



GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

Maintenance Handbook
on
Tap Changer
of
AC Electric Locomotives

CAMTECH/2002/E/GR/1.0

MARCH, 2002

**Centre
for
Advanced
Maintenance
TECHnology**



Maharajpur, GWALIOR - 474 020

FOREWORD

The proper maintenance of Tap Changer is necessary for trouble free operation of Electric Locomotive and to avoid failure enroute. CAMTECH has prepared this handbook to cover all essential aspects of maintenance of Tap Changer.

The handbook describes various maintenance schedules along with their periodicity and detailed procedure to be adopted during repair and overhauling. A very useful compilation of list of common defects and their remedies is included in the handbook. The staff in maintenance depots will benefit from these, which in turn will be reflected in improved reliability and availability of Electric Locomotives and thus economy in operation.

*CAMTECH, GWALIOR
21ST MARCH, 2002*

*M.L.GUPTA
EXECUTIVE DIRECTOR*

PREFACE

The Tap Changer used in AC electric locomotives is vital equipment and its proper upkeep and maintenance is necessary to ensure reliability and availability of AC electric locomotives. This handbook on "Maintenance of Tap Changer " has been prepared by CAMTECH with the objective of making our maintenance personnel aware of correct maintenance and overhaul techniques to be adopted in field.

It is clarified that this handbook does not supersede any existing provision laid down in the "Maintenance manual of electric locomotive" or "AC traction manual" and instructions issued by Railway Board/ RDSO.

I am sincerely thankful to all officers and staff of electric loco directorate of RDSO/ LKO for their valuable comments. I am also thankful to all field personnel who helped us in preparing this handbook.

Technological upgradation and learning is a continuous process. Hence feel free to write to us for any addition/ modification in this handbook or if you have any ideas. We shall highly appreciate your contribution in this direction.

CAMTECH, GWALIOR
20TH MARCH' 2002

RANDHAWA SUHAG
DIRECTOR

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ISSUE OF CORRECTION SLIPS

The correction slips to be issued in future for this handbook will be numbered as follows:

CAMTECH/2002/E/GR/C.S. # XX date-----

Where “XX” is the serial number of the concerned correction slip (starting from 01 onwards).

CORRECTION SLIPS ISSUED

Sr. No.	Date of issue	Page no. and Item no. modified	Remarks

CHAPTER 1

INTRODUCTION

The single phase high voltage tap changer is used to notch the control winding on the high voltage side of the transformer up and down through 32 steps.

The tap changer is directly built on the transformer, the selectors and circuit breakers together form a constructional unit.

The circuit breaker is provided with magnetic blowout, and supported on two insulated columns . It is mounted on the oil filled selector casing.

Transformer and selector are separated by oil tight seals so that during overhauls only the oil from the selector casing need to be drained.

Tap changer is designed for higher service voltage (25 to 30 kV) and for high switching frequencies. This is equipped with a circulating pump and a filter for the selector oil. This device is intended to keep the selector oil clean over long periods of operations by extracting metallic particles, which may break off from the control gear.

Since two shaft extensions are available at the selector, the drive can be built on at the right-hand or left-hand end, depending on the space available.

1.1 THE SELECTOR ASSEMBLY

The selector assembly consists of following components:

Item	Description
11	Base frames with covers
12	Contact plate with connecting pins
13	Selector housing with covers
14	Drive shaft with gearing
15	Notching wheel with contact arm
16	Bushing and contact rings
19	Components for fitting air-motor and Cowling

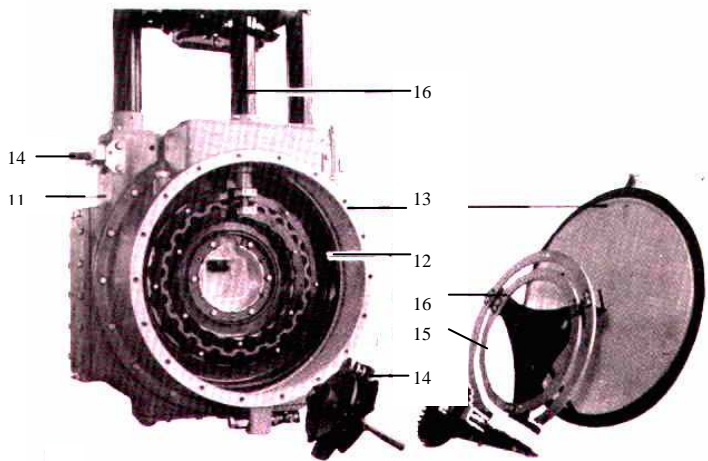


FIGURE 1.1 SELECTOR ASSEMBLY

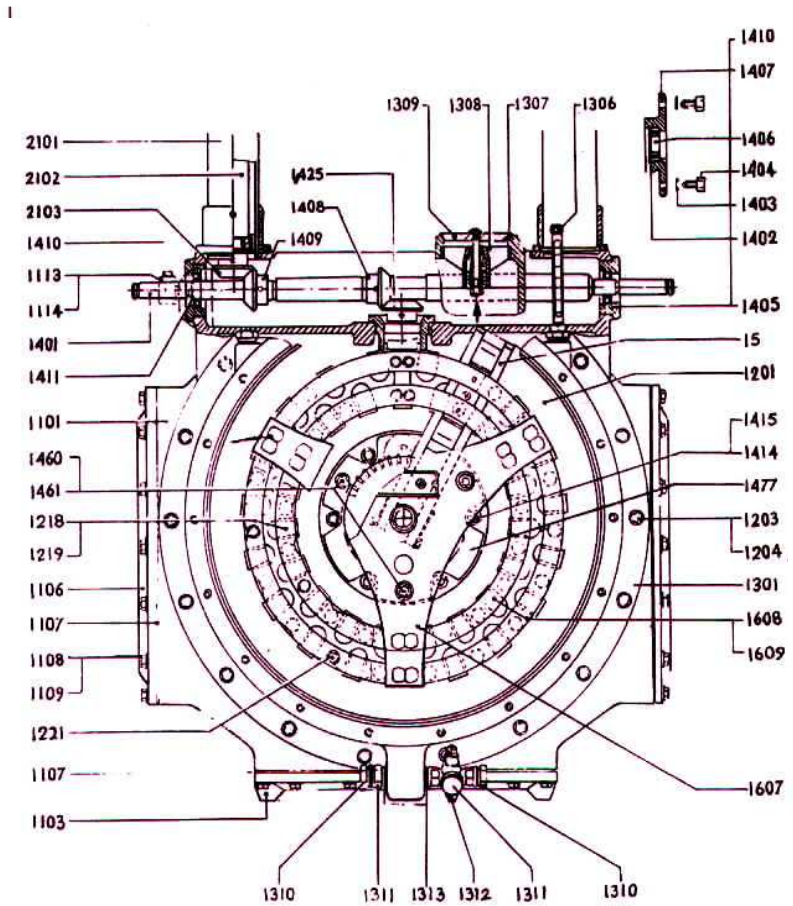
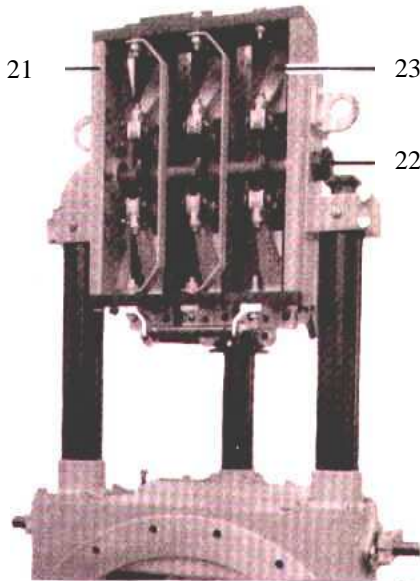


FIGURE 1.2 SELECTOR FRONT VIEW

Details of figure 1.2

Item	Description	Item	Description
11	Base frame complete.	14	Driving shaft with gearing
1101	Base frame	1401	Driving shaft
1102	Sealing ring	1416	Gearing insert complete.
1103	Base cover	15	Stepping wheel with contact arm
1104	Drain plug	1521	Distance tube
1105	gasket	1522	Circlip
1108	Hexagonal bolt	16	Bushing and contact rings
1109	Spring washer	1601	Bushing, double pole
1110	Cover plate (upper)	1602	Hexagonal bolt
1111	Hexagonal bolt	1603	Spring washer
1112	Spring washer	1607	Carrier plate with guide sleeve
12	Contact plate complete	1608	Contact ring, inner
1201	Contact plate	1609	Contact ring, outer
1202	Sealing ring	1613	Hexagonal bolt
1203	Hexagonal bolt	1614	Spring washer
1204	Spring washer	1615	Circlip
1205	Potential contact	21	Support with circuit breaker
1208	Contact pin, inner	2101	Support, left
1209	Contact outer	2132	Support, right
13	Selector housing with cover		
1301	Selector housing	1305	Spring washer
1302	Cover	1311	Oil-drain connection
1303	Gasket	1314	Drain plug
1304	Hexagonal bolt		

1.2 CIRCUIT BREAKER



Details of Figure 1.3

Item	Description
21	Support with breaker frame
22	Breaker shaft
23	Switching element
24	Magnetic core with blowout coil
25	Arcing chamber

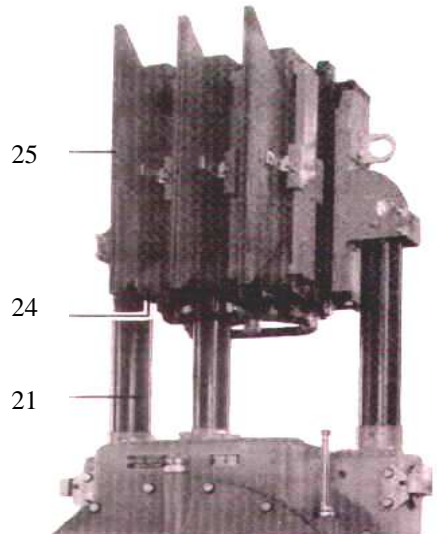


FIGURE 1.3 CIRCUIT BREAKER ASSEMBLY

1.3 OPERATING PRINCIPLE OF GR

The moving contact rollers K1 and K2 in the selector actuate with the current cut off. Before a roller leaves the fixed contact, the relevant circuit is interrupted by the associated circuit breaker. The connections of the tap changer in the high voltage circuit of the transformer are shown in figure 1.4 and sequence of movements of the selector and of the circuit breaker contacts is shown in fig. 1.5.

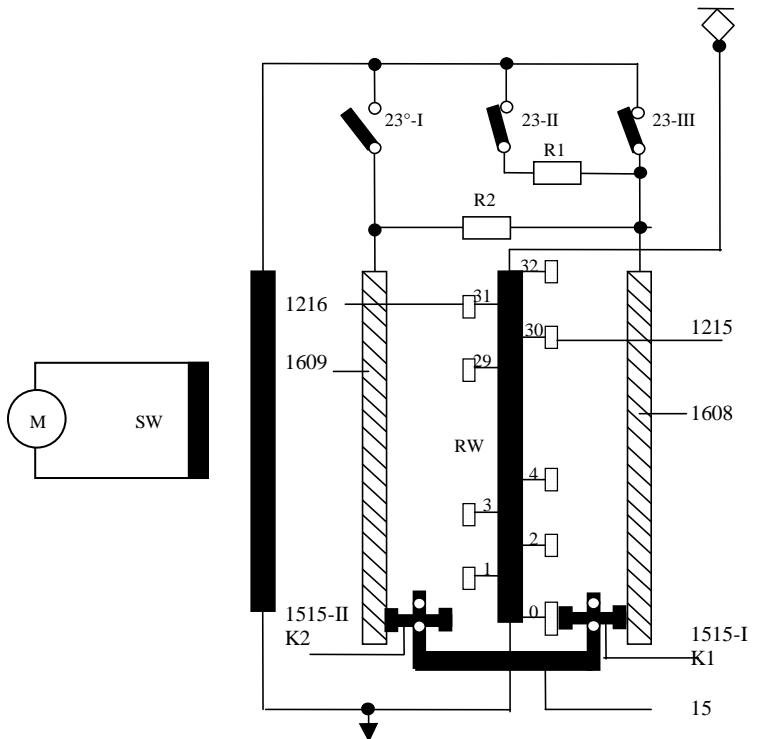


FIGURE 1.4 CONNECTION OF TAP CHANGER TO THE TRANSFORMER

When changing over, the resistor R1 carries the current for a short time together with a circulating current produced by the tapping winding about to be switched in or out.

