



# Installation and Maintenance

## RECEIVING

Make an external inspection of the transformer and the boxes containing its supplies immediately upon receipt. If their condition indicates evidence of rough handling, do not unload. Before unloading, a damage claim must be filed and an inspection made by a representative of the carrier. This inspection by the carrier can have considerable bearing on the outcome of claims for internal damage found during subsequent inspection. Check the materials received against the shipping list and report any shortages to the nearest Apparatus Sales Office of the General Electric Company along with a prompt report of any damage in transit.

Transformers are normally shipped completely assembled, liquid-filled and ready to install. When shipping limitations require the removal of certain parts, the various openings are sealed with temporary covers. If the insulating liquid has been removed for shipment the transformer will be filled with dry nitrogen or carbon-dioxide gas. These units should normally arrive at the destination with a slight positive gas pressure (except in cold weather when a partial vacuum may exist) and are to be liquid filled before being placed in service.

If a gas-filled transformer is received with the pressure-vacuum gage indicating zero and there is no change in this reading with changes in temperature, a leak may have developed with the possibility of moisture having entered the tank. If there is reason to suspect that moisture is present, it may be necessary to dry the transformer. Questions concerning the need for drying should be referred to the General Electric Company. Information on drying procedures is contained in the leaflet on "Transformer Drying".

## HANDLING

The direction of shipment shown on the Outline drawing must be observed

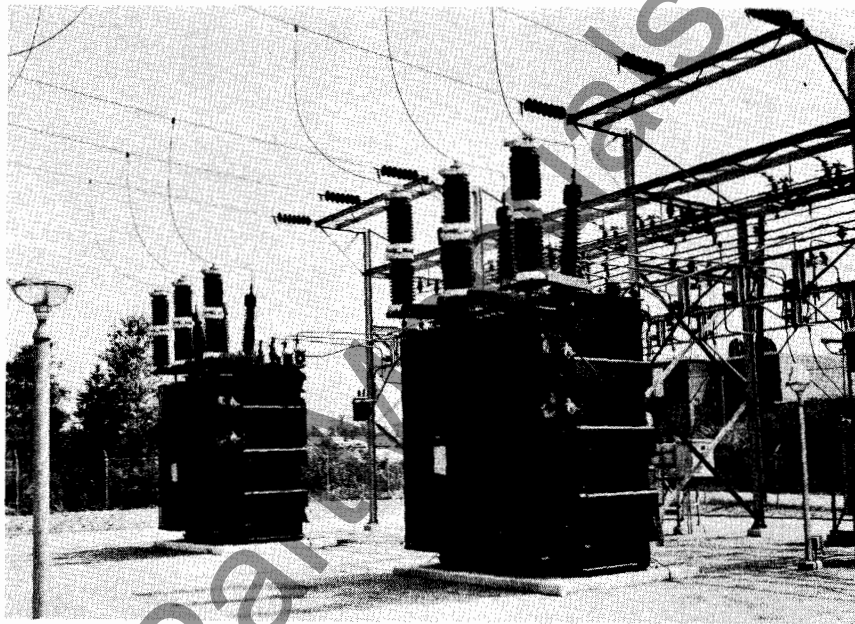


Fig. 1 Typical Installation

whenever the transformer is placed in transit. The unit should always be handled in an upright position unless recommendations for special handling are obtained from the General Electric Company. Junction boxes, when provided, can normally be removed to facilitate installation of the transformer. Before moving a transformer, remove any lightning arresters that may be mounted on it.

## LIFTING

Lugs are provided for lifting the complete transformer, and where necessary, provisions are included for lifting the various parts. Lift the transformer by means of the main lifting lugs, using cables long enough to obtain cable pull angles not over 30 degrees from vertical. See Fig. 2. Use a spreader bar or lifting beam parallel to the long axis of the transformer where necessary in order to obtain proper cable angles.

To prevent buckling of the tank walls when lifting the completely assembled transformer, the cover must always be securely fastened in place. Location of

the center of gravity and the approximate weight of the transformer are shown on the Outline drawing. The weight is also given on the nameplate.

## JACKING

Jacking facilities consisting of a base overhang or separate jack bosses are provided as shown on the transformer Outline drawing and as illustrated in Fig. 3. Do not attempt to raise a transformer by placing jacks under drain valves, pipe connections or other attachments.

## ROLLING OR SKIDDING

The transformer can be rolled (see Fig. 4) or skidded by means of pulling holes provided at the base. Cables can be attached with a hook or clevis, or by placing a loop around bolts in the holes. Restraining cables should be used when rolling downgrade.

## STORING

If the equipment is to be subjected to storage it is preferable to prepare

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.



Fig. 2 Lifting

the unit for service prior to the storage period. If this is not convenient, all supplies such as bushings, radiators, accessories, etc., should be stored indoors. To avoid moisture damage, unpack boxes or crates containing excelsior and open those covered with paper to provide free ventilation.

Before placing a sealed-tank transformer in storage, make sure the insulating liquid is at its proper level, add dry nitrogen in the gas space until the pressure reaches 3 psi, and then seal the unit. Before placing the transformer in service after a period of storage, re-establish the transformer seal as explained under "Sealed-Tank Transformers". Refer to separate instructions for storage of transformers utilizing other types of oil preservation systems. Make sure that the insulation and insulating liquid are dry before energizing a transformer after continued idleness. (See separate instructions on insulating liquids and transformer drying.)

#### SPARE TRANSFORMERS

To facilitate emergency installation of spare transformers, they should be maintained during storage as though they were in service. Make periodic inspections of the liquid level, its dielectric strength, and when furnished, fans, pumps, alarms, control circuits, and load-tap-changing equipment. Also check the pressure gage to make sure the transformer seal is being maintained and inspect junction boxes and other compartments for evidence of moisture condensation.

#### GAS FILLED SHIPMENTS

Transformers shipped gas filled may be stored in that condition providing a positive gas pressure is maintained. Add gas of the same type as that used for shipment as identified by a tag enclosed with the shipping list. Fig. 5 shows two charts that indicate the proper gas pressure to hold under vari-

ous conditions of altitude and temperature. If the storage period extends into warm weather, release gas as required to limit the pressure to 5 psi. (Transformers equipped with pressure-vacuum bleeders will do this automatically.)

