GENERAL INFORMATION

COMMUNICATIONS

Should communications be desirable or necessary regarding the installation covered by this instruction book, or an individual device included in the installation, replies will be greatly facilitated by citing the General Order (G.O.) Number for the complete equipment, and the nameplate readings, in detail, of the apparatus involved.

Should particular information be desired, please be very careful to state clearly and fully the question for consideration, and the associated conditions.

Communications should be addressed to the nearest Westinghouse Electric Corporation Sales Office. Local Sales Engineering or service representatives are usually available for quick consultation.

DAMAGE IN SHIPMENT

Before accepting the shipment from the transportation company, examine the crate to determine whether damage has occurred in transit. If the crate is damaged, the machine may be damaged. If so, immediately notify the transportation company and also notify the nearest Westinghouse District Sales Office, giving as much information as possible concerning the nature of the damage. Keep written records of all actions taken in connection with such incidents.

STORAGE

If the apparatus is not to be installed immediately, store in a heated, ventilated building in a location free of excessive dust or vapors.

UNPACKING

The base of the cabinet is bolted to the skid, and crating encloses the entire cabinet. When removing the crate, great care should be used to avoid damage to any part of the unit. After removal of the crate, opening the doors will give access to 4 bolts which fasten the cabinet base to the skid. When these bolts have been removed, the lifting hooks can be used to lift the control from the skid.

It is strongly urged and necessary that all relays, contactors, and linestarters be investigated to see that the armatures are free to move.

GENERAL INSPECTION

1. Examine apparatus to make sure it is not damaged in any way.

2. Check the nameplates on the wall of the cabinet to see that the ratings agree with the voltage and frequency of the power supply.

3. Make certain that the armatures of all rotating equipment turn easily, particularly if the machines are not installed until some months after having been received.

4. All power connections should be installed in accordance with standard practice as outlined in the applicable electrical codes.

LOCATIONS

The rectiflow control unit need not be placed near the drive motor, since they will be connected together only by wiring. The control unit must be mounted on a firm, level foundation that is free of excessive vibration.

The control cabinet should be mounted in a well ventilated location where the ambient temperature will not rise above 40° C. The installation must be made in a clean, dry place not exposed to dripping moisture, oil vapor or steam, and not exposed to dirt from coal, ashes, or any other dusty material. The control should never be placed in a room where any hazardous process is used, or where inflammable gases or combustible materials may float in the air. If such conditions exist, the rectiflow control unit should be placed in a separate room where ventilating air is controlled to prevent explosions.

If mounted near a wall, leave at least 24 inches spacing between the back of the cabinet and the wall. This space is necessary for removing back covers for servicing the control.

The holes in the cabinet base plate that were used to bolt it to the skid can be used as mounting holes for securing the cabinet in its permanent position. This equipment is designed for indoor installation.

The usual precautions should be observed in the installation of Rectiflow. See that the armature can be turned freely by hand. If the motor is geared or direct coupled, correct alignment is very important. Flat or V-belt drives should be accurately aligned and proper belt tension maintained. The motor should have a suitable degree of enclosure against dust and moisture for the condition of the application.

WIRING

The Rectiflow is to be wired to the control unit as indicated by the external connection diagram. Correct size leads should be used for the rated current of the machine. Check motor nameplate data for rated current.

The remaining connections carry only control currents and should be wired with a flexible type of wire of about #14 size.

Refer to instruction tag to make sure that the correct voltage and frequency is used with the rectiflow control.

CAUTION

Adjustable resistors have been preset at the factory and will probably not require adjustment. If any adjustments are needed, they can be made during the initial run in accordance with specifications on the elementary diagram.

Many of the circuits on this unit are high voltage, high power. Always open the primary circuit before changing any connections.

The power transformer, a-c motor, and linestarter coil must be connected to the same a-c supply voltage. On drives, which use 110 volt control for the linestarter, the control transformer must be connected to the same a-c supply voltage as the power transformer and a-c motor.

Do not remove any tubes or tube connections while drive is running.

SAFETY FOR PERSONNEL

To insure maximum safety for personnel, it is suggested that the recommendations of the National Electrical Code, National Safety Code, and all applicable local safety regulations be thoroughly fulfilled in the installation and operation of this equipment. The following precautions should be carefully observed.

1. Make certain the equipment is properly connected before any attempt is made to operate the controls.

2. Do not operate the equipment as a complete unit without first testing the operation of the individual units as thoroughly as possible.

3. Never operate contactors or relays by hand without first making certain the power is completely disconnected.

MAINTENANCE

General

A regular inspection and maintenance procedure is valuable in minimizing "Down" time by detecting potential troubles before they occur.

Remove dust from all parts of the control with a soft brush or an air hose. If an air hose is used, the supply must be free from dirt and water.

Use fuses of the same size as originally furnished. The fuses provide short circuit protection and minimize fire hazard. When fuses "blow" it is an indication of trouble in the control and not an indication that the fuse is too small.

Average voltage across the control bus will decrease as aging of rectifiers occurs. This voltage should be kept near to the voltage given on the elementary diagram, by use of the extra transformer taps.

It is best to study the control when it is new and operating normally and this inspection may then be used as a guide in the location of trouble.

