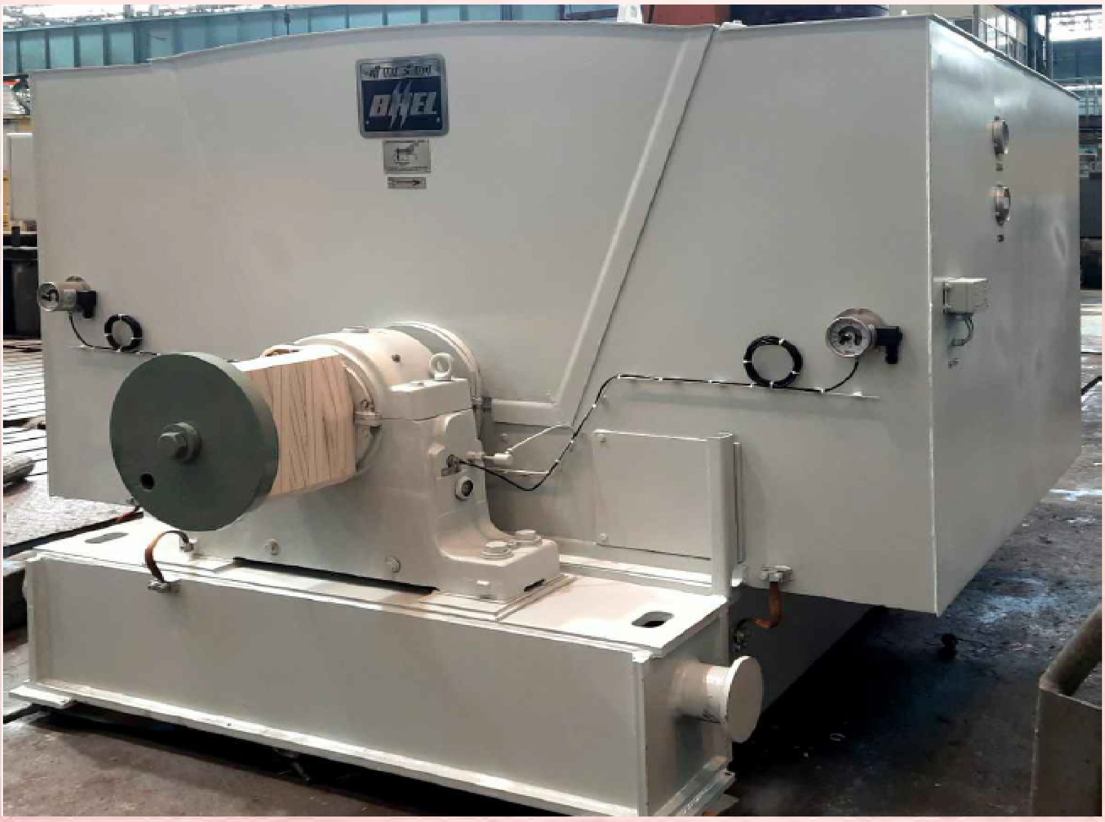
OPERATION AND MAINTENANCE MANUAL FOR



CYLINDRICAL ROTOR SYNCHRONOUS GENERATOR

BHARAT HEAVY ELECTRICALS LIMITED

ELECTRICAL MACHINES GROUP

BHOPAL - 462022

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CONTENTS

CHAPTER — 1

DESCRIPTION OF CYLINDRICAL ROTOR SYN. GENERATOR

GENERAL

The generator is cylindrical rotor construction. The excitation power is provided to the field circuit by a brushless exciter through rotating rectifier mounted on the generator shaft at its non-driving end. The complete rotor consists of shaft, rotor core, field winding, damper winding, fans and brushless exciter rotor. The stator consists of the stator core, foot plates, air baffles and stator winding. The enclosure consists of the inner and outer components. The phase and neutral leads are either terminated in separate terminal boxes mounted on the outer enclosure or brought out in the form of insulated rectangular copper terminals at the generator bottom. The rotor is assembled on one/ two pedestal sleeve type journal bearing (s) with forced oil or ring oil lubrication. The baseframe supports the stator, bearings, enclosure and brushless exciter stator. The basic construction of the generator is shown in the exploded view (Fig. 1.1). The machine is transported after work's testing in complete assembled condition.

ROTOR

The rotor consists of shaft, rotor core, field winding, damper winding, fans and brushless exciter rotor (Fig. 1.7).

SHAFT

The shaft is designed sufficiently rigid to take care of transmitting torques, minimum static deflection and natural frequency away from rated speed. The shaft has axial grooves milled into the middle section & thus takes the form of a spider shaft (fig. 1.3). The cooling air flows through these grooves and gets distributed to field winding overhang and radial ventilating ducts in the rotor core. The shaft is provided with shaft extension on drive end for assembly of half coupling.

ROTOR CORE

The rotor core consists of varnished insulated electrical sheet steel pressed axially by end plates through clamping bolts. This prevents vibration of crore and teeth thus reduces machine noise. The rotor core has radial ventilating ducts through which cooling air flows. A number of round copper damper bars are inserted in the rotor slots and welded with the end plated on either side. The rotor core is shrunk fitted on the shaft (Fig. 1.5).

FIELD WINDING

The field winding consists of single layer formed wound coils which are inserted in the slot groups together with main pole insulation. Each coil consists of high quality glass fibre insulated copper straps (Fig.1.4). The coils are held tightly by insulated wedges & filler strips. The coil leads are brazed and connected in series. The starting and end coil leads are connected with the exciter. The winding over hang is supported on winding support which is of floating type to cater for thermal expansion axially. A banding relieves the winding overhang from centrifugal stresses. Retaining rings of high strength non—magnetic material are fitted on banding in case it is not sufficient to overcome the centrifugal forces. The rotor is impregnated in a vacuum tank with a synthetic resin which has a low viscosity and thus good penetrability and cured in an oven. A balancing disc with fan is screwed with the winding support on either side (Fig. 1.5).

STATOR

The stator consists of the stator core, foot plates, air baffles and the stator winding (Fig. 1.8). It transmits the force resulting from the torque to the foundation via the base frame. The stator core consists of low loss electrical sheet steel. The core is stacked by pressing firmly steel laminations together between end plates and fixed in the position by welding axial ribs (steel angles) with the core and the end plates. The sheets are insulated from each other by coats of varnish on both sides. The core is divided into packets by riadial ventilating ducts (Fig. 1.10 & 1.11). An eye is welded to each end plate for lifting of complete machine.

The skewed stator slots results in reduced noise level. The stator winding is a double layer lap winding. Each individual bar/coil consists of a turn/ several turns which for large current ratings are made up of parallel insulated copper strands. The individual bars/coils are inserted into the slots of the stator core. To achieve reliability stator winding joints are brazed. Bar/coil main insulation consists or required layers of mica glass fibre tape applied continuously from one end to another.

To prevent movement of the winding overhang in circumferential direction on short circuits, they are braced by means of appropriate spacers fitted between the winding overhang. To minimise the effect of radial forces, insulated rings are fitted around the bottom layers & are fixed in place by insulated support brackets.

The wound stator is impregnated in a vacuum tank with synthetic resin. After impregnation, the stator is cured at the appropriate temperature.

BEARINGS

Sleeve type journal bearings are used because of simplicity, longer life and service reliability. The bearing liners are usually made with a shell of cast iron/cast steel to which babbit metal lining is bonded. The liners in two halves are housed in the pedestal assembly. The bearings are self aligning type with spherical seating (Fig. 1.12).

Brass rings are provided in the bearing for lubrication. The ring rotates with the shaft and takes oil from the pedestal oil sump to the journal. Flood lubrication is required in case rings are not sufficient to lubricate & cool the bearings (Fig. 1.13).

Both bearings are insulated and drive end bearing is earthed to prevent circulating shaft current. A steel plate sandwithched between tow insulating plate is provided below each pedestal assembly for measurement of bearing IR. Each bearing is provided with resistance temperature detector/dial type thermometer with electrical contacts for alarm/trip in case of excessive bearing temperature.

ENCLOSURE

The enclosure is required as protection against coming into contact with live and rotating parts and against the ingress of foreign material at the same time it is used for guiding the cooling air and suppressing machine noise (Fig. 1.14).

The enclosure is made up of the inner and outer components. The inner enclosure is made of glass-fibre-reinforced material in parts. They are bolted together at the joints and are fixed to the stator end plates.

The outer enclosure is made of rolled steel plates. It consists of the removable top cover &

bottom cover in two parts. (Fig. 1.15). Rubber seals are provided between the top and bottom covers and between bottom cover and base frame to prevent the penetration of dust and also dampen the machine noise.

The outer enclosure, baseframe and the stator of the machine are fitted with air baffle and partitions to form ventilation circuit.

BASEFRAME

The baseframe supports the stator, bearings, enclosure and brushless exciter stator. The forces produced in the machine during normal operation or on short circuits are transmitted via the baseframe and the anchoring elements to the foundation.

It is made of flat steel and rolled steel sheets welded together to form a box. Four lifting ballards provided in the baseframe are sufficient for lifting of the complete machine (Fig. 1.16).

Elongated holes are provided in the baseframe for fixing the machine with the foundation.

The baseframe is anchored to a concrete foundation by means of T—head bolts inserted into anchor plates or sleeves. In case baseframe is anchored to a steel foundation, it is fixed by means of fixing bolts.

THERMAL PROTECTION OF STATOR WINDING

The temperature of the stator winding is monitored by resistance temperature detectors embedded in the stator winding.

If the winding temperature at the points where the temperature sensors are installed reaches or exceeds the permissible limit value, an alarm singal is given or the machine shut down automatically, depending on the temperature attained.

The connecting leads of the temperature sensors are terminated in an instrument terminal box.

ANTICONDENSATION HEATERS

The machine is fitted with an anti—condensation heating system (Fig. 1.17). The system is so designed that the temperature of the active parts of the machine is always higher than the ambient temperature and that condensation is prevented.

The anti—condensation heating system consists of heaters connected together as per the connection scheme and the connecting leads are terminated in a terminal box.

The anti—condensation heating system should be switched off when machine is in operation and to be switched on during periods of shut—down.

DESCRIPTION OF BRUSHLESS EXCITER

GENERAL

The brushless excitation system for a Synchronous generator consists of three distinct parts, namely —

a) The a. c. exciter
b) The rotating rectifier system
c) The solid state protection system

The a.c. exciter is a 3-phase alternator which has the armature housed in the rotor and the salient pole with the field windings are mounted on the stator. The a.c. generated on the rotor is fed to the rectifier system which is also mounted on the rotor itself. Thus a d.c. voltage is available which can be directly fed to the generator field. For the purpose of making the assembly simpler and compact the a.c. exciter, the rectifier system and the protection system devices are mounted on the same shaft of the synchronous generator at its non—driving end.

ROTOR

The rotor consists of a spider plate which is meant for supporting the armature of the exciter, the rectifier and the protection system. It is a circular plate which has four/six channels/sections welded on to this spider plate. These channels also serve as the arms for supporting the armature core, the rectifier system and the protection system (Fig. 1.18).

The armature core is made of low loss circular electrical sheet steel stampings which are assembled over these channel arms and are clamped between two pressing end plates.

The rectifier diodes are of stud type construction which are fitted to the heat sinks. Two diodes of different polarities are fitted to the same heat sink. The heat sink along with these diodes are fitted on the underneath of the channel arms.

VARISTOR ASSEMBLY, OVERVOLTAGE PROTECTION

A voltage dependent resistor is provided to protect the rectifier bridge against induced over voltages in generator field under abnormal operating conditions. The varistor assembly comprises of two annular ring varistors, connected in parallel and secured to a central stud by insulating washers and nuts. The varistor assembly is mounted on a balancing plate which in turn is fitted on a core support plate by four hexagonal bolts.

R-C-CIRCUIT

A snubber circuit is also provided to protect the rectifier circuit elements against voltage spikes caused due to commutation. It consists of two R—C elements connected in parallel between the collector rings and mounted on special clamps. These clamps are welded to varistor support plate.

ARMATURE WINDING

The a.c. exciter is designed for a low voltage and high current application.

The armature winding is of double lap wound coils housed in semienclosed slots and secured properly with wedges. The individual coil consist of a number of round enamell covered copper wires. Complete winding system is suitable for class "B" temperature rise. The terminals of the armature winding are directly connected to the heat sinks which support the diodes.

STATOR

The stator body is a shell, constructed of a rolled mild steel plate. It also functions as a yoke for the exciter and is meant for carrying flux. The exciter poles are directly bolted on the yoke. The body is of raised feet type construction. An adequate lifting arrangement is provided on it.

The poles are of laminated construction, where pole stampings are stacked together and rivetted under pressure. The field winding is made of round enamell covered wires and is secured over the pole body. The insulation system used is suitable for class "B". All the field coils are connected in series and the terminals are brought out on the terminal box (Fig. 1.18).

OPERATION OF THE EXCITER

The connection of the rectifier and protection circuit is shown in the (Fig. 1.19). The three leads of the exciter armature are connected with six diodes of recifier bridge. At the output side, the forward polarity diode leads are connected with one ring, making it a positive bus and the negative polarity diodes are connected with other ring, making it a negative bus. These rings are inturn connected with the field winding of the generator.

When the machine starts rotation, the a.c. exciter generates a small voltage due to the residual magnetism in the field system. This residual voltage is sufficient to self excite the generator exciter system.

To protect the diode bridge from abnormal operating conditions like voltage surges caused by short circuit faults occuring at the generator terminals, varistors are connected in paralled with the rectifier bridge. If the voltage level of the d.c. bus increases beyond a prescribed voltage, the varistor behaves as if shorted and thereby provides a path to bypass the surge.

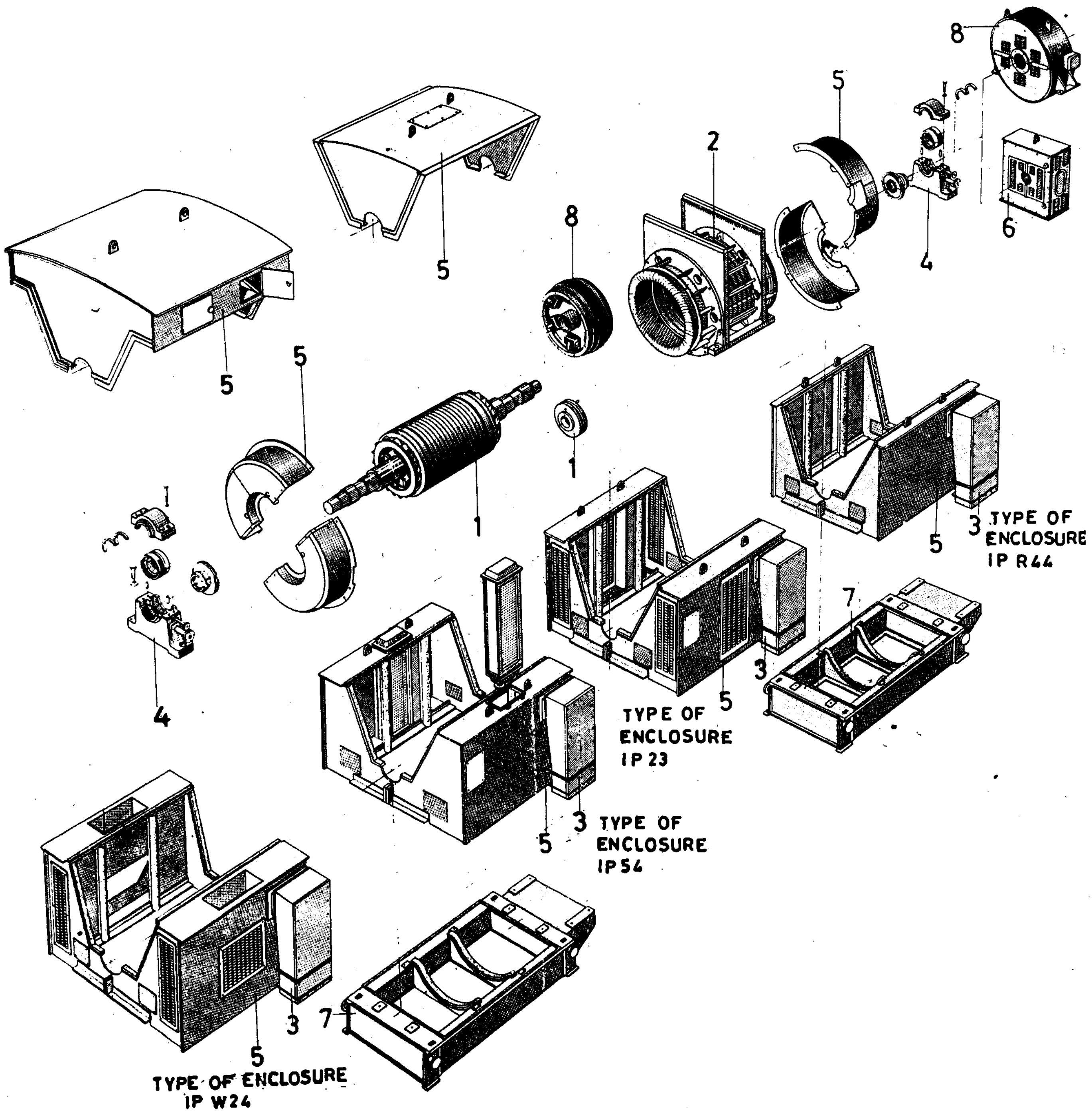
The field winding of the brushless exciter is fed through an automatic voltage regulatro (AVR) which derives power from the generator terminals. The AVR also control the generator terminal voltage within specified limits during normal operating conditions and also during transient load changing conditions.

COOLING

The brushless exciter is of a drip proof type (IP 23) construction. It is naturally cooled. The cooling air passes through the openings in the spider and over the heat sinks. The pole coils are designed for natural cooling.

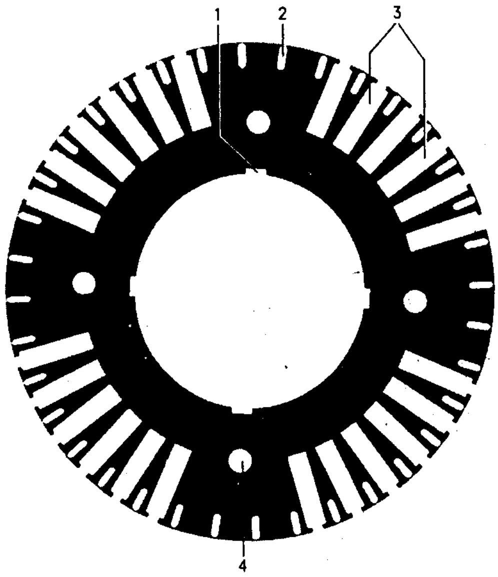
MAINTENANCE

The brushless exciter required very less maintenance. Due to the dust deposits on the heat sink surface, a periodic cleaning is required by blowing compressed air over it. Otherwise brushless excitation system is free of maintenance, has a high operational safety and is widely used.



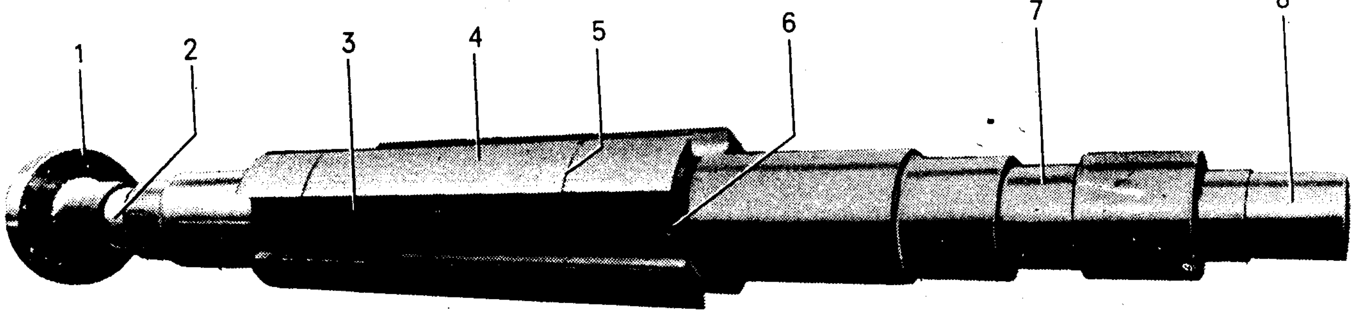
1. Rotor
2. Stator
3. Terminal box
4. Radial sleeve bearing
5. Enclosure
6. Base Frame
7. Brushless Exciter

Fig. 1.1 Synchronous Machine with Cylindrical Rotor type of construction B3/D5;



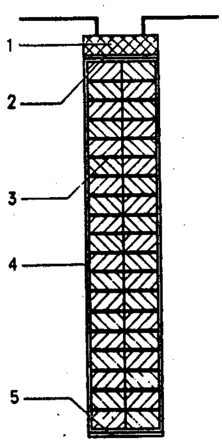
1. Slot for key
2. Slot for starting winding
3. Slot for field winding
4. Hole for clamping bolt

Fig. 1.2 Lamination for a cylindrical rotor



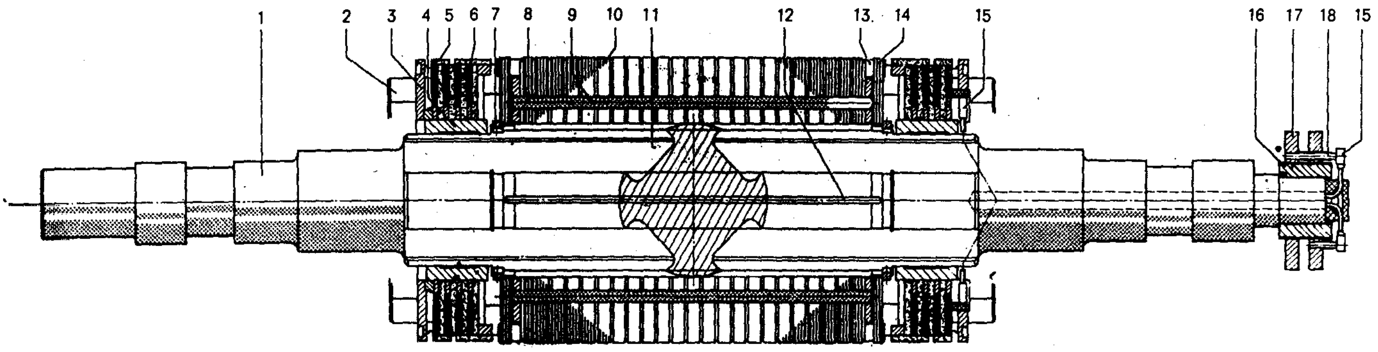
1. Coupling Flange
2. Drive End Journal
3. Axial duct
4. Core Seating
5. Radial keyway
6. Hole for exciter lead
7. NDE Journal
8. Exciter Seating

Fig. 1.3 Shaft



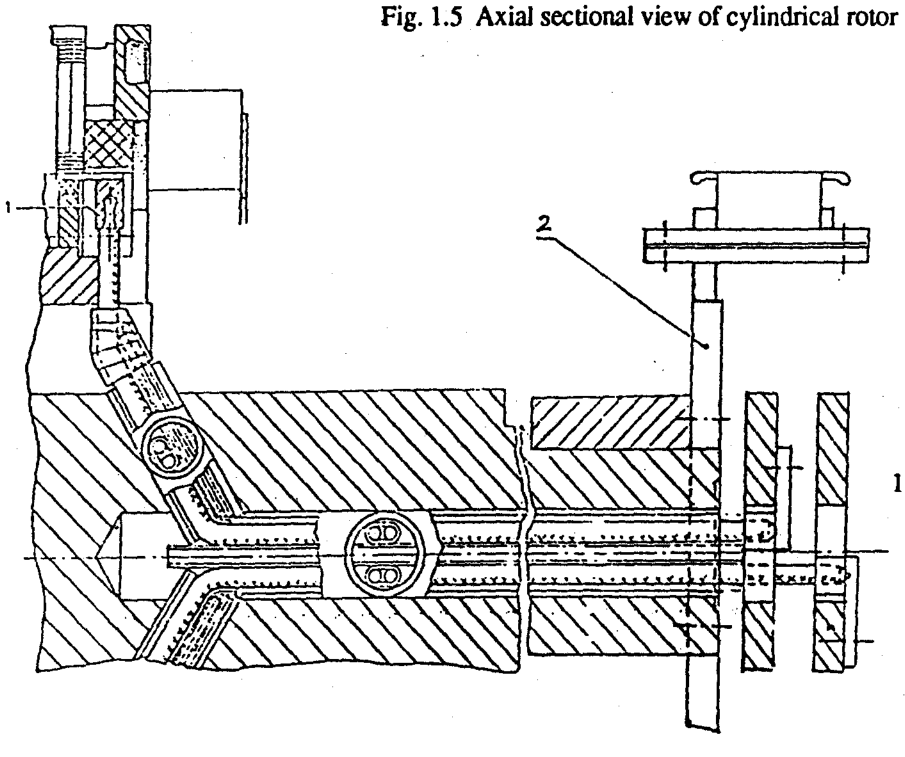
1. Slot wedge
2. Filler strip
3. Turn insulation
4. Main insulation
5. Bottom strip