The high-value resistor R2 serves as the connection between equal potentials, which ensures that the branches of the circuit being interrupted at the given potential. The making angles of the contact, as the angle of rotation of the selector drive shaft, must remain within a tolerance of $\pm 3^\circ$.

While the rollers remain at the segments 1 and 0, the breaker I close and take over the service current. A circulating current then flows through the resistor R1 produced by the tapping winding 0-1 until the breaker II opens. Finally the disconnected contact roller runs off segment 0. The tap changer is now at step 1.

The critical angles (referred to the drive shaft) between the switching sequences at the circuit breakers and in the selector are designated with the letters x and y. Deviations in accordance with tolerances indicated must be taken into account. The maximum permissible rotational speed at the drive shaft can be determined from the values of these angles (quoted for new contacts) and from the time taken for the arc to quench during and interruption. As the arcing tips of the breaker contacts piece wear the critical angles and thus also the safety margins increase. The mechanical method for achieving the intermittent switching movement is shown in fig.1.6.

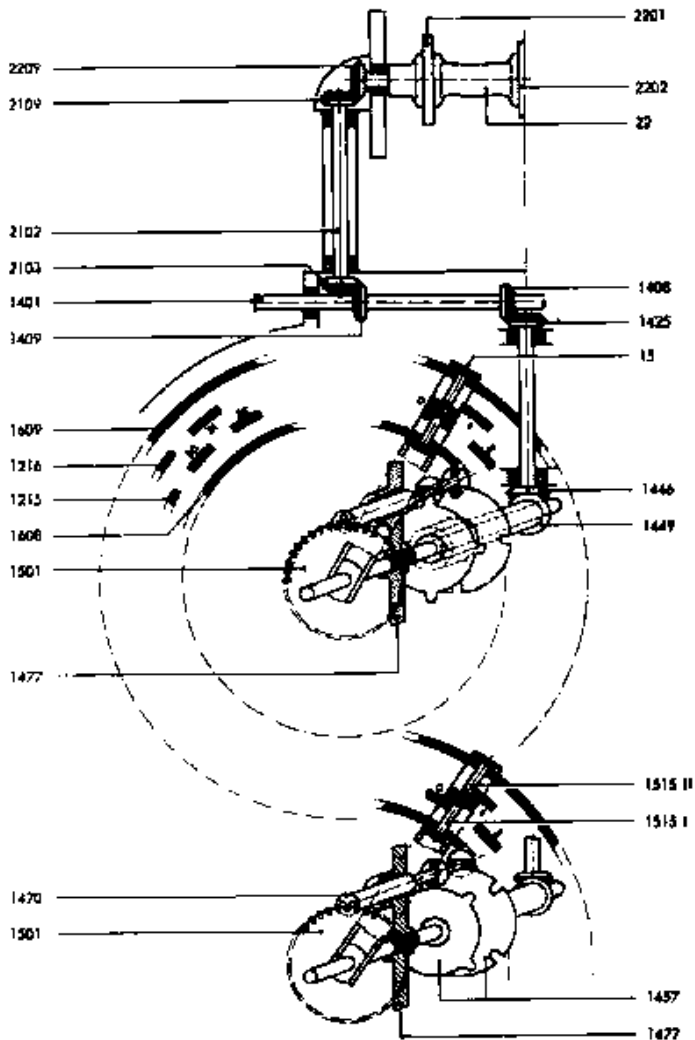


FIGURE 1.6 **INTERMITTENT SWITCHING
MOVEMENT**

1.4 AIR MOTOR MG-2 WITH CONTROL UNIT

The motor is of the four cylinder-reciprocating type is used to drive tap changer. A pressure reducing valve, a three- way cock and a pressure gauge to read between 0 and 10 kg/cm² are connected in series with the motor. It is advisable to couple a two pole auxiliary switch with this three-way cock so that when the latter is closed, the control leads are switched off at the same time. The electrically operated pneumatic control unit is connected to the air motor by two connections and one return line. Depending on the pulses received this unit allows the motor to run in steps or continuously in either direction.

Facilities are provided for incorporating one or several drums for control, indicating and interlock contacts. The air motor and its control unit is virtually unaffected by temperature changes, moist air, shock and vibration. The motor is provided with an enclosure to protect it against dust etc. The air motor and control unit is shown in figure 1.7 and figure 1.8 respectively.

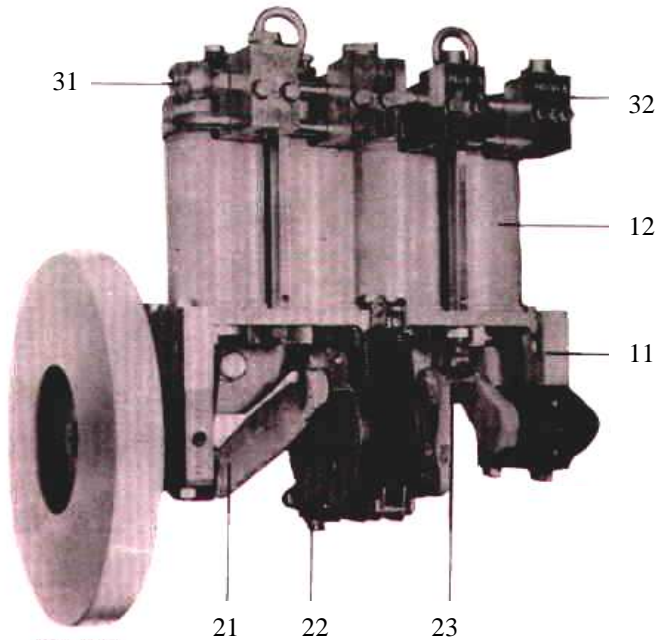


FIGURE 1.7 AIR MOTOR

Details of figure 1.7

Item	Description
11	Base plate
12	Cylinder
21	Crankshaft
22	Notching
23	Piston with connecting rod
31	Air line
32	Three way valve

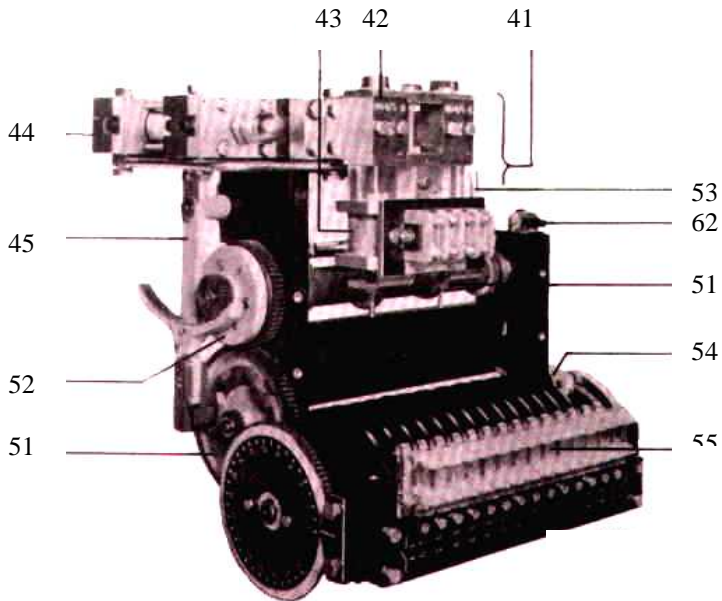


FIGURE 1.8 CONTROL UNIT

Details of figure 1.8

Item	Description	Item	Description
41	Control block	52	Planetary gearing
42	Three way valve	53	Valve push rod
43	Operating solenoid	54	Stop
44	Control cylinder	55	Auxiliary switch drum
45	Control lever	61	Gearing
51	Camshaft	62	Counter

1.5 OPERATING PRINCIPLE OF SMGR

The SMGR is controlled by pneumatically damped movements, which thus saves wear on the mechanical components of this equipment. The motor operates at a service pressure between 2.5 and 3.5 kg/cm². Function of Air Motor is shown in figure 1.9. The crankshaft is held in the tapping positions by two pistons under pressure via two connecting rods (e.g. I and III). Each switching process takes place as a result of the venting of one cylinder and the simultaneous pressurizing of another one. When the tap changer “notches up” the cylinder I is vented and II pressurized. When the tap changer “notches down” the same process is repeated in cylinders III and IV.

Details of Figure 1.9 and 1.10

Item	Description	Item	Description
12	Cylinder I-IV	4517	Journals
21	Crankshaft	4521	Guide pin
2112	Flywheel	51	Camshaft
22	Notching	52	Planetary gearing
23	Piston with connecting rod	5201	Annulus
31	Air line	5209	Pinion
3120	Three way cock	53	Valve push rod
3121	Reducing valve	54	Limit stop
32	Three way valve I-IV	55	Auxiliary switch drum 10°/step
42	Three way valve "UP-Down"	5506	Cam plates 1-14
43	Operating solenoid	5514	Auxiliary cam operated switches 1-14
44	Control cylinder	6101	Gearwheel on crankshaft
45	Control lever	6103	Intermediate wheel
4502	Toothed segment	6110	Spur gear with indicator disc

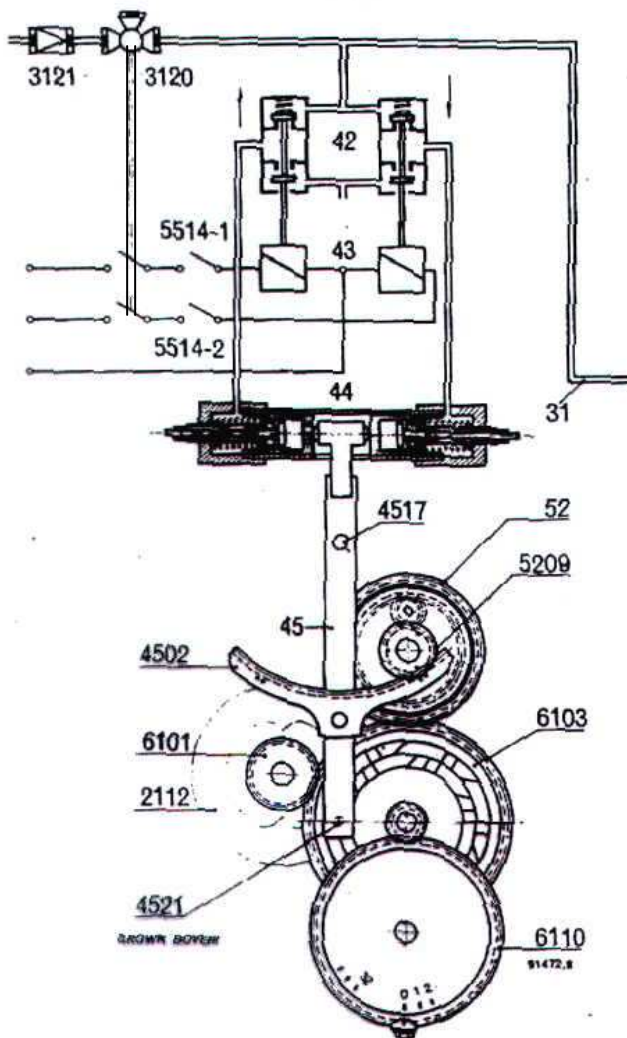


FIGURE 1.9 FUNCTION OF AIR MOTOR

Cyclic distribution (determined by control pulses) over the four cylinders enables any sequences of switching steps in either direction. The notching holds the motor at the tapings when no air pressure is available; this also ensures that the crankshaft stops in the correct position. Function of control unit is shown in figure 1.10.