SERVICING HINTS

General Remarks

1. Check the a-c line power supply and all connections to see that they are made in accordance with the external connection diagram.
2. Check the transformer secondary voltages to determine if they are approximately as given on the elementary diagram.

Motor Fails to Start

1. Check fuses and overload relays for closed circuits.
2. Check contactors and relays to make sure their contacts are closing properly.

   Check for an open armature circuit.

Current Limit

Relay "FF" is provided to limit the current during acceleration.

When the armature current exceeds a preset value, relay "FF" energizes, applying full field current to the shunt field. The drive immediately starts slowing down. The output horsepower is reduced as is the armature current. When the armature current approaches a lower preset value, relay "FF" de-energizes and the field excitation returns to the value set by the speed con-rol. The drive will speed up, increasing armature current and horsepower output until the relay again picks up and the cycle begins again. The relay exercises a field fluttering action limiting the armature current until the speed stabilizes.

GENERAL INFORMATION

COMMUNICATIONS

Should communications be desirable or necessary regarding the installation covered by this instruction book, or an individual device included in the installation, replies will be greatly facilitated by citing the General Order (G.O.) Number for the complete equipment, and the nameplate readings, in detail, of the apparatus involved.

Should particular information be desired, please be very careful to state clearly and fully the question for consideration, and the associated conditions.

Communications should be addressed to the nearest Westinghouse Electric Corporation Sales Office. Local Sales Engineering or service representatives are usually available for quick consultation.

DAMAGE IN SHIPMENT

Before accepting the shipment from the transportation company, examine the crate to determine whether damage has occurred in transit. If the crate is damaged, the machine may be damaged. If so, immediately notify the transportation company and also notify the nearest Westinghouse District Sales Office, giving as much information as possible concerning the nature of the damage. Keep written records of all actions taken in connection with such incidents.

STORAGE

If the apparatus is not to be installed immediately, store in a heated, ventilated building in a location free of excessive dust or vapors.

UNPACKING

The base of the cabinet is bolted to the skid, and crating encloses the entire cabinet. When removing the crate, great care should be used to avoid damage to any part of the unit. After removal of the crate, opening the doors will give access to 4 bolts which fasten the cabinet base to the skid. When these bolts have been removed, the lifting hooks can be used to lift the control from the skid.

It is strongly urged and necessary that all relays, contactors, and linestarters be investigated to see that the armatures are free to move.

GENERAL INSPECTION

1. Examine apparatus to make sure it is not damaged in any way.
2. Check the nameplates on the wall of the cabinet to see that the ratings agree with the voltage and frequency of the power supply.
3. Make certain that the armatures of all rotating equipment turn easily, particularly if the machines are not installed until some months after having been received.

4. All power connections should be installed in accordance with standard practice as outlined in the applicable electrical codes.

LOCATIONS

The rectiflow control unit need not be placed near the drive motor, since they will be connected together only by wiring. The control unit must be mounted on a firm, level foundation that is free of excessive vibration.

The control cabinet should be mounted in a well ventilated location where the ambient temperature will not rise above 40° C. The installation must be made in a clean, dry place not exposed to dripping moisture, oil vapor or steam, and not exposed to dirt from coal, ashes, or any other dusty material. The control should never be placed in a room where any hazardous process is used, or where inflammable gases or combustible materials may float in the air. If such conditions exist, the rectiflow control unit should be placed in a separate room where ventilating air is controlled to prevent explosions.

If mounted near a wall, leave at least 24 inches spacing between the back of the cabinet and the wall. This space is necessary for removing back covers for servicing the control.

The holes in the cabinet base plate that were used to bolt it to the skid can be used as mounting holes for securing the cabinet in its permanent position. This equipment is designed for indoor installation.

The usual precautions should be observed in the installation of Rectiflow. See that the armature can be turned freely by hand. If the motor is geared or direct coupled, correct alignment is very important. Flat or V-belt drives should be accurately aligned and proper belt tension maintained. The motor should have a suitable degree of enclosure against dust and moisture for the condition of the application.

WIRING

The Rectiflow is to be wired to the control unit as indicated by the external connection diagram. Correct size leads should be used for the rated current of the machine. Check motor nameplate data for rated current.

The remaining connections carry only control currents and should be wired with a flexible type of wire of about #14 size.

Refer to instruction tag to make sure that the correct voltage and frequency is used with the rectiflow control.

CAUTION

Adjustable resistors have been preset at the factory and will probably not require adjustment. If any adjustments are needed, they can be made during the initial run in accordance with specifications on the elementary diagram.

Many of the circuits on this unit are high voltage, high power. Always open the primary circuit before changing any connections.

The power transformer, a-c motor, and linestarter coil must be connected to the same a-c supply voltage. On drives, which use 110 volt control for the linestarter, the control transformer must be connected to the same a-c supply voltage as the power transformer and a-c motor.

Do not remove any tubes or tube connections while drive is running.

SAFETY FOR PERSONNEL

To insure maximum safety for personnel, it is suggested that the recommendations of the National Electrical Code, National Safety Code, and all applicable local safety regulations be thoroughly fulfilled in the installation and operation of this equipment. The following precautions should be carefully observed.

