

Westinghouse Large Synchronous and Induction Motors

Installation

Operation

Maintenance

INSTRUCTION BOOK

Westinghouse Electric Corporation
East Pittsburgh, Pa.

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PREFACE

This instruction book is intended to serve as a guide during the installation and operation of the machine so that maximum useful life will be obtained. Every machine should be kept clean, and should be inspected at regular intervals. In this manner, most difficulties will be found and corrected before they become serious enough to cause a shut-down.

Westinghouse

Large Synchronous and Induction Motors

Part I

GENERAL INFORMATION

Shipment and Handling

Before shipment, all motors are assembled, inspected and tested to eliminate electrical and mechanical defects. If the crate or wrapping appears damaged, the motor should be unpacked at once, in the presence of a claim adjuster, and all apparent injuries and breakage reported to the Transportation Company. When writing to the Westinghouse Electric & Manufacturing Company concerning the machine, always give the serial number which appears on the name plate or on the end of the shaft.

All lifting should be done by means of eye-bolts or lifting bars when provided. Never lift or support the stator by the core, punchings or coils. When lifting completely assembled machines which are mounted on a bedplate, slings should be attached in the openings which are provided. Arrange the slings so that the weight is distributed uniformly and use care to avoid distortion of the bedplate. The weight of the motor should be supported by the frame feet when it is not being lifted.

If the machine has been exposed to a low temperature, the covering of the winding should not be removed until the temperature of the machine is nearly as high as that of the room in which it is to be unpacked. Otherwise, "sweating" may result.

Storage

Machines which cannot be installed as soon as received, should be stored in a room which is clean and dry. Refer to the section entitled "Machines Out of Service" for the method of protection during this period.

Location

It is important that the location of the

machine meet the requirements of the National Board of Fire Underwriters and all local regulations. The following additional considerations should also govern the location.

- a) Install the machine so that it is well ventilated and easily accessible for cleaning, inspection and assembly.
- b) Avoid exposure to mill and coal dust, or any other injurious substances.
- c) Protect the machine from moisture, acid or alkali fumes.

The motor room must be well ventilated so that the hot air can escape and will not be re-circulated through the machine. Unless the room is large and well ventilated, natural ventilation will not be sufficient. If the machine is designed to take air from the pit, suitable ducts must be provided in the foundation. The outline drawing shows the approximate size of the pit.

Foundation and Erection

The foundation should consist preferably of solid concrete walls or piers, which should be carried down far enough to rest on a solid sub base. If it is necessary to support the machine on steel work instead of concrete, the beams or girders should be adequately braced and supported by columns. A rigid foundation is essential so that vibration and misalignment during operation will be reduced to a minimum. Pedestal type motors depend on the foundation to help maintain accurate alignment of the shaft and air gap.

The outline drawing, which is furnished with each machine, gives all dimensions necessary for the location and mounting. A template made to the dimensions on the outline drawing will simplify the work of locating the foundation bolts. It is best to provide for some varia-

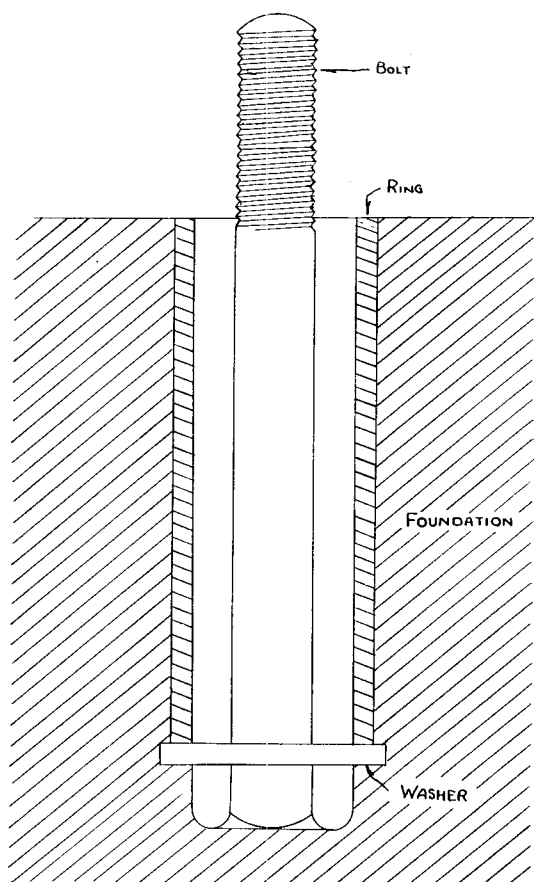


FIG. 1—METHOD OF ANCHORING FOUNDATION BOLT

tion in the location of the foundation bolts. This can easily be done by locating the bolts in steel pipe embedded in the foundation, as shown in Fig. 1 and 2.