The control unit is designed so that each step of the driven unit corresponds to two switching steps of 90° each at the crankshaft. The control pulses to the cylinders are initiated by the three way valves, which in turn are operated by camshaft. The camshaft is coupled to the crankshaft through gearing (ratio 1:1). The intermediate planetary gearing can reset the position of the camshaft with respect to the crankshaft so that the valve positions are changed over for running in notching up or down. The motor rotates in the clockwise or counter clockwise direction. External control commands act upon the solenoid valves and are transmitted to the control cylinder as pressure pulses. This causes the lever arm with the toothed segment to rotate about the pivot either towards the right (notching up) or to the left (notching down). The toothed segment engages with the pinion, which carries the axis of the planet wheel. When the annulus is stationary, movement of the planet wheel causes the camshaft to rotate in one or the other direction by 75° (lead angle). This involves a displacement relative to the crankshaft, which is maintained as long as the control command persists. Short control commands are continued mechanically so that the motor can complete one entire tap change. The guide pin on the swung out control lever then runs over a cam on the gearwheel. A mechanical interlock prevents overrunning the limit position when the operating mechanism is actuated by hand.

CHAPTER 2

MAINTENANCE

2.1 PERIODIC SCHEDULES

The activities to be carried out during various periodic schedules are as under:

Indication: "*" work to be done, "-" Work not to be done

S.N	SCHEDULE ACTIVITIES	I A	I B	I C	AO H	IO H
SMGR						
1.	Carry out general inspection and cleaning	*	*	*	*	*
2.	Check tightness of connections	*	*	*	*	*
3.	Overhaul SMGR	-	-	-	*	*
4.	Examine all auxiliary contacts for cracks, carbonisation, tightness of all connections. If required, replace by nylon auxiliary switch.	-	-	*	*	*
5.	Clean all auxiliary contacts.	-	-	*	*	*
6.	Check and lubricate all the gears and other parts.	-	-	*	*	*
7.	Check all drive parts visually for any abnormality.	-	-	*	-	-
8.	Overhaul control block.	-	-	*	*	*

S.N	SCHEDULE ACTIVITIES	I A	I B	I C	AO H	IO H
9.	Check proper clamping and strengthening of ZSMGR panel.	-	-	*	*	*
10.	Check smooth operation of ZSMS	-	-	*	*	*
11.	Ensure locking of SMGR foundation bolts by plate or lock nut.	-	-	*	*	*
12.	Check notching spring, selector lever bolt SMGR foundation for any cracks.	-	-	*	-	-
13.	Check connection tightness of SB and foundation bolts.	-	-	*	-	-
14.	Die penetrant test on crankshaft, SMGR support bolt and notching spring.	-	-	-	*	*
15.	Ensure 100% replacement of " <i>Must change items</i> ".	-	-	-	*	*
16.	Leakage testing of SMGR.	-	-	-	*	*
17.	Load testing of SMGR along with GR and CGR on test panel.	-	-	-	*	*
18.	Paralleling of SMGR auxiliary cam switches with spare one.	-	-	*	*	*
19.	Check SMGR crank shaft alignment during overhauling as per Adtranz Jigs and Fixture.	-	-	-	*	*

S.N	SCHEDULE ACTIVITIES	I A	I B	I C	AO H	IO H
20.	Modification to connection lever of SMGR for tap changer to avoid air leakage RDSO/WAM4/58.	-	-	-	*	*
21.	Modification to control lever of SMGR for tap changer - RDSO/WAM4/117.	-	-	-	*	*
22.	Application of loctite between the mating surface of cams shafts and grub screw and tap holes of tap changer - RDSO/WAM4/145.	-	-	-	*	*
23.	Ensure provision of ceramic filter.	-	-	-	*	*
TAP CHANGER						
1.	Check condition of RGR and RPGR	*	*	*	*	*
2.	Check oil level if less, add up to 40 ° C	*	*	*	*	*
3.	Check colour of silica gel and replace/recondition if necessary.	*	*	*	*	*
4.	Check connection of double pole bushing to CGR1 and 3.	*	*	*	*	*
5.	RGR (Other than Lacchman make) IR valve to be checked (with 1000 V megger. (Min - 19 MΩ)	*	*	*	*	*
6.	Check BDV of oil as per IS: 6772	-	-	*	*	*
7.	Check condition of selector (In 2 nd IC)	-	-	*	*	*
8.	Check tangential play in moving contact (2 nd IC)	-	-	*	*	*

S.N	SCHEDULE ACTIVITIES	I A	I B	I C	AO H	IO H
9.	Check DGA, if acetylene contents are more than 3 PPM then open the GR cover and check.	-	-	*	*	*
10	GR oil flushing to be done if due.	-	-	*	*	*
11	Check for any oil leakage.	*	*	*	*	*
12	Drain the oil and remove the cover. Clean with jet and nylon brush.	-	-	-	*	*
13	Check angle setting and contact shorting	-	-	-	*	*
14	Check RPGR value and condition.	-	-	-	*	*
15	Replace all gaskets	-	-	-	*	*
16	Check safety valves and manual drive for proper functioning. Overhaul safety valve.	-	-	-	*	*
17	Replace top and bottom oil seal.	-	-	-	-	*
18	Maintenance of Tap changer by set of jigs and fixtures and special tools of M/s Adtranz only.	-	-	-	*	*
19.	Fastening RGR and CGR support plates on Tap changer assembly RDSO/WAM4/ 52	-	-	-	*	*
20	Modified flexible connection between RGR & GR - RDSO/WAM4/136.	*	*	*	*	*
21	Provision of canopy on safety valves of Tap changer RDSO/WAM4/187.	*	*	*	*	*

S.N	SCHEDULE ACTIVITIES	I A	I B	I C	AO H	IO H
22	Permanent connection of 16th Tap in place of spring loaded connection. RDSO/WAM4/192.	-	-	-	*	*
23.	Replacement of insulating oil & Silica gel of Air drier of GR.	-	-	-	*	*
24.	100% Replacement of " Must change items "	-	-	-	*	*
25.	Check working of safety valves whenever GR cover open/ canopy provided	*	*	*	*	*
26.	Overhaul	-	-	-	*	*
CGR						
1.	Check Arc Chute for flash mark, crackness and ensure intactness of latches.	*	*	*	-	-
2.	Measure contact pieces dimensions. Replace if less than 36 mm.	*	*	*	*	-
3.	Lubricate mechanical joints/ pins of CGR assembly.	-	-	*	*	*
4.	Check CGR sequence through MOM.	-	*	*	*	*
5.	Check CGR to RGR and CGR1 to A34 connection. it shall not be close to foundation.	*	*	*	*	*
6.	Check tightness of contact screw and foundation screw.	*	*	*	*	*

S.N	SCHEDULE ACTIVITIES	I A	I B	I C	AO H	IO H
7.	Check play of camshaft of CGR assembly and replace if required.	-	-	-	*	*
8.	Check arc horn.	-	-	*	*	-
9.	Overhaul.	-	-	-	*	*
10	Use of high temperature grease type MECKBR-300 for GR.	-	-	*	*	*
11	Check sequence pressure of CGRs as per SMI 50.	-	-	-	*	*
12	Testing of contact pressure of CGRs as per SMI 50.	-	-	-	*	*
13	Modification to fixing arrangement for blow out coil of CGR to ensure locking of Tap changer. RDSO/WAM4/128.	-	-	-	*	*
14	Provision of latch assembly of CGR arc chute.	*	*	*	*	*
15	Replacement of contact tips should not be done ON position.	*	*	*	*	*
CIRCUIT BREAKER						
1.	Dismantle switching elements (load switch)	-	-	-	*	*
2.	Inspect cams of S 2220.1 ... S 2220.3 for wear and tear/ functional check.	-	-	-	*	*
3.	Clean/inspect arcing chamber S 27 & arcing horn S 2531.	-	-	-	*	*

S.N	SCHEDULE ACTIVITIES	I A	I B	I C	AO H	IO H
4.	Inspect/replace CGR contacts S 2529 and S 2530. Tighten Allen bolts with 2.5 Kg-meter torque.	-	-	-	*	*
5.	Clean switching elements and carry out functional checks with the use of special tools.	-	-	-	*	*
6.	Lubricate contact pivot (S2528) with high temperature grease.	-	-	-	*	*
7.	Tighten Allen key bolts M6, M8 & M12 with torque wrench.	-	-	-	*	*
PHGR						
1.	Check the working of PHGR	*	*	*	*	*
2.	Check visually for any leakage.	*	*	*	-	-
3.	Tightness of pipe line clamp as per RDSO/MODI/114.	*	*	*	*	*
4.	Overhaul PHGR and replace rubber items.	-	-	-	*	*
5.	Filter cleaning to be done.	-	-	*	-	-
6.	Attend the booking if any.	*	*	*	-	-
7.	Provision of modified PHGR.	*	*	*	*	*
8.	Ensure support for oil flow indicator as per RDSO/MODI/162.	*	*	*	*	*

S.N	SCHEDULE ACTIVITIES	I A	I B	I C	AO H	IO H
RGR						
1.	Inspect elements for overheating/cracking.	-	-	*	*	*
2.	Inspect insulators for cracks.	-	-	-	*	*
3.	Carry out meggar test and measure resistance value.	-	-	-	*	*
4.	After overhauling, carry out tests as described and record.	-	-	-	*	*

2.2 REPAIRING/ OVERHAULING OF "GR"

2.2.1 Removal of Contact Arm

- Lift contact rollers, place hexagonal key and turn through 90°.
- Remove bolts at bushing and circlip, lift out carrier plate contact rings.
- Remove circlip and distance tube. Lift out contact arm with stepping wheel.

2.2.2 Removal of Roller Contacts

Turn roller-lifting gear at bolt to position "On" with key. Undo lacing and push out insulated tube. Withdraw outer contact-roller casing (hold roller with thumb), whereupon contact roller with bearings, roller guide and pressure springs are now free to drop out. Remove bolts and push out insulated tube to withdraw inner contact rollers with contact housing. The fixed and moving insulation in the selector can now be cleaned.

2.2.2.1 Check for wear

If the tracks on the segments and rails are deeper than 0.5mm, these parts have to be renewed. The contact rollers are allowed to wear to a minimum diameter of 17 mm; contact rollers with smaller diameters have to be changed. When the rollers run correctly, the contact surface on the segments, rings and contact rollers should be polished bright.

Check roller guide and bearing for wear renew as necessary. The roller guide must move freely in the housing.

2.2.2.2 Refitting contact arm

Before fitting the complete roller housing on the table plate, ensure that rollers turn easily under pressure of spring during backward and forward movements. For the lacing, use good quality hemp string (1 to 2 mm thick). Before fitting the complete contact arm with stepping wheel, lift rollers when fitted set "0" position with checking pin.

2.2.3 Removal and dismantling of gearing

- Remove 3 bolts and withdraw gearing plate with bearing journal. Do not remove 6 bolts since will this release oil from transformer.
- Remove threaded pin, circlip and pull out distance tube.
- Make a note of the number at shims position during removal of drive wheel so that the original settings can be retained during reassembly.

