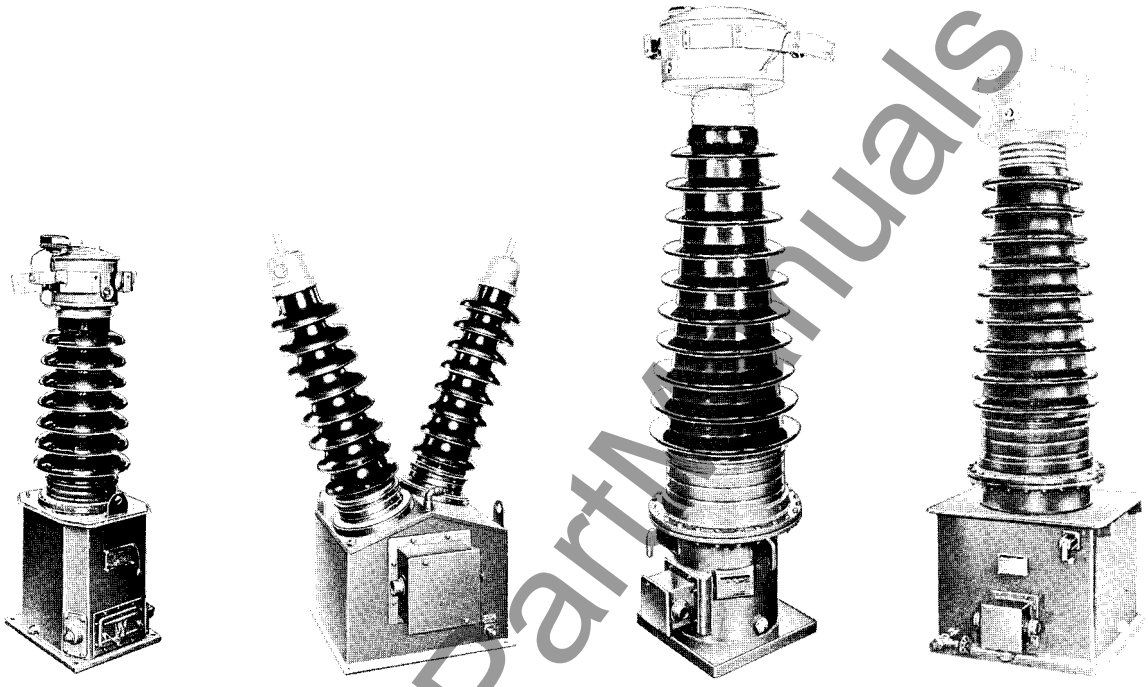
Instructions for Type APT Potential Transformers and Type ACT, OCT Current Transformers

I.L. 44-067-15



TYPE OCT 69 *TYPE APT 350* *TYPE ACT 650* *TYPE APT 550*

FIG. 1. Various Types of Oil-Immersed Instrument Transformers

Instrument transformers in general, although they are precision devices and should be carefully handled, are actually of rugged construction and generally simple and foolproof. Usually no special instruction besides what is given on the Instruction Plate is necessary for their operation. A review of the Catalog Section and the Instruction Plate, as well as the data given in this leaflet, is suggested. Also, see Technical Data 44-060.

RECEIVING

Instrument transformers when shipped have been thoroughly tested for defects. When received by the customer, they should be carefully examined before they are accepted from the carrier. If any damage is evident, a claim should be filed with the transportation company and the manufacturer should be notified at once.

HANDLING

Instrument transformers are usually of very rugged construction, but they may be damaged by rough handling.

When oil-immersed instrument transformers cannot be moved by a crane, they may be skidded or moved on rollers, but care should be taken not to damage the tank base nor to tip them over. Oil-immersed instrument transformers should not be lifted or moved by means of a jack or pry under the drain valve, and no mechanical force should be applied to the leads or bushings.

In cases where the transformer center of gravity is relatively high, a lifting cable guide is supplied to prevent accidental tipping over when lifting the transformer. In these cases it is not advisable to move the transformer on rollers or by skidding.

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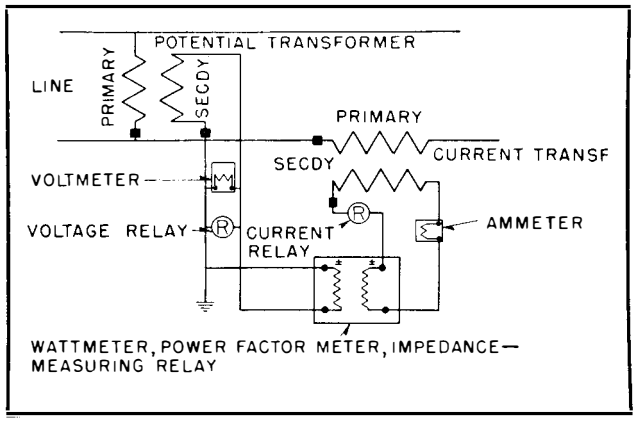

FIG. 2. Connection of Current and Potential Transformers in a Simple Single-Phase Circuit

Avoid acute tilting prior to installation as the air above the oil level in the expansion caps may be forced into the case. When excessive tilting is necessary remove the filling plugs at the top of the primary bushings and fill the expansion caps completely full of clean dry oil. The excess oil can be drained out later to restore the proper oil level.

Before shipment, the transformer is filled with oil to the proper level and sealed pressure tight. Occasionally the oil gauge may indicate high or low oil level due to the temperature at the time. However, in the case of a two bushing APT, the oil level may not be equal in both bushings. This condition can be caused by tilting or severe shipping shocks and is corrected by removing both filling plugs which will equalize the oil level. Replace the plugs and reseal using thread cement such as Westinghouse M#6707-3.