The top of the concrete foundation should be roughened, cleaned and washed before the bedplate is placed upon it. A roughened surface permits a good bond between the foundation and the grout.

The machine, completely assembled, should be adjusted on the foundation by means of steel plates and shims beneath the bedplate so that the bedplate is substantially level, the stator air gap is correct and the coupling alignment is satisfactory. These checks should be made with the foundation bolts pulled tight. The bedplate should then be grouted to the foundation.

A wooden form is the best method of retaining the grout inside and outside the bedplate. The grout is mixed in the proportion of one part clean sand to one part Portland cement. Add water until the mixture is thin enough to be tamped thoroughly under the base. Fabricated

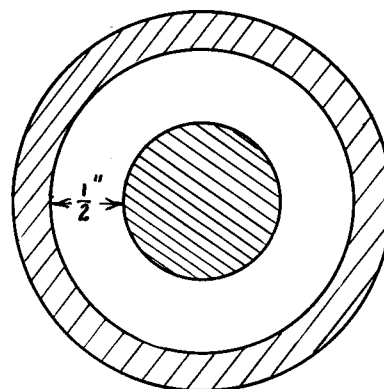


FIG. 2—SECTION SHOWING CLEARANCE BETWEEN PIPE AND BOLT

bedplates are preferably grouted to the bottom of the web as shown in Fig. 3. Rails are grouted to within a half inch of the top.

The entire operation of mixing and pouring the grout should be completed without interruption and as rapidly as possible.

Coupling Alignment

The motor should be accurately aligned with its connected mechanical load so that shaft stresses, vibration and coupling wear will be reduced to a minimum. Rigid couplings should be checked for alignment and truth by loosening the bolts and measuring with thickness gauges between the coupling faces with the shafts setting at four angular positions, equally spaced. The alignment should be sufficiently accurate to give no more than .002 inches variation between the faces, per 12 inches of

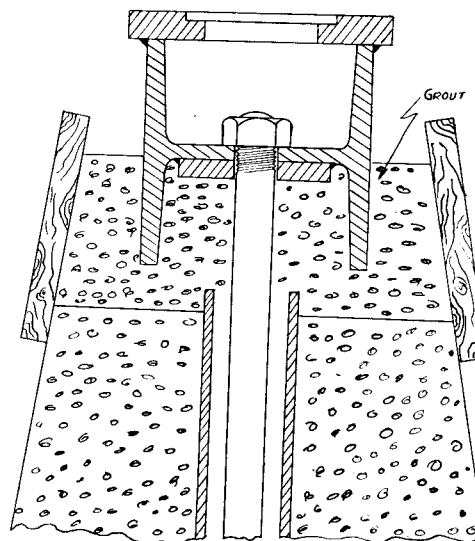


FIG. 3—SETTING OF STRUCTURAL STEEL BEDPLATE

Large Synchronous and Induction Motors

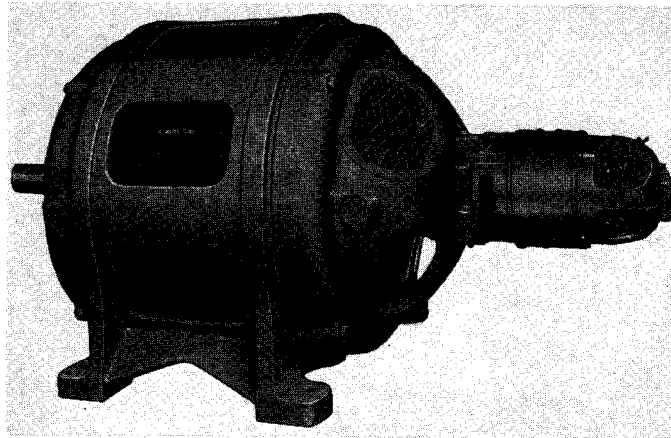


FIG. 4—TYPE G SYNCHRONOUS MOTOR AND DIRECT CONNECTED EXCITER

face diameter. Care should be observed in checking the alignment to insure that the pilot fit in the coupling is not so tight that it affects the alignment measurements.

Flexible couplings should not be forced to accommodate excessive misalignments. This will produce undue wear and can cause vibration. Fast type flexible couplings should be aligned, as outlined in the Bartlett Hayward catalogue, by checking between the coupling hub faces with feeler gauges and with straight edges from one hub cylindrical surface to the other. This will eliminate both offset and angular misalignment.

Some flexible couplings are not arranged so that they can be readily checked for alignment, and when this is the case, dial indicators should be used for alignment purposes. Mount the indicator on one shaft and read radial as well as axial variations between the coupling halves as they are revolved slowly together. Where the two half couplings float axially with respect to each other, it is necessary to use two indicators mounted 180° apart and obtain the difference in the two axial readings in order to check the angular alignment.