- The actuating pins are hardened ($HR_c 58 \pm 4$).
- Renew lantern gear pinion when rollers are considerably worn. Minimum permissible diameter 15.5 mm. When refitting the reassembled gearing the wheels should be set to a tapping position with the aid of the checking pin.

2.2.4 Work on the Selector, which involves draining of Transformer

- Remove contact pins and renew gaskets.
- Open up side possibly also base covers.
- Loosen connecting terminal.
- Remove special nut in the contact plate (front) and withdraw pin in direction of terminal.
- Hold connecting terminal with spanner during loosening or tightening of clamping nuts.

2.2.4.1 Removal of Bearing Flange

- Remove the horizontal shaft first. Remove driving mechanism.
- Expose shaft extension; i.e. remove gear wheel and setting device.
- Remove circlips on both sides.
- Unhold journal bearing and withdraw.
- Pull out shaft the right. Remove bolts at bearing flange and withdraw this flange together with bevel wheel and coupling tube.

2.2.4.2 Dismantling of Bearing Flange

- Knock out securing pin, pull out coupling pins and coupling tube. Release tab washers and withdraw bevel gear with shaft and ball bearings.
- Note number of shims. These shims must be positioned before refitting of ball bearings.
- During removal and refitting of coupling shaft ensure that the feather edge of the sealing ring is not damaged.
- During renewed of this deal it should be reinserted with a tube or ring 50/57 mm in diameter.
- Remove bevel wheel with shaft.
- Remove contact arm and gearing.
- Take off lock nut and remove threaded pin.
- Remove bevel wheel with shaft and ball bearing in a downward direction. If the sealing ring has to be taken out of this bearing, the upper bearing flange requires removal.

2.2.5 Work on Circuit Breaker

2.2.5.1 Removal of Switching Element

- Remove arcing chamber
- Set tap changer so that the rollers upper and lower are loose. Lift off switching element with insulated rail.
- When refitting element ensure that the insulated bar does not become wedged between the connecting plates and the mating contacts.
- When refitting the contact lever care must be taken that the individual washers, i.e. plain washer, dished washer and plain washer, are correctly located. Ensure that the pin washers are not mixed up since these are used as shims of varying thickness.
- Renew worn out arc horns. Maintain 0.5 to 1 mm clearance between contact and arc horn.
- Clean insulated parts with dry, clean rag.

2.2.5.2 Removal of Circuit Breaker Shaft

Details of circuit breaker and camshaft assembly are shown in figure 2.1 and figure 2.2 respectively.

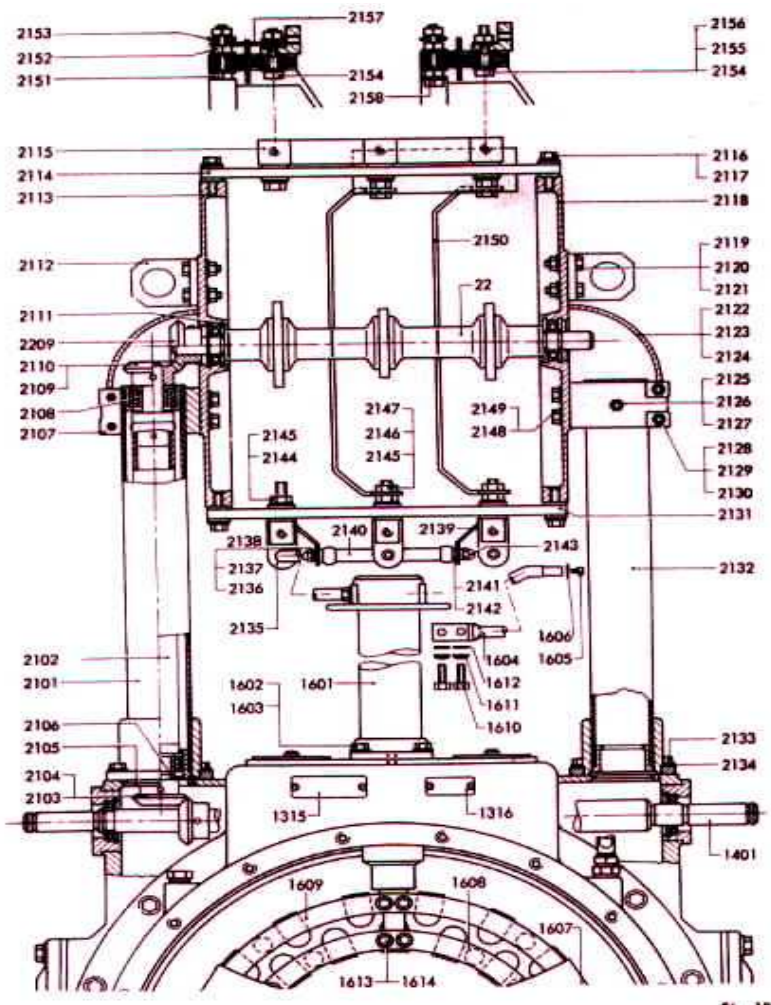


FIGURE 2.1 CIRCUIT BREAKER ASSEMBLY

Details of figure 2.1

Item	Description	Item	Description
1316	Rating plate	2122	Hood
1401	Drive shaft	2123	Hexagonal bolt
1601	Double pole Bushing	2124	Spring washer
1602	Hexagonal bolt	2125	Threaded pin
1603	Spring washer	2126	Hexagonal nut
1604	Connection	2127	Spring washer
1605	Hexagonal bolt	2128	Hexagonal bolt
1606	Spring washer	2129	Hexagonal nut
1607	Carrier plate with guide sleeve	2130	Tab washer
1608	Contact ring inner	2131	Insulated plate, lower
1609	Contact ring outer	2132	Support, right
1620	Hexagonal bolt	2133	Hexagonal bolt
1611	Spring washer	2134	Spring washer
1612	Washer	2135	Connecting angle
1613	Hexagonal bolt	2136	Wire connection
1614	Spring washer	2137	Hexagonal bolt with nut
2101	Support left	2138	Spring washer
2102	Coupling shaft	2139	Connecting link
2103	Bevel wheel	2140	Resistor R2

Item	Description	Item	Description
2104	Securing pin	2142	Hexagonal bolt
2105	Centering	2143	Cap nut
2106	Dust cover	2144	Hexagonal bolt
2107	Clamp	2145	Washer (soft copper)
2108	Self aligning ball bearing	2146	Contact bolt
2109	Bevel wheel	2147	Contact nut
2110	Securing pin	2148	Hexagonal bolt
2111	Circlip	2149	Spring washer
2112	Lifting link	2150	Connection
2113	Bearing plate, left	2151	Contact bolt
2114	Insulated plate, upper	2152	Contact nut
2115	Connection bar	2153	Spring washer
2116	Hexagonal bolt	2154	Hexagonal bolt
2117	Spring washer	2155	Spring washer
2118	Bearing plate, right	2156	Hexagonal nut
2119	Hexagonal bolt	2157	Connection
2120	Spring washer	2158	Hexagonal bolt
2121	Hexagonal nut	22	Camshaft
2141	Insulated sleeve	2209	Bevel wheel

- Remove connections between capacitor bushing and circuit breakers.
- Remove bolts and threaded pin at terminal clamps. Lift breaker frame from the carrying links.
- Unscrew bearing plate on the right and take off bolts on top and bottom.
- Remove circlip and withdraw ball bearing as well as cam plates.

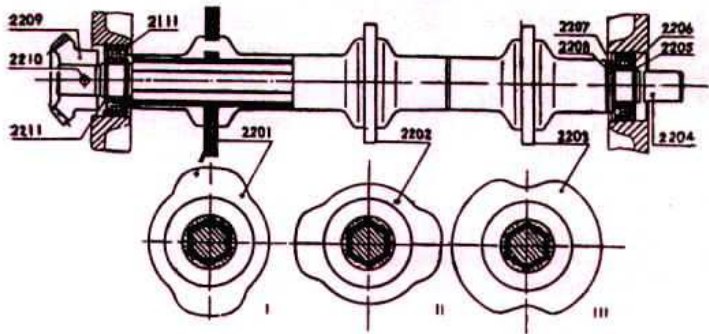


FIGURE 2.2 CAM SHAFT ASSEMBLY

Details of figure 2.2

Item	Description	Item	Description
2111	Circlip	2206	Ball bearing
2201	Cam plate I	2207	Circlip
2202	Cam plate II	2208	Shim
2203	Cam plate III	2209	Bevel wheel
2204	Shaft	2210	Securing pin
2205	Circlip	2211	Circlip

- Ensure shims are correctly fitted.
- Now to remove coupling shaft, lift off support and remove base bolts.
- Knock out pin at upper bevel wheel. Withdraw bevel wheel and withdraw coupling shaft downwards. During refitting ensure that the dust cover is positioned between bevel wheel and ball bearing.

2.2.6 Mounting Tap Changer on the intermediate reservoir

This is sealed from the transformer with an insulated plate, the bushings having to be oil tight as well. The reservoir is filled through a connecting pipe to the transformer, in which a stopcock has to be fitted, which can be closed when draining the intermediate reservoir. A vent valve is provided at the highest point of the reservoir, which remains open during filling until the oil overflows. The reservoir can be emptied through a drain cock.

The electrical leads are equipped with plugs, which can easily be connected with the terminal pins on the selector.

2.2.6.1 Procedure

- Remove base and side covers also cover plate on selector frame.
- Lightly and uniformly coat gasket between selector and transformer with a paste prepared from talcum powder and a little vaseline to prevent the gasket sticking to the metallic parts.

- Tighten nuts in the selector frame uniformly.
- At least two, preferably four spring washers should be placed under the nuts to avoid leakage.
- The plugs of the connecting leads are now fitted in a straight line to the contact pins of the selector. Push home connects terminals as far as body of plug. Hold with open-ended spanner and tighten clamping nuts.
- First make connections for the inner circle and check them. Fit all covers.
- After filling transformer and intermediate reservoir, check for leaks.

2.2.6.2 Removal of Drive

A 4-cylinder MG 2-air motor provides the drive power. If for some reason the drive has to be removed, the following points should be borne in mind.

- Removal and refitting of the drive should only be attempted, when both tap changer and drive are in the “0” position.
- If the front part of this cowling is removed the motor can be suspended from the eyebolts.
- The drive can be withdrawn complete with the support.
- Remove bolts. When secure with two securing pins (diameter 8 and 5 mm, length 28 mm), ensure red marking at bevel wheels is lined up.
- Separate drive from support (latter remains attached to rear side of cowling on tap changer).

- Disconnect air pipe remove nuts and lift off motor.
- When refitting, motor is placed on the two guide wedges on support.
- Before the nuts are tightened the motor can then be moved in a horizontal direction so that the engagement of the teeth of the bevel wheel can be accurately set.
- The control connections can be brought to the drive with the aid of plugs or through the stuffing glands. In the former case the plug is withdrawn as the drive is removed and the airline unscrewed at the outer union threads.
- If the lines enter through stuffing glands, they have to be disconnected at the inner terminals (cam-type switches and coils). The airline should be disconnected and the connecting plate removed from the cowling. These operations are also to be carried out if the entire tap changer is removed complete with drive.
- Manual operating mechanisms as emergency devices can be coupled to the free shaft extension or at various points of the compressed air operating mechanism.

