ON LOAD TAP CHANGER SERIES RS9/RS9.3

Inspection, Maintenance and Repairs Manual

EA 765e rev.01.16

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APPENDICES

1. GENERAL ASPECTS

The RS9/RS9.3 OLTCs are designed for regulation of power transformers under load. The regulation is performed by modifying the transformer ratio by means of switching the take-off leads of the transformer winding.

The RS9/RS9.3 OLTCs are produced in different variations, depending on:

- The maximum rated current;
- The highest voltage of the tap changer;
- The number of phases;
- The number of regulation steps;
- The selector insulation class;
- The type of the change-over selector.

Three-phase OLTCs are used most often for voltage regulation in the transformer neutral. Single-phase OLTCs can be used in various connection diagrams. The RS9/RS9.3 OLTCs are driven by motors, which allows for using local, remote and automatic control. The motor drive is installed outside the transformer tank.

2. TECHNICAL DATA

Table 1

<table>
<tr><th>No.</th><th>Main parameters</th><th>Unit</th><th colspan="30">Value</th></tr>
<tr><td>1.</td><td>Maximum rated current I_{Um}</td><td>A</td><td colspan="5">200
III; I</td><td colspan="5">400
III; I</td><td colspan="5">630
III; I</td><td colspan="5">800
I</td><td colspan="5">1200
I</td><td colspan="5">1600
I</td></tr>
<tr><td>2.</td><td>Breaking capacity:
- rated ($Uj.I_{Um}$)
- maximum ($Uj.2I_{Um}$)</td><td>kVA
kVA</td><td colspan="5">800
1600</td><td colspan="5">1400
2800</td><td colspan="5">1890
3780</td><td colspan="5">2000
4000</td><td colspan="5">3000
6000</td><td colspan="5">3200
6400</td></tr>
<tr><td>3.</td><td>Maximum step voltage (phase) Uj
(see appendix RS9/RS9.3-01)</td><td>V</td><td colspan="5">4000</td><td colspan="5">3500</td><td colspan="5">3000</td><td colspan="5">3000</td><td colspan="5">2500</td><td colspan="5">2000</td></tr>
<tr><td>4.</td><td>Resistance to short-circuit current:
- constant current k.z.- 3s.
- shock</td><td>kA
kA</td><td colspan="5">4
10</td><td colspan="5">8
20</td><td colspan="5">12,6
31,5</td><td colspan="5">16
40</td><td colspan="5">24
60</td><td colspan="5">24
60</td></tr>
<tr><td>5.</td><td>Electric endurance under load at I_{Um} and cosφ=l:
- number of switching operations till inspection
- number of switching operations till contact replacement</td><td></td><td colspan="5">100000
500000</td><td colspan="5">100000
500000</td><td colspan="5">50000
250000</td><td colspan="5">70000
400000</td><td colspan="5">60000
250000</td><td colspan="5">50000
200000</td></tr>
<tr><td>6.</td><td>Mechanical endurance</td><td></td><td colspan="30">1 000 000</td></tr>
<tr><td>7.</td><td>Number of steps</td><td></td><td colspan="30">up to 35</td></tr>
<tr><td>8.</td><td>Peak voltage of the device (insulation to earth):
- test voltage 50 Hz, 1 min.
- impulse test voltage full wave 1,2/50</td><td>kV
kV
kV</td><td colspan="5">41,5
110
250</td><td colspan="5">72,5
140
350</td><td colspan="5">123
230
550</td><td colspan="5">170
325
750</td><td colspan="5">245
460
1050</td><td colspan="5">300
460
1050</td></tr>
<tr><td>9.</td><td>Insulation class of selector</td><td></td><td colspan="6">K</td><td colspan="6">L</td><td colspan="6">M</td><td colspan="6">N</td><td colspan="6">P</td></tr>
<tr><td>10.</td><td>Impulse test voltage of full wave 1,2/50
- per step
- between parts operating under voltage of regulation winding - range</td><td>kV
kV</td><td colspan="6">100
230</td><td colspan="6">120
300</td><td colspan="6">140
350</td><td colspan="6">140
420</td><td colspan="6">140
490</td></tr>
</table>

3. FUNCTIONING PRINCIPLE

The RS9/RS9.3 OLTC is designed on the basis of indirect commutation, i.e. the selection process is separated in time and space from the process of switching under load.

The current-free selection of the desired lead is performed by the selector. For every phase, it has two lines of fixed contacts. The odd leads of the transformer winding are connected to one of the lines, and the even leads are connected to the other row. One movable contact operates with each row of fixed contacts. The movable contacts for the odd and even leads perform an alternating movement in such a manner that when the current flows through the even contacts, the odd contacts are free and can select without current the next odd lead. If the current loaded contacts are the odd ones, the current free selection of the next leads is performed by the free even contacts.

Upon completion of the selection process, the diverter switch for a very brief time transfers the load onto the selected step. The diverter switch is designed in such a manner, that the current to the load is not switched off during the switching operation, and the leads of the commuting step of the transformer winding are not bypassed. This is achieved by using auxiliary contacts, which switch on the active resistors for hundredths of a second. The rapid switching process makes possible the use of small volume resistors.

The increase (doubling) of the regulation range is achieved by means of the change-over selector. The latter has two variations: a reverse change-over selector and a coarse-step change-over selector. In the first case, the double use of the selector contacts and leads of the transformer winding is achieved by means of switching the end leads of the regulation winding in the following manner: In the first passage of the contacts in the selector, the electric drive force (e.d.f.) of the regulation winding is added to the e.d.f. of the main winding, while in the second passage, the former is substracted from the latter. When using the coarse-step change-over selector, the coarse step of the transformer winding is being switched -on and -off.

In the case of a narrow range of adjustments, the OLTC can be used without a change-over selector.

Appendix RS9/RS9.3-02 shows an electric kinematic diagram of the OLTC with a reverse change-over selector. The OLTC is shown operating at the second step of the regulation winding . The route of the current is shown in bold lines. In order to switch over from second to third step, the motor drive turns the horizontal shaft (1) to 33 turns. By means of the worm gear (2), with a gear-ratio of 33:1, the movement is transferred to the vertical insulation shaft (4), and by means of the cylindrical gear (5), with a gear ratio of 2:1, the movement is transferred upwards to the diverter switch and down to the selector.

The double disc with rollers (6) and the Geneva nuts (7) drive consecutively the two shafts (8) of the selector. The movable contacts (9) and (10) of the selector are connected to these two selector shafts. In the shown position, the movable contacts of the odd leads (10) are not under load and they move current-free from the first to the third step. The load current flows through the movable contacts of the even leads (9), which at this time do not move.

The diverter switch is driven by the lever transmission (3). During the selection process, the diverter switch is prepared for switching, accumulating energy in the switching spring. At the end of the selection (some spare movement is provided for), the diverter switch transfers the load from contacts (32) to contacts (31), i.e. from the second to the third step of the regulation winding. During this switching operation, the load current flows consequently through resistors R_1 and R_2 (the values of R_1 and R_2 are equal). The coils of the regulation winding between leads 2 and 3 for part of the duration of the switching operation (during the bridging) are connected via resistor R ($R = R_1 + R_2$). The value of the resistors has been selected in such a manner, as to prevent the circulating current from exceeding the permissible value.

In case it becomes necessary after the switching to the third step to return to the second step, it will be sufficient to turn over the diverter switch from Position 31 to Position 32. In this case, the selector does not perform any movement of the contacts, since the movable contacts of the even leads remain on the fixed contacts. This is achieved as a result of the free movement between the large gear (5) and the double disc (6). The actuating of the diverter switch without moving the selector is performed with every change of the direction of the regulation.

For the selector with the “K” contacts on the phase (K = 10, 12, 14, 16, 18 steps) in the case of a reverse change-over selector, the regulation winding can be used with n = K - 2 steps or with n = K steps.

In the diagram shown in Appendix RS 9/RS9.3-02, the regulation winding has n = K - 2 steps; this results in N = 2n + 1 operating positions with various voltages when using twice the regulation winding by means of the reverse change-over selector.

From Position “1” to Position “K - 1” the operating coils of the regulation winding are switched on according to the coils of the main winding . In Position “K”, the current flows only through the main winding and the regulation winding can be switched over current-free by means of the reverse change-over selector. In this way, upon second passage along the fixed contacts, the coils of the regulation winding are connected counterwise to the coils of the main winding .

4. DESIGN DESCRIPTION

The OLTCs in the RS series have a contemporary integration design. All the OLTCs can be built into the transformer tank, while only the carrying flange with the parts installed on it remain outside of the tank.

The general outlook of the three-phase RS9/RS9.3 is shown in Drawing RS9/RS9.3-04. The carrying flange (1) can be disassembled, which makes it possible to install the OLTC also into transformers of the bell type.

On the carrying flange (1), the worm gear housing (6) is installed. It has a digital indicator of the operating positions and mechanical blocking system for the end positions.

Also, the following parts are installed on the carrying flange: three flanges (4) for connecting the oil pipe for the protective relay and the siphon, the bleeding plug (40), the lifting rings (42) and the cover (5). The cover is equipped with a protective membrane (3), a flange (2) for connecting to the emergency exhaust pipe for hot gases and vapors in case of failure of the membrane, and an opening for installation of the temperature relay/sensor (41). If a special design is ordered, a pressure-reduction valve of the Qualitrol type can be installed instead of the membrane.

The drive shaft can be input from the right, from the left or from both sides of the worm gear; this is to be specified at the time of ordering. In the cover of the drive shaft, there is a window for observing the number of the operating position and the normal position indicator.

The protective relay can be connected to any one of the three flanges (4), while the siphon pipe can be connected either from the left or from the right, looking from the side of the change-over selector.

The carrying flange (1), the cover (5), the insulation cylinder (9) and the bottom (24) form the oil compartment, in which the diverter switch is installed. This tank is sealed and separates the contaminated oil from the pure oil in the transformer tank.