1. Make certain the equipment is properly connected before any attempt is made to operate the controls.

2. Do not operate the equipment as a complete unit without first testing the operation of the individual units as thoroughly as possible.

3. Never operate contactors or relays by hand without first making certain the power is completely disconnected.

MAINTENANCE

General

A regular inspection and maintenance procedure is valuable in minimizing "Down" time by detecting potential troubles before they occur.

Remove dust from all parts of the control with a soft brush or an air hose. If an air hose is used, the supply must be free from dirt and water.

Use fuses of the same size as originally furnished. The fuses provide short circuit protection and minimize fire hazard. When fuses "blow" it is an indication of trouble in the control and not an indication that the fuse is too small.

Average voltage across the control bus will decrease as aging of rectifiers occurs. This voltage should be kept near to the voltage given on the elementary diagram, by use of the extra transformer taps.

It is best to study the control when it is new and operating normally and this inspection may then be used as a guide in the location of trouble.

SERVICING HINTS

General Remarks

1. Check the a-c line power supply and all connections to see that they are made in accordance with the external connection diagram.

2. Check the transformer secondary voltages to determine if they are approximately as given on the elementary diagram.

Motor Fails to Start

1. Check fuses and overload relays for closed circuits.

2. Check contactors and relays to make sure their contacts are closing properly.

   Check for an open armature circuit.

3. Check voltage of transformer secondary.

Motor Stops Suddenly

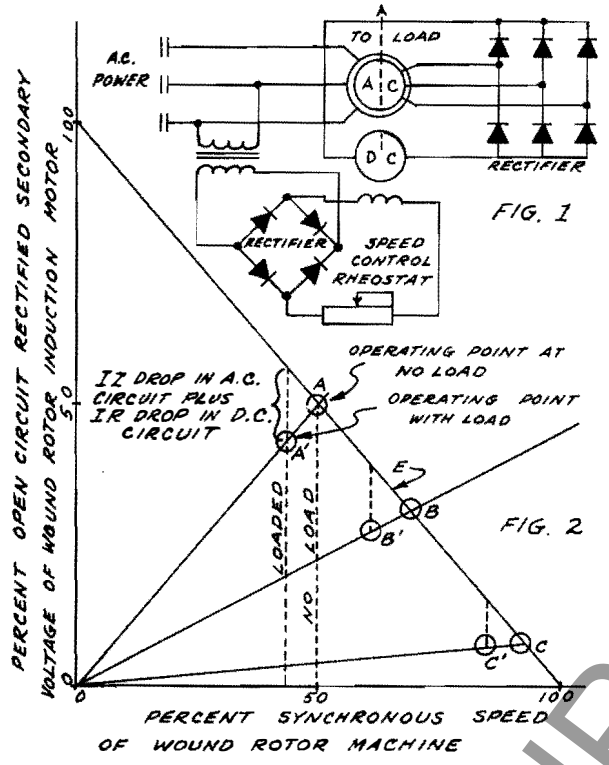
1. Check fuses.
2. Check overload relay. Before resetting the overload relay, time must be allowed for the relay to cool. Check armature circuit for consistent overload.
3. Check for failure of main power supply.

No Field Current

1. Check for an open field rheostat.
2. Check to be sure that proper d-c voltage is available across the field circuit.
3. Check for open field circuits or open motor field windings.

Westinghouse

INSTRUCTION MANUAL FOR ROTATING MACHINE OF WESTINGHOUSE RECTIFLOW DRIVE



Speed and Voltage Relationships for Rectiflow Drive with 2 to 1 Speed Range

THEORY OF OPERATION

The Westinghouse Rectiflow a-c adjustable speed drive consists of a wound rotor induction motor and a d-c motor connected to the same output shaft, and a semiconductor rectifier. The rectifier rectifies the slip power to the armature of the d-c motor. The d-c motor converts the slip power to mechanical output. The field of the d-c motor is separately excited to permit speed control. Speed range is determined by the base speed of the d-c motor and the relationship of its rated voltage to the induction motor rotor voltage.

The operation of the a-c motor part of the drive is like that of a conventional wound rotor motor. The d-c machine on the other hand provides the unique characteristics. A counter EMF is generated by the d-c motor that bucks the rectified a-c rotor circuit voltage. The difference between these voltages is such that the rectified rotor voltage is just sufficient to circulate load current through the a-c rotor, the rectifier and the d-c armature. If the d-c motor field is weakened during operation, the generated back EMF decreases, allowing more current to flow. This produces more torque in both a-c and d-c machines and the drive accelerates to a higher speed. As the speed increases the rotor slip voltage decreases and the BEMF increases. Acceleration ceases when these voltages differ by the amount required to circulate running load current at the new speed.

The sketch, figure #1, shows a simplified diagram of the Rectiflow drive with a speed regulator for controlling the d-c motor excitation. The curve, figure #2, indicates rectified a-c rotor circuit and d-c armature voltages as functions of drive speed for several values of d-c motor field strength. As is the case with drives having a power rectifier the drive will not regenerate.