INSTALLATION

Before instrument transformers are installed they should be carefully inspected for breakage, damage that may be responsible for oil leakage, misplacement of parts during shipment or storage, and carefully examined for moisture. All accessible bolts, nuts and studs should be tight. Instrument transformers should be installed on solid supports, and all connections should be made so that no mechanical stress is put on the leads or terminals of the transformers.

Instrument transformers are designed for accurate metering, relaying, and control device applications. They are mounted in pressure tight fabricated steel cases, with cover mounted bushings and are suitable for outdoor service. All current transformers have series-parallel primary windings to provide for double current ratios. When shipped from the factory, they are connected for the higher current rating unless otherwise specified. Secondary leads terminate in clamp or stud type connectors located in a weatherproof junction box suitable for conduit connection.

OPERATION

The Insulating Function of High Voltage Instrument Transformers. The primary reason for use of high voltage instrument transformers is the necessity of insulating instruments and relays from the line voltage. The conventional connection is shown in Fig. 2.

More complicated arrangements are used in three-phase or differential circuits. The secondary circuit must always be grounded because while the secondary circuit and the transformer tank are insulated from the high voltage, they are coupled to it electrostatically as shown in Fig. 3.

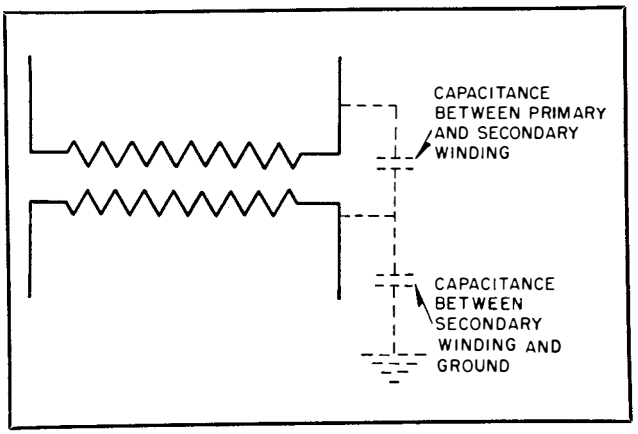

FIG. 3. Equivalent Circuit Showing Capacitance Effect

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The windings of the transformer may be thought of as plates of a capacitor. The electrostatic voltage from the secondary winding to ground will depend on the relative capacitances and may easily reach a dangerous and destructive value unless the secondary winding is connected to ground. **Therefore, the secondary circuit should always be grounded.** (See AIEE Application Guide for Grounding of Instrument Transformer Cores and Secondary Circuits).

Short-Circuit of Potential Transformers. Short-circuit of a potential transformer secondary is like short-circuit of any other transformer; it burns out in a very short time. Accidental short-circuits do occur, and the windings are designed to withstand the large mechanical forces which result, but they cannot be practically designed to carry the short-circuit current for much more than one second. **The secondary winding of a potential transformer should never be short circuited.**

Current Transformers with Open-Circuited Secondary.
Normally the secondary winding delivers a secondary current in correct ratio to the primary current into a burden never in excess of a few ohms, requiring only a low voltage at the secondary terminals. But, if the secondary circuit is opened, the impedance of the burden in effect becomes infinite, and the current transformer does its best to supply the corresponding infinite voltage. In other words, the entire primary current becomes exciting current for the iron core. Oil-immersed transformers generally can develop more than 5000 volts (crest value) which is both dangerous and destructive. **The secondary winding of a current transformer should never be open circuited.**

Insulation Structures, Processing, and Dielectric Losses.

Modern transformers usually have an insulation structure composed of paper, pressboard, and oil, so arranged that the mechanical and dielectrical strengths of each are used to best advantage. (See Technical Data 44-060).

These insulation structures are thoroughly dried under heat and vacuum to remove moisture, and impregnated with oil. The whole transformer is filled with oil under a vacuum to make sure that no air pockets or bubbles remain inside the insulation structure at any point.

The power factor of the majority of all Westinghouse oil-immersed instrument transformers above 25 kv class is now measured as a part of the routine test to detect excess moisture and other impurities in the insulation or oil. Certain impurities in the oil or in certain insulation parts may cause higher power factor but without reducing the insulation strength, and are not cause for rejection.

However, oil-immersed instrument transformers with a record of increased power factor (H to L + Grd.) from one check period to the next may need to be removed from service and revamped.

Insulation Classes, Tests, and Service Voltage.
Instrument transformers, as well as other kinds of transformers, are given "Insulation Class" ratings, as the ASA Standard C-57.11, Paragraph 11.030 states: "to indicate the dielectric tests which the apparatus is capable of withstanding."

In addition, the ASA Standards include tables indicating application of standard transformer ratings. Tables 13-11.410 and 13-22.110 are reproduced on pages 4 and 5 (in part, 25 kv and up).

The voltage ratings 24000/24000 Y etc., may need some explanation. This means that the line-to-line system voltage should not exceed 24000 volts whether the transformers are connected in delta, or if they are connected in wye. The 24000 volt transformer is not good for continuous operation with 24000 volts line to ground, because this is equivalent to a $24000\sqrt{3}$ or 41600 volt system. This same principle applies to all transformers in Group 2.