Fig. 1.4 Cross section of field slot



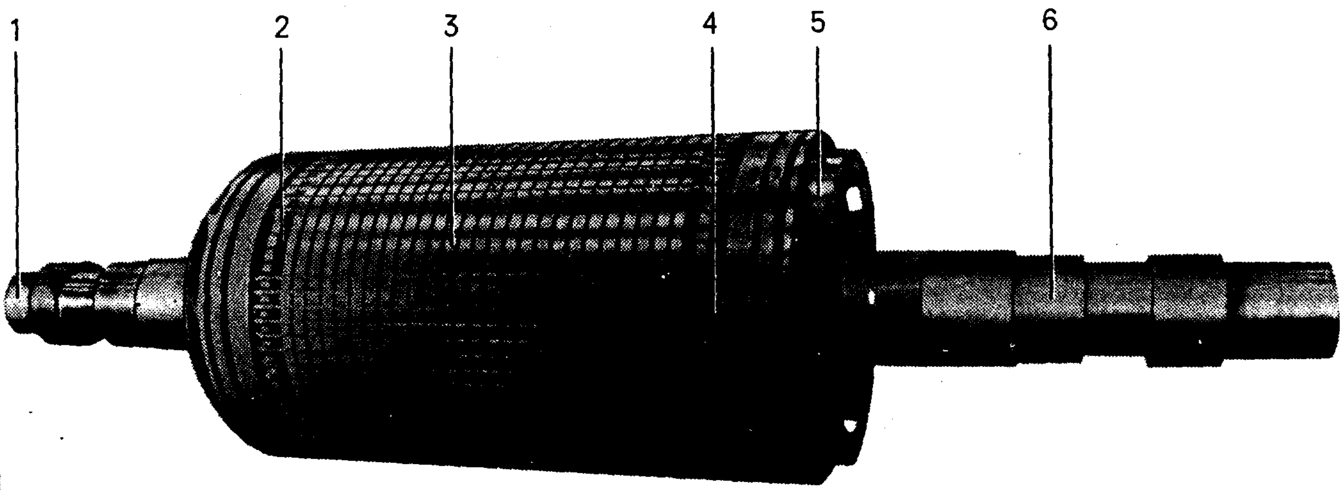
1. Shaft 2. Fan 3. Balancing Disc 4. Winding Support 5. Banding 6. Field Winding
7. Key 8. End Plate 9. Clamping Bolt 10. Rotor Core 11. Air Duct 12. Keyway
13. Damper Bar 14. Exciter Lead 15. Exciter Hub 16. Exciter

Fig. 1.5 Axial sectional view of cylindrical rotor



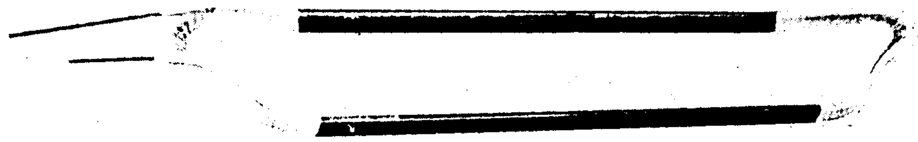
1. Coil Connection 2. Exciter

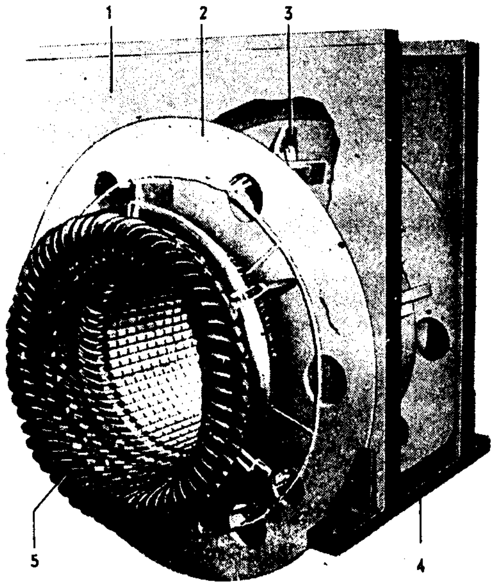
Fig. 1.6 Exciter Lead



1. Journal for Exciter 2.Damper Winding 3. Rotor Core 4. Field Winding 5. Fan 6. Shaft

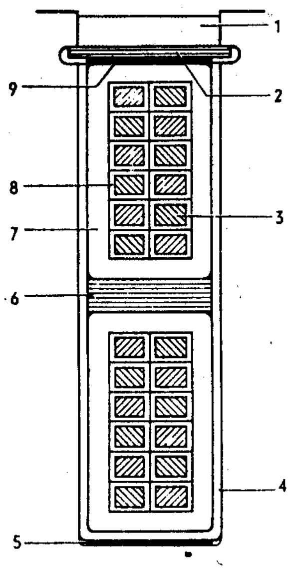
Fig. 1.7 Cylindrical Rotor





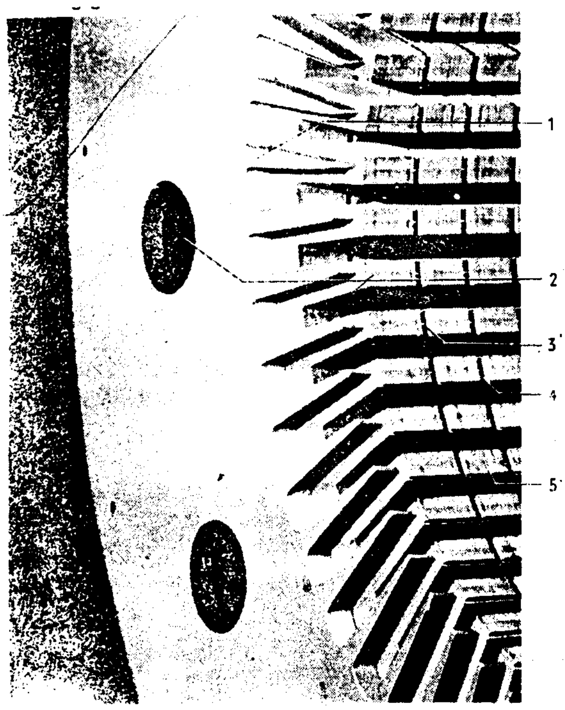
1. Air Baffle 2. Stator Core 3. Lifting Eyes
4. Foot Plate 5. winding

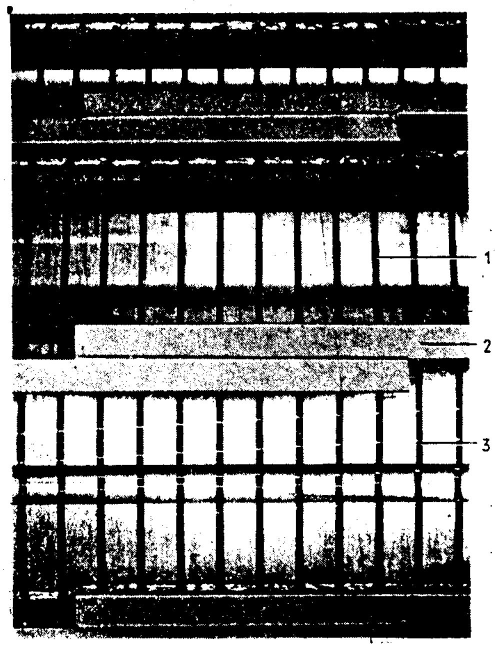
Fig. 1.8 Stator



1. Slot Wedge
2. Strand
3. Slot Lining
4. Bottom Strip
5. Separator
6. Main Insulation
7. Strand Insulation
8. Packing Strip

Fig. 1.9 Stator coil & cross Section of Stator slot

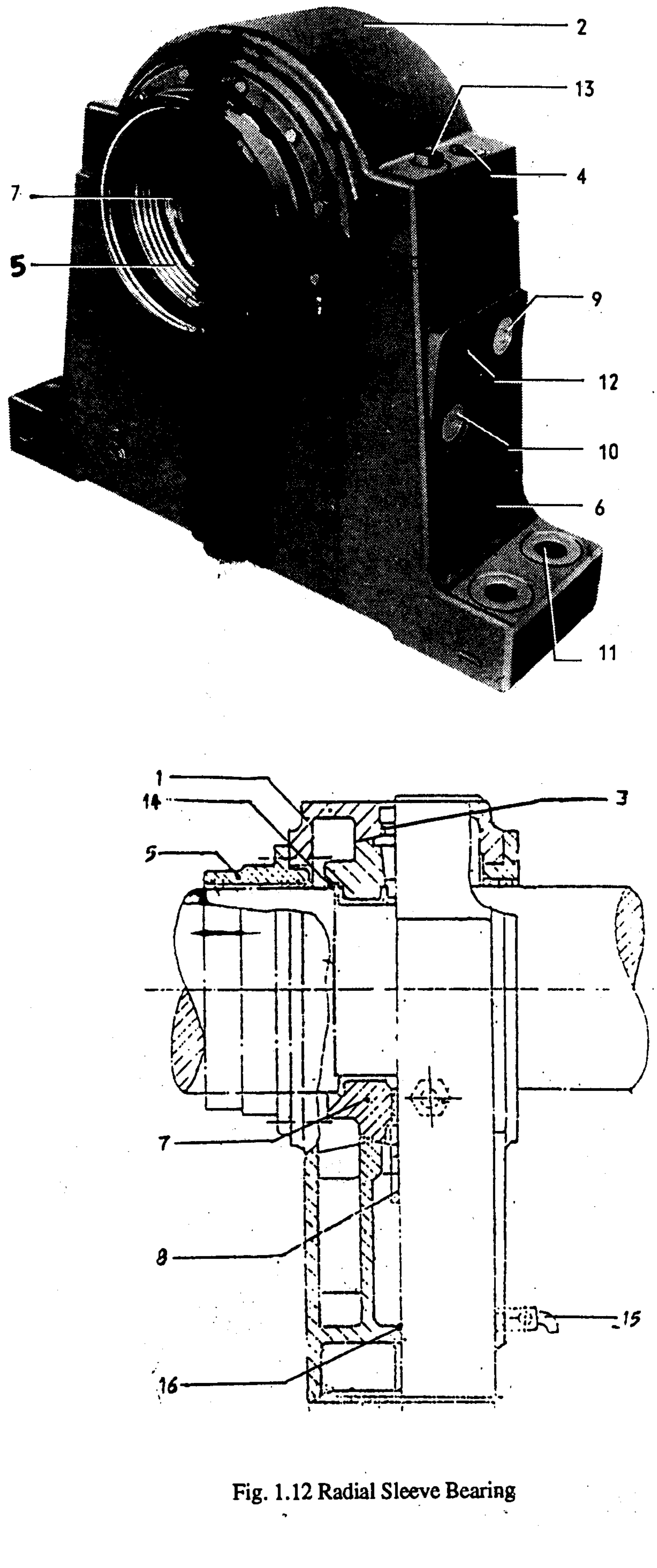




1. End plate 2. Ventilating Opening 3. Spacer Plate
4. Ventilating duct 5. Core packet 6. Axial Rib

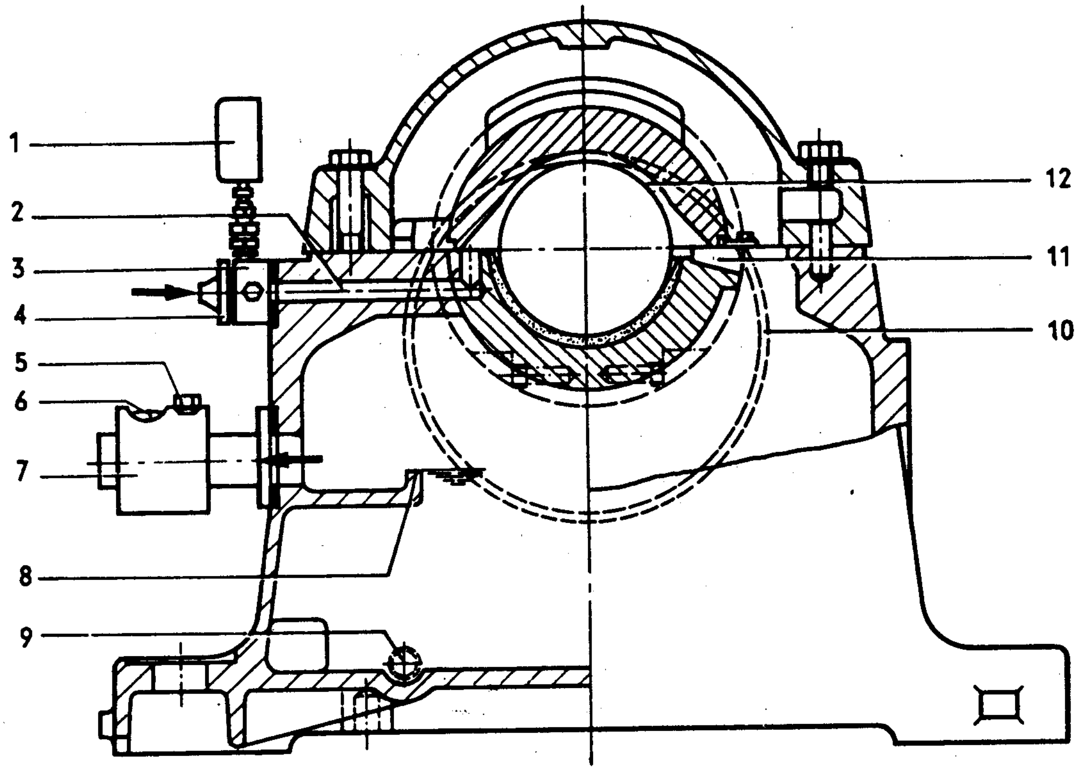
Fig. 1.10 Stator Core

Fig. 1.11 Core Clamping



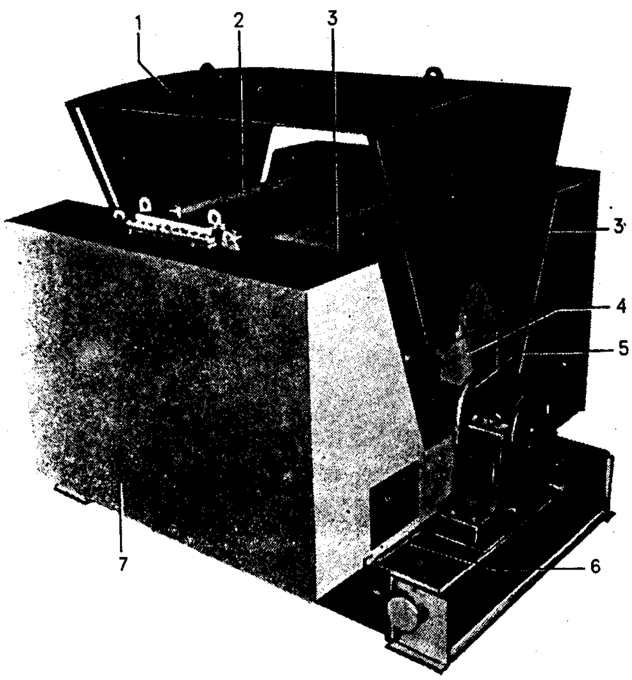
1. Top Bearing Liner
2. Bearing Cover
3. Locating Ring
4. Screw Plug (oil filler, tapped hole for eyebolt)
5. Oil sealing ring
6. Bearing Pedestal
7. Bottom bearing liner
8. Oil ring
9. Sightglass for oil ring
10. Sightglass for oil level
11. Hole for holding bolt
12. Thermometer hole
13. Screw for bearing cover
14. Oil sealing ring (liner)
15. Oil drain cock
16. Pedestal dowel

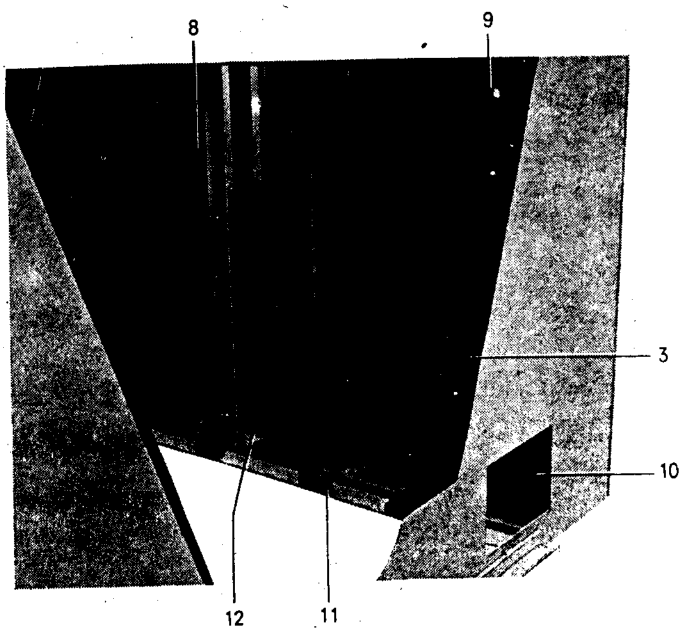
Fig. 1.12 Radial Sleeve Bearing



1. Pressure gauge
2. Oil inlet
3. Throttling flang
4. Thermometer hole plug
5. Sight glass
6. Oil outlet
7. Oil drain cock
8. Oil ring

Fig. 1.13 Bearing with forced oil lubrication

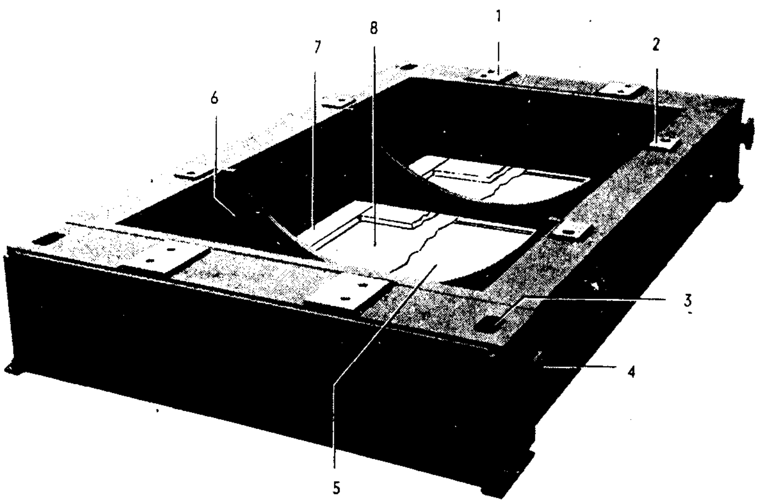




1. Top cover of outer enclosure
2. Seal between stator & top cover
3. Seal between top & bottom cover
4. Winding Shield (Inner enclosure)
5. Shaft Seal
6. Seal between base frame & outer enclosure
7. Bottom cover of outer enclosure
8. Seal between stator & bottom cover
9. Hole for stator cable
10. opening for stator fixing
11. Rubber pad for outer enclosure fixing
12. Space for air cooler

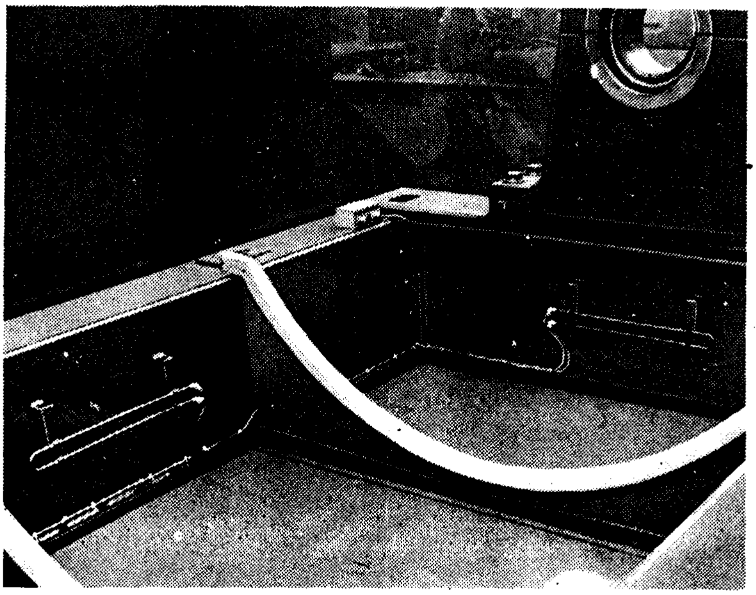
Fig. 1.14 Enclosure

Fig. 1.15 Bottom Cover of outer Enclosure



1. Seating face for bearing
2. Seating face for stator
3. Opening for anchoring arrangement
4. Lifting ballards
5. Closed bottom
6. Sealing wall

