

INSTRUCTIONS

**PYRANOL TRANSFORMERS  
INCLUDING  
PYRANOL IMMersed  
CURRENT-LIMITING REACTORS**



**GENERAL  ELECTRIC**

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# PYRANOL TRANSFORMERS

## INCLUDING

### PYRANOL IMMERSED CURRENT-LIMITING REACTORS

*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.*

#### PYRANOL

Pyranol\* is a cooling and insulating liquid which is noninflammable, chemically stable, and nonsludging. Pyranol supplied for use in transformers is straw-yellow in color, and has a Saybolt viscosity of about 54 seconds at 37.8 C (100 F).

Mineral oil is completely miscible in transformer Pyranol and affects its noninflammable characteristics. Since it is practically impossible to separate the two liquids after they have been mixed, it is important that contamination with any petroleum oils be avoided.

Materials which are not soluble in Pyranol have been selected for use in constructing Pyranol transformers. No materials should be used in contact with transformer Pyranol except those approved by the General Electric Company.

#### PYRANOL IMMERSED CURRENT-LIMITING REACTORS

A Pyranol immersed current-limiting reactor differs from a Pyranol immersed transformer in that it usually has no core. It generally consists of one winding immersed in Pyranol in a standard transformer tank.

The following instructions, given for transformers, apply to these reactors.

#### INSTALLATION

##### Inspection

Before installing, inspect the transformer carefully for damage which might have occurred in transit. Tighten any parts which may have

worked loose, such as nuts and leads. Inspect the lead seals which are used to seal the valves at the base of the tank. They should be unbroken when the transformer is received.

Pyranol transformers are pressure-tight and are normally shipped completely assembled in their tanks filled with Pyranol, ready to install.

Pyranol used for filling transformers should have a dielectric strength of 30 kv or higher. When the dielectric strength of Pyranol in transformers in service reaches 25 kv or lower, it should be filtered in accordance with the section on "Drying and Filtering Pyranol."

If the dielectric strength is very low, or if there is other evidence of free water, the core and coils should also be dried in accordance with instructions on "Drying Pyranol Transformers." Under certain temperature conditions, the Pyranol may condense into drops on the under side of the pressure-relief diaphragm. These drops should not be mistaken for free water.

Methods of sampling and testing Pyranol are covered in the section on "Sampling Pyranol."

If the transformer is to be operated at a high altitude (3000 feet or more above sea level) open a fitting above the liquid level, either the top sampling valve on the side of the tank or the filling plug in the cover, in order to equalize the internal and external pressures at approximately 25 C before it is placed in operation.

If a transformer must be opened for inspection out-of-doors on a damp or stormy day, proper precautions should be taken to prevent the entrance of moisture.

Occasionally, due to weight or space limitation, it is necessary to ship Pyranol transformers filled with gas.

When transformers are shipped filled with gas, the following procedure may be found useful. A  $\frac{1}{4}$ -in. pipe connection will be found on the cover fitted with a plug so that a gage reading four to five pounds may be fitted to this connection to determine if the gas in the tank still remains under pressure. If a positive pressure is shown on the gage, the core and coils are

\*Registered trade-mark for G-E askarel.

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dry and it should be unnecessary to dry out the transformer. Inspect the coils, the inside of the tank, and underneath the cover for moisture; if any is found, dry the transformer.

Before permitting the gas to escape, the core and coils should be at the same or higher temperature than the surrounding air; otherwise moisture will condense on the internal parts. The core and coils of a transformer shipped in this manner should be immersed in Pyranol before being exposed to air because the insulation is more susceptible to moisture after such complete drainage for shipment. The gas should be forced out by opening the vents and slowly filling the tank with Pyranol through the bottom valve. Regardless of the method followed, the core and coils should be brought up to or above the temperature of the surrounding air before opening the tank for any reason.

**Note that the inert gas used in shipment is very little lighter than air and must be completely dissipated before anyone is allowed to enter a tank.**

### **Handling**

Lugs or eye nuts are provided for lifting the complete transformer and, when necessary, additional nuts and eyes are supplied for lifting the various parts. Transformers should be lifted by means of the lugs provided on the side of the tank and proper spreaders should be used to obtain a vertical lift. The cover of the transformer should be bolted securely in place to prevent buckling of the tank wall.

When necessary, transformers are provided with means for lifting with jacks, either by means of special jack bosses welded to the transformer case, or by an extension of the base of the transformer. In no case should the transformer be moved or lifted by placing jack or tackle under the drain valves, radiator connections, or other attachments. When rollers are used, skids should be provided to distribute the stress over the base.

### **Foundation**

The only foundation necessary for the installation of Pyranol transformers is a level floor

strong enough to support the weight. If the transformers are supplied with removable junction boxes, the boxes may be detached to facilitate lowering the tanks into vaults.

If the transformer is equipped with a diaphragm mounted in the side of the tank, the transformer should be so placed that the diaphragm is not facing an aisle or passageway.

### **Connections**

Do not change connections on a transformer that is under excitation or make any connection except those authorized by the diagram or nameplate accompanying the transformer.

Tap leads on some transformers are connected to a ratio adjuster, the handle of which may extend through the cover or through the side of the tank or it may be under the cover. When the ratio-adjuster handle is brought out through the main cover or the side of the tank, the exposed mechanism is protected by a ratio-adjuster cover. This cover must be in place to avoid the entrance of moisture.

Leads not in use should be insulated from ground and from all other leads.

Regardless of the floor or foundation on which the transformer is placed, unless prevented by special operating conditions, the tank should be grounded permanently and effectively by connecting to the grounding lug at the bottom of the tank.

A good permanent low-resistance ground is essential for adequate protection. A poor ground may be worse than no ground at all, since it gives a false feeling of safety to those working around the equipment and may result in loss of life or damage to the apparatus.

When a transformer or autotransformer is specially designed for use on a system having a solidly grounded neutral, be sure that the neutral lead, as indicated on the nameplate, is permanently and solidly grounded without resistance. In transformers specially designed for this service, whether single-phase or three-phase, the neutral lead is usually brought out through a bushing of a lower voltage rating than the line bushings. If the neutral is not solidly grounded, sufficient voltage may appear from

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neutral to ground to cause arc-over of the neutral bushing.

A transformer or an autotransformer is occasionally grounded through a low impedance or a tuned impedance of a higher value. In such instances the neutral bushing is of sufficient insulation strength to meet the specific conditions. Special instructions accompany units for such applications.

A single-phase transformer 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 voltages.

Two transformers of similar voltage rating may be operated safely in multiple when they have the same polarity, ratio, phase rotation, and angular displacement, and approximately the same per cent impedance.

When desiring to operate transformers in multiple that are not of identical design, communicate with the nearest sales office of the General Electric Company for information. Be sure to give serial numbers of the transformers that are to be operated in multiple.

Every transformer should be protected from lightning disturbances by some form of direct stroke protection and an approved lightning arrester should be installed as near as possible to the transformer to be protected. Provide the arrester with an efficient ground.

### **Pressure Test**

Pressure test all Pyranol transformers before placing them in service. Subject the tanks to an internal pressure of five pounds per square inch when the installation is completed, using dry compressed air or dry nitrogen introduced through the filling hole in the cover. When this pressure has been attained, shut off the supply and allow the transformer to stand for 12 hours. Observe the pressure reading during this period and examine the tank and fittings for leaks. If the pressure holds constant, the joints are satisfactory. Leaks above the Pyranol level may be located by applying a solution of soap and glycerin to all gasketed joints, pipe fittings, and cable connections.

### **Cooling Coils on Water-cooled Transformer**

The cooling coils are thoroughly dried before shipment, and all traces of moisture are removed by means of a hot-air blast. Do not remove the caps from the terminals of the coils until ready to install or test them. Never circulate water through the coils unless the tank is filled with Pyranol as moisture might condense on the coil and later be absorbed by the Pyranol.

After the tank is filled with Pyranol, make a final pressure test on the cooling coils at about 150 lb per sq in. The best method is to use dry air pressure, so that any leaks may be located by observing bubbles in the Pyranol. If air is not available, fill the coils with Pyranol and apply pressure. After obtaining pressure, disconnect the supply, and after a half hour determine whether any fall in pressure is due to a leak in the coil or in the fittings at the ends of the coils.

### **Gaskets**

For gasket materials and methods of applying see the section on "Gaskets."

### **Storage**

Before storing a transformer, check it to see that the Pyranol is at the proper level. Renewal coils and insulation should also be stored under Pyranol in a container that can be sealed from the air. The storage room should be clean and dry and, when possible, without extreme temperature changes. Before a transformer is placed in service from storage, instructions given under "Inspection" should be observed, particularly with regard to moisture.

## **MAINTENANCE**

In general, from the standpoint of maintenance, operation, overvoltage protection, and overcurrent protection, Pyranol transformers should be treated the same as oil-filled transformers. Specific instructions on items peculiar to Pyranol transformers are given in sections which follow.

### **Handling Pyranol**

Transformer Pyranol may be handled in the same manner as mineral oil. Continued exposure

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to liquid Pyranol may produce local skin irritations. Cleanliness among workmen handling Pyranol constitutes an adequate safeguard against such effects. Ordinary medicinal washes will remove any irritation caused by Pyranol coming in contact with an open cut or skin abrasion. A drop of castor oil will neutralize any irritation caused by contact of liquid transformer Pyranol with the eyes. As with most volatile materials, exposure to concentrated Pyranol vapors in unventilated rooms should be avoided.