The diverter switch consists of the contact system, the spring energy accumulator and the active transition resistors. It operates according to the “flag” diagram with two auxiliary contacts per phase.

The kinematic diagram is designed in such a manner, as to provide for closure of only one of the main contacts (18) in normal position. Both auxiliary contacts remain simultaneously closed in the bridging position during the switching operation for a very brief period of time (ranging from 0.5ms to 6 ms). This period of time remains practically unchanged until the final wearing out of the contacts.

The fixed main contacts (18) and the fixed auxiliary contacts (10) of the diverter switch are installed onto the insulation cylinder (19). The movable contacts (12) are installed on brackets (11) and are directed by the radial channels (20) at the bottom of the diverter switch.

The movable contact system is driven by the spring energy accumulator by means of the central star (13). The spring energy accumulator consists of the switching springs (21) and the fixing mechanism (22) installed at the bottom (20).

The resistors (14) are installed as a separate unit, which is fixed over the contact system by means of bolts (15). The diverter switch is connected to the contacts of the oil tank by means of safety bolts (16) and can be uninstalled from the tank by means of a hoist (Drawing No. 206.2), which is supplied together with the OLTC.

The selector is located under the oil tank. Its carrying structure consists of: upper shield (26), lower shield (39), cells of the insulation bars (27) and the central pipe (37). The rakes carry the fixed contacts (28) to which the leads of the transformer winding are connected. The movable contacts (29) are installed on the vertical insulation shaft (38). The Geneva gear (25) for the two shafts of the selector is located on the upper shield (26). On the central pipe, the current transfer rings (32) are installed. The conduits (36) pass through the central pipe (37) transfering the current from the rings (32) upwards to the diverter switch.

The change-over selector is located to the side of the selector and consists of the insulation sectors (35) with the fixed contacts (34), the insulation shaft (31) and the movable contacts (30).

The RS9/RS9.3 OLTCs are made in three variations - with a coarse-step change-over selector, with a reverse change-over selector, or without a change-over selector.

5. INSPECTION AND REPAIR

It is necessary to carry out inspections in order to guarantee a high degree of operational reliability. For this reason, it is important to follow accurately the activities described below.

- The oil quality in the diverter switch compartment should be checked by the OLTC user according to the instructions.

- An inspection should be performed in the case os an activated protective device – activated URF 25/10 protective relay, activated protective valve for pressure relief (protective membrane), activated fast–acting relay.

Table 2

Type of RS 9/RS 9.3 tap changer	Rated current of the transformer up to	Number of the switching operations without an oil	Number of the switching operations with an oil filter1
III - 200	200	100 000	150 000
III - 400	400	100 000	150 000
III - 630	630	50 000	80 000
I - 200	200	120 000	150 000
I - 400	400	120 000	150 000
I - 630	630	80 000	120 000
I - 800	800	70 000	100 000
I - 1200	1200	50 000	70 000
I - 1600	1600	40 000	60 000
II - 200	200	100 000	150 000
II - 400	400	100 000	150 000
II - 630	630	50 000	80 000

[1] If Um of the tap changer is greater than 245kV, then the number indicated in the talbe should be reduced with 40%.

5.1. Inspection and repair of the diverter switch

5.1.1. Taking out of the diverter switch

CAUTION!

All repair or inspection activities should be performed only when the transformer and the MDU are entirely disconnected and safeguarded according to the given country's safety regulations for electrical installations operating at a voltage above 1000V.

a) Drain the oil from the conservator and the oil compartment of the tap changer.

b) Using the handle, turn the motor drive unit manually at 8 revolutions.

c) Unscrew the nuts (Pos.1); afterwards, remove the cover of the tap changer (Pos.2, Fig.1).

d) It is necessary to take out the siphon (Pos. 4); the bolt (Pos. 3, Fig.2) should be unscrewed beforehand.

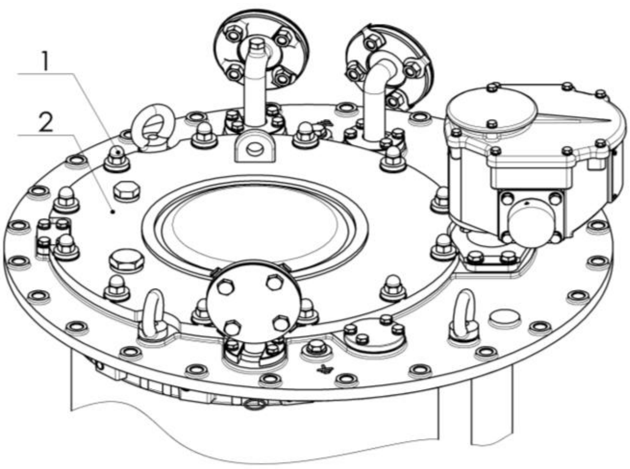


Fig. 1

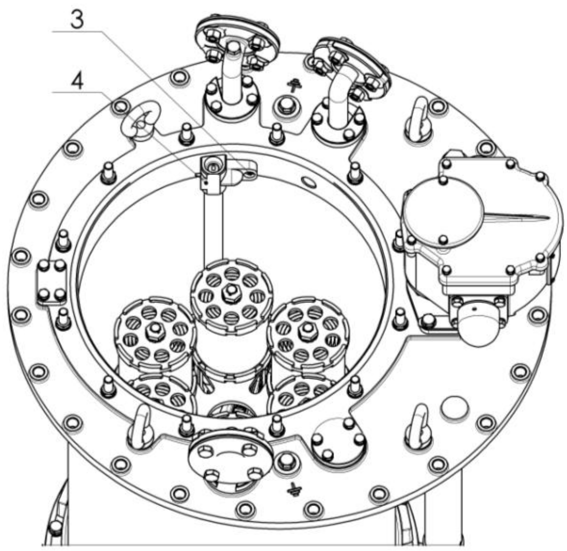


Fig. 2

CAUTION!

- After the cover is removed, it is important not to allow foreign objects or impurities into the oil compartment.

- When the cover is made of aluminium, it is important not to damage the protective membrane (which is part of the cover) after the cover is removed.

d) Unscrew the 14 special (Pos.5, Fig. 3).

e) Using the hoist (included in the standard OLTC equipment) carefully take out the diverter switch that is hooked up with the ring. After taking out the diverter switch, it is necessary to record the position at which it has operated (even/uneven) in order to prevent improper installation.

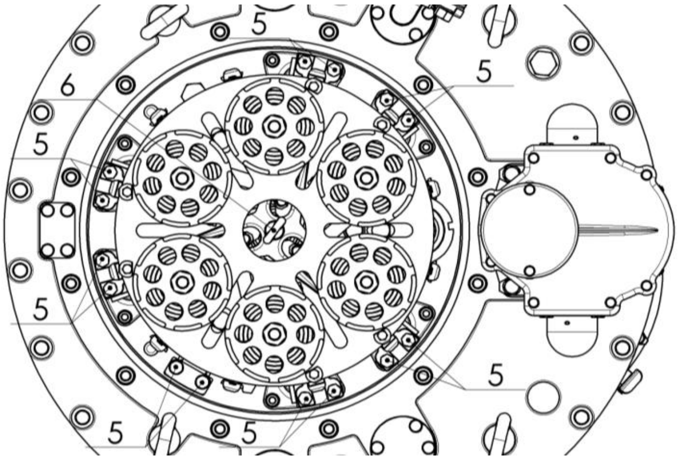


Fig. 3

CAUTION!

After taking out the diverter switch, close the cover in order to prevent impurities, dust, or moisture from entering into the tank.

5.1.2. Uninstalling the transition resistors

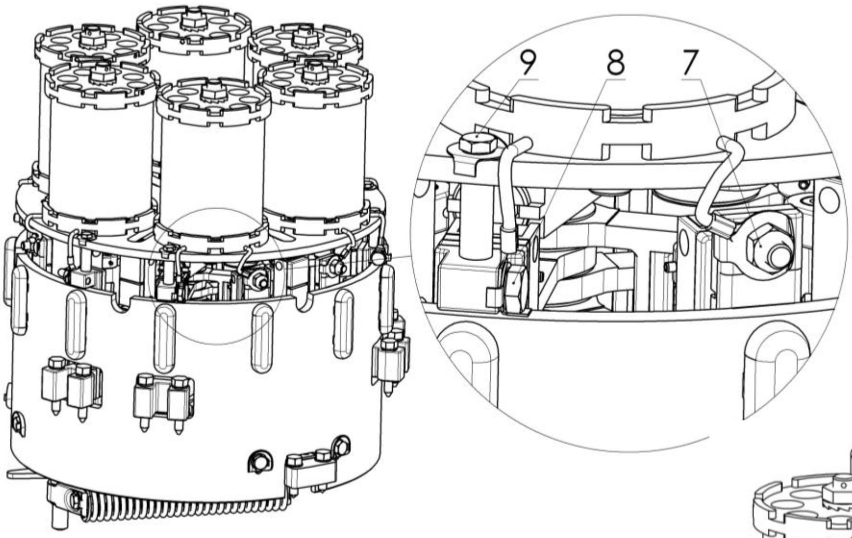


Fig. 4

It is necessary to uninstall the transition resistors. For this purpose, it is necessary to unscrew bolts (Pos. 7 and 8, Fig.4) connecting the resistance leads to the fixed contacts. Unscrew also the bolts (Pos.9) by which the carrying plate is fastened. After the plate is uninstalled (as it is shown Fig. 5) , measure the resistance value and compare it with the one specified in the OLTC passport.