Nitrogen gas can be obtained from the Air Reduction Sales Company in cylinders containing 220 cu. ft. of gas at atmospheric pressure, compressed to 2000 psi at 70F. Orders for this gas should specify "Special dry nitrogen to General Electric specification D27A3A".

Carbon dioxide gas can be purchased in cylinders containing 450 cu. ft. at atmospheric pressure, compressed to 850 psi at 70F. Cylinders are available at sales outlets of the Liquid Carbonic Corporation, whose main office is in Chicago, Ill., or the Pure Carbonic Company with its main office in Newark, N. J. Orders for this gas should specify *dry industrial carbon dioxide gas.*



**Fig. 3 Jacking**

The proper regulating valve should be obtained for introducing gas into the transformer. Before transferring any gas, invert the cylinder for 24 hours in an ambient temperature not lower than 20C. With the cylinder still inverted, open the valve for a few seconds to remove any moisture that might accidentally be present. Return the cylinder to an upright position for transferring the gas and discontinue its use when the pressure drops to 150 psi.

### SEALED-TANK TRANSFORMERS

Sealed-tank transformers are provided with a gas space above the insulating liquid. This space serves to cushion the tank against changes in pressure created by expansion and contraction of the liquid. Under normal operating conditions the space remains sealed from the atmosphere, thus protecting the insulating liquid against contamination and maintaining its dielectric strength at a high value over a long period of time. When the space available in the main tank is limited, additional space is sometimes provided by piping down to the channel braces or, occasionally, by the use of a separate expansion tank.

Oil-filled units are equipped with a pressure-vacuum bleeder which maintains the internal pressure or vacuum within the operating limits shown on the transformer nameplate. It is seldom required to operate, however, and functions primarily as a safety device. For further information refer to the instructions pertaining to that device.

### APPLYING THE SEAL

After the installation and assembly work has been completed, establish the

tank pressure as follows:

Liquid Temperature Degrees C	Approximate Starting Pressure, psi	
	Without Bleeder	With Bleeder
25	0.0	3
30	0.5	3
35	1.0	3
40	1.5	3

If it is necessary to reduce the tank pressure, the excess can be bled off through the pressure test valve. If a transformer without a bleeder is sealed when the temperature is below 25C, it should be resealed at the proper pressure as soon as the temperature rises above 25C. This will avoid excessive pressures at normal operating temperatures.

### Flushing

Flushing of the gas space in oil-filled transformers is not considered necessary since the oxygen in the air combines chemically with the oil during the first few weeks of operation. In Pyranol® filled transformers there is no chemical reaction, but the oxygen does not pre-

sent an explosion hazard because of the non-flammable characteristics of the Pyranol insulating liquid.

However, if it is the user's practice to purge the gas space, this can be done by removing the pipe plug from the vent hole on the manhole cover (or main tank cover) and admitting dry nitrogen gas through the transformer pressure test valve. Allow the nitrogen to flow until the escaping gas tests five percent oxygen or less. After 24 hours, analyze the gas again and repeat the flushing operation if necessary. No more than three flushings should be required.

### OTHER PRESERVATION SYSTEMS

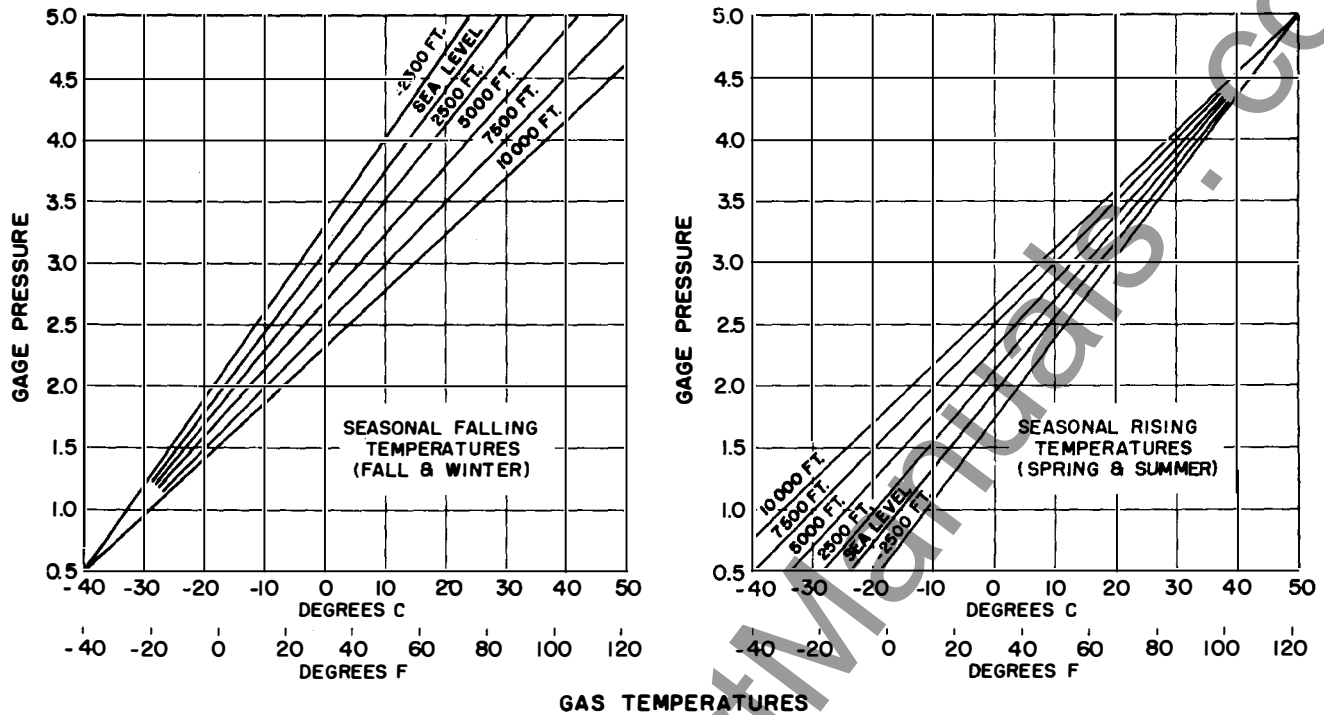
Information on other types of oil preservation systems such as conservators, automatic-gas-control equipment, and gas-oil-seal units will be found in applicable instructions supplied when that equipment is furnished.