Fig. 1.16 Base Frame



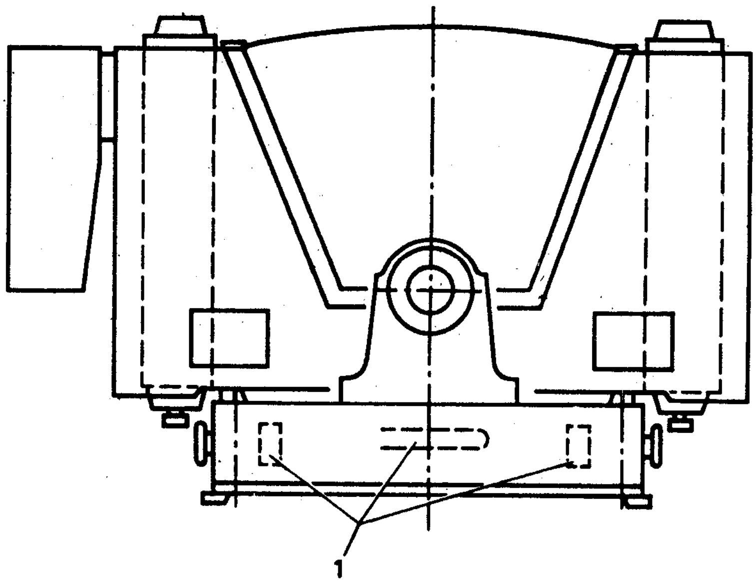


Fig. 1.17 Anticondensation Heater Fixing in Baseframe

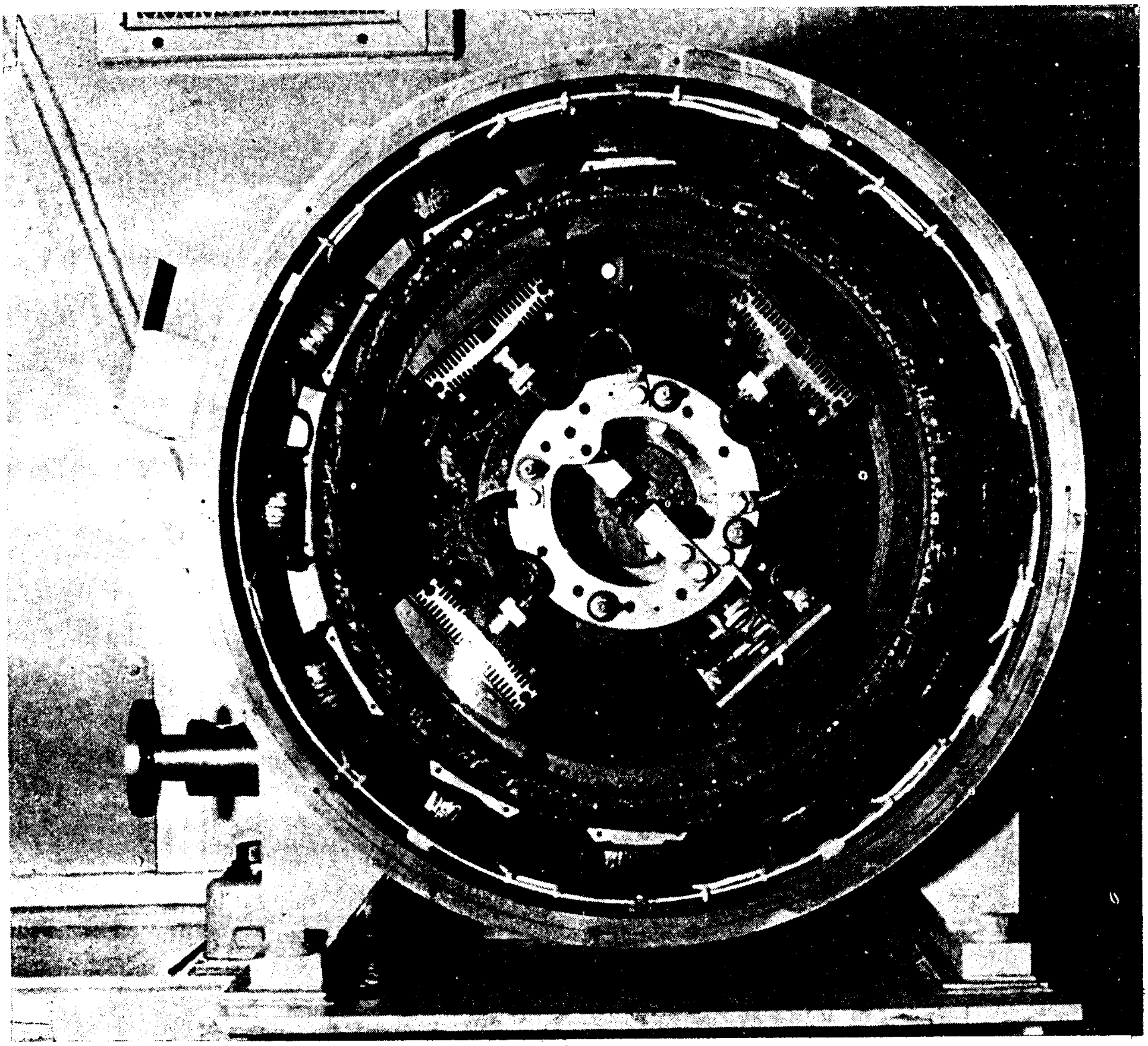


Fig. 1.18 Brushless Exciter

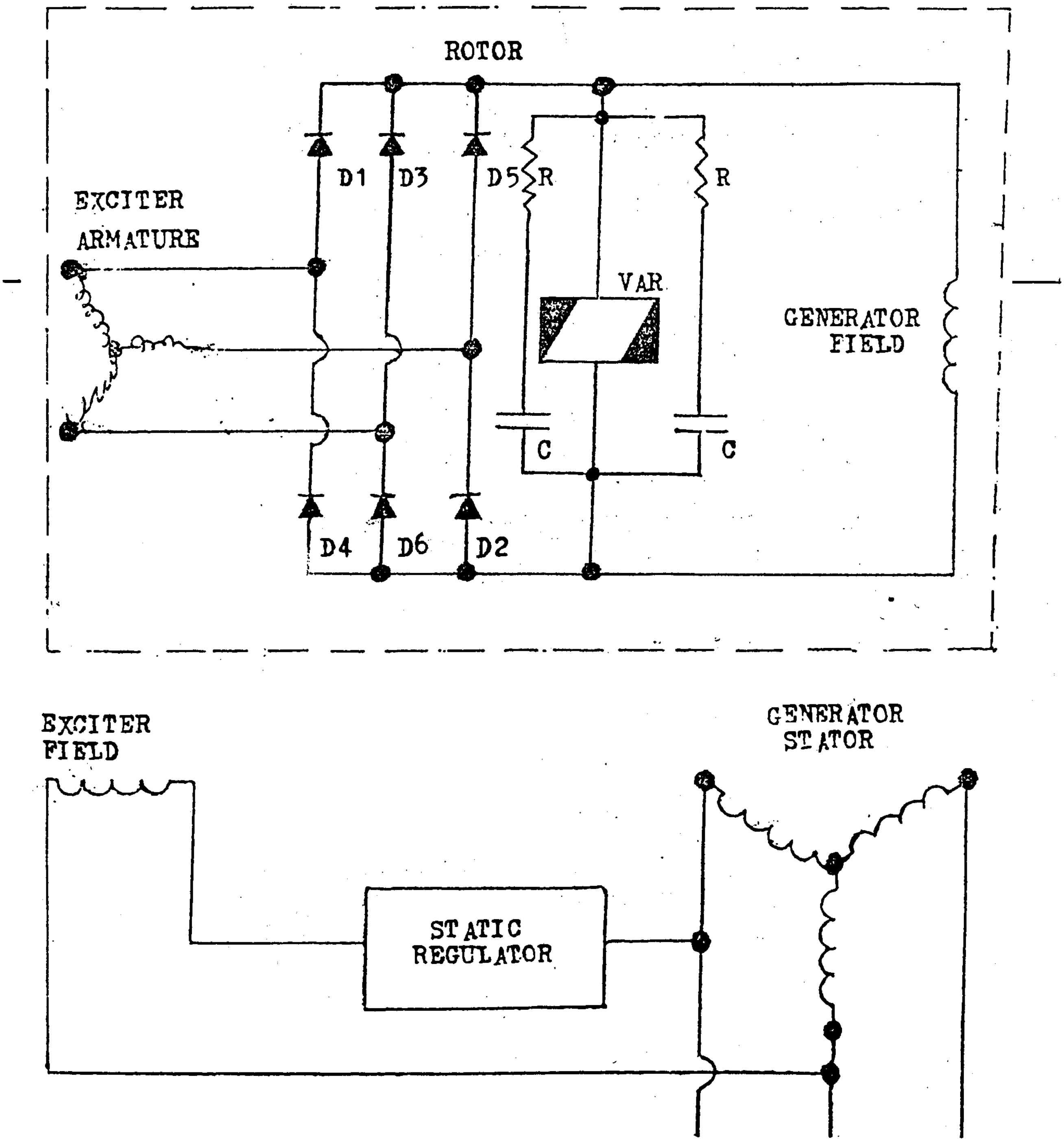


Fig. 1.19 Connection of Rectifi er & Protection Circuit

CHAPTER — 2

INSTALLATION

STORAGE

The warehouse where the equipment is to be stored should be clean, dry & well ventilated. It should be treated by pesticides/insecticides against insects, fungus etc.

The protective coating applied to machined surfaces should not be disturbed. The plastic covering should be put back after inspection of the component. Some components may be wrapped with VCI (Volatile Corrosion Inhibitor) coated paper. This paper should be restored to its original place as far as possible. Cotton bags containing Silica Gel provided inside some of the packing cases should also be restored to their original place. The Silica Gel should always be in the activated condition which is shown by its deep blue colour. If this colour changes, the Silica Gel should be heated untill it regains the deep blue colour.

The packed cases should be inspected once in every two months especially in damp weather for fungus, dampness or any sign of deterioration of packing material.

To prevent atmospheric condensation on insulated materials, the warehouse where assembled machine, stator, rotor, stator wils & other insulated materials are stored, should be kept at least 10 deg. C above the dew point. Relative humidity should preferably be kept below 40%. Above this figure vulnerability to corrosion, rotting etc increases at a rapid rate.

HANDLING

Check the loading capacity of the floor (consult the building drawing) before starting the transport and hoisting operations.

Adhere to the local applicable safety rules and regulations. If the crane is used, check the brake of the hoisting gear by trial braking under load. Keep the time for which the load is freely suspended to a minimum. Before transporting a load, remove loose parts or secure them to prevent them falling off. When the ropes have been attached, align the crane hook with the load such that the crane hoisting ropes are suspended vertically. (for illustration refer fig. 2.1 to 2.5).

IMPORTANT : — Persons are not permitted under suspended loads. Should work be necessary under the load, support the later so that safe conditions are obtained. Transport of persons together with the load is not permitted. Use a guide rope in addition if long objects are handled.

When loading the crane to full capacity, support heavy parts during lifting and lowering (e.g. by a crossed stack of beams) to prevent damage to the load in the event of the crane failing. Tilting of loads must be in parallel to the drum axis of the rope winch.

Lower the loads at a low speed, using the lowest speed of the hoisting gear if the crane handles the maximum permissible load.

Only one person should be responsible for giving signals during the handling operations and also for selecting and using suitable tackle, giving due consideration to the loads involved.

The weights of the various machine parts will be found on the packings, on the drawings or the consignment notes.

Select and check the hoisting tackle to suit the loads to be handled, giving due consideration to the location of the centre of gravity, the angle of spread and bending radii involved. The carrying capacity of the takle, hooks and shackles are punch—marked at clearly visible points.

Important : — The maximum permisible carrying capacity of the hoisting must be maintained. Protect the tackle from moisture. Do not use damaged tackle. For fixing the hoisting tackle, only use the linking elements provided (bolts, screws and nuts) and uniformly tighten the later evenly (diagonally opposite bolts etc.).

Important : — Firmly screw in or lock the eyebolts and nuts upto the shoulder otherwise there is the danger of breaking them off. Use washers, if necessary. Check that the thread of the tapped holes and eyebolts are the same. Eyebolts should, wherever possible, be loaded only in the direction of the bolt axis. Use wooden spreaders if necessary.

Lift packed machine parts only at the marked points protected by metal plates, and transport them in the correct position. Note the top markings.

Insert wooden spreaders if the rope angle at the load becomes too small. Too small an angle may cause the rope to slip (Fig. 2.2). The spreaders also protect sensitive parts of the load from the pressure exerted by the rope (Fig. 2.3). Determine the rope cross section on the basis of the calculated crane hook loads ml and m2.

METHOD OF ANCHORING

Various different methods are employed for anchoring machine on the foundations (Fig. 2.6). The method to be employed for a particular machine is shown in the dimension drawing prepared once a contract has been signed.

RAG BOLTS : — Are suspended in prepared blind holes in the foundation and then grouted in with concrete over their full length. They cannot be loaded to full capacity untill the concrete grout has set completely. In order to ensure proper adhesion between the rag bolt and the concrete grout the bolt must be cleaned of any loose rust and grease before it is inserted in the foundation.

T. Head bolts may be used only in conjunction with anchor plates or anchor sleeves. Anchor plates are used when the machine is mounted on a concrete slab or over a foundation pit with side niches, i.e. when the T—heads of the bolts are accessible. If the heads of the bolts will not be accessible in the foundation it is necessary to use anchor sleeves which are grouted in.

Note : — Anchor sleeves must be grouted in accurately in accordance with the instructions given in the dimension drawing because their position cannot be corrected subsequently. Whenever T—head bolts are used they are inserted into the foundation head first from above and then into the anchor plates or anchor sleeves; the bolt is then turned through 90 degree so that the head engages in a slot. The bolts can carry full load immediately.

With outdoor machines and in order to protect them against corrosion, the T—head bolts should be painted in addition with cold bitumen before being inserted in the foundation.

The bolt holes or anchor sleeves should be filled with concrete packing after the machine has been aligned. The grouting concrete used for the baseframe or soleplates should not be used to fill the holes or sleeves. Machines with baseplates are usually secured to concrete foundations with

T—head bolts in the same manner described for baseframes and soleplates.

Baseframes, baseplates and machines with no base are secured to steel foundations with hexagonal— head bolts or other fixing bolts.

RECOMMENDATIONS FOR INSTALLATIONS

When receiving and storing the machine and removing the packing, follow the instructions. Before beginning installation of the machine, carefully check all the foundation dimensions. Particular attention should be paid in checking that the size and location of the holes for the anchor bolts and of the ducts for piping, cables and ventilation are correct. If a check is carried out at this stage, any inaccuracies can still be corrected.

Note : — The lifting eyes on the top of the outer enclosure are only to be used for lifting the outer enclosure itself. For transporting the whole machine there are two eyes on the stator which in the case of machines with degree of protection IP 23 and IP 54, are easily accessible after removal of the cover 2 (fig. 2.7) on the top of the outer enclosure. When lifting the machine by the ballards of the baseframe, the ropes should not touch against the edges of the cover. Use rope spreaders made of wood. (fig. 2.8). Remove all the packing except for the packing base. Release the fixing elements in the packing base. Remove the poly they lene sheeting from the coupling and the shaft. Treat the machined surfaces of the shaft and the coupling. Fit the coupling half, if supplied as a separate item. Should the coupling halves already be fitted, remove the transport block of the coupling sleeve, if provided. Check the coupling end faces with a hairline gauge, especially in the areas around the holes.

Note : — The coupling end faces must be absolutely even. Correct any unevenness. Follow the instruction of the coupling manufacturer. Remove the block 1 (fig. 2.9) and the four bolted on supports 4 (fig. 2.7 and 2.8) required for securing the rotor during transportation. After slackening the joint bolts and flange bolts, take out the sealing rings 2 (fig. 2.9).

Remove the bolts 5 (fig. 2.9) on the flange of the machine—side sealing ring 3 and slacken the clamping bolts 7. After slackening the joint bolts, take out sealing ring 4. Remove the fixing bolts of the bearing cover and take off the bearing cover. Yye bolts can be fitted in the oilfitting hole in place of the locking bolts for lifting off the bearing cover. Remove the joint bolts of the machineside sealing ring 3 and lift of the top half of the sealing ring.

Lift off the top bearing shell and remove the pad on the shaft. Remove the thermometers from the bearing. Place a hydraulic jack under the shaft in the immediate proximity of the radial sleeve bearing. Insert a copper plate approximately 10mm thick between the shaft and the jack. Locate the shaft radially by inserting wooden wedges between the shaft and the bearing housing. Align the hydraulic jack to the shaft centre. Set up a magnet gauge to zero in the shaft centre. Lift the shaft a maximum of 0.5 mm by mean of the hydraulic jack. Lock the jack piston to prevent it from sinking down. Provide an additional support for the shaft, if necessary.

When removing the anti—corrosion coating from the shaft journal, thread a clean polythylene steet at least 600 mm wide and approximately 1000 mm long between the shaft and the bearing housing to prevent the interior of the bearing housing from becoming contaminated. Treat the machined surfaces of the shaft and of the bearing parts. i.e. the bearing housing, sealing rings, top and bottom bearing liners, oil rings, sealing rings and the fixing bolts. Inspect the interior of the bearing housing for foreign bodies, flush with kerosene and blow out with dry compressed air. Wet the running surface of the shaft with clean oil and apply a thin film of lubricant e.g. Molykote Paste G to the seating surface of the bottom bearing liner in the bearing housing.

Note : — Pay attention to the correct operating position of the bearing liner. Place the bottom bearing liner on the shaft & carefully turn it into the bearing housing. Lower the shaft. Repeat the operations described for each bearing.

Release and remove the top cover of the outer enclosure 1(fig. 2.7). Check the air gap between the stator and the rotor with long feeler gauges (approx 1000 mm). Insert the feeler gauges between the rotor and stator cores, using the same amount of force at each measuring point. Do not use feeler gauges wider than 8 mm, otherwise the curvature of the stator bore will falsify the measurement. Remember that the total thickness of the shims under the bearing can only be altered with the approval of the machine supplier. After the measurements have been completed, replace the cover.

INSTALLING : —

There are three variants (fig. 2.11) by which the machine can be secured to the baseframe to match it to the existing operating conditions. The particular variant for the machine is depicted in 'Machine dimension drawing'. Prior to installing the machine, treat all the surface coming into contact with grouting concrete in accordance with their function. To install the machine in accordance with the 'Dimension drawing', mark the bearing surfaces of the levelling plates, pour a 2 cm thick layer of concrete onto the foundation and embed the levelling plates. Trim the concrete at the side upto the top edge of the levelling plates, then check their horizontal position and if necessary realign them. Ensure that the necessary height of one and then the other levelling plates is attained by placing shims on them. Clean all the holes, including tapped holes, and machined surfaces of the soleplates. In case of 'Variant 1', the blocks are dispatched pinned and tackwelded to the soleplates. Prior to installing the machine, break the tack welds. If the machine is rigged for Variant 1 or 2 place it on the foundation in accordance with "Method I' or 'Method II'.

Method I

Bolt the soleplates to the baseframe and align to the contours or the holes of the anchoring points. Insert shims between the baseframe and the soleplates. Place the machine with the bolted on soleplates onto the aligned levelling plates and roughly align it with the coupling of the aligned machine. If supplied insert the anchor plates in the recesses in the foundation, fit the T—head bolt and tighten the nut of the T—head blot so that the machine is firmly fixed for measuring the alignment.

Method II

Place the soleplates on the aligned levelling plates. Check that the soleplates are truly horizontal and compensate any different in height by inserting or removing shims as necessary. Use shims to establish the correct elevation of one seating surface for the machine and then repeat the process for the other seating surface. The reference points are the geometrically determined points on the machine foundation, in the machine house or on the machine floor. String two measuring wires between the datum marks of the machine axes (longitudinal and transverse axes). Starting from the fixing holes of the baseframe, align the soleplates the machine axes (longitudinal and transverse axes). Carefully lower the machine onto the soleplates, insert the T—head bolts, turn the head 90 degree and tighten the nut so that the machine is firmly fixed for measuring the alignment.

If variant 3 is provided for securing the machine proceed as follows. Place the soleplates with the rag bolts inserted in them on the aligned levelling plates and align them horizontally to the necessary height. The reference points are the geometrically determined points on the machine foundation or machine floor. String two machine axes (longitudinal and transverse axes). Starting from the fixing holes of the baseframe, align the soleplates with the measuring wires.

Grout the rag bolts and after the concrete has set tighten them up with the necessary torque. Carefully lower the machine onto the soleplates, insert the T—head bolts, turn the head 90 degree and tighten with the necessary torque so that machine is firmly fixed for measuring the alignment.

AIR GAP

Generator air gap can be measured at 0, 90, 180 & 270 degree position. Generator air gap is set at work hence its measurement is not necessary unless & untill it is disturbed.

It is desirable to avoid continuous taper through out core length while measurements are taken at the same point on either side of the stator.

Care should be taken to measure the air gap from iron to iron and not from wedge to iron. A standard feeler gauge along with a set of feeler gauges having thickness ranging from 0.1—1 mm each of suitable length should be used to measure the air gap.

Axial alignment

Position 1:

1st measurement 95
2nd measurement 100
3rd measurement 93
4th measurement <u>100</u>
388:4=97

Position 2:

1st measurement 100
2nd measurement 100
3rd measurement 102
4th measurement <u>98</u>
400:4
=100

Position 4:

1st measurement 92
2nd measurement 92
3rd measurement 87
4th measurement <u>95</u>
366:4=91.5

Position 3:

1st measurement 85
2nd measurement 90
3rd measurement 85
4th measurement <u>98</u>
358:4=89.5

Evaluation

I. $\frac{97 - 89.5}{2} = 3.75$

Deviation in the vertical plane

II. $\frac{100 - 91.5}{2} = 4.25$

Deviation in the horizontal plane

The air gap can be adjusted by means of steel shims provided between baseframe and bearing pedestals.

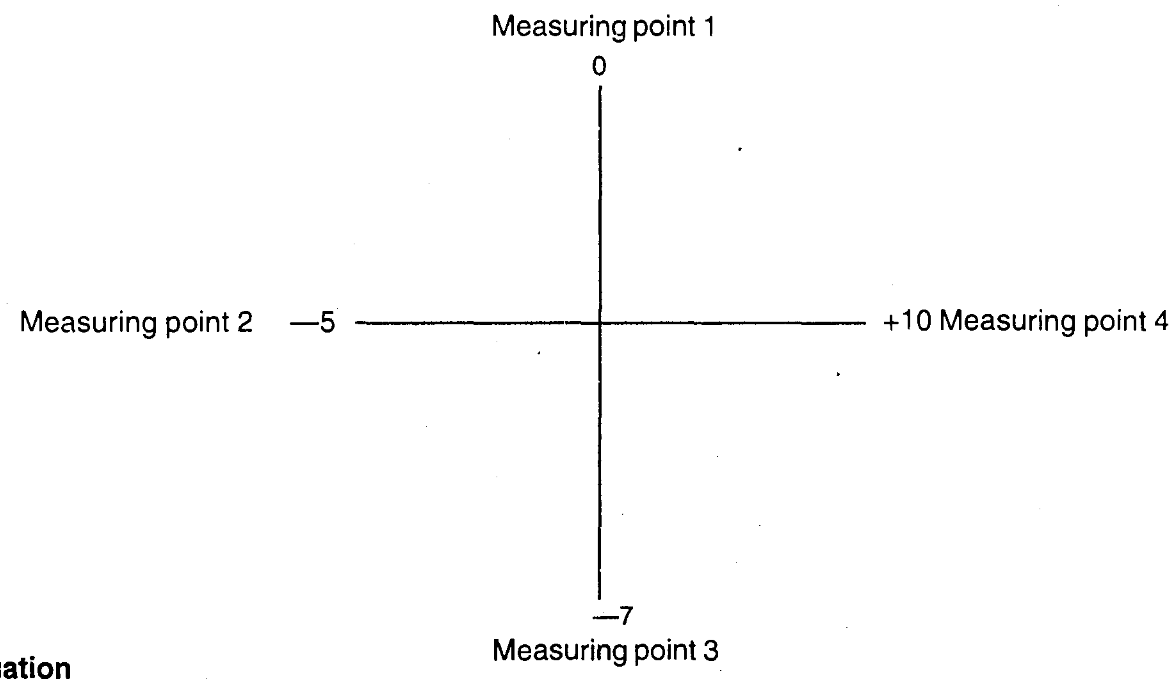
The variation on air gap should be limited to +/—5% of average air gap.

Measure exciter air gap at the centre of each pole on either side & ensure its variation within +/—10% of average air gap. Air gap can be adjusted by means of steel shims provided between pole & exciter stator frame.

ALIGNMENT

Align the coupling half of the electrical machine to that of the coupled machine both axially and radially. Prior to doing so, check the play between the web of the bearing pedestals and the bearing liner shoulders, if shoulder be the same on both sides. For aligning the coupling make a fixture for taking a setscrew or dial gauge and secure it to one of the coupling halves. Align the rotor to the dirve end bearing liner and ensure that the axial bearing play on the coupling side corresponds to nominal gap minus 1mm. Align the uncoupled machines so that there is a gap of 1mm between the coupling flanges. Align the rotor axially, to the drive end bearing liner and then align the machines with the axial clearance between the coupling halves given in the dimension drawing or by the manufacturer of the couplings. To fix the rotor, insert copper or brass angles whose thickness corresponds to bearing play required for alignment, between the bearing face and shaft shoulder.

Note : — Before taking a measurement, make sure that the anchoring elements of the machine are firmly tightened. Using feeler gauges and gauge blocks (if necessary), measure the axial clearance between the coupling flanges at four points 1,2,3,4 at the periphery. Turn the two rotors (together, if possible) and repeat the measurement in positions spaced 90° apart; record the values measured. Measuring point 1 is always at the top, i.e. the coordinates are not turned.



Evaluation

I. $-7 / 2 = 3.5$ Raise shaft by 0.035 mm

II. $\frac{10-(-5)}{2} = 7.5$ Move shaft 0.075 mm to right

Determine the mean value from the four values measured. Adjust an equal axial clearance at all measuring points, allowing for the necessary axial clearance between the half couplings and the bearing end float, namely :

Vertically by removing or adding shims underneath the baseframe, and horizontally by shifting the complete machine by means of hydraulic jacks, steel wedges. The axial location of the shaft with respect to the bearing liner must not be altered. Measure the radial offset between the coupling surface, using the measuring device, micrometer screw and feeler gauges and/or dial gauge, at the four points 1,2,3,4 and record the values measured. Determine the mean value from diagonally opposite measuring points i.e. 2 and 4 in the horizontal plane and 1—3 in the vertical plane and adjust and equal radial distance between the coupling surfaces. Make the vertical and horizontal adjustment as described under "Axial.alignment".