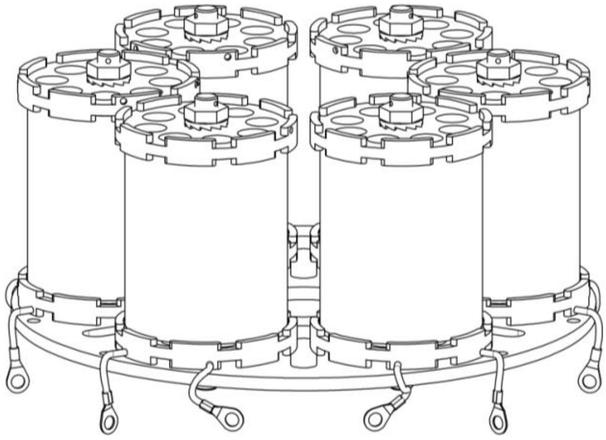


Fig. 5

CAUTION!

The leads of the resistors should not be folded too many times in order not to be broken. If there are any broken resistors, they should be replaced with new ones.

5.1.3. Viewing of the diverter switch

- Check the screw junctures. If there are any loose connections, they should be tightened.
- Check the insulation parts – if they are whole, if there is any soot formation on them, or whether the plates or the insulation cylinder have been deformed in any way.
- Measure the transition resistance of the current carrying loops / circuits – the odd contact (31) towards the common contact (N) and the even contact (32) towards the common contact (N) for each phase (Fig. 6). Compare the measured values with the passport data (under 350 μΩ). If the measured calue is above the specified one, the contact surfaces should be cleaned with an abrasive sponge.

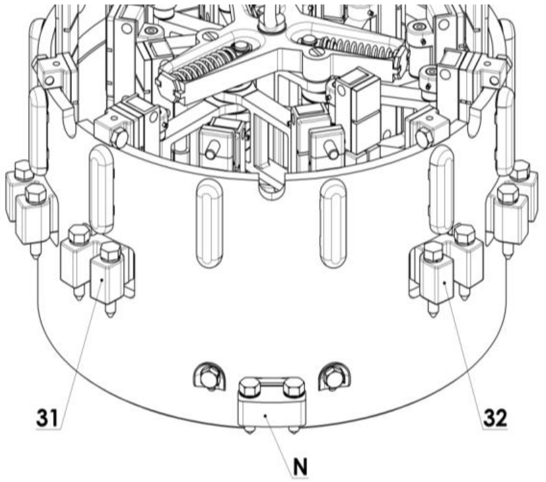


Fig. 6

- Check the condition of the bearings of the locking mechanisms (Pos.10, Fig.7 and the bearings of the moving contacts (Pos. 11).

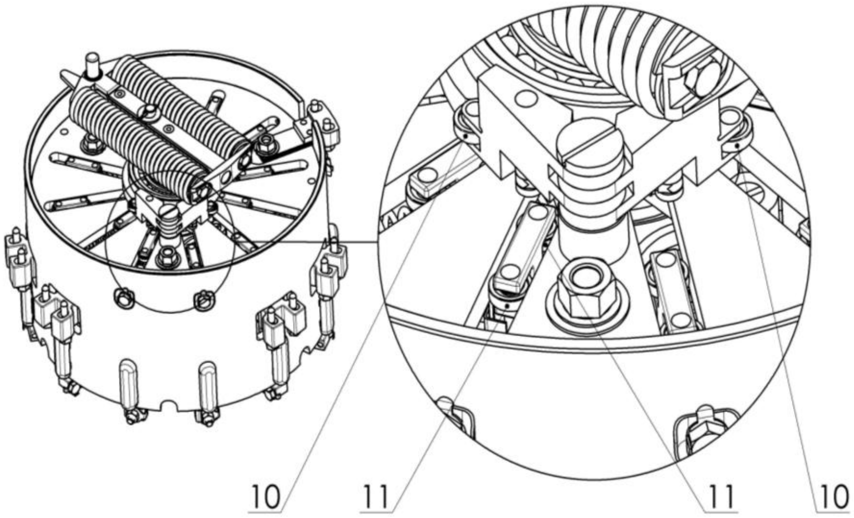


Fig. 7

- Check the wholeness of the flexible connections (Pos. 12, Fig. 8) between the moving contacts situated at the bottom of the diverter switch.
If the connections are broken, they should be replaced with new ones.
- Check whether any of the contacts in the operating area have been worn out.

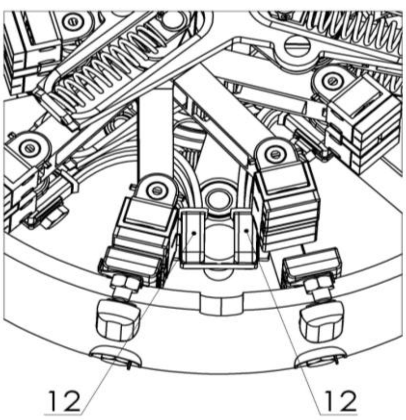


Fig. 8

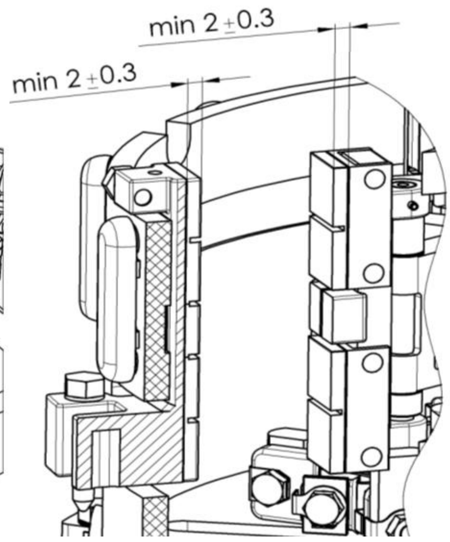


Fig. 9

If the thickness of any of these contacts is less than 2 mm, it should be replaced with a new one.

<u>CAUTION!</u>

All activities related to replacement of worn out parts with new ones should be performed by HHIB specialists or by specifically trained personnel.

After all of the above mentioned activities are completed, the diverter switch should be washed with pure transformer oil.

5.2. Inspection of the selector

Inspection or repair of the selector should be perfomed during planned repair works of the transformer so that the selector can be accessible.

5.2.1. Viewing of the selector

- Check the screw junctures. If there are any loose connections, they should be tightened. Special attention should be paid to the fixed contacts.

- Check whether the insulation parts are whole, whether there is any soot formation or laminated areas on them, and whether the plates or the insulation cylinder have been deformed in any way.

If there are any damaged insulation parts, they should be replaced with new ones.

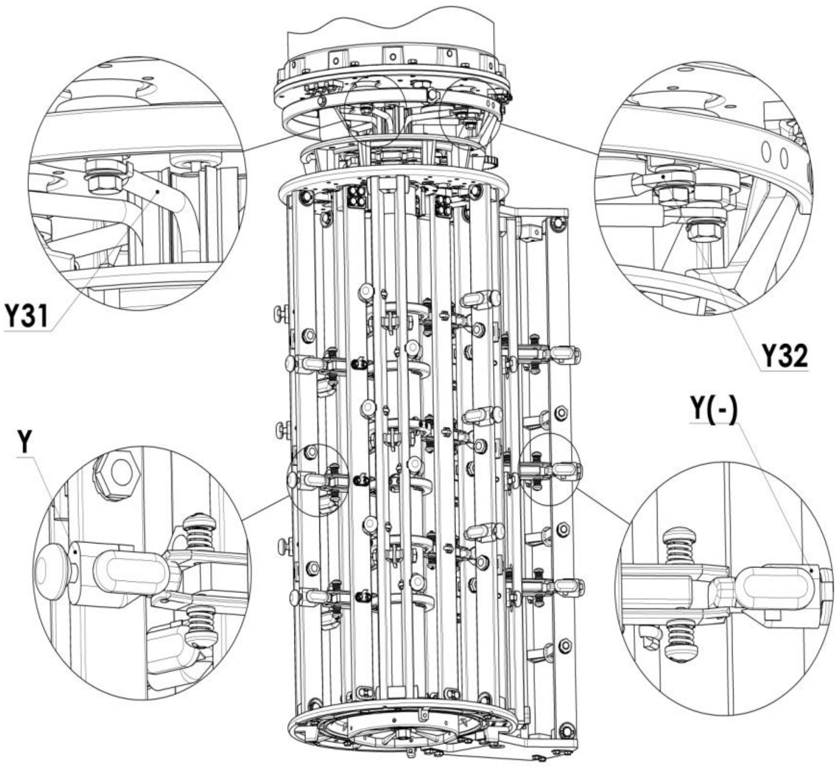


Fig.10

- Check the transition resisitance of each phase for every tap position and compare it with the passport data. The transition resistance should be measured from fixed contact Y to the end of the permanent connection. If the contact is uneven, the transition resistance should be measured to the end of the permanent connection of contact Y31. If the contact is even, the transition resistance should be measured to the end of the permanent connection of contact Y32 situated at the bottom of the oil compartment (Fig.10). Perform these measurements for each of the phases.

When the tap selelctor stands at postion K, measure the transition resistance of the change-over selector as well – from Y (-) / (+) to Y32. If the measured values are higher than the specified ones, it is necessary to do the following:

- Measure the thickness of the fixed contacts (Fig.11). If it is 1 mm less than the specified value in Table 1, then both the moving and the fixed contacts should be replaced with new ones. If the contacts are not mechanically worn out, the fixed contacts should be silver coated again.
- For each position, it should be checked if the moving contact stands on the flat part of the fixed contact. If the moving contact doesn't come to stand there, it is necessary to readjust or to repair the mechanism (Fig. 12).
- View the tap selector mechanism. If any of the parts are significantly worn out, or if there are clearances in the Geneva gears that are larger than 0.5 mm, it is necessary to repair or to replace the mechanism.

