



SHZV Vacuum On-Load Tap Changer Operation Instructions

HM 0.460.1902



Shanghai Huaming Power Equipment Co.,Ltd.

Attentions

1. Please read this instruction before using our products.
2. SHZV on-load tap changer maintenance should be carried out by trained professional engineers.
3. Huaming reserved rights for technical data and operation instructions we provided due to upgrade of our products.
4. Any technical data beyond the products and applications in this instruction, please communicate with Huaming to make special design solutions for you.

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1 General

Until now, the oil-immersed on-load tap changer (hereinafter referred to as OLTC), being widely used in worldwide substation, inside which the oil is an insulation medium for OLTC themselves and for extinguishing arc occurred on the main switching contacts and transition contacts, as well as a medium for lubrication of mechanical parts and for cooling of contacts and all other current-carrying parts. Therefore, this type OLTC is also called the OLTC of arc-extinguishing inside the oil. The carbonization of oil for this type of OLTC is inevitable during the operating of tap changer. With the switching times increasing, inside the OLTC oil chamber there will be more and more carbonizations. Therefore, except from neutral point connection, in application for other winding connections of transformer, or power transformer with voltage of 220kV or above, the auxiliary device like online oil filter plant has to be assembled with the oil-immersed OLTC in order to guarantee the insulation level of oil and to decrease the carbon granule. When this kind of OLTC is used in the rectification and furnace transformer, it operates very frequently under the full-load or even over-load, which quickens the wearing-out of arcing contacts, the carbonization of oil and also the wearing-out of mechanical parts. As a result, such works as continual changing of new oil and replacement of arcing contacts, frequent inspection and maintenance have to be done to make the OLTC reliable, even replacing the new OLTC within the service life of transformer, the cost for maintaining its normal operation is quite expensive.

How to improve the performance of OLTC in terms of design and to make the transformer oil only as a medium for insulation and to preserve the good insulation level and lubricating property of oil during long operation, in whatever occasion the OLTC is used, the least inspection and maintenance can reach the long-term reliability and lowest cost for operation. For this purpose, Huaming Company, with more than ten years of focusing on it, has launched a new model of tap changer characterized by oil-immersed and arc-extinguishing inside vacuum interrupter –that is type SHZV OLTC.



Fig.1 Outline view of SHZV OLTC

The type of oil-immersed and vacuum arc-extinguishing OLTC-SHZV, with arc contacts replaced by vacuum interrupter, has very prominent advantages:

1. The current breaking in the vacuum interrupter, and the arc produced also extinguishing in the vacuum interrupter, which solved the problem of oil carbonization. Therefore there is no need to equip with online filter plant under any application condition.
2. Since the carbonization of oil in the oil compartment is eliminated, the carbon granule adhered to the surface of insulation material does not exist any longer, the insulation level is guaranteed.
3. The task of carrying current for long time is undertaken by special mechanical main contacts while the vacuum interrupter only taking the current instantly through, so the overload capacity of OLTC has been improved greatly.
4. All the vacuum interrupters are fixed firmly and mal-operation will not happen.

The highest voltage of the OLTC is 252kV, three-phase OLTC is application for neutral point winding connection of transformer with voltage up to 550kV, and single-phase OLTC can be used for any selectable winding connection, the max. rated through current of tap changer is 1000 Amp. in three-phase and 2400 Amp. in single-phase.

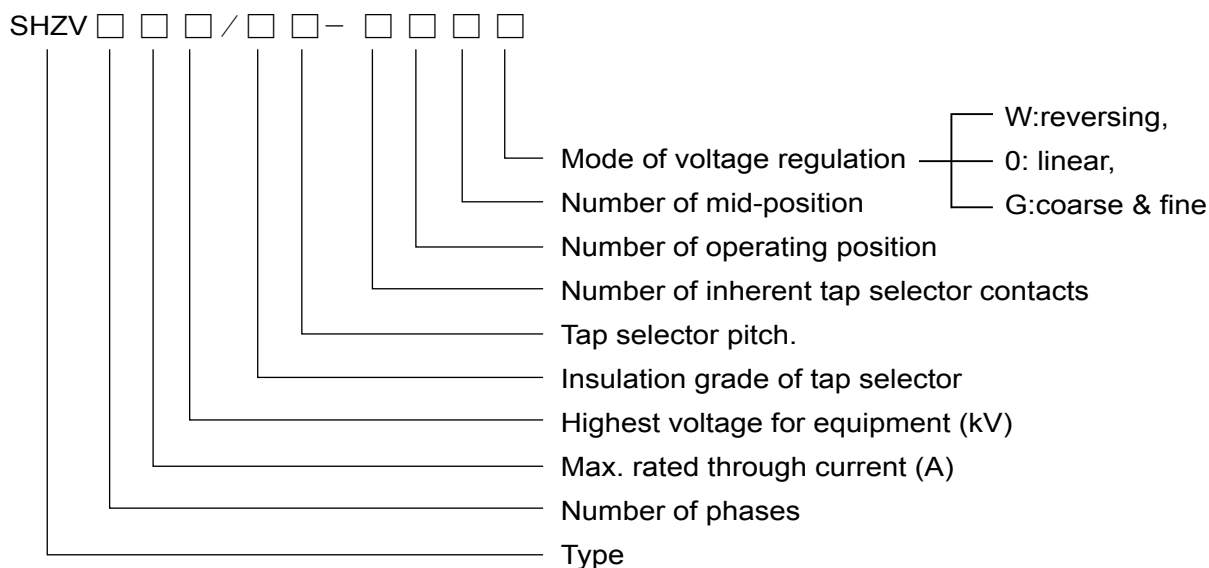
SHZV structure is the combined type and is composed of diverter switch and tap selector.

SHZV is installed on the top cover of transformer by its head flange, and connected to SHM-III motor drive unit through the upper gear box on the cover of OLTC, bevel gear (auxiliary devices) and driving shaft (horizontal & vertical), realizing the switching operation of OLTC by motor or remote control.

This operation instruction includes all the necessary information for the installation and operation of SHZV OLTC. The structure is subject to change without notice.



1.1 Designation of the tap changer model number



1.1.1. Designation of regulation steps

- Linear regulation: Take 10090 as example, it denotes that contact quantity is 10, and the number of operation position is 9.
- Reversing regulation: Take 10193W as example, it denotes that contact quantity is 10, the number of operation position is 19, and the number of mid-position is 3.
- Coarse & fine regulation: Take 10191G as example, it denotes that contact quantity is 10, the number of operation position is 19, and the number of mid-position is 1.

1.1.2 Insulation grade of tap selector

The insulation for the tap selector can be classified into 4 different grades, namely B, C, D, DE. Table 1 shows the data of the internal insulation level. The basic connection diagram and the symbol for insulation distance is show in Fig. 2.

1.1.3 The operating condition of OLTC

- The storage ambient temperature of OLTC is from -25°C to 40°C . The storage humidity of the OLTC should be no more than 85 percent.

The service temperature of standard designed OLTC is -25°C to 40°C .

If the temperature exceeds the range of above (-25°C to 40°C), please specify when ordering.

- To meet the ordering requirements and comply with the operating environment, if the requested service temperature is out of the range of -25°C to 40°C , the material and accessories of the OLTC will be specially designed and selected.

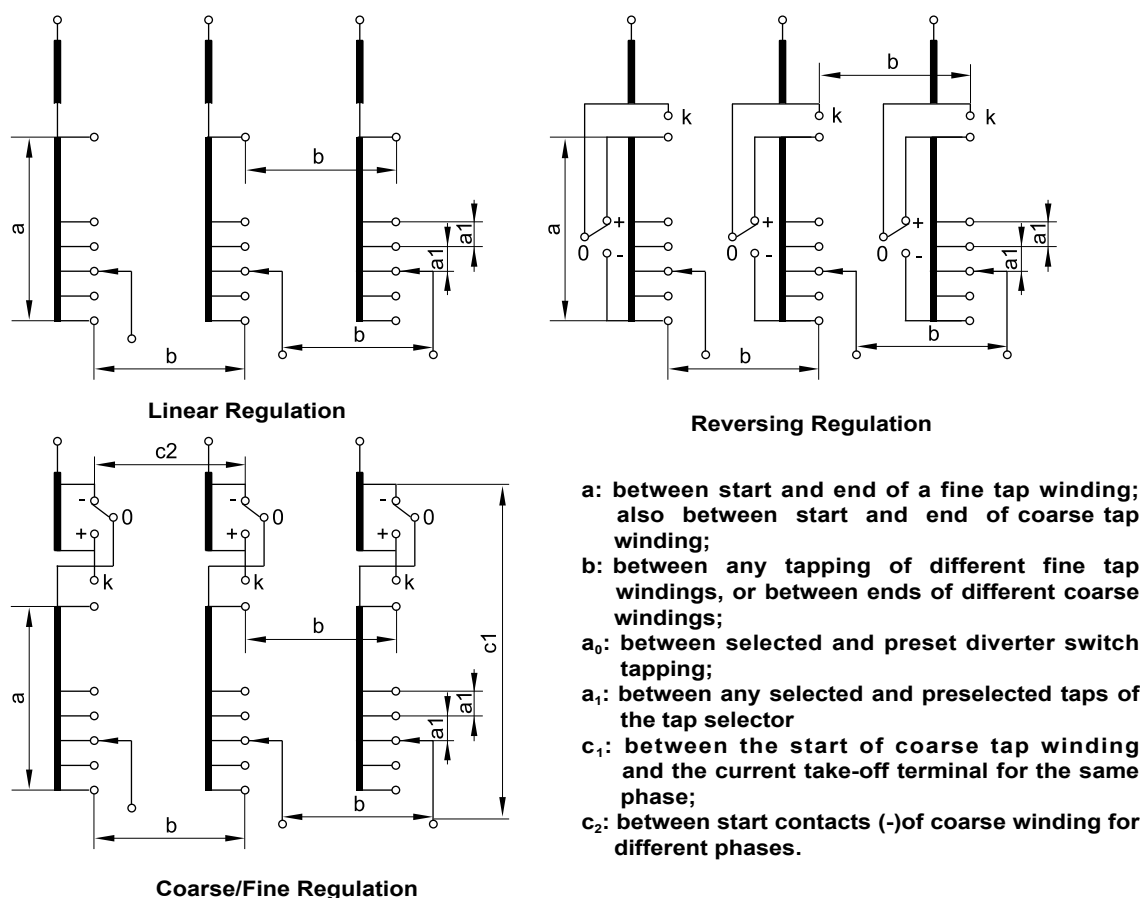
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Insulation grade of tap selector (Table 1) Unit: kV

Insulation distance mark	Tap selector size B		Tap selector size C		Tap selector size D		Tap selector size DE	
	1.2/50 μ s	50Hz 1min	1.2/50 μ s	50Hz 1min	1.2/50 μ s	50Hz 1min	1.2/50 μ s	50Hz 1min
a	265	50	350	82	490	105	550	120
b	265	50	350	82	490	146	550	160
a ₀	90	20	90	20	90	20	90	20
a ₁	150	30	150	30	150	30	150	30
c ₁	500	145	550	180	590	225	660	230
c ₂	500	145	550	195	590	225	660	250

Note: when a₀ (internal insulation distance) represents spark gap, its insulation is :50Hz,1 min:20kV; 1.2/50 μ s:90~130kV, and respond 100% against 130kV.



Spark Protection Gap (I≤600A) Zinc Oxide Varistor (I≥800A)

Fig.2 Basic Connection Diagram & Definition of Insulation Distance Marks

- The vertical inclination level of the OLTC on the transformer towards ground level should not exceed 2%.
- The installation site should be free from serious dust and other explosive and corrosive gases.

1.1.4 Technical Data of Type SHZV (cylinder tap selector) On-Load Tap Changer (Table 2-1)

Item	Description		SHZVIII			SHZVI				
1	Max. rated through current (A)		400	600	1000	400	600	1000	1600	2400
2	Rated frequency (Hz)		50 or 60							
3	Connection		3-phase Y-connection for neutral point only			Single-phase for any selectable winding connection				
4	Max. rated step voltage (V)		4000							
5	Rated step capacity		1500	1600	3000	1500	1600	3000	4400	5600
6	Short-circuit current test (kA)	Thermal (3s)	6	8	12	6	8	12	24	24
		Dynamic (peak)	15	20	30	15	20	30	60	60
7	Max. operating positions		14 without change-over selector; 27 with change-over selector							
8		The highest voltage for equipment (kV)	72.5		126		170		252	
		Rated separate source AC withstand voltage(kV/50Hz,1min)	140		230		350		460	
		Rated lightning impulse withstand voltage (kV,1.2/50μs)	350		550		750		1050	
9	Tap selector		Categorized into B, C, D, DE four sizes							
10	Mechanical life		Not less than 1,500,000 operations							
11	Electrical life		Not less than 600,000 operations							
12	Oil compartment of diverter switch	Service pressure	0.03 MPa							
		Leakage test	No leakage under 0.08 MPa for 24 hours							
		Over pressure protection	Rupture disc bursts at 300 ± 20% KPa							
		Protective relay	Set oil flow speed at 1.0m/s ± 10%							
13	Motor drive unit		SHM-III or CMA7							

Note: SHZV with cylinder tap selector is applicable for the contact pitches of 10, 12 and 14 in linear, reversing and coarse and fine regulating.