You will note from figure #2 that the secondary a-c voltage is proportional to the slip of the wound rotor motor. If the d-c field is open and the linestarter A is closed the wound rotor induction motor comes up to full speed. The performance under these conditions is exactly the same as a wound rotor induction motor with a small amount of external resistance. If the d-c motor field is now strengthened to 50%, the d-c voltage rises to the value marked D on the diagram. This voltage is higher than the secondary a-c voltage and no current will flow from the a-c wound rotor through the rectifier and through the d-c machine. The Rectiflow's speed will decrease until the point E is reached where the a-c secondary voltage is higher than the d-c counter EMF and current flows. This current produces torque both in the a-c rotor and the d-c armature. As additional load is applied, the speed drops slightly, the a-c voltage increases and the d-c counter EMF decreases permitting more current to flow until the required torque is obtained.

The Rectiflow drive rotating machines are of two general types of construction. The smaller ratings are built unit frame. That is, both the a-c and d-c rotors are on the same shaft; the a-c and d-c frames are bolted together using an adapter and only two bearings are required. The larger ratings consist of standard, two-bearing, a-c wound rotor and d-c motors coupled together on a bedplate.

WARRANTY

The corporation in connection with apparatus sold agrees to correct any defect or defects in workmanship or material which may develop under proper or normal use during the period of one year from the date of shipment, by repair or by replacement F.O.B. factory of the defective part or parts, and such correction shall constitute a fulfillment of all the corporations' liabilities in respect to said apparatus, unless otherwise stated in the quotation.

Any defects that may develop should be referred to the nearest Westinghouse Sales Office for complete servicing information.

GENERAL

To obtain long satisfactory service from rotating electrical equipment, it is necessary to properly install, operate and maintain such equipment. The following gives the simple precautions and instructions for such care. Properly maintained equipment will require very little care other than periodic inspections and lubrication. The most important factor is to keep the apparatus clean and free of oil, water and other foreign material.

INSPECTION

As soon as the apparatus is unpacked give it a thorough inspection. Look especially for any loose field connections, bolts, covers, broken brushes or brushholders and any noticeable damage to coil insulation. Repair immediately any damage found. If machine has been in storage some time or has been exposed to dampness, the insulation resistance should be checked. See instructions under "Maintenance" - Insulation. See that nameplate reading agrees with the voltage and frequency provided for the motor.

The shaft extension may be coated with a slushing compound to prevent rusting during shipment and storage. This slushing compound may be removed by wiping with turpentine or a petroleum solvent, such as benzine, gasoline, Stoddard solvent, etc. See precautions under "Maintenance" for use of these solvents.

INSTALLATION

Mounting

Locate the motor in a place that is clean, dry and well ventilated. For exceedingly dirty applications forced ventilated or fan cooled enclosures are available for most ratings. The external air temperature should not exceed 40° C or 104° F. If protecting shields or guards are used, they must not obstruct the free flow of air around the motor.

Fasten to a rigid foundation using bolts or screws of the largest size permitted by the drilling in the mounting feet. The motor must rest evenly on all mounting pads. When slide rails are used for belted or chain drive service motor should be securely bolted to the traveling member of the slide rails.

Electrical Connections

CAUTION: DO NOT APPLY POWER TO RECTIFLOW DRIVE UNTIL ROTATION AND D-C ARMATURE AND RECTIFIER POLARITY HAVE BEEN CHECKED AND FOUND CONSISTENT. FAILURE TO DO THIS MAY RESULT IN A DAMAGED RECTIFIER UNIT.

Install all wiring and fusing in accordance with the National Electric Code and local requirements.

A-C Connections

Connect primary (stator) leads to the power supply through a suitable switch and overload protection. Connect secondary (rotor) leads to a-c terminals of rectifier.

On unit frame sets the a-c leads are located in the conduit box on the a-c end. The rotor leads are located in the d-c conduit box. On large rectiflow drives where the a-c and d-c units are individual two-bearing machines coupled together on a bedplate, the a-c rotor leads are in the same location as a standard wound rotor motor.

To change direction of rotation of three phase motors, interchange any two primary line leads. To change direction on two phase 4-wire motors, interchange the primary line leads of either phase. To change the direction of two phase 3-wire motors, interchange the two outside primary line leads.

A. D-C Connections

Connect D-C end by referring to the tabulation below and any diagrams which may accompany the control.

Connections - Rotating facing Commutator End

Clockwise Rotation:

Connect A1 to - terminal of Rectifier
Connect A2 to + terminal of Rectifier
Connect F1 to + terminal of Field Supply
Connect F2 to - terminal of Field Supply

Counterclockwise Rotation:

Connect A1 to + terminal of Rectifier
Connect A2 to - terminal of Rectifier
Connect F1 to + terminal of Field Supply
Connect F2 to - terminal of Field Supply

Bias Field F3 - F4:

Refer to the Elementary Diagram to determine whether the field must be connected ACCUMULATIVE or DIFFERENTIAL with respect to the main shunt field. (In some cases it is not to be connected at all.)