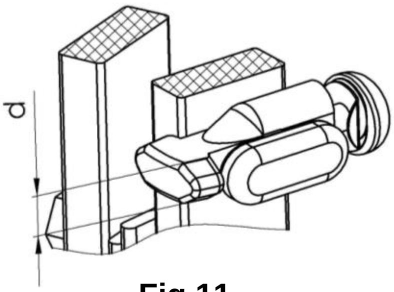


Fig.11

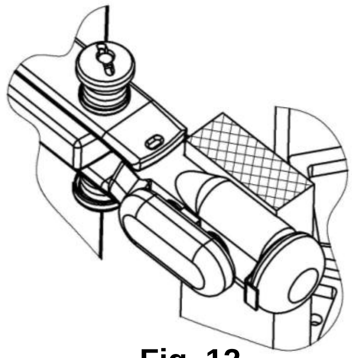


Fig. 12

Table 3

	Resistance value, μΩ				
Rated current, A	200	400	630	1200	1600
Thickness of the fixed contacts d, mm	**16**	**16**	**20**	**20**	**23**
Fixed contact Y to the end of the permanent connection Y31/Y32	**550**	**360**	**250**	**280**	**310**
Change-over selector Y to the end of the permanent connection Y32	**850**	**560**	**400**	**310**	**370**

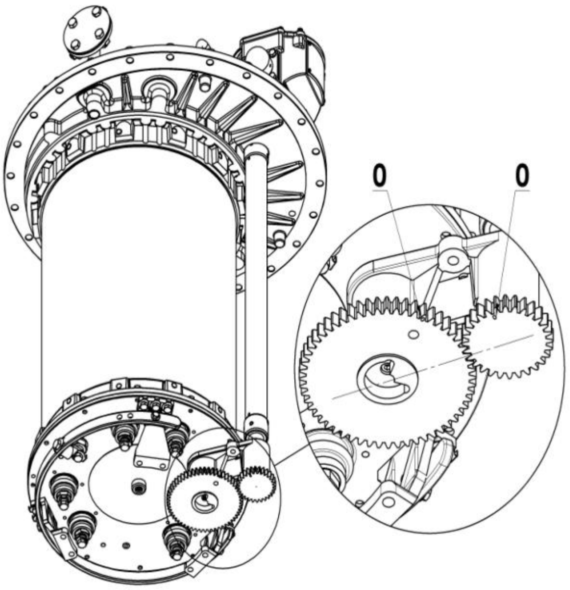


Fig. 13

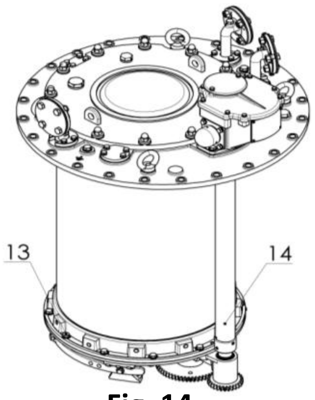


Fig. 14

5.3. Inspection of the oil compartment

After the diverter switch is taken out, the oil compartment should be disassembled. Therefore, before starting the inspection, the mechanisms should be blocked in order to prevent further misalignment.

The markers that are designated as “O” in Fig. 13 and that can be symmetrically situated on both sides of the axial line, should not be displaced.

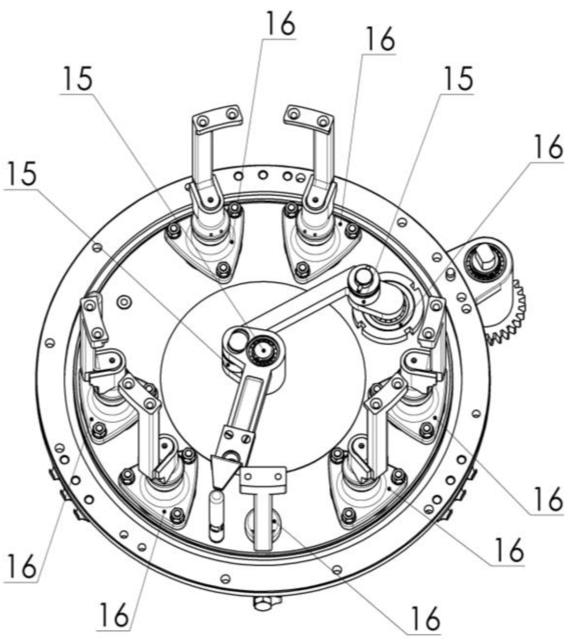


Fig. 15

5.3.1. Removing of the insulation cylinder from the bottom

- Unscrew the bolts at the bottom of the cylinder (Pos. 13, Fig. 14).
- Lift the oil compartment, while holding the insulation shaft (Pos. 14).

5.3.2. Viewing of the bottom

Check the clearances of the movable connections (Pos. 15, Fig. 15). If he clearance is above 0.5 mm, it is necessary to replace the friction parts with new ones.

- If there are any leakages, it is necessary to repalce the gaskets and the shaft seals that ensure oil-proof tightness of the parts (Pos. 16, Fig. 15).
- After the viewing of the bottom is completed, it should be washed with pure transformer oil in order to remove metal chips and any other impurities.

5.3.3. The installation of the cylinder is performed in a reverse sequence. The gasket at the bottom should be replaced with a new one. Make sure that the cylinder is oriented in the right direction, so that the driving shaft (Pos.14, Fig. 14) comes to stand in a perpendicular position vis-à-vis……. The bolts (Pos. 13) should be tightened with a torque of 25 Nm.

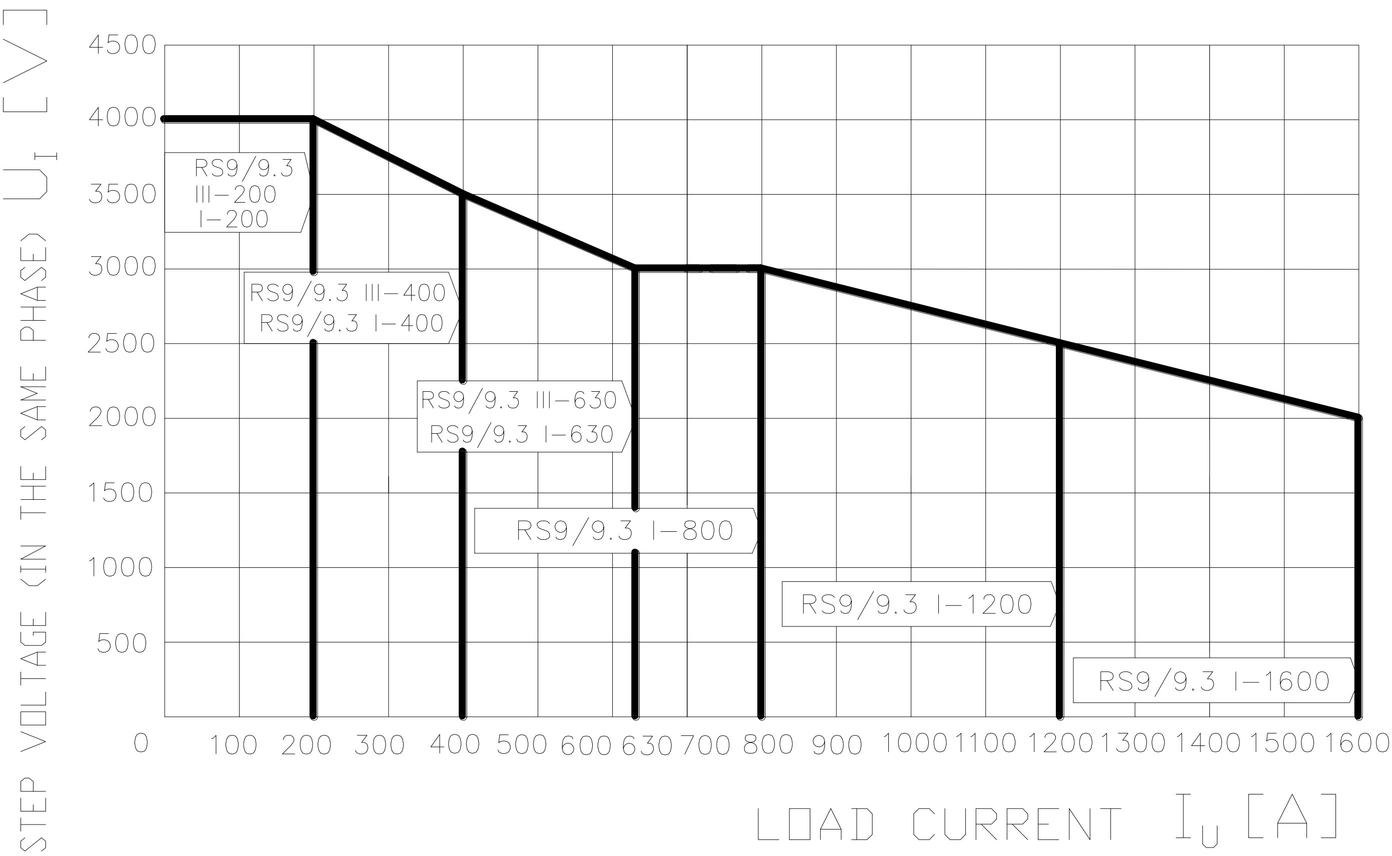
<u>CAUTION!</u>

- Detailed information about the type, location and the number of the given spare part can be found in the RS 9 /RS 9.3 Parts Catalog.

- After completing the activities related to the inspection and repair of the diverter switch, the tap selector, and the oil compartment, the tap changer should be reinstalled according to the instructions in the RS 9 /RS 9.3 Installation and Operation Manual.

The technical and design characteristics described here apply to the product at the time of publication and may change without notice.