SHZV VACUUM ON-LOAD TAP CHANGER OPERATION INSTRUCTIONS

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Technical Data of Type SHZV (cage tap selector) On-Load Tap Changer (Table 2-2)

Item	Specification		SHZVIII	SHZVI		
1	Max. Rated Through Current (A)		600	600	1200	1500
2	Rated Frequency (Hz)		50 or 60			
3	Number of phases and application		3-phase, neutral point	1-phase, at any position on the winding		
4	Max. rated step voltage (V)		4000			
5	Rated step capacity (kVA)		1600	1600	3000	4000
6	Short Circuit Current Test(kA)	Thermal (3s)	8	8	24	24
		Dynamic (Peak)	20	20	60	60
7	Max. number of Operating Positions		with change-over selector: 35 without change-over selector: 18			
8	Insulation to ground	Highest Voltage of Equipment (kV)	72.5	126	170	252
		Power Frequency withstand voltage (50 Hz 1min)	140	230	325	460
		BIL kV(1.2/50μs)	325	550	750	1050
9	Tap Selector		4 grades of B, C, D, DE according to insulation level			
10	Mechanical life		Not less than 1,500,000 operations			
11	Electrical life		Not less than 600,000 operations			
12	Oil Compartment of diverter Switch	Operating pressure	0.03Mpa			
		Sealing property	No leakage under 0.08Mpa for 24 hours			
		Over Pressure Protection	Bursting cap bursts at 300±20% kPa			
		Protection Relay	Setting at oil flow speed of 1.0m/s±10%			
13	Equipped with Motor Drive Unit		SHM-III or CMA7			

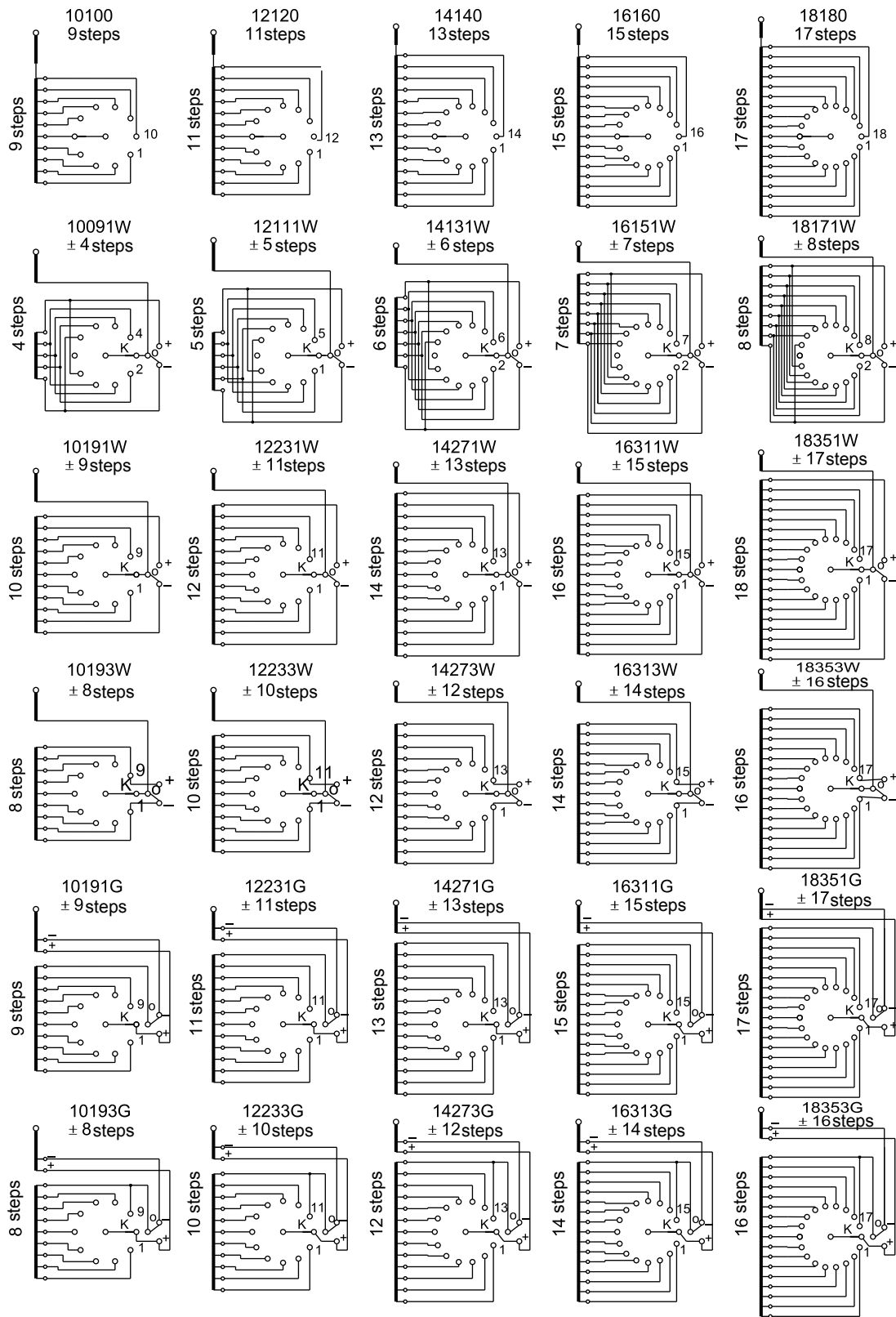


Fig.3 Basic Circuit Diagram

1.1.5 Mode of Voltage Regulation

There are 3 modes of voltage regulation for SHZV OLTC, i.e. linear regulation, reversing regulation, coarse and fine regulation. For the connection mode please see Fig. 4.

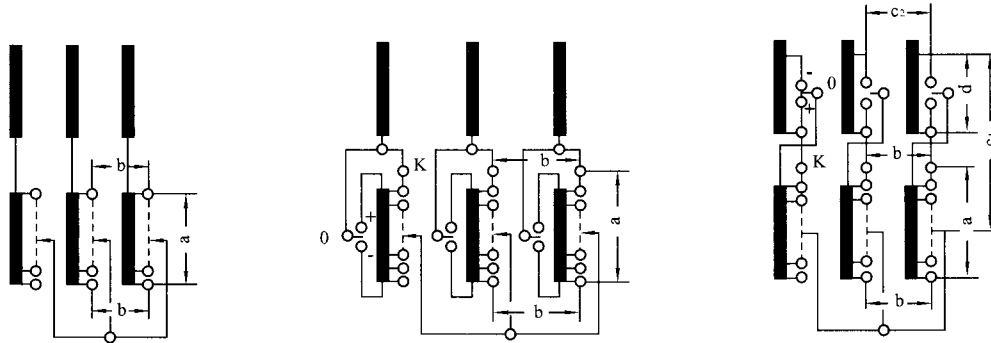


Fig. 4 Mode of Voltage Regulation

1.1.6 Under 1.2 times of max. rated through current, the temperature rise of long-term current-carrying contacts and conductive parts shall not exceed 20K against oil.

1.1.7 Under 1.5 times of the max. rated through current and the corresponding rated step voltage, when OLTC transfer continuously for half cycle, the maximum temperature rise of the transition resistor shall not exceed 350K against oil.

2. Construction of type SHZV OLTC (cylinder tap selector)

2.1 Type SHZV tap changer is a combined type OLTC, it is comprised of diverter switch and tap selector.

When starting motor drive unit, the retarding mechanism on the head part of tap changer drives the spring accumulation mechanism of diverter switch store to energy and tap selector operation via the insulation shaft outside the cylinder (please see Fig.1).

2.2 SHZV with cylinder tap selector is applicable for the contact pitches of 10 and 14, in linear, reversing, coarse and fine regulating.

2.3 Oil compartment of diverter switch (please see Fig.5)

The oil compartment of diverter switch separates the oil in the oil compartment from the oil in the transformer tank, so as to keep the oil in the transformer clean. It is composed of four parts: head flange, top cover,



- ① Top Cover
- ② Head flange
- ③ Insulation cylinder
- ④ Tank bottom

Fig.5 Oil compartment

insulating cylinder and tank bottom.

2.3.1 Head flange (Please see Fig 5-1)

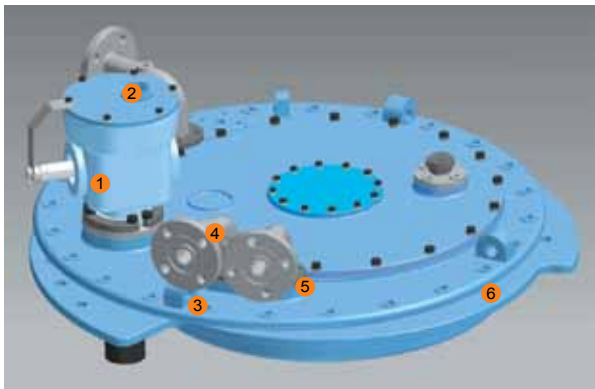
Head Flange has two layers, that is mounting flange and supporting flange, both of them are made of casting aluminum alloy. Supporting flange is connected with the insulation cylinder via rivets, and the tap changer is installed onto the transformer tank cover via the mounting flange.

There are three bending pipes on the supporting flange. The pipe R is connected to the oil conservator via protective relay. Oil suction pipe S is used to suck the oil from the bottom of the oil compartment during changing or filtering oil of diverter switch through connecting between head flange of tap changer and an insulation oil pipe. The pipe Q acts as oil filling for the diverter switch. Another pipe E2 acts as the vent pipe for transformer oil overflow. All the pipe connections can be turned to suitable angle according to the installation requirement, which should be fixed tightly by the clamp plates after the adjustment.

There is also one tap position indication mechanism on the mounting flange.

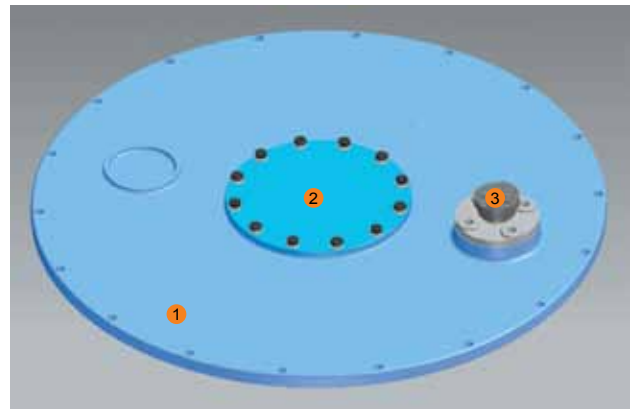
2.3.2 Top cover (Please see Fig. 5-2)

A bursting cap is installed on the top cover of tap changer to prevent the oil compartment from overpressure bursting; the oil overflow vent screw is also installed on the top cover.



- | | |
|-------------------|-----------------------|
| ① Bevel gear box | ② Position indicating |
| ③ Mounting flange | ④ Bending pipes |
| ⑤ Clamp plate | ⑥ Supporting flange |

Fig.5-1 Head flange



- | | |
|---------------------------|----------------|
| ① Top cover | ② Bursting cap |
| ③ Oil overflow vent screw | |

Fig.5-2 Top cover

2.3.3 Tank bottom (Please see Fig.6)

Tank bottom is made of casting aluminum alloy with good sealing performance and free from leakage. All the driving gears are installed on it, which is easy for installation and maintenance.

The coupling part of tank bottom adopts the multi-groove coupling structure, so as to avoid wrong coupling. There are oil-drain bolts on the tank bottom, also equipped with special wrench for users to drain the oil or condensation remainder after vapor-phase drying.

2.4 Diverter switch insert (Please see Fig. 7)

It adopts the whole sectorial contact shell connection, and complete insert type structure, which is convenient for maintenance and installation.

2.5 Tap selector (Please see Fig. 8)

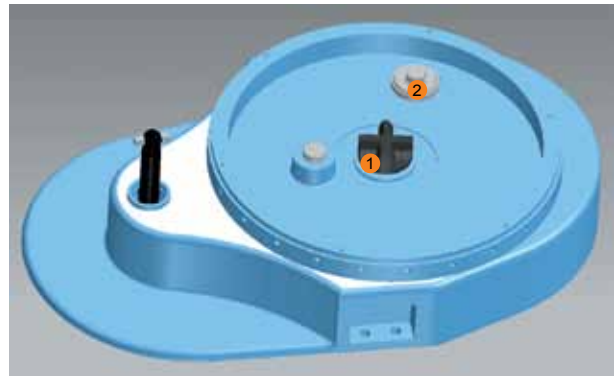
Tap Selector is composed of step-by-step drive mechanism and contact system. Tap selector can be installed with or without change-over selector.

2.5.1 Geneva wheel mechanism (Please see Fig.9)

This mechanism structure is arranged by the upper & lower Geneva wheels, the two Geneva wheels run alternately via the gears of tank bottom driving the dialing part, always one no-load moving contact unit being pre-selected onto the fixed contact of adjacent operation position. Mechanical limit parts are installed with the Geneva wheel mechanism in order to prevent overpass the end tap position.

2.5.2 Change-over selector

Change-over selector is classified into reversing selector and coarse selector. It is a simple and compact device. The fixed contact of change-over selector is installed on a semi-circular insulating cylinder.



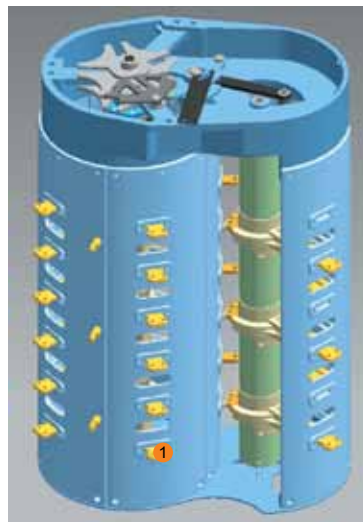
2.5.3 The contact of change-over selector (Please see Fig. 10)

① Coupling parts at the tank bottom ② Oil-drain screw

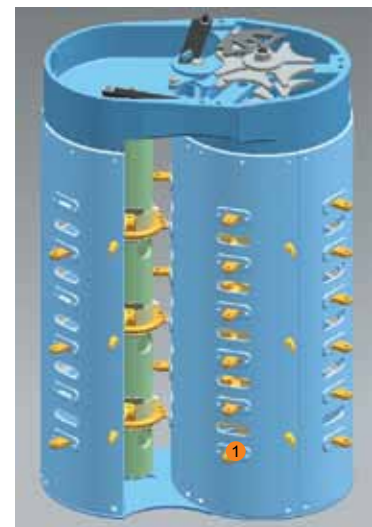
Fig.6 Tank bottom



Fig.7 Diverter switch insert



① Current $\geq 600\text{Amp}$



① current $\leq 600\text{Amp}$

Fig.8 Tap selector

The moving & fixed contact of change-over selector adopts multipoint contacting mode, it has the features of low constriction resistance, reliable current-carrying, low temperature rise and strong short-circuit proof capability.

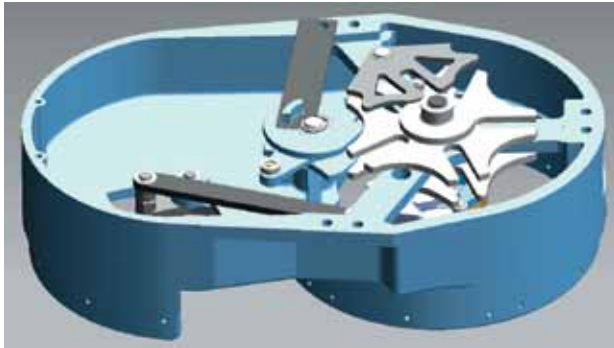


Fig.9 Geneva wheel mechanism

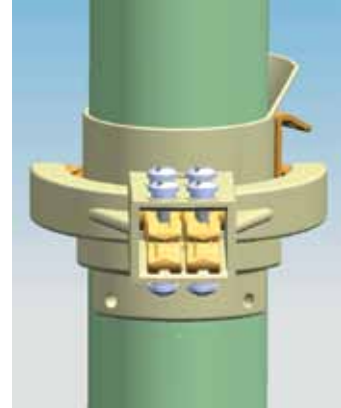


Fig.10 Contact of changer-over selector

3. Construction of type SHZV OLTC (cage tap selector)

3.1 Type SHZV with cage tap selector

Cage-shape tap selector borrows from that of CM series OLTC, therefore, it can be applied where CM series OLTC are used. Note: this shape tap selector is applicable for Max. three phase current up to 600A.