Take the measurements for the radial and axial alignment at the same time and at the same points in each case. Axial and radial alignments are considerably simplified if the vertical deviation have been compensated.

Repeat the operations described until the two coupling halves are correctly aligned radially and axially and have the specified axial clearance.

Permissible tolerance	Radial runout (mm)	Axial runout (mm)
Rigid coupling	0.03	0.02
Flexible coupling	As indicated by the coupling manufacture.	

If the electrical machine is to be coupled with a prime mover or a driven machine whose operating temperatures considerably higher or lower than the erection temperature e.g. a compressor, cold water pump etc, the expected expansion or contraction due to the temperature difference should be taken into account during the radial alignment. That means the electrical machine must be installed higher or lower according to the data supplied by the manufacturers of the prime mover or driven machine. Enter the alignment data in the log sheet in the presence of the authorised representatives of the customer and of the manufacturer of the drive/ driven machine and have them sign it. After aligning, secure the machine to the sole plates in accordance with the variant (see also fig. 2.11) depicted in the dimension drawing. For variant 1 fit the wadge 2 between block 3 and the footplate of the baseframe and weld the two together. For variant 2, fix the machine as given under 'Anchoring drawing'. For variant 3, mark off the holes in the corner footplates on the soleplates, ream them jointly and insert the adaptor sleeve with hexagon — head bolts. These bolts act as an aid for removing the sleeves.

Grout the soleplates of the aligned and secured machine with concrete ensuring that the baseframe is not grouted as well (see also dimension drawing). Repeat the radial and axial measurements, as described. Record the values.

Remove the metal angles fitted between the shaft shoulder and the bearing end faces, carryout the coupling acceptance inspection in the presence of the authorised representatives of the customer and of the manufacturer of the prime mover or the driven equipment. The dimension certificate should be signed by these representatives. Couple the machines when the acceptance inspection has been completed. When the machines have been coupled, the bearing end float with respect to the bearing liner must correspond to the value given in the machine data/drawing. Check the radial bearing play by taking lead imprints . For taking the lead imprint, pack the oil pockets of the bottom bearing liner with a non—linting rag. Place six pieces of lead wires (e.g. twisted lead cable wire) on the shaft journal and the joint face of the bottom bearing liner. Fit the top bearing liner, hit it with a lead hammer and detach the top liner. Measure the thickness of the compressed lead pieces with external micrometer screws, using the thickness values measured (a....c.... and a'...b'), calculate the radial bearing play from the following formula : —

b — (a + c)/2 = radial play
b' — (a' + c')/2 = radial play

Remove the rag from the oil flutes. Oil rings should be stored only on flat level surfaces. Check them for roundness and the position of the centre of gravity by rolling them on a smooth horizontal steel plate. Straighten and unround rings or replace. Avoid brushing and burrs when straightening and ensure that the hinge and joint have no projection edges. Carefully open the oil rings at their joints and lower them into the bearings. Do not force them into position. Afterwards reclose the ring joints tightly. After the oil rings have been fitted, finally lock the joint bolts of the oil rings with a punch mark on the recess for the bolt head. Apply the thin uniform coating of sealing compound (e.g. Hylomar SQ 32/M, to the joint faces).

Fit the machine side sealing ring 3 (fig. 2.9) and the outer enclosure shaft seal 4 (fig. 2.9) and bolt to the joint. Fit the top bearing liner. Place the bearing cover on the bearing housing and tighten the fixing bolts firmly. Insert the sealing ring concentrically to the shaft and bolt it to the bearing. Tighten the clamping bolts 7 (fig. 2.9) so that the rubber sealing of the shaft seal 4 (fig. 2.9) is compressed to approximately 15 mm and tighten the joint bolts firmly.

In the case of air—cooled bearings, fit the fan covers as necessary. In accordance with the order, the bearings are fitted with thermometers which should be inserted in the thermometer holes if provided. The temperature sensors should first be coated with a thick layer of thermally conductive paste. In the case of contact thermometers, the switching points must be set, the determinative factor in this case being the bearing temperature measured at maximum ambient temperature.

The electrical leads of the monitoring and protective devices are led inside the electrical machine to terminal blocks in the auxiliary terminal box. This auxiliary terminal box is located behind a cover bolted to the bottom cover of the outer enclosure. After loosening the cover bolts, the auxiliary terminal box can be swung out and opened. The electrical leads of the monitoring and protective devices must be connected in line with the circuit diagram in the terminal box.

Lay the pipes between the connecting flanges of the cooler elements & the cooling water supply and make sure there is a slight gradient at the outlet side (see also dimension drawing). Fit the pipes, treat with acid and install them. Open the vent cocks on the cooler elements. Fill the pipe system and the air—to—water cooler with clean water. Close the vent cock when water starts to follow out of the cocks.

Fit the pipes for the bearing oil supply between the bearing connections and the oil supply unit. The oil outlet pipes must be laid at a gradient of at least 5% so that the outlet flow of the oil is unhindered. Fit the pipes, treat with acid flush coat and install them. Flush the pipe system with kerosene and then blow out with compressed air.

Fill the bearing housing with oil of an acceptable quality upto the sight glass, only use an oil of acceptable quality as indicated by the machine manufacturer.

Connect the machine baseframe to the protective earthing system.

DRYING OF WINDINGS

MICALASTIC insulation is basically not affected by moisture. Terminals as well as conductor bars, coils or connections fitted during the installation that are not insulated to the same degree as the rest of the winding can, however, be endangered by moisture. Shipping, storage, construction work or a long period of standstill can cause a film of moisture to form inside the machine on the surface of the insulation which must be dried before commissioning by one of the methods given.

Because a film of moisture on the insulation inside the machine cannot always be visually detected, other detection methods such as insulation resistance and polarisation index must be used.

The insulation resistance should always be determined because information on the condition of the winding can be derived from this. Record the measured values and compare them with earlier values, if available.

During the drying process the surface moisture is driven off by heating the winding. If individual portions of the windings are installed at site, for example after closing the stator joints, these parts must be dried before varnishing, preferably by hot dry air.

Where anti—condensation heating is fitted, this should be switched on as early as possible in order to prevent the ingress or condensation of moisture. The rotor winding is normally heated sufficiently by the surrounding air when the stator is heated by passing current through it. Drying the machine whilst running is preferable to drying at standstill.

INSULATION RESISTANCE OF HV WINDINGS

The insulation resistance provides information about the surface moisture content, contamination and any damage to the windings. The measuring procedure is detailed in 'Measuring the Insulation Resistance.' With HV windings the following values should be measured :—

1) Insulation resistance of each phase to earthed frame & to the other earthed phases.
2) Insulation resistance of all winding phases to earthed frame.

The insulation resistance tester (motorised) should produce a voltage of 500 to 3000 V, preferably 1000 V. The temperature of the winding is measured by built in sensors (normally resistance thermometers).

The insulation resistance is taken at 30s, 1 min and then at every minute upto 10 min after the test voltage has been applied.

The length of the measurement period is determined by the absorption current which is caused by the polarisation of the dielectric. The dielectric polarisation index is also used as an indication of the condition of the winding insulation.

Comparative Rating	$\frac{R10\,min}{R1\,min}$ PI or N PI = polarisation Index	Drying
Dangerous	less than I	yes
Poor	1 to 1.5	yes
Questionable	1.5 to 2	recommended
Satisfactory	2 to 3	no
Good	3 to 4	no
Very good	more than 4	no

It is the ratio of two readings of the insulation resistance taken at specified time intervals during the same measurement i.e. at the same temperature (R 60_S = Insulation resistance reading 60_S after the test voltage has been applied).

The polarisation index should be determined before and after drying — in the event that the winding requires drying — at the same temperature because to a certain extent the index is temperature dependent.

The insulation resistance of the complete winding to earth should have a certain minimum value which is shown in the (fig. 2.18) as a function of the winding temperature. In order to eliminate the dependence of the insulation resistance on the size of the machine, the ordinate is formed by the (constant) product of the winding capacitance and the insulation resistance which is known as the insulation time constant T where T = R_{10} x C in Mega Ohms Micro Farad or S. The insulation resistance is the 10 min. value which is considered to be the final measurement value.

If the machines are subject to foreign standards, the minimum values contained therein must be observed. In certain cases the formula R_{ist}, min = KV + 1 in Mega Ohms may also be used with reference to IEEE recommendation St 43 — 1974 for the minimum value of the insulation resistance where Ris, min is the value at 40°C & KV is the rated machine voltage.

The winding capacitance C (all 3 phases to earth) may be determined from a loss — tangent test if carried out by measuring the current input at 220 V AC (50Hz or 60 Hz) or by means of capacitance measuring bridge.

$$C = \frac{1}{U.\omega}$$

In practice it is sufficient with small and medium machines i.e. upto approx. 20 MVA to use the minimum insulation value in accordance with the IEEE formula given above.

The measured value R1 min, (i.e. 1 minute value) is sufficient.

To determine the insulation resistance at other temperature, the rule of thumb can be used i.e. for 10 K temperature rise the insulation resistance is halved and for 10 K temperature drop it is doubled.

The exact coversion can be seen in (fig. 2.18). Drying can be stopped when the minimum insulation resistance is reached. If either of the measurement methods — polarisation index or insulation resistance — produces values that are too low, the winding should initially be visually examined for moisture, contamination or damage. If deficiencies cannot be detected or cannot be dealt with then the winding should be dried. Of course drying is also necessary, when inspite of good polarisation index and insulation values, moisture is visible on the windings.

Low insulation resistance values of new or repaired windings can also be caused by resin before it has completely cured. In this case the final insulation resistance value is only attained after an extended operating period (several 100 hours). If doubtful measurement results are obtained, it is important to determine the cause. In any case, when low insulation resistance values are obtained, carryout thorough cleaning and also, if required, drying.

INSULATION RESISTANCE OF LV WINDINGS

For LV windings using MICALASTIC insulation, basically the same applied as for H.V. windings. Here the insulation resistance can be in the k.Ohms range at higher temperatures; it is therefore advisable to carry out the measurement with voltages less than 500 V, for example 100 V. The insulation resistance of rotor winding is measured relative to the earthed shaft.

During operation, the insulation resistance of the field winding of synchronous machines should not fall below a value of 0.1 M.Ohms at operating temperature particularly in the case of single—layer windings. If the insulation resistance does fall below this value the winding must be cleaned and/or dried. Special attention should be paid to the pole connections and the slipring leads.

When new, their insulation resistance per pole should be R_{is}> 200 M.Ohms at room temperature. Accordingly this results in a minimum value for the complete winding of R_{is}, (min) > 200/No. of poles M.ohms. After prolonged storage or after prolonged operation the insulation resistance should initially be measured with a low voltage (<500 V) so that damage is not caused to the insulation as a result of the test voltage. If such damage does occur it must be repaired.

DRYING METHODS

For the purpose of dryout of windings, heat can be applied in three ways : —

1. By producing heat losses in the machine itself i.e. by operating the machine on short circuit.

2. By feeding current from external energy sources to produce heat losses in the windings e.g. with the aid of MG. welding sets or controllable high-current rectifiers.

3. By applying heat after suitable covering with tarpaulins, wood cladding etc.

With all these methods some air circulation must naturally be provided to allow the moisture to escape.

A steady temperature of about 60° C is desirable for the drying process. However this temp. should be achieved within four hours after starting the drying process. The magnitude of the current in the winding or the quantity of heat applied should be controlled so as to fulfil this requirement i.e. starting with low values and regulated according to the temperature rise. During the drying process only the insulation resistance of the whole winding to earth is measured i.e. the 10 min value, according to Fig 18. The insulation resistances are converted to the reference temperature of 75°C from curve B.

Example : Measured at 40°C, R_{is} (40) = 33 M. Ohms

R_{is} (75) = 0.125 x 33 = 4.1 M. Ohms

Avoid temperature variations during the drying process. With fully encapsulated machines provision should be made (by removing covers etc.) to permit the moisture to escape and for clean dry air to enter. Measure the temperature, using the built in resistance thermometers (slot thermometers) if possible. In addition, in the case of running machines, measure the inlet and outlet (cold and hot air) temperatures. Where slot thermometers are not provided and in any case with stationary machines, install alcohol thermometers on the winding overhang if possible. The most important measurement is the temperature at the highest point. Mercury thermometers should not be used because of incorrect reading and danger of breakage of thermometers due to high expansion of Mercury.

The rise in temperature above the ambient temperature of machines without resistance thermometers should be calculated from the increase in the measured winding resistance.

For every 10 K temperature rise, the resistance of copper rises by 4%. After completing the drying process, the machine should be loaded as soon as possible to prevent moisture from being reabsorbed. Where anti—condensation heating is provided, this should naturally be put back into service after drying. The windings of generators should preferably be dried with the machine running on short circuit to prevent hot spots being formed by heat accumulation. The three phase short circuit link should be designed so that the rated current of machine does not cause the link to be noticeably heated (typical value 1 A/mm2). Connect the shortcircuit link as close as possible to the generator terminals. If circuit — breakers or isolating breakers are in circuit between the generators and the short circuit link, measures must be taken to ensure that they cannot be opened during the drying process. If this did occur, voltage would immediately appear at the generator terminals. Voltage transformers or capacitors in the region of the short circuited winding should be disconnected since they introduce errors into the insulation resistance measurement.

During the shortcircuit drying of windings the following should be observed : —

Switch the voltage regulator changeover switch to Manual. With transipol excitation each phase of the secondary winding of the air gap reactor is individually short circuited. Break the connection between the excitation transformer higher—voltage winding and the air gap reactors and feed the secondary winding of the excitation transformer from an external system. Beware danger of feedback voltage. In the first 6 to 8 hours, increase the stator current from about 50 percent to a value such that the winding temperature does not exceed 60°C. Set the cooling water flow accordingly. Do not exceed the rated current and energise the over current protection including the de-excitation equipment. If the short circuit is in the zone of the differential protection, short circuit the current circuit of the current transformers. Record the slot temperature, inlet and outlet temperatures and the generator current every hour.

Monitor the progress of the drying process by repeated measurement of the insulation resistance — three phases to earthed frame — while observing the winding temperature (see example fig. 2.18). For this measurement the winding must be isolated.

If the MG. welding sets are to be used for drying machine windings certain precautions must be taken before connecting them in parallel. Measure the open circuit DC voltages to ensure that they are all equal. Connect the excitation winding F_1 — F_2 of all the welding sets required to operate in parallel through an additional switch. This allows all the field windings to be switched on or off together depending on whether the three phase motors of the MG. sets have been started or stopped. Because there is no ventilation, adjust the maximum permissible current per winding phase to 50% of the rated current. Measure the current and voltage of each MG. set. Connect the individual phases of the winding either in series or parallel. With series connection, connect the individual phases unsymmetrically (e.g. plus to U_1, U_2 to V_1, V_2 to W_1, W_2 to minus) in order to keep the axial magnetic flux in the shaft low. Where the neutral point is not brought out, two phases must be inevitably be paralleled and connected in series to the third phase. Change the connection order about every hour so that the winding is evenly heated. With the neutral point open, measure the insulation resistance of each phase to earth hourly. Before switching off a direct current, the current should be gradually reduced otherwise the winding inductance will cause heavy arcing.

Since the temperature distribution of a machine at standstill is different from that in the running condition, a winding temperature of 60°C must not be exceeded. If the rotor is in position, turn it by 90° every hour.

If methods 1 and 2 cannot be applied, the machine must be dried with hot air produced from an external heat source. This method of drying is usually adopted for synchronous machines where direct heating by means of current losses is not possible or when an MG. welding set cannot be used. The heaters should be arranged so that by means of suitable covers the winding being heated is in the hot air stream without concentrating the heat to the extent that excessive temperatures are reached. This requires that a continuous circulation of air takes place.

The hot inlet air temperature should not exceed 80°C and the outlet air temperature should be at least 10 K above the ambient air temperature. Do not allow the air temperature within the machine to drop below the dew point i.e. there must be no moisture condensation forming at the outlet. BECAUSE OF THE RISK OF FIRE THIS METHOD OF DRYING REQUIRES CONSTANT MONITORING to a much larger extent than the other two methods. This method also requires that the rotor should be turned by 90° about every hour.

MEASURING THE INSULATION RESISTANCE

To measure the insulation resistance, motorised megger 500 to 3000 V DC is used, the preferred voltage being 1000 V. For approximate readings on smaller and medium sized machines, commercially available insulation testers (e.g. megger) are sufficient. Before measurement, the insulation material (dielectric) must be completely discharged. When a DC voltage Uo is applied across an insulating dielectric of capacitance C, a charging current $i_c = \frac{U_o}{R} e^{-(t/T)}$ flows which is dependent on the circuit resistance R and the time constant T=R x C and which dies away exponentially (for all practical purposes within a fraction of a second).

The charging current i flowing after the inrush current has died away consists of the constant leakage current i_∞ and the time variable surrent i', the polarisation current component resulting from the polarisation of the insulation and which may take a few minutes or several hours to die away (fig. 2.19). To assess the condition of the insulation, the theoritical final value for the insulation resistance $R_{is\infty}$ would have to be determined as the quotient from the test voltage U_0 and the leakage current i_∞. In practice it is sufficient to determine the insulation resistance R is after 10 min. $R_{is} = U_0/i_{10}$ min where Uo is the test voltage and i_{10} min is the leakage current measured after 10 minutes.

The insulation resistance is heavily temperature—dependent. For this reason, the winding temperature must be carefully determined. The measurement must be converted to a reference temperature (see drying of windings).

The polarisation index N is given by the ratio
$N—i_{1min}/i_{10\,min}/R_{10\,min}/R_{1min}$
i_{1min} = current measured after 1 min.
i_{10} min = current measured after 10 min
for a constant test voltage U_o

The polarisation index provides information about the rate at which the polarisation current decays and, if necessary, permits an approximate assessment of the magnitude of the leakage current. Polarisation index values lower than 2 and as low as 1 indicate very high leakage due to contaminated or damp insulation. Very dry insulation can have a polarisation index of more than 4. Because the time required for discharging the polarisation current corresponds to the respective charging time (fig. 2.19), measurement errors can be introduced if the insulation has previously been charged. In the same way deviations from the nominal test voltage introduce errors.

In the circuit 'three phases in parallel to earthing casing' (fig. 2.20), it is mainly the insulation resistance in the slot that is measured.

The measurement "one phase to earthing casing and to the other two earthed phases" (fig. 2.21) also includes the insulation resistance between adjacent phase in the winding overhang in addition to the insulation resistance in the slot region of the phase under test. In both the cases leakage currents at the terminals and, where provided, at the winding overhang support are included in the measurement. During the location of defects, surface leakage currents may be conducted away, if considered necessary by guard rings (fig. 2.22).

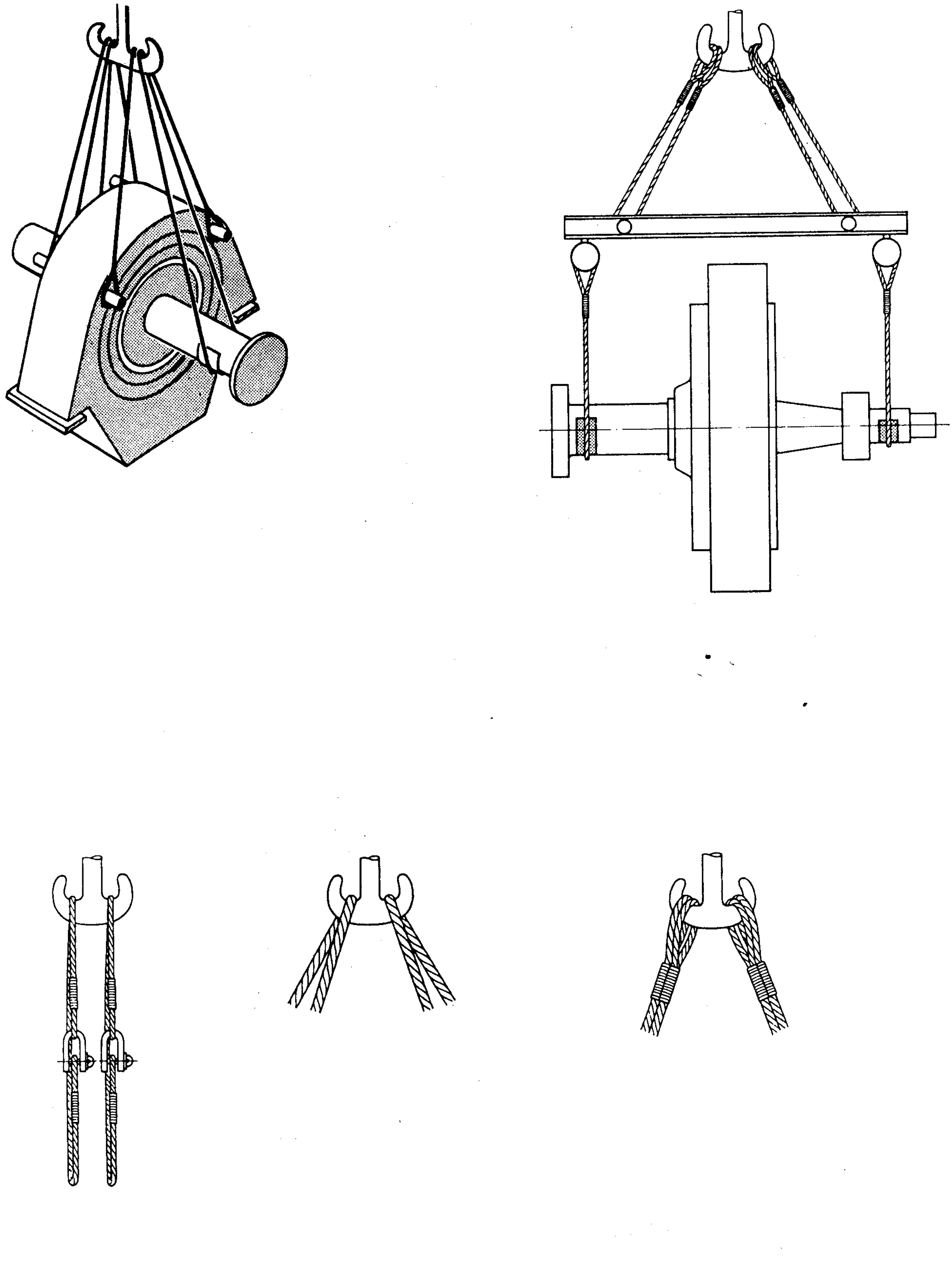


Fig. 2.1 Attaching wire ropes to double hooks

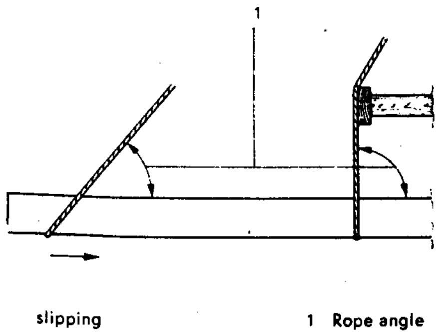


Fig. 2.2 Enlarging the rope angle by means of spreaders

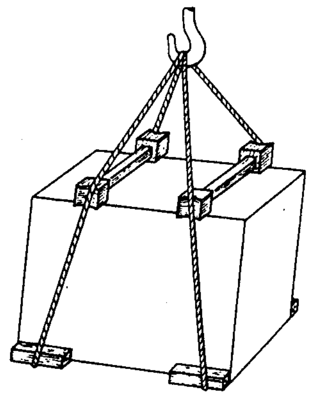
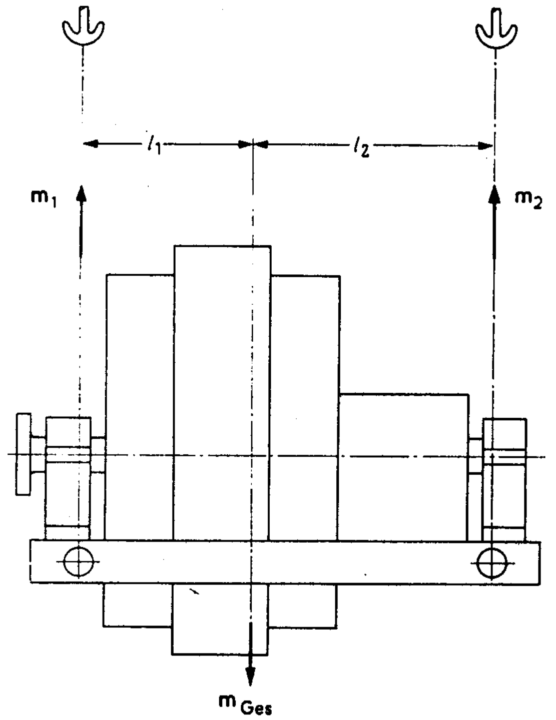
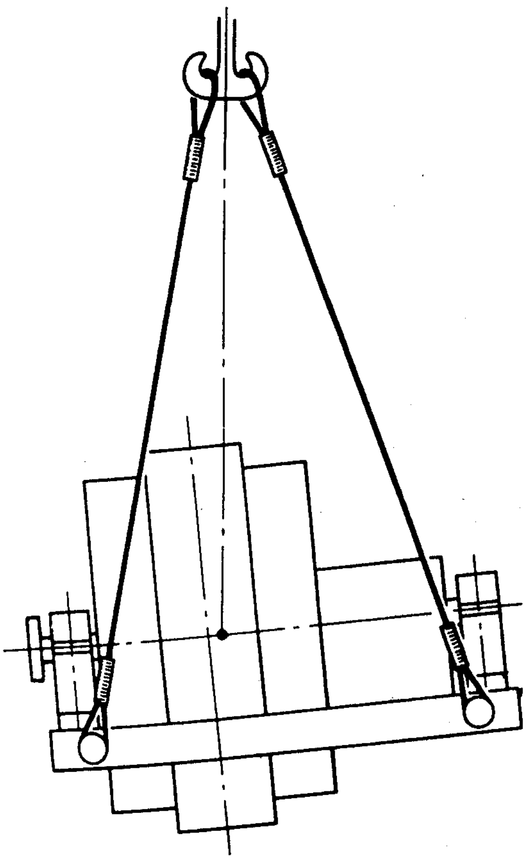