Transformer Pyranol must be handled in containers, pipes, all-metal hose, etc., which are free from oil, grease, pitch, or other foreign materials, since these contaminate the liquid and decrease its noninflammable properties. It is desirable that all such apparatus used in storing or transporting transformer Pyranol be maintained for exclusive use with Pyranol, as it is extremely difficult to remove all traces of oil or other Pyranol contaminants from equipment of this type.

All-metal hose must be used in handling Pyranol instead of rubber-lined hose, since rubber is affected by Pyranol.

### **Filling Transformers**

Although all Pyranol transformers are shipped filled with Pyranol, it may be necessary to refill a transformer. If so, proceed as follows:

Before filling the transformer make sure that joints are tight. Open all air vents.

In order to prevent aeration of the Pyranol, it is preferable to fill the transformer through the drain valve with a filter press. Fill to the 25 C mark on the gage or up to the lower sampling valve if no gage is provided.

Baked-on Glyptal paint is resistant to the action of Pyranol. Air-cured Glyptal paint used for touch-up work in the factory and for repainting in the field, however, requires a rather long curing period. Therefore, care should be taken to remove all traces of Pyranol that is spilled or dripped on the outside of the transformer.

### **Gaskets**

Gaskets installed on Pyranol transformers

should be made of special cork or other approved material furnished by the General Electric Company.

In applying a replacement gasket, proceed as follows:

1. Remove all traces of the old gasket material and cementing compound adhering to the gasket surface.

2. Brush the gasket surfaces which are to be joined and the surfaces of the gasket itself with G-E Compound No. 880 (use G-E Compound No. 1276 on small distribution transformers) and allow to dry.

3. If a cover gasket is being replaced, brush the bottom surface of the gasket and the tank gasket surface with the compound and set the gasket in position on the tank, using clamps or weights at frequent intervals to obtain the best possible adhesion to the metal. Allow the compound to set at least an hour so that when the weights or clamps are removed the gasket will not slip. After the weights are removed, brush the top surface of the gasket and the cover gasket surface with the compound. Bolt or clamp the gasket surfaces together immediately with uniform pressure at all points until the spring washers, if any, are flat or until clamps are reasonably tight. After four hours, give a second tightening until the same conditions are met.

4. If a bushing or similar gasket is being replaced, steps 1 and 2 should be followed, after which all the surfaces should be given a second coat of the compound. Bolt or clamp the gasket surfaces together immediately with uniform pressure at all points until they are reasonably tight. Give a second tightening after four hours.

Extra gaskets and cementing compounds for Pyranol transformers should be obtained from the General Electric Company.

When assembling pipe fittings, clean the threads thoroughly to remove all oil, grease, Pyranol, old compound and dirt. Apply a coating of G-E Compound No. 880 or No. 1276 to the threads and screw the mating parts tightly in place.

### **Periodic Inspection**

After the first few days of operation, the top and bottom Pyranol should be tested for dielectric strength. Refer to the section covering "Method of Taking Samples and Testing Pyranol."

Pyranol samples may be drawn and tested on the same schedule as transformer oil. The inspection should be systematized and accurate records kept. If, at any time, the Pyranol tests below 25 kv, at room temperature, a filter press may be used to restore the dielectric strength to above 30 kv.

If no facilities are available for making dielectric tests, samples may be sent to the General Electric Company, Pittsfield, Mass., in sample bottles obtained from the General Electric Company. Attach a tag to each sample, giving distinctly the serial number of the transformer or drum from which the sample was taken, the date on which the sample was taken, whether the sample was taken from the top or bottom of the transformer, whether the transformer is located indoors or outdoors, the weather at the time of sampling, and the temperature of the liquid at the time of sampling. These samples should be packed carefully to avoid breakage in transit.

Keep the level of the Pyranol in the transformer up to or above the mark on the Pyranol gage, or up to or above the lower sampling valve.

The condition of the external transformer surfaces should be examined at regular intervals. If it is found that weathering is taking place, the surface should be cleaned thoroughly and repainted with a good grade of durable paint recommended by the General Electric Company.

It is recommended that a pressure test be made in accordance with instructions under this subject once a year, or more often for severe operating conditions, to make sure that a complete seal is maintained.

### **Water-cooled Transformers**

The ingoing cooling water should not have a temperature of over 25 C. Supply enough water so that the difference in temperature between

the ingoing and the outgoing is not more than 10 C. It is recommended that thermometers be permanently installed in the ingoing and outgoing water connections, so that the difference in temperatures may be readily observed. Where multiple cooling coils are employed, see that the flow through each section is such as to produce the same temperature rise in each.

To prevent condensation, never allow water to flow through any portion of an exposed coil above Pyranol in a transformer.

Nearly all cooling water will in time form scale or sediment in the cooling coil, which materially decreases the efficiency of the coil. This is indicated by a high Pyranol temperature and a decreased flow of water, load conditions and water pressure remaining the same.

Scale and sediment can be removed from a cooling coil without removing the coil from the tank. Disconnect both inlet and outlet pipes from the water system and temporarily pipe the coils to a point several feet away from the transformer, where the coil can be filled and emptied safely. Take special care to prevent any acid, dirt, or water from getting into the transformer.

Blow or siphon all the water from the cooling coil, and pump it full of a solution of hydrochloric (muriatic) acid, specific gravity 1.10. (Equal parts of commercially pure concentrated hydrochloric acid and water will give this specific gravity.)

After the solution has stood in the coil about an hour, flush out thoroughly with clean water. If all the scale is not removed the first time, repeat the operation until the coil is clean, using a new solution each time. The number of times it is necessary to repeat the process will depend on the condition of the coil, though ordinarily one or two fillings will be sufficient.

The chemical action which takes place may be very violent and often forces acid, sediment, etc., from both ends of the coil; therefore, it is well to leave one end partially open to prevent abnormal pressure.

Cooling coils with the ends through the cover will not drain under any conditions. To remove the water, blow them out with air under pressure of from 10 to 100 lb per sq in.

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A cooling coil with both ends through the tank near the bottom, or with one end near the top and the other near the bottom, will only partially drain, even with both ends wide open. With such constructions a petcock located on the elbow at the upper end of the coil must always be opened while blowing out with air.

If a water-cooled transformer is to be removed from service, it is recommended that the cooling coil be drained thoroughly, dried by hot air, filled with transil oil, and sealed.

### **Limiting Temperatures**

Do not run an artificially cooled transformer continuously, even at no load, without the cooling medium. If the circulation of the cooling medium is unavoidably stopped, immediately reduce the load as much as possible and keep a close watch on the winding temperature (if a temperature indicator is available) and on the Pyranol temperature.

For continuous full-load and overload operation, refer to ASA guide for loading power and distribution transformers ASA-57.1, -57.2 and -57.3.

### **Sampling and Testing Pyranol**

In the sampling and testing of transformer Pyranol, as with any insulating liquid, strict attention should be given to the cleaning and drying of sampling and testing receptacles.

Samples of Pyranol which is questionable should be submitted to the General Electric Company, Pittsfield, Mass., for laboratory tests. When the factory analysis of a sample indicates soluble contamination of a character that impairs the serviceability of the Pyranol, detailed recommendations for correcting the situation will be made. Oil is the only contaminant usually found in Pyranol which cannot readily be removed by the combination of fuller's earth and paper filtration described in these instructions. It is essential, therefore, that the operator be particularly careful to avoid Pyranol contamination by oil.

The procedure outlined herewith should be followed to obtain consistent results from samples taken either for field or factory tests.

### **Sampling from Transformers**

1. Samples should preferably be taken when the temperature of the transformer is near 25 C. Take samples from outdoor apparatus on a clear day only, and guard against contamination by wind-blown dust, etc.

2. Glass bottles for samples should be obtained from the General Electric Company, Pittsfield, Mass. These will be supplied filled with new transformer Pyranol to prevent contamination of the bottle and to replace the Pyranol which is withdrawn as the sample.

3. If in emergency it is necessary to use other containers than the sample bottles obtained from Pittsfield, only small-neck glass bottles should be used and the following procedure should be followed in cleaning the container.

Rinse sample containers with oil-free gasoline. Then wash them with strong soapsuds, rinse thoroughly with water, and dry in an oven at 105 C to 110 C for at least eight hours. After drying, the bottles must be tightly stoppered with a glass stopper, or with a clean cork protected by clean metal foil.

4. Impurities tending to affect the dielectric strength of Pyranol will in general be at the top of the liquid, and therefore the sample should be taken from the top through the small valve or plug provided for this purpose. Carefully clean the valve or plug and allow enough Pyranol to run out so that any moisture or foreign material which may have collected in the drain pipe, valve, or plug is removed.

5. After the new Pyranol contained in a sample bottle received from Pittsfield is poured into the transformer, allow the sampling bottle to drain thoroughly.

6. Draw a sample into the bottle, leaving sufficient air space to allow for possible expansion of the Pyranol. Carefully seal the container to prevent any exposure of the Pyranol to the atmosphere, using the stopper removed from the bottle.

7. If it is necessary to sample when the transformer is appreciably warmer or cooler than 25 C, the transformer tank should be

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vented to the air at the first opportunity that presents itself when it is near that temperature. This should be done so that excessive pressure or vacuum will not result when extensive changes in temperature take place during operation.

*Sampling from Drums*

1. Take samples from drums after the Pyranol has remained undisturbed for at least eight hours. Samples should be taken only when the Pyranol is at least as warm as the surrounding air. If drums are outdoors, take samples on a clear day only and guard against wind-blown dust, etc. Take a sample from the top of the drum by means of a chemically clean thief. Observe sampling precautions before outlined.