2.2.7 Taking into Service

- Remove locking device or slide along shaft.
- Fill selector housing with clean transformer oil (about 75 litres at 20°C)
- Oil level gauge is provided with a scale, which allows for changes in temperature. The electrical breakdown strength of oil should attain at least 50 kV/cm for one minute between 13mm dia. spheres, distance 2.5 mm.
- Check selector housing and fittings for leaks
- If necessary retighten nuts and bolts. Repeat this check after commissioning.
- Check operation of control system and drive.
- Before voltage is applied to the tap changer, the following checks should be carried out:
 - The arc chambers must be in position on the circuit breakers and the locking mechanism engages.
 - The connections between the circuit breakers and the diverted resistor must be correctly made and proof against failure. If necessary retighten terminal bolts.
 - Check the resistor R1 (diverted resistor) for faults which may be the result of damage during transport. During the first runs check should also be undertaken to ensure that the resistor is not being subjected to excessive vibration.

- After filling with oil the tap changer should be operated over the entire range of steps from 0 to 32 and back before carrying out the voltage check; this ensures that air bubbles which may be adhering to parts of the unit rise to the surfaces.
- A check under voltage is not to be attempted earlier than ½ hour after filling of the selector with oil.

2.3 OVER HAULING OF SMGR

2.3.1 Removal of Control Unit

- Remove the control leads at the coils and the cam-operated switches.
- Remove air- line by unscrewing the hollow bolt.
- Unlatch spring-loaded push rod and swing forwards. Remove bolts of control block and lift off control unit.
- When refitting the control unit this should be set to step 0. The motor should also be set so that the red dot ● on the pinion is at the front and when inserting the control unit engages between the two dots ●● on the gearwheel. Before fitting control unit swing push-rod forward.

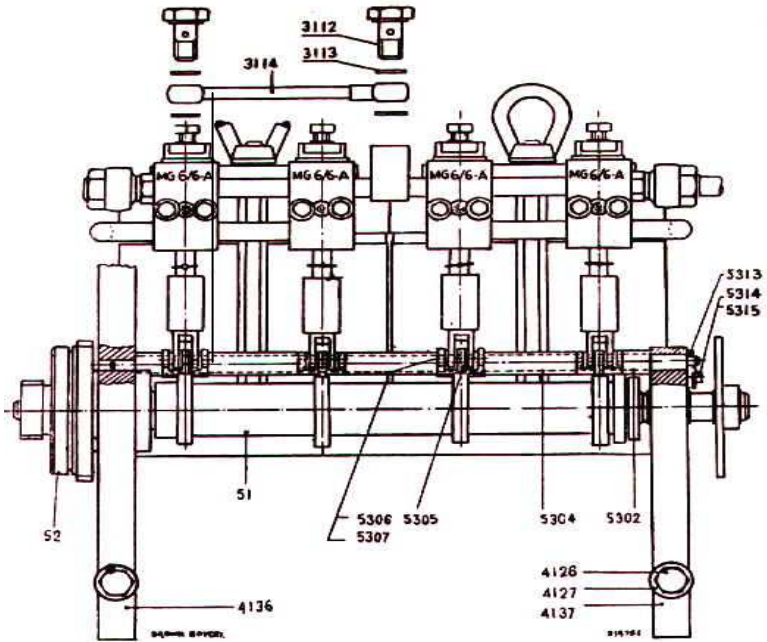


FIGURE 2.3 CONTROL UNIT ASSEMBLY

Details of Figure 2.3

Item	Description	Item	Description
5301	Bearing bolt	5309	Push rod
5302	Distance sleeve (short)	5310	Spring
5303	Link	5311	Push rod nut
5304	Distance sleeve (long)	5312	Split pin
5305	Roller (radial ball bearing)	5313	Link
5306	Pin	5314	Hexagonal nut
5307	Disc	5315	Spring washer
5308	Push rod bolt		

2.3.2 Work on Motor

- Disconnect air -line and remove air supply systems parts. This also exposes the valves.
- Check gaskets and replace as necessary.
- Raise cylinder, remove nuts and eye-nuts from studs and lift off securing plates.
- Remove and dismantle pistons and connecting rods as shown in figure 2.4

Details of figure 2.4

Item	Description	Item	Description
23	Piston with connecting rod	2307	Bearing pin
2301	Circlip	2308	Needle bearing
2302	Thrust ring	2309	Connecting rod
2303	U-section ring	2310	Circlip
2304	Piston skirt	2311	Securing bolts
2305	Circlip	2312	Bearing clamp
2306	Piston	2313	Bearing shells

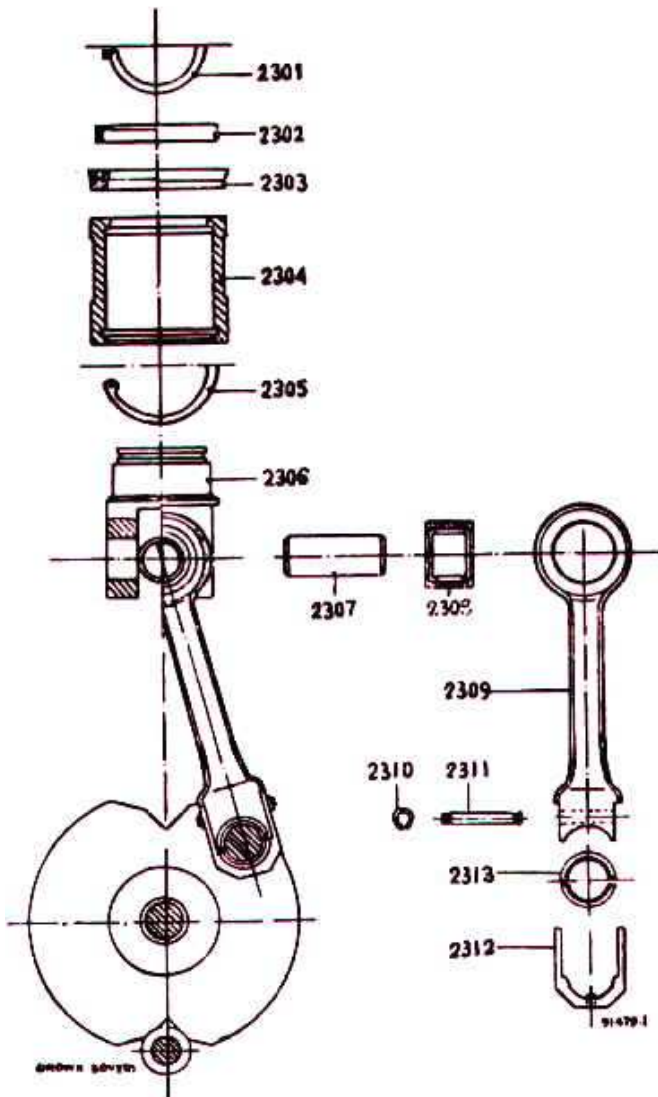


FIGURE 2.4 PISTON WITH CONNECTING ROD

- Clean cylinder and connecting rod with piston and relubricate.
- Renew worn U-section rings. The shell bearings of the connecting rods must not be cleaned with petrol (gasoline).
- Renew worn bearing shells also being soaked in oil before fitting.
- The crankshaft is removed together with the flywheel and the bearing plates. Swing out notching springs at the notching lever, and then remove nut. Ensure that the crankshaft is not distorted in the process. Use screw clamp to pull off the flywheel.
- Replace worn valve push rods and sealing nipples. Check valve stroke.

2.3.2.1 Dismantling control cylinder

Remove hollow bolts and airlines. Unscrew nuts at screwed pin. Dismantle components as shown in fig. 2.5. ***On no account unscrew*** nuts 4413 and 4415, otherwise the piston stroke has to be reset after reassembly. Clean cylinder and piston with clean rag. If necessary renew sealing ring. Before reassembly lightly grease cylinder and piston with approved grease.

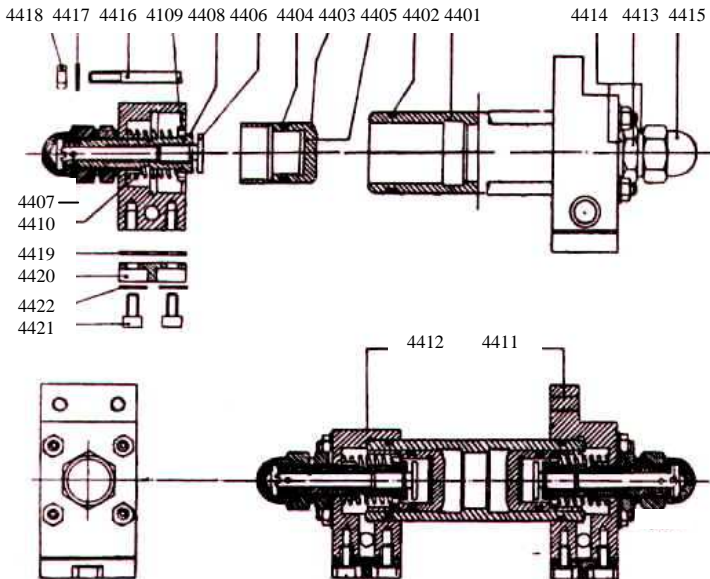


FIGURE 2.5 CONTROL CYLINDER ASSEMBLY

Details of figure 2.5

Item	Description	Item	Description
4401	Cylinder	4412	Cylinder cover
4402	Sealing ring	4413	Hexagonal nut
4403	Piston	4414	Seal
4404	Sealing ring	4415	Cap
4405	Buffer	4416	Threaded pin
4406	Setting screw	4417	Spring washer
4407	pin	4418	Hexagonal nut
4408	Centering screw	4419	Gasket
4409	pressure ring	4420	Cover
4410	Spring	4421	Allen screw
4411	Cylinder cover with thread	4422	Spring washer

Details of figure 2.6

Item	Description	Item	Description
4501	Control lever	4521	Guide pin (1)
4502	Toothed segment	4522	Spring loaded pin bearing
4503	Nut locked with pin	4523	Spring loaded pin
4504	Lever link	4524	Pressure spring (1)
4505	Needle bearing support	4525	Guide pin bearing
4506	Needle bearing support roller	4526	Needle bearings (2)
4507	Lever link complete	4527	Cylinder bolt
4508	Hexagonal bolt	4528	Pin
4509	Nut locked with pin	4529	Hexagonal nut
4510	Pin	4530	Pin
4511	Bearing sleeve	4531	Fitting tool for 4512
4512	Needle bearing	4532	Fitting tool for 4526

Check toothed segment and guide pin for wear and renew as necessary. Refit with the help of tools. The components of the control lever are shown in figure 2.6.

2.3.2.3 Removal of camshaft

- Remove circlip, cam plate, key and cover washer. The shaft extension is then pulled through the ball bearing.
- Dismantle camshaft. Components of camshaft are shown in figure 2.7.

- When reassembling camshaft check position of the cam plates with respect to the key ways.

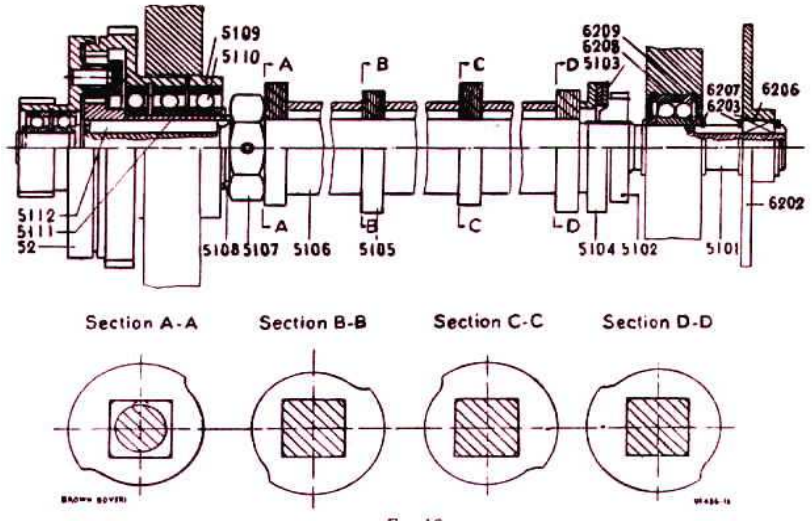


FIGURE 2.7 CAMSHAFT ASSEMBLY

Details of figure 2.7

Item	Description	Item	Description
5101	Shaft	5107	Nut locked with pin
5102	Slotted nut	5108	Circlip
5103	Spring washer	5109	Bearing
5104	Spring plate	5110	Ball bearing
5105	Cam plate (4)	5111	Distance ring
5106	Distance tube	5112	Key

2.3.3 Checks and setting of the solenoid armature strokes

For the operational motor set to step 0 and proceed as follows:

1. Close pressure line cock.
2. Unlatch push rod for valve of cylinder II and IV.
3. Turn drive with flywheel to step 1 and unlatch push rods I and III.
4. Open air line and carry out checks or settings of the solenoids.
5. Close air line.
6. Latch valve push rods I and III and turn drive to step 2.
7. Latch valve push rods II and IV and return drive step 0.
8. Open airline & operate drive Electro- pneumatically.