14400 for 25000 Grd. Y indicated in Group

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TABLE 13-11.410 (in Part)

NAMEPLATE MARKING					STANDARD DIELECTRIC TESTS			
						Standard Impulse Tests		
						Chopped Wave		Full Wave
Standard Insulation Class Kv	Standard Marked Ratio	Standard Primary Voltage Ratings Volts	Usual Circuit Voltage Volts	Permissible Transformer Connections	Standard Low Frequency Test Kv RMS	Crest Voltage Kv	Min. Time to FO Sec.	Kv Crest
GROUP 2—25 TO 345 KV, FULL INSULATION, WYE VOLTAGE LIMIT EQUALS DELTA VOLTAGE LIMIT								
25	200:1	24000/24000Y	24000	Delta or Wye	50	175	3.0	150
34.5	300:1	34500/34500Y	34500	Delta or Wye	70	230	3.0	200
46	400:1	46000/46000Y	46000	Delta or Wye	95	290	3.0	250
69	600:1	69000/69000Y	69000	Delta or Wye	140	400	3.0	350
92	800:1	92000/92000Y	92000	Delta or Wye	185	520	3.0	450
115	1000:1	115000/115000Y	115000	Delta or Wye	230	630	3.0	550
138	1200:1	138000/138000Y	138000	Delta or Wye	275	750	3.0	650
161	1400:1	161000/161000Y	161000	Delta or Wye	325	865	3.0	750
196	1700:1	196000/196000Y	196000	Delta or Wye	395	1035	3.0	900
230	2000:1	230000/230000Y	230000	Delta or Wye	460	1210	3.0	1050
287	2500:1	287000/287000Y	287000	Delta or Wye	575	1500	3.0	1300
345	3000:1	345000/345000Y	345000	Delta or Wye	690	1785	3.0	1550
GROUP 3—25 KV TO 345 KV, REDUCED INSULATION AT NEUTRAL END, FOR CONNECTION DIRECTLY TO GRD.								
25	120/200:1	14400 For 25000 Grd.Y	24000	Grd.Y only	50	175	3.0	150
34.5	175/300:1	20125 For 34500 Grd.Y	34500	Grd.Y only	70	230	3.0	200
46	240/400:1	27600 For 46000 Grd.Y	46000	Grd.Y only	95	290	3.0	250
69	350/600:1	40250 For 69000 Grd.Y	69000	Grd.Y only	140	400	3.0	350
92	480/800:1	55200 For 92000 Grd.Y	92000	Grd.Y only	185	520	3.0	450
115	600/1000:1	69000 For 115000 Grd.Y	115000	Grd.Y only	230	630	3.0	550
138	700/1200:1	80500 For 138000 Grd.Y	138000	Grd.Y only	275	750	3.0	650
161	800/1400:1	92000 For 161000 Grd.Y	161000	Grd.Y only	325	865	3.0	750
196	1000/1700:1	115000 For 196000 Grd.Y	196000	Grd.Y only	395	1035	3.0	900
230	1200/2000:1	138000 For 230000 Grd.Y	230000	Grd.Y only	460	1210	3.0	1050
287	1500/2500:1	172500 For 287000 Grd.Y	287000	Grd.Y only	575	1500	3.0	1300
345	1800/3000:1	207000 For 345000 Grd.Y	345000	Grd.Y only	690	1785	3.0	1550

3 means that the transformer is suitable for connection to a 25000 volt system, connected from line to ground only, but it may be used in this way on grounded or ungrounded systems. According to Paragraph 13-00.432, these transformers "shall be suitable for operation at 1.73 times rated line to ground voltage under emergency conditions without appreciable injury . . . . . ". The 120/200 to 1 ratio means that both ratios are available, for separate or simultaneous use, by means of a double secondary winding or by a tap in the secondary.

Potential transformers connected line to ground on an ungrounded system may be subjected to destructive voltage caused by the phenomenon called "ferro-resonance" or "neutral inversion". Neutral inversion and means for its control are discussed in Westinghouse Technical Data Section 44-060 and references in its Bibliography.

If one terminal of a transformer is connected to a line, but the other terminal left unconnected, the capacitive current into the winding may induce a rather high voltage.

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TABLE 13-22.110 (in Part)

STANDARD INSULATION CLASSES AND STANDARD DIELECTRIC TESTS FOR CURRENT TRANSFORMERS

Standard Insulation Class (Nameplate Rating)	Maximum Line-to-Line Voltage	STANDARD DIELECTRIC TESTS			
		Standard Low Frequency Tests	Standard Impulse Tests		
			Chopped Wave		Full Wave
			Crest Voltage	Minimum Time to Flashover	
Kv	Kv	Kv Rms	Kv Crest	Seconds	Kv Crest
25	25	50	175	3.0	150
34.5	34.5	70	230	3.0	200
46	46	95	290	3.0	250
69	69	140	400	3.0	350
92	92	185	520	3.0	450
115	115	230	630	3.0	550
138	138	275	750	3.0	650
161	161	325	865	3.0	750
196	196	395	1035	3.0	900
230	230	460	1210	3.0	1050
287	287	575	1500	3.0	1300
345	345	690	1785	3.0	1550

The secondary winding should be loaded with resistance to prevent the high induced voltage.

Operation With Rated Voltage to Ground During Line-to-Ground Faults.

Transformers are designed with the expectation that the system to which they are connected will be sufficiently well grounded to maintain the neutral at ground potential, with each line above ground at $1/\sqrt{3}$ of rated line-to-line voltage. No system is really ever totally isolated from ground. The so-called "ungrounded" system is actually connected to ground by the capacitance and leakage resistance of its lines to ground.

If a line becomes grounded, line-to-line voltage is applied from line to ground on the other two lines, and to the terminals of transformers connected to them. This will overstress the line bushings as well as the winding insulation; corona, with resulting radio interference and deterioration of insulation, may result. Continuous operation with one line grounded or partially grounded should not be contemplated.

Yet it is obvious that lines sometimes do become grounded, and transformers must be designed for emergency operation at line-to-line voltage applied from one terminal to ground. Operation under this condition should be contemplated for emergencies only with the knowledge that transformer insulation deterioration is being accelerated.

METERING UNITS

Metering units are complicated only in that they consist of two or more transformers in one tank. The individual transformers and their principles of connection and operation are not different from any other instrument transformers.

A diagram nameplate is mounted on all metering units to show the schematic connections between the primary windings of potential and current transformers and the connections to the terminals. This should be studied carefully. All secondary leads are brought out to the secondary terminal block so that they are available for any con-

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nection arrangement which may be desired. **Particular attention should be given to correct identification of secondary leads** as confusion of current and potential transformer leads can cause severe damage (see Short Circuit of Potential Transformers and Open Circuit of Current Transformers). The marking of the leads of the transformers are in accordance with the EEI Metermen's Handbook.