Fig. 2.3 Load protected from rope pressure by means of spreaders

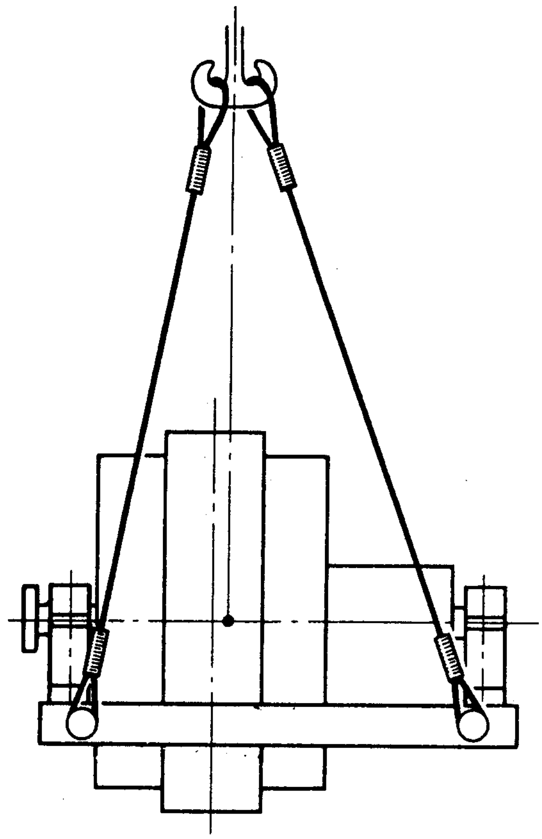


Example :
m_{tot} = 30 t = Total weight of machine
l_1 = 1m m_1 = 30 x 2/3 = 20 t
l_2 = 2m m_2 = 30 x 1/3 = 10 t

Fig. 2.4 Determining the crane load with unsymmetrical centre of gravity



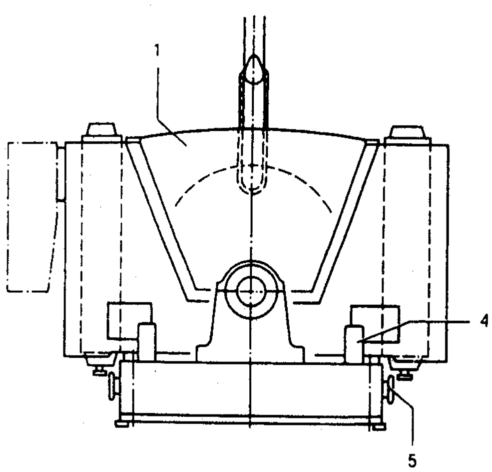
Ropes of equal length

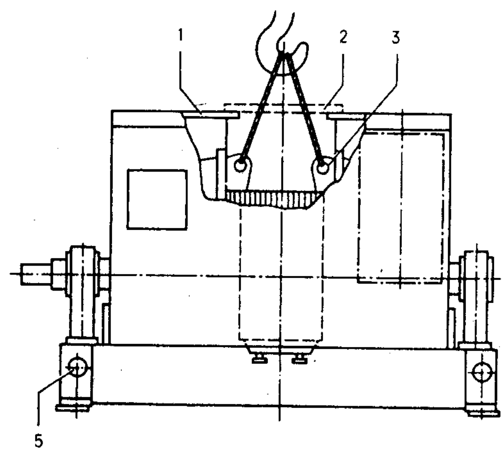


Ropes of different lengths

Fig. 2.5 Load with unsymmetrical centre of gravity attached to one crane hook

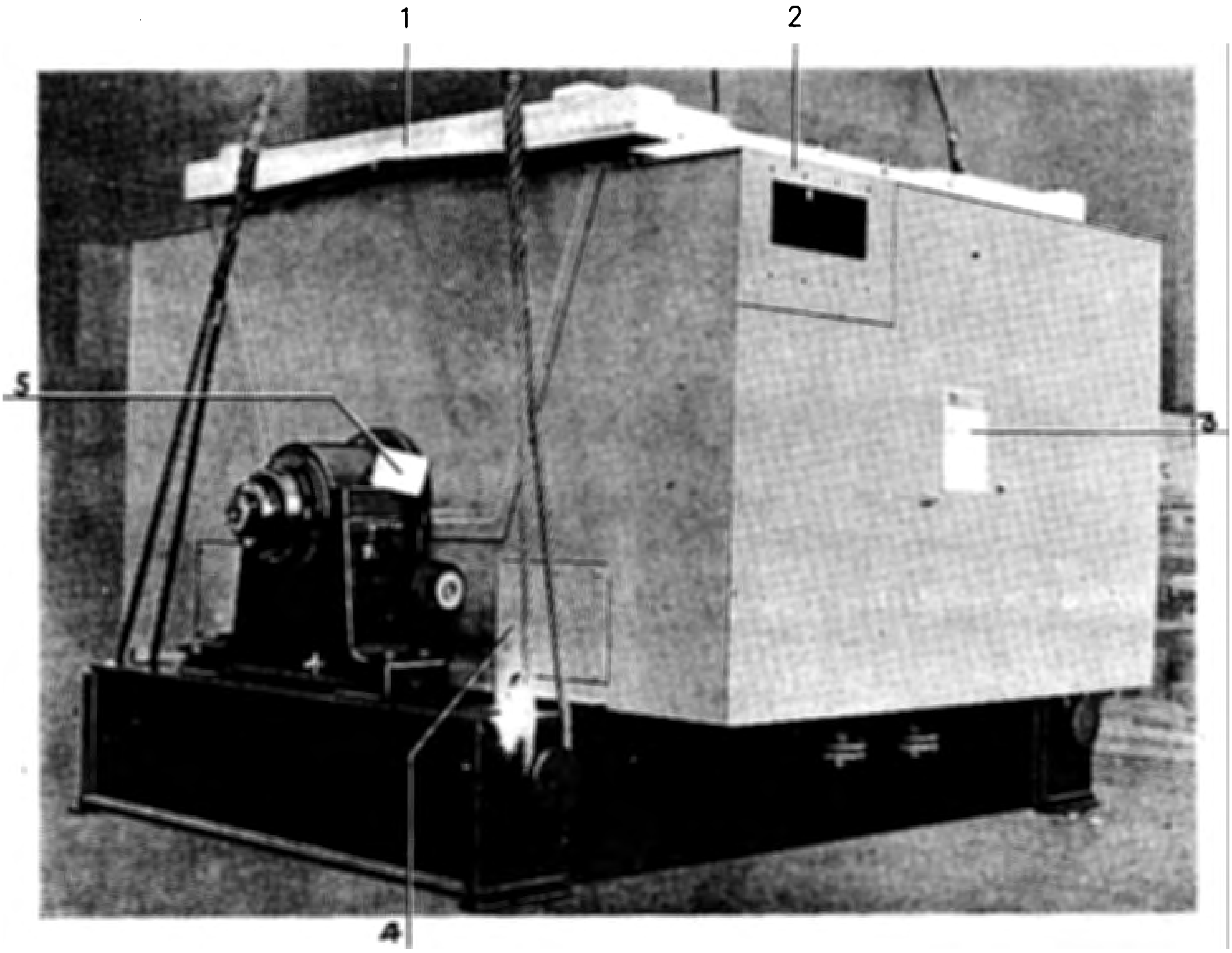
Fig. 2.6 Methods of Anchoring





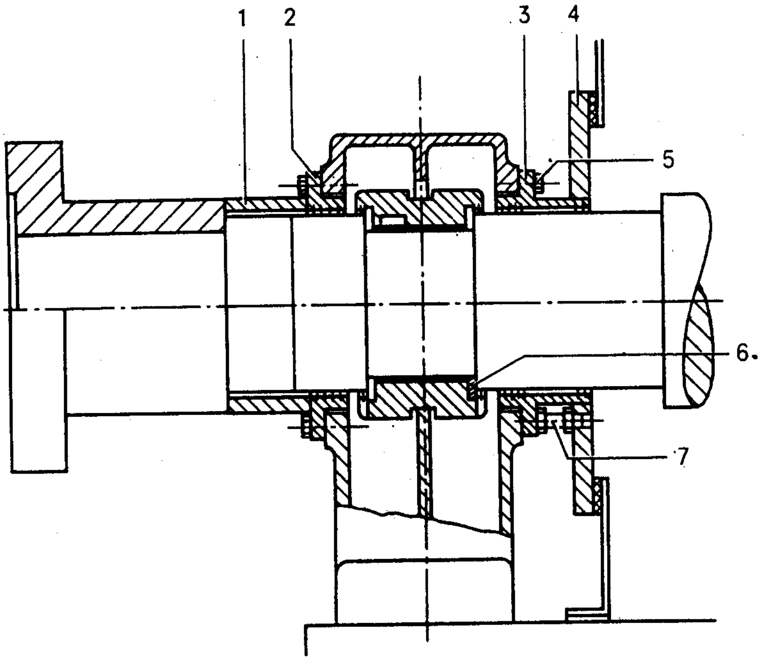
1. Top of the outer enclosure
2. Cover (removed for lifting the machine)
3. Eyes on the stator
4. Support for the outer enclosure during transportation
5. Lifting ballards

Fig. 2.7 Lifting the machine by the lifting eyes of stator



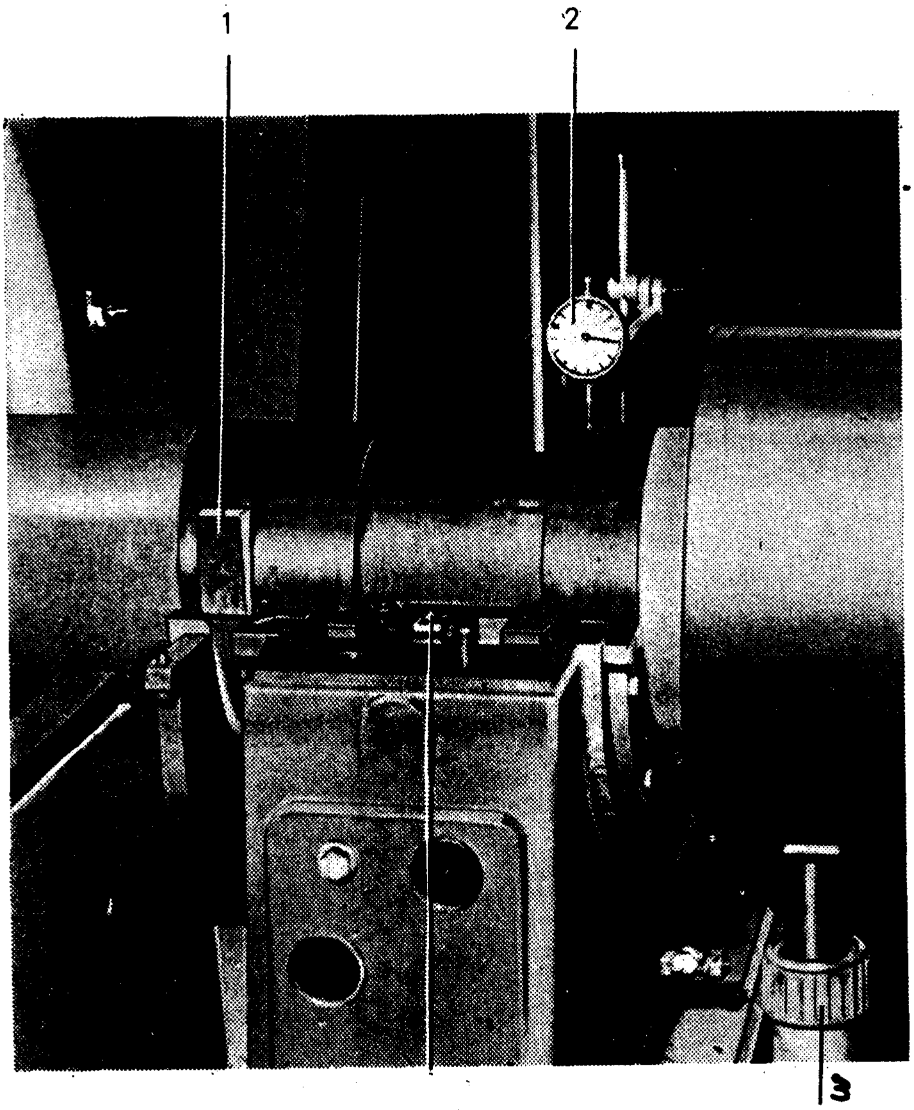
1. Rope spreader
2. Flange for terminal box
3. Recommendations for installation
4. Support for the outer enclosure during transportation

Fig. 2.8 Transporting the complete machine



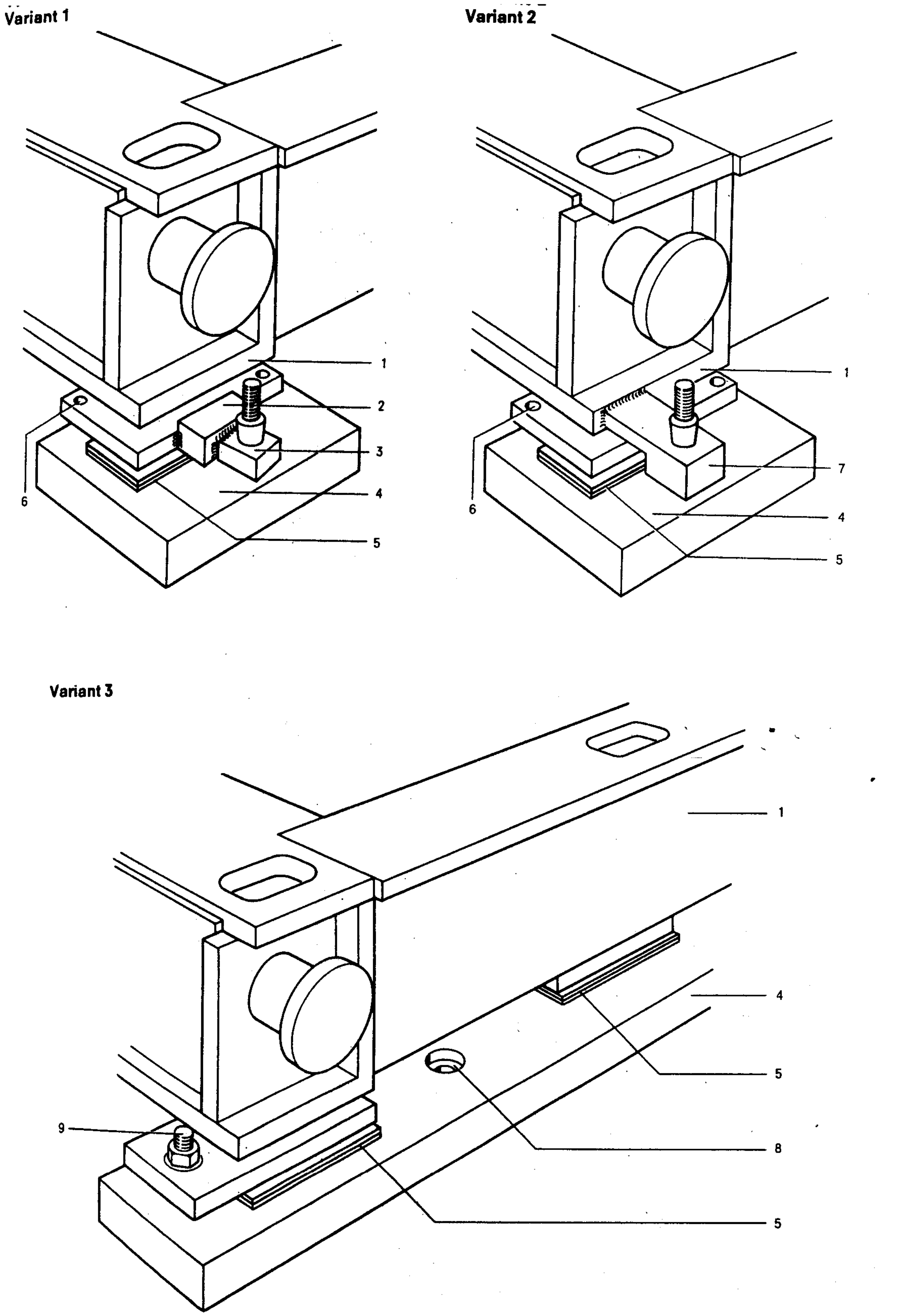
1. Block
2. Sealing ring outer
3. Sealing ring inner
4. Shaft seal
5. Bolt
6. Pad
7. Clamping bolt

Fig. 2.9 Transport block on the bearing



1. Shaft wedge
2. Magnet gauge stand with dialgauge
3. Hydraulic jack

Fig. 2.10 Lifting off the shaft



1. Baseframe
2. Wedge
3. Block with taper pin
4. Soleplate
5. Shims
6. Hole for securing soleplate to baseframe
7. Angle block with taper pin
8. Rag bolt for anchoring to soleplate
9. Adapter sleeve

Fig. 2.11 Securing the baseframe

Fig. 2.12 Sliding an anchor bolt into a foundation recess

Fig. 2.13 Anchor plate with the T-head bolt properly sealed

Fig. 2.14 Checking the alignment using feeler gauges & gauge blocks

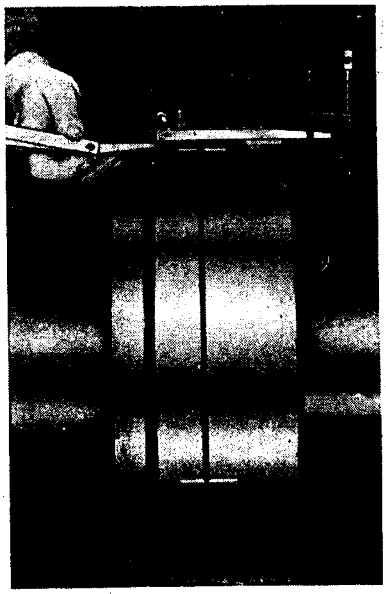


Fig. 2.15a Checking the radial alignment with micrometer screw and feeler gauges

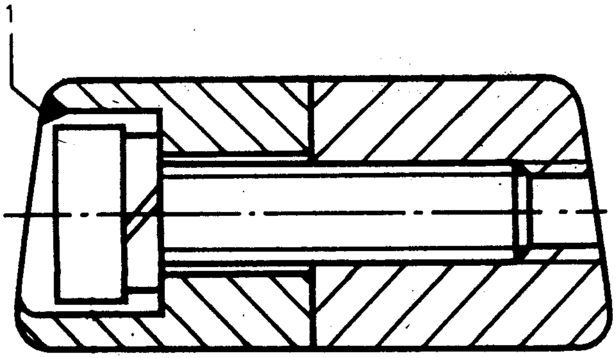


Fig. 2.16 Locking the oil ring joint bolt by a punch mark 1

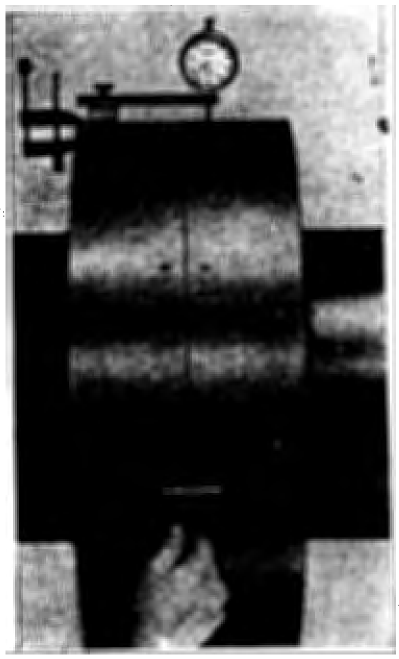
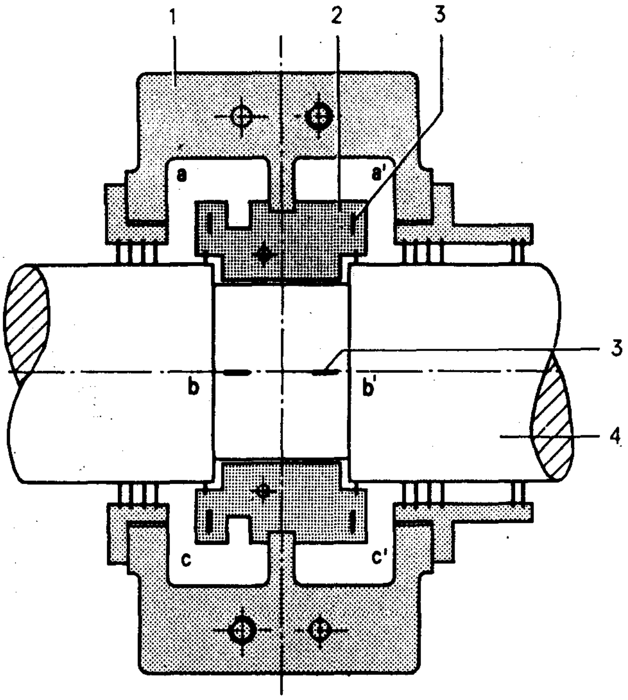
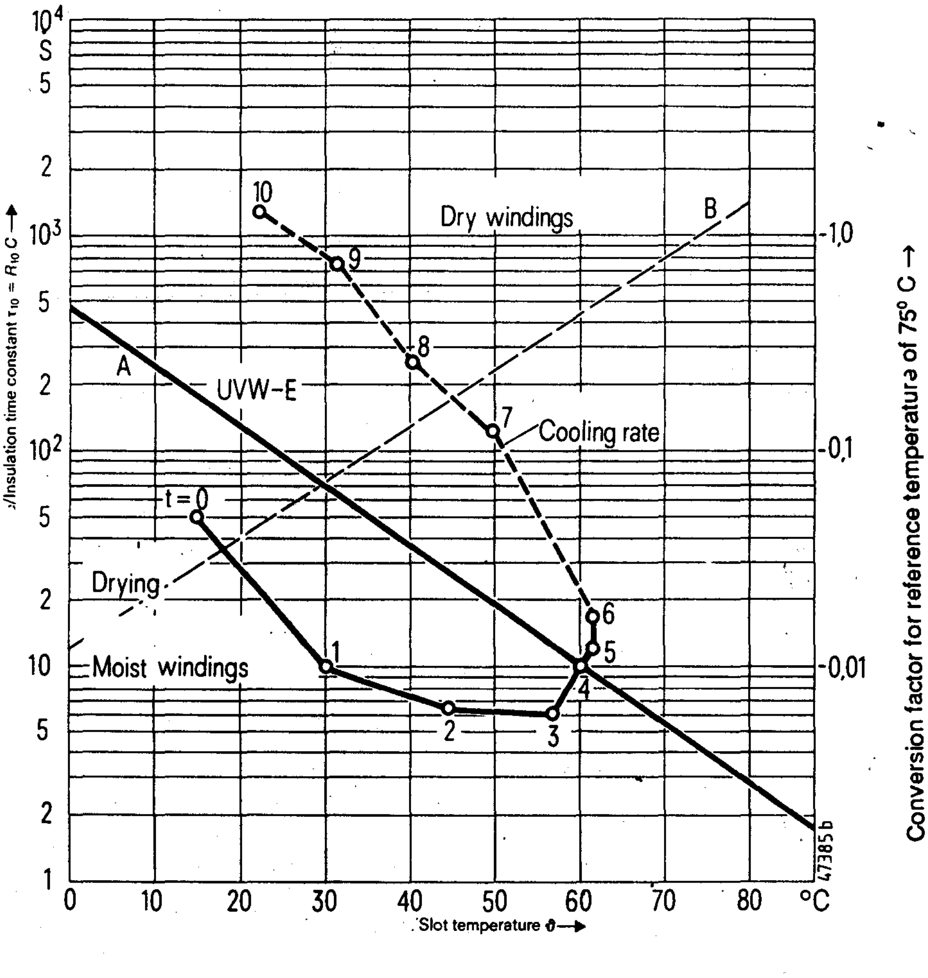