B. Checking Polarity and Rotation

In order to check consistency of D-C armature and rectifier polarity and rotation, proceed as follows:

1. Disconnect seal-in contacts around the start pushbutton so that the power is applied only as long as the pushbutton is held depressed.
2. Short circuit all three phases of the A-C rotor circuit at the rectifier. (Leave the starting resistors in.)
3. Disconnect D-C armature lead from positive (+) terminal of rectifier. Also disconnect shunt field leads F1 - F2 and differential (accumulative) field leads F3 - F4.

4. Momentarily apply A-C power and note rotation. Chage A-C stator connections if necessary to obtain proper rotation.

5. With the D-C shunt field F1 - F2 energized, again apply A-C power and check polarity of D-C armature lead and rectifier. JOG ONLY MOMENTARILY AS THE ROTATING UNIT MUST NOT REACH A HIGH SPEED WHEREBY THE CEMF WILL BE OF SUCH MAGNITUDE TO CAUSE A SEVERE FLASHOVER AT THE D-C ARMATURE. CEMF MUST NEVER EXCEED 600 VOLTS.
(On a 3 to 1 speed range, CEMF will build up to 3 times rated D-C volts at maximum speed and full field.) If the armature lead polarity is negative (-), shut off A-C power and reverse connection to both armature (A1 - A2) leads. Repeat polarity check.

6. If all above check, connect D-C armature leads to rectifier, + to + and - to -, connect field leads F3-F4 as shown on diagram, remove short on A-C rotor and set is read to operate.

GENERAL

The conduit boxes may be rotated 90 degrees or 180 degrees for use with horizontal conduit or conduit from above. A conduit box is supplied, but conduit and conduit fittings are not furnished with the machine. These items may be purchased from any Electrical Dealer, or Plumber's Supply House.

When the machine is mounted on a bedplate, or on slide rails for belt adjustment, flexible metallic conduit should be used to protect the leads. In making this connection a squeeze connector should be used for attaching the flexible conduit to the conduit box. Squeeze connectors may be straight, 45 degrees, or 90 degrees. In order to connect a squeeze connector to the conduit box first remove the cover of the box. Run a locknut well down the threads of the connector and place the connector in the hole in the bottom of the conduit box. Screw a conduit bushing over the end of connector, swing the connector to the desired position and draw the locknut up tight against the box. Follow the same procedure with rigid conduit or reducing bushing.

OPERATION

Before Starting

Check to see that all connections are made and all joints are tight. Examine the brushes and brushholders. The brushes should be free to slide in the holders and should be bearing against the surface of the commutator or slip ring. If any broken brushes are found they should be replaced. (See instructions under "Maintenance" - Brushes). The holders should be providing approximately two pounds per square inch pressure and should be located 1/16 to 1/8 inch from commutator surface. If d-c brush rig has been disturbed during installation it should be returned to the correct position as set at the factory and which is marked by means of a dowel or chisel marks on rocker ring and bracket. Always keep the rig in this position. Examine air gaps and remove any foreign material found therin. See that rotating members turn freely.

Starting

Make sure that consistency of rotation and polarity of d-c armature and rectifier has been established as outlines under "Electrical Connections."

Apply power to the Rectiflow by operating the a-c starter. Allow the unit to operate at no load for a period of time meanwhile checking for evidence of rubbing or overheating of bearings. While the unit is running at no load, operate the d-c field rheostat to see if speed variation is obtained consistent with the operation of the rheostat.

After load is applied look for evidence of sparking at the d-c commutator. The unit should carry rated load with little sparking. If severe sparking occurs, see comments under "Maintenance".

MAINTENANCE

Although rectiflow rotating units require a minimum of attention in service they should be inspected at regular intervals to guard against damage resulting from excessive dirt, moisture, friction, vibration, brush wear, slip ring and commutator wear; which are contributing causes of 90% of all motor failures.

Guard Against Dirt

Keep the insulation and mechanical parts of the motor clean. Wipe top of the access cover before removing to check brushes, commutator, and slip rings. Normal brush, commutator, and

slip rings. Normal brush, commutator, and slip ring wear will produce a conducting dust that should be removed at regular intervals to prevent accumulation in the windings. Dust that is free of oil or grease may be removed by wiping with a clean dry cloth or preferably by suction. Blowing with compressed air is not recommended as this may drive the dust into the windings.

When grease or oil is present wipe with a cloth moistened (but not dripping) with a petroleum solvent of a "safety type" such as Stoddard solvent or similar material available under various trade names. When an accumulation of dirt is difficult to remove, carbon tetrachloride is more effective than petroleum solvents. (Wear neoprene gloves to prevent skin irritation when using either petroleum solvents or carbon tetrachloride.)

Petroleum solvents are flammable and comparatively non-toxic. Carbon tetrachloride is non-flammable, but is highly toxic. Suitable ventilation should be provided to avoid breathing the vapor. When ventilation is not sufficient to prevent a distinct odor of carbon tetrachloride, a chemical cartridge respirator or gas mask must be used.

Guard Against Moisture

Drip-proof motors should always be guarded against the accidental intrusion of water from splatter or splashing. Stand by motors should be run at least once a week to guard against moisture condensation. Where motors are subject to extreme moist conditions or to alternate heat and cold when not in operation, a means of keeping the internal temperature above that of the surrounding air should be used, such as space heaters. Before starting motors which have been subjected to moisture, the insulation resistance should be checked by using a 500 volt megger. If resistance is below 2 megohms dry the winding in an oven or with circulated warm air.