Primary Bushings.
Insulated primary coil leads are brought out through porcelain weather casings. These casings are mechanically supported by rolled-on flanges with synthetic silastic cushion gaskets between flange and porcelain. The bushing flanges are then welded or bolted to the case.

In all oil-immersed instrument transformers, the oil is common to both tank and bushings. All primary bushings terminate in an expansion cap with a liquid level gage. Should adjustment of the liquid level be necessary, remove filling plugs at the top of bushings, add clean dry oil to established normal liquid level and reseal the filling plugs with thread cement such as Westinghouse M#6707-3. The potential terminal at the top of the bushing is a standard ASA 1 1/8 inch, 12 thread terminal stud.

Changing Weather Casings on Types APT-ACT-OCT.
This is an involved operation requiring special procedure. For information contact nearest Westinghouse Office.

INSPECTION FOR DAMAGE

If there is reason to believe the transformer has been internally damaged by shipment or handling, it may be necessary to remove it from the tank for inspection. Care should be taken to put it back under oil within 8 hours if possible, especially in humid weather.

The transformer should be refilled under vacuum if the oil is drained for any reason, or if the core and coils are removed from the tank. (See following section on Maintenance.)

MAINTENANCE

Modern transformers are sealed to prevent entrance of moisture and oxidation of the oil. This eliminates the deterioration of the oil, and oil maintenance is usually unnecessary. A periodic check of the oil level is all that is usually necessary. In case of doubt as to whether a leak has occurred and moisture has entered, a measurement of oil strength and insulation power factor is desirable. (See I.B. 45-063-100 Insulating Oils for Electrical Apparatus).

Insulation power factor should be measured only after the transformer has been disconnected for several hours to permit it to attain a uniform temperature. The power factor (H to L + Grd.) corrected to 20°C. should be approximately 2% or lower.

If measurements indicate that moisture is entering the transformer, the first step is to find the leak and eliminate it; the second, to dry out the transformer. The means to be used depends on the type of transformer and the available equipment. Drying in a vacuum oven after draining the oil is the ideal method, and 24 hours at 90°-100°C. in vacuum (28 in. mercury, or better) will usually dry the transformer. If a vacuum oven is not available, application of vacuum to the tank for 48 hours after draining the oil, without any heat, will remove moisture which has entered recently. Other means can be suggested by the factory depending on circumstances. Heating at a temperature of 100°C. or more in air can cause sufficient chemical change in oil-impregnated insulation that the power factor may increase instead of decrease. After drying, the transformer should be refilled by applying a vacuum to one filling plug for at least 2 hours, then admitting oil through the drain valve or any other fitting. The oil should be admitted slowly to reduce foaming and the vacuum should be maintained for at least an hour after the transformer is full.

TAKING OIL SAMPLE

Notes on Oil Level and Pressure Variations.
These instrument transformers are sealed

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pressure tight. Therefore the internal pressure will vary with temperature. In cold weather the units are expected to be under negative pressure. For these reasons, before taking an oil sample it is important that the internal pressure be neutralized by opening the filling plug located above the oil level (very top of line bushing stud on potential transformers for 25 through 69 KV classes).

Potential transformers for 25 through 69 KV classes are filled almost completely with oil. Other oil immersed instrument transformers of types APT, OCT, and ACT have bushings which terminate in an expansion cap. In these types the oil level indicator follows temperature variations.

Refinishing Notes.

Any portion of the paint film damaged during shipment or installation should be repaired promptly. To repair, clean damaged portion by best means available, i.e., sandpaper, scraper, blasting, etc. If film is broken to the base metal, then apply a coat of primer, intermediate, and finish with the proper drying between coats. Surface scratches and mars can usually be repaired by application of the finish coat only. During the installation process, all exposed nuts and bolts should be given a finish coat of paint. The aerosol dispenser cans are ideal for this type of operation.

The life of transformer paint is not indefinite and, should, therefore, be maintained by periodic inspections, touch-ups and refinishing when necessary.

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Instructions for Oil-Filled Instrument Transformers

- **Types APT, LPT, MSV & PVT Voltage Transformers**
- **Type ACT Current Transformers**
- **Type MPT Metering Units**

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SAFETY PAGE

Keep this Instruction Book available to those responsible for the installation, maintenance, and operation of the transformer.

The installation, operation and maintenance of a transformer presents numerous potential unsafe conditions, including, but not limited to, the following:

- High pressures
- Lethal voltages
- Hazardous chemicals
- Moving machinery
- Heavy components

Specialized procedures and instructions are required and must be adhered to when working on such apparatus. Failure to follow instructions could result in severe personal injury, death, and/or product or property damage.

Additionally, all applicable safety procedures such as OSHA requirements, regional and local safety requirements, safe working practices, and good judgment must be used by personnel when installing, operating, and/or maintaining such equipment.

Safety, as defined in this instruction book, involves two conditions:

1. Personal injury or death

2. Product or property damage (includes damage to the transformer, other property, and reduced transformer life.)

Safety notations are intended to alert personnel of possible personal injury, death or property damage. They have been inserted in the instructional text prior to the step in which the condition is cited.

The safety notations are headed by one of three hazard intensity levels which are defined as follows:

DANGER – immediate hazard which will result in severe personal injury, death, or property damage.

WARNING – hazard or unsafe practice which could result in severe personal injury, death, or property damage.

CAUTION – hazard or unsafe practice which could result in minor personal injury, or property damage.