It is necessary for the various operations to be carried out in the sequence indicated so that the control lever, which changes position during actuation of the valves, can return to the rest position.

2.3.3.1 Armature Setting

- Unscrew nut and unscrew core a few turns. Loosen nut at setting screw.
- Slide 0.5 mm feeler gauge between push rods.
- Screw in setting screw until slight leak of air occurs at valve.
- Screw out setting screw until again valve just seals.
- Tighten nut and lock.

2.3.3.2 Core Setting

- Depress push rod in direction of arrow until valve opens and seals.
- Screw core in until valve vents slightly.
- Unscrew core until valve just seals and then by another turn (correspondence to an additional 0.5mm armature stroke).

By following this procedure the minimum armature stroke and the minimum attraction voltage of the solenoid is obtained. Check valves of correct operation and lock nuts with tab washers.

2.3.4 Changing Cam Plates

- Unscrew the carrier plate with the connections after removing bolts.
- Turn switch drum until slots in cam plates is to the rear.
- Using 36-mm spanner hold nut locked with pin and loosen slotted nut with hooked spanner until sufficient play is obtained.
- Slightly tilt cam plate to be replaced so that it can be withdrawn from the guide groove of the distance sleeve. Pull out cam plates towards the front.

2.4 CHECK SHEET FOR OVERHAULING

S.N	ITEM	Standard	Actual
1.	Check complete body, contact plate and segment etc. for any crack and damage.	No crack No damage	
2.	Check bevel wheels for any wear tear.	No wear & tear.	
3.	Check the bearing condition.	Good.	
4.	Check double pole bushing for any crack and damage.	No crack.	
5.	Check the insulation resistance with 2.5 kV.Megger between a) Pole to pole b)Pole to earth	100 M. ohm	
6.	Replace all rubber items & oil seal 100%.	To be Replaced.	
7.	Check the height of contact arm spring under load test of 6.2 kg. as per SMI-8.	15.3mm (min.)	
8.	Check the contact roller for any pitting and over heating.	No pitting & overheating	
9.	Check the contact roller diameter.	17mm (min.)	
10.	Check radial play between contact roller pin & bearing.	0.4 mm.	

S.N	ITEM	Standard	Actual
11.	Check play between contact roller housing.	Around 0 to 5 mm.	
12.	Check the wear on contact track. If found excessive wear or surface is very rough, replace them.	0.5 mm deep (Max.)	
13.	Check the gap between contact segment and contact plate at back side.	3 to 1mm.	
14.	Check the diameter of lantern gear pinion rollers.	15.5 mm(Min.)	
15.	Check the contact roller position on contact ring.	Middle \pm 3mm	
16.	<p>Check movement play at contact arm -</p> <p>a) Breaker on tapping Position, pin of lantern gear pinion vertical Move contact arm to and fro by hand. The total deflection should not exceed the standard value.</p> <p>b) Breaker in intermediate position, pin of lantern gear Horizontal. The total deflection of contact arm should not exceed the standard value.</p>	<p>10 mm (Max.)</p> <p>4 mm (Max.)</p>	

S.N	ITEM	Standard	Actual
17.	Check the tightness of the following with torque wrenches. a) Hexagonal bolt on selector housing with moving frame. b) Special hexagonal bolt for fixing insulating ring inner and outer. c) Special nut and conical nut-part. No. 1214 & 1217.	3.5 M-kg. 0.5 to 0.6 M-kg. 2.0 to 2.5 M-kg.	
18.	Check the dielectric strength of oil for 1 minute with 2.5 mm gap between 13 mm diameter spheres.	50 kV	
19.	Check free operation of safety valve	Free	
20.	Clean the oil indicator & check oil level.	Above 20° C mark	
21.	Making & braking angles of GR Inner ring. Outer ring		

S.N	ITEM	Standard	Actual
22.	Check the degree setting of CGR make and brake CGR-I } CGR-II } Close Open Close CGR-III }	35± 3 - 145± 3 125± 3 - 145± 3 170± 3 - 190± 3	
23.	Check the condition of potential contact	Good	
24.	Replace PHGR filter 100%	Replaced	
25.	Replace all rubber 'O' ring of PHGR 100%.	Replaced	
26.	Check the working of PHGR at 3 Kg/Cm ² pressure	30 to 40 strokes per minute.	
27.	Check for any oil leakage.	No leakage	
28.	Check the three way cock hole dia. as per SMI-88.	8.5 mm	
29.	Check the colour of silicagel	Blue	
30.	Any other remarks.		

CHAPTER 3

STICKING OF SMGR, CAUSES AND SUGGESTIONS TO AVOID FAILURES OF GR/ SMGR

3.1 STICKING OF SMGR

Probable causes for sticking of SMGR may be following.

1. Guide pin (part No. 4521) stuck up.
2. Gap between control lever and intermediate gear exceeds 0.7mm.
3. Pressure leakage from MG 6/6A and MG 4/5 A valves.
4. Improper setting of control block.
5. Progression and regression time of SMGR become more/ less (9 to 13 seconds)
6. Lifting valve plunger (part no. 5317) stuck up.
7. Improper profile of intermediate gear segment/ breakage or crack of segment.

3.1.1 **Reasons for guide pin jam**

- a. Deposition of dry grease around guide pin.
- b. Deposition of grease in the intermediate gear segment.
- c. Loss of spring tension or breakage of compression spring of control lever guide pin.
- d. Rubbing of wearing plate of control lever with guide pin.

3.1.2 **Gap between control lever and intermediate gear exceeds 0.7mm**

- a. Increasing or decreasing play between control lever and circlip provided on journal pin due to less or more shim washer (part no. 4515)
- b. Loosening of needle bearing of control lever provided on journal pin.
- c. Journal pin worn out.
- d. Internal play between intermediate gear and bearing pin.
- e. Less or more shim washer between intermediate gear and circlip.
- f. Bending of control lever (part no. 4501)
- g. Pin (part no. 6109) worn out.
- h. Needle bearing (part no. 6104) worn out at journal pin end.
- i. Improper fitting of journal pin.

3.1.3 Pressure leakage from MG 6/6A and MG 4/5A valves

- a. Improper setting of valve plunger.
- b. Valve plunger part no. 3209/429 stuck up.
- c. Valve jam due to corrosion.
- d. Improper sitting of push rod and lifting valve plunger.
- e. Mis-alignment of push rod.
- f. Valve seat defective.

3.1.4 Improper setting of control block

- a. Improper setting of control cylinder affected lead angle.
- b. Not using proper grease (Bharat MP-2) between control cylinder and piston as well as increased greasing interval.
- c. Using inferior quality of 'U' section ring (bucket)
- d. Leakage of air from air coupling in the SMGR.
- e. Pressure settings become less or more through pressure reducing valve on control panel.

3.2 **SUGGESTIONS TO AVOID FAILURES OF GR/ SMGR**

1. Guide pin should be lubricated only by machine oil H 20/1.
2. Segments of intermediate gear should be lubricated only by graphite oil.
3. Repositioning of wearing plate should be done when it is rubbing with control lever of guide pin. Compression spring must be changed during POH.
4. Gap between control lever and intermediate gear segment should be maintained between 0.4 to 0.7 mm. This gap should be checked during every IA/IB/IC/ schedules.
5. Air leakage test of SMGR should be performed in every schedule. The leakage should not be more than 10% in 10 minutes.
6. Free movement of valve plunger should be ensured in every AOH. The valve plunger should be replaced in every POH.
7. Gap between adjustable valve screw and bolt head should be maintained between 0.4 to 0.7mm. This gap should be checked during every IA/IB/IC schedule.
8. Plunger should move free in the bearing pin with strap part no. 5301. The play between spacer and shim should not be more than 0.2mm.
9. The setting of control block should be ensured.

10. Setting of control cylinder should be done as per instructions of SWT 5013.
11. Only Bahrain MP-2 or servogem-2 grease should be used for lubrication of cylinder. Greasing should be done in every IC schedule.
12. After changing of 'U' section ring. The plunger gap should be checked and it should be maintained within 0.4 to 0.7 mm.
13. Setting of pressure reducing valve in the control panel should be checked during every IA/IB/IC schedules.
14. Working of inter lock 1-2, 3-4, 5-6, 7-8 at half notch and interlock 41-42, 43-44, 47-48, 49-50, 53-54, 55-56, 57-58 all 'O' close interlock and 61-62, 83-84 and 89-90 should be checked properly.
15. Working of interlock of ZSMS switches should be checked during every IA/IB/IC schedules.
16. To avoid voltage stress concentration at corner portion of segment where the roller will into contact, the sharp edges of inner segment to be chamfered. This will increase the gap by 1.25mm
17. Knurlings to be provided on a portion of roller which travels on insulating ring. This will avoid dragging and pitting of rollers.
18. Replace adjusting knob of pressure regulating valve with metallic knob and check nut.
19. Carry out Die Penetrant Test on crankshaft, SMGR support bolt, pneumatic piping and notching spring during overhauling.

20. Ensure implementation of various SMI's/ MI's issued by RDSO as per annexure - A.
21. Ensure 100% replacement of "**Must change items**" during AOH, IOH and POH.
22. Perform leakage testing of SMGR after overhauling.
23. Conduct load testing of SMGR along with GR and CGR on test panel.
24. Paralleling of SMGR cam switch.
25. Align SMGR crankshaft during overhauling as per adtranz jigs and fixture.
26. Take measures to prevent burning of notch repeater.
27. Perform dielectric test of GR oil in every IC. Conduct BDV testing with 100 kV motorised equipment.
28. Flushing of oil if BDV found less.
29. Flushing of new tap changer oil after 10,000km or where more than 25% taps have been changed.
30. Provide modified PHGR and test on test bench during AOH/IOH schedules.
31. Ensure replacement of rubber kit during every AOH/IOH & POH.
32. Use set of special tools of M/s Adtranz.
33. Ensure quality control of CGR contacts, GR segments, roller, contact ring, insulating ring and contact plate.

34. Ensure periodic replacement of insulating oil and silica gel of air dryer of GR.
35. Use direct filling arrangement for GR.
36. Use of high temperature grease type MECK BR-300 for CGR.
37. Measure switching angle of contact segment of GR in AOH, IOH and POH.
38. Check pneumatic pipe line from EV PHGR to PHGR for crackness, air leakage from drain cocks etc. during periodic schedules.
39. Conduct DGA of tap changer oil in IC.
40. Plan to replace cast grid RGR with steel punched grid RGR.
41. Procure set of two sealing rings for control cylinder of SMGR in kit from approved sources only.
42. Ensure replacement of worn out shaft on condition basis both top and bottom oil seal during AOH & IOH.
43. Clean hollow insulator, bake at 80°C then apply anti tracking varnish.
44. Ensure modification of 16th tap connection by flexible connection.
45. Check operation of safety valve after fitment of canopy.