2. Clean the glass thieves in the same manner as the bottles are cleaned and store them in a dust-free cabinet, preferably at a temperature not less than 37.8 C (100 F).

*Testing for Dielectric Strength*

For testing the dielectric strength of Pyranol the technique as specified by the American Society for Testing Materials in the test method entitled, "The Standard Method of Testing Electrical Insulating Oils" shall be followed. The following precautions and modifications must be observed.

1. Set the spacing of the electrodes at 0.100 inches.

2. The test cup and electrodes should be wiped clean with dry, calendered tissue or clean, dry chamois and thoroughly rinsed with oil-free dry gasoline.

3. Fill the test cup with dry gasoline and make a breakdown test under standard conditions of voltage application (3 kv per second rise). If the dielectric strength is not less than 25 kv, the cup is considered suitable for testing purposes. The usual precautions in handling gasoline should be observed.

4. Immediately after the final rinsing with gasoline, the test cup should be rinsed with the Pyranol under investigation and the test proceeded with at once.

5. The temperature of the Pyranol when tested should be the same as that of the room which should be between 20 C and 30 C (68 F and 86 F). Testing at lower temperature is likely to give variable results which may be misleading.

6. After filling the test cup, the Pyranol should be allowed to stand for three minutes before test in order to allow entrained air bubbles to escape.

7. When making tests, take only one test per filling, filling at least three times and averaging the results.

*Drying and Filtering Pyranol*

Transformer Pyranol will seldom require filtration because the tank of a Pyranol transformer is sealed. When it is necessary to filter Pyranol to remove moisture or foreign material, the following is the recommended procedure:

The Pyranol purifier consists of a specially proportioned filter press, a positive-volume gear pump, driving motor, combined drip pan and mixing tank, and the necessary piping valve, strainer, gages and drying ovens. Any equipment used for filtering Pyranol should first be thoroughly cleaned to remove foreign material, including oil. Oil contamination should be avoided because oil is completely miscible in Pyranol and cannot be separated by any practical method. It is recommended that whenever possible separate equipment be reserved for the exclusive use of Pyranol.

TO REMOVE MOISTURE FROM PYRANOL OR ANY INSULATING LIQUID A THOROUGHLY DRY FILTERING MEDIUM IS ESSENTIAL. Filter paper and fuller's earth are used for this purpose in the Pyranol purifier, and the effectiveness of the filtering process is proportional to the care and thoroughness with which these materials are dried initially.

*Drying the Paper*

The filter paper should be separated as it is hung on the rods in the oven, to permit free

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circulation of air and insure the most rapid drying. The paper should be dried from six to twelve hours (depending upon the condition of the paper and the separation of the sheets), at a temperature of 85 to 100 C. After drying it should be taken from the oven directly to the filter or, if this is not convenient, it may be stored in dry Pyranol for future use. When transferring the paper, care should be taken to handle it as little as possible to avoid the absorption of moisture from the hands and to minimize the time that the paper is exposed to the air. Filter paper exposed in normal atmosphere will reabsorb, in as little time as ten minutes, two-thirds of the moisture that it will ultimately take up from the air.

### *Drying the Fuller's Earth*

The drying of fuller's earth requires temperatures higher than the 85 to 100 C used to dry the filter paper. Placed in pans two or three inches deep, fuller's earth can be dried in from two to three hours, if held at a temperature of 200 C or higher. A temperature of 300 C can be used without impairing the earth. In fact, it dries faster at these high temperatures and gives up a greater percentage of its normal moisture content.

When a high-temperature oven is not available the standard filter-paper oven may be utilized by operating it at a temperature of 125 C and keeping the earth in the oven for about 24 hours in pans not over three inches deep. Filter paper will be physically weakened if subjected to these temperatures and, therefore, cannot be safely dried with the earth.

### *Handling Dried Filtering Medium*

Because any dry filtering medium will reabsorb moisture from the air in a matter of minutes, it is essential that it be protected from contact with the air while being transferred from the oven to the filter press. Where the oven is located immediately adjacent to the filter, the individual sheets of paper and the earth may be quickly transferred from the oven to the filter, but where the oven is located

some distance away, the filtering medium, as soon as removed from the oven, should be covered with dry Pyranol, and should remain covered until loaded in the filter. Filter paper or fuller's earth once submerged in Pyranol cannot be effectively re-dried.

### *Charging the Filter*

The frames and plates should be placed alternately and so positioned that, when facing the pump or head end of the equipment, the small projections on their top edges are at the right-hand side.

Three sheets of dry filter paper should be placed between each plate and the adjacent frame, care being taken that the holes in the paper correspond to those in the plates. As soon as they are thus positioned, the plates and frames should be pushed together, to prevent free circulation of air past the paper while the remaining sheets are being inserted. When all the sheets are in position, the press should be clamped securely by means of the compression screws at the back of the assembly.

The charge for the filter should consist of six pounds of 80/300 mesh fuller's earth (the equivalent in volume to a little more than one gallon liquid measure). About a third of this charge should be mixed with five or six gallons of clean Pyranol in the mixing tank. When thoroughly mixed, the valve leading from the mixing tank to the pump and that between the press outlet and the drip pan should be opened, while the other valves should be closed. The motor should then be started to circulate the Pyranol and fuller's earth mixture through the press and thus deposit a layer or cake of fuller's earth on the surface of the filter paper. After the pump has been running about five minutes, the remainder of the six-pound charge of earth may be added gradually to the mixing tank, being careful to stir the mixture thoroughly to prevent any dry lumps of earth being drawn into the pump. The addition of the remainder of the earth will take from 10 to 15 minutes. It is recommended that the outfit be run at least five minutes after the last of the earth is

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added to make sure that all earth is deposited in the press and that the cake is of proper depth.

The purifier is then ready for use.

### *Operation*

The most effective procedure for filtering is to pump the Pyranol through the filter and into a clean tank. When this is not practical, the circulation method may be used, whereby the impure fluid is pumped directly from the transformer tank through the filter and back to the same tank. In such cases it is recommended that the transformer be de-energized.

Since most of the free water and sediment are usually found near the top surface of the Pyranol, the inlet to the filter should be connected to the top of the transformer tank and the return fluid delivered into the bottom. During the filtering operation any air which has been drawn into the filter press will be discharged into the bottom of the transformer tank and therefore sufficient time (two hours or more) should be allowed for this air to escape before the transformer is re-energized. If these instructions are followed, there should be no difficulty in obtaining a dielectric strength of 30 kv or higher, as measured with one-inch disks set 0.1 inch apart.

### *Cleaning the Filter*

Compressed air passed through the press will release a considerable amount of Pyranol that would otherwise be retained in the earth and filter paper.

To do this, first close all valves except the one leading from the filter press outlet to the drip pan. Then connect a supply of dry, oil-free compressed air to the connection at the press inlet and pass the air through the press until no further Pyranol is discharged into the drip pan. Air pressures as high as 100 pounds can be used; the higher the pressures the more rapidly the Pyranol is forced out.

In addition to saving Pyranol this operation simplifies the subsequent removal of the earth and filter paper. After blowing out the press, the individual frames, with the filter paper held

in position on each side, can be lifted from the press intact, and the earth and paper discarded with minimum effort.

### *Pump*

The purifier is equipped with a constant-volume gear pump having a built-in relief valve adjusted to limit the output pressure to 100 pounds per square inch. The higher specific gravity of Pyranol does not permit long or high "suction" lifts, hence it is desirable to so locate the filtering apparatus that the inlet connections will be as short as practical. The Pyranol should preferably flow into the pump by gravity. Where long runs cannot be avoided, the use of large hose will give the best results.

Where it is necessary to filter Pyranol in transformers located in subway manholes or street vaults, space limitations usually make it impractical to lower the purifier into the vault. To maintain full capacity operation under these conditions, it is recommended that a portable auxiliary motor and pump unit be installed in the vault to pump the Pyranol up to the filter.

After the equivalent of several months of continuous service, the abrasive action of the fuller's earth passing through the pump gears may cause considerable wear, particularly if the Pyranol and fuller's earth are not well mixed. The filter is designed for convenient pump replacement and when this wear has advanced to the extent that the output of the apparatus is appreciably below normal, a new pump should be installed. While individual repair parts can be obtained for these pumps, the wear will be found to be so generally distributed over the whole pump that a complete replacement is advisable.

### *Motor*

The 1.5-horsepower motor is geared directly to the pump. Ordinarily, a single-phase, 110/220-volt 60-cycle induction motor is supplied, but motors for other voltages and frequencies or for direct current may be obtained.

**Strainer**

The strainer is provided to prevent anything of appreciable size from entering and injuring the pump. It is easily accessible and should be thoroughly cleaned at regular intervals.

**Electric Drying Oven**

The oven for this purifier requires approximately 1400 watts and is designed to operate from either 110-volt or 220-volt single-phase alternating current. The oven is provided with an automatic heat control to avoid overheating the paper and earth. The oven is divided into four compartments, each with rods for suspending the filter paper for drying.

**Drying Pyranol Transformers**

Pyranol transformers should be dried by the short-circuit method with the transformer kept sealed since loss of Pyranol due to evaporation will result from the temperatures which the transformer must necessarily attain in order to drive off moisture. During the heat run the Pyranol should be circulated through a paper filter press or, preferably, through a filter press with fuller's earth and paper. Either method will remove the moisture from the Pyranol, but the latter will, in addition, remove soluble contaminants from the liquid itself. (Drying will be slower than if it were feasible to thoroughly ventilate the top of the tank because moisture filtration from the hot Pyranol is rather slow at high temperatures.)