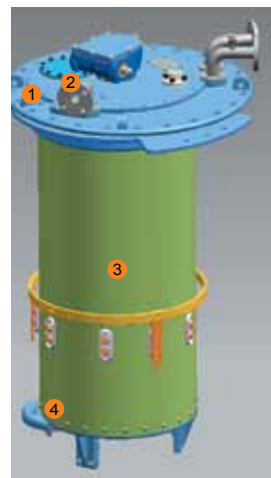
3.2 Oil compartment of diverter switch

The oil compartment of diverter switch separates the oil in the oil compartment from the oil in the transformer tank, so as to keep the oil in the transformer clean. It is composed of four parts: head flange, top cover, insulating cylinder and tank bottom. (See Fig.11)

3.2.1 Head flange

Head Flange has two layers, that is mounting flange and supporting flange, both of them are made of casting aluminum alloy. Supporting flange is connected with the insulation cylinder via rivets, and the tap changer is installed onto the transformer tank cover via the mounting flange. (See Fig.11-1)

There are three bending pipes on the supporting flange. The pipe R is connected to the oil conservator via protective relay. Oil suction pipe S is used to suck the oil from the bottom of the oil compartment during changing or filtering



- ① Head flange
- ② Top cover
- ③ Insulation cylinder
- ④ Tank bottom

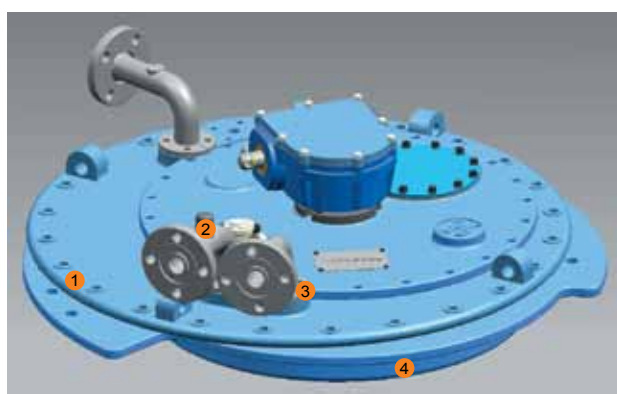
Fig.11

oil of diverter switch through connecting between head flange of tap changer and an insulation oil pipe. The pipe Q acts as oil filling for the diverter switch. Another pipe E2 acts as the vent pipe for transformer oil overflow. All the pipe connections can be turned to suitable angle according to the installation requirement, which should be fixed tightly by the clamp plates after the adjustment.

There is also one tap position indication mechanism on the mounting flange.

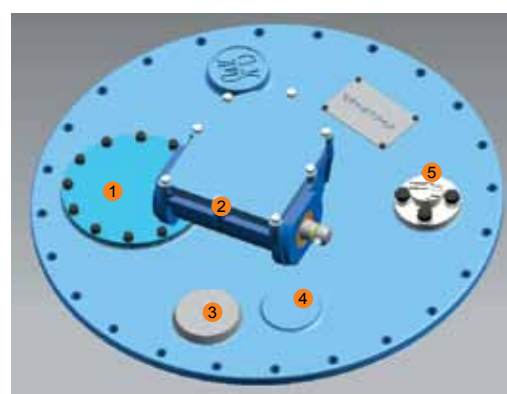
3.2.2 Top cover

A bursting cap is installed on the top cover of tap changer to prevent the oil compartment from overpressure bursting; the oil overflow vent screw is also installed on the top cover. (See Fig.11-2)



- | | |
|-------------------|---------------------|
| ① Mounting flange | ② Bending pipe |
| ③ Clamp plate | ④ supporting flange |

Fig.11-1 Head Flange



- | | |
|---------------------------|------------------|
| ① Bursting cap | ② Bevel gear box |
| ③ Position indicating | ④ Top cover |
| ⑤ Oil overflow vent screw | |

Fig.11-2 Top cover

3.2.3 Tank bottom

Tank bottom is made of casting aluminum alloy with good sealing performance and free from leakage. All the driving gears are installed on it, which is easy for installation and maintenance.

The coupling part of tank bottom adopts the multi-groove coupling structure, so as to avoid wrong coupling. There are oil-drain bolts on the tank bottom, also equipped with special wrench for users to drain the oil or condensation remainder after vapor-phase drying. (See Fig.12)

3.3 Diverter switch insert (See Fig.13)

It adopts the whole sectorial contact shell connection, and complete insert type structure, which is convenient for maintenance and installation.

3.4 Tap selector (See Fig.14)

Tap Selector is composed of step-by-step drive mechanism and contact system. Tap selector can be installed with or without change-over selector. (Refer to CM type OLTC operation instruction and technical data)

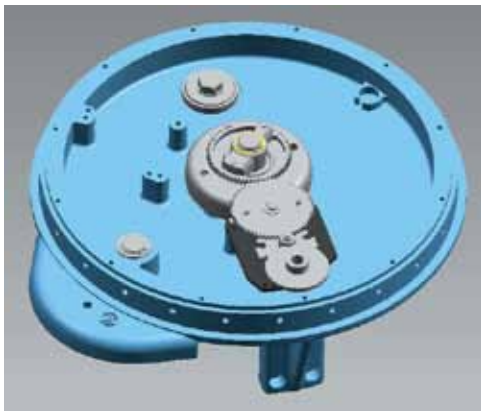


Fig.12 Tank bottom



Fig.13 Diverter switch



Fig.14 Tap selector

4. Operating Principal of Diverter Switch

Type SHZV on load tap changer adopts the principle of single resistor transition circuit; the contact switching sequence is shown in Fig.15. The red line in the figure denotes the path of the current.

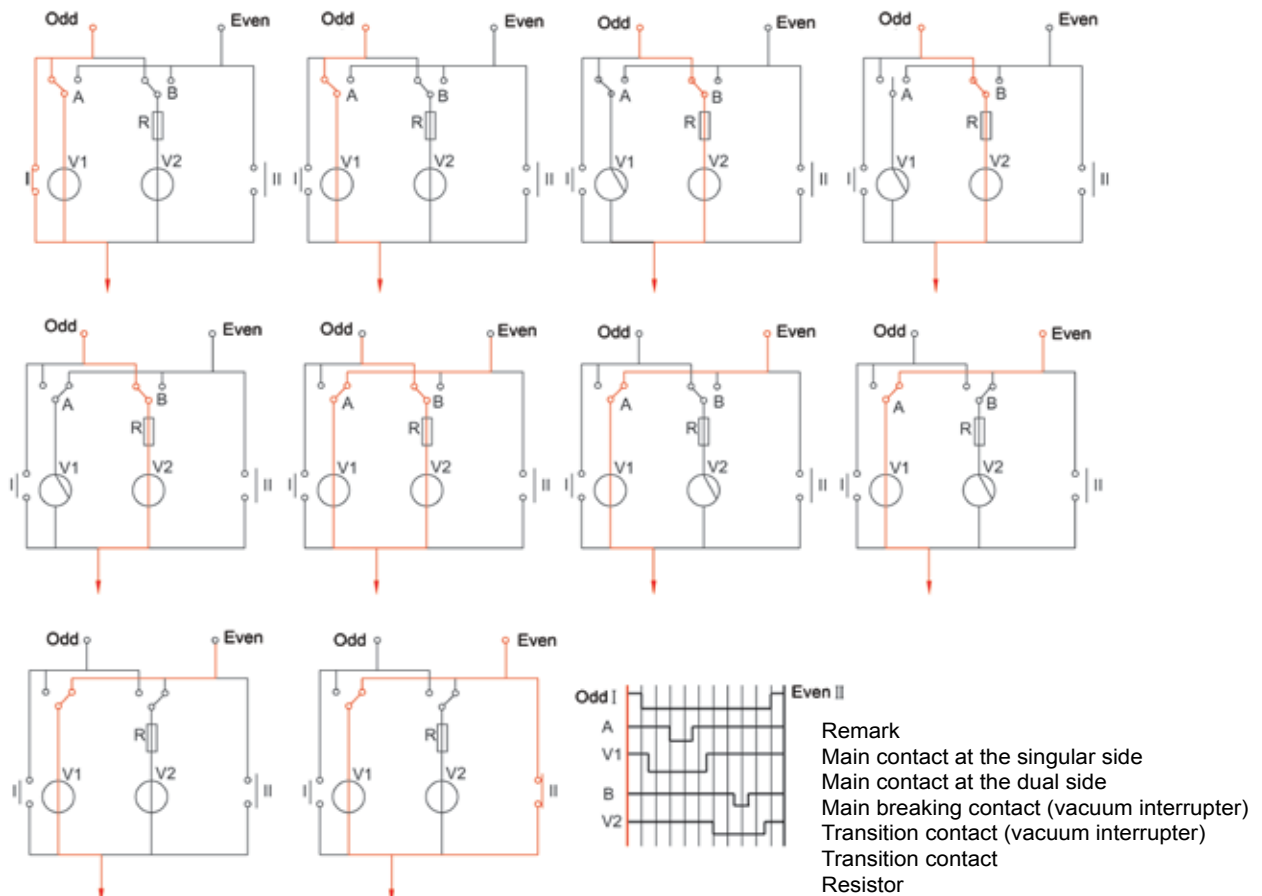


Fig.15 Diagram of contact switching sequence

4.1 Mechanical operating principle of the tap changer

Tap change operation begins with the motor of motor drive unit, the driving force is transmitted to the bear gear box through the vertical driving shaft, then transmitted to the retarding mechanism on the head flange via the horizontal driving shaft, and its output shaft drives the insulation shaft rotate. The rotation of insulation shaft then drives the main driving system to operate the spring accumulation mechanism (the energy released from the energy-storing mechanism drives the diverter switch operate), and the Geneva wheel mechanism of tap selector, the rotating of Geneva wheel mechanism makes the singular or dual moving contact of tap selector rotate one operating position.

5. Installation Method of SHZV On Load Tap Changer (Suitable for bell-type transformer)

Tap changer is installed on the cover of transformer tank by the head flange

A mounting flange of $\phi 650\text{mm}$ inner diameter and oil proof sealing gasket (prepared by the user, see Fig.19) are required on the transformer tank cover. Stud can be used with one end threaded into the mounting flange; the stud should stand out at least 45mm above the mounting flange.

5.1 The procedures for installing SHZV OLTC on the bell type transformer tank cover are as following:

The OLTC with “bell-type” installation has a specially designed head flange which can be dismantled. It is composed of two parts: one is an intermediate flange temporarily installed on the transformer supporting structure, the insulating cylinder of the diverter switch oil compartment is installed on this flange; the other is the head flange fixed on the transformer tank cover. These two flanges are firmly connected together by means of sealing O- ring gasket and fasteners.

5.1.1 Remove the mounting flange from the head cover

5.1.1.1 Loose the fixing plate of the bevel gear box on the head flange. Put the fixing plate on the shaft in a flat side, and fasten it well as Fig. 16, in order to avoid the shaft of the bevel gear box rotating, which will change the installation position of diverter switch insert. (Please remember to turn the fixing plate to the operation position after installation of the tap changer)

5.1.1.2 Remove the top cover of the tap changer flange (see Fig.5-2). Take care of the sealing O-ring on the cover.

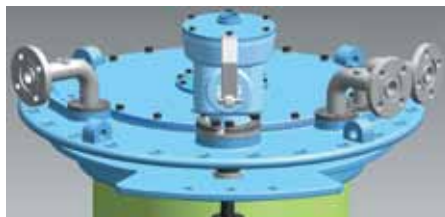
5.1.1.3 Remove the M8 fixing nuts and gaskets that fixing the diverter switch (see Fig.17).

5.2.1.4 Carefully lift out the active part of diverter switch and keep it in clean place.

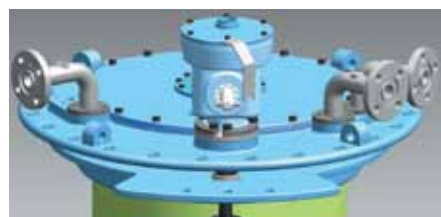
Note: Don't turn it optionally after lifting out the diverter switch.

5.1.1.5 Remove the oil suction pipe. Take care of the sealing O-ring on the suction pipe head.

5.1.1.6 Loosen the connection bolts between supporting flange and mounting flange, and pay attention to the triangle locating mark between two flanges. Remove the mounting flange, and keep the o-ring between the two flanges properly. (See Fig.18)

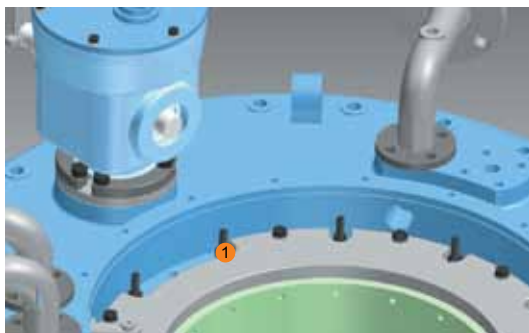


Fixing location of positioning plate



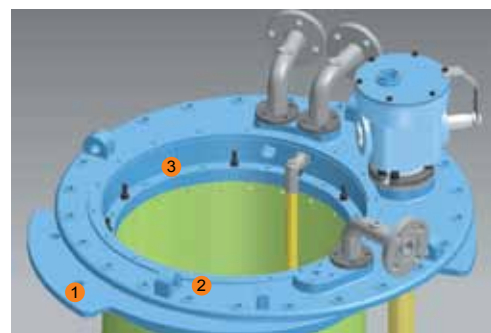
Loosening location of the positioning plate

Fig.16 Head of OLTC



① M8 fixing nut

Fig.17



① Supporting flange ② mounting flange
③ connection bolt

Fig.18

5.1.2 To ensure the correct mounting of the tap changer, the tap changer should be pre-assembled.

5.1.2.1 Pre-match the supporting and head mounting flanges

An adjustable supporting structure should be provided in the transformer, lift the assembled tap changer onto the supporting structure, that make the supporting flange of tap changer can be temporarily mounted on the supporting structure.

Pre-mount the head flange onto the mounting flange of transformer tank cover, adjust the position of tap changer and supporting structure, which will ensure that the head flange are aligned naturally with supporting flange, thus finalizing the installation position of tap changer on the supporting structure.

5.1.2.2 Adjust the assembly space between supporting flange and head mounting flange

To adjust flexible supporting structure, raise or lower the installation height of the supporting flange to ensure the installation space between supporting flange and head flange to be 5~20mm.

When the pre-installation of tap changer on the supporting structure of transformer has been confirmed correct, connect the leading wire between tap changer and transformer tap winding as per the following instruction in section 5.3. After the tap leading wire has been connected, go through the pre-installation sequence once again, if the position of tap changer is unchanged and the leading wire meets requirements (with suitable length, without the deformation and stress on tap changer), it can ensure that the position of two flanges is correct during final assembly of the tap changer onto the transformer.

5.2 The procedures for installing SHZV OLTC (only suitable for the OLTC with cage tap selector) on the standard type transformer tank cover are as following:

5.2.1 Mounting flange

Mounting flange is necessary during the OLTC flange installation on the transformer. The surface of the flange must meet the sealing requirement. (See appendix 4)

5.2.2 Install OLTC onto tank cover

Lift the oil compartment of diverter switch into the transformer through hole carefully. Fix the OLTC flange on the installing flange with bolts after ensuring the position is correct.



① connection bolt

Fig.19

5.2.3 Assemble tap selector with oil compartment

5.2.3.1 Connect tap selector with oil compartment

5.2.3.2 Fasten 6 M12 screws (See Fig.19)

5.2.3.3 Connect the 6 leads between oil compartment of diverter switch and tap selector.

5.3 Connect leading wire between voltage regulation winding and tap changer

The voltage regulation windings should be connected to the terminals of tap selector according to the connection diagram. The terminal number of the tap selector is marked on the insulating cylinder, which is accordant with tap number of the voltage regulation windings.