### INSTALLATION

Provide a strong, level foundation, preferably of reinforced concrete. For transformers having flanged wheels, rails must also be provided. When key in-



**Fig. 4 Rolling**



Example of use of graphs:

- Altitude — sea level, present temperature — 15 C
- If seasonal falling temperatures, gas pressure at 15 C (from curve) — 4.1 psi
- If seasonal rising temperatures, gas pressure at 15 C — 2.8 psi

**Fig. 5 Gas pressure to be applied at various temperatures and altitudes to maintain an internal pressure between 0.5 and 5 psi**

terlocks are used with disconnect switches, circuit breakers, tap changers, etc., make sure all components using the same key are installed in the same circuit.

Select a location where air can circulate freely. If the transformer is to be installed in a compartment or vault, provide adequate ventilation to avoid overheating. At high altitudes, decreased air density reduces transformer cooling efficiency and lowers bushing arc-over voltages. If transformers are to be moved to an elevation above 3,300 feet, consult the nearest Apparatus Sales Office of the General Electric Company relative to their suitability for operation at the higher altitudes. Transformer finishes and components are designed for normal life in a non-corrosive atmosphere. Atmospheres which include corrosive agents may require additional protective measures.

Transformers shipped gas filled are to be liquid filled before being opened for assembly or inspection, as outlined under "Liquid Filling". If the transformer is to be filled under a high vacuum it may be opened prior to filling as explained under "Vacuum Filling".

**CAUTION**—Before removing a man-hole cover, shipping plate, or other device, vent the transformer to atmospheric pressure. Do not enter the transformer until the gas space has been flushed with fresh air or a suitable oxygen supply is available.

Temporary shipping parts are marked red and must be removed before placing the transformer in service. These may include both internal and external parts such as braces, bushing terminal block supports, the tape used to secure terminal board links, covers, breathers, or pipe caps and plugs.

All parts removed for shipment are identified by appropriately marked copies of the shipping list. These parts are to be installed as shown on the transformer Outline Drawing. When working on a transformer with the cover open, exercise care to see that no foreign matter is dropped into the tank. It is recommended that workmen tie tools to the tank before using them inside. All parts within the tank and all parts to be installed within the tank should be kept warmer than the surrounding air to prevent condensation.

Complete information on the accessories can be found in the leaflets per-

taining to those devices. The danger of breaking bushings can be minimized by installing them last. For wiring details, refer to the transformer Connection Diagram. When installing breathers, be sure they are turned down to prevent entrance of moisture. Use G-E Compound A15A11A or Teflon tape to seal threaded joints. When installing radiators, keep the valves closed until ready to complete the liquid filling or to lower the liquid level for an internal inspection. When a radiator has been filled do not close both top and bottom valves at the same time unless the radiator is to be immediately removed. Damaging hydrostatic pressures can be generated by temperature changes when both valves are closed.

**INSPECTION**

After installation work has been completed and before energizing the transformer, make an internal and external inspection for loose, damaged, and displaced parts. A weighted sealed beam lamp of the pyrex glass type will aid in making an inspection through the insulating liquid. Enclose the lamp in fine mesh wire before lowering it into the tank to prevent scattering of the glass in case the lamp is accidentally

broken. It is recommended that a lamp cord having synthetic insulation be used and that the lamp be immersed in the liquid before being turned on.

A more thorough internal inspection can be made by lowering the insulating liquid to the top of the core. Be sure the windings and end insulation are not exposed to the air. On transformers shipped gas filled this inspection can be made prior to the final filling or in the case of high vacuum filling, before any liquid has been added. See "Liquid Filling".

Examine the core, coils, and underside of the cover for signs of moisture and conduct dielectric test of the insulating liquid in the main tank and all compartments. If evidence of moisture is found or if the windings or end insulation have been exposed to the atmosphere, it may be necessary to dry the transformer. Questions concerning the need for drying a particular transformer should be referred to the nearest Apparatus Sales Office of the General Electric Company. For information on drying procedures refer to the instructions on "Transformer Drying".

If the liquid level is lower than that called for on the transformer nameplate (measured from the top of the manhole flange), the required amount of liquid should be added through a manhole as described under "Final Filling".

#### Check List

The following list can be used as a general guide for inspecting, checking, and testing the various accessories and other features of the transformer, when provided. For detailed information, refer to the applicable instructions.

1. Make certain all parts shipped separately have been assembled.
2. Make an internal inspection for loose or damaged parts and check:
  - A. For correct terminal board connections as shown on the nameplate.
  - B. To see that all terminal nuts and connecting links are tight, including the load-tap-changer terminal board.
  - C. Obvious lead clearances.
3. Check to see that all temporary shipping braces, etc. (items painted red) have been removed.
4. Be sure radiator valves are open.
5. If desired, make a low voltage ratio test on each tap changer and LTC position.
6. Operate the tap changer to see that the wedge seats itself properly in

each tap position. The tap changer drive will be at the center of a high torque region when the wedge is in an operating position.

7. Check the gas system on transformers equipped with an automatic gas seal.
8. Inspect accessories and control equipment and check wiring and alarm circuits.
9. Check fan operation, making sure that the number, type, and location agree with the transformer Outline drawing.
10. Check operation of pumps (the liquid flow gage will not indicate oil flow if pump rotation is incorrect.)
11. Inspect load-tap-changing equipment as follows:
  - A. Open the compartments and check for loose or damaged parts, including cracked porcelain, etc.
  - B. Make sure the breathers have been installed on the liquid-filled switch compartment.
  - C. Operate through all positions by hand and check for binding.
  - D. Operate through all positions by motor and check the limit switches, position indicator, operation counter, automatic features, and dynamic braking (when furnished).
12. Make sure all gasketed parts having grooves or stops are drawn up metal to metal and tighten all valve stem nuts.
13. Check the level and dielectric strength of the insulating liquid in the main tank and in all separate compartments such as junction boxes, throats, disconnect switches, potential devices, etc. The level of the liquid in the main tank should be measured from the top of the manhole flange and compared with the dimension given on the nameplate.