A filter press which has been reserved for use with Pyranol is preferable. If, however, in an emergency it is necessary to use a paper filter press which has been used previously for oil, it must be thoroughly cleaned, removing all traces of oil by the use of Pyranol, carbon tetrachloride, naphtha or gasoline. The Pyranol and windings should be heated by short-circuiting one winding and applying suitable voltage and current to the other winding. The desired temperature may be attained by blanketing the tank and the cover should be lagged in order to prevent condensation.

The following table gives the maximum allowable load which may be used with various corresponding maximum allowable top Pyranol temperatures. It is desirable to hold 85 C top Pyranol temperature with 50 per cent load if this is possible. A load of 125 per cent may be used at the start until the top Pyranol reaches 65 C, then reduce the load for obtaining constant temperature in accordance with the following tabulation.

MAXIMUM ALLOWABLE SHORT-CIRCUIT AMPERES IN PER CENT OF FULL LOAD		Maximum Allowable Top Pyranol Temperature
Self-cooled Trans.	Water- and Forced-Pyranol Cooled Transformer	
50	50	85 C
75	60	80 C
85	75	75 C

When heat is generated in the windings, do not allow the top Pyranol temperature to exceed the specified value for a given per cent load, since the windings are at a higher temperature than the Pyranol and damage to insulation will result.

The filtering, if done continually, may keep the Pyranol temperature too low, hence it may be preferable to filter periodically.

The drying should be continued until the dielectric strength of the Pyranol is restored to at least 30 kv when tested with the Pyranol at room temperature.

**Spare Transformers**

Time and expense will be saved if spare units are kept in readiness for instant use. The following items should be inspected during periods of idleness: Pyranol level, Pyranol dielectric strength, relief diaphragms, fan control and conduit, mercury seals, load-ratio control, also nitrogen-gas analysis for oxygen content, gas supply and control, gas relief pressure alarm (when nitrogen gas seal is used).

Also inspect for condensation in all cabinets, junction boxes, as well as on the underside of covers of apparatus not having conservators or nitrogen gas seal.

## **LOCAL CONDITIONS AFFECTING THE OPERATION AND LIFE OF TRANSFORMERS**

### **Impure Air**

Unless special care is taken, trouble may be experienced with transformers which are installed where abnormal conditions prevail.

Bushings must be kept clean, since the formation of conducting deposits may cause bushing arc-overs.

Transformers near the seacoast should be kept well painted to prevent the corroding of any metal parts by the damp salt air.

Conduit piping leading from the station to the terminal box at the transformer should be sealed to prevent warm air flowing to the box and condensing.

### **Altitude**

If a transformer is moved to a location of a higher altitude, the effects are to increase its temperature rise (if self-cooled) and to lower the arc-over voltage of the bushings due to the decreased air density. These effects must be considered if a transformer is operated at a higher altitude than that for which it was designed.

Standard bushings may be used at any altitude up to 3300 feet. If transformers are to be moved to an elevation higher than 3300 feet, first communicate with the nearest office of the General Electric Company relative to suitability of the bushings.

### **Transformer Housing**

When large self-cooled Pyranol transformers are installed in vaults or compartments, it is necessary to thoroughly ventilate the compartment. Provide cool air inlets in or near the floor and outlets in or near the roof. Have the latter six feet or more above the top of the transformer. The number and size of air outlets required will depend on their distance above the transformer, and on the efficiency and load cycle of the apparatus. In general, provide about 20 square feet each of inlet and outlet

opening for each 1000 kva of transformer capacity. If the transformer will be required to operate for considerable periods at continuous full load, the areas of openings should be increased to about 40 square feet per 1000 kva of transformer capacity.

Arrange the air inlets and outlets so that they are permanently open. Do not use as ventilators windows or doors which may be opened and closed by attendants, due to the danger of excessive heating in case they are inadvertently left closed during periods of heavy load or high temperature.

If forced ventilation is used, supply about 5000 cubic feet of air per minute for each 1000 kva of transformer capacity, and conduct the incoming air directly to the transformers so that it will flow up through and around the radiating members of the tank. If this cannot be done and the air is merely moved through the room, provide about 10,000 cubic feet per minute for each 1000 kva.

Do not let the temperature of the room in which the transformer is installed exceed the temperature of the air entering the room by more than 5 C. The entering air should come from the outside, or at least from a source not much warmer than the outside air.

## **ACCESSORIES**

### **Thermometers**

#### *For Small Transformers*

The thermometers usually furnished with these transformers are known as Form P. This type of thermometer is attached to the side of the tank near the top, with the bulb extending into the top Pyranol, supported by a short length of capillary tubing.

Each thermometer is equipped with a maximum reading hand which may be reset by rotating the knurled projection in front of the case. Do not turn the maximum reading hand past the instantaneous indicating hand.

This type of thermometer when provided with alarm contacts is known as Form P-2. When this thermometer is shipped from the

## *GEH-1093A Pyranol Transformers Including Pyranol Immersed Current-limiting Reactors*

factory, the alarm contacts are set to operate at 65 C for water-cooled transformers, and at 80 C for self-cooled transformers.

If the bulb interferes with the removal of the core and coils from the tank, the tubing may be bent to one side. Do not bend it at the same place often enough to fatigue the metal.

### *For Other Transformers*

Thermometers for larger transformers are known as Form M. The bulb of this thermometer is located in the top Pyranol with the indicating dial mounted near the nameplate.

The capillary tube passes through the cover of cover-lifted transformers, and through the tank wall on other types. On transformers with the thermometer tube passing through the cover, detach the thermometer dial and place it on top of the cover before removing the transformer from the tank. On other types the cover may be removed without disturbing the thermometer. If the transformer is to be lifted out of the tank, first remove the thermometer bulb from its supporting bracket.

Thermometer readings taken frequently will indicate abnormal conditions affecting the transformer. The reading must not be relied upon as an indication of permissible load, except with the limitations noted under "Limiting Temperatures."

All Form M thermometers are provided with alarm contacts. When these thermometers are shipped from the factory, the alarm contact is set to operate at 65 C for water-cooled transformers and at 80 C for self-cooled transformers. These contacts may be readily adjusted to operate at other points on the scale.

To adjust the alarm contacts of Forms P-2, M-12, or M-121 thermometers, first take off the bezel ring and glass by removing the six clamping screws. Immerse the bulb of the instrument in a fluid at the desired alarm temperature. Loosen the screw holding the cam on the pointer spindle, and rotate the cam until the contacts just close.

To check the setting, lower the temperature of the thermometer bulb approximately five

degrees. If the setting is correct, the contacts will open.

To change the alarm adjustment on Forms M-10, M-11, M-14, and M-15 thermometers, unscrew the bezel ring that secures the glass. It will be seen that the circuit is made between a contact on the instrument hand and another carried at the end of a hairspring. This second contact is held in position by an arm which shows the contact setting on the instrument scale. It is held in place by friction. To change the setting, rotate the arm until it points to the desired temperature upon the scale, then replace the bezel.

### *Thermotel*

When a Thermotel is supplied with the transformer, frequent observations should be made, since the Thermotel indicates the maximum percentage of the transformer capacity utilized since the last observation, assuming that the Thermotel was reset at that time. Should an overload occur for a sufficient length of time to produce an unsafe operating condition, the indicating semaphore will be tripped. When this occurs, the semaphore should be reset by moving the small lever at the bottom of the Thermotel to the left. Then make observations from day to day and if the semaphore is tripped the second time, the cause should be determined.

Resetting the semaphore also resets the maximum indicating hand to give an instantaneous reading.

### *Relief Diaphragm*

A pressure relief diaphragm is standard equipment on all Pyranol transformers above 25 kva.

This device consists of a diaphragm made of frangible material, held in place by flanges fastened to the transformer.

In an older type, the diaphragm is held between one flange welded to the transformer and another separate flange by cap screws fitted with lock washers. The diaphragm is protected on both sides by cushioning gaskets.

The technique employed in bolting down this type of diaphragm and making the seal is of prime importance, since the rupture strength of the frangible material depends materially on the care with which this operation is performed.

Clean the gasket surface of the tank flange thoroughly. Coat both sides of the inner gasket with G-E No. 880 or No. 1276 Compound, lay it on the tank flange and place the diaphragm over the gasket, being careful to center it properly. Lay the cushion gasket over the diaphragm and assemble the clamping ring over the cushion, holding it in place with cap screws.

Equal distribution of stress can be obtained by tightening the three alternate cap screws until the spring in the lock washer is almost taken up. The cap screw diametrically opposite the third screw tightened should then be turned until the spring in the lock washer is taken up. The two screws diametrically opposite the other two screws are then to be tightened in the same way. This tightening process is to be repeated until the gasket is compressed to half its original thickness or until there is a space of  $\frac{1}{32}$  inch remaining between the grooved flange and the clamping ring.

In a newer type, the frangible material is held between two flanges separate from the transformer. The diaphragm with cushioning gaskets on each side is assembled between these flanges under a press so that uniform pressure around the whole circumference is obtained. This assembly is held together with countersunk flat-head screws. In bolting this assembly to the tank a gasket covered with G-E No. 1276 Compound on both sides is placed on the tank flange and the diaphragm assembly is bolted to it with cap screws fitted with lock washers in the manner specified above for the other type of diaphragm. This type of diaphragm is shown in Fig. 1.