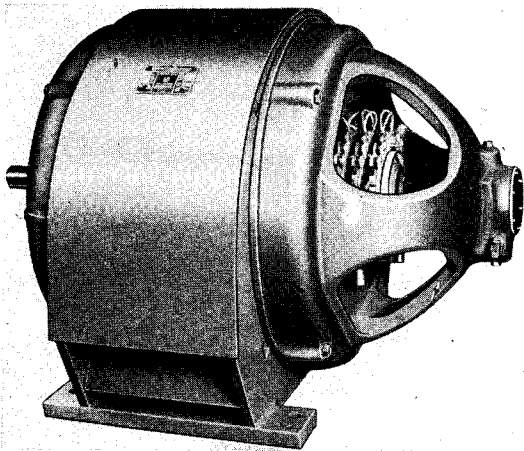


FIG. 5—TYPE CW WOUND ROTOR (BRACKET TYPE)
INDUCTION MOTOR

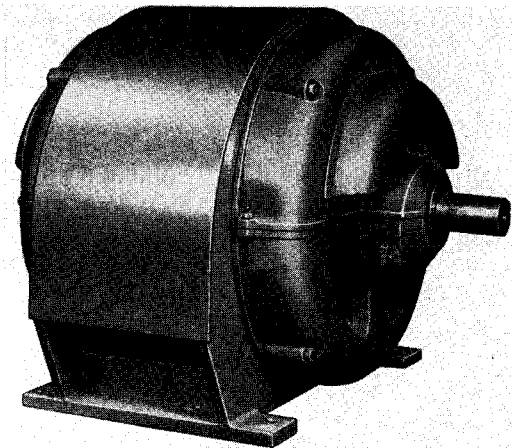


FIG. 6—TYPE CS SQUIRREL CAGE DRIPPROOF
INDUCTION MOTOR

Part III

BELTED MOTORS AND EXCITERS

Slide Rails

Belted motors are usually furnished with slide rails to permit movement to obtain proper belt tension. The rails must be accurately leveled and securely bolted to the foundation. The rails should be located so that the shaft of the motor is parallel with that of the machine which it drives.

Distance Between Pulleys

The minimum distance between pulleys

should be approximately $2\frac{1}{2}$ times the diameter of the larger pulley. If the distance is smaller, an idler pulley may be required for flat belt drives.

Belt Tension

The belt tension should just be tight enough to avoid slipping, and must not be excessive, otherwise the bearings may be damaged from overheating. Avoid vertical belt drives except where the belt pull with respect to the motor is downward.

Part IV

STARTING AND OPERATION

Connections

Connect the motor by referring to the diagram which is furnished with the control apparatus. Standard motors are connected as follows:

a) Three-phase, three-wire power supply. Connect the three line leads to the three motor terminals. To reverse the direction of rotation, interchange any two leads.

b) Two-phase, four-wire power supply. Connect the leads from one phase to motor terminals marked T-1 and T-3, and the leads from the other phase to motor terminals marked T-2 and T-4. To reverse the direction of rotation, interchange the leads of one phase.

c) Two-phase, three-wire power supply. Connect the two outside leads to motor terminals T-1 and T-2 and the common lead to T-3 and T-4 joined together, or to T-3 if the motor is internally connected for 3-wire operation. To reverse the direction of rotation, interchange the two outside leads.

When the machine has more than the standard number of leads, refer to the connection name plate or to the outline drawing.

All wiring must be installed in accordance with the National Board of Fire Underwriters and the local requirements.

Grounding

It is recommended that the frame of the motor be grounded as protection to the operator in case of a breakdown of the stator winding.

Rotation

All motors having straight radial blowers are suitable for either direction of rotation. Two-pole motors always have inclined blade or propeller type blowers and are suitable only for one direction of rotation. A rotation plate shows direction of rotation.

Starting—All Motors

Before starting the motor for the first time, the following instructions should be carefully observed:

1. Be sure that the voltage and frequency on the nameplate correspond with that of the power line.

2. Check all connections to make certain that they have been properly made.

3. Fill the bearings with a good grade of oil to the height indicated on the gauge. (Refer to the section entitled "Bearings" for the proper grade of oil.)

4. Inspect all electrical clearances. Be sure that brush shunts do not touch each other.

5. Carefully examine the interior of the motor, coil ends, air gap, slip rings, spider, and the spacer between poles for loose objects such as bolts, nuts, and tools.

6. Be sure that all moving parts have sufficient clearance with respect to the nearest stationary part.

7. If possible, turn the rotor by hand to see that it rotates freely.

8. As soon as the machine has started, observe the oil rings to see that they are turning and are feeding oil to the bearings.