#### LEAK TESTS

Inspect the entire transformer for evidence of leaks and make the following pressure test. Introduce dry air or nitrogen through the pressure test valve until the tank pressure reaches a value just slightly less than the maximum operating pressure shown on the nameplate. Seal the transformer at this pressure and make an examination for leaks over a period of 12 hours. Leaks above the liquid level can be located by applying a solution of soap and glycerin to all gasketed joints, pipe fittings, etc.

#### PAINT FINISH

Use an oil solvent to thoroughly re-

move any oil on the outside of the tank or on gaskets. This will avoid the false impression of leaks in the future. In the case of Pyranol insulating liquid it will be necessary to use naphtha or benzene to remove all traces of the liquid because of its tendency to soften the paint.

When the installation has been completed, clean all damaged paint areas and, using the touch-up paint provided, apply one primer coat and two finish coats. Allow at least 16 hours drying time between coats. Examine the paint finish at periodic intervals for signs of deterioration and clean and repaint as required.

## CONNECTIONS

Transformers having internal terminal boards are normally shipped connected for the highest rated voltage. When shipped otherwise, a tag fastened to the nameplate will indicate the connections that have been made. Before applying voltage to a transformer, see that all connections are tight and that the windings are connected for the desired voltage. Make no connections except those authorized by the nameplate.

#### TANK GROUNDING

Ground the tank permanently and effectively by means of the ground pads provided at the base of the tank. A good, permanent, low-resistance ground is essential for adequate protection. A poor ground may be worse than none at all as it gives a sense of false security to those working around the equipment and may result in serious injury or damage to the transformer.

#### SYSTEM GROUNDING

Transformers having reduced insulation at the neutral end of a winding or in a neutral bushing can be operated with the neutral either solidly grounded or grounded through an impedance which will limit the low frequency and impulse voltages from neutral to ground to values consistent with the insulation levels shown on the nameplate.

#### LINE AND LOAD CONNECTIONS

Make line and load connections tight and see that there are no strains on the terminals which will cause the joints to become loose. Provide sufficient flexibility in the leads to prevent porcelain breakage caused by expansion and contraction. The bushings will support a considerable weight of conductor, but long spans of unsupported conductor, especially if outdoors, should be avoided. Refer to the bushing instructions for more detailed information.

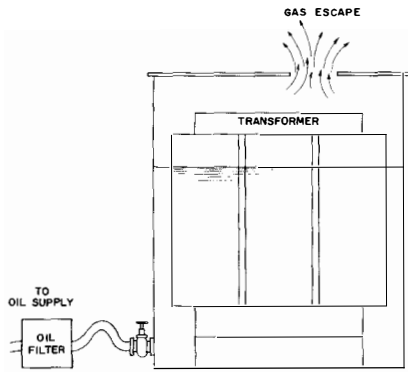


Fig. 6 Filling without vacuum

Single-phase transformers suitable for Y operation on either the high or the low voltage side may be so connected on either side, but not simultaneously on both sides unless precautions are taken to suppress third harmonic voltage.

LIGHTNING PROTECTION

Protect every transformer from lightning disturbances by some form of direct stroke protection and by approved lightning arresters that are installed as near as possible to the transformer and are directly and effectively grounded. The incoming line should be brought to the arrester first and then to the transformer bushing.

LIQUID FILLING

Vacuum filling is required on all transformer with a basic impulse insulation level of 350KV and above as shown on the nameplate. This requirement applies to the initial filling and at any time thereafter if the coils and/or end insulation are exposed to the atmosphere. All other transformers can be filled without vacuum. However, if the user prefers, any unit can be vacuum filled providing the vacuum drawn does not exceed the limit for which the tank is braced as shown on the transformer nameplate.

Detailed information on sampling, testing, and handling procedures for insulating liquids are contained in separate instructions. The following paragraphs describe procedures to be used in oil filling. The "Filling Without Vacuum" method may also be used in those few cases where Pyranol® insulating liquid has been removed for shipment. When transferring the liquid to the transformer, it should be passed through a filter press to remove any undetected moisture or sediment. The filter system must be tight to prevent air from being drawn into the pumping equipment on the intake side.

Once oil filling has started it should

be continuous. If work is to be done inside the transformer or an inspection is to be made, discontinue filling when the coils and end insulation are covered, or in the case of vacuum filling, when 85% of the amount of oil called for on the nameplate has been added.

**WARNING**— *Static charges can be developed when transformer oil flows in pipes, hoses, and tanks. To accelerate dissipation of the charge in the oil, ground the filter press, transformer tank, and all windings (if accessible) during the oil pumping and filtering operation. Since conduction through the oil is slow, it is desirable to maintain these grounds for at least an hour after the oil flow has been stopped.*

*If the bushings were removed for shipment and the windings cannot be grounded during the initial oil filling, discharge the windings with a ground stick before inspecting the interior or installing the bushings.*

*Arcs can occur from the free surface of the charged oil even though the previous grounding precautions have been taken. Therefore explosive gas mixtures should be removed from all containers into which oil is flowing.*

FILLING WITHOUT VACUUM

The transformer should not be opened until ready to proceed with the filling operation. To fill the unit, pump filtered oil in through the drain valve while exhausting the shipping gas through a manhole opening as shown in Fig. 6. (CAUTION—Vent the transformer to atmospheric pressure before removing the manhole cover.) Small bubbles may prevent the transformer from reaching its full insulation strength for some time after being filled and therefore a waiting period should be observed to give the bubbles a chance to rise to the surface or be absorbed by the oil.

Before applying full voltage, transformers shipped nitrogen filled should be allowed to stand for a minimum of 24 hours after filling and as long thereafter as possible. Carbon dioxide units should be given at least 48 hours and preferably much longer. The oil level will drop slightly as the bubbles dissipate and the oil permeates various parts of the transformer, so before placing the unit in service the level should be checked and corrected.