Guard Against Friction

Excessive friction and overheating of bearings is usually traced to one of the following causes:

a. Excessive belt tension.
b. Poor alignment causing excessive vibration or binding.
c. Bent shaft.
d. Excessive end or side thrust due to gearing, flexible couplings, etc.
e. Lack of oil in sleeve bearings.
f. Lack of or too much grease in ball bearings.

Guard Against Vibration

To avoid failures due to vibration, a few simple checks should be made regularly.

Check for misalignment such as may be caused by foundation settling or heavy floor loading. These may be causing vibration through misalignment.

Check to see if vibration from the driven machine or another nearby machine is being transmitted to the motor.

Check for excessive belt or chain tension or the push-apart effect inherent in spur gears.

Check the motor mounting bolts and bracket bolts to be sure they are tight.

Guard Against Excessive Brush Wear

Excessive brush wear may result from brushes too tight in holders. A free sliding fit should be maintained between brushes and brush holders by cleaning both when necessary.

The ends of all brushes should be fitted to the commutator or slip ring so that they make good contact over their entire bearing face. This can best be accomplished after the brushholders have been adjusted and the brushes inserted. Lift a set of brushes sufficiently to permit a sheet of sandpaper to be inserted. Draw the sandpaper in the direction of rotation under the brushes releasing the pressure as the paper is drawn back. Be careful to keep the ends of the paper as close to the commutator or slip ring surface as possible as this will avoid rounding the edges of the brushes. It

will be found that by this means a satisfactory contact is quickly secured. Use sandpaper grade 1-1/2 for the roughing out and grade 0 for the final fit.

Make frequent inspection to see that:

1. Brushes are not stocking in holders.
2. Shunts are properly attached to brushes and holders.
3. Tension is changed as brush wears. Maintain approximately two pounds per square inch.
4. Worn out brushes are replaced before they reach their limit of travel and break contact with the commutator.
5. Remove the free copper picked up by the face of the brush.

NEVER LUBRICATE BRUSHES OR SLIP RINGS. Use the correct grade and size of brush which may be obtained by contacting the nearest Westinghouse Sales Office.

Guard Against Grooved, Rough, or Eccentric Commutators, and Slip Rings

Slip rings should be maintained smooth and true but not necessarily at a bright metallic color (brown oxide color indicates good brush and slip ring life). Grind or turn slip rings if necessary to restore a smooth and surface. If slip rings become pitted or burned, check for improper functioning of secondary circuit or for open in a-c rotor circuit.

Under normal conditions the d-c commutator should require very little attention beyond frequent inspection. The surface should always be kept smooth. If, through extreme carelessness, neglect or accident, it becomes badly roughened, the armature should be removed and the commutator turned down in an engine lathe.

Sometimes a little sandpapering is all that is necessary. Emery cloth or paper should never be used for this purpose because of the continued abrasive action of the emery which becomes embedded in the copper bars and brushes. Even when sandpaper is used the brushes should be raised and the commutator wiped clean with a piece of canvas. Cotton waste should never be used.

All commutators are thoroughly baked and tightened before leaving the factory, but if a bar should work loose it should be attended to promptly. The same may be said of flat spots or "flats" which will sometimes occur, due to a loose bar, unusually soft copper or even too severe flash or short circuit.

Under normal conditions the commutator should become dark and highly polished after a few weeks' operation, and remain unchanged for years. There should never be any lubricant used on the commutator.

Trouble is sometimes experienced from the burning out of mica insulation between segments. This is most commonly caused by allowing the mica to become oil soaked or by the bars loosening between them. It is rarely, if ever, definitely traced to excessive voltage between bars. When this burning does occur, it may be effectively stopped by scraping out the burned mica and filling the space with a solution of sodium silicate (water glass) or other suitable insulating cement.

Even with the most careful workmanship, high mica sometimes develops and starts sparking, which burns away the copper and aggravates the difficulty. By prompt action, serious damage can be prevented by cutting away the mica to a depth of one-sixteenth of an inch below the adjacent copper.

Sparking at D-C Brushes

Sparking at the brushes may be due to any of the following causes:

a. Machines may be overloaded.
b. The brush may not be set exactly on neutral.
c. The brushes may be wedged in the holders or have reached the end of their travel.
d. The brushes may not be fitted to the circumference of the commutator.
e. The brushes may not bear on the commutator with sufficient pressure.
f. The brushes may be burned on the ends.
g. A commutator may be rough; if so, it should be smoothed off.
h. A commutator bar may be loose, or may project above the others.
i. The commutator may be dirty, oily or worn out.

j. The carbon brushes may be of an unsuitable grade.
k. The brushes may not be equally spaced around the periphery of the commutator.
l. Some brushes may have extra pressure and may be taking more than their share of the current.
m. High mica
n. Vibration of the brushes.
o. Incorrect brush angle.

There are other causes, but localized sparking may be due to an open circuit or loose connection in the armature. This trouble is indicated by a bright spark which appears to pass completely around the commutator and may be reco nized by the scarring of the commutator at the point of open circuit. If a lead from the armature winding to the commutator becomes loose or broken it will draw a bright spark as the break passes the brush position. This trouble can readily be located, as the bars adjacent to the disconnected bar will be more or less pitted.