Fig. 2.15b Checking the radial alignment with dial gauge



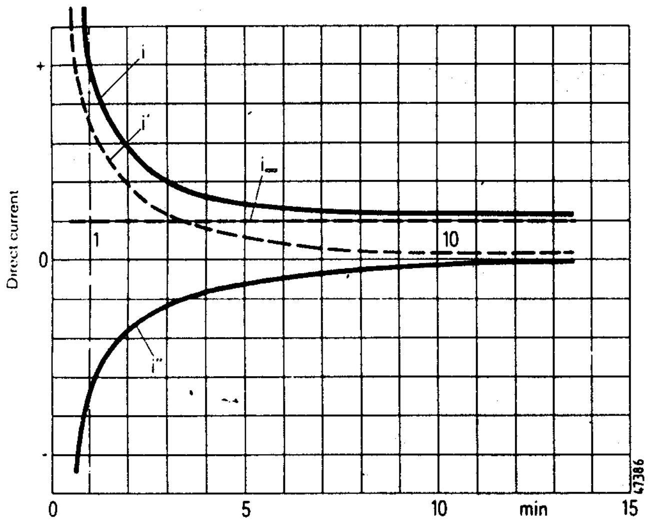
1. Joint face of the bearing housing
2. Joint face of the bottom bearing liner
3. Lead wires
4. Machine shaft

Fig. 2.17 Arrangement of the lead wires for measuring the radial bearing play



Minimum value of .ıe insulation time constant and example of a drying process

Fig. 2.18



i = i∞ + i' = charging current
i' = polarisation current
i" = dischage current
i∞ = leakage current

Fig. 2.19 Current - time characteristic for DC measurements

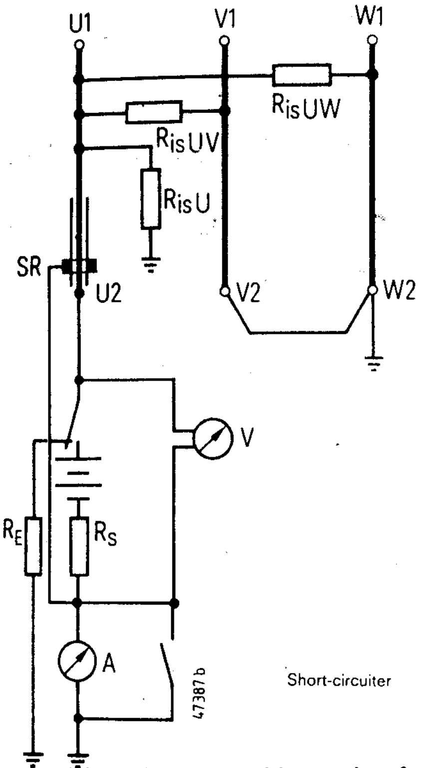
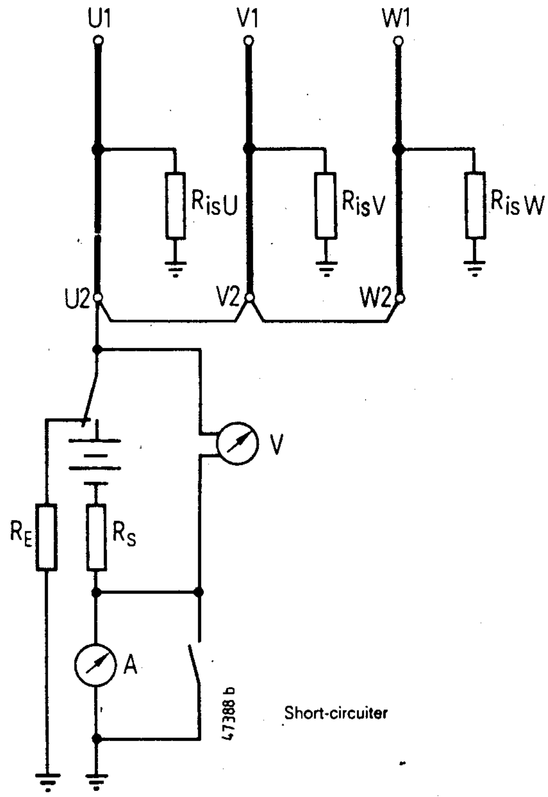
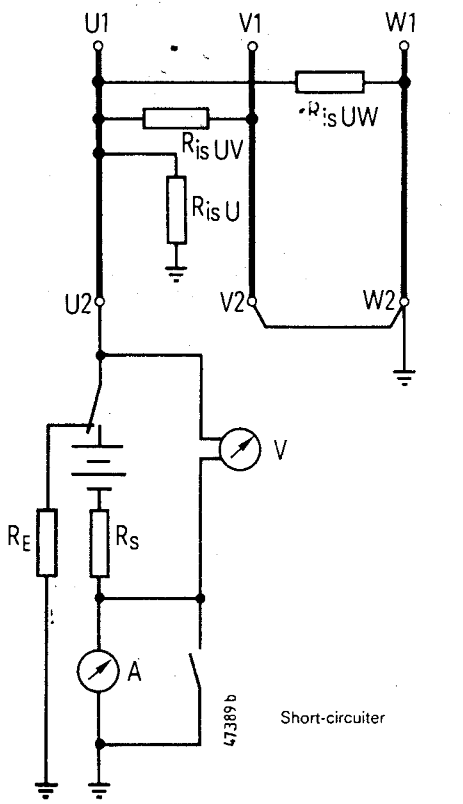


Fig. 2.21 Circuit "One phase to earthing casing & to the other two earthed phases connected to frame"



R_{isU}, R_{isV}, R_{isW}: Insulation resistance phase to frame
R_{isUV}, R_{isUW}: Insulation resistance between phases
$R_s = U_B/M_A$ Protective resistor
U_B Battery voltage
M_A Ammeter measuring range
R_E discharge resisstor

Fig. 2.20 Circuit "Three phases in parallel to earthing casing"



SR : Guard ring formed from wire or metal foil wound onto the surface of the insulation
R_s : Protective resistor
Fig. 2.22 Guard ring circut

CHAPTER — 3

COMMISSIONING, OPERATION AND SHUTTING DOWN

WORK PREPARATORY TO COMMISSIONING

After Initial Assemby	M/Cs Stopped for Testing but ready for operation	After an Inspection	Inspections	M/C PART
1	2	3	4	5

INSPECTING THE MACHINE PARTS PRIOR TO ASSEMBLY

1	2	3	4	5
*		*	Check the embedded resistance thermometers, using a measuring bridge, for proper functioning.	Stator
		*	Before attaching the winding shield, check the number of uncovered ventilating openings in the end walls of the enclosure.	
		*	Check the fans for correct mounting, noting the direction of rotation. Check the bearing for contamination.	Rotor

INSPECTING THE COMPLETED MACHINE

1	2	3	4	5
*	*	*	Measure the winding and insulation resistance of the stator winding to frame and adjacent windings. Carry out HV test as per IS.HV test need not be carried out on completely assembled machines.	Stator
*		*	Measure the air gap and axial offset. Make sure that no parts of the rotor rub against the stator.	
*	*	*	Check all fixing screws and taper pins for tight fit. Check the anchoring elements of the machine for tightness.	

1	2	3	4	5
*		*	Measure the insulation resistance of the rotor winding to the shaft and the winding resistance. Measurement need not be carried out on machines shipped in assembled condition.	Rotor
*		*	Check the bearing surface for contamination and the oil rings for correct position.	Bearing
*		*	Check the axial & radial play values for the radial sleeve bearing.	
*		*	Check the sealing rings, insert—type seals and oil lines and fittings for correct assembly.	
*		*	Check the bearing insulation for proper location and condition. Measure the resistance of the insulation.	
*	*	*	Check all fixing screws, bolts and taper pins for tight fit.	
*		*	Check the monitoring devices for correct connection and functioning.	Accessories
			Check the initial setting of the contact making devices on the monitoring equipment.	
*		*	Check the anticondensation heaters for correct installation, connection and functioning.	
*		*	Check the cooling water piping for correct installation and correct circulation.	

1	2	3	4	5
*		*	Check all electrical connections for tight fit (terminal box, CT casing & secondary TB). Inspect all earthing connections.	Connections

FILLING AND COMMISSIONING THE WATER SUPPLY SYSTEM

*		*	Open the vent valves. Fill the pipe system with clean water. Close the vent valves when water comes out from the valves. Inspect the connections for leaks.	Coolers
*		*	Fill the ring lubricated bearings with the specified amount of suitable oil.	Bearings
*		*	Check the oil filling on the sight glass.	Oil circulating system
*		*	Fill the oil system of forced lubricated bearings with oil of prescribed quality.	FOL System
*	*	*	Check the oil pump for proper functioning and the oil flow for the correct direction.	
*		*	Check the connections for leaks. Adjust the correct oil flow rate and pressure.	
*		*	Check the separately fitted fans (where provided) for satisfactory operation (direction of rotation) and the air flow.	Fans

STARTING THE GENERATOR

Switch off the anticondensation heating system.

Having conducted the above mentioned checks the following operations are to be carried out step by step before starting the machine.

a) The generator should be spun at a low speed ensuring that there is no jamming, unwanted noise or runout of shaft. The speed should then be slowly raised to the rated speed ensuring that there is no abnormal noise.

b) The bearing temperature is to be carefully observed when the generator is spun. The temperature should increase gradually without sharp kicks, with uniform increment and within a few hours of operation it should become almost constant. If the temperature increases sharply even if the absolute temperature is not high, the generator should be stopped and the bearings checked. Check operation of the oil rings while the generator is coasting.

c) After the first run, the generator should be shut down for inspection. The machine should be thoroughly inspected and mechanical fastenings checked for looseness.

PUTTING INTO OPERATION

a) Start the generator and check its operation without excitation at rated speed. Record the temperature of the bearings.

b) Switch on the excitation system and increase field current to build up voltage in the generator. Check the generator output for voltage and phase balance before synchronising.

c) Synchronise and load the generator. The load should be increased gradually and sufficient time should be allowed at every stage for stabilisation. Check for abnormal noise.

Take the voltage, current, power and excitation readings and compare with rated values and note. Keep a continuous check on the temperature of the bearings, stator winding, the inlet and outlet air and of the cooling water during a prolonged period of time and record the values when steady state conditions have been obtained. Check the oil pressure and flow rate of bearings and correct if necessary.

OPERATION

By operation is understood the use of the machine for its designed purpose. This necessitates certain tests to be performed in order to ensure that the machine runs efficiently and that it conforms to relevent regulations. To be able to detect faults at an early stage and thus avert damage, continuous monitoring is a requirement. From changes, taking place over a period of time, it may be assumed that the performance has been impaired. In order to prevent damage, the machine should be examined as early as possible. Measuring instruments and test equipments are built into the machine for the tests as ordered. However, not all operations and conditions can be monitered by technical equipment. Thus, at suitable intervals, visual and mechanical checks of the machine are recommended. In general the following quantities and conditions should be checked on parts of the set as required by the respective machine design.

QUANTITIES AND CONDITIONS	MACHINE PART
Winding temperature. Cooling air inlet temperature. Cooling air outlet temperature. Cooling water inlet and outlet temperature. Pressure drops across the air filter. Sealing of the cooling water piping. Leakage water in the housing. Machanical vibrations	Stator
Winding temperature	Rotor
Bearing temperature and circulating oil pressure. Circulating oil flow, oil film pressure in oil lift system, oil level in bearing pedestals Sealing of the bearing and oil piping Running smoothness	Bearings
Stator voltage and current, Power Excitation voltage and current	Complete Machine

SHUTTING DOWN

The following sequence should be followed for stopping the machine running on load :

a) Reduce the output of the machine till it is almost zero.

b) Trip line circuit breaker

c) Reduce the field current till the terminal voltage is almost zero.

d) Trip field circuit breaker

e) Switch off FOL system after machine comes to standstill.

f) Switch off cooling water supply to cooler.

g) Switch on anticondensation heaters.

When the machine is shut down for a long period the following precautions must be taken :—

a) The anti—condesation heaters should be switched on and the temperature inside the machine to be maintained about 5°C above ambient.

b) The insulation resistance of the stator and field windings are to be taken regularly, at intervals of one month and a record maintained.

The following checks are to be made when the machine is started after prolonged shutdown.

a) The insulation resistance of the stator and field windings should be checked. If these values are lower than recommended, the machine should be put on dryout.

b) The insulation resistance of the pedestal bearings should be checked.

PROTECTIVE MEASURES ON STATIONARY MACHINES WHICH ARE READY FOR OPERATION (in addition to regular maintenance)

Special measures are necessary for the protection of machines, which are ready for starting, when operational requirements necessitate them to remain at standstill and when the possibility of the machine being endangered by environmental conditions at the site must be considered.

Periods of standstill occur, for example, in the following cases : —

— Between connecting up and commissioning the machine.

— On machines which are only used occasionally e.g. emergency generating sets.

— non — spinning reserve.

To maintain readiness for operation, the following are examples of measures which must be taken : —

— Prevent condensation in the machine e.g. by anti—condensation heating or air de—humidifier.

— Start the machine at least once every four weeks. Where applicable, make allowance for the specified operations in 'WORK PREPARATORY TO COMMISSIONING' 'STARTING UP' and 'SHUTTING DOWN'. If starting is not possible, at least the rotor should be turned at the interval mentioned.

— IN ORDER TO PREVENT ANY DAMAGE TO THE DIODES OF BRUSHLESS EXCITER, GENERATOR FIELD CABLES MUST BE DISCONNECTED BEFORE CARRYING OUT ANY TEST / MEASUREMENT ON GENERATOR FIELD WINDING.

CHAPTER — 4

FAULT DIAGNOSIS CHART

FAULT DIAGNOSIS CHART

FAULT											POSSIBLE CAUSE		REMEDY
Exct. Current varying	Humm during Startup/running	Excess gear noise during startup	Howling noise	Screeching noise	Grinding noise	Excessive Temperature	Individual Wdg. Sections overheat	Radial Oscillations	Axial Oscillations	Enclosure vibrates			
*							*				Over load	:	Reduce loading
*	*						*	*			One supply phase open circuited One supply phase opencircuit after switch on Open circuit in field circuit	:	} check switchgear & supply circuit
*	*							*			Stator winding incorrectly connected	:	Check winding connections
*	*							*			Interturn shortcircuit in stator wdg.	:	Disconnect m/cs, feel surface of endturns & check temp. rise. Remove Shortcircuit
*									*		Interturn shortcircuit in field winding	:	Check Temp rise. Discoloured varnish may be a hint. Remove short circuit.
				*							Rotor core rubbing against stator core. Windage noise, small gaps or sharp corners in air circuit.		Check air gap and realign Avoid narrow gaps or sharp corners.
					*						Rotating parts rub against stator parts		Realign m/c, check rubbing noise
					*						Reduced air supply, wrong fan direction. Insufficient cooling water supply		Check air/water supply, clean filter, check air path, interchange fans if wrong fan direction.
											unbalance in rotor		Uncouple and rebalance the rotor.
									*		Unbalance in coupled machine		Rebalance the coupled machine
									*		Magnnetic unbalance, rotor out of true		Consult supplier, True rotor by skimming.
									*		Misalignment, uneven running caused by gearing, Resonance with foundation, changes in foundations		Realign the machine set, allow for displacement resulting from temperature rise, Check coupling, Bring gearing in order. Reinforce foundation. Consult supplier
										*	Shocks transmitted from coupled machine		Check coupled machine
										*	Resonances, insufficient rigidity		Obtain instructions from supplier, reinforce enclosure

FAULT DIAGNOSIS CHART
(For Sleeve bearings)

FAULT: Bearing overheats	FAULT: Bearing Temperature varies or rises abruptly without externally traceable cause	FAULT: Oil blackens prematurely or contains abraded matter	FAULT: Bearing loses oil	FAULT: Oil drawn into machine	POSSIBLE CAUSE		REMEDY
*	*				Oil aged or contaminated, High viscosity	:	Clean bearing housing, renew oil, check viscosity
*	*	*			Low oil level, oil ring out of true, rotates irregularly or stalls, especially at low speeds	:	Check oil level and top up, if necessary, check oil rings for roundness, realign & straighten or even replace them
		*	*		Viscosity of oil too low	:	Check viscosity; change oil if low
			*		Oil viscosity too high due to low oil temperature, especially during startup	:	Heat bearings or oil during or prior to startup
			*	*	Oil foams	:	Inspect bearing vent. Use different oil type after enquiring with supplier. Use antifoam additive
*	*				Forced lubrication fails. Oil or cooling water failure	:	Inspect oil supply system. Remove disturbance
			*	*	Oil pressure of forced lubrication system too high, more than 0.5 bar	:	Reduce oil pressure, install pressure reducing valve
			*		Forced lubricated bearing flooded	:	Adjust correct oil rate. Check oil discharge for obstruction. Check oil level in bearings
*	*	*			Residual oil pressure of bearings with jacking oil arrangement drops during operation with jacking inoperative	:	Check oil pressure piping and non-return valve; check bearing shells for canting. Remedy disturbance
*					Excessive axial thrust. Thrust from coupling Excessive radial load, inadequate radial play	:	Inspect for magnetic centre. Check alignment. Realign bearings and/ or machine. Raream bearingshell
		*			Excessive radial play	:	Change oil after consultation with supplier, use oil with high viscosity.
			*		Oil return openings in or under lower sealing ring half clogged	:	Clean oil return openings.
*	*	*			Damage to bearing lining. Defective bond between lining & supporting block of bearing shell	:	Inspect bond. Replace lining. (ensure correct shape of oil pockets and oil grooves)
*					Too small oil pockets, transition to bearing surface not smooth enough	:	Refinish oil pockets.
			*	*	Sealing rings defective. Gap between shaft and sealing ring too large	:	Replace sealing rings.
*	*	*			Bearing currents	:	Inspect bearing insulation & replace if necessary.

CHAPTER — 5

MAINTENANCE

MAINTENANCE AND INSPECTION SCHEDULE FOR MECHANICAL MACHINE PARTS

Maintenance Intervals			Inspection and maintenance work
1st Insp.	2nd Insp.	3rd Insp.	
1	2	3	4
			ALIGNMENT OF MACHINE :
			a) Foundation, rotor and bearing,
*		*	Check the foundation for settling or cracks.
*		*	Check rotor alignment. Realign if necessary.
*		*	b) Check the air gap and axial offset. Realign if necessary the stator.
*		*	c) On enclosure, check the clearance to rotating parts. Realign the enclosure components if necessary.
			MACHINE ANCHORS AND FIXING ELEMENTS
*		*	a) For base frame, soleplates, stator, bearings and enclosure :— check all foundation anchoring elements for tight fit. Check all fixing bolts and screws of the machine parts, including taper pins and washers for tight fit. Retighten if necessary. For locking only use new locking elements.
*		*	b) Check the balancing weights for tight fit and retighten if necessary. For locking only use new locking elements.
			CONDITION OF COUPLING
*		*	a) Rigid coupling :— Check all coupling bolts and locking elements for tight fit. Retighten if necessary. Use new locking elements. Inspect

1	2	3	4
			coupling bolts for fretting corrosion.
*		*	b) Coupling with tangential keys : — Check the keys and associated locking elements for tight fit. If necessary drive in the wedging elements and fit new key locks. Use new locking elements. Inspect for fretting corrosion.
*		*	c) Toothed coupling :— Check to see that the coupling housing can be shifted axially. Should this not be the case, clean the coupling and check alignment of the machine.
*	*		Change the oil. Clean the oil filled coupling & check its condition. Clean the oil lubricated coupling and check its condition.
*		*	d) Flexible coupling :—Check the axial clearance, check the pins for tight fit and retighten if necessary. Inspect the compression sleeves. Replace the entire set if necessary.
			FIXING ELEMENTS OF MACHINE PARTS
			1. Stator
*			a) Check the point pressure of the stato core.
		*	b) Check the joint pressure of the stator core particularly the fit and locating of the joint spacers. Correct the spacers, if necessary, and retighten the joint bolts.
			2. Poles :
*		*	Check the fixing elements of the poles and pole winding supports for tight fit. Retighten or fit new wedges, if necessary. Use new locking elements.
			3. Rotor :
*		*	Check the keys of the hub and rotor yoke,

1	2	3	4
			including the associated locking elements, for tight fit. Drive in the wedging elements, if necessary, and fit new wedge locks. Use new locking element.
			4. Machine pit :
*		*	Inspect the stator pit and machine for signs of incipient damage, if necessary, locate the defect and take the necessary measures.
			5. Air to water cooler :
*	*		Clean the cooler. Determine the cleaning intervals according to the degree of contamination. Inspect corrosion protection.
			SUPPLY SYSTEM AND MONITORING DEVICES
*	*		1) Clean the oil filter. Determine the cleaning intervals according to degree of contamination.
*		*	2) Check the oil supply system for correct functioning.
*		*	3) Check the monitoring and indicating devices for correct fuctioning. Replace/rectify if necessary.

Note : —

1) 1ST INSPECTION AFTER 400 operating hours, but not later than one year.

2) 2ND INSPECTION AFTER every 4000 operating hours but not later than 1 year.

3) 3RD INSPECTION AFTER every 8000 operating hours but atleast every 2 years.

MAINTENANCE AND INSPECTION SCHEDULE FOR BEARINGS : —

Maintenance Intervals			Inspection and maintenance work	
1st Insp.	2nd Insp.	3rd Insp.		
1	2	3	4	
			CONDITION OF BEARINGS	
*	*		Clean and inspect the bearing insulation and the insulation of the pipe and thermometer connections. Replace the insulation, if necessary. Fix the inspection intervals as required for the degree of contamination. Check the pressure in the sealing — air chambers, where provided,	
*			CHANGE THE OIL ++	
*	*		Bearings upto 250 mm dia	Please refer Bearing inspection plate
*		*	Bearings with dia from 280 mm upwards	
after 20000 operating hours			Bearings lubricated from central oil supply system and provided with filters	
			Note :— for the intervals applicable to bearings with diameters from 500 mm onwards and bearings with builton oilpump, refer to the bearing instruction plate.	
*		*	Check shaft lift oil system.	
*		*	Check the radial and axial play.	
*		*	Inspect the bearing surfaces	

1) 1ST INSPECTION AFTER — 4000 operating hours or 1000 operations but not later than 1 Year.