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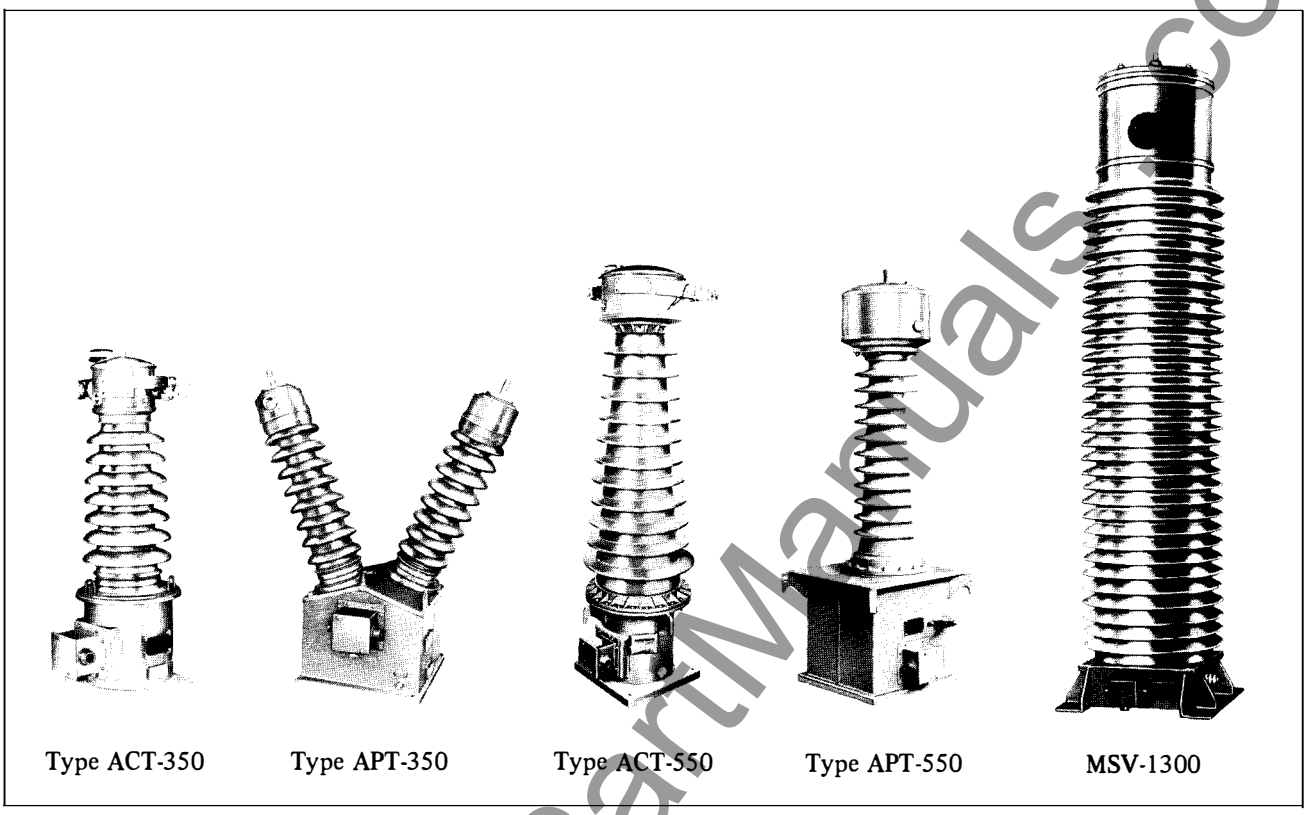

Fig. 1 *Various Types of Oil-Immersed Instrument Transformers*

This information gives procedures to be followed from the time a Westinghouse Oil Filled Instrument Transformer is received until it is energized. A review of the Instruction Plate, Warning Plates and the data given in this leaflet is recommended.

RECEIVING, HANDLING, STORAGE

Receiving. Instrument transformers have been throughly tested and inspected for defects before shipment. When received, they should be carefully examined before they are accepted from the carrier. If any damage is evident, a claim should be filed with the transportation company and reported to a Westinghouse representative.

Check List

1. Are there any indications of external damage?

2. Is the paint finish damaged?

3. Are all gauges, valves and fittings which were shipped attached still in place and undamaged?

4. Is there any evidence of liquid leakage?

5. Are any porcelains chipped or otherwise damaged?

Handling. Transformers will normally be shipped in an upright position filled with oil. Transformers must be handled in the normal upright position. High voltage units too high for upright shipment will be crated for horizontal shipment in nitrogen. When these units have been uprighted and uncrated they must be handled in the normal upright position.

Lifting hooks or eyes are provided for crane lifting. When the transformer is lifted, all hooks or eyes must be used. When oil filled instrument transformers cannot be moved by a crane, they may be skidded or moved on rollers, but care should be taken not to damage the tank base or to tip them over. They should not be lifted or moved by means of a jack, and no mechanical force should be applied to the leads on bushings.

In cases where the center of gravity is relatively high, a lifting cable guide should be used to prevent accidental tipping over when lifting the transformer. In these cases it is not advisable to move the transformer on rollers or by skidding.

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WARNING

Avoid acute tilting (greather than 20°) as the air above the oil in the expansion cap may be forced into the insulation structure. When excessive tilting is necessary remove the filling plugs at the top of the expansion cap and fill the expansion caps completely full of clean dry oil before replacing the filling plugs. The excess oil must be drained out immediately after the handling is completed to restore the proper oil level and prevent excessive pressure due to oil expansion. Failure to follow this procedure could cause danger to life and damage to property.

Storage. Transformers shipped in nitrogen that cannot be installed immediately may be stored temporarily in nitrogen for up to three months after date of arrival at the site.

A transformer stored in liquid can be made ready for service at any time by completing the installation steps providing it receives the same inspection and maintenance as a transformer in service.

TEMPORARY STORAGE (UP TO 3 MONTHS) IN NITROGEN

If the transformers cannot be installed immediately upon delivery, and oil filling is also impractical at that time, it is permissible to store the transformers in nitrogen for up to three months, after date of delivery at the site.