Starting—Synchronous Motors

The following additional requirements should be observed when starting synchronous motors:

1. See that the damper segments of engine type machines assembled in the field are connected at the split and the nuts are tightened.
2. Be sure that the field switch is in the position to short the field through the resistance provided for that purpose, and that the circuit is closed.
3. After starting and when constant speed has been reached, the field switch is thrown, applying the exciting voltage to the field winding.
4. Adjust the field current to the value marked on the motor name plate, which will give rated power factor at rated load.

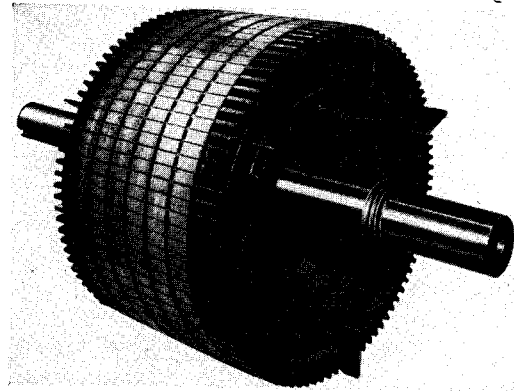


FIG. 10—ROTOR OF TYPE CS SQUIRREL CAGE INDUCTION MOTOR

Starting—Induction Motors

1. Be sure that the correct value of resistance is connected in the secondary circuit.
2. Never apply a wound rotor motor to plugging service unless it was designed for that service.

Part V

COLLECTOR RINGS AND BRUSHES

Brushes and Brush Rigging

The brush holders should clear the collector rings by approximately one-eighth inch. Brush shunts must not be permitted to touch each other or any part of the brush rigging.

Replacement brushes are ground in by drawing fine sandpaper under each brush in the direction of rotation, while pressing the brush against the ring, until the contour of the brush is the same as that of the ring.

The spring tension should be adjusted to give a brush pressure of $2\frac{1}{2}$ pounds per square inch for carbon, and $3\frac{1}{2}$ pounds per square inch for

metallized brushes. The pressure should be equal on all brushes so that the current will divide evenly.

The brushes must move freely in the holder. If there is a tendency to stick, rub the side of the brush with fine sandpaper. The correct grade of brush is supplied with the motor, and for best results, this grade should always be used.

Collectors—Low Speed

All motors having split spiders are also provided with split collector rings. The bolts at the split must be removed when assembling the spider. Dowels are provided so that the halves of the collector rings can be accurately bolted together. If the halves do not fit together exactly, they should be lined up by tapping with a rawhide mallet or wooden block.

All collector rings are turned concentric with the bore of the hub. If care is taken in assembling the spider on the shaft, the rings will run true. An eccentricity of $1/64$ inch is permissible on low-speed machines. If the eccentricity is greater than this, the nuts on the collector studs should be slightly loosened and the rings tapped lightly into position. A dial

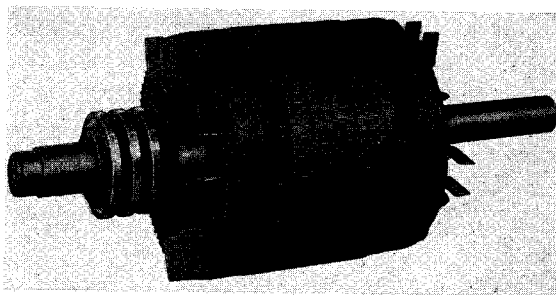


FIG. 11—ROTOR OF TYPE CW WOUND ROTOR INDUCTION MOTOR

gauge will be found convenient for measuring the eccentricity.

Collectors—High Speed

High speed collector rings must run true at all times, otherwise they must be ground or turned to restore a smooth and true condition. Hand grinding or turning is not advised because the eccentricity may actually be increased by this method.

General Information

It is important that the collector and brush rigging be kept clean at all times. If dirt and dust are permitted to accumulate, a flashover is likely to result. Most collector ring troubles are due to lack of proper care and maintenance.

Any black spots that appear on the surface of the collector rings should be removed by lightly rubbing with fine sandpaper. These spots are not serious in themselves, but they will lead to pitting of the rings unless removed. If the condition is corrected as soon as it is found, no harm will be done to the rings.

Sometimes an imprint of the brushes will be found on the surface of the collector rings. This usually occurs on a machine which is subjected to moisture or acid fumes which act on the sur-

face of the rings. When the machine is shut down, the fumes will act upon the surface of the ring except where it is in contact with the brushes. The difference in surface caused by this condition may cause a slight burning as the ring rotates.

Brush imprint on the rings may also be caused by a slight unbalance in the rotor which may cause a jerk or movement in the ring once every revolution. The brush jumps slightly with a small arc which, in time, burns an imprint of the brush on the ring. Elliptic or egg-shaped rings may also cause this condition.