APPENDIX: RS9/9.3-01
BREAKING CAPACITY OF RS9/9.3 DIVERTER SWITCH

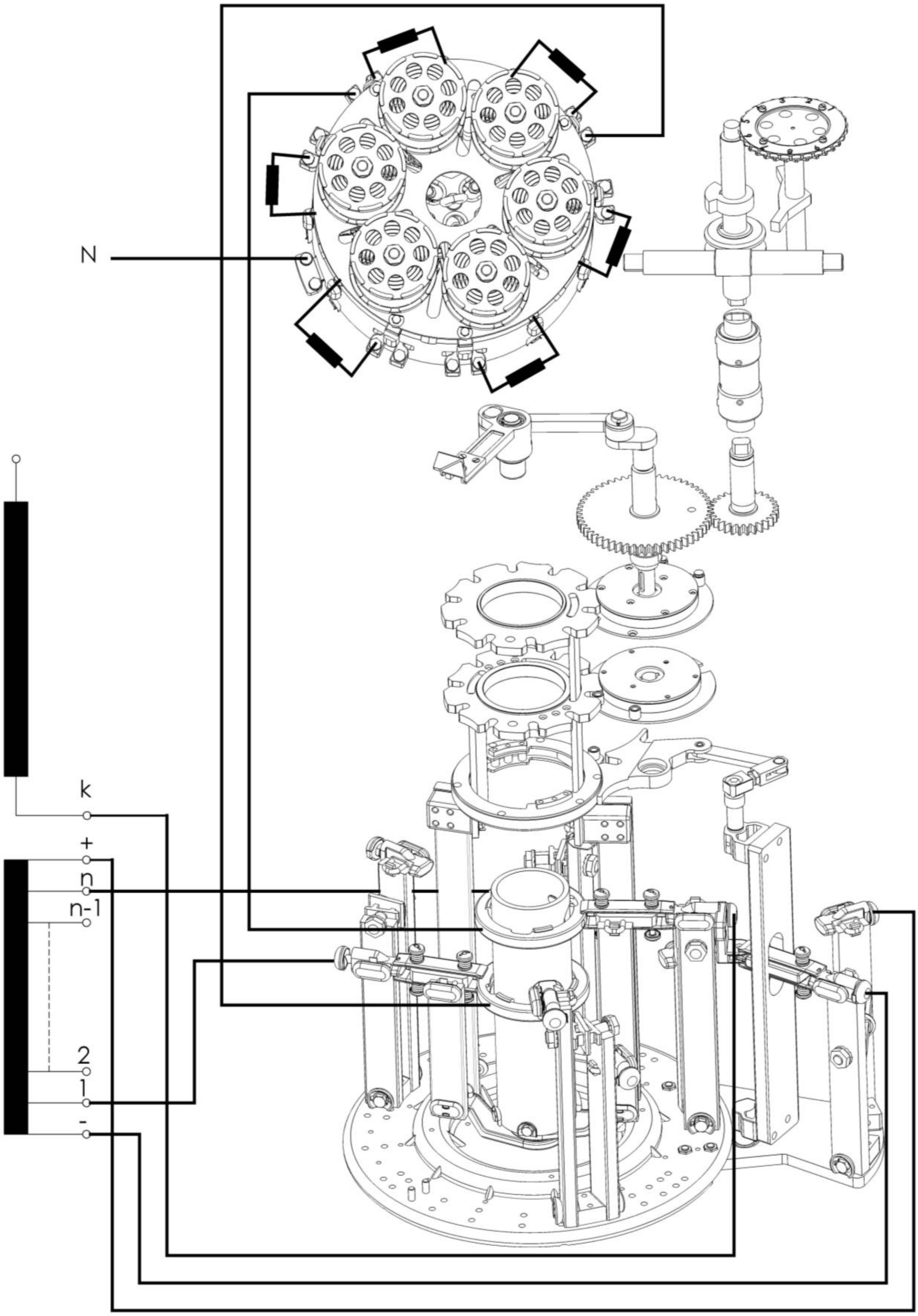


MAXIMUM RATED THROUGH CURRENT: I_{Um} =200,400,630 A;

STEP VOLTAGE U_i DETERMINED FROM DIAGRAM FOR THE RELEVANT CURRENT I_U ;

SWITCHING CAPACITY $P_{stN} = U_i . I_{Um}$ kVA;