Storage in nitrogen requires positive assurance that the gas pressure is continuously maintained on the transformers. The best method of accomplishing this is by use of Inertaire® equipment. Temporary pipe connections can be made using the vacuum and oil filling connections in the cap at the top of HV bushing. The Electric Service Department can obtain, upon request, the necessary Inertaire equipment for proper storage.

The transformers must be placed on a solid, level, foundation in the storage area. Ground the tank and HV bushing of each unit.

The Inertaire equipment must be installed within one week after delivery. Following the installation and with a full cylinder of dry nitrogen, pressure test for four hours at six PSIG. Check for and stop all leaks in the system. After pressure testing, reduce the pressure to three PSIG. A positive nitrogen pressure must be maintained at all times.

Transformer gas pressure and cylinder pressure should be recorded every day for the first two weeks. These readings should preferably be taken at approximately the same time every day and the time and temperature noted on the log. After two weeks of daily logging with stable conditions, the frequency of pressure readings may be reduced to once a week. *An accurate log is important,* as it may be the determining factor in any decisions that may have to be made on additional drying of the insulation. Follow all instructions for the particular Inertaire equipment used or information provided by the Engineering and Service Department. Transformers *should not* be stored for *more than three months* without being filled with oil.

To place the units in service, the same procedure must be followed as though the transformers had just been received. When vacuum filling with oil, the length of the vacuum period prior to oil filling, specified on page 10 shall be increased to six hours instead of four hours, and the post filling or tail vacuum be increased to two hours.

Storage in Oil. If the transformers are to be stored for more than three months they must be filled to the proper level with oil. Prior to storage, the oil filling procedures specified must be followed.

INSTALLATION

Before instrument transformers are installed, they should be carefully inspected for breakage or damage during storage that may be responsible for oil leakage. Low oil level or evidence of leakage must be corrected. All accessible bolts, nuts and studs should be tight. They should be installed on solid supports, and all connections should be made so that no mechanical stress is put on the leads or terminals of the transformer.

Grounding of Secondary Circuit and Tank

Although the secondary circuit and the transformer tank are insulated from the high voltage,

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they are coupled to it electrostatically. The windings of the transformer may be thought of as plates of a capacitor. The electrostatic voltage from the secondary winding to ground will depend on the relative capacitances and may easily reach a dangerous and destructive value unless each secondary winding is connected to ground.

WARNING

One terminal of each secondary winding should always be grounded. The tank should also be solidly grounded. A ground pad is provided near the base of the transformer for the purpose of grounding the tank. Failure to ground the secondary circuit and the tank could cause danger to life and damage to property.

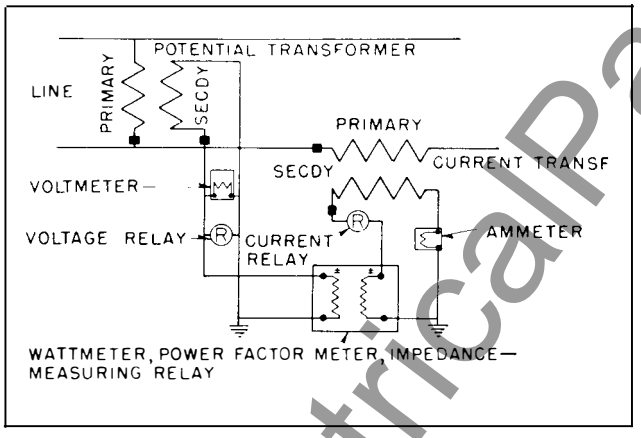

Fig. 2 *Connection of Current and Potential Transformers in a Simple Single-Phase Circuit*

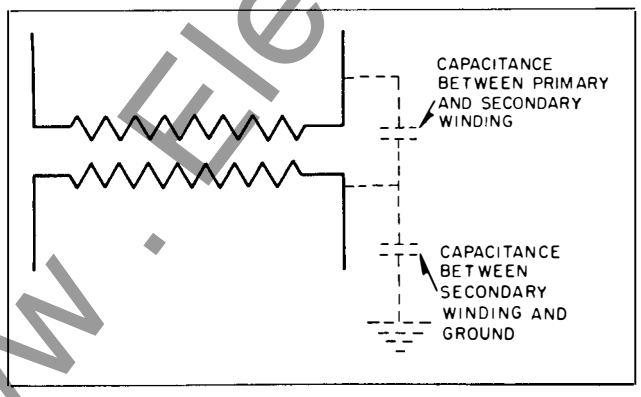

Fig. 3 *Equivalent Circuit Showing Capacitance Effect*

Connection of Current Transformer Primary

Type ACT current transformers are normally supplied with a series parallel primary winding. When shipped from the factory they are connected for the higher current rating unless otherwise specified. The connection should be checked and changed if necessary to suit the current of the primary circuit.

Connection of Current Transformer Secondary

The secondary winding of a current transformer or each secondary winding of a multiple secondary current transformer should never be left open circuited. If the secondary circuit is opened the impedance of the burden in effect becomes infinite, and if the primary winding is carrying current the current transformer does its best to supply the corresponding infinite voltage. Although practically the voltage is limited, oil immersed transformers generally can develop more than 5000 volts (crest value) which is dangerous and destructive. Each Secondary must be grounded as described in Grounding of Secondary Circuit and Tank, Page 6.

WARNING

The secondary winding of a current transformer should never be open circuited. Open circuit of the secondary winding of a current transformer when the primary winding is carrying current could cause danger to life and damage to property.

Connection of Voltage Transformer Primary

The primary terminals of a fully insulated two bushing voltage transformer are connected to the high voltage lines. In the case of a graded insulation single bushing voltage transformer the fully insulated terminal is connected to the high voltage line and the reduced insulation terminal is solidly grounded. This ground consists of a copper strap connecting the reduced insulation terminal to the tank. This ground connection (and the tank ground) must always be in place when the transformer is energized.

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WARNING

The reduced insulation neutral terminal of a graded insulation single bushing voltage transformer should always be solidly grounded. Failure to ground the neutral bushing could result in danger to life and damage to property.