Outdoor power transformers are provided with a type of pressure relief which is mounted at the end of a curved pipe on the cover as shown in Fig. 2. The relief diaphragm is a thin disk of molded material (Herkolite) firmly held

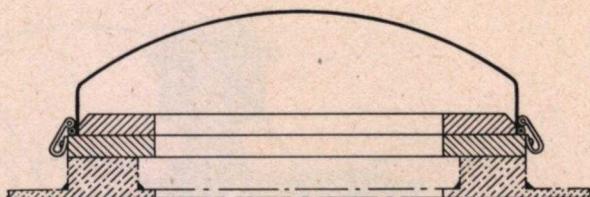


Fig. 1. Section through the Relief Diaphragm

between gaskets and clamping rings. This relief disk is protected from the weather and mechanical injury by a metal cover held firmly over it by spring tension. Through the edge of this cover opposite the hinge is the relief pin which is screwed into the diaphragm clamping ring to hold the cover closed. This relief pin is made of treated aluminum to prevent corrosion. It will break at 10 pounds tension.

On occurrence of a sudden pressure within the transformer tank the diaphragm will move out against the cover, putting tension on the relief pin which breaks when the tension reaches a predetermined value. As soon as this relief pin breaks, the diaphragm comes against a knife edge centrally located over the front of the diaphragm. This knife edge cuts through the diaphragm which breaks open to relieve the pressure. As soon as the pressure has been relieved, the cover is closed by spring tension, shutting firmly against a rubber gasket. This action prevents any moisture from entering the transformer.

To renew the relief diaphragm after it has been ruptured, it is necessary to take out the cap screws and remove the front clamping ring. There are notches provided under opposite edges of this ring into which wedges can be inserted to separate the flanges. When putting in a new relief diaphragm, a new diaphragm gasket must be used. Brush this gasket on both edges and one side with a thin coat of G-E No. 880 or No. 1276 Compound and allow it to set. Then apply a fresh coat of the compound to the gasket ring in the metal and put the gasket in place. No compound should be used on the gasket surface which comes against the diaphragm. Bolt the clamping ring and cover assembly firmly in place.

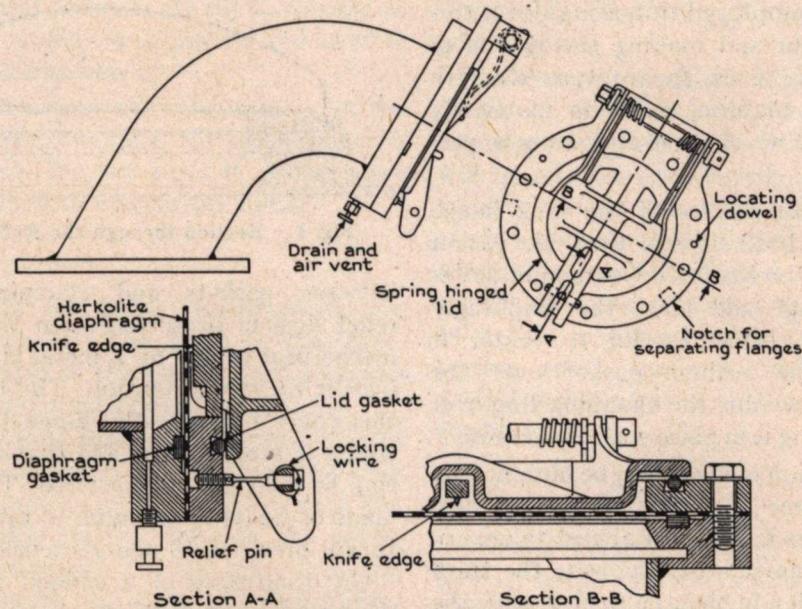


Fig. 2. Pressure Relief for Outdoor Power Pyranol Transformers

Put a new aluminum relief pin through the steel pin in the edge of the cover and screw it into the steel clamping ring. Use a nail in the hole just above the threads of the relief pin to screw it in place, and draw it down only enough so that the head of the relief pin comes against the steel pin in the cover without putting any stress on the aluminum pin. Do not turn the relief pin by its top end. After the relief pin is screwed in place, seal it to prevent tampering by using a piece of copper wire through the hole in the head of pin and passing the wire around the steel pin as shown in Fig. 1.

For shipping purposes the aluminum relief pin is removed and shipped separately with extra pins, gaskets and relief diaphragms. The relief cover is also securely closed with wire. The wire must be removed and the relief pin must be assembled in place as previously described.

Pyranol filled junction boxes on power transformers are provided with a pressure relief similar to one of the types previously described.

#### Gas Absorbers and Vent Pipes

Pyranol transformers can be installed in a building without fireproof vault, in accordance with the requirements of the 1940 National Electrical Code\* since in sizes above 25 kva they are equipped with pressure-relief diaphragms or vents. This diaphragm meets the code requirements for transformers installed in well-ventilated areas. The upper steel clamping ring which fastens the diaphragm to the transformer is provided with tapped holes, arranged to permit the easy attachment of a vent pipe that can be carried to the outside air, to a chimney, or to some other ventilating flue.

#### Vent Pipe

When a vent pipe is provided for carrying

\* LIQUID THAT WILL NOT BURN: A transformer immersed in an approved liquid that will not burn and rated in excess of 25 kva shall be furnished with a pressure-relief vent. If installed in a poorly ventilated place inside of a building, it shall also comply with one of the following conditions:

1. It shall be furnished with a means for absorbing any gases generated by arcing inside the case, or
2. The pressure-relief vent shall be connected to a chimney or flue which will carry such gases outside the building. (Article 4503, section b.)

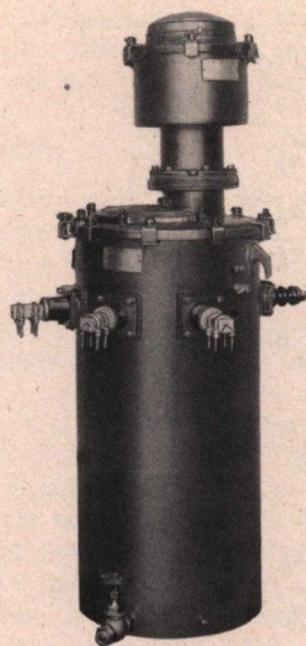


Fig. 3. Pyranol transformer with gas absorber

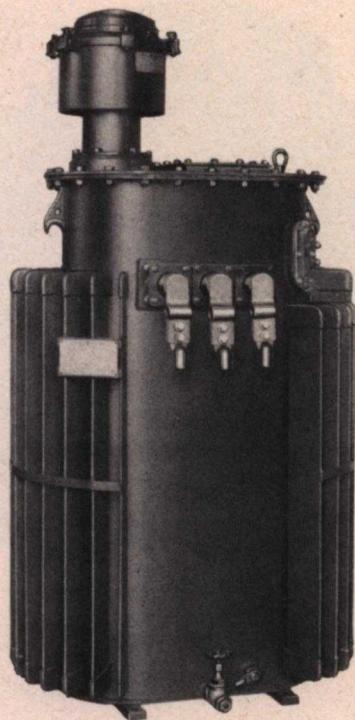


Fig. 4. Pyranol transformer with gas absorber

gases away from a poorly ventilated area, it is recommended that its diameter be no smaller than the clear diameter of the frangible diaphragm to which it is attached; that is, either six or eight inches, as shown in the outline (Fig. 5). It is also recommended that the metal of which the vent pipe is made shall not be lighter than No. 16 gage and that it shall be installed with the minimum of bends in order to provide a free passage of gas. It is further recommended that provision be made for inspecting the diaphragm and for removing any moisture that may accumulate on it. It is preferable that the pipe be so arranged that moisture cannot collect on the diaphragm.

#### *Gas Absorber*

Where it is not practical to install a vent pipe, a gas absorber can be installed on the flange over the frangible diaphragm, as shown in Figs. 3, 4, and 6. It is designed to absorb the gases produced by arc disintegration of part of the Pyranol in the transformer: two per cent of

the Pyranol in distribution and power transformers, and five per cent for a-c network transformers.

This absorber has a steel tank with a mounting flange at the bottom for attachment to the relief vent of the transformer tank. At the top is a diaphragm, with protecting cover.

Inside the absorber tank are several trays, one above the other, each of which has a perforated steel bottom. The trays are fastened together by a center bolt to facilitate assembly, and the entire group is secured to the absorber tank by two studs. The bottom tray is filled with chipped marble; the upper trays contain G-E Compound A50P9. For transformers over 500 kva, all trays contain the compound.