Brush imprints due to moisture or fumes will occur at any point where the motor happens to stop. Imprints due to unbalance will always occur at the same place on the ring.

Since there is always an electrolytic action on the surface of a steel ring, the collector operation of a synchronous motor is improved by reversing the polarity of the rings at intervals of two weeks.

The brushes and rings of wound rotor induction motors may be burned if an attempt is made to start a heavy load with too little resistance in the secondary circuit.

Part VI

ELECTRICAL MAINTENANCE

Machines Out of Service

Machines which will be shut down for an extended period require special care. The room in which the machine is located should be kept dry and warm to prevent condensation of moisture on the windings. Brushes should be lifted and the collector rings should be coated with paraffin or rust-resisting compound. This coating must be carefully removed and the brushes lowered before the motor is started.

Bearing surfaces should be inspected frequently and the surfaces must be kept coated with heavy oil to avoid rusting.

Before a machine is started after an extended period of idleness, it must be given a thorough inspection and cleaning. Remove all grease from the collector rings and polish, if necessary. Measure the insulation resistance to determine whether or not drying out is required.

Cleaning Insulation

Electrical machinery should be kept free from accumulation of dirt so that the ventilating ducts will not be clogged and so that con-

ducting paths will not be formed between live parts.

Compressed air is very effective in removing dirt which does not adhere too tightly. The air must be free from moisture and the pressure should not exceed 50 lbs. per square inch, to avoid damage to the outer covering of the insulation.

When the dirt contains grease or oil, a solvent will usually be required to remove it. The cleaning is done by sponging with rags which have been wet in the solution. The solvent should be applied sparingly, and the insulation must be thoroughly dried afterward to remove the solvents generally used are benzine or carbon-tetrachloride, or a mixture of the two. These compounds must be used with care because of their inflammable, explosive or toxic nature.

Warm water may sometimes be used effectively, but the washing must be rapid, and the apparatus must be thoroughly dried in an oven

or with a jet of hot air to prevent the water soaking into the windings.

Cleaning by wiping with a dry cloth is often satisfactory and is recommended wherever it can be used. Waste should not be used, because the lint may adhere to the winding, collecting dust, moisture, and oil. If the insulation shows signs of dryness, it should be cleaned and varnished, preferably under the direction of a Westinghouse Service representative.

Drying Out

If the motor has been subjected to extreme dampness, drying out will be necessary. The simplest method is by the application of external heat, preferably with electric heaters or with hot air blown over the windings. The temperature of the insulated parts should be maintained, 15 to 25°C. higher than the ambient temperature of the air, but not less than 40°C. or more than 80°C. total temperature. The process should not be hurried and must be continued until the insulation resistance reaches a satisfactory value.

Insulation Resistance

Insulation resistance measurements are made to determine the condition of the winding, and are especially useful when drying out a winding. The resistance may be measured either by a megger or by using a 500-volt direct-current circuit and a 500 volt direct-current voltmeter. The insulation resistance is calculated by the following formula:

$$R' = \frac{R (V - V')}{V' (10^6)} \text{ where}$$

V = Line Voltage

V' = Voltage reading with insulation in series with voltmeter.

R = Resistance of Voltmeter.

R' = Resistance of Insulation in megohms.

A convenient connection diagram is shown in Fig. 12.

The insulation resistance of a machine at the operating temperature should not be less than that given in the following formula:

$$R \text{ (Megohms)} = \frac{\text{Terminal Voltage}}{\left(\frac{\text{Rating in Kv-a}}{100} \right) + 1000}$$

Additional information will be found in the Westinghouse Handbook "Maintenance Hints".