Connection of Voltage Transformer Secondary

Short-circuit of a voltage transformer secondary is like a short circuit of any other transformer; it burns out in a very short time. Accidental short circuits do occur, and the windings are designed to withstand the large mechanical forces which result, but they cannot be practically designed to carry the short-circuit current for more than one second. The secondary winding of a voltage transformer should never be short circuited. Each Secondary must be grounded as described in Grounding of Secondary Circuit and Tank, Page 6.

WARNING

The secondary winding of a voltage transformer should never be short circuited. Short circuiting the secondary winding of a voltage transformer could cause danger to life and damage to property.

FERRORESONANCE

Overvoltages have been experienced on power systems due to ferroresonance. The overvoltages involved saturation of a voltage transformer and may cause failure of the transformer.

Voltage transformers connected line to ground on an otherwise ungrounded system may be subject to ferroresonance as treated in Westinghouse Technical Data 44-060. In addition, ferroresonance has occurred on well grounded systems when high series breaker capacitances couple an otherwise de-energized voltage transformer to the system. The later case is applicable to gas breakers used on EHV systems where the coupling capacitance of an open breaker is 1300 pfds.

Steady state operation of voltage transformers under overvoltages due to ferroresonance can lead to thermal failure. Repeated occurrences of ferroresonant conditions can also electrically or mechanically weaken the voltage transformer such that an electrical or mechanical failure can more easily occur when the transformer is subjected to any abnormal system condition.

Methods of preventing ferroresonance on ungrounded systems are given in Technical Data 44-060. Method of preventing ferroresonance on transformers coupled to a system by the capacitance of an open breaker also require loading the secondary winding with a resistor.

Wye connected load resistors equal to or less than 1.25 ohms will eliminate ferroresonance for single and two breaker connections at 345 kV. It requires switching to insert the resistance after the circuit breakers are open.

Test Procedures Before Energizing

- Type APT Voltage Transformers, Single Phase and Three Phase – 450 KV BIL and above
- Type MSV Voltage Transformers – All Ratings
- Type PVT Power Voltage Transformers – All Ratings
- Type ACT Current Transformers – 450 KV BIL and above

Within one month before energizing the above transformers the bottom oil should be sampled and analyzed as a routine part of the installation procedure.

Instrument transformers are sealed pressure tight; therefore, the internal pressure and oil level will vary with temperature. In cold weather the units are expected to be under negative pressure. For these reasons, before taking an oil sample it is important that the internal pressure be neutralized by opening a filling plug located on the top of the bushing cap. The filling plug should be opened in dry weather only. Do not take samples on days of high humidity. Once the cap has been opened, the sample should be taken promptly and the cap resealed using Westinghouse 53351ER Teflon ribbon or equivalent on the pipe threads to prevent entrance of moisture. Pipe plugs must be fully tightened.

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The sampling procedure should begin with draining and discarding approximately one pint of oil from the drain valve to insure that the sample taken will not be that which was stored in the sampling pipe. The sample must be taken in a dry, contamination-free, approved oil sample bottle.

The oil must be tested for dielectric strength per ASTM D877 and it is recommended that moisture content be measured per ASTM D1533. The limits are 30 KV minimum dielectric strength and 20 parts per million maximum moisture content.

Sampling and testing procedures are detailed in I.B. 45-063-100.

On three phase APT units, the oil sample should be taken before the procedure described below to equalize the oil level is carried out.

For the above transformers, a measurement of the insulation resistance of each winding to all other windings and ground should be made with the windings under oil. These readings should be comparable with measurements made at the factory. A measurement of the overall insulation power factor from high voltage to low voltage and ground is recommended.

Equalization of Oil Level in Two Bushing APT Voltage Transformers, Three Phase APT Voltage Transformer and MTP Metering Units

Before shipment the transformer is filled with oil to the proper level and sealed pressure tight. In the case of a two bushing APT, the three phase APT and MTP metering units, the oil level may not be equal in all bushings. This condition can be caused by tilting or severe shipping shocks and is corrected by removing all filling plugs which will equalize the oil level. Air entrapped in the tank is removed by drawing a few drops of oil from a bleeder valve in the top of the tank. This procedure should be carried out after the unit is installed on a permanent foundation or platform and not subject to further handling.

The following procedure should be followed to equalize the oil level after installation:

1. Vent each of the HV bushing caps simultaneously by removing a pipe plug from each bushing cap.

2. Draw a few drops of oil (approximately 1 oz.) from the bleeder valve adjacent to the instruction plate.

3. Should adjustment of the liquid level be necessary, add clean dry oil WEMCO C PDS #55822AG to establish normal liquid level. The transformer oil temperature at the time of installation affects the oil volume and may cause the gage to read slightly differently than at the reference 25°C. The effect is not great for oil temperature from 0°C to 50°C and the liquid level should be adjusted to the reference level when the oil within the transformer is between these temperature limits.

4. After the above has been completed, the pipe plugs in the bushings CAPS should be resealed using Teflon ribbon, such as Westinghouse 53351ER. Check the bleeder valve to be certain it has been resealed.

WARNING

This oil equalizing procedure should be followed before energizing on all units having more than one primary bushing to insure proper oil levels in all bushings. Failure to follow this procedure could cause danger to life and damage to property.

VACUUM FILLING

WARNING

Transformer oil is a flammable liquid. Under some conditions, closed compartments may contain mixtures of air and vapors which are flammable or explosive. Oil pumping or filtering operations can generate electrostatic charges which upon discharge, can ignite a fire or explosion or cause injury to personnel. All equipment used for oil treatment or handling, the transformer tank, and all bushings should be electrically grounded to prevent accumulation of such charges. No smoking or other sources of sparks or flames should be permitted in the vicinity of oil handling operations. Failure to follow these instructions could cause danger to life and damage to property.