ANNEXURE - A**LIST OF SMI'S/MI'S**

S.No.	Title	No.
1.	Breakage of MOM taper pin.	RDSO/ELRS/SMI/17
2.	Malfunctioning of modified control lever of TC	RDSO/ELRS/SMI/18
3.	Sluggish operation of SMGR	RDSO/ELRS/SMI/20
4.	Breakage of support block of auxiliary switch.	RDSO/ELRS/SMI/21
5.	Sticking up of tap changer between notches	RDSO/ELRS/SMI/22
6.	Sticking of control lever guide pin.	RDSO/ELRS/SMI/46
7.	Adjustment of lead angle of control cylinder.	RDSO/ELRS/SMI/48
8.	Lubrication to be used for TC.	RDSO/ELRS/SMI/49
9.	Testing of contact pressure of CGR 1,2,3	RDSO/ELRS/SMI/50
10.	Lubricants to be used for GR	RDSO/ELRS/SMI/80
11.	Roller contact force in GR	RDSO/ELRS/SMI/82
12.	Oil leakage through three way cock	RDSO/ELRS/SMI/88

S.No.	Title	No.
13.	Tightening of electrical connection of CGR.	RDSO/ELRS/SMI/90
14.	Journal pin checking and procedure for replacement	RDSO/ELRS/SMI/101
15.	Lubrication to the groove of piston.	RDSO/ELRS/SMI/105
16.	Cleaning of GR after 10000 KM	RDSO/ELRS/SMI/106
17.	List of various torque values	RDSO/ELRS/SMI/113
18.	Breakages of needle roller bearing	RDSO/ELRS/SMI/117
19.	Tightening of connecting terminal with nut	RDSO/ELRS/SMI/118
20.	Replacement procedure for bevel gear	RDSO/ELRS/SMI/129
21.	Replacement procedure for air motor support	RDSO/ELRS/SMI/134
22.	Dismantling instruction & fixture details for removal of pinion of crank shaft of SMGR	RDSO/ELRS/SMI/135
23.	Condition monitoring of GR oil through DGA	RDSO/SMI/138
24.	Maintenance schedule for GR	RDSO/ELRS/SMI/143
25.	Flashing inside GR	RDSO/ELRS/SMI/144

S.No.	Title	No.
26.	Crank shaft fracture	RDSO/ELRS/SMI/145
27.	Breakage of pin of SMGR	RDSO/ELRS/SMI/146
28.	Support for oil indicator to Tap changer	RDSO/WAM4/62.
29.	Provision of taper hole to accommodate the taper pin in the manual drive of Tap changer	RDSO/WAM4/69.
30.	Clamping arrangement for PHGR	RDSO/WAM4/114
31.	Modification to fixing arrangement for blow out coil of CGR to ensure locking of Tap changer	RDSO/WAM4/128.
32.	Modified flexible connection between RGR & GR of Tap changer	RDSO/WAM4/136.
33.	Introduction of locktite between the mating surface of cams & cam shaft, grub screw and taper holes of Tap Changer	RDSO/WAM4/145.
34.	Provision of grub screw locking for CG bush & gear housing assembly of manual drive for tap changer	RDSO/WAM4/146.

S.No.	Title	No.
35.	Modification in insulating ring (1218, 1219) fixing arrangement	RDSO/WAM4/157.
36.	Replacement of cast iron transition resistance (RGR) by stainless steel transition resistance in Tap changer	RDSO/WAM4/161
37.	Provision of canopy on safety valves of Tap changer	RDSO/WAM4/187
38.	Permanent connection of 16th tap in place of spring loaded connection	RDSO/WAM4/192
39.	Modification to control circuit to GR on WAG-5 locos	RDSO/WAG5/218
40.	Modification in the air supply line to ensure effective operation of the oil pump (PHGR) fitted with the oil pump device in the Adtranz make Tap Changer no. 32.	RDSO/MS/0269
41.	Measures to prevent burning of notch repeater used in loco.	RDSO/WAM4/200

ANNEXURE - B**LIST OF SPARES REQUIRED FOR AOH/IOH****AOH KIT**

The following components of Tap Changer, No. 32 (Adtranz make) are to be replaced compulsory by new ones during AOH Maintenance Schedule.

SN	PART NO.	DRG.NO.	DESCRIPTION	QTY/TC
A. SELECTOR (GR)				
1.	S 1519	SWT-435200-P1	Fibre glass cord	1
2.	S1306.2/ S1306.5	AM-502840-P!	Packing (Oil level indicator)	2
3.	S3309	AG- 549697-P1	Gasket (Oil flow indicator)	2
B. CIRCUIT BREAKER (CGR)				
1.	S1515	AG-546151-R1	Contact Roller complete	2

SN	PART NO.	DRG.NO.	DESCRIPTION	QTY/TC
C. OIL FILTRATION UNIT				
1.	S3235	SWT-435167-P1	Cup Seal	2
2.	S3270.3	SWT-435167-P2	Cup Seal	2
3.	S3221/ S3225	SWT-435430-P3	'O' Ring	1
4.	S3224/ S3252	SWT-435430-P2	'O' Ring	2
5.	S3251	SWT-435430-P5	'O' Ring	6
6.	S3254	SWT-235033-P27	Gasket	1
7.		0450222008/ HB	Mico Filter Element	1
D. AIR MOTOR				
1.	A1213	SWT-435144-P2	Packing Ring	4
2.	A2303	SWT-435461-P1	Sealing Ring	4
3.	A3108	AG- 544441-P2	Gasket	4
4.	A3111/ A4120/ A4430.19	AG- 544441-P1	Gasket	8
5.	A4430.4	AM-404742-P1	Packing Ring	2
6.	A4430.2	AG-413762-P25	Damping Gasket	2

Note: The above list does not include standard hardware items (such as Roll pins, circlips, washers, copper washers etc.) which also need to be changed during AOH.

IOH KIT

The following components of Tap Changer, No.32 (Adtranz make) are to be replaced compulsory by new ones during IOH Maintenance Schedule

A. SELECTOR (GR)

SN	PART NO.	DRG.NO.	DESCRIPTION	QTY/TC
1.	S1519	SWT-435200-P1	Fibre Glass Cord	1
2.	S1306.2/A 1306.5	AM-502840-P1	packing (oil level indicator)	2
3.	S3309	AG-549697-P1	Gasket (oil flow indicator)	2
4.	S1303	AG-207812-P1	Gasket	1
5.	S1320.1	AG-544325-P4	Packing Ring	2
6.	S1434/ S1440	SWT-435381-P1	Oil seal	2
7.	S1421	AG-544325-P5	Packing ring	1
8.	S1218	AM-200095-R2	Insulating ring (inner)	1
9.	S1219	AM-200095-R1	Insulating ring (outer)	1
10.	S1515	AG-546151-R1	Contact roller complete	2

B. CIRCUIT BREAKER (CGR)

SN	PART NO.	DRG.NO.	DESCRIPTION	QTY/TC
1.	S2529	AG-540123-P1	Contact	6

C. OIL FILTRATION UNIT (PHGR Circuit)

SN	PART NO.	DRG.NO.	DESCRIPTION	QTY/TC
1.	S3235	SWT-435167-P1	Cup seal	2
2.	S3270.3	SWT-435167-P2	Cup seal	2
3.	S3221/ S3225	SWT-435430-P3	'O' ring	1
4.	S3224/ S3252	SWT-435430-P2	'O' ring	2
5.	S3251	SWT-435430-P5	'O' ring	6
6.	S3254	SWT-235033-P27	Gasket	1
7.		0450222008/HB	Mico filter element	1

D. CU GASKETS

For oil pipe line, oil flow indicator, oil pump device.

SN	PART NO.	DRG.NO.	DESCRIPTION	QTY/TC
1.	S3290.12	MT-430152-P19	CU Gasket	2
2.	S3290.14	MT-430152-P18	CU Gasket	2
3.	S3290.10	MT-430152-P13	CU Gasket	1
4.	S3290.17	SWT-435491-P13	CU Gasket	1
5.	S3433	MT-430152-P34	Gasket	7
6.	S3422/ S3406	MT-430152-P23	Gasket	20

E. AIR MOTOR

SN	PART NO.	DRG.NO.	DESCRIPTION	QTY/TC
1	A1213	SWT-435144-P2	Packing ring	4
2	A2303	SWT-435461-P1	Sealing ring	4
3	A3108	AG-544441-P2	Gasket	4
4	A3111/ A4120 A4430.19	AG-544441-P1	Gasket	8
5	A4430.4	AM-404742-P1	Packing ring	2
6	A4430.2	AG-413762-P15	Damping Gasket	2
7	A2209	SWT-435581-R1	Spring with eyes	2
8	A4540.7	AM-401107-P1	Compression spring	1
9	A3209/ A4209	AG-544415-P1	Push rod with seal	6
10	A4206/ A3206	AG-544411-P1	Valve nipple	6
11	A1929.1	MT-430189-P471	Roll pin (8/45)	1
12	A1929.2	MT-430189-P371	Roll pin (5/45)	1
13	S4212	MT-430189-P471	Roll pin (8/45)	1
14	S4216	MT-430189-P371	Roll pin (5/45)	1
15	S4217	MT-430189-P471	Roll pin (8/45)	1
16	S4218	MT-430189-P371	Roll pin (5/45)	1

F. ACCESSORIES**C.G. GRID ELEMENT RGR**

SN	PART NO.	DRG.NO.	DESCRIPTION	QTY/TC
1	S3809	KB-473201-P1	Insulating washer	106
2	S3822.2	B-406533-P2	Micanite tube	2
3	S3830.2	SWT-435218-P3	Insulating tube	4
4	S3830.3	SWT-435218-P1	Insulating washer	8
5	S3830.4	SWT-435218-P2	Insulating washer	8

G. S.S. ELEMENT RGR

SN	PART NO.	DRG.NO.	DESCRIPTION	QTY/TC
1	S4415	KB-473201-P2	Mica washer 21/50/2	141
2	S4416.2	B-406533-P2	Samica glass tube	3
3	S4406.2	SWT-435218-P3	Insulating tube	4
4	S4406.3	SWT-435218-P1	Insulating washer	8
5	S4406.4	SWT-435218-P2	Insulating washer	8

Note: The above list does not include standard hardware items (such as roll pins, circlips, washers, copper washers etc.) which also need to be changed during IOH.