BREAKING CAPACITY $P_{stmax} = U_i . 2I_{Um}$ kVA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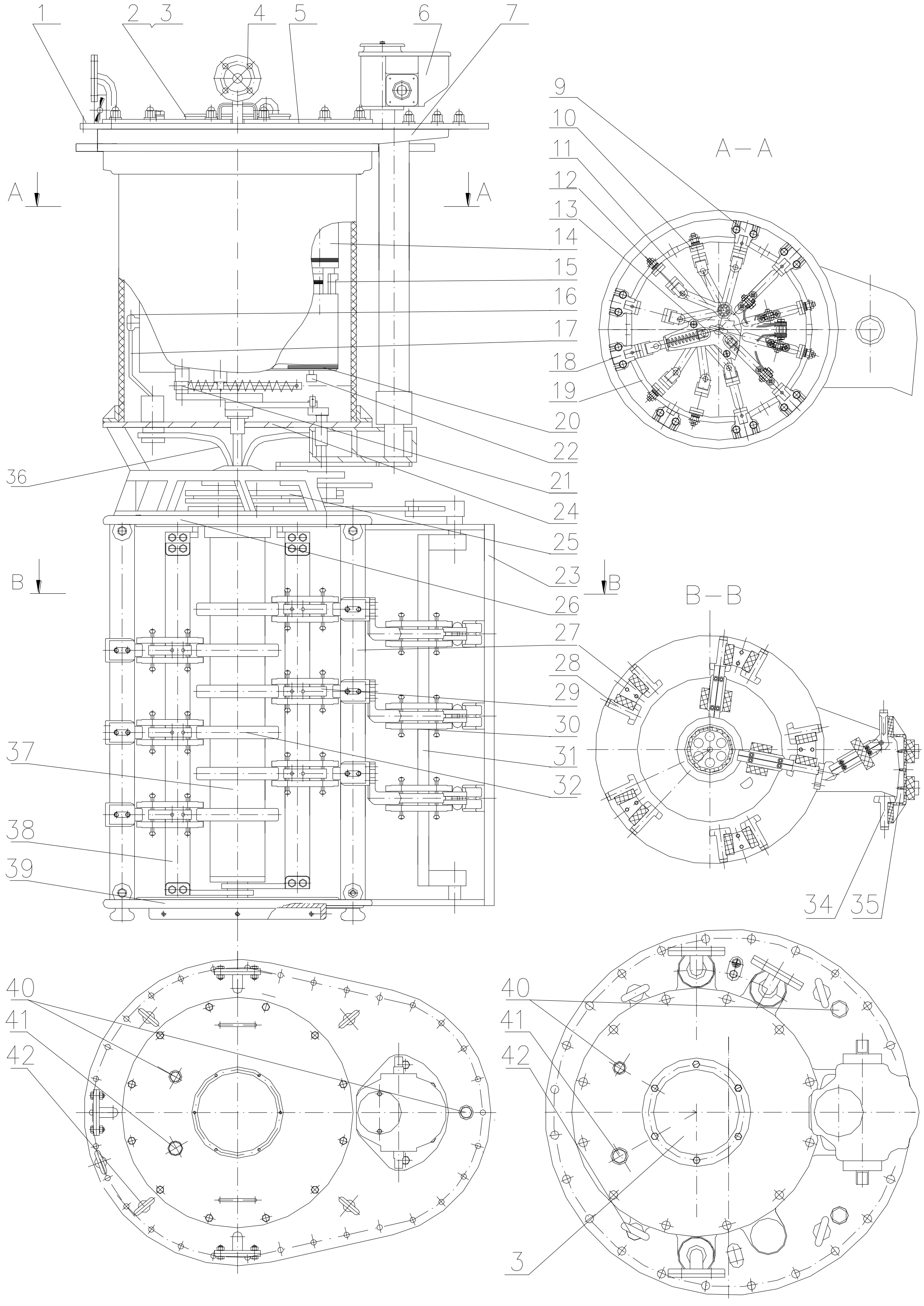
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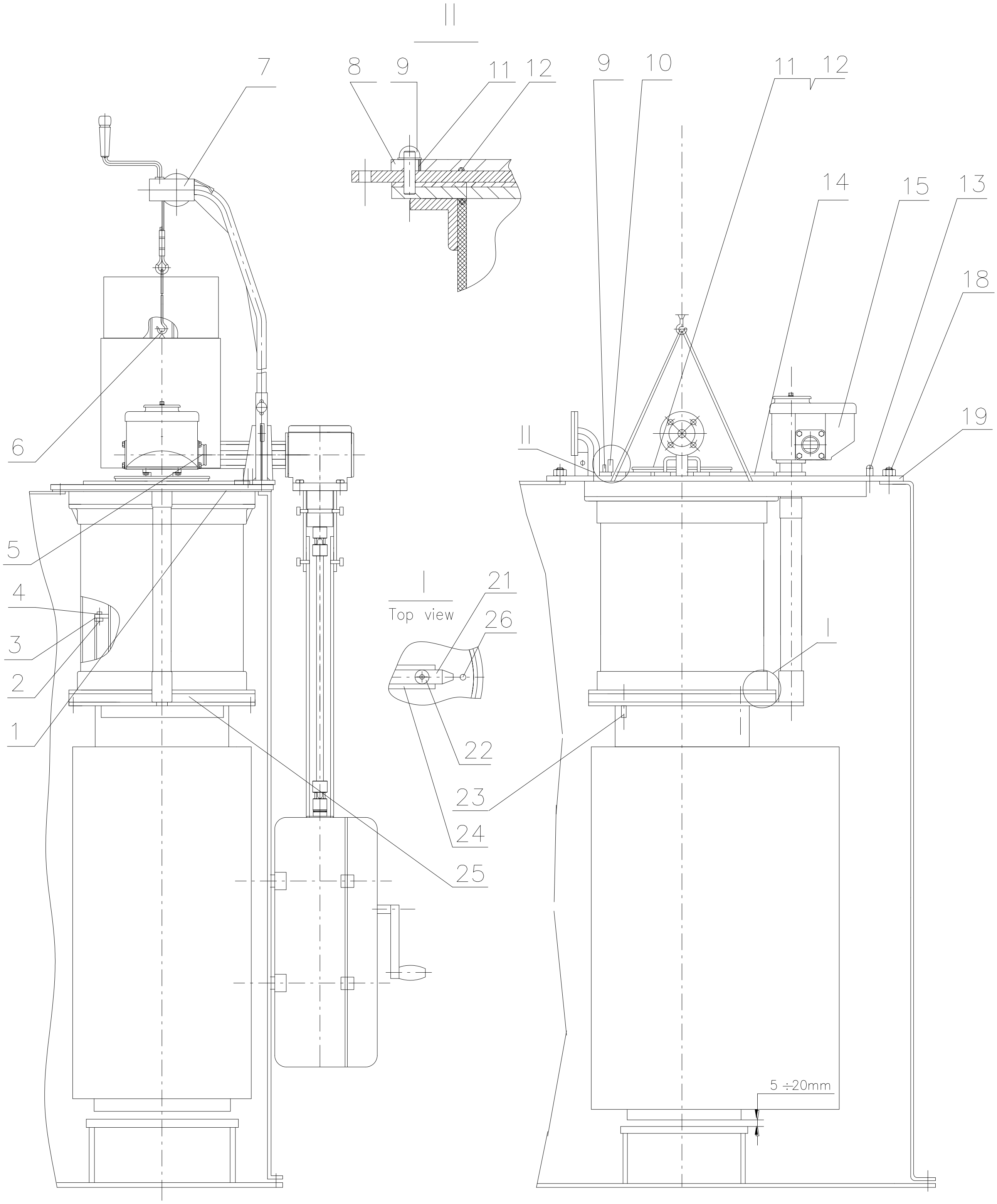
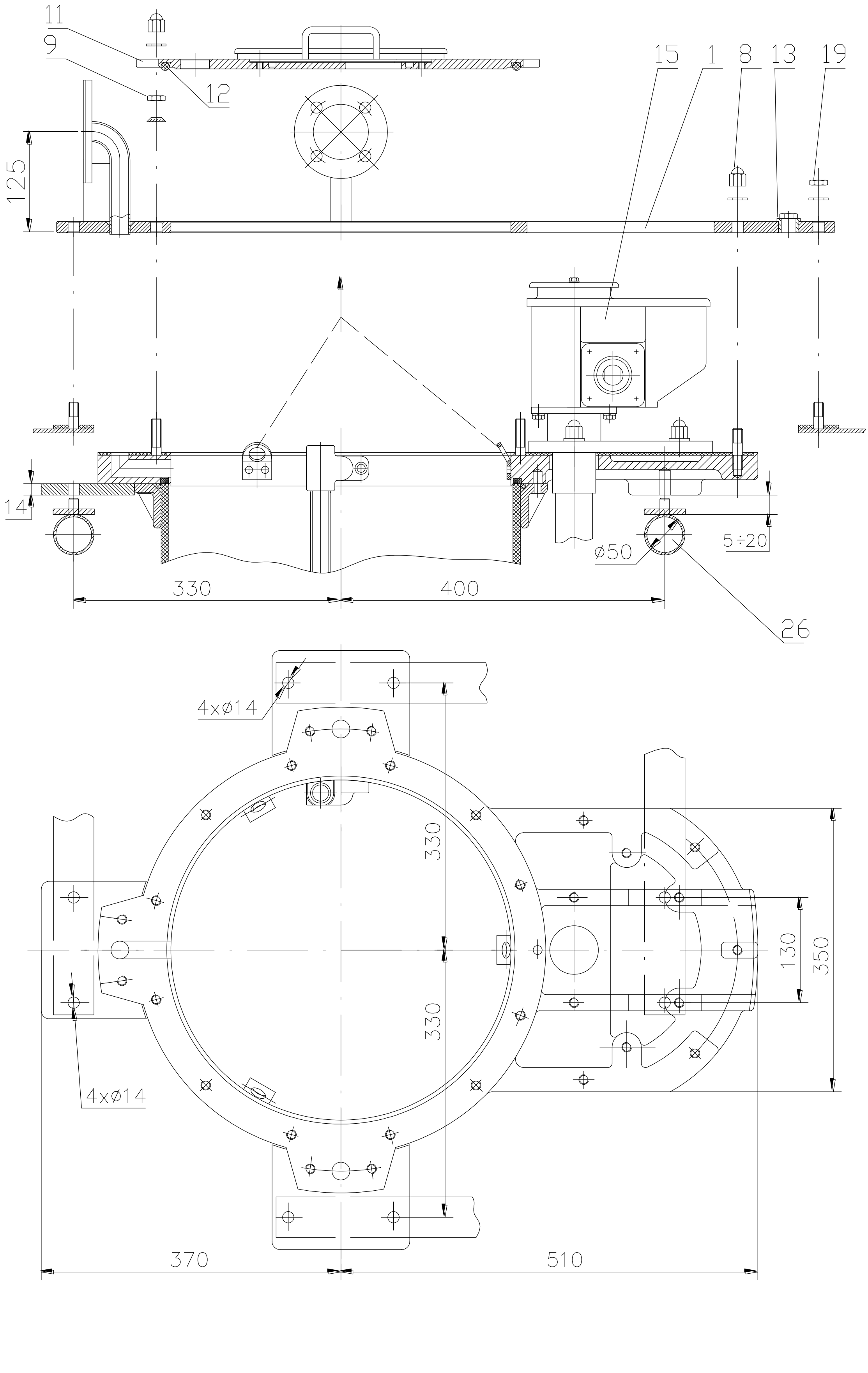
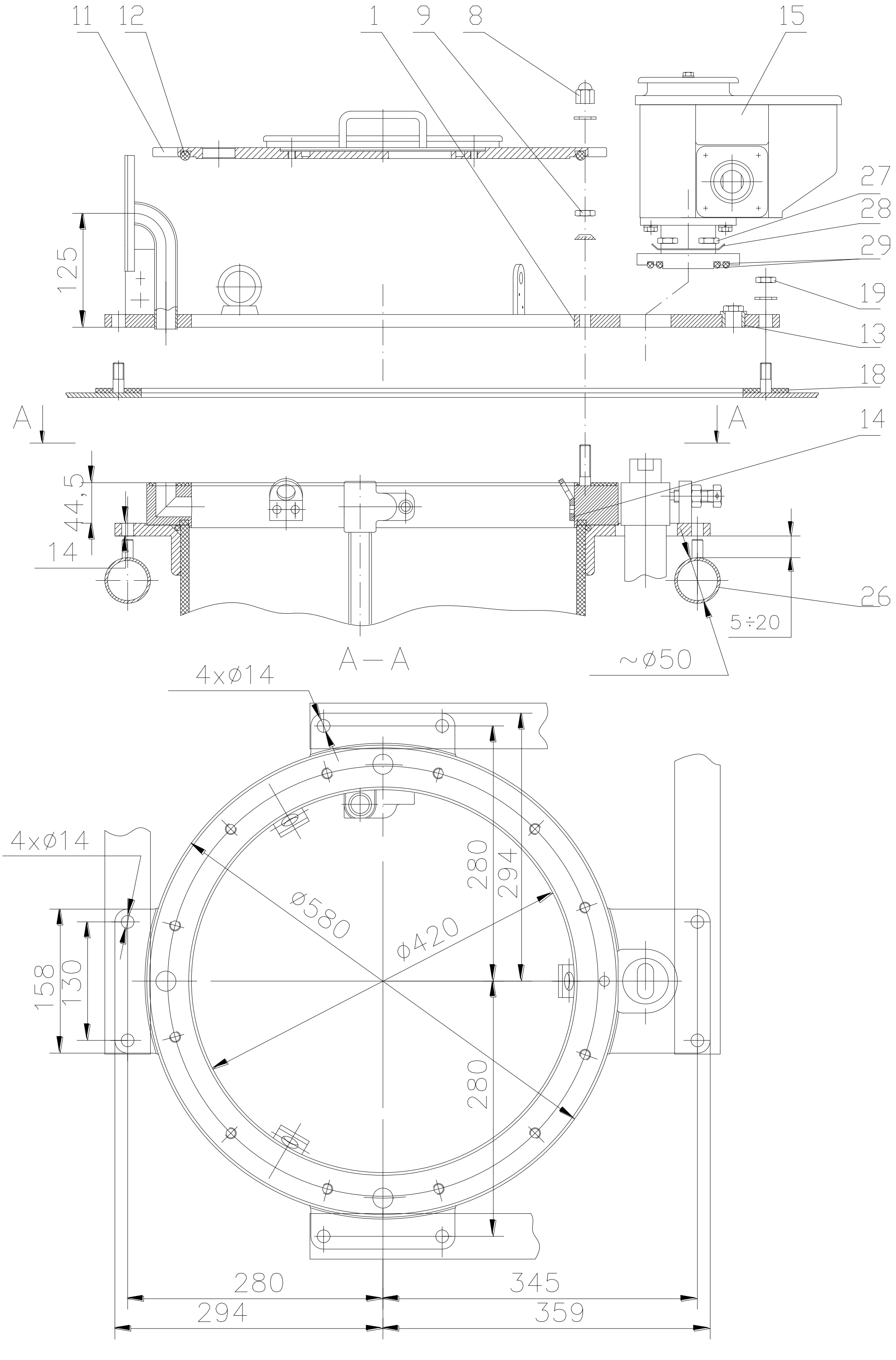
A– A
B– B
RS 9
RS 9.3

APPENDIX: RS9/9.3-07
MOUNTING OF OLTC RS9/9.3
IN TRANSFORMER




11
9
12
125
15
1
8
13
19
14
5÷20
ø50
330
400
26
4xø14
330
330
130
350
4xø14
370
510