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Filling With Oil

Samples of oil should be drawn from the lowest point of each container in which oil is received. These samples must be tested and inspected. Do not use oil from any container unless the sample meets all of the following requirements:

Oil Condition as Received

Visually Detectable Water – None
Dielectric Strength – 30 KV Minimum
Power Factor – .05% Maximum
Water Content – 35 ppm Maximum

Filtering and degassing equipment to deliver clean dry degassed oil to the unit with a maximum water content of 20 parts per million and a gas content of 1% or less is a necessity.

After the unit has been placed in an upright position, drain residual oil from bottom of tank. This will reduce positive nitrogen pressure to zero. Then the two pipe plugs in the cap may be removed preparatory to filling with oil, but only if the temperature of the transformer is at least 10°C higher than the dew point of the surrounding air.

The vacuum line should immediately be connected to one of the pipe tapped openings from which the plug has been removed and the oil line for filling oil should be connected to the other. The oil line should have a valve which can be closed, and the vacuum pump should be started at once. The vacuum pump should be capable of maintaining a vacuum of not over 2 Torr absolute pressure. A gauge which will read absolute pressure should be connected into the vacuum line at the transformer, and a valve for closing the vacuum line provided between the gauge and the vacuum pump.

After this vacuum has been obtained, close the vacuum line and observe the rate of rise of absolute pressure. If the absolute pressure rises to more than 25 Torr in 30 minutes, there must be leaks which will have to be located and corrected.

After obtaining an absolute pressure of 2 Torr of mercury in the transfromer tank, the vacuum should be maintained by continuous pumping for *at least four hours.* The filling may then begin by opening the valve in the oil line slowly so the vacuum does not fall below 3 Torr of mercury, or rate of filling exceed 5 GPM.

The oil should not spray in front of the vacuum opening in the tank and must not be allowed to overflow into the vaccum line. It is advisable to provide an oil trap in the vacuum line to protect the pump from transformer oil.

Oil should be admitted to the transformer tank until the oil level reaches the 25°C level or a level corresponding to the oil temperature if the oil is not approximately 25°C. After the oil reaches the proper level and the oil inlet valve is closed, the vacuum pumping should be continued for approximately *one hour.* Break vacuum with dry nitrogen.

The transformer should be vacuum filled with oil at +30°C to 0°C above ambient transformer temperature. The oil must be at ambient temperature or warmer but at least 20°C. The transformer should never be operated or left standing out of service without the oil showing on the gauge. If the ambient temperature varies materially from 25°C. (77°F.) when the unit is filled, the oil level should be checked when the average oil temperature is 25°C. and if not at the marked oil level, sufficient oil should be put in or taken out to bring the level to the proper height, and the transformer sealed at atmospheric pressure.

FILLING OR ADDING OIL IN THE FIELD

NOTE: All transformers are processed and filled at the factory with oil that meets the federal Polychlorinated Biphenyls (PCB) regulations in effect at that time. The purchaser should take the necessary precautions so that PCB contamination is not introduced during field oil filling or maintenance of the transformer.

MAINTENANCE

Modern transformers are sealed to prevent entrance of moisture and oxidation of the oil. This eliminates the deterioration of the oil, and oil

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maintenance is usually unnecessary. A periodic check of the oil level is all that is usually necessary. Improper oil level or evidence of leakage must be corrected.

WARNING

Once a unit has been oil filled either at the factory or in the field, it should never be operated or left standing even out of service without the oil gauge indicating an oil level within the max. and min. limits marked on the oil gauge dial face. Failure to follow this instruction may result in danger to life and damage to property.

In case of doubt as to whether a leak has occurred and moisture has entered, a measurement of oil strength and insulation power factor is desirable. (See I.B. 45-063-100 Insulating Oils for Electrical Apparatus.)

Insulation power factor should be measured only after the transformer has been disconnected for several hours to permit it to attain a uniform temperature. The power factor (H to L + Grd.) corrected to 20°C. should be approximately 1% or lower. Transformers with a record of increased power factor from one check period to the next may have to be removed from service and dried.

If measurements indicate that moisture is entering the transformer, the first step is to find the leak and eliminate it; the second, to dry out the transformer. The means to be used depends on the type of transformer and the available equipment. Drying in a vacuum oven after draining the oil is the ideal method, and 24 hours at 90°-100°C. in vacuum (10 Torr absolute pressure, or better) will usually dry the transformer. If a vacuum oven is not available, application of vacuum to the tank for 48 hours after draining the oil, without any heat, will remove moisture which has entered recently. Other means can be suggested by the factory depending on circumstances. Heating at a temperature of 100°C. or more in air can cause sufficient chemical change in oil-impregnated insulation that the power factor may increase instead of decrease. After drying the transformer should be refilled in accordance with instructions under Vacuum Filling page 9.

Taking Oil Samples

These instrument transformers are sealed pressure tight. Therefore, the internal pressure and oil level will vary with temperature. In cold weather the units are expected to be under negative pressure. For these reasons, before taking an oil sample it is important that the internal pressure be neutralized by opening the filling plug located above the oil level. Follow instructions under Test Procedures Before Energizing, page 8, in taking samples.

Refinishing Notes

Any portion of the paint film damaged during shipment or installation should be repaired promptly. To repair, clean damaged portion by best means available, i.e., sandpaper, scraper, blasting, etc. If film is broken to the base metal, then apply a coat of primer, intermediate, and finish with the proper drying between coats. Surface scratches and mars can usually be repaired by application of the finish coat only. During the installation process, all exposed nuts and bolts should be given a finish coat of paint. The aerosol dispenser cans are ideal for this type of operation.

The life of transformer paint is not indefinite and, should, therefore, be maintained by periodic inspections, touch-ups and refinishing when necessary.

RENEWAL PARTS

If renewal parts are required, order from the nearest Westinghouse Sales Office, giving description of parts wanted, with transformer type designation, serial number and style number, as stamped on the transformer nameplate.

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