There is a M10 bolt on each of tap selector terminals. The tap of the voltage regulation winding can be connected directly with tap selector terminal via this bolt. Install the shield cover according to the following schematic drawing. After tightening it by the M10 connecting nuts and gaskets, the washer of shield cover should be turned up 90° in two sides. (Please see Fig.20)

5.3.2 Attentions should be paid during the leading wire connection between the tap selector and transformer tap winding

5.3.2.1 The connection leading wire should not cause the tap selector deform due to tension. The connection wire should be wired to the tap selector in dual direction from the tap winding, thus to avoid deforming the cage of tap selector due to stressing the lead wire in single direction.

The connecting wire between the end clamping piece of transformer lead wire and tap selector terminal should have enough length, it should be soft and should not be coated with insulating paint to avoid the wire become harder after paint drying which will make the tap selector deform under tension.

The terminal wire of the tap selector should be led out from the exterior of the cage. Never allow the wire passing through the interior of the cage.

The tap changer shall be lifted up 5~20mm after the connection of the lead wire. Therefore, special care should be given to the degree of tightness of the connecting wire. When mounting the supporting flange onto the supporting structure, it will be better to put a pad between the supporting flange and the head flange before connecting the leading wire, so as to obtain the required actual assembly height. After connecting the wire, the temporary pad will be removed. Check the degree of tightness of the lead wire and whether the tap changer is affected by tension.

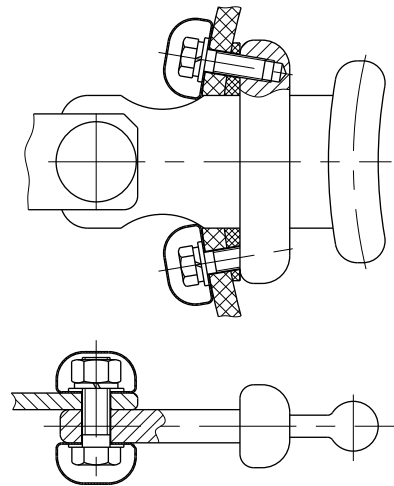


Fig.20 Schematic diagram of fastening the wiring terminals of tap selector

5.3.2.2 Please don't damage the terminals of the tap selector during connecting the lead wire.

5.3.3 The connecting of diverter switch output terminal

There is one circular conducting ring on the oil compartment of diverter switch (please see Fig.21), the connectors of neutral point of tap changer are directly connected to this conducting ring, there are some through-holes of 10.5mm diameter on this



Fig.21 conducting ring

ring, bolts will pass through this hole and connect with the connector lugs of leading wire, then fixed with shield cover and M10 nuts., etc. After fastening the wiring nuts, the washer of shield cover should turn up 90° in two sides, the nuts should be fastened tightly as to avoid loosening.

5.4 Transformer Ratio Test

Before drying the transformer, a ratio test should be carried out with AC voltage. To operate the tap changer, insert a short pipe of 25mm diameter into the horizontal shaft of retarding mechanism on the tap changer flange, and connected them with a M8 screw. A crank handle is equipped on the other end of the short pipe.

8.25 turns of the horizontal driving shaft are required for each tap changing operation. Because the tap changer has not be immersed with oil, so the tap change operation should be reduced to minimum.

After the ratio test, the tap changer position must be adjusted to the setting position set by the manufacturer. This position can be determined according to the setting position diagram.

5.5 Drying and Oil Filling

Generally the tap changer is dried together with the transformer; however, it can be dried separately via the same drying process. The purpose of drying is to ensure the insulation level of the tap changer. The process is as following:

5.5.1 Vacuum drying

5.5.1.1 Drying in the oven room

During drying in the oven room, the tap changer's cover must be removed. Remove the blind cover on the suction pipe S and make sure to keep the oil pipe unobstructed.

The tap changer is put into the oven room with a temperature about 60°C and heated in the air under atmospheric pressure. The rate of temperature rise is 10°C /h, and heated to the max. temperature of 110°C . Drying is carried out in the circulating air for 10 hours under max. temperature 110°C .

5.5.1.2 Drying in the transformer oil tank

When the transformer is processed with vacuum drying in its oil tank, the top cover of the tap changer should be kept tightly closed throughout the whole process. To ensure sufficient drying of the interior of the oil compartment and the incorporated diverter switch unit, a by-pass pipe supplied by our factory (see appendix 8) must be used to connect the oil filling flange Q on tap changer head with the overflow pipe flange E on the transformer oil tank (see appendices 1 and 2).



5.5.2 Vapor phase drying

When vapor phase drying is employed for drying the transformer and tap changer, the oil drain bolt at the bottom of the oil compartment should be loosened by special wrench to drain the kerosene condensate from the oil compartment. After the vapor phase drying, the oil drain bolt must be fastened again.

5.5.2.1 Drying in the oven room

In the case of oven room drying, the top cover of the tap changer must be removed. Make sure to keep the oil suction pipe unobstructed.

Under the kerosene vapor temperature of 90°C , the duration of heating is 3-4 hours. Raise the temperature of kerosene vapor at a rate of $10^{\circ}\text{C}/\text{h}$. Max. temperature is 125°C . The time for drying basically depends on the time required for transformer drying.

5.5.2.2 Drying in the transformer oil tank

If the transformer is vapor-phase dried in its tank, the diverter switch insert should be lifted out. After the vapor phase drying, check the oil drain bolt at the bottom of the oil compartment to make sure it is tightly fastened.

Attentions should be paid after the drying process of a tap changer:

- a. Do not operate the tap changer after drying without oil filling. If operation is required after drying, then the diverter switch oil compartment shall be fully filled with transformer oil and the tap selector should be lubricated with transformer oil.
- b. Check the tightness of fasteners. If any fastener is found loose, it must be retightened and locked against looseness.

5.5.3 Oil filling

The top cover of the tap changer should be closed again, and tighten the 24 pieces of M10 bolts. Please pay attention to the correct position of the sealing O-ring.

Both the transformer and diverter switch are filled with oil under vacuum. New transformer oil is filled into the tap changer to the level of the transformer tank cover. Therefore, the by-pass pipe provided by our factory should be installed between oil filling flange on the tap changer head and the transformer oil-overflow flange, in order that the oil compartment of the diverter switch and the transformer can be vacuum extracted simultaneously.

5.6 The installation of connection pipes

The head flange of the tap changer is equipped with three bending pipes. The orientation of these

connection pipes can be adjusted according to the mounting requirements. After loosening the clamp plates, these connection pipes can be swiveled freely.

5.6.1 Connection pipe of protective relay

Protective relay is installed on the pipe connection between the bending pipe of the tap changer head and the oil conservator, and should be as close as possible to the head of the tap changer. Normally it is connected directly to the flange of the bending pipe R. It must be installed horizontally with the arrow of the gas relay pointing to the oil conservator, the connection pipe should lean upwards 2%.

5.6.2 Pipe connection of oil suction

There is an oil suction pipe in the oil compartment. It is used to extract the oil from the bottom of the diverter switch oil compartment during maintenance or changing oil. Therefore, a pipe lower than the oil compartment bottom has to be installed at the transformer oil tank, its upper end is connected on the flange of suction pipe, lower end fixed with an oil-drain valve. If opening the valve, the oil can be extracted because of the siphonage principle.

This pipe connection may also be used as the oil filling pipe of an oil filter plant.

5.6.3 Pipe connection of oil filling

This pipe is used as the oil return pipe of the oil filter plant. It is sealed with blind cover when oil filter plant is not installed, it can also be led out by a pipe with valve at the lower end, thus for the filtering oil circularly of oil filter plant.

5.7 The installation of motor drive unit

The motor drive unit is used to drive the tap changer to carry out the tap tap change operation; it can be operated manually or automatically.

Attentions should be paid during the installation of motor drive unit:

5.7.1 The motor drive unit and tap changer must be in the same setting position, which is indicated in the tap changer connection diagram supplied with the equipment.

5.7.2 The motor drive unit must be mounted at the provided place on the transformer tank in a vertical position, deflection not allowed.

Attention: The mounting plate of the motor drive unit should be flat, otherwise the motor drive unit will be deformed by twisting and its operation will be affected.

For the installation details of the motor drive unit, please see the operation instructions of motor drive unit.



5.8 Installation of bevel gear box

The overall and mounting dimension of the bevel gear box, see the appendices 6 and 7 .

5.8.1 The bevel gear box is to be mounted onto the supporting bracket of the transformer tank cover by 2 pieces of M16 bolts.

5.8.2 Driving Shaft (square shaft): check if the two shaft ends are in a line during installing, see the appendix 10.

5.8.2.1 Installation of horizontal driving shaft

Loosen the fixing plates (6 pieces of M8 bolts) of transmission reducer on the tap changer head and swivel the reducer to align its horizontal shaft with the horizontal shaft of the bevel gear box.

Subtract 9mm from the length between the horizontal shafts of the reducer box on the tap changer head and the bevel gear box is the actual length of the horizontal driving shaft. Get rid of the burring and a gap (a total of about 2mm) is reserved at the connection of the two horizontal driving shafts because of thermal expansion and cooling contraction.

Install the horizontal driving shaft and tighten the fixing plate of bevel gear box.

5.8.2.2 Installation of the vertical driving shaft

According to the dimension between the bevel gear and the vertical driving shaft of the motor drive unit, minus 9mm and determine and machine the actual size of the vertical driving shaft. After taking account of the expansion and contraction, certain gap (a total of gap about 2mm) should be reserved for the connection of vertical driving shafts.

Install the vertical driving shaft; the locking plate in the clamping brackets near the motor drive unit can only be tightened after checking the connection between the motor drive unit and tap changer. The length of the vertical driving shaft may exceed 2 meters. In order to avoid swaying we recommend installing a middle gear as a support for the vertical shaft. This can be specially supplied upon request..

5.9 Installation of three single phase tap changer

Attention: the arrangement of three single phase tap changers on one transformer, since it will cause the operation of the diverter switch during the adjustment of gear box, so after adjustment, must check if each diverter switch is on same position and they has simultaneous action when operated by hand crank.

5.10 Verification of the connection between the tap changer and motor drive unit

Attention: After connecting the tap changer with the motor drive unit, manually operate for a complete cycle to make sure the position indication is identical between the motor drive unit and the tap changer before any operation by motor drive unit.

When the tap changer has been connected to the motor drive unit, the time interval between the instant switching of the diverter switch and the ending of operation of the motor drive unit should be same in both directions of rotation.

In order to make sure the reliability of operation of tap changer, if vertical or horizontal shaft is disconnected from the tap changer, test has to be performed after re-connection.

The verification of connection is carried out according to the following procedure:

5.10.1 Rotate the hand crank in direction of $1 \rightarrow N$. After the action of diverter switch (start when the sound of switching is heard), turn the hand crank continuously and record the number of turns until the centre mark line within grey area on the indicating dial of the motor drive unit appears on the same line with the arrow. Record the number of turns as m .

5.10.2 Rotate the hand crank in the reverse direction of $N \rightarrow 1$ to return to its setting position. Record the number of turns k in the same way as above.

5.10.3 The connection will be correct if $m=k$. If $m \neq k$ or $|m-k| > 1$, then loosen the vertical driving shaft and rotate the hand crank $1/2 |m-k|$ turns in the direction of increment of turns, and finally connect the vertical driving shaft to the motor drive unit.

5.10.4 Check the difference of turns between the motor drive unit and the tap changer in the same way as mentioned above, until the number of turns in two directions of switching operations is same.

For example:

The verification of connection of Type SHZV tap changer and Type SHM-III motor drive unit: take 10193W as example, turn from position 9b (setting position) to position 9c, $m=5$ turns. Turn backward from position 9b to position 10 (the original setting position), $k=3$ turns. The difference of turns of the handle $m-k=5-3=2$ turns.

Turns to be adjusted $1/2 |m-k| = 1/2 (5-3) = 1$ turn.

Loosen the connection between the vertical driving shaft and the motor drive unit. Turn the hand

crank in the direction 9b → 9c for one turn. Then again make connections.

Check that the difference of turns in both directions has been balanced.

- a. Record the number of turns m & k under connected condition.
- b. Turn $\frac{1}{2} | m-k |$ turns in the direction of the increment of turns in the condition of loosening the connection
- c. Again make connection and verify until $m=k$.

5.11 Operational test of the tap changer

5.11.1 Mechanical operational test

Before transformer test under charged condition, 5 complete cycles of mechanical operating test (no less than 200 operations) must be performed. There should be no failure from the tap changer and motor drive unit. The position indication of the motor drive unit, its remote position indication and the position indication of the tap changer should be the same. Both the mechanical and electrical limit protection should be reliable.

5.11.2 Final oil filling

Final oil filling is done after the operating test of the tap changer through the oil conservator. Before oil filling, loosen the vent screw on the suction pipe. Use a screw driver to pry up oil overflowing vent on the top cover of tap changer. (See Fig. 22)

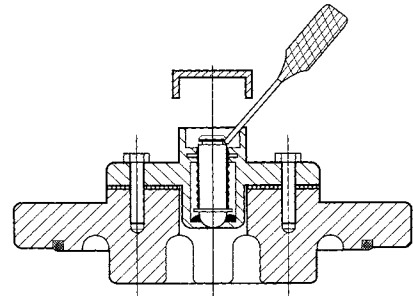


Fig.22 Schematic diagram of oil vent on top cover when filling tap changer with oil

5.11.3 Grounding connection

The grounding screw on tap changer head should be connected to the transformer tank cover.
The grounding screw on motor drive unit should be connected to the transformer tank cover.
The grounding screws for protective relay QJ4-25 should be connected to the transformer tank cover.

5.11.4 Transformer ratio test

After completing the above-mentioned operations, the transformer acceptance test can now be performed. The tap changer should be tested with the conservator.

5.12 Transportation of transformer together with the tap changer

When the tap changer is assembled to the transformer, careful consideration shall be given to

safety of transportation (for example, to increase the temporary supporting). The tap changer is of the immersed type, it is not necessary to remove it for transportation. If there is trouble which requires dismantling, the motor drive unit should be loosened at the setting position, so that it can be transported in the horizontal position. After arriving on site, the motor drive unit can be restored by means of the method mentioned above.

If the transformer is transported or stored without the conservator, then the bypass pipe (see the appendix 8) supplied by our factory can be installed between the oil filling flange of the tap changer and the overflow pipe flange of the transformer.

If transformer is required to be transported or stored without oil filling, then the oil in the oil compartment of the diverter switch must be completely drained. The bypass pipe must be installed at that time so that the oil compartment and the transformer oil tank will be subjected to the same pressure (nitrogen sealing).

In order to avoid damaging the tap changer caused by the shifting of moving parts, they must be temporarily secured.

Note: the bypass pipe shall be removed from the tap changer head when the transformer is installed on-site and before putting it into operation.

5.13 Put into operation on site.

When the transformer is installed on site, the installed position of the tap changer and the tightness of the connecting wire should be checked either by lifting the insert or by entering into the transformer oil tank.