When an arc in the transformer generates gas and raises the pressure sufficiently to break the diaphragm on the transformer, the gas passes into the absorber and is absorbed by the compound. Liquid carried along with the gas is stopped by the chipped marble and drains back

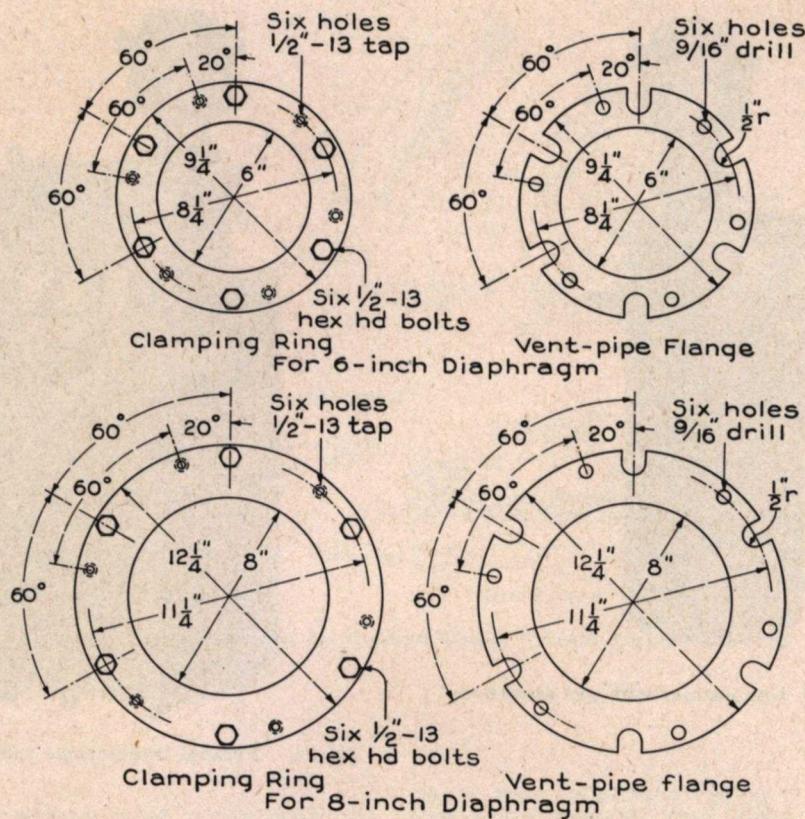


Fig. 5. Vent Pipe Flange Outlines and Dimensions

into the transformer. If the gas exceeds the capacity of the absorber, the top diaphragm breaks.

#### *Application*

Under the provisions of the National Electrical Code, it is the responsibility of the local code authority to determine whether vent pipes or absorbers are required for a given installation. Important factors to be considered are: The energy available in the circuit to which the transformers are connected; the type of protective equipment; the area and volume of the room in which the transformers are installed; the ventilation facilities in the room; the number of people employed in the area; and the proximity of the employees to the transformers.

If absorbers are used, it is recommended that one absorber be used with each transformer. If one absorber is connected to two or more transformers by means of a header pipe, there is the possibility that if one transformer fails and sufficient gas is generated to break the glass diaphragm in that transformer, the pressure in the header pipe may also be sufficient to break the diaphragms in the other transformers. Furthermore, if more than one transformer were simultaneously involved in trouble, sufficient gas might be produced to exceed the capacity of one absorber.

The absorber should be inspected at intervals to make certain that the diaphragms are intact and that the compound in the absorber trays has not become damp or caked.

When a gas absorber is supplied, a separate

instruction book accompanies the apparatus which describes the installation, operation, and care of the device.

### **Sampling Valve**

Some transformers are provided with a sampling valve in which the height of the intake may be carried to coincide with the rise and fall of the Pyranol level caused by temperature changes. This type of valve makes it possible to obtain a sample at the surface of the Pyranol at any time.

The valve is placed in the tank wall at a point about one inch below the 25 C Pyranol level. The intake pipe is a tube inside the tank located parallel to the tank wall, the end of which may be raised or lowered by rotating the outside part of the valve by moving the handle which extends below it. Note that when the handle points straight down, the intake pipe points straight up and is in position for maximum Pyranol level. The valve is fitted with a knurled nut which may be opened by hand or by the use of a coin or screwdriver.

To take a sample, set the operating handle pointing down, open the valve, and rotate the operating handle slowly until the liquid begins to flow, at which point the rotation should be stopped to assure getting a sample of the surface liquid.

Some transformers do not use the rotating feature, in which case the sample is taken by merely opening the valve, allowing the liquid to flow out.

Pyranol transformers are sealed and no breathing takes place with the rise and fall of the Pyranol level. Thus, when the Pyranol is at a temperature other than 25 C, there is either a pressure or a vacuum within the tank, depending upon whether the temperature is above or below 25 C. For this reason it is advisable to take a sample only when the Pyranol level gage is resting on or slightly above the 25 C mark. If the valve has been opened at any other time and the vacuum or the pressure has been relieved, the valve should again be opened when the Pyranol next passes the 25 C level so that no



**Fig. 6. Absorber**

abnormal pressure or vacuum will be developed during subsequent changes in temperature.

### **Ratio Adjusters**

Ratio adjusters furnished with transformers are of several types, known as "drum," "plunger," "crab" and "wedge."

Indicating marks on stationary and rotating parts of all adjusters must be in alignment when the adjusters are on the first position.

**NOTE.**—Do not attempt to change connections by means of the ratio adjuster while a transformer is under load or excitation.

#### *Drum Type*

A change in voltage ratio with a drum-type ratio adjuster is made by a partial turn of the handle. Remove the two bolts that hold the handle in place or the cover over the handle and turn until the index line points directly to the desired figure on the dial before connecting the transformer in circuit. After the handle is in the proper position, it should be locked securely by replacing the two bolts, or the cover.

Before removing a power transformer cover, take out the bolts that attach the ratio adjuster to the cover flange, then lift the handle and shaft out of the cover. Do not replace a cover on a tank with the operating rods in place. First assemble the cover and lower the rods through their respective openings, noting that they engage properly with the adjusters, and finally add the cover-operating mechanism to indicate the tap actually in circuit. Indicating match marks on the rods and on the internal structure show the proper assembly of these parts.

Sometimes in reassembling it may be necessary to change the vernier coupling in order to obtain proper alignment of the shafts.

When more than one operating rod is furnished, the rods are numbered in accordance with the nameplate, and are not interchangeable. The slot and pin joining the rod to the operating cap are larger on one side of the rod than on the other to aid in making correct assembly. A vernier coupling is used between the rod and the operating cap to assure that the indicator points directly to the dial number when the adjuster mechanism is in a correct operating position. Be sure that the operating cap does not force the rod down on the mechanism. It should be possible to move the rod slightly up and down and rotate it an equal distance either side after the assembly is completed; otherwise the mechanism might be damaged. If this vertical play is not obtained, remove the metal sleeve from one end of the rod, cut a small amount from the rod and replace the sleeve. Use compound on the gasket in the joint between operating cap and cover, but not on the gasket in the upper part of the cap or on those around the shaft in the stuffing box.

#### Plunger Type

The plunger-type ratio adjuster provides solid insulation between each tap connection. This insulation must be lifted over the contact members each time the taps are changed.

To change taps, remove the two hex-head bolts in the cap and lift off the cap. Pull up the handle as far as it will come (about seven inches). Rotate the handle until the pointer end

is over the desired tap position and then push down into the original position. Tighten the gland and bolt down the cap.

The contactor is of the scraping type and is self-cleaning, but if it is considered desirable to make an inspection, proceed as follows:

Remove the cap, lift up the handle as in changing taps, and turn the contactor to a neutral position. It will stand in this position. Then remove the three studs and take off the clamping ring. Lift straight up on the handle. This will remove the small cover through which the shaft passes, and also the operating shaft and contactor.

When it is desired to remove the transformer cover, the ratio-adjuster contactor should first be removed from the transformer.

#### Crab Type

If it is desired to remove the core and coils from the tank, the universal joint that ties the operating rod with the shaft should be disconnected. Indicating marks on the adjuster and cylinder should line up when the indicator is on Position No. 1.

When assembling, the position indicator on the cover may be made to agree with the actual position of the adjuster by means of a special position indicator coupled to the adjuster shaft and located near the top of the core.

#### Wedge Type (See Fig. 7)

A tap position is accurately given by the notched brass indexing disk, located directly under the driving pin. In the fully closed contact position, the large end of the driving pin is adjacent to the indexing notch.

To operate the adjuster, remove the two bolts which hold the operating mechanism cap, lift off the cap and invert it. Fit the inverted cap on the end of the operating shaft and use it as a hand wheel to set the adjuster. To lock the adjuster in position, after setting the adjuster, replace the cap and bolts.

The indexing disk is assembled about a cam which is eccentric with the shaft between tap positions, and concentric only on full contact positions.

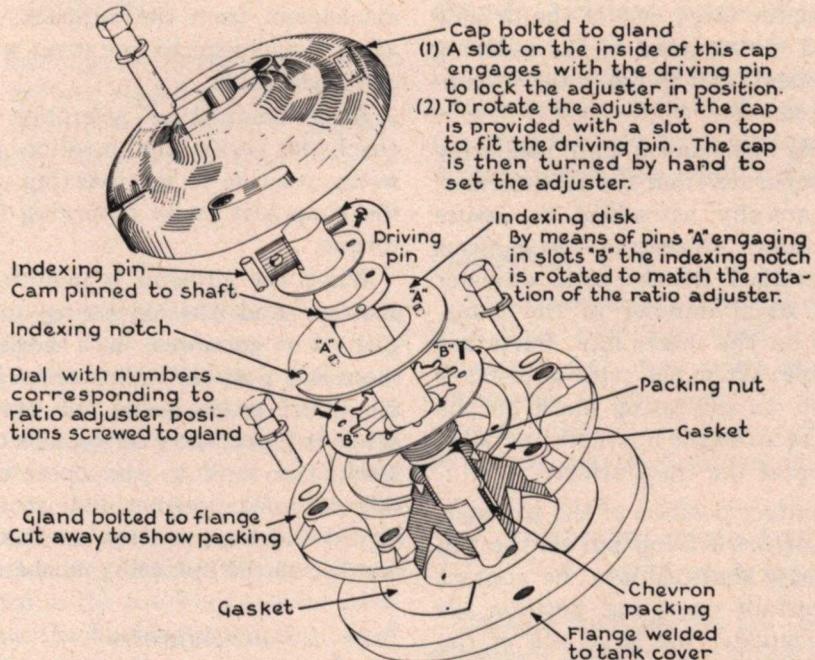


Fig. 7. Details of Operating Mechanism for Wedge-type Adjuster

The unique characteristics of the wedge-type adjuster provide a convenient and easy means of checking the location of the contact wedge and following its motion from one position to the next. The operating shaft turns 300 degrees for each tap change in the 6-point adjuster and 315 degrees for each tap change in the 8-point adjuster.