Flashover

A flashover happens when arcing occurs between adjacent brushholder brackets. In general, it is caused by excessive voltage, or by abnormally low surface resistance on the commutator between brushholders of opposite polarity. Any condition tending to produce poor commutation increases the danger of flashover. Among other causes are the following:

1. Rough or dirty commutator.
2. A drop of water on the commutator from leaky steam pipes or other source.
3. Short circuits on the line producing excessive overload.

Stator and Rotor Windings

Do not allow dirt to accumulate on rotor or stator windings. Revarnishing of the windings when motors are overhauled will lengthen their life.

CAUTION: DO NOT APPLY VARNISH WITHOUT FIRST REMOVING DIRT FROM THE WINDINGS. SUITABLE VARNISH MAY BE OBTAINED FROM THE NEAREST WESTINGHOUSE SALES OFFICE.

Sleeve Bearings - Operation and Care of

When machines are installed, put a good grade of light dynamo oil in each bearing housing. Use oil of a viscosity of from 185 to 212 seconds at 40° C. This oil is satisfactory for normal temperature down to 0° C or 32° F. For oils suitable for lower temperature secure special engineering recommendations.

The correct level of the oil is one-eighth inch below top of combination over gauge and filling device. Close down cover when through oiling. When machines are first started, feel bearing housings occasionally to see that bearings are not overheating.

The frequency of bearing inspection depends on the conditions surrounding your application. Do not add oil unless the oil level has dropped more than one-eighth inch below the top of the combination overflow gauge and filling device. Do not oil bearings while the motor is running. Do not flood with oil. Do not spill oil over the housing or the bracket. Old oil should be drained from the housing once a year and replaced with new oil.

Ball and Roller Bearings - Operation and care of

Quietness and life of ball and roller bearings depends largely on cleanliness and proper lubrication.

Inspection

1. When the machine is installed make certain that the rotor turns easily, particularly if the machine is not installed until some months after being shipped.
2. Never open the bearing housing under conditions which would permit entrance of dirt.
3. External inspection of the machine at the time of the first greasing soon after it is put into operation will determine whether the bearings are operating quietly and without undue heating.

Further inspection will not be necessary except at frequent intervals, probably at greasing periods.

4. If practicable, it is desirable for the most satisfactory service, to open the bearing housings once a year, or after every 5,000 hours' operation, to check the condition of the bearings and grease. If difficult to inspect the pulley or pinion end bearing, the condition of the bearing at the opposite end will usually be representative of both.
5. If grease deterioration has occurred or if dirt has gained entrance to the housing, the bearing and housing parts should be thoroughly cleaned out and new grease added.

Grease Lubrication

1. Grease is generally used as a lubricant. Ordinary cup greases are not satisfactory because of great tendency to deteriorate under the severe churning action of the bearings. To be suitable for ball or roller bearing lubrication a grease should be compounded from a pure mineral oil and a sodium base soap. It should be free from dirt and fillers, such as powdered mica, flake graphite, etc. It should be free from acid or alkali or from ingredients which will form these compounds. It should not melt at the highest operating temperature of the bearings and it should maintain a fairly uniform consistency over a large temperature range. Westinghouse grease meets these requirements. Keep greases clean by using only closed containers.

Do Not Over Lubricate

2. A small amount of lubricant is essential, sufficient to maintain a film of lubricant over the surface of the balls and races. Too much grease will cause churning, overheating and grease leakage. If grease leakage occurs the bearing has been over filled, or the grease used is not suitable for the particular application.

If high pressure guns are used, great care should be used to avoid over lubrication.

When shipped from the factory, grease lubricated ball and roller bearing machines have sufficient grease of the right grade to last for a limited period. However, a charge of grease should be added soon after the machine is put in operation, and thereafter at suitable intervals, as determined by experience. As a guide, it is suggested that grease should be added every three months of operation in amounts as indicated in the following table. If experience indicates that these quantities result in a surplus of grease in the bearing, the quantity should be reduced or the greasing periods lengthened or both. The ideal condition is that the bearing housing be from 1/3 to 1/2 full of grease.

As the shaft extension diameter is easily determined and is roughly proportional to the bearing size the following table for grease additions is prepared on this basis.

Shaft Extension Diameter	Amount of Grease to be added
3/4 to 1-1/4"	1 cu. in.
Above 1-1/4 to 1-7/8"	1-1/4 cu. in.
Above 1-7/8 to 2-3/8"	2-1/2 cu. in.
Above 2-3/8 to 3"	4 cu. in.
Above 3 to 4"	7 cu. in.
Above 4 to 5"	10 cu. in.

1 oz. = 1-1/4 cu. in.

3. When surplus grease sump below bearing is supplied, this should be kept empty at all times.

Regreasing (Not Pre-Lubricated Type)

4. When the bearing housing has been disassembled and the bearing thoroughly cleansed with a suitable solvent it should be immediately regreased with Westinghouse grease after first spraying or flushing with good lubricating oil. Apply the new grease either from a tube or by hand, over and between the balls or rollers. Do not use more than the amount specified in the table.