11
12
1
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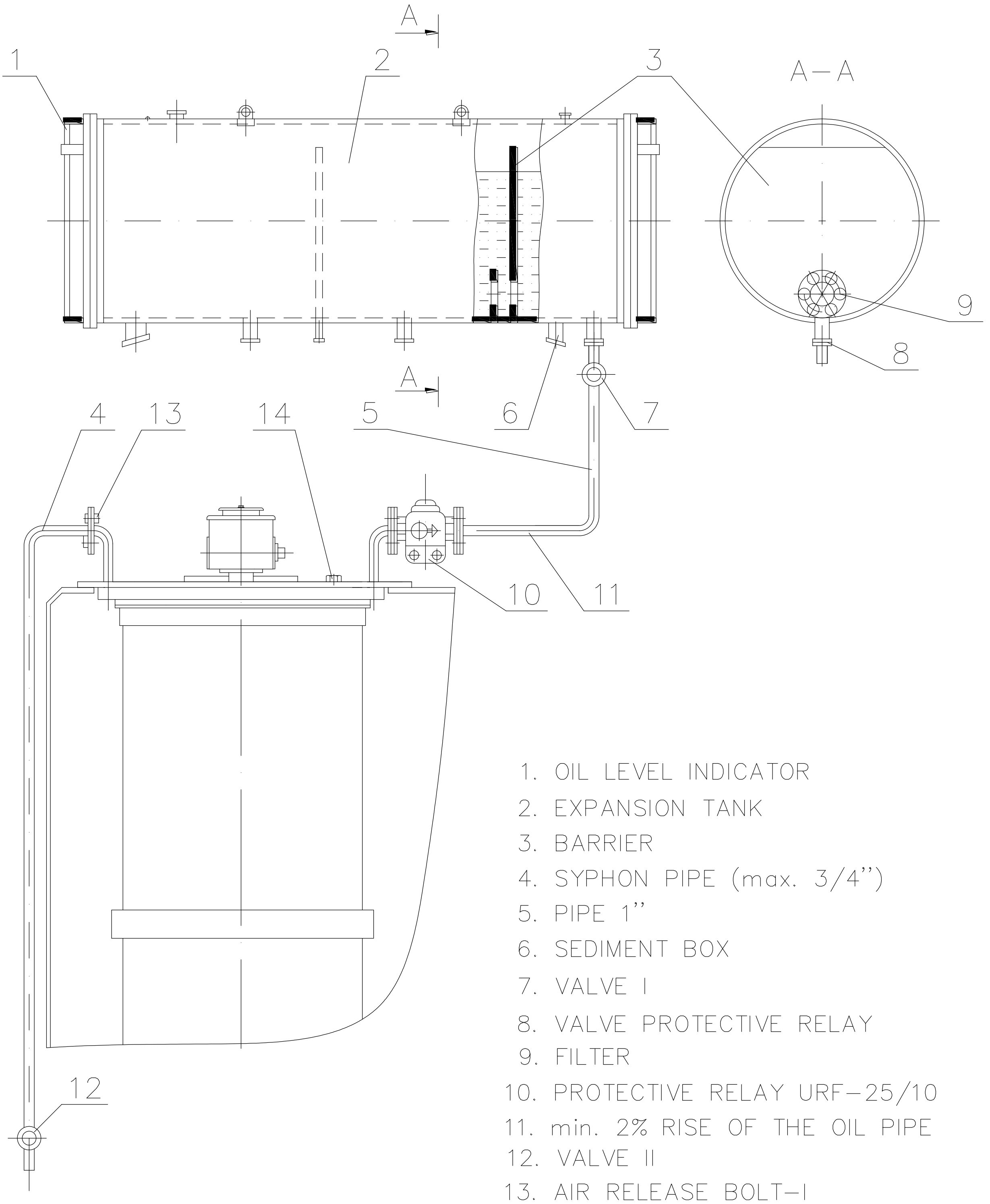
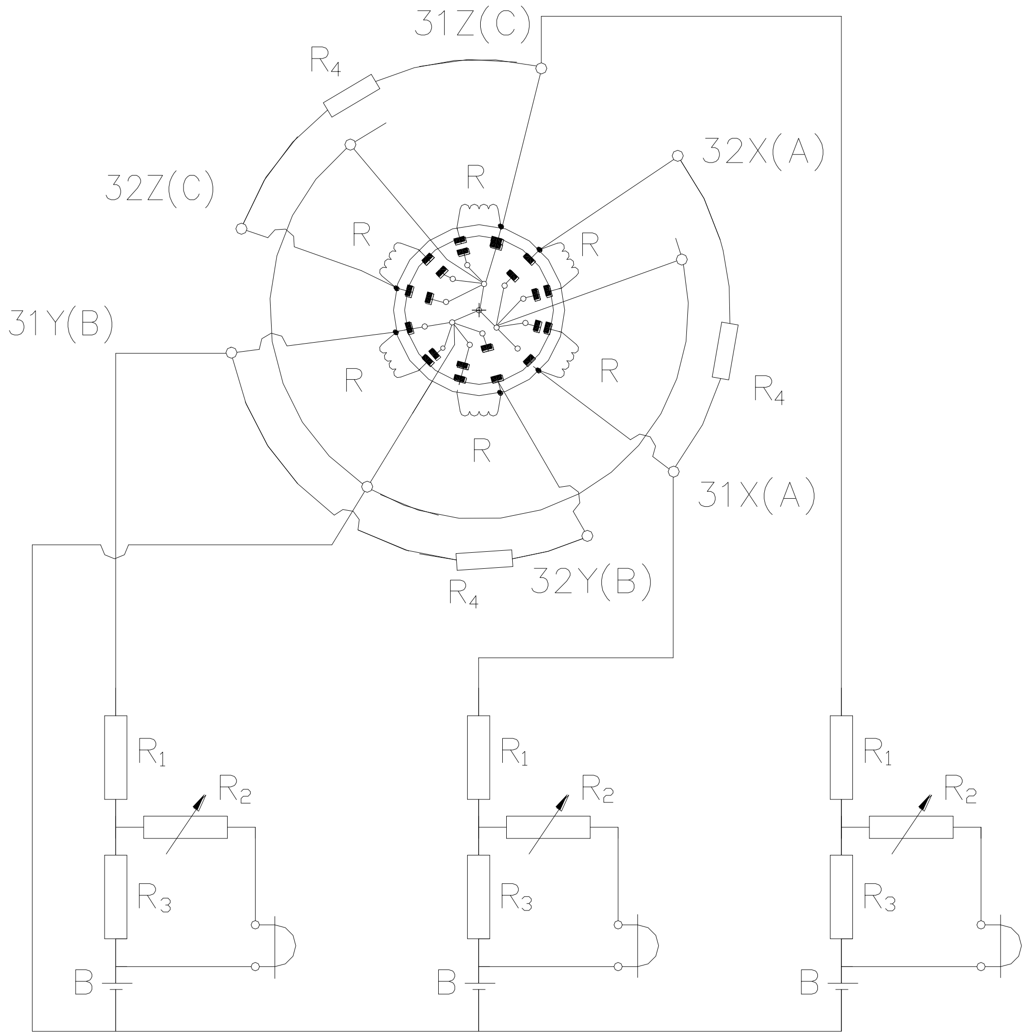
27
28
29
19
13
18
14
26
125
A
A
44,5
14
5÷20
A–A
~ø50
4xø14
4xø14
ø580
ø420
280
294
280
158
130
280
345
294
359

APPENDIX: RS9.3-09
DIAGRAM FOR MAKING AN OSCILLOGRAM OF THE DIVERTER SWITCH



1. OIL LEVEL INDICATOR
2. EXPANSION TANK
3. BARRIER
4. SYPHON PIPE (max. 3/4'')
5. PIPE 1''
6. SEDIMENT BOX
7. VALVE I
8. VALVE PROTECTIVE RELAY
9. FILTER
10. PROTECTIVE RELAY URF–25/10
11. min. 2% RISE OF THE OIL PIPE
12. VALVE II
13. AIR RELEASE BOLT–I
14. AIR RELEASE BOLT–II