Before putting into operation of the transformer, the operating test of the tap changer and motor drive unit must be done according to section 5.10, and at the same time, check the proper functioning of the Protective relay.

The Protective relay should be connected to the tripping circuit of the line circuit breaker, in case the Protective relay is energized, it will instantly cut off the transformer circuit. "Transformer Off" test button on the top of the Protective relay can be used to test the function of the Protective relay. Open all the valves between the conservator and the tap changer to prepare the tap changer for operation, at that time, the gas accumulated under the tap changer top cover will expel a slight amount of oil. When the tap changer is verified to have everything set all right, then it can be put into operation.

6. Operation Supervision

To ensure the normal operation of the tap changer, it is necessary to have the periodical appearance inspection with transformer. And the inspection content as following:

6.1 Tap changer flange: if there is any leakage from each joint between protective relay and pipeline.

6.2 If the seal property of the motor drive unit is good or not.

6.3 Transformer oil in the oil compartment of tap changer should be tested according to user's relative operation rules.

6.4 If the heater and other devices inside the motor drive unit are good or not.

6.5 Withdraw the sample oil from the oil compartment of diverter switch periodically. And the oil requirement should be as following table.

Connection	Breakdown voltage	Water content
Neutral point regulation	$\geq 30\text{KV}/2.5\text{mm}$	$< 40\text{ppm}$
Others except neutral point	$\geq 40\text{KV}/2.5\text{mm}$	$< 30\text{ppm}$

6.6 Do not operate the on load tap changer frequently when the transformer is overloaded. It must be equipped with "over current self-locking contact ", so that the tap changer will not be operated when the load current exceed 2 times of I_u .

6.7 The tripping contact of the Protective relay QJ4-25 is set to operate at oil speed of 1.0m/s +10%. This contact should be connected with the tripping circuit of the transformer circuit breaker. In case a fault occurs with the on load tap changer, then large amount of gas will generate, causing a rush of oil flow to move the relay flapper, which closes the tripping contacts, and cuts off the transformer incoming current, thus avoid the fault to extend. Once the gas relay operates, don't re-close the transformer before the inspection by lifting the diverter switch insert.

6.8 An overpressure explosion protection cover is installed on the top cover of the tap change which should not be damaged during normal tap changing operation of the diverter switch. Only when a fault is generated within the switch, then the cover bursts when the pressure in the oil compartment exceeds $0.3 \pm 20\% \text{MPa}$, thus it functions as an overpressure protection to avoid overspreading of the fault. During installation and maintenance of the on load tap changer, please pay special attention not to damage the bursting cover (please see Fig.5-1 and 11-2).

7. Maintenance period

7.1 Maintenance should be carried on every 300,000 operations of tap changing.

7.2 Diverter switch should be replaced after 800,000 operations.

7.3 Maintenance should be carried on tap selector after 800,000 operations.

The maintenance of the tap changer is normally performed by Huaming. And usually the maintenance can be finished within one day.

8. Scope of the Complete Set of Equipment

8.1 Scope of delivery of the complete set of the tap changer

- a. Tap changer body
- b. Protective relay
- c. Driving shaft and bevel gear box
- d. Motor Drive Unit
- e. Accessories including remote position indicator, etc.

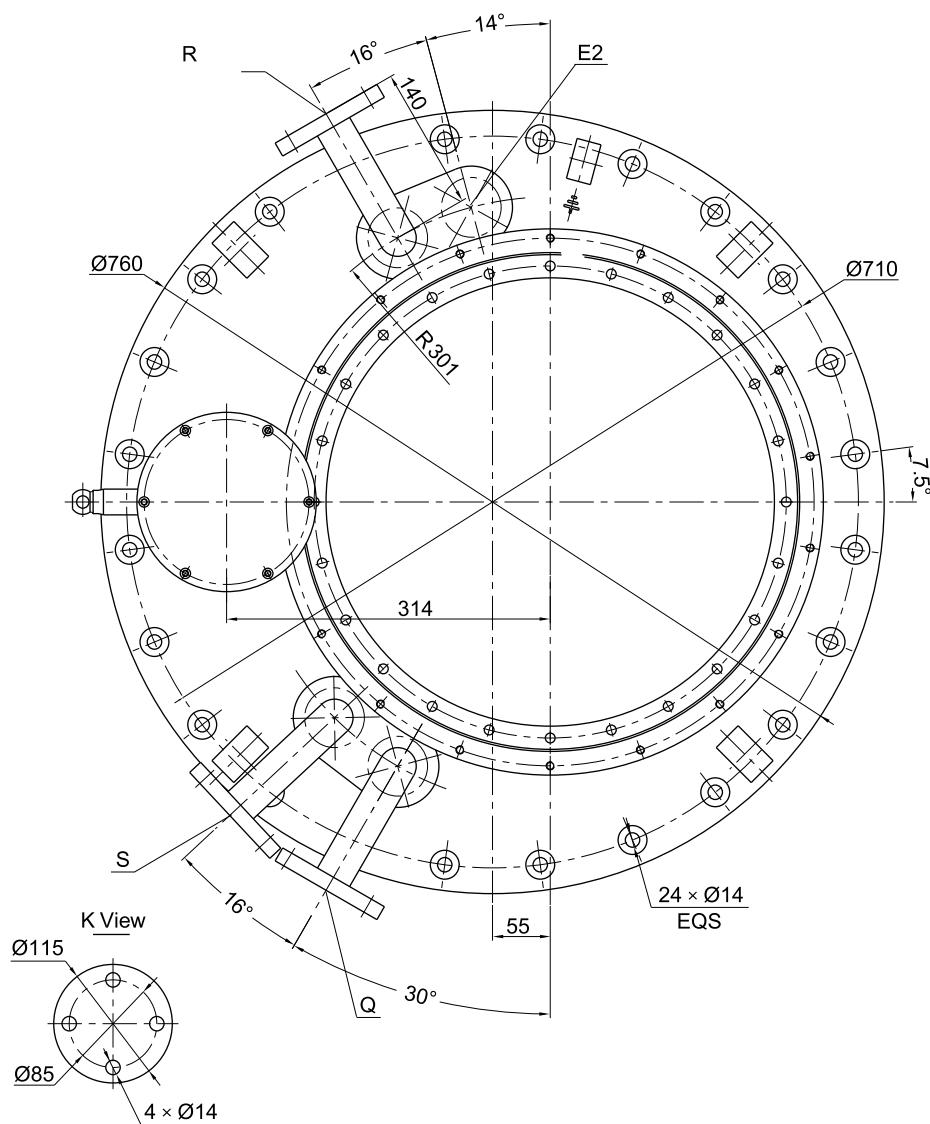
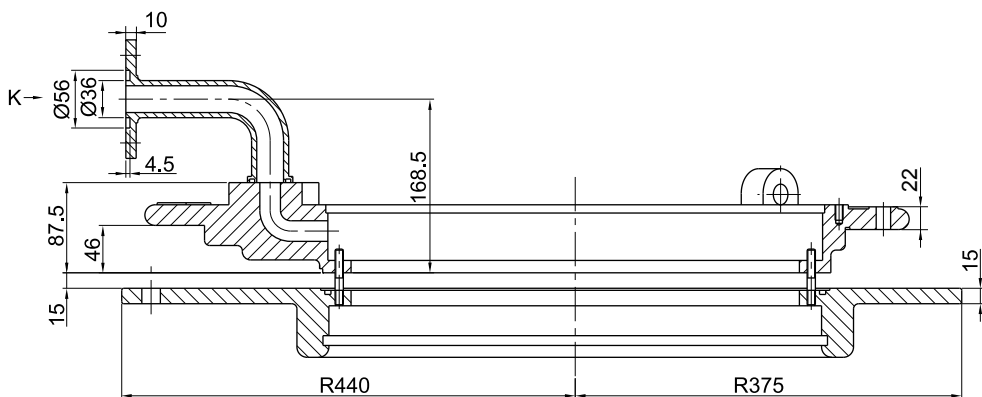
Check the contents according to the packing list. Place the tap changer equipment in a well ventilated warehouse with relative humidity less than 85% and temperature between -25°C and +40°C . There should be no corrosive gas and the goods should not be affected by rain or snow.

Note: the six lead wires on the tap selector should be transported separately. The relevant terminal number of diverter switch is shown on the joint face of the lead wire. The fixed bolts at both ends should be tightened and the shield cover should be assembled according to requirements.

9. Appendix

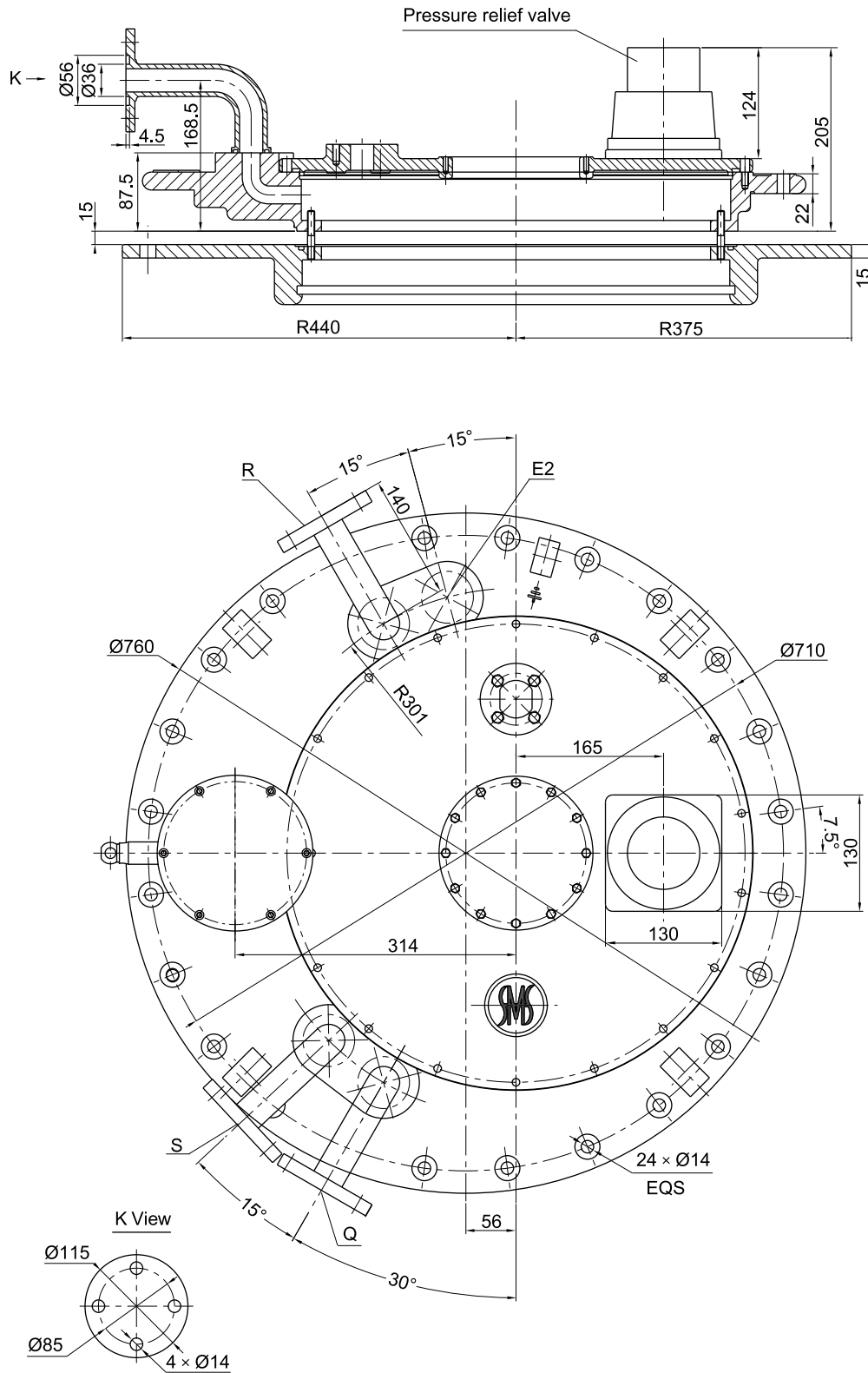
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Appendix 1. SHZV bell-type head flange,overall dimension cylinder tap selector



Unit:mm

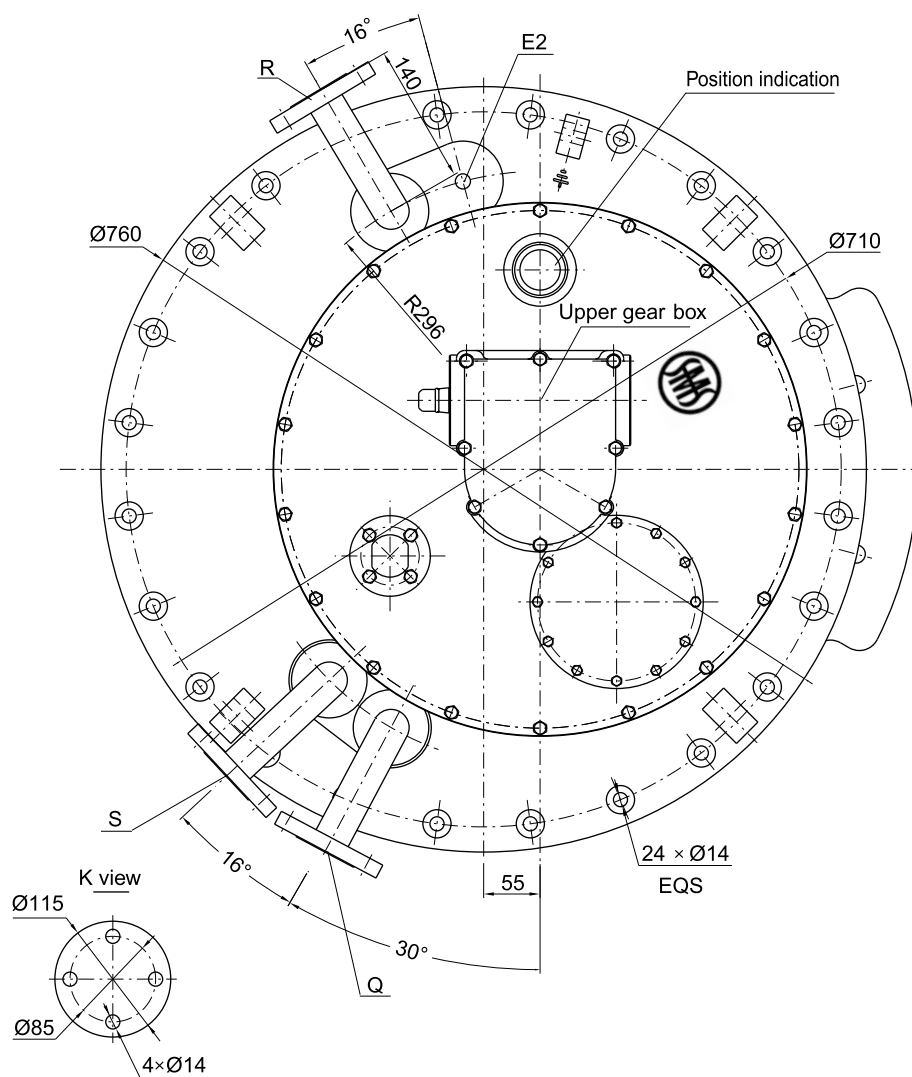
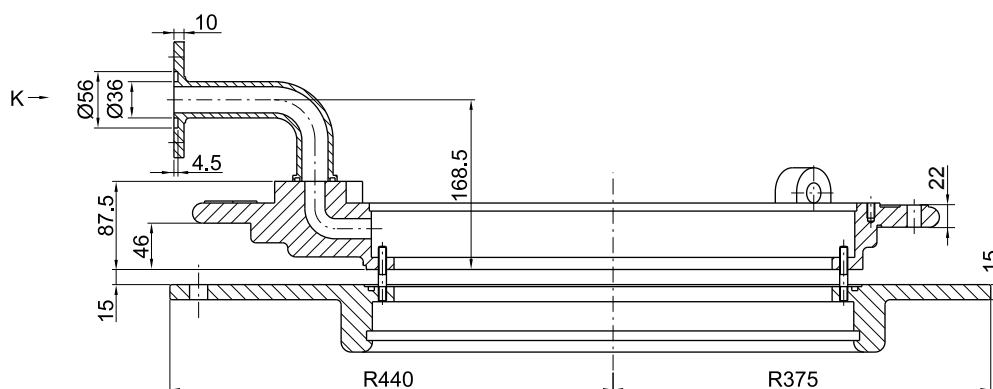
Appendix 2. SHZV bell-type head flange with pressure relief valve, overall dimension, cylinder tap selector