Westinghouse Grease - Ordering Data		
8 oz. tube	---	Style No. 1360876
1 lb. can	---	Style No. 1248911
5 lb. can	---	Style No. 1248912
10 lb. can	---	Style No. 1248913
25 lb. can	---	Style No. 1360877

Refer to the nearest district office of the company for Westinghouse Grease packed in larger containers.

Cleanliness

Ball and roller bearings are especially sensitive to even a small amount of dirt. Hence, they must be protected from it at all times. If necessary to disassemble the bearing housing, first thoroughly remove dirt from all adjacent parts so that dirt will not fall into bearing or interior of housing.

Prelubricated Bearings

Some motors are supplied with pre-lubricated bearings which do not require servicing. These motors are identified by a decal near the bearing housing and usually by the omission of grease fittings and drains.

A grease having high stability is permanently sealed in these bearings by the bearing manufacturer. Both laboratory tests and years of actual service have proved that this grease will give long service.

Bearings from several suppliers are used in LIFE-LINE motors; for a given size motor, the bearings of all suppliers are interchangeable. The details of the seal construction vary somewhat depending upon the bearing manufacturer, but each type of seal is equally effective in keeping out foreign material and retaining the lubricant.

Disassembly and Assembly

The following instructions apply to the large Rectiflow drives where the a-c and d-c units are individual two-bearing machines coupled together on a bedplate:

If, for any reason, a machine must be removed from a bedplate, the following procedure should be followed:

1. Remove coupling bolts to disengage shaft from other units.
2. Remove dowel in feet of machine to be removed from bedplate by tightening nut on dowel pin until entire dowel can be removed. There should be two dowels per frame located diagonally opposite each other.
3. Remove holding-down bolts in feet, being careful to observe and maintain correct shims under each foot for reassembly.

Reassembly of Machines

After a machine has been removed from a bedplate, reassemble as follows:

1. Place machine on bedplate with same shims under each foot as when disassembled.
2. Start holding-down bolts, but do not tighten.
3. Install dowel bolts, and driven down as far as possible.
4. Tighten holding-down bolts, and drive dowels all the way in.
5. Install coupling discs and bolts. Machine is ready to run.
6. Observe the rules for starting as given under "Operation".

Torque Limit

A torque limit circuit is provided which will stop the Recti-Flow drive if the torque exceeds a preset value.

In a RectiFlow drive for a given torque, the armature current varies directly with the speed. Therefore, at any given torque, the armature current ÷ speed = a constant. The armature current IR drop across the commutating field is fed into a power amplifier. The gain of the amplifier is varied by means of potentiometer "PL" in the feedback network. Potentiometer "PL" is coupled to the speed control powerstat, so that the amplifier gain is varied inversely with the speed of the RectiFlow. The output of the power amplifier for a given load torque remains a constant over the speed range of the drive. Relay "TL" in the output circuit of the amplifier picks up whenever the torque exceeds a preset value. Contact "TL" in the control circuit stops the drive when the relay energizes.

A type MW overload relay in the amplifier output circuit supplies inverse time torque limit protection. Contact "TOL" in the control circuit stops the drive on sustained overtorque.

As an optional feature a relay may be added to operate an alarm circuit in advance of the operation of relay "TL."

... be equal ... effect ...

... open ... in a ... be taken ... bias ... the ...

... a ... and

armature ...

... it. ... for ... and slip ... and ...

THIS ADD... Its excess ... slip rectifier ... of the negative EMF ... of the high speed, ... produce a circulating ... and as a consequence ... damaged.

In some ... circuit might ... In these cases, ... no load condition, ...

... 60% of ...

... of circulating ...

... current in the armature ... for rating.

... no load, and read the

4. Load the drive down to full load and note the speed. Remove the load and read the circulating current.

   a. If the top speed, full load is adequate and the circulating current is below 60% of rated, no further adjustment is necessary.

   b. If the top speed, full load, is higher than required and the circulating current is over 60% of rated, adjust bias field resistor to decrease current.

   c. If the top speed, full load, is lower than required and circulating current is less than 60% of rated, adjust bias field resistor to increase current and speed but do not exceed 60% of rated current.

... be equal ... effect ...

... open ... a ... be taken ... provide a bias ... changing the ...

... armature ...

This ... This ... compensating for part of ... the d-c armature and slip ... and the ...

THIS ... excess ... motor-slip rectifie... of the negative ... high speed, ... produce a ... and as a consequence ... be damaged.

In some ... circuit might already ... In these cases, ... condition, ...

... acceptable is 60% of ...

... of circulating ...

3. ... current in the armature ...

... load, and read the ...

4. Load the drive down to full load and note the speed. Remove the load and read the circulating current.

   a. If the top speed, full load is adequate and the circulating current is below 60% of rated, no further adjustment is necessary.

   b. If the top speed, full load, is higher than required and the circulating current is over 60% of rated, adjust bias field resistor to decrease current.

   c. If the top speed, full load, is lower than required and circulating current is less than 60% of rated, adjust bias field resistor to increase current and speed but do not exceed 60% of rated current.