Starting from an operating position, the contact pressure is reduced to zero during the first 30-degree movement of the shaft. To shift the wedge to a point entering the next operating position requires about  $\frac{2}{3}$  of a revolution. As there is little or no friction to overcome, the torque will be noticeably small. A 30-degree movement is then required to drive the wedge home and to build up the contact pressure.

The operating position can be identified as the middle of a 60-degree arc of high torque, that is, at the point where this torque passes through a maximum value.

The position of the wedge can also be determined by using a 115-volt lamp in series with the winding containing the ratio adjuster.

(Short-circuit the opposite winding or lamp will not light.) The perfect position is midway in the band wherein the lamp shows light. Due to the design, however, the efficiency of the contact is not impaired if the wedge position is a few degrees either side of the perfect setting.

Fig. 7 shows the parts of the operating mechanism and position-indicating device located either on the transformer tank wall or on the cover. Do not disturb the mechanism assembly unless it is necessary to tighten the stuffing box. If the relation of the pins (A) to the slots (B) is changed from the factory setting, wrong contact position and indicated tap change will result.

To tighten the stuffing box, note the indicated position of the adjuster and remove the top driving pin and the cams, being careful not to move the drive shaft. Tighten the packing nut and reassemble the parts. Make sure that the drive shaft has not turned and that the indexing disk is assembled over the cam so that the position indicated is the same as it was originally. In an

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operating position the large end of the driving pin points toward the numeral in the indexing notch and the numeral cast in the outer circumference in the gland.

If the operating mechanism and insulating rod are shipped separate from the transformer, they must be carefully assembled to assure satisfactory operation. Operating mechanisms and rods are identified by the ratio adjuster number and the serial number of the transformer as shown on the nameplate. **Parts are not interchangeable.** When the ratio adjuster is in Position No. 1, an indicating mark on the insulating rod is in an exact line with mark on the top core clamp of the transformer.

To check the contact position of the adjuster, note the position of the driving pin on the top of the ratio-adjuster shaft. When the contact wedge is in a certain operating position, as shown on the nameplate, the large end of the driving pin points to the corresponding number marked on the top ratio-adjuster head. When the adjuster head is not visible and the contact position unknown, determine its location as outlined above.

Couple the insulating rod to the operating mechanism and lower it through the opening in the tank or cover over the driving pin on the ratio-adjuster shaft. Make sure that the correct rod is used for the adjuster in question as the slots in the lower end of the rod must match the driving pin. The insulating rod should be entirely suspended from the operating mechanism; none of its weight should be carried by the ratio adjuster.

Align the bolt holes in the mechanism gland with those on the tank or cover flange and start one or two bolts by hand to prevent the gland from turning. Check the operating position to be sure that the operating mechanism and the adjuster are in alignment. The large end of the top driving pin on the operating mechanism will point in the direction of the contact wedge and at the same time will indicate the position on the mechanism gland. If the indexing notch on the operating mechanism does not indicate the same numerical position, disengage the

mechanism from the adjuster, reset the operating mechanism to line it up with the adjuster and reassemble.

After completing assembly, make a final check to verify the position of the contact wedge relative to the indexing notch, either by the lamp test or by observing the variation in torque.

When the adjuster is mounted in a vertical position and the operating mechanism used with it is mounted in a horizontal position, there is a position indicator on the bracket for the bevel gears inside the transformer tank. When it is necessary to reconnect the drive shaft inside the tank to the operating mechanism, this internal position indicator must be observed and must be set on the same position number as the operating mechanism.

### *Tests on Ratio Adjusters*

It is good policy to test each ratio adjuster to make sure that the positions are correct and that the steps are progressive. This can be done by applying a low voltage to one winding and measuring the voltages on the other winding for each position of the adjuster.

### *Operation from Floor Level*

For hand operation of a ratio adjuster from the floor level (excitation removed) the operating drive is usually brought out through the side of the tank.

This drive is provided with a mercury-seal Pyranol stop to prevent Pyranol leakage from the transformer.

In some cases it is necessary to remove the drive shaft for shipment. In such instances the mercury is shipped separately from the bearing housing and should be installed on assembly of the transformer.

For replacement or installation of the mercury after assembly of drive shaft on transformer, remove the upper pipe plug in the bearing housing and fill with mercury to this level. Replace and tighten plug sealed with G-E Compound No. 880.

## BUSHINGS

Replacement bushings for Pyranol transformers should be ordered especially for use in Pyranol. Since instruction books are shipped with bushings, only brief general instructions are given here.

### Installation

See that bushings are clean and dry when installed. To expose the insulating material, other than the porcelain, to dirt or moisture is to invite deterioration and possible failure in service. Do not attempt to install the bushings in the transformer during damp or stormy weather without providing adequate means for keeping all moisture out of the transformer.

Bushings not having detachable conductors should be installed in the covers of transformers by first mounting the bushing upon the cover and subsequently connecting the terminals at the lower ends of the cable conductors to their respective leads from the transformer windings.

The small gaskets beneath the terminal cap should be in perfect condition and should be made absolutely tight. A defective gasket or leak from any source at this point will allow water to be brought up into the central tube from where it can run down into the transformer.

### Line Connections

When connecting the bushings to the line or external circuit, inspect the terminals or couplings after the connection is made to make sure that they are tight. The line connection must not bring any strain on the terminals which will cause the joints or contacts to become loose. Sufficient flexibility in the connecting leads must be provided to avoid mechanical strains due to expansion or contraction which may break the porcelain. The bushings will support a reasonable weight of connecting conductor, but long spans of unsupported conductor, especially if out of doors, should be avoided.

Bushings should be inspected at regular intervals and kept reasonably free from dust and

dirt. In locations where abnormal conditions prevail, such as salt deposits, cement dust, acid fumes, etc., it should be recognized that a special hazard exists, and the bushings should be cleaned regularly to avoid accumulations on the external surface, which may result in flashover.

### Connectors

A standard line of terminal connectors for use with both solid and filled bushings has been developed and these parts may be ordered as accessories to the bushings. These connectors provide for attaching cables, rods, tubes, and bars to the various standard bushings.

## BUSHING-TYPE CURRENT TRANSFORMERS

Bushing transformers are those in which the secondary coil and core surround a bushing, the conductor of which forms the primary. This secondary coil and core are located either in an adapter outside the main transformer cover or in a cradle suspended from the inside of the cover. These current transformers are used to actuate either relays or ammeters. See nameplate on secondary outlet for turn ratios.

### Installation

The bushing current transformers are usually shipped completely assembled in the power transformer, or at least in place in the high-voltage bushing adapters. It is then only necessary to inspect them to see that they are dry. If evidence of moisture is found they must be disassembled and the secondary coil dried by hot air, not exceeding a temperature of 90 C.

If the bushing transformer is shipped separately, assemble it in place with insulation as shown in Fig. 8. Be sure that the coil is right side up as indicated by the word "TOP" painted thereon. Handle the coil carefully so that the edges of the core will not injure the conductor insulation.

Connect the leads to the inside terminals of the outlet block, making sure that the letters on the inside and outside leads correspond.

## GEH-1093A Pyranol Transformers Including Pyranol Immersed Current-limiting Reactors

To assemble the current transformer in the bushing adapter, remove the top of the adapter, fit the transformer into place and replace the adapter, using a cork gasket treated on both sides with G-E Compound No. 880. Bolt the top down squarely to compress the gasket evenly.

On double-section tanks it is sometimes necessary to remove this type of current transformer from the underside of the cover for shipment. In such cases reassemble with the end marked "TOP" uppermost in accordance with Fig. 8. The insulating tube can be pushed up while tightening the jam nut. New plate washers are furnished and should be folded as indicated. Maintain the  $\frac{3}{8}$ -inch overhang of the current transformer inside the supporting plate opening.

### Connections and Polarity

Insulate all leads not in use from all other leads and ground. Do not allow the secondary circuit of a current transformer to remain open. It must be closed through a burden or by the short-circuiting links provided for the purpose.

The relative instantaneous directions of primary and secondary currents are as shown in Fig. 9.

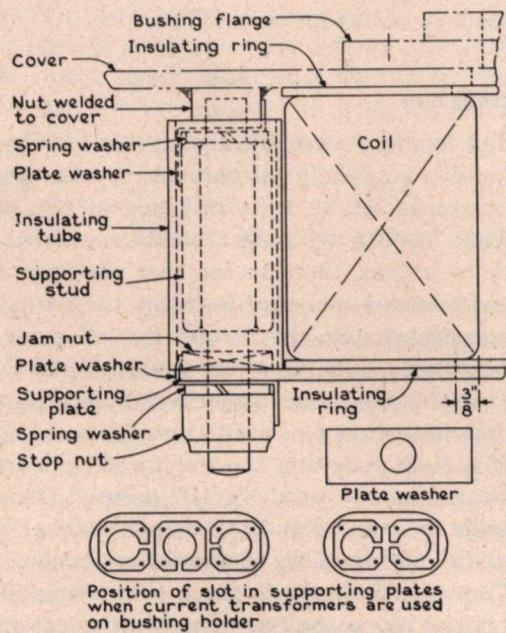


Fig. 8. Current Transformer Support

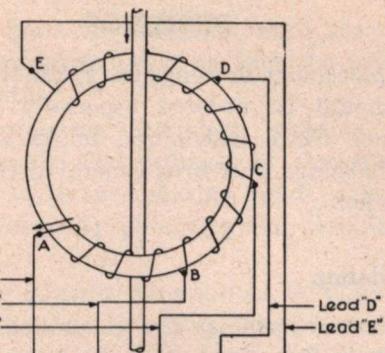


Fig. 9. Schematic Diagram of Bushing Transformer, Showing Method of Marking Leads and Method of Tapping Secondary Winding

### PYRANOL IMMERSED AIR-PRESSURE-COOLED TRANSFORMER

This transformer is a Pyranol immersed transformer cooled by jets of air (under pressure) or by free air discharge applied to the cooling surface.