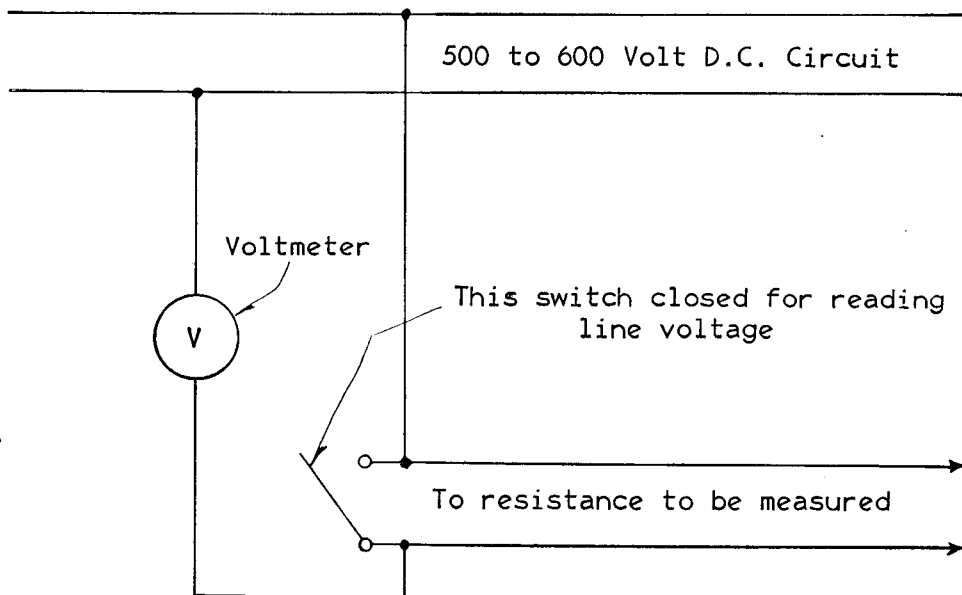


FIG. 12—DIAGRAM OF CONNECTIONS FOR MEASURING INSULATION RESISTANCE

Part VII

HORIZONTAL BEARINGS

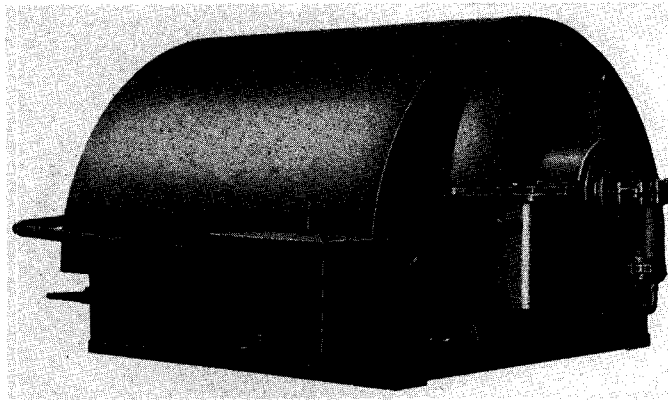


FIG. 13—TYPE CS SQUIRREL CAGE INDUCTION MOTOR, 3600 RPM.

Sleeve Bearings (1800 rpm. and below)

Sleeve bearings which operate at 1800 rpm. and below are normally self-cooled and ring-lubricated.

Before starting the motor, fill the bearing reservoir with the proper grade of high-quality lubricant, to the level marked on the oil gauge or to within $\frac{1}{8}$ inch of the top of the cup, if no oil gauge is provided. Engine oil having a viscosity of 180 to 220 SSU at 100°F. is recommended for these lower speed bearings.

The bearings should be inspected at regular intervals to check the amount and condition of the oil in the reservoir as well as the operation of the oil rings. At intervals of from six months to one year, depending upon operating conditions, the bearing reservoirs should be drained, flushed out and refilled.

Certain pole and punching combinations have a tendency to produce circulating currents between the shaft and the bearing. When this condition may exist, the front bearing is insulated to prevent the flow of current. This insulation must not be short-circuited. If oil pipe or electrical connections are made to the bearings, insulated joints must be inserted in the pipe or conduit.

Sleeve Bearings (3600 rpm.)

Motors which operate at 3600 rpm. have flood-lubricated bearings. There are three types of lubrication systems for supplying oil to the bearings. One method consists of a positive feed oil pump, mounted at the front end of the motor, and driven from the end of the shaft.

Oil is drawn from a tank or reservoir mounted on the side of the frame and pumped through pipes which connect to the bearings. A second method is similar except that the oil pump is driven by a separate motor. The third method is to supply oil from a central system.

To supplement the flood system of lubrication, the bearings are sometimes provided with oil rings. These rings supply oil during the period required for the pump to fill the bearing supply pipes.

When the oil rings are used, the motor bracket is shaped to form a reservoir which supplies oil to the rings. The reservoir is kept full by the flood system. However, for the initial start, this reservoir must be filled by pouring in oil through the oil ring sight holes, thus insuring that the bearings will be lubricated as soon as the shaft begins to revolve. It is not necessary to repeat this operation until the housing has been drained for cleaning.

Use only the best grade of turbine oil having a viscosity of 140 to 160 SSU at 100°F. for the bearings of these 3600 rpm. motors. Each bearing requires $\frac{3}{4}$ gallon of oil per minute. The rate of flow must never exceed 1 gallon per minute. For oil systems integral with the motor, the rate of oil flow is set at the factory and further adjustment is not required. When either of the other two systems is used, the rate of flow must be adjusted by means of a valve or orifice before permanently connecting the bearing supply pipes.

For the integral system, with the pump driven from the main shaft, the tank is located on the side of the frame at such height that

the pump is automatically primed when the tank is filled to the level shown in the gauge. Always maintain the oil level between the marks on the gauge. A lower level may prevent the priming of the pump, and a higher level may prevent free drainage from the bearings.