ANNEXURE - C**KIT OF STANDARD HARDWARE FOR
TAP CHANGER**

S.N	PART NO.	DESCRIPTION	DRG.NO.	QTY/KIT
1	A1906	Hex Screw M8 x 20	MT430106 P2610	50
2.	A1907/A1936 A6302/A6418 A6509/A6514 S1415/S1460 S1464/S1611 S1614/S2127 S2182/S3450 S3816/S3905	Belleville spring washer dia 9/18	MT430151 P23	50
3.	A1908/S2183 S3449/A6508	Hex Nut 0.8D x M8	MT430108 P 2018	50
4.	A1909	Hex Screw M10 x30	MT430872 P362	50
5.	A1910/A2109 A4127/S1109 S1112/S1204 S1305/S1403 S1603/S2117 S2120/S2134 S2149/S2155 S3426/S3453 S3710	Belleville spring washer dia 11/22	MT430151 P26	50

S.N	PART NO.	DESCRIPTION	DRG.NO.	QTY/KIT
6.	A1912.1	Roll Pin 8 x 28	MT430189 P467	50
7	A1912.2/ A4519	Roll Pin 5 x 28	MT430189 P367	50
8	A1913	Hex Screw M12x 45	MT430872 P415	50
9	A1914/A1941	Belleville spring washer dia 14/28	MT430151 P28	50
10	A1923.2	Hex Nut 1/2" BSP	MT430232 P2004	50
11	A1928/A1930 A2113	External Circlip A24	MT430201 P24	50
12	A1931	Hex Socket HD.Cap Screw M10 x 40/25	MT430956 P2209	50
13	A1935	Hex Screw M8 x 25	MT430106 P2612	50
14	A1937	Hex Screw M6x12	MT430106 P2507	50
15	A1938/A1945/ A3110/S3457/ S3705/A4102/ A5513/A6306/ A6308/A6503/ A6512	Belleville spring washer dia 7.5/14	MT430151 P22	50
16	A1939/S3456 A6511/S3610 S3707	Hex Nut 0.8D x M6	MT430151 P2017	50

S.N	PART NO.	DESCRIPTION	DRG.NO.	QTY/KIT
17	A1940	Hex Screw M12 x20	MT430106 P2810	50
18	A1942	Hex Nut 0.8D x M6	MT430108 P2020	50
19	A1944/A5512 A6305	Hex Screw M6 x 15	MT430106 P2508	50
20	A1947/ A4150.14	Hex Nut 0.8D x M5	MT430108 P2016	50
21	A1948/A4150.8 A4150. 15/ A4150. 22 A5315/ A5516 A6110.4/A6432	Belleville spring washer dia 6/12	MT430151 P19	50
22	A1949/A5314/ A5515/A6328/ A6431	Hex Screw M5 x 15	MT430106 P2409	50
23	A2107	Hex BoltM10 x 150/32	MT430871 P380	50
24	A2108/S2121 S2129/S2156	Hex Nut 0.8D x M10	MT430957 P113	50
25	A2114	Hex Bolt M10 x 160 x 32	MT430871 P381	50
26	A2115	Roll Pin dia 5 x 16	MT430189 P362	50
27	A2212.4	Plain Washer dia 8.4/15 x 1.5	MT430828 P2014	50

S.N	PART NO.	DESCRIPTION	DRG.NO.	QTY/KIT
28	A2301	External Circlip 152	MT430201 P42	50
29	A2314.2/S1405.1 S1433/S1441 S1503/S2111	Internal Circlip 152	MT430202 P52	50
30	A3109	Hex Bolt M6 x 70/ 18	MT439005 P270	50
31	A3207/A2407	Internal Circlip 116	MT430202 P16	50
32	A4101	Hex Bolt M6 x 45/ 17	MT430222 P2514	50
33	A4124	Hex Socket HD. Screw M8 x 70/22	MT430511 P215	50
34	A4125/S4517	Belleville spring washer M8 x70/22	MT430190 P118	50
35	A4134/A6502	Hex Bolt M6 x 30/ 17	MT430222 P2511	50
36	A4139	Slotted head screw M8 x 25	MT430229 P2930	50
37	A4150.11/ A4150.16	Counter sunk Screw 90° M5 x10	MT430237 P2713	50
38	A4150.21 A6110.3	Hex Screw M5 x10	MT430106 P2406	50
39	A4150.32	Hex Nut 0.5D xM6	MT430439 P2012	50
40	A4150.7	Hex Screw M5 x12	MT430106 P2407	50

S.N	PART NO.	DESCRIPTION	DRG.NO.	QTY/KIT
41	A4430.17 A4430.22 S2535/S1529	Belleville spring washer dia 6.4/14	MT430151 P20	50
42	A4430.18/A4504 A4540.11/S1529	Hex Nut 0.8D xM6	MT430957 P111	50
43	A4430.21	Hex Socket HD Cap Screw M6 x12	MT430956 P2005	50
44	A4430.7 A4540.12	Roll Pin 2 x 12	MT430189 P110	50
45	A4514/A5404 A6109/A6403	External Circlip A10	MT430201 P10	50
46	A4516/ S2410 S 2530	Hex Socket Hd. Cap Screw M8 x 30/22	MT430956 P2109	50
47	A4540.10	Roll Pin 4 x 14	MT430189 P311	50
48	A4540.9/A4503	Slotted CH.HD. Screw M6 x 2.0	MT430229 P2876	50
49	A5317.9	Split Pin A2 x 15	MT430405 P2209	50
50	A5402/A5523/ A6111/A6203 A6310/A6408	External CirclipA17	MT430201 P17	50
51	A5408/A6413 A6107/S3603	Belleville spring washer dia 18/28	MT430704 P6	50
52	A5414	Roll Pin 8 x 25	MT430189 P466	50

S.N	PART NO.	DESCRIPTION	DRG.NO.	QTY/KIT
53	A5509/A6327 A6426	Belleville spring washer dia 32/48	MT430704 P10	50
54	A5517	Hex Bolt M8 x 80/ 22	SWT439005 P322	50
55	A5521/A6317 A6405	Roll Pin 4 x 36	MT430189 P319	50
56	A5524/A6417 A6209/A6309	Internal Circlip 140	MT430202 P40	50
57	A6114	Hex Bolt M8 x 45/21	MT430222 P 2614	50
58	A6115	Special washer dia 8.4 x 15	MT430198 P17	50
59	A6205	Slotted Ch HD Screw M4 x 20	MT430229 P2676	50
60	A6301	Hex Screw M 6 x 25	MT430872 P2211	50
61	A6307	Hex Bolt M6 x 130/18	SWT439005 P278	50
62	A6311	Roll Pin dia 6 x 28	MT430189 P417	50
63	A6420/S1416 S1528/S2514 S2525/S3906	Hex Nut 0.8 D x M8	MT430957 P112	50
64	A6506/S2160.6	Hex Bolt M6 x 35/70	MT430222 P2512	50
65	S1101.2	Helicoil M 10 x 1.5 P x 1.5D	MT430935 P62	50

S.N	PART NO.	DESCRIPTION	DRG.NO.	QTY/KIT
66	S1105	Gasket Diameter 21/ 25 x 1	MT430152 P28	50
67	S1108/S1304	Hex Screw M10 x 30	MT430872 P 2362	50
68	S1111/S1404 S1427/S1602 S2133/S2148 S3714	Hex Screw M10 x 25	MT430872 P2361	50
69	S1203	Hex Bolt M10 x 55/ 26	MT430871 P367	50
70	S1220/S2160.2	Belleville spring washer dia 6.4/14	MT430190 P116	50
71	S1227/S1436	Roll Pin dia 3 x 25	MT430189 P216	50
72	S1230	Roll Pin 3 x 12	MT430189 P210	50
73	S1411/S1615 S2205/S2220.5	External Circlip A25	MT430201 P25	50
74	S1414/S1461	Hex Bolt M8 x 40/22	SWT439005 P 314	50
75	S1422	CH HD Screw M5 x 10	MT430229 P2766	50
76	S1447	External Circlip A20	MT430201 P20	50
77	S1451	Hex Bolt M8 x 25	MT430872 P2261	50

S.N	PART NO.	DESCRIPTION	DRG.NO.	QTY/KIT
78	S1465	External Circlip A55	MT430201 P 55	50
79	S1469	Internal Circlip 142	MT430202 P 42	50
80	S1471	Slotted head Grub Screw M5 x 6	MT430440 P2706	50
81	S1480.1/S1481.1 S1929.1/S2104/ S2100.2/S2210.1	Roll Pin 8 x 45	MT430189 P 147	50
82	S1480.2/A1481.2 /A1929.2 S2104.2/ S2210.2	Roll Pin 5 x 46	MT430189 P371	50
83	S1507	Hex Bolt M8 x 75/22	SWT439005 P 271	50
84	S1510	Hex Bolt M6 x 80/18	SWT439005 P 272	50
85	S1530/S3706 S3909	Punched washer diameter 6.6/12	MT430827 P2011	50
86	S1610/S3903	Hex Screw M8 x16	MT430872 P2259	50
87	S2216/S3709	Hex Bolt M10 x 35/26	MT430871 P363	50
88	S2119/S2154	Hex Bolt M10 x 45/25	MT430871 P365	50
89	S2126	Hex lock Nut 0.5D x M8	MT430439 P2013	50

S.N	PART NO.	DESCRIPTION	DRG.NO.	QTY/KIT
90	S2128	Hex Bolt M10 x 120/25	MT430871 P 377	50
91	S2145/S2161 S3406	CU Gasket diameter 14/20 x 1	MT430152 P23	50
92	S2153	Belleville spring washer dia 13.5/28	MT430190 P122	50
93	S2164	Roll Pin dia 5 x 20	MT430189 P364	50
94	S2184	Punched washer diameter 9/17	MT430827 P2015	50
95	S2185/S3448	Hex Screw M8 x 30	MT430106 P2614	50
96	S2404	Hex Bolt M6 x 30	MT430872 P2210	50
97	S2406	Hex Socket head cap screw M6 x 30	MT430956 P2009	50
98	S2407	CU Gasket diameter 6.5/11.2 x 1	MT430152 P11	50
99	S2408/S2532	Hex Socket head screw M6 x 20	MT430956 P2007	50
100	S2409	Punched washer dia 6.6/11 x 1.6	MT430828 P2011	50
101	S2411	Spring washer	SWT 435227 P1	50
102	S2413	Hex Socket head screw M12 x 35	MT430956 P108	50

S.N	PART NO.	DESCRIPTION	DRG.NO.	QTY/KIT
103	S2604	Socket head cap screw M6 x 25	MT430956 P2008	50
104	S2606	Hex Socket Hd Cap Screw M8 x 50/28	MT430956 P2163	50
105	S3236	Spring washer B12	MT430197 P218	50
106	S3303	Gasket dia 16/22	MT430152 P27	50
107	S3305	Gasket dia 9.7/17	MT430152 P18	50
108	S3306	Hex Bolt M4 x 40/13	MT430222 P233	50
109	S3307	Belleville spring washer dia 5/10	MT430151 P17	50
110	S3308	Hex Nut 0.8D x M4	MT430108 P2014	50
111	S3425	Hex Screw M10 x 30	MT430106 P2714	50
112	S3428/S334/ S3435	Gasket diameter 22/31.5 x 1	MT430152 P34	50
113	S3429	Slotted CH HD Screw M4 x 5	MT430229 P2660	50
114	S3430	Spring washer B4	MT430197 P606	50
115	S3431	Punched washer diameter 4.5/9 x 0.8	MT430827 P2008	50
116	S3438/S3464	Gasket diameter 11/17 x 1	MT430152 P19	50

S.N	PART NO.	DESCRIPTION	DRG.NO.	QTY/KIT
117	S3441/S3611	Hex Screw M6 x20	MT430106 P2510	50
118	S3451	Hex Bolt M10 x 35/25	MT430222 P2712	50
119	S3421/S3452	Hex Nut diameter 0.8D x M10	MT430108 P2019	50
120	S3454	Punched washer diameter 10.5/22	MT430827 P2017	50
121	S3455	Hex Screw M6 x25	MT430106 P2512	50
122	S3602	Gasket diameter 17/34 x 3	MT430152 P42	50
123	S3404	Special Nut 3/8"BSP	MT430232 P2003	50
124	S3609	Belleville Spring washer dia 6.4/14	MT430151 P21	50
125	S3704	Hex Screw M6 x35	MT430106 P2515	50
126	S3814	Hex Screw M8 x20	MT430106 P4610	50
127	S3818	Hex Screw M12 x 30	MT430872 P412	50
128	S3904	Plain washer diameter 8.4/18 x0.5	MT430445 P2023	50
129	S3908	Rivet diameter 3 x 8	MT430223 P8563	50

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6. Suggestions given by RDSO.
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8. Maintenance practices studied during visits at various sheds.