Air for cooling one transformer or a bank is supplied by a unit blower and motor or by small weatherproof outdoor fans which may be hand- or automatically controlled.

All equipment is designed for outdoor service.

The motor and blower and the fan motors require the care usually given such apparatus.

If "Mercoid" controls or Type CR relays are furnished for fan control or breaker trip, they are adjusted at the factory and should not be disturbed. If changes need to be made, recommendations should be obtained from the factory.

It is recommended that the fan control circuit be automatically de-energized whenever the differential relays remove a transformer from service.

When fans are not in use, they should be operated periodically to make sure they are in satisfactory condition.

### FORCED PYRANOL TRANSFORMERS

In forced Pyranol cooled transformers, the Pyranol is cooled by circulation (forced) through an external cooler.

**NOTE.**—The Pyranol must be circulated and cooled at all times regardless of whether or not the transformer is carrying a load.

A special Pyranol cooler is generally furnished as well as a pump and motor. Each requires the care and attention always given such apparatus. The cooler is designed for outdoor installation, and may be installed in either the vertical or horizontal position.

The piping connection should be such that the water passes through the tubes in the opposite direction to the Pyranol flow. This is essential in order to obtain maximum efficiency of heat transfer. It is also essential that the water pressure be kept below the Pyranol pressure to prevent any water entering the Pyranol should a leak develop in the cooler. The coolers in most cases are designed so that this difference will always exist when rated Pyranol flow and water flow are maintained.

One end of the cooler is provided with a floating head, and provision in the piping should be made to allow for the removal of this head.

When forced-air coolers are used instead of water coolers special instructions will be furnished.

As the Pyranol enters the bottom of the transformer under considerable pressure, it is necessary that a Pyranol strainer be used to prevent the discharge of dirt and foreign material into the windings of the transformer.

Therefore, the Pyranol strainer, which is always supplied, should be installed in the cold Pyranol inlet to the transformer. It is well to install a pressure gage on each side of this strainer to determine the pressure drop across the strainer. If the strainer is not kept clean, the Pyranol flow through the transformer may be reduced to such an extent that dangerous temperatures will develop.

The quantity of Pyranol circulated has a direct bearing upon the heating and temperature rise of the transformer. It is very desirable, therefore, that the inlet and outlet temperatures of the Pyranol be measured and recorded to check the quantity of Pyranol flowing.

The top Pyranol is cooled about 15 C during passage through the cooler, and the water

temperature increased about 5 C. Usually the water flow is 50 per cent greater than the Pyranol flow.

The tubes in the cooler should be kept clean at all times. To clean, remove the cover plates from each end of the cooler and clean the inside surface with a wire brush.

The external surface of the tube bundle may be cleaned by flushing out with a volatile cleansing fluid that must be dried out by passage of hot air through this section of the cooler.

Coolers may be tested at a pressure of 100 lb per square inch to determine whether there is any leakage.

It is possible to cool the Pyranol from a bank of transformers by using one cooler and one Pyranol pump; but this practice is not favored. In such installations equalizers must be used to obtain proper Pyranol distribution, which is difficult to obtain and uncertain. Also, in case of trouble in one unit, damaged Pyranol would be pumped directly into the good transformers.

A separate cooler and Pyranol pump for each transformer are recommended.

#### **IF TRANSFORMER DOES NOT OPERATE**

If a Pyranol transformer fails to operate, it is recommended that the unit be sealed immediately from the atmosphere and the nearest General Electric Company office notified. A sample of the Pyranol should be taken from the top of the transformer and inspected for discoloration and the presence of water. The Pyranol should then be promptly circulated through a Pyranol purifier until the Pyranol is clear and the dielectric strength is normal. Refer to instructions under "Drying and Filtering."

The transformer should be kept sealed and the interior should not be removed for examination until recommendations for examination are received from the General Electric Company. After the examination is made, the interior should again be immersed in the Pyranol and the unit kept sealed until the repair parts are available.

As early as possible, a one-quart sample of the purified Pyranol obtained in accordance with

instructions covering SAMPLING PYRANOL, together with information as to the serial number, the rating of the transformer and the results of the inspection of the original Pyranol sample should be sent promptly to the Pittsfield Works of the General Electric Company, Pittsfield, Mass., in order that an analysis and recommendations for repairs can be made.

### JUNCTION BOXES

A transformer is sometimes equipped with a junction box, a metal housing that completely incloses the connection between the transformer bushing and the cable. It should be kept filled to the proper level with the insulating medium specified, Pyranol oil, or petrolatum. For the lower voltages air is sometimes used.

Before making the connections, refer to the special instructions furnished with the cable end or cable terminal.

### TRUCKS

Bearings, whether bushed or of the roller type, have a  $\frac{1}{8}$ -in. pipe plug provided in the end of the journal. To lubricate the bearing, remove the plug and insert an Alemite fitting. Trucks are shipped with the bearings filled with grease, but the bearings should be inspected and refilled from time to time to prevent corrosion.

### LOAD-RATIO CONTROL

Transformers which are equipped with load-ratio control, that is, those arranged to permit a change of taps without disconnecting the load, require the addition of a number of mechanical parts, and call for special electrical connections. Their installation, therefore, needs special attention. For this reason all such transformers are covered by a special instruction book which should be thoroughly read before any attempt is made to assemble or operate such transformers.

### RENEWAL PARTS

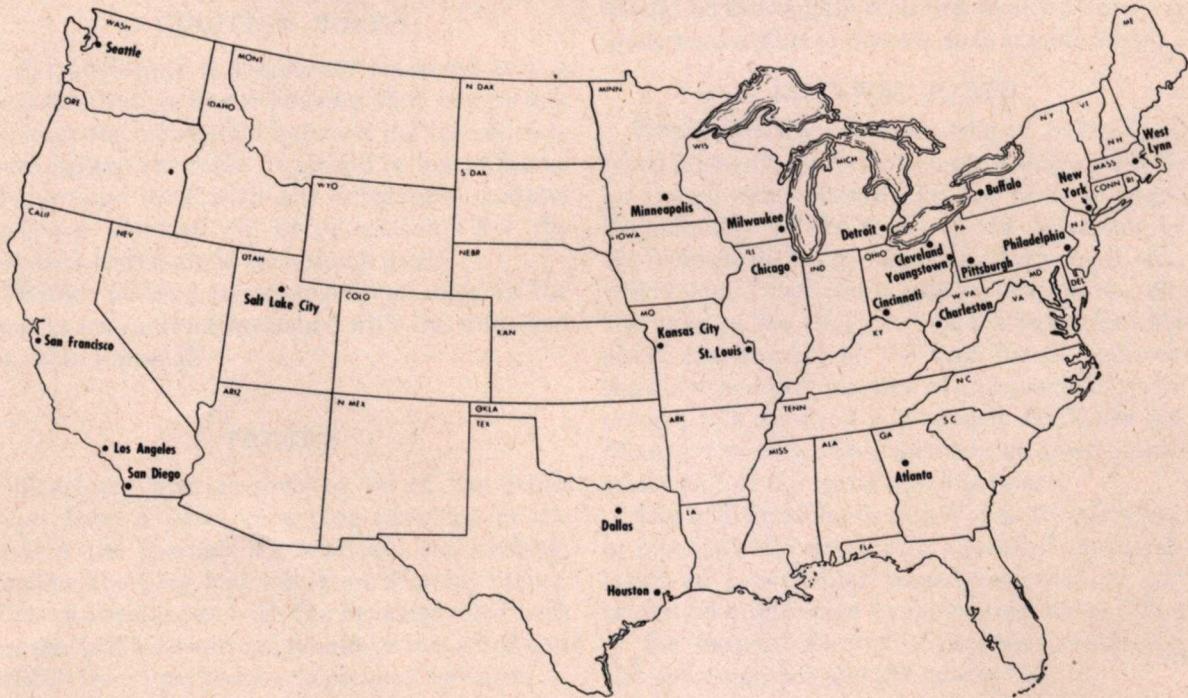
When ordering renewal parts or Pyranol, or when requesting information regarding a particular transformer, always state the serial number. This number will be found on the nameplate of the transformer. On large transformers it also will be found stamped on the top core frame, the top band of the tank, and on the cover directly above the number on the tank band. A sketch showing the exact location of coils, insulation, or other parts required will greatly facilitate the filling of the order. This sketch must always state which side of the transformer is shown.

Any additional information as to the electrical or mechanical construction, operation, or installation of a particular transformer may be obtained by application to the nearest Sales Office of the General Electric Company, mentioning the serial number and the rating.

## WHEN SERVICE IS REQUIRED

**G**ENERAL ELECTRIC operates 23 apparatus service shops strategically located and competently manned by trained personnel. Each shop is a complete service unit with modern equipment for repairing, reconditioning, and rebuilding G-E apparatus to factory specifications. The services of these shops are available at any time of day or night for work in the shops or on purchaser's premises.

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