2) SUBSEQUENT INSPECTIONS EVERY — 4000 operating hours, but not later than 1 Year.

3) SUBSEQUENT INSPECTIONS EVERY — 8000 operating hours (16000 operating hours in the case of continuous operation), but at least every two Years.

++ The oil change intervals given can be extended after consultation with experts of the oil supplier if the oil is continuously checked for aging and contamination, by examining the samples.

MAINTENANCE AND INSPECTION SCHEDULE FOR STATOR AND ROTOR WINDINGS : —

Maintenance Intervals		Inspection and maintenance work
1st Insp.	2nd Insp.	
1	2	3
		1. STATOR WINDING
*	*	— Clean winding and ventilation ducts.
*	*	— Check slot wedges for tight fit
*	*	— Check overhang bracing.
*	*	— Check condition of winding insulation, including ring circuits and end connections.
		2. ROTOR WINDING
*	*	— Clean winding and ventilation ducts. **Note :—** If oily dirt deposits are found determine their origin.
*	*	-- Check slot wedges for tight fit
*	*	— Check bandings for satisfactory condition
*	*	— Check the cap rings for tight fit on the glasstape serving.
		3. LEADS ON STATOR AND ROTOR
*	*	Check ring circuits and end leads of stator winding, exciter leads, terminal boards and connecting bars, as well as all insulating elements, fixing screws and locking elements to see that they are clean and tight. Use new locking elements when retightening the screws.

1	2	3
		4. CONNECTIONS
*	*	Check stator connections for good contact, retighten terminal screws, if necessary, and secure with new locking elements. Check earthing terminals.
		5. ALL WINDINGS
	*	— Check insulation resistance with hand or motorised megger.
	*	— Measure the respective winding temperature. Record the values. Compare the values with those of the previous inspection.

Note :— 1ST INSPECTION AFTER 4000 operating hours or 1000 operations but not later than 1 year.

SUBSEQUENT INSPECTIONS every 8000 operating hours (16000 operating hours in the case of continuous operation) but not later than every 2 years.

MAINTENANCE OF WINDINGS :

Before beginning any work on the machine isolate it from the supply, earth it and ensure that it cannot be switched on inadvertently. Lock the rotor against unintentional turning. First remove the parts of the enclosure necessary to gain access to the windings for visual inspection and for necessary cleaning. With machines in which the stator can be adjusted, shift it in the correct direction (see dimensional drawing) with the aid of the tackle provided.

While cleaning the winding care must be taken not to damage the insulation through the use of unsuitable sharp — edged tools or excessive stressing of winding parts by applying too much force (blows or treading on the windings etc.). Windings, air ducts etc. which are thickly covered with loose dust should be cleaned by blowing out the dust with dry compressed air (max 4 bar) and / or sucking it out with a suitable vacuum cleaner. The compressed air and vacuum equipment should have a plastic nozzle. Layers of dirt sticking firmly to the winding should first be wiped out with a dry rag. This is particularly true for areas where oil has been deposited and those in which brake dust have also accumulated. Should these measures not be adequate, use clean rags soaked with perchloroethylene, white spirit or a perchloroethylene and white spirit mixture. Wiring out the rags to ensure that only dirt and not the varnish coating is removed during cleaning. Use a moistened rag wound onto a strip of wood or plastic where access is difficult.

DO NOT USE BRUSHES. It is important that all deposits be removed from the connecting points, the cording, bracing elements, ring circuit conductors and outgoing leads. Wipe down treated areas with dry rags until a fresh rag shows no trace of dirt. IMPORTANT : COIL SIDE AND OVERHANG CORONA SHIELDING MAY BE DAMAGED BY SOLVENTS. FOR THIS REASON DO NOT USE SOLVENTS IN THE SPACE BETWEEN THE CORE AND THE CURVED PART OF THE CONDUCTOR OR COIL.

After carefully cleaning the windings, the following checks should be made :—

1) Check the insulation of the windings & connections.
2) Check the spacers, cording, slot wedges, bandings & struts for tightness.
3) Check the winding coils and connection points for breaks, unstisfactory brazing, interturn shortcircuits and shortcircuits to frame.
4) Check that all leads are properly connected and that all fixing and terminal screws are tight. Tighten if necessary, using only new locking elements.

If the coating of varnish on the windings is damaged during cleaning or checking, these patches must be touched up with an oil resistant air drying insulation varnish.

IT IS MOST IMPORTANT THAT THE VARNISH USED SHOULD BE COMPATIBLE WITH THAT USED DURING MANUFACTURE AND THAT IT ALSO EXHIBITS GOOD ADHESIVE PROPERTIES. The varnish should be applied in even layers, as thinly as possible, either by spraying or brushing and afterwards allowed to dry thoroughly. After all maintenance work is carried out, check for IR value.

MAINTENANCE OF SLEEVE BREARINGS :

Maintenance includes following :—

1) Checking lubricating system for proper functioning.

2) Checking the bearing temperature.

3) Checking the oil at the intervals specified.

4) Checking the bearing insulation.

5) Inspecting the parts subject to wear. (bearing liner, oil rings, sealing rings).

CHECKING LUBRICATING SYSTEM FOR PROPER FUNCTIONING

Observe the oil rings through sight glasses and check the oil circulating and jacking pumps by reading the instruments provided. Sleeve bearings are fitted with an oil level glass. Top up the oil upto the centre oil level mark or upto middle of sight glass. The oil level must not drop below the lower edge of the sight glass. The oil quantity should be as given in the bearing data. In case of forced oil lubricated bearings, they are provided with a regulating valve at the oil inlet. The oil flow rate at a constant oil pressure of 0.5 bar should not be exceeded. If a higher oil pressure prevails at the oil inlet, a pressure reducing valve must be installed in the tube system. The oil flow rate must not be altered.

CHANGING THE OIL

While working on open bearings take care to prevent any silicon contamination. For changing the oil shut down the machine, isolate and lock against prevent unintentional restarting. Open the oil drain valve to drain off the old oil, preferably with the machine at operating temperature. There upon flush with clean oil of suitable quality. Leave the drain open until flushing oil has drained out completely. Close the drain valve and fill with oil of suitable grade upto the middle of the oil level glass. Oil should be poured only through the hole which is provided in the bearing cover and closed off by a marked screw plug.

CHECKING THE BEARING TEMPERATURE

VDE 0530 permits a max. temperature rise of 50°C for sleeve bearings, considering coolant temperature of 40°C. The temperature measuring points are located close to the bearing surfaces. This is done to detect immediately the defect in good time. The temperature of the bearings should dbe checked at regular intervals and values recorded. If larger temperature variations or abrupt changes are noticed without externally traceable cause, inspect the bearing and change the oil if necessary.

Some bearings are fitted with monitoring devices for measuring the bearing temperature. If an unusual high temperature is noticed take an exact measurement by means of a thermometer. With contact thermometers the operating points have to be set on the basis of the bearing temperature vb measured at the highest ambient temperature.

Operating point settings for contact thermometers	Recommended max. operating point
Alarm contact v_b + 5°C	85°C
Tripping contact v_b + 10°C	90°C

CHECKING THE BEARING INSULATION

All pedestal bearings are installed on insulated mountings. In case of machine or machine sets with more than one bearing, one bearing is earthed by means of an earthing connection. The position of the earthing terminal is shown in the dimesional drawing.

Check the condition of the bearing insulation and if necessary change it. Select the cleaning intervals depending upon the degree of contamination of the insulating parts, to prevent from forming creepage paths. Measure the dielectric strength by means of a Megger with 100 v on the insulated bearing. The dielectric strength should be at least 1 K ohms. Experience indicates that considerably higher values are obtained from newly insulating materials. If lower values are found, inspect and replace the insulating material where necessary.

In the case of uncoupled machines or where the coupling between the machines is electrically insulated, the insulation resistance of pedestal bearing can be measured between bearing and earth after undoing earthing connection.

The insulation resistance of the individual insulating layers below the bearing feet can be checked by means of the measuring plate installed between the insulation layers.

INSPECTING THE PARTS SUBJECT TO WEAR

After certain minimum speed has been reached, sleeve bearings run under conditions of true fluid friction. Serious wear on the bearing liner can only occur if the oil contains impurities or is very old, if the axial thrust is too high, if bearing currents are present or if mixed friction occurs after operation below the minimum speed for an extended period. A small amount of wear also occurs during the startup and shutdown of the machine. The bearing should be opened and the liner removed if sludge formation is noticed during the oil change in addition to normal oil turbidity e.g. after a preceding temperature increase or if checking of the radial and axial play and of the bearing surfaces becomes necessary according to the time intervals given in maintenance and inspection schedule for mechanical machine part.

Remove the bearing liner. Before starting dismantling, drain the oil from the bearings and carefully remove the thermometers. The temperature detectors and the capillary tubes must not be kinked or bent excessively.

To avoid damage to the other bearings of a shifting system when the shaft is being lifted to replace only one bearing liner, loosen the covers of all other bearings in the section upto the flexible coupling. In the case of shafting system with rigid couplings and machines with greatly differing shaft dimensions/diameters, take care that unloading of one bearing does not excessively stress the weakest shaft of the system. In any case, disconnect the coupling of the weakest shaft.

If the bottom bearing liner is not to be replaced for some time, remove the sealing rings and support the rotor on V—Blocks placed directly at the position of the bearing. The rotor of machines with enclosures made in one part can be allowed to rest on the stator core after the sealing rings have been removed and the core surface lined in an appropriate manner e.g. with rubber sheeting.

With the bearing open, measure the axial play between the shaft shoulder and the appropriate end face of the bearing using feeler gauges.

When the machine is running, the oil film transmits the load to the entire bearing surface, so that the cylindrical shape of the bearing needed to set up the required oil wedge is more important than the bright surface in the bearing caused by the shaft under conditions of mixed friction. Slight defects on the bearing surfaces e.g. threading, can be removed by scraping. The cylindrical shape of the bearings must be maintained when re-finishing their surface. Emery cloth and similar means must be under no circumstances used since any particles left would cause damage to the bearing. Fit replacement bearing lines if more severe damage is found e.g. strong threading, damage due to bearing currents, loose white metal, dislocated lining, defective end faces on locating bearings. Clean the replacement liner and remove any defects and pressure marks. Make sure that the transitions between the oil pockets and grooves and the bearing surfaces are scraped smooth and are without sharp edges. In case of strong threading refinishing must be carried out on a machine tool.

Oil rings must be checked for roundness. Hinges and locks must be without projecting edges. The oil rings must be stored on an even flat surface. After the oil rings have been fitted finally lock the joint bolts of the oil rings with a punch mark on the recess for the bolt head.

Replace any damaged sealing rings. Fit the new sealing rings and refinish the edge, if necessary, using a spoon scraper. When inserting (turning in) the rings, bring the marks on the ring joint faces into coincidence with those in the sealing grooves in the bearing liners. Replace the insert—type sealing rings and replace any defective sealing strips. Carefully close the bearing when checking of the parts subject to wear has been completed. Before fitting the top bearing liner and the bearing cover, check the shaft deflection. To seal off the bearing cover, apply a uniform thin film of liquid sealing agent.

REMOVING THE ROTOR :

In addition to the normal tools required for such work, lifting tackle and ropes with load carrying capacity adequate for lifting the stator and rotor must be at hand. Isolate the machine from supply system and lock the main switch so that it cannot be closed unintentionally. Follow the relevant safety rules/ regulations. Depending on the extent of dismantling, a method out of given below is to be selected.

The method I is to be used when rotor radius is more than the bearing pedestal height (shaft centre height - baseframe height) and it is possible to uncouple the machine by shifting the rotor axially in the bearings, for example in case of rigidly coupled machines with coupling centring or if the type of coupling used permits uncoupling without having to shift the rotor e.g. curved tooth coupling, or when the rotor and stator can be raised jointly from the baseframe. If the carrying capacity of the crane installation is insufficient to lift the rotor and stator jointly and the rotor radius is less than the bearing pedestal height, the rotor can be removed using method II without having to shift the stator axially.

METHOD — I

Remove the exciter stator and joint bolts of the sealing cover and of the insert sealing rings and clamping bolts. Remove the fixing bolts of the bearing cover and take off the bearing cover. For lifting off the bearing cover eyebolts can be screwed into the oil—filter holes instead of the screw plugs. Lift the top bearing liner and set it down on a clean wood or press board surface. Open the oilring locks of bearings with oil ring lubrication and take out the oil rings. After removing the oil rings, fit them together again and lay them down flat. Unbolt the conductor connections or bars from the winding end leads (fig. 5.3). Mark the cable ends clearly for reassembly. Remove the connecting leads of all the resistance temperature detectors (stator winding)/ air/bearing) from the instrument terminal box. Any other connections between the stator & outer enclosure should also be removed & marked for reassembly. Remove the erection opening cover 4 (fig. 5.2) and remove the four stator fixing bolts (fig. 5.5).

The position of the rotor with regard to the winding shields or to the stator must be marked on the shaft before it is removed (fig. 5.7). Remove the winding shields. Spread 5 mm thick x 1000 mm wide hard rubber sheet at stator bore (bottom side) before lifting stator and rotor to avoid direct contact between stator and rotor core, retaining ring and stator winding overhang. The length of rubber sheet is required to be about 50 mm more than stator core length.

Attach the stator to the lifting tackle with two ropes of the same length and of adequate load carrying capacity. Align the crane hook above the middle of the stator and start to lift at the minimum lifting speed—if necessary, by inching. The stator is located on the base frame by dowel pins or four angle sections. When raising pinned stators from baseframe, lever the stator off the pins by means of a crowbar or similar tool. As soon as the stator and rotor are clear smoothly increase the crane hook speed. Two erectors should guide the shaft, one at each end, so that the bearings are not damaged. Set down the stator/rotor horizontally at a site suitable for removing the rotor. Cover the open radial sleeve bearing immediately with clean plastic sheet to prevent the journal surfaces from damage.

In case of machines with flexible couplings, draw off the half coupling from the shaft and slide on the dummy shaft as far as possible after first placing pressboard round the end of the machine shaft. The tubular dummy shaft should be so aligned so as not to damage the machine shaft. There must be only a small clearance between its inside diameter and the outside diameter of the machine shaft, otherwise the later would become damaged by edge loading. In case of machines with flanged shaft, blot the flanged dummy shaft in place after first fitting a 2 mm thick piece of pressboard between the flange faces (fig. 5.8). Lift the stator/rotor and set down the rotor on assembly support of adequate height. Wedge the shaft tight to stop it rolling away (fig. 5.9). Lower the stator slightly until there is roughly a uniform air gap around the circumference. Move the stator carefully along towards the end where the dummy shaft is fitted and set it down (fig. 5.10). Avoid doing any damage to the stator winding and the rotor core. Attach wire ropes to the rotor shaft. Use protective sheeting for the shaft and wooden spreader blocks when doing this. Lift the rotor, remove the assembly supports and withdraw the rotor from the stator (fig. 5.11). Set the rotor down on supports at a suitable site and wedge it against rolling away.

Before reassembly, carefully clean all the machine parts. Blow out the air slots in the stator and rotor with dry compressed air (max. pressure 4 bar). Refitting of rotor is carried out in reverse sequence. When the rotor is inserted into the stator it must be set down exactly in accordance with the mark (fig. 5.7) made on the shaft.

METHOD — II

Open the DE and NDE bearings as described in Method I above and lift off the top bearing liner. Determine the position of the shaft in the bearing pedestal (fig. 5.12). Record dimension A as the rotor must be returned to this position when the machine is reassembled. Insert a strip of pressboard 6 (1—2 mm thick, approx 400 mm wide and approx 2 m long) into the air gap at the top and the bottom between the rotor and stator cores, (fig. 5.13). Place hydraulic jacks 2 under the shaft close to the radial sleeve bearings. Insert copper pads (approx 10 mm thick) between the shaft and the hydraulic jack 2 (fig. 5.13). Lock the fhaft radially by inserting wooden wedges between the shaft & the bearing housing. Align the jacks with the centre line of the shaft. Place a dial gauge with a magnetic stand on the bearing joint face at the DE and ND ends and set the gauges to O at the highest point on the shaft. Raise the shaft max. O.5 mm using the hydraulic jacks. Lock the pistons of the hydraulic jacks and also support the shaft, if necessary. Remove the bottom bearing liners from the bearing pedestal by turning about the shaft. Remove the expanded rubber mat 10 (fig. 5.1) for the outer enclosure from the baseframe near the bearing pedestals.

Following removal of the bottom bearing liners, raise the rotor evenly using the hydraulic jacks until the pressboard strip in the top air gap between the rotor and the stator cores cannot be moved any more.

Screw in two bolts into the holes in the bearings pedestal face at the DE side. Remove the pedestal foot bolts. Carefully lift the pedestal using the lifting gear and remove it from the baseframe. Remove the alignment shims under the bases of te pedestals in sets, tie each set together and mark them accordingly so that they can be used for reassembly. Using the lifting gear, move the pedestal axially towards the stator and set it down inside the baseframe on steel supports placed there for this purpose. The stator winding must not be damaged. Lift the ND end bearing pedestal in the same manner and set it down at the ND end within the baseframe on steel supports.

Attach the ends of the rotor by rope of suitable carrying capacity to two hoists if possible, or one hoist and an adjustable spreader hoist (fig. 5.14). Position the crane hook over the centre of the rotor and take up the slack in the ropes. Lower the hydraulic jacks under the shaft evenly and remove them.

Align the rotor within the stator so that the air gap is approximately uniform around the circumference. Withdraw the rotor towards the ND end as shown in (fig. 5.14). Set it down with the D-end of the rotor core resting just inside the stator core and with the ND end of the shaft resting on a suitable support. Fix a dummy shaft to the coupling (fig. 5.15). In the case of machines with a flanged shaft, first fit a 2 mm thick piece of pressboard between the flange faces. Do not damage the windings and cores. Attach the lifting gear at the driving end to the dummy shaft, lift the rotor slightly, remove the support and withdraw the rotor as far as possible and set it down on a suitable assembly support. Arrange the ropes as shown in (fig. 5.15), raise the rotor slightly and withdraw the dummy shaft from the stator. Set down the rotor on suitable supports and wedge the shaft to prevent it rolling. Remove the dummy shaft.

Before assembly carefully clean all the machine parts and blow out the air slots in the stator and rotor with dry compressed air (max. pressure 4 bar). Check the paint work and touchup wherever necessary. The rotor is refitted in the reverse sequence. After the stator has been set down on the baseframe or the rotor has been placed on the bearing liners check gap between the stator and the rotor. If necessary, realign the stator. Check the alignment of the electrical machine. Before closing the sleeve bearings, apply a thin even layer of a sealant e.g. Hylomar SQ 32/M, to one of the joint faces. For bearings with oil ring lubrication, check and close the rings as described. Tighten all fixing bolts with the required torque.

REMOVING THE EXCITER :—

The procedure for dismantling the exciter is as follows : —

1. Disconnect the leads at the terminal box of exciter field.
2. Remove the end cover on the non drive end.
3. Release the foot bolts & dowels fixing the stator frame to the base stool.
4. Hold the stator frame by means of eyebolts and lift the stator up slightly (Poles on the lower side of stator should not rub against the armature core). The stator in this position can be slide axially towards the non-drive end and clear of rotor.

5. Remove the cable connection from collector rings of exciter rotor to generator field.

6. Unscrew the four bolts, fixing the spider plate of exciter to the generator shaft.

7. By holding the exciter rotor, with the help of wire ropes on the core portion, the rotor can be slide away from generator shaft.

REPLACEMENT OF COMPONENTS

Remove the end cover on ND end of exciter.

CHANGING OF DIODE

Diodes : Stud type
BHd N30 16 Forward polarity — 3 Nos.
BHd N31 16 Reverse polarity — 3 Nos.

Remove the six diode connections from DC rings. Check for the healthiness of each diode. A healthy diode will exhibit a high resistance in blocking direction and low value of resistance in forward direction. The faulty diode can be unscrewed from the heat sink (with the help of a double ended spanner). A new diode of correct polarity can be screwed on the heat sink and the other end is bolted to connector ring.

CHANGE OF VARISTORS

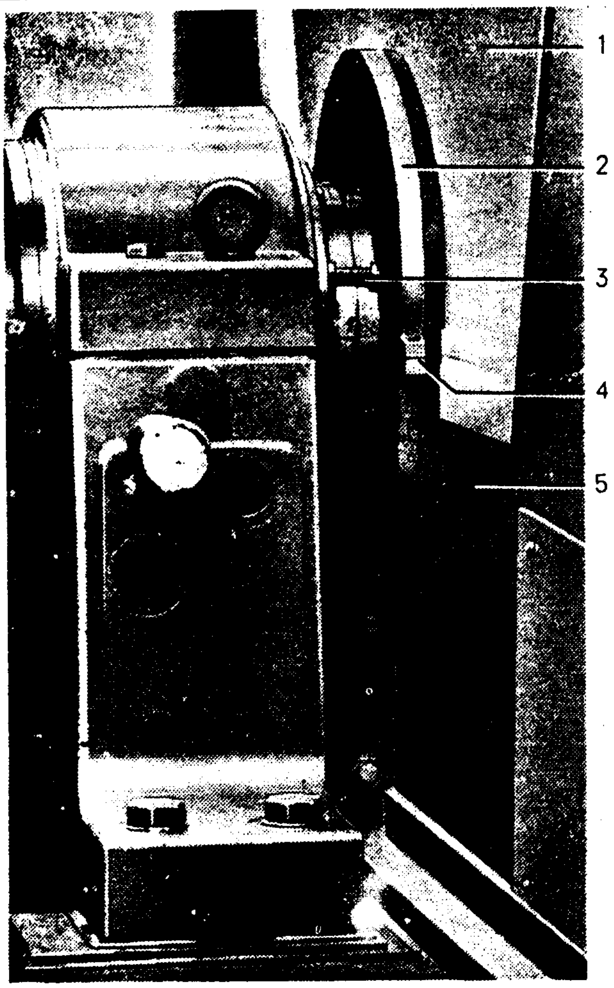
Two varistor of type 30 AS 862 are connected in parallel between the collector rings.

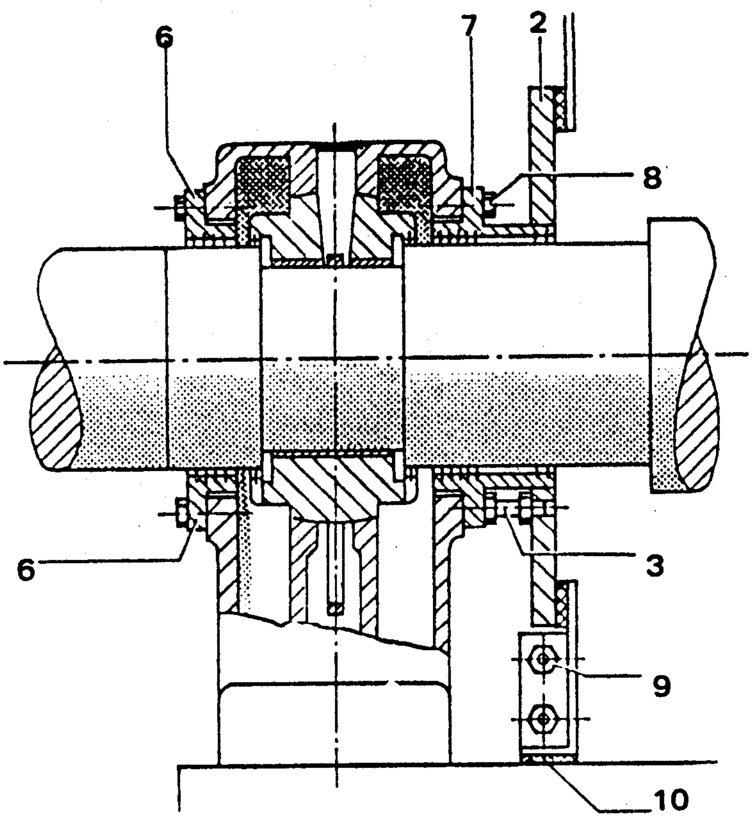
Remove the connecting strips from the varistor assembly to the connector rings. Unscrew the four bolts fixing the balancing plate to core support plate. The balancing plate along with varistor assembly can be slided out of rotor. First of all varistors should be inspected for physical damage, then perform resistance measurement across each varistor. For this remove the link making the parallel covers of the varistors. Then apply a DC voltage of the order of 30 to 50v and under this condition healthy varistor will slow very high resistance. The varistors can be separated by releasing the top hexagonal nuts, washers. After fitting spare varistor, it is essential to perform a resistance measurement across the terminals as described above.