Unit:mm

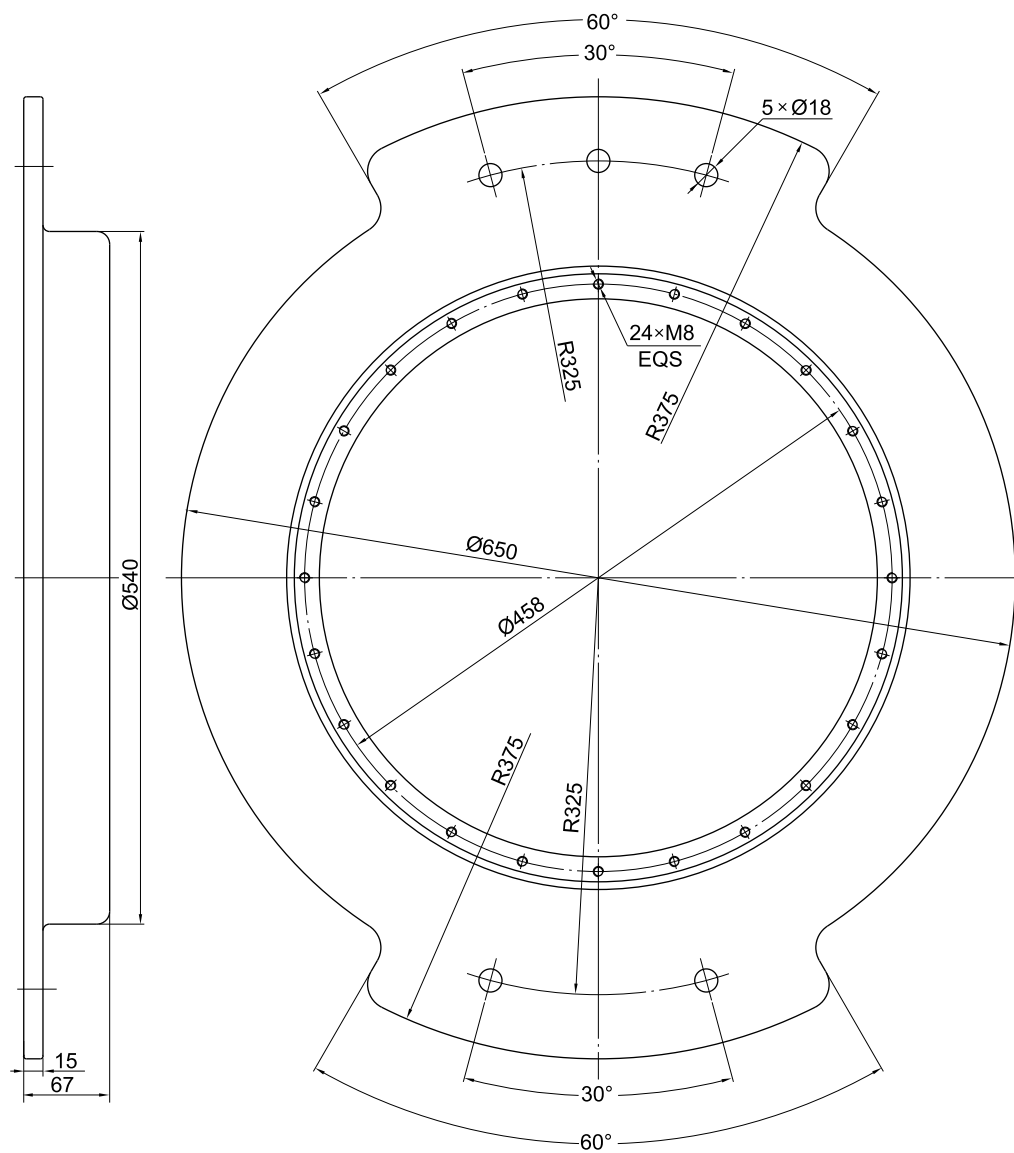
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Appendix 4. SHZV bell-type head flange, overall dimension, cage tap selector



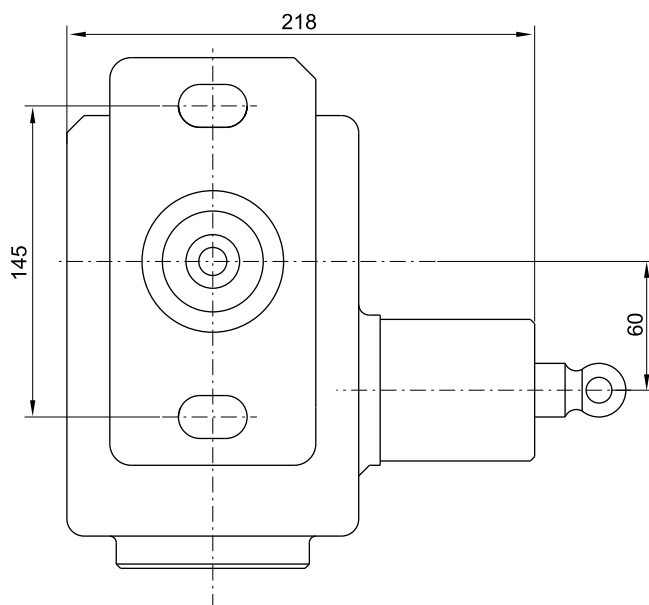
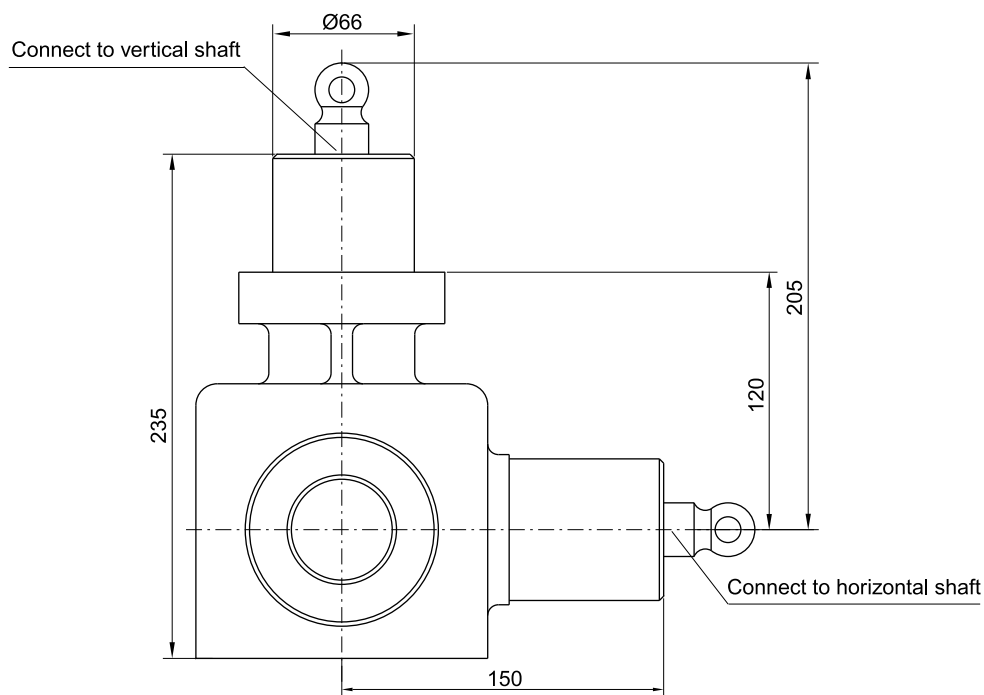
Unit:mm