VACUUM FILLING

The transformer may be opened prior to vacuum filling providing there is no free water in the form of rain or heavy fog nor a threat of any precipitation at the time the unit is opened. If the core

and coil assembly is exposed to the atmosphere during inspection or installation, the total exposure time should not exceed 24 hours. A positive nitrogen-gas pressure must be established following inspection and each time the transformer is sealed at the end of a working day.

Laboratory tests indicate that once the cellulosic insulation in the transformer has been oil soaked, it absorbs moisture very slowly. If the entrance of free water is avoided, the only moisture to enter the transformer will be the result of surface condensation and this can be withdrawn before oil filling by the application of a high vacuum.

Connections

Connect the oil line to the top filter press valve on the transformer and install a 100 psi pressure gage next to the valve as shown in Fig. 7. A high reading gage is suggested to prevent damage should the oil filter be started with the valve shut. Introducing oil at the top of the transformer serves to deaerate it as it falls and also aids in the removal of any free air entering through the oil handling equipment.

A high efficiency vacuum pump having a piston displacement of approximately 50 cubic feet per minute will generally be adequate for most transformers. The vacuum line is to be connected at the top of the transformer through a cut-off valve. If suitable pipe connections are not already available, construct a temporary plate for one of the cover openings and install the necessary piping on this plate. The vacuum connection should be located as far away from the oil inlet as possible and piping should be kept short.

Precautions

1. It is undesirable to draw a vacuum on a partially filled transformer. The vacuum will tend to release any gases dissolved in the oil and the resulting bubbles can easily become trapped, forming voids in the insulation system. If the core and coils are already covered, filling may be completed through a manhole with a hose as ex-

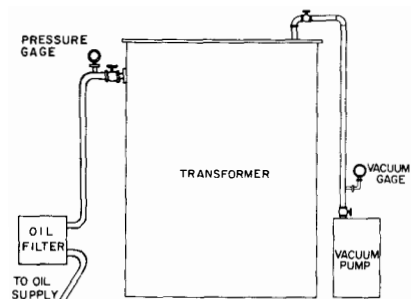
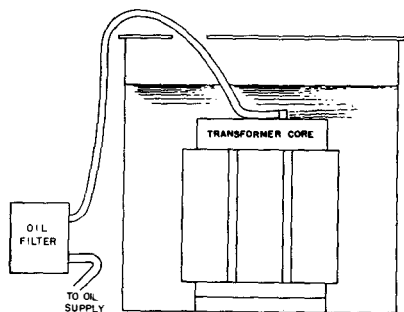


Fig. 7 Filling under vacuum



**Fig. 8 Method used to complete filling**

plained under "Final Filling". Otherwise, the unit should be drained and then refilled under vacuum.

2. All leaks must be detected and repaired before the filling process is started in order to prevent the entrance of air or moisture as the vacuum is drawn.

3. Before filling a sealed-tank transformer under vacuum, remove the pressure-vacuum bleeder and replace it with a pipe plug.

4. Automatic - gas - control equipment must have the gas regulator and supervisory equipment protected by closing the feeder valve between the sump compartment and the transformer.

5. Gas-oil-seal transformers must have the expansion tank isolated by removing the  $\frac{1}{2}$ " pipe plug from the block where the piping enters the transformer tank and inserted a  $\frac{1}{8}$ " pipe plug into the opening provided for sealing.

6. Oil-filled compartments, such as the tap selector portion of load-tap-changer equipment, disconnect switches, junction boxes, etc., must not be subjected to more than a 5 psi vacuum.

7. Conservator-type transformers require a slightly different filling procedure. See "Conservator-Type Transformers".

#### Filling

If the core and coil assembly has not been exposed to the atmosphere before oil filling, draw a vacuum not to exceed 25 millimeters of mercury absolute pressure and hold for a period of 4 hours prior to and during the oil filling. If the unit has been exposed, surface moisture should be removed by drawing a vacuum of 2 millimeters absolute pressure and holding for four hours plus a period of time equal to the exposure time. Keep the vacuum pump running during the holding period if necessary in order to maintain the required vacuum. The maximum hold time will be 28 hours.

After the vacuum has been held for the required period of time, open the top filter press valve on the transformer and start the filter press equipment. Maintain the vacuum on the transformer while filling and limit the rate of oil flow to a maximum of 25 gpm. In order to avoid the possibility of drawing air into the system, the top filter press valve should be adjusted to maintain a positive pressure on the oil line. If difficulty is experienced in holding vacuum during the oil filling, further throttling of the oil flow may be necessary. After the transformer has been filled, allow it to stand for at least 24 hours before energizing.

#### Conservator-Type Transformers

When vacuum filling conservator-type transformers proceed as follows:

1. Connect the oil line to the pipe nipple provided on the cover of the transformer.

2. Avoid drawing a vacuum on the conservator tank by closing its shut-off valve (or by installing it later).

3. Vacuum fill with 85% of the main tank oil.

4. Add the remainder of the main tank oil as explained under "Final Filling".

5. Seal the unit and complete the filling through the conservator tank as explained in separate instructions on conservator-type transformers.

#### FINAL FILLING

When adding oil after the windings are covered and the initial filling has been discontinued, or after the level has been lowered for inspection or assembly, it should be added through a man-hole. Lay the hose on top of the core and direct the oil flow parallel to and along the top of the core as shown in Fig. 8. Filling in this manner minimizes aeration of the oil and the possibility of entrapping air in the insulation or coils below the level of the initial oil filling. As a final step before placing the unit in service, remove any oil spilled on the outside of the transformer to avoid the false impression of a leak in the future.

#### GASKETS

Gaskets used to maintain the transformer seal have been selected for their ability to resist deterioration by the insulating liquid and to avoid contamination of the liquid. Gaskets made of nitrile (Buna N) and fluorinated rubber (Viton, Fluorel, etc.) are used on oil-filled transformers and silicone and fluorinated rubbers are used on Pyra-

nol-filled units. Gaskets provided with the transformer or as replacement items are especially compounded to G-E specifications and substitution of improper materials for these gaskets will result in unsatisfactory joint life.