CHANGING OF RC CIRCUIT

RC circuit consists of two assemblies, each assembly has a capacitor 0.47 MF, 630 V and a resistor 33.0 ohm, 25 W.

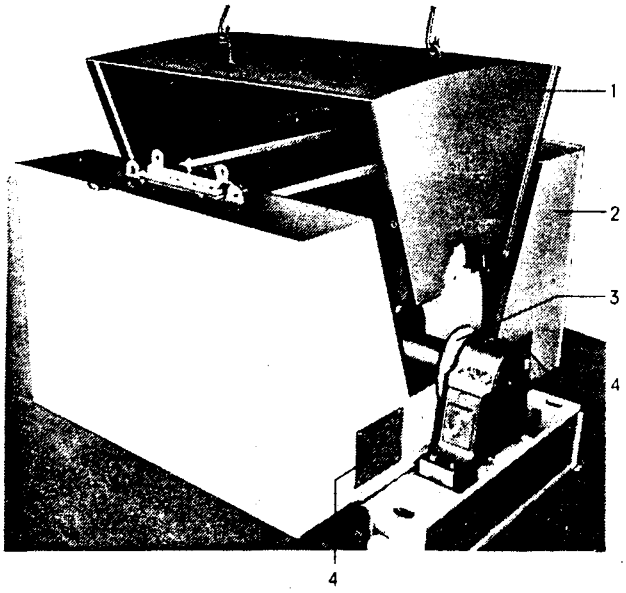
The capacitor and resistor can be removed from the assembly after unscrewing the Hexagonal locking nut, at the top of the assembly.





1. Top section of the outer enclosure
2. Sealing cover for the shaft gland
3. Clamping bolt
4. Joint of the sealing cover
5. Bottom section of the outer enclosure
6. Insert sealing•ring
7. Machine-side inert sealing ring
8. Flange bolts
9. Joint bolt for 5
10. Expanded - rubber mat.

Fig. 5.1 Sleeve bearing



1. Top section of the outer enclosure
2. Bottom section of the outer enclosure
3. Sealing cover for the shaft gland
4. Opening for fixing the stator

Fig. 5.2 Lifting off the top section of the outer enclosure

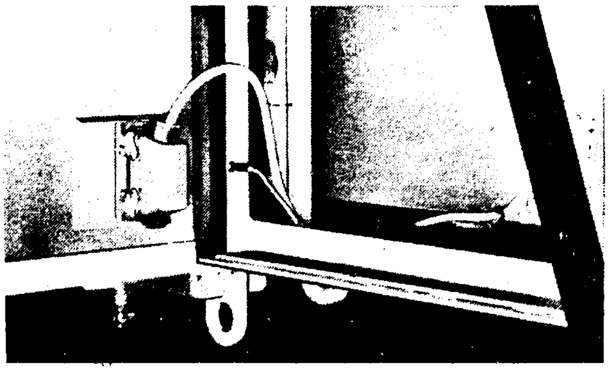


Fig. 5.4 Plug in device for the embedded theromometers

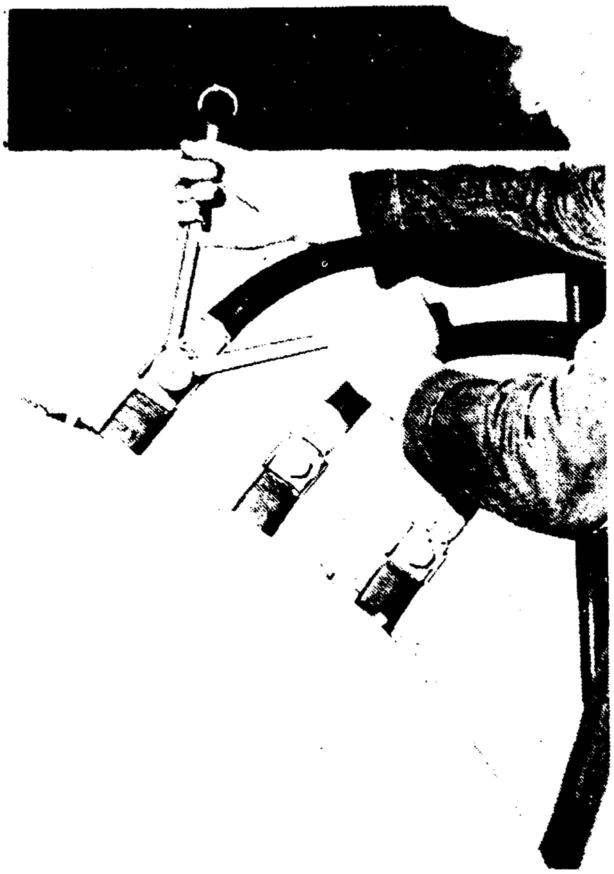
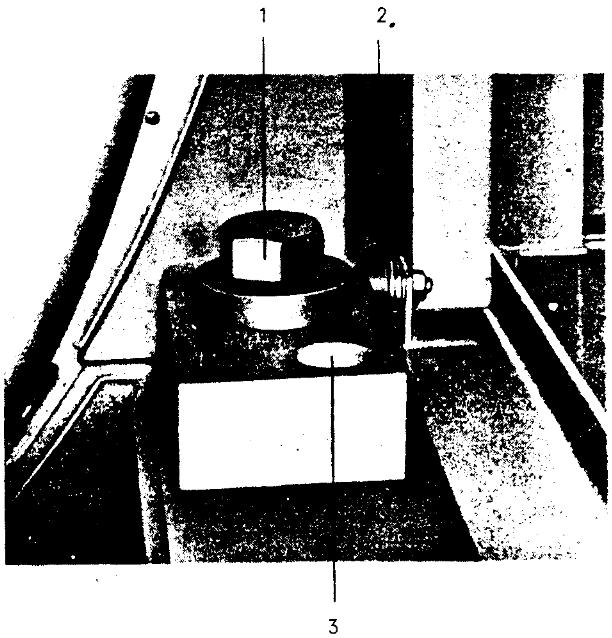
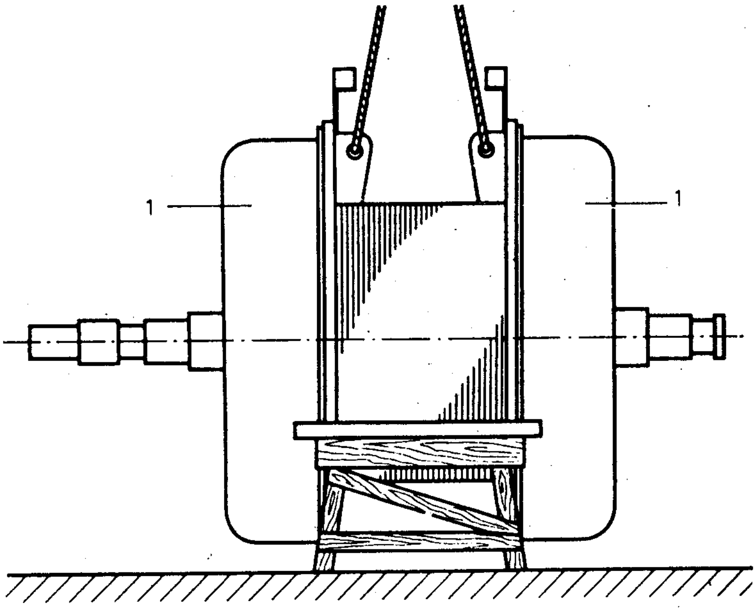


Fig. 5.3 Unbolting the conductor connections from the winding end leads



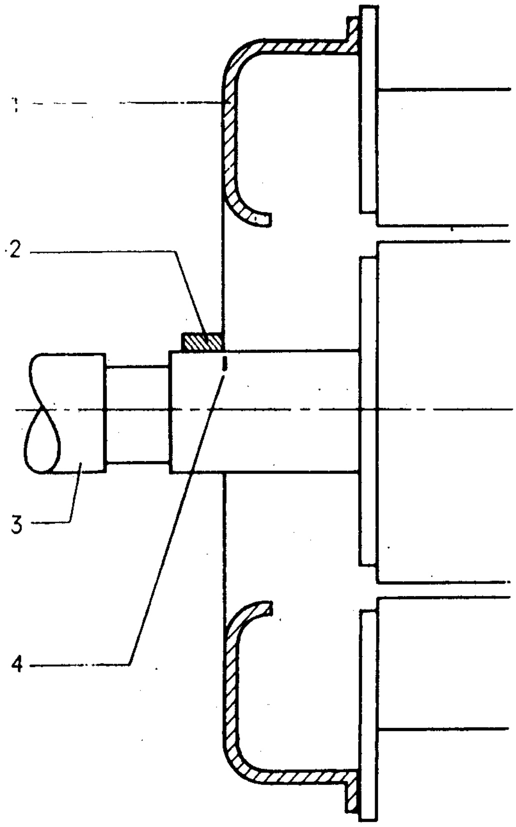
1. Stator fixing bolt
2. Rubber pad for supporting the outer enclosure on the stator
3. Cylindrical pin for fixing the stator

Fig. 5.5 Fixing the stator to the baseframe (view through the erection opening in the outer enclosure)



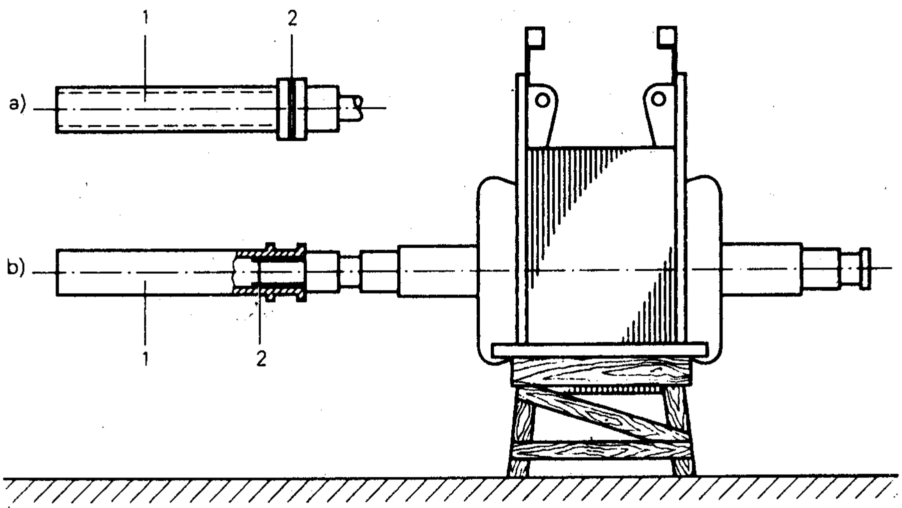
1. Winding Shield 2. Straight edge
3. Shaft 4. Mark

Fig. 5.6Setting down the stator / rotor on a pedestal



1. Winding Shield 2. Straight edge
3. Shaft 4. Mark

Fig. 5.7 Mark the position of the rotor



1. Dummy shaft 2. Protective sheeting

Fig. 5.8 Different types of dummy shaft

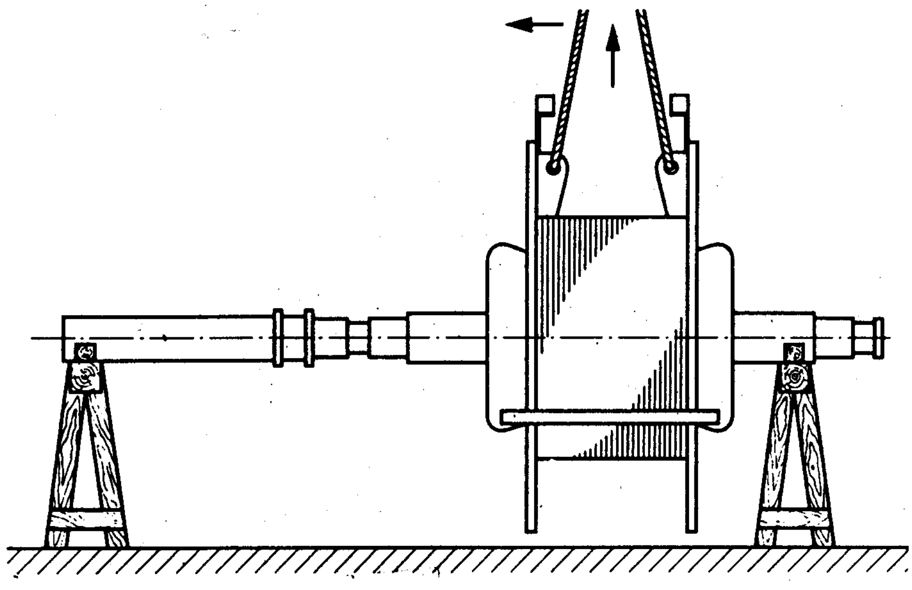


Fig 5.9 Rotor set down on pedestals Stator drawn off to the side

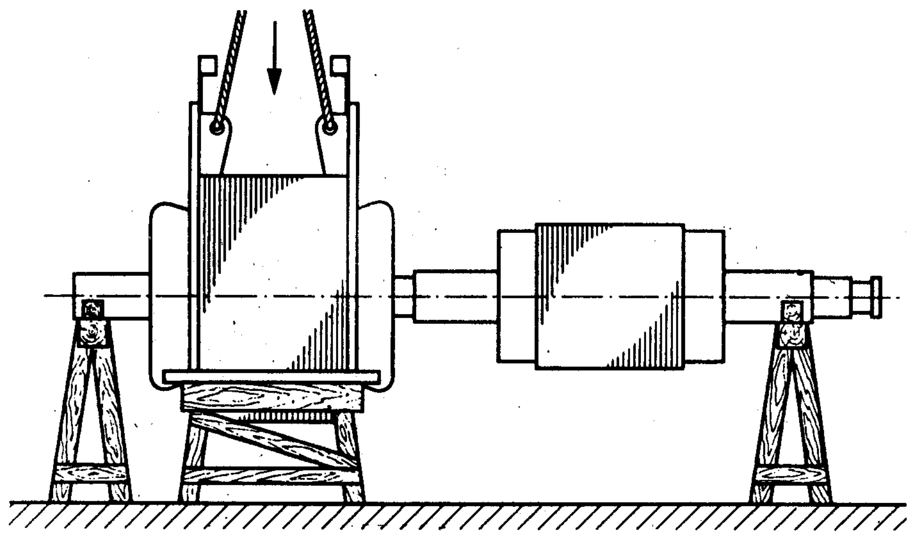


Fig. 5.10 Stator drawn off to the side and set down on pedestals

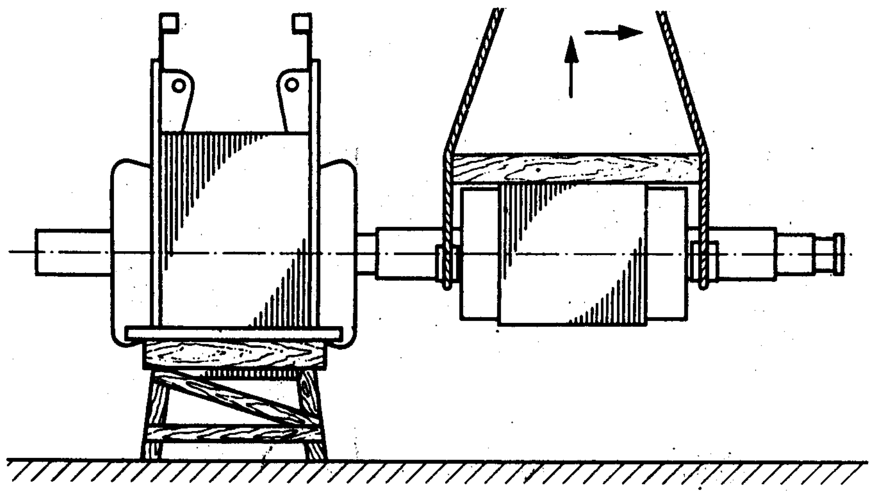


Fig. 5.11 Lifting the rotor, withdrawn dummy shaft from stator and set down rotor at the erection site

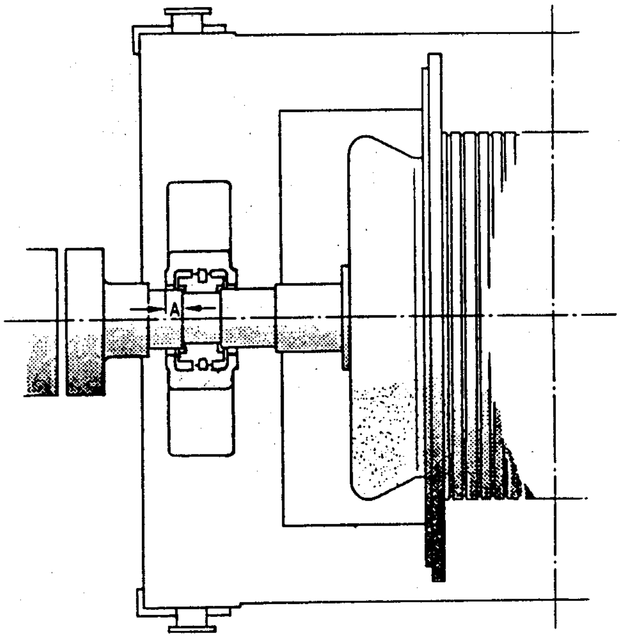
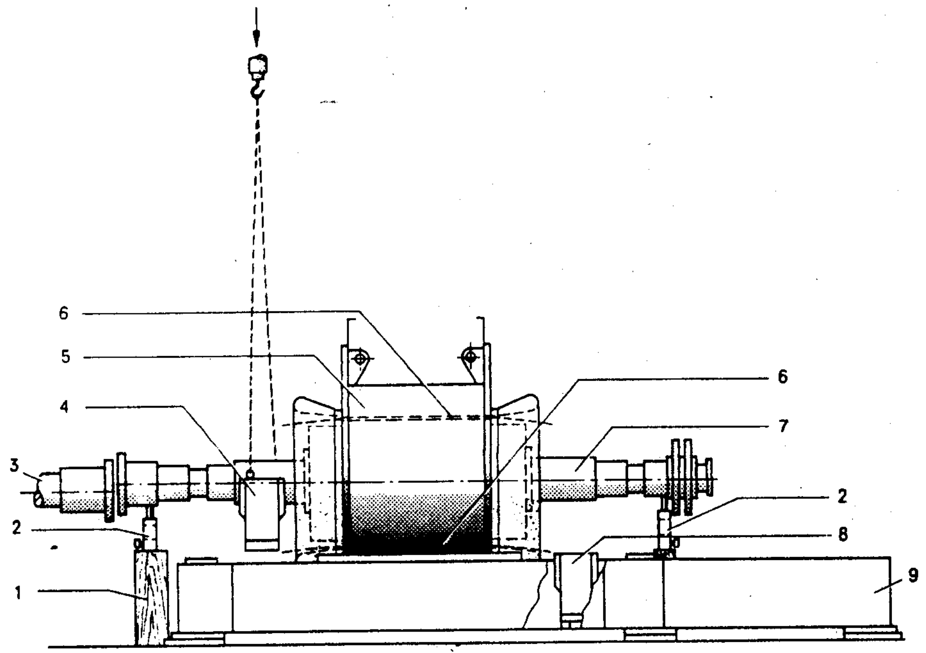
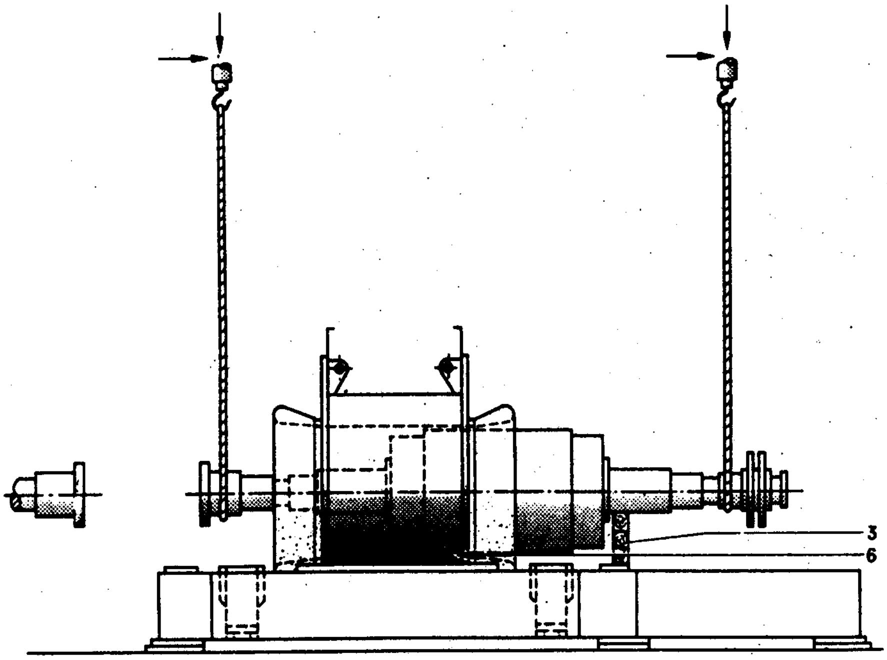


Fig. 5.12 Determining the asembled position of the shaft relative to the bearing pedestal



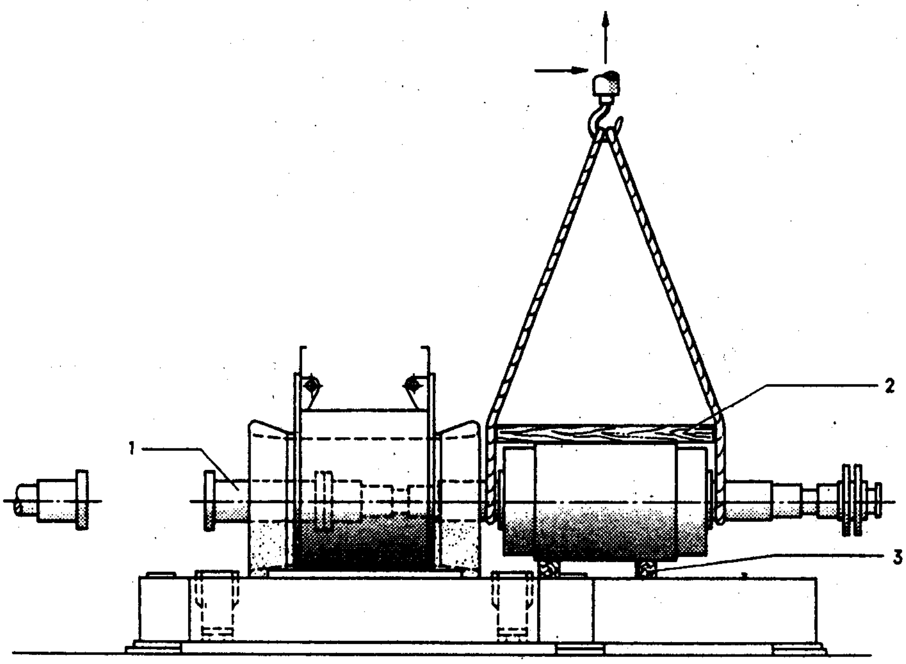
1. Assembly support
2. Hydraulic jacks
3. Flange of coupled machine
4. A-end bearing
5. Stator
6. Pressboard insert between the rotor and stator
7. Rotor
8. B-end bearing set down in the baseframe
9. Baseframe

Fig. 5.13 Rotor with hydraulic jacks raised. Dismantling the bearings



3 Square timber supports
6 Pressboard insert

Fig. 5.14 Withdrawing the rotor and setting it down in the stator core and assembly support for attaching the dummy shaft



4 Assembly supports
5 Rotor of brushless exciter

Fig. 5.15 Rotor set down for repositioning of the hoists (Shown with the hoists repositioned)