**Appendix 5. SHZV bell-type supporting flange,
 overall dimension, cage tap selector**



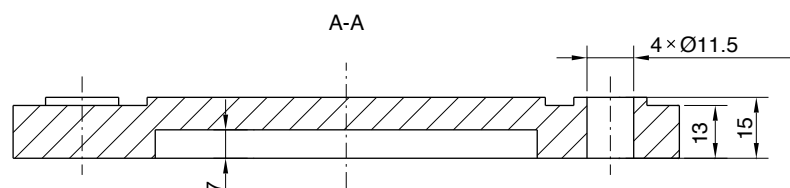
Unit:mm

Appendix 6. The overall dimension of 4:1 bevel gear

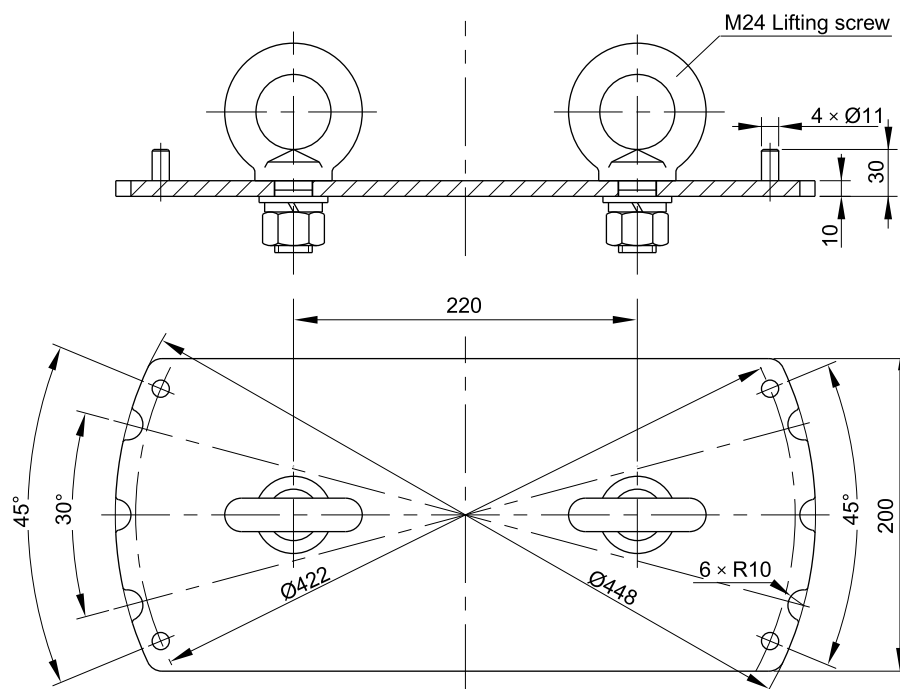


Unit:mm

Appendix 7. By-pass pipe, overall dimension

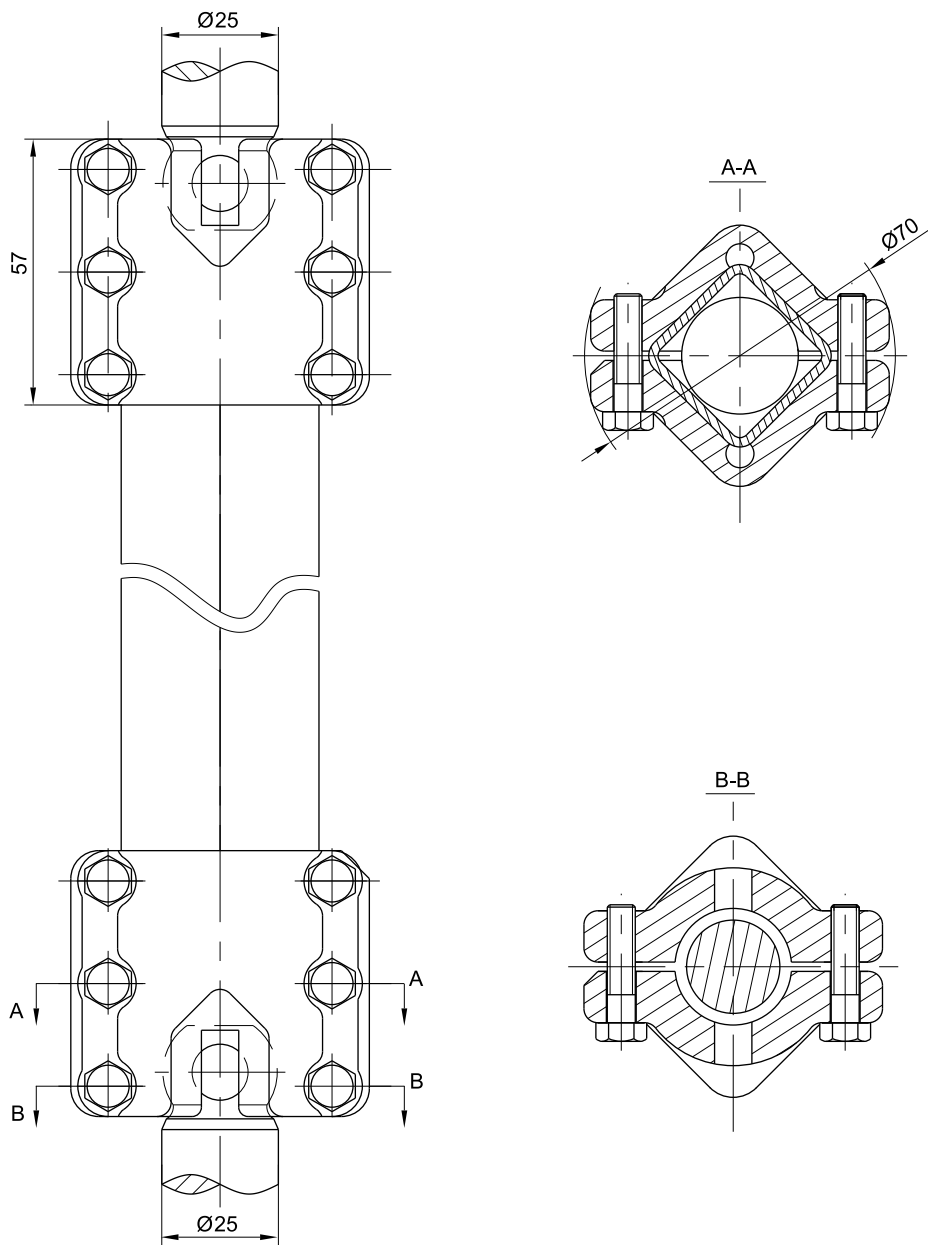


Appendix 8. Bell-type lifting plate dimension



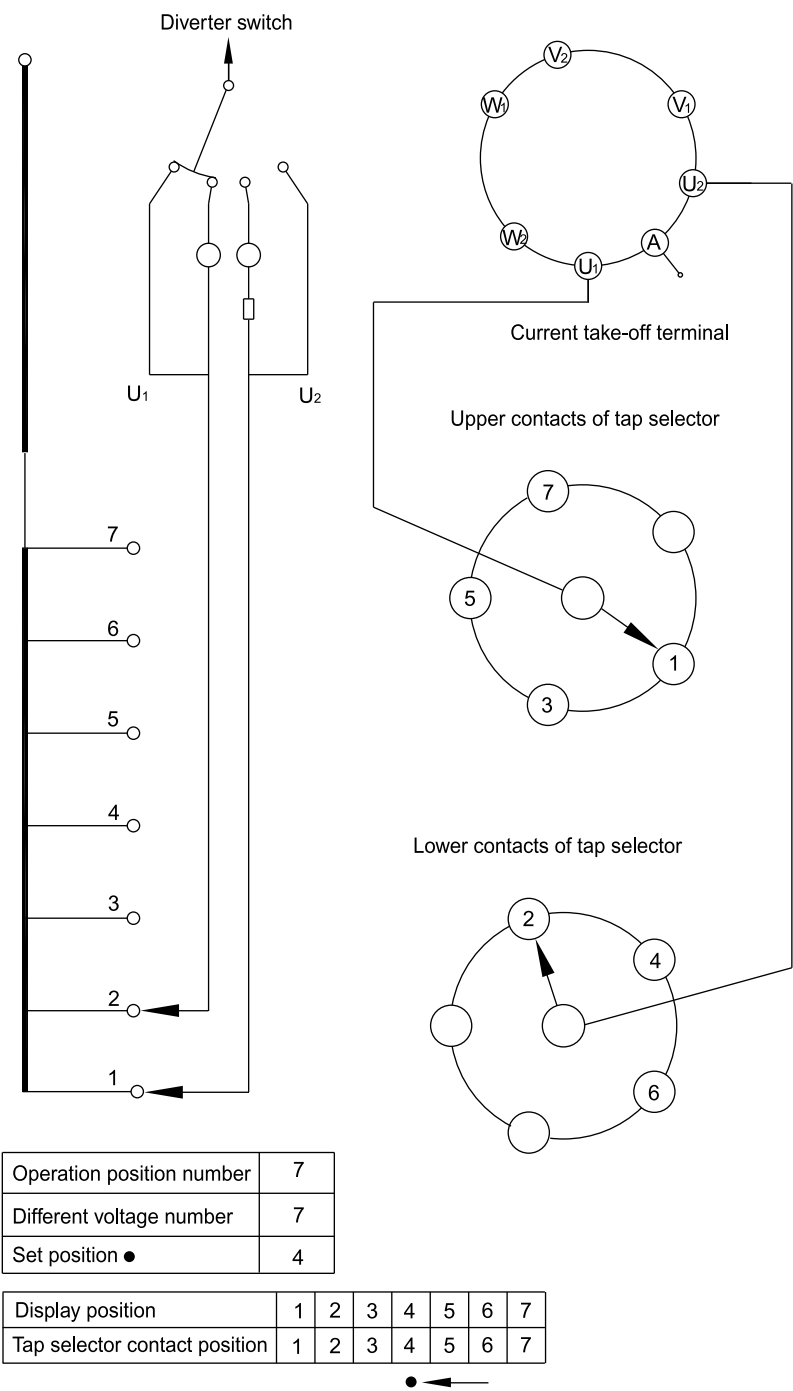
Unit:mm

Appendix 9. Schematic drawing for connection of horizontal shaft and vertical shaft



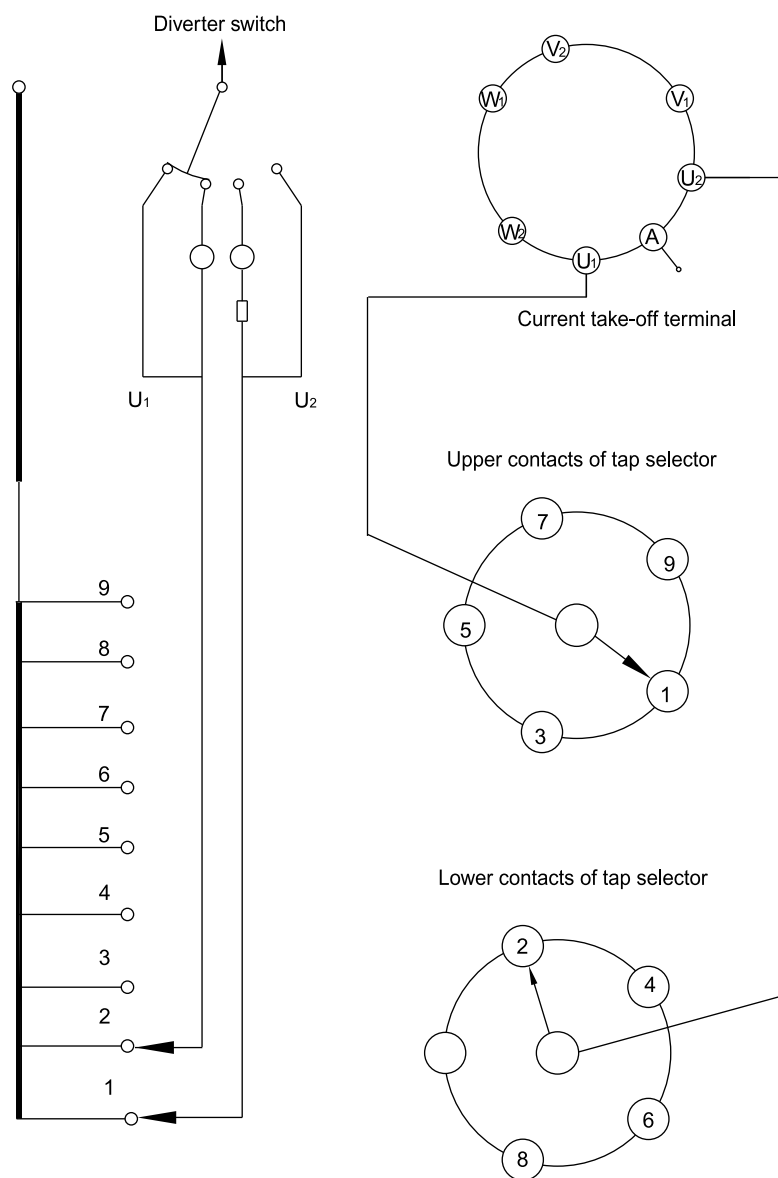
Unit:mm

Appendix 10. SHZV (10070) operating position table and connection diagram



●Drawing is shown at the set position

Appendix 11. SHZV (10090) operating position table and connection diagram



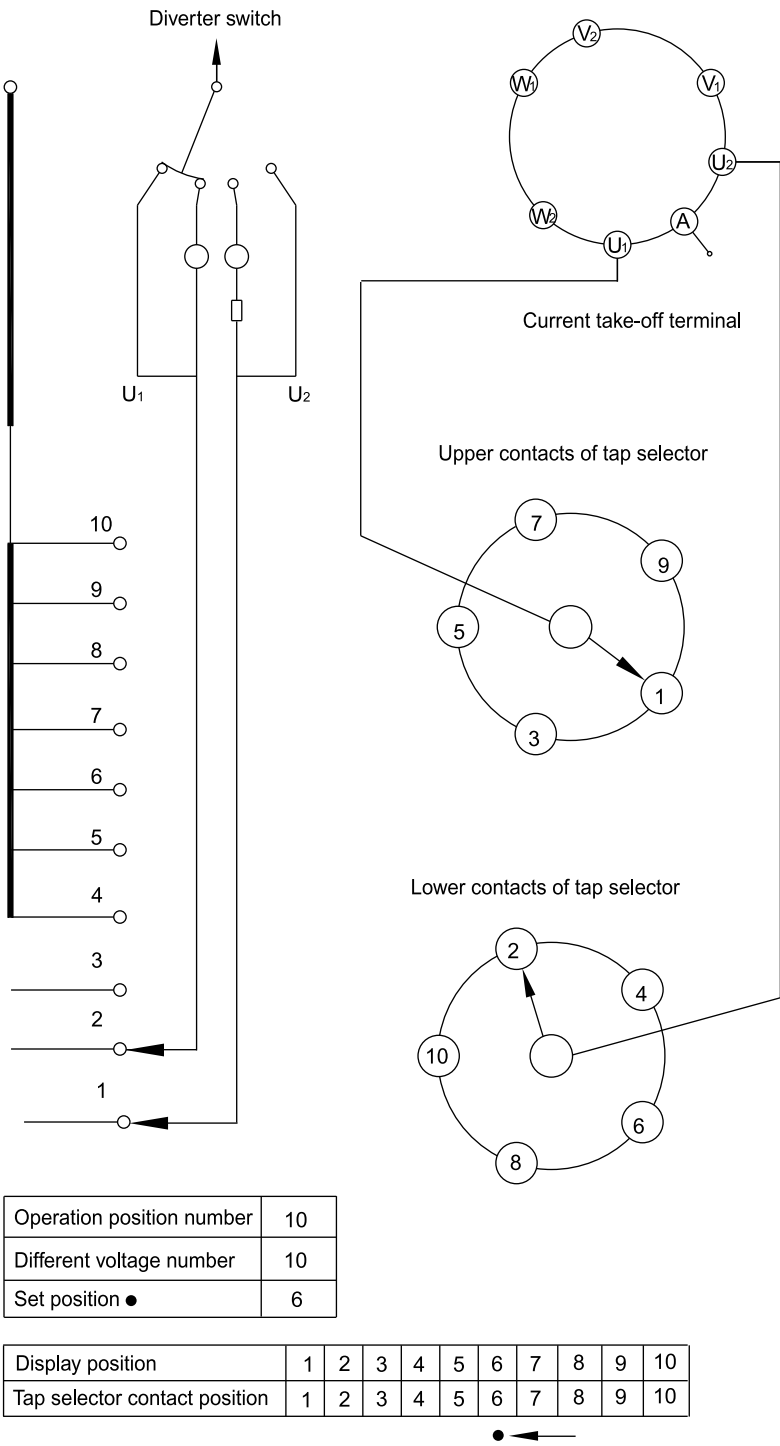
Operation position number	9
Different voltage number	9
Set position ●	5

Display position	1	2	3	4	5	6	7	8	9
Tap selector contact position	1	2	3	4	5	6	7	8	9



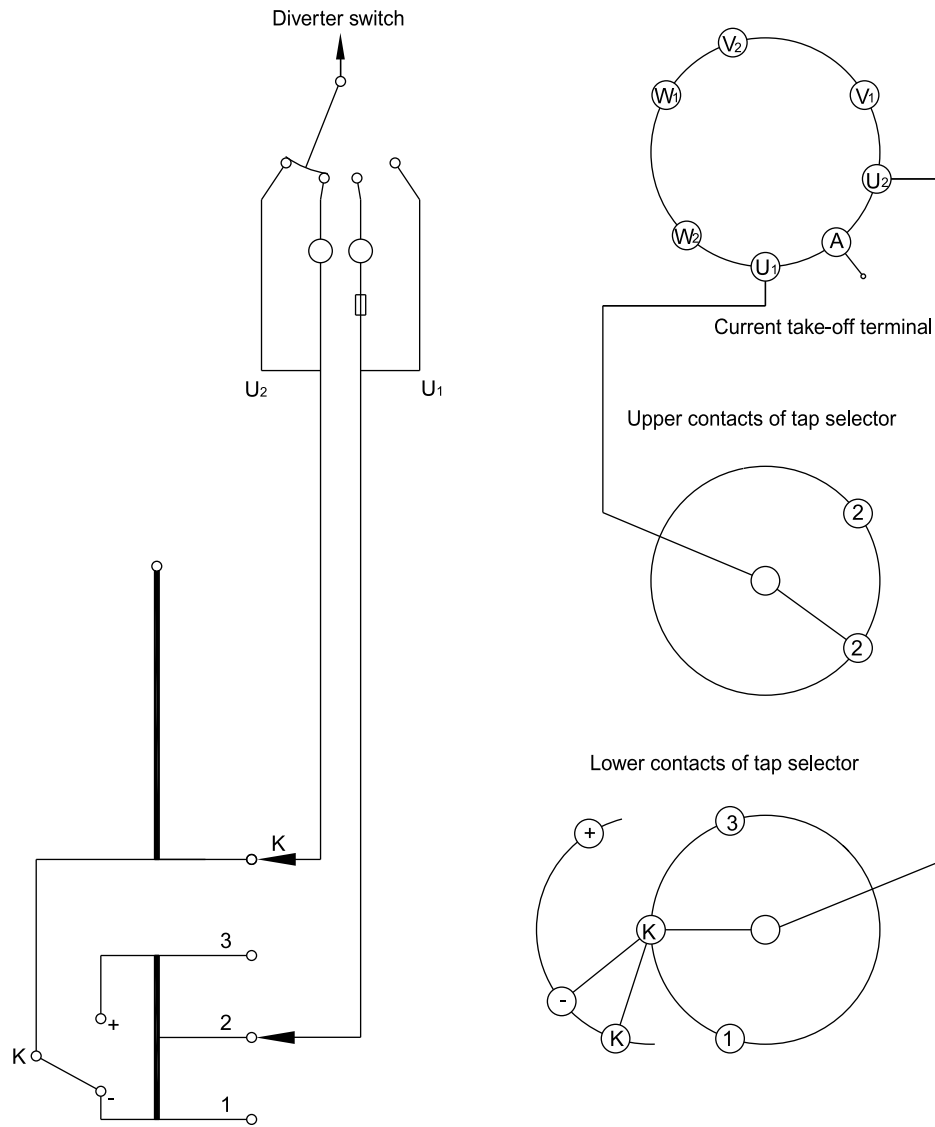
● Drawing is shown at the set position

Appendix 12. SHZV (10100) operating position table and connection diagram



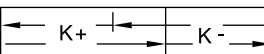
●Drawing is shown at the set position

Appendix 13. SHZV (10051W) operating position table and connection diagram



Please connect terminal 1 and "-", 3 and "+", 2 and 2 in the same phase.