Replacement or spare gaskets can be purchased to size through the nearest Apparatus Sales office of the General Electric Company. Identify the parts wanted as explained under "Renewal Parts". If an extended storage period is anticipated it is recommended that spare gaskets be placed in a clean, dark place away from high temperatures.

All of the gaskets used to maintain the transformer seal can be reused many times unless damaged. Before installing a new gasket or replacing an old one, thoroughly clean the gasket surfaces. Although in most cases no sticker is required, the compound furnished with the gaskets may be used if desired. All gaskets are to be installed with their widest dimension next to the gasket surface and in the case of scarfed gaskets made from strip material it may be necessary to use a sticker to hold them down. Square gaskets with scarfed joints should be installed with the scarf laying flat, in a position where the compression forces will clamp the joint together, rather than on edge where clamping tends to open the joint and produce leaks. Compress the gasket approximately one-third, or to the stops when provided in either the mating parts or in the gasket itself. Gaskets are compressed to the stops when there is a noticeable increase in the torque required to tighten the bolts. A leak test is recommended following the opening and closing of any gasketed joint affecting the transformer seal.

#### WEATHERPROOF JOINTS

If a removable, air-filled compartment is shipped separately, a length of sponge rubber gasket is furnished for the purpose of weatherproofing the joint between the compartment and the transformer. Install this gasket just outside the mounting studs or bolt holes and for the best weather-resistant joint allow the piece across the top to overlap the two side pieces.

To install a sponge rubber gasket, clean the surface on which it is to be mounted and apply a thin coat of the adhesive furnished to both the metal and the gasket. (Do not apply adhesive to the edges or outside surface of the gasket). Allow the adhesive to dry until it is no longer tacky and then press the gasket against the metal with enough pressure to make a good contact.

When a retaining strip is provided

the gasket should be assembled with its inner edge in contact with the strip. Tighten the gasket down to this stop or in the absence of a stop, compress it to approximately 1/2 size.

**MAINTENANCE**

Certain items on the transformer should be inspected at regular intervals. The following table can be used as a general guide under average conditions, although the actual frequency of inspection should be adjusted for each application according to the importance of continuity of service and as experience dictates. Refer to the instructions pertaining to a particular device for detailed information on maintenance or testing of that item.

ITEMS TO INSPECT	SCHEDULE
Ambient Temperature	H
Liquid Temperature	H
Winding Temperature	H
Load Current (amperes)	H
Voltage	H
Pressure Gage (tank)	D
Liquid Level	D
Insulating Liquid	Note 1
Alarm and Control Circuits	M
Ground Resistance	Q
Automatic gas-control equipment	
1. Transformer gas-pressure gage	D
2. Gas Cylinder content	D
3. Low-pressure alarm circuit	Q
Load-Tap-Changer	Note 2
Fans	M

H-Hourly D-Daily M-Monthly Q-Quarterly  
 Note No. 1 Test after the first few days, six months, one year, and then yearly.  
 Filter when need is indicated by laboratory tests.  
 Note No. 2 Refer to the load-tap-changer leaflet.

**EXTERNAL CLEANING**

The bushing porcelains should be inspected at regular intervals and kept reasonably free from dust and dirt. In locations where abnormal conditions prevail, such as sand storms, salt deposits, cement dust, acid fumes, etc., a special hazard may exist, and the bushings should be cleaned regularly to avoid accumulations on the external surface which may result in flashover.

Keep the heat radiating surfaces of the transformer clean. Transformers, especially those near the seacoast, should be kept painted to prevent corroding or rusting of metal parts. Periodically inspect the small screened openings in the breathers and/or pressure-vacuum bleeder to be sure they are clean and operating.

All ground buses and all wiring leads to ground must be kept in good condi-

tion. Climatic and topographical conditions largely determine the inherent characteristics of the ground. Proper relay operation in a system depends on the ground resistance being low at all times. A low ground resistance is of such importance that it should be measured quarterly.

**CIRCUITS AND CONTROL EQUIPMENT**

- Inspect monthly for the following:
- Control-circuit voltage
  - Collections of dirt or gum
  - Excess heating of parts—evidenced by discoloration of metal parts, charred insulation, or odor
  - Freedom of moving parts (no binding or sticking)
  - Corrosion of metal parts
  - Remaining wear allowance on contacts
  - Excess slam on pickup
  - Proper contact pressure
  - Loose connections
  - Condition of flexible shunts
  - Worn or broken mechanical parts
  - Excessive arcing in opening circuits
  - Excessive noise in a-c magnets
  - Evidence of dripping water or liquids falling on controls
  - Operation—including proper functioning of timing devices, etc.

Grease, oil or sticky dirt may be removed with a lint-free cloth moistened in a nonflammable cleaning fluid. Do not soak the parts with the cleaner; but use just enough to loosen grease or dirt so that it can be wiped off. For cleaning small parts, a small paint brush dipped into the cleaning solution is good for getting into corners and crevices.

**INTERNAL MAINTENANCE**

Under normal operating conditions, internal inspections should not be necessary except when a need is indicated by laboratory analysis of samples of the insulating liquid. If laboratory tests show signs of sludging in an oil-filled transformer, the internal parts should be thoroughly cleaned. Untanking is usually necessary to remove the sludge in the windings. Cleaning may be done by forcing oil under pressure from a nozzle onto the internal parts. Great care should be exercised in order not to damage any insulating material. Recondition or replace the old oil, referring to the applicable leaflets. Severe cases of sludging should be referred to the nearest Apparatus Sales Office of the General Electric Company for recommendations.

**Untanking**

If it should ever become necessary to untank the core and coils, disconnect any wiring from cover outlets and remove any parts which are connected

between the cover and the sides of the tank. If the transformer has a welded cover, remove the weld bead as explained under "Removing and Rewelding Covers" before opening the unit. Drain the insulating liquid and remove or disconnect the bushings, current transformer secondaries, winding-temperature devices, liquid-level gage, and any other parts which might get damaged or interfere with removal of the core and coils. Refer to the instructions on wedge-type tap changers and remove the tap-changer operating mechanism, making sure that it is first set on Position 1.