APPENDIX: RS9.3-09
DIAGRAM FOR MAKING AN OSCILLOGRAM OF THE DIVERTER SWITCH

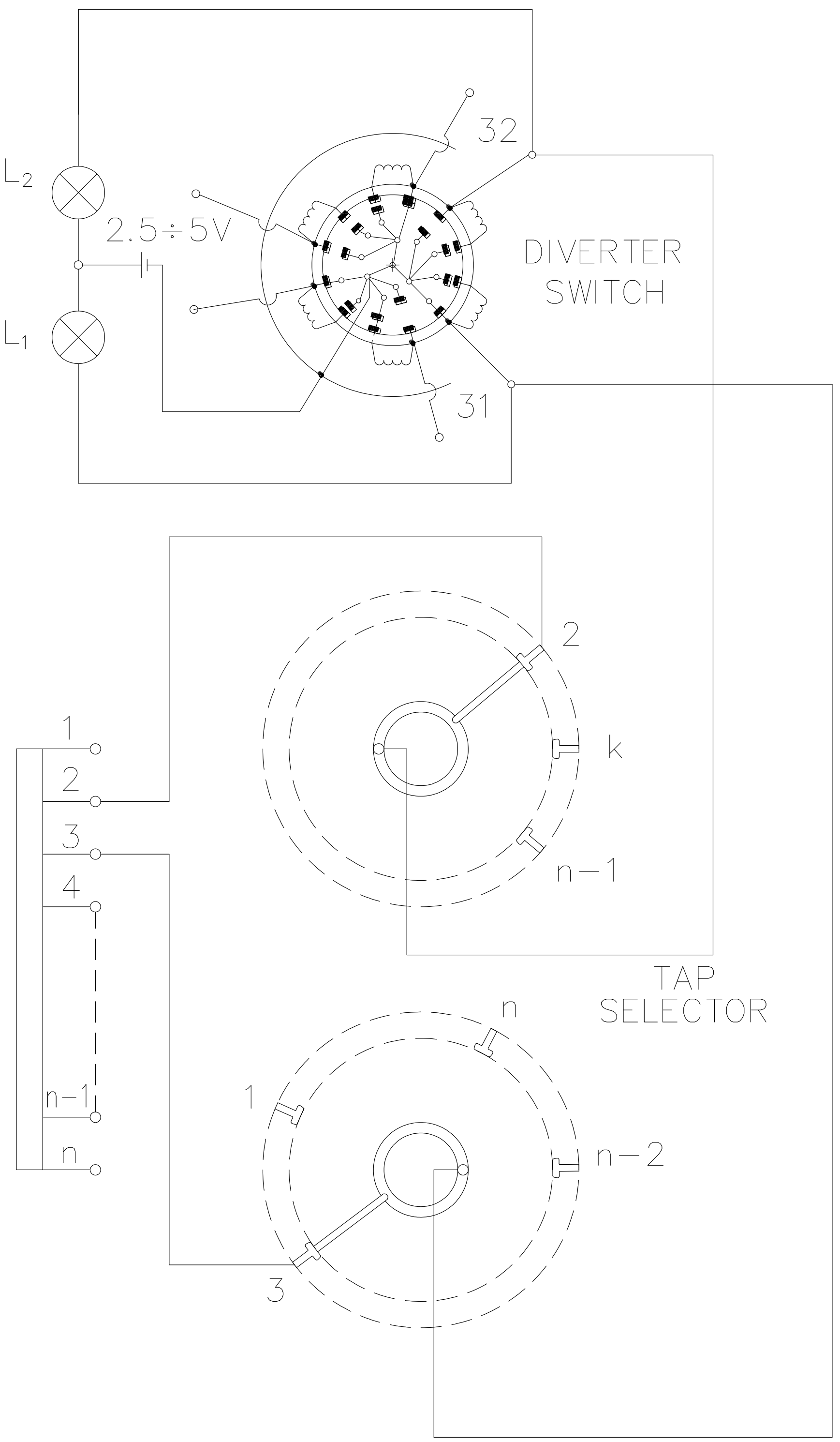


R – DIVERTER SWITCH TRANSITION RESISTORS

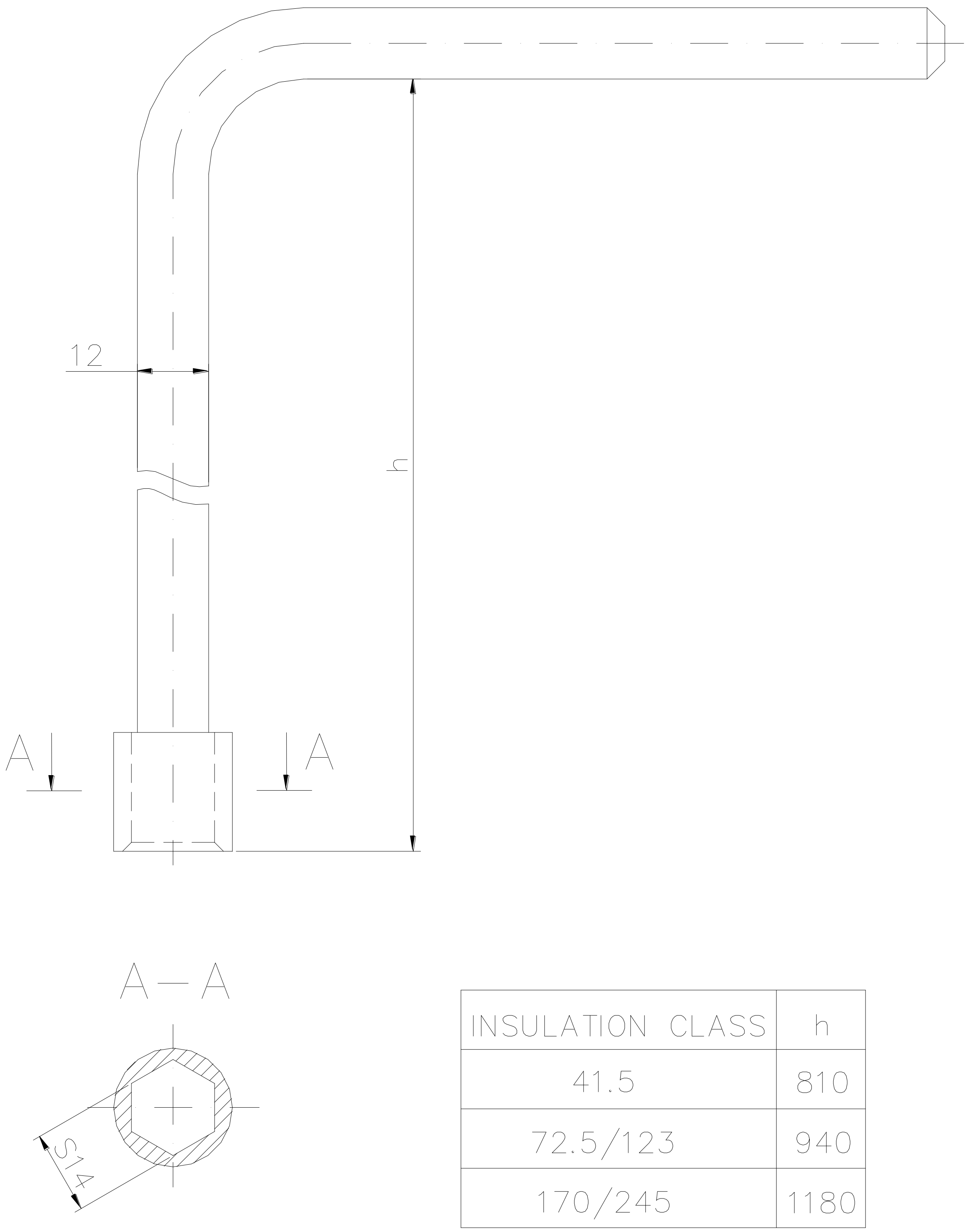
$R_1 \div R_4$ – EXTERNAL RESISTORS, SHALL BE CHOSEN IN CONFORMITY WITH THE OSCILLOGRAPH WHICH IS USED

B – BATTERY 20 V

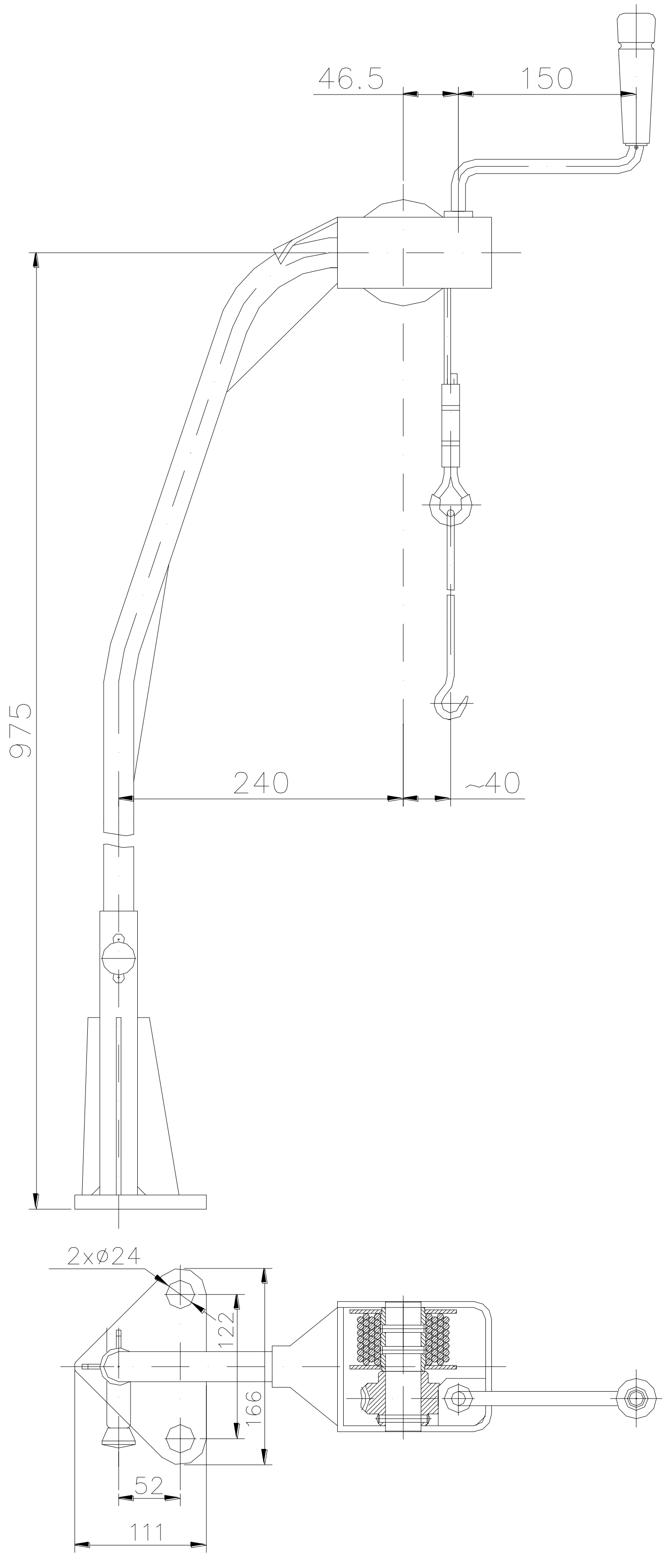
NOTE : THE CURRENT IN THE DIVERTER SWITCH CIRCUIT WITH CONTACTS 31X, 31Y, AND 31Z CLOSED SHALL BE AT LEAST 2A.


32
L2
2.5÷5V
DIVERTER
SWITCH
L1
31
2
1
2
k
3
4
n−1
TAP
SELECTOR
n
1
n−1
n
n−2
3

SPECIAL WRENCH S 14



INSULATION CLASS	h
41.5	810
72.5/123	940
170/245	1180


46.5
150
975
240
~40
2xø24
122
166
52
111

HYUNDAI
HEAVY INDUSTRIES CO. BULGARIA

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