For the system which has a separately driven pump and separately mounted tank, locate the tank as specified on the outline drawing. It is recommended that the starter of the pump motor be interlocked with the main motor starter so that the main motor cannot be started unless the oil pump is in operation.

The radiating surface of the tank and connecting pipes is usually sufficient to keep the oil and bearings cool enough for satisfactory operation. However, an oil cooler may be required under certain conditions of operation.

Anti-Friction Bearings

Ball and roller bearings are frequently used with large industrial motors. These bearings are used where the motor must be able to withstand end thrust or when their use has been requested by the customer.

The anti-friction bearings in large horizontal motors are usually grease-lubricated. They are packed with grease when assembled at the factory and require only the addition of approximately one ounce (2 cu. in.) of grease every three months. At intervals of approximately two years, depending upon the application, the bearing should be cleaned thoroughly and then repacked with grease. When repacking, the bearing and seal cavities beside it should be filled approximately two-thirds full of a good quality sodium base grease of the channeling type.

The greases listed below are satisfactory for the lubrication of ball and roller bearings. One of these greases or an equivalent should be used:

Lubriko M-6

Lubriko M-21

Master Lubricants Corporation.

Starfak Regal No. 2

The Texas Company.

Norma Hoffman No. 51

Norma Hoffman No. 58

Norma Hoffman No. 66

Norma Hoffman Bearing Company.

Part VIII

VERTICAL MOTORS

Vertical construction is frequently used for both synchronous and induction motors. The most common application is that of driving a centrifugal pump. Vertical motors may be described as open, drip-proof, weather-proof, or splashproof. The shaft is either solid or hollow, depending upon the requirements of the pump. Both cast and fabricated construction are used. Large motors are usually fabricated.

The thrust bearing of a vertical motor is required to support the weight of the pump runner, connecting shaft and pump thrust in addition to the weight of the rotating parts of the motor. The thrust bearing may be either Kingsbury or anti-friction type.

Kingsbury Thrust Bearing

The Kingsbury bearing consists of a runner, keyed or bolted to the upper end of the motor shaft, and a set of segmental babbitted shoes

which support the runner by means of oil film between the lower polished surface of the runner and the upper babbitted surfaces of the shoes. The bearing assembly is adjusted so that the segmental shoes divide the load equally.

The bearing used in Westinghouse motors is not a self-aligning type. Each shoe is supported by an individually adjusted jack screw, and if the bearing is dismantled for any reason except failure, the adjustment of the jack screws should not be disturbed. When new shoes are installed or it is thought that the adjustment is faulty, the bearing should be readjusted as described in the following paragraph:

Uncouple the motor from the load and place in a level position. Shim the runner so that it is in the exact center of the upper guide bearing. Remove the lower guide bearing. Adjust the jack screws by means of a wrench by "feel"

until the shoes carry approximately equal loads and the shaft is in the center of the lower guide bearing fit. After this adjustment has been made, measure the gap in four equally spaced points around the periphery. Diametrically opposite air gap measurements should be within 10% of each other. This adjustment requires an experienced workman, and it is advisable to obtain the services of a Westinghouse representative.

The shoes of a Kingsbury bearing are carefully scraped to fit the runner surface and should show a characteristic marking pattern over the entire shoe surface. Less than 70% contact is not satisfactory and the bearing may "wipe" during starting.

Kingsbury bearings should be lubricated with a good grade of engine or machine oil. A viscosity range of 200 to 250 SSU at 100°F. is recommended for bearing operations at speeds of 600 rpm. and above, while 250 to 325 SSU at 100°F. should be used in lower speed bearings. Examine the oil at regular intervals for contamination and acidity, replacing if necessary.

Anti-Friction Thrust Bearings

Anti-friction thrust bearings are either angular contact ball, tapered roller, or flat roller type. The flat roller bearing requires an upper guide bearing to hold the shaft in its central position.

Anti-friction thrust bearings require no adjustment, but must be properly assembled, and the guide bearings accurately aligned. In addition, the oil pot must be absolutely free of contamination. Care should be observed in dismantling or assembling these bearings to insure that they are not loaded by the pulling device or become nicked or damaged in any manner. Damage of any type will shorten the life, and may cause immediate failure.

The bearing pot should be kept filled to the level marked on the oil gauge. This level may change slightly when the motor is in operation because of the circulation of the oil and change in viscosity as the oil becomes warm. For these reasons, the oil level must be checked when the machine is not in operation.