If the transformer is provided with load-tap-changing equipment, disconnect all leads from the windings and reactor to the LTC terminal board. Make sure all leads are tagged in order to aid in proper reassembly. *Some transformer tanks may be unstable if the core and coils are removed from the tank and the load-tap-changer equipment is left in place.* It is recommended that the stability of the tank be checked as the core and coils are lifted and that blocking be added under the LTC compartment if required.

The steel wedges or anchor blocks between the top core clamps and tank wall must be removed before the core and coils can be taken out. Carefully lift the core and coils out of the tank, using a lifting beam or spreader (See Fig. 9) when needed to keep slings from interfering with the superstructure or when a series transformer is mounted on the end of the core and coil assembly. The untanking height is shown on the transformer Outline drawing. Since the clearance between the core and coils and the tank wall is usually small, exercise care to prevent damage to parts such as pressboard casings and lead supports.

**Retanking**

When replacing the core and coils, follow the procedure outlined above in reverse order. Note that locating pins are welded to the base of the transformer tank to prevent the core and coils from shifting. The holes provided in the cross-bars or angles under the bottom core clamps must positively fit over these locating pins. After the transformer is completely reassembled, it may be necessary to dry the unit. For information on how to conduct a drying run, refer to the instructions on transformer drying. Questions on the necessity of drying a particular transformer should be referred to the nearest Apparatus Sales Office of the General Electric Company.

**LOAD RECORDS**

Daily records of load and voltage on

the transformer should be checked occasionally to see that the transformer is operating within the prescribed limits and is being used efficiently. When tapped windings are used, over-excitation and excessive core loss can result from improper tap connections.

#### TEMPERATURE RECORDS

Changes in indicated temperatures are often the only means by which the operator can detect the occurrence of abnormal conditions within the transformer. Operating temperatures, therefore, are important from this standpoint and should be carefully recorded and examined as often as practical, along with coincident records of ambient temperature, load and excitation. Examination of such records will enable the operator to protect the transformer from extended periods of abnormal operating temperatures which may affect its life expectancy. If a temperature is indicated which is more than 5 C higher than attained under the same conditions of load, excitation, and ambient temperature when the transformer was first placed in service, notify the nearest Apparatus Sales Office of the General Electric Company.

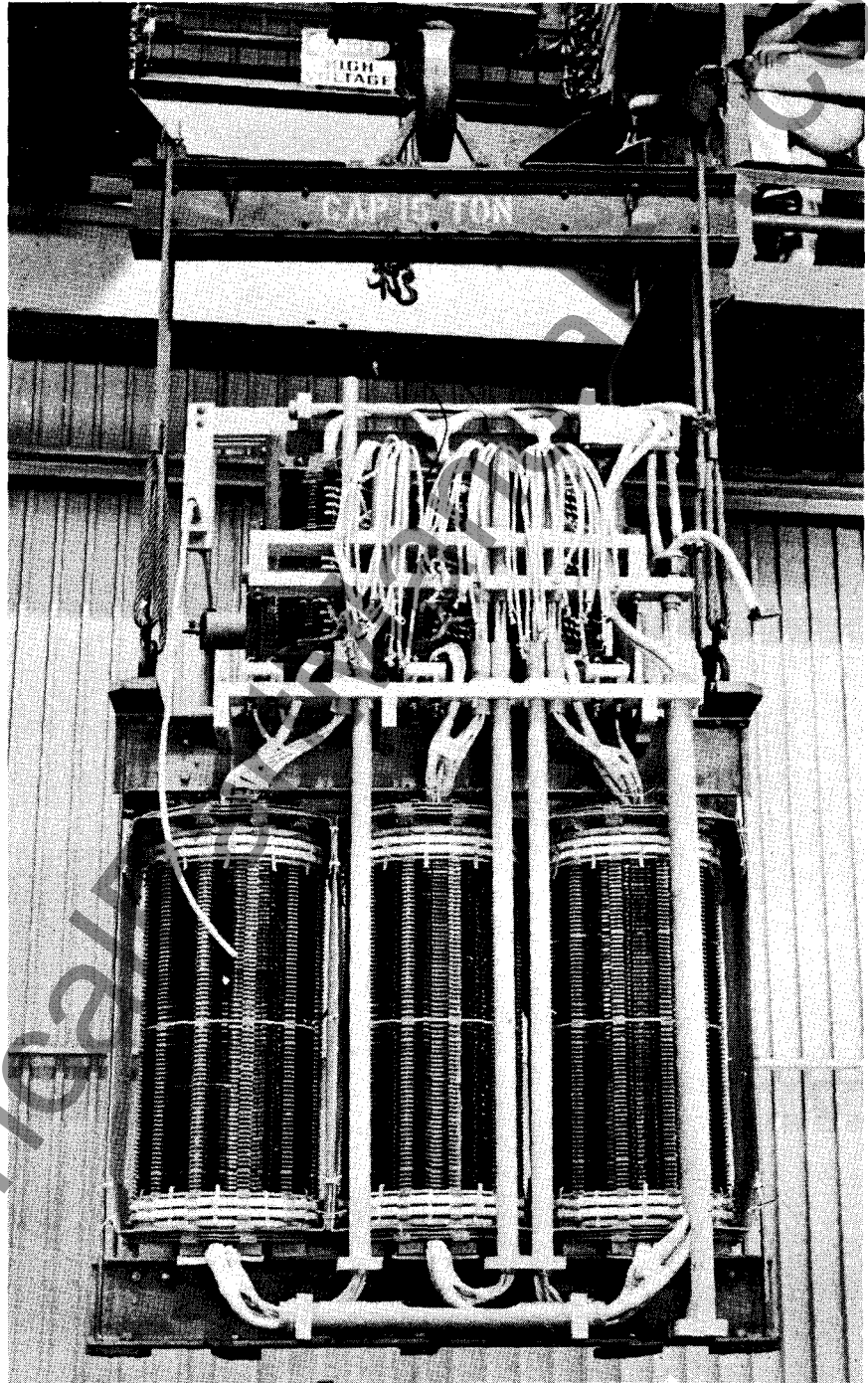
#### OPERATING TEMPERATURE

The operating temperature of the transformer should not exceed values given in ASA Standard C57.12-1958 for Transformers, Item 12-05.110. Temperatures above those recommended will result in accelerated deterioration of the liquid and may or may not affect the insulation, depending upon the hottest-spot temperature of the windings.