A good grade of engine or machine oil having a viscosity of 180 to 250 SSU at 100°F. is

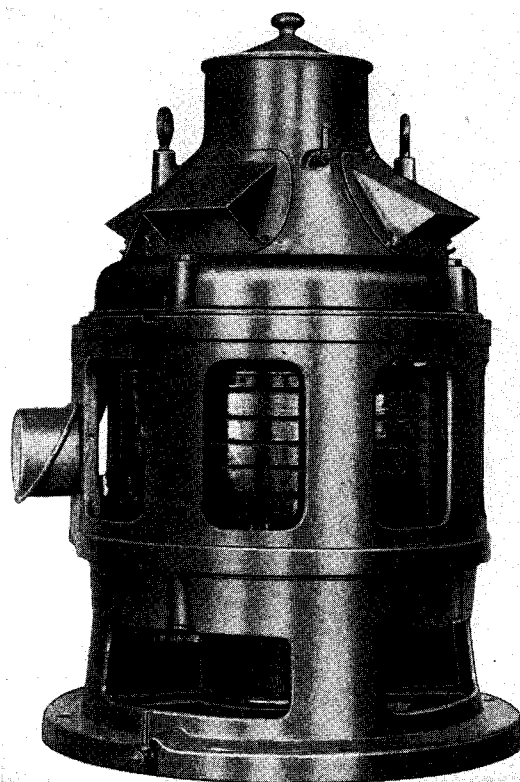


FIG. 14—VERTICAL INDUCTION MOTOR

recommended. Examine the oil at regular intervals for contamination and acidity, replacing if necessary. When the oil is changed, carefully clean and flush the oil pot to eliminate any chance of contamination.

Cooling of Thrust Bearings

Thrust bearings are usually self-cooled, but high thrust and high speed may require additional cooling. The cooling coil is usually installed in the oil pot, surrounding the bearing. Clean water, free from sediment or corrosive compounds, should be used in these coils.

Guide Bearings

Lower guide bearings are either anti-friction or sleeve type and should receive the same care and treatment as the thrust bearing. These bearings are usually very lightly loaded, and require practically no maintenance, but should be inspected at regular intervals to insure satisfactory operation. Use the same quality and grade of oil as recommended for the thrust bearing.

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Upper guide bearings are required only with Kingsbury bearings or flat roller thrust bearings. When used, they are lubricated by the same oil as the thrust bearing, and should receive the same care and treatment.

Alignment

Vertical motors are provided with a base having a machined lower surface, and when required, a rabbet fit is also furnished. It is not recommended that these parts be used for alignment purposes unless a further check of

the shaft alignment is made to insure accuracy, because the motor base is not always concentric and square with respect to the shaft.

The alignment of the coupling of a vertical motor should be checked in the manner outlined for horizontal machines. When the motor has a hollow shaft, the alignment of the inner shaft should be checked with respect to the hollow shaft to make certain that the coupling at the upper end of the motor is not subjected to excessive bending moments during operation.

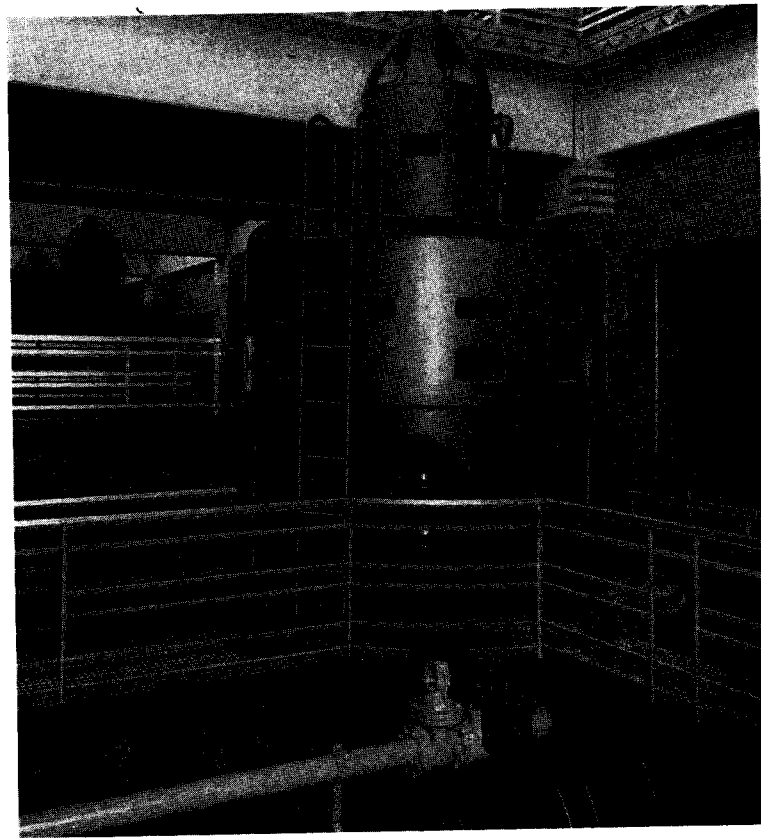


FIG. 15—INSTALLATION OF VERTICAL SYNCHRONOUS MOTORS

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.