The top-liquid temperature alone is NOT recommended for indicating safe overload conditions within the apparatus. Hottest-spot temperature readings will give a more accurate indication of load conditions within the equipment, because the hottest-spot temperature rise over the top-liquid temperature varies widely for different methods of cooling and different loads. For continuous overload operation of the transformer, refer to the ASA Loading Guide, Appendix C-57.92. If there is doubt about a specific piece of equipment, contact the nearest Apparatus Sales Office of the General Electric Company for advice.

#### INSULATING LIQUID

The dielectric strength of the insulating liquid should be checked after the first few days of operation, again after six months, and at the end of one year. After one year, a periodic sampling and testing schedule should be established at intervals of one year or less, depending on local climatic conditions, the load on the transformer and the impor-



**Fig. 9 Transformer core and coils showing use of lifting beam**

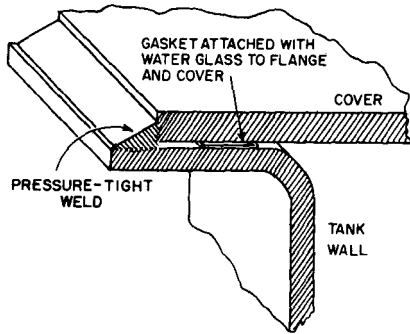
tance of minimizing interruptions. Refer to the instructions pertaining to transformer insulating liquids for information on the techniques of sampling and testing and the method of filtering when laboratory test indicate the need.

#### REMOVING AND REWELDING COVERS

Welded covers can be removed by chipping out the weld bead with diamond-point chisels and a pneumatic

hammer or by the oxygen gouging method. The latter method is considerably faster and is recommended for all welds of 5/16" and over where adequate precautions can be taken for the fire hazard which exists with oxyacetylene cutting operations.

When removing the weld bead, the cover should be clamped to the tank flange to hold it in place and prevent chips or welding slag from entering the transformer. Protect all openings against the entrance of foreign matter. Before



**Fig. 10 Tank and cover arrangement**

oxygen gouging on oil-filled transformers, thoroughly flush out the air space inside the tank with *dry* nitrogen or carbon dioxide gas and maintain a small flow of the gas during the gouging operation. (This precaution is not necessary for transformers filled with Pyranol insulating liquid).

The entire weld may be removed in one pass, providing care is taken to avoid deep gouging of the edge of the cover or tank flange. The joint should be ground or chipped clean for rewelding before the cover is removed. Ox-acetylene cutting torch equipment is necessary with gouging tips similar to Air Reduction Style No. 183. For best performance of the gouging operation, a cutting torch similar to Airco Series 3000 having a graduate control of the high-pressure oxygen flow is recommended. Tip sizes and gas pressures recommended for various fillet weld sizes are as follows:

Fillet Weld Size		Tip Size	Oxygen Pressure	Acetylene Pressure
5/16-in.		No. 8	60 psi	8 psi
3/8 and 7/16-in.		No. 10	70 psi	9 psi
1/2-in. and up		No. 12	75 psi	9 psi

**REWELDING THE COVER**

Before replacing the cover, remove all traces of dirt, grease, and insulating liquid from the areas to be welded. Cement a gasket to the tank flange or cover by applying a coat of water glass (sodium silicate) to both surfaces. The gasket should consist of a piece of 3/8-inch loose-twist glass or asbestos roving or a strip of 1/16 x 1 1/2-inch dry asbestos folded to make it 3/4-inch wide and should be located approximately 1/2-inch from the outer edge of the cover. See Fig. 10. Clamp the cover to the flange during the welding operation to compress the gasket and prevent slag or spatter from entering the transformer.

Seal all openings to prevent any possibility of welding spatter entering the transformer. For oil-filled transformers, thoroughly flush out the air space with *dry* nitrogen or carbon dioxide and maintain a small flow of gas during the welding operation.

The arc welding process, using 3/16 or 1/4 inch diameter electrodes, is recommended for rewelding the cover. The fillet should be built up with a series of passes to a thickness comparable to that of the original weld. In order to make a pressure tight joint, slag and spatter should be completely removed before each succeeding pass and at each point where the arc is interrupted.

When the welding has been completed, remove all scale and pressure test the joint as explained under "Leak Test". After a satisfactory test, clean the weld and adjacent surfaces and apply one primary coat and two finish coats of paint.

**RENEWAL PARTS**

Orders for renewal or supply parts

should be placed with the nearest Apparatus Sales Office of the General Electric Company. Specify the quantity required and give the catalog or drawing number along with part numbers whenever possible. Catalog numbers of the parts most likely to need replacing, such as the arcing contacts in load-tap-changing equipment, are listed in the applicable leaflets. If the required numbers are not available, describe the parts in detail. When requesting information or ordering parts for a particular transformer, always include the serial number appearing on the transformer name-plate.

Materials that are unaffected by Pyranol have been used in constructing Pyranol transformers and no substitutions should be made for these materials without the approval of the General Electric Company. Any renewal parts supplied will be manufactured from the same or similar materials as those used for new transformers. Successful operation of the renewal parts is contingent upon proper field assembly, the condition of the remaining parts, and a thorough drying cycle if moisture has entered the transformer.

**WHEN YOU NEED SERVICE**

If you need to repair, recondition, or rebuild any electric apparatus, a G-E Service Shop near you is available day or night, seven days a week, for work in the shop or on your premises. Latest factory methods and genuine G-E renewal parts are used to maintain the original performance of your G-E equipment. For full information about these services, contact the nearest Apparatus Sales Office or General Electric Service Shop.

MEDIUM TRANSFORMER DEPARTMENT



ROME, GEORGIA