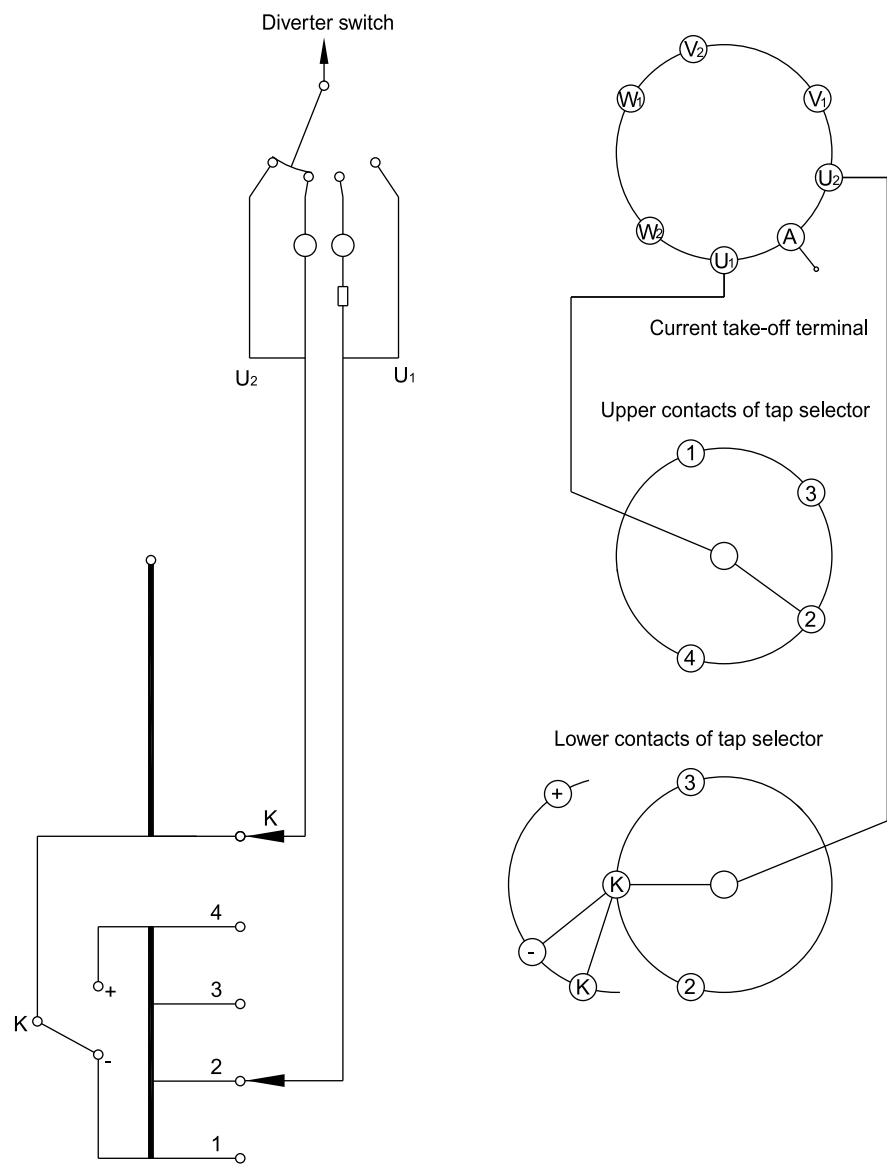
Operation position number	5
Different voltage number	5
Set position ●	3

Change-over selector					
Change-over selector location	1	2	K	2	3
Display position	1	2	3	4	5



● Drawing is shown at the set position

Appendix 14. SHZV (10071W) operating position table and connection diagram



Please connect terminal 1 and "-", 4 and "+", 2 and 2, 3 and 3 in the same phase.

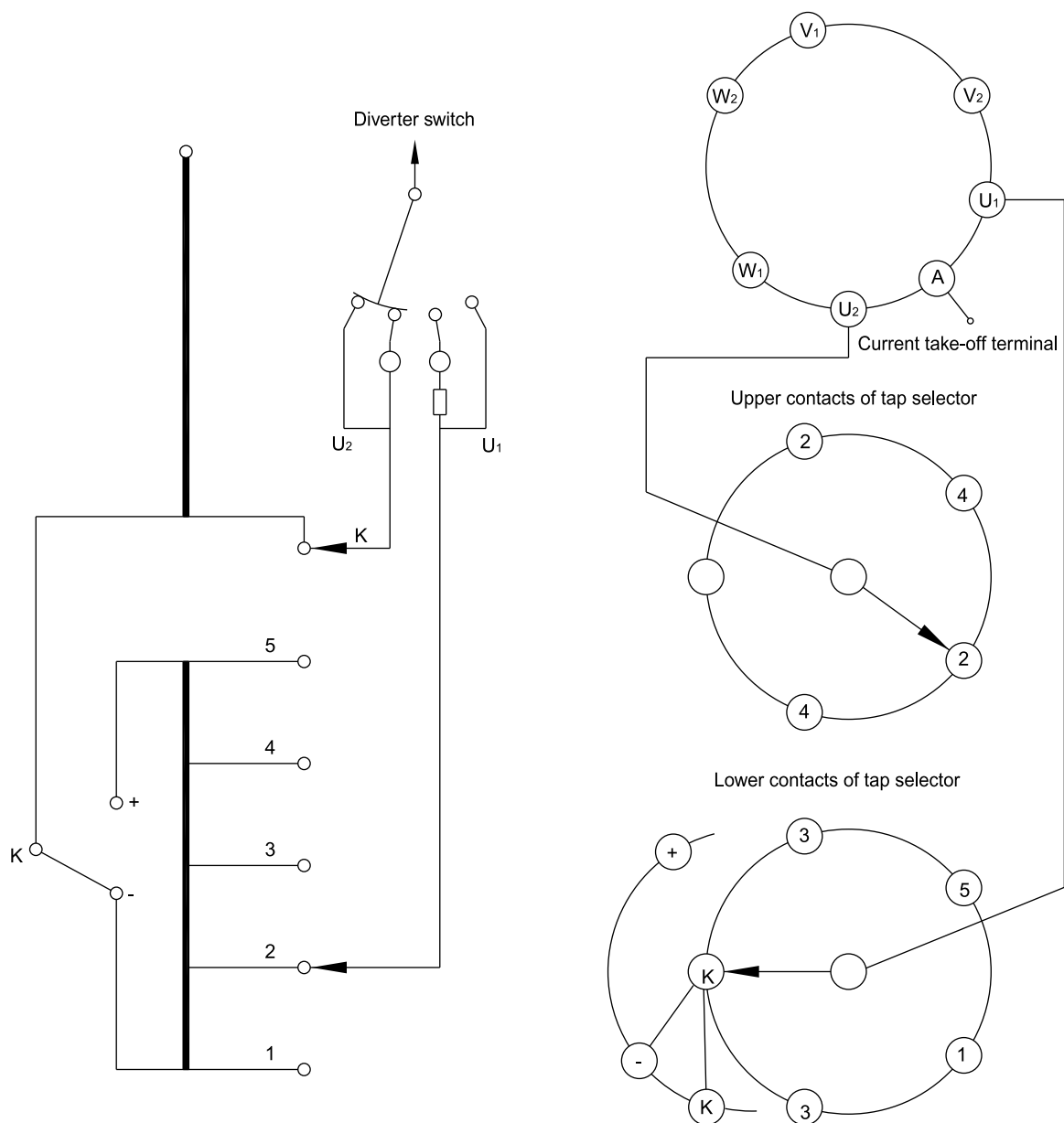
Operation position number	7
Different voltage number	7
Set position ●	4

Change-over selector	← K+ → K- →						
Change-over selector location	1	2	3	K	2	3	4
Display position	1	2	3	4	5	6	7

● ←

●Drawing is shown at the set position

Appendix 15. SHZV (10091W) operating position table and connection diagram



Please connect terminal 1 and "-", 5 and "+", 2 and 2, 3 and 3, 4 and 4 in the same phase.

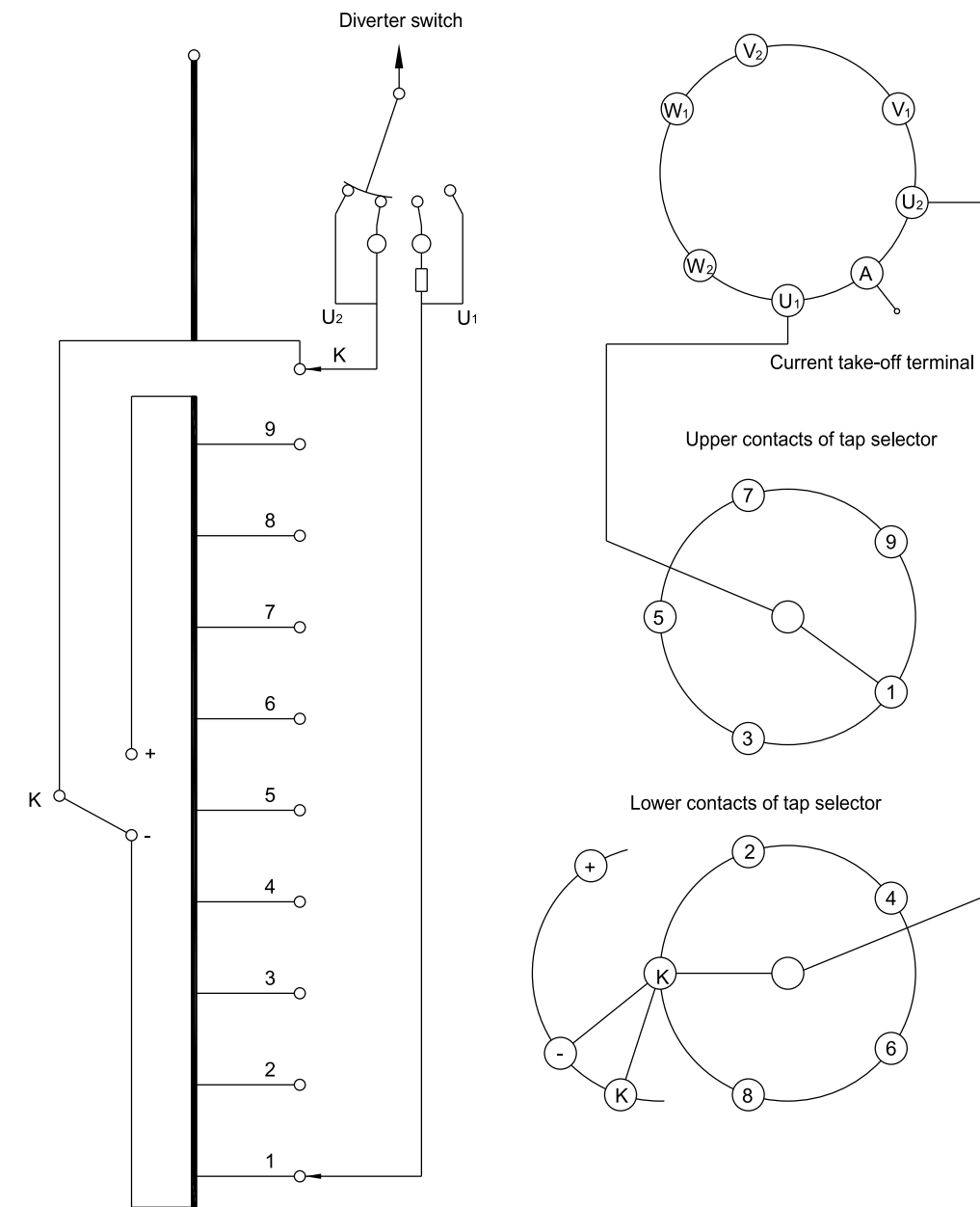
Operation position number	9
Different voltage number	9
Set position ●	5

Change-over selector	<div style="display: flex; justify-content: space-around; align-items: center;"> ← K+ → ← K- → </div>								
Change-over selector location	1	2	3	4	K	2	3	4	5
Display position	1	2	3	4	5	6	7	8	9

● ←

● Drawing is shown at the set position

Appendix 16. SHZV (10191W) operating position table and connection diagram

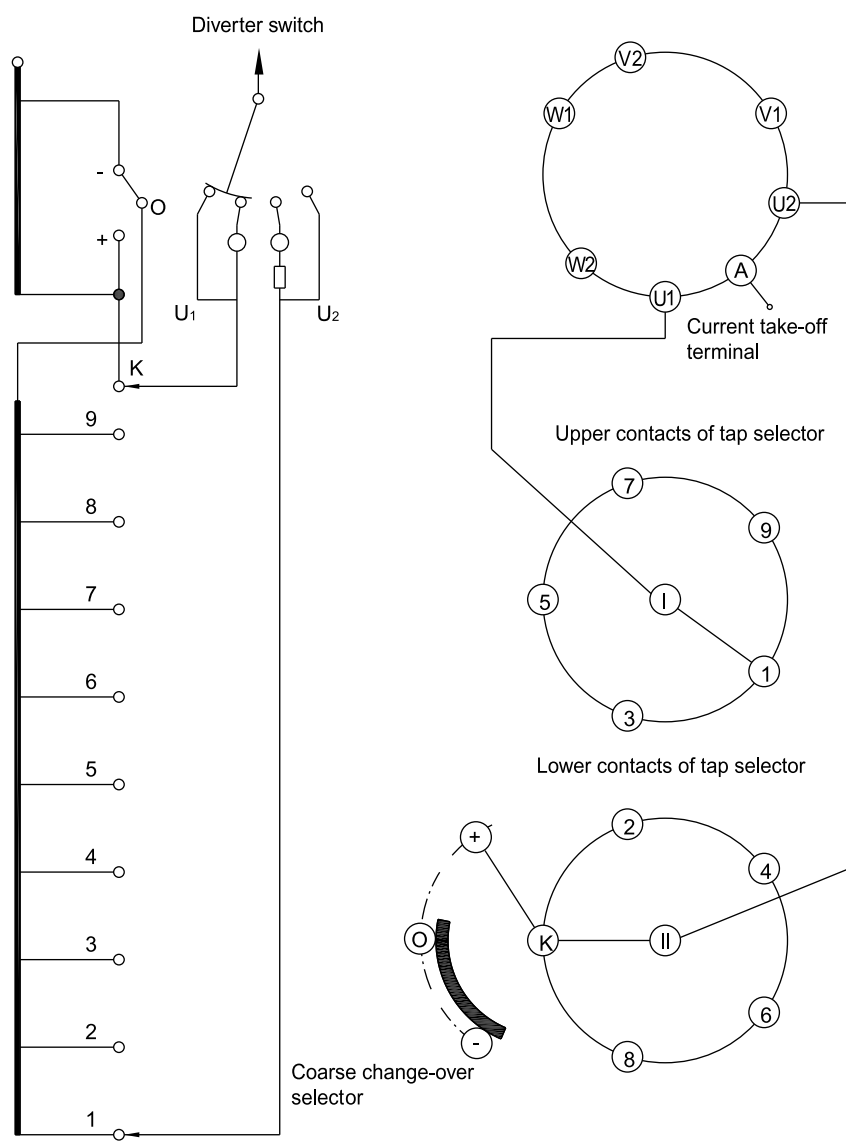


Operation position number	19
Different voltage number	19
Set position ●	10

Change-over selector	<div>← K+ →</div>										<div>← K- →</div>								
Change-over selector location	1	2	3	4	5	6	7	8	9	K	1	2	3	4	5	6	7	8	9
Display position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

● Drawing is shown at the set position

Appendix 17. SHZV (10191G) operating position table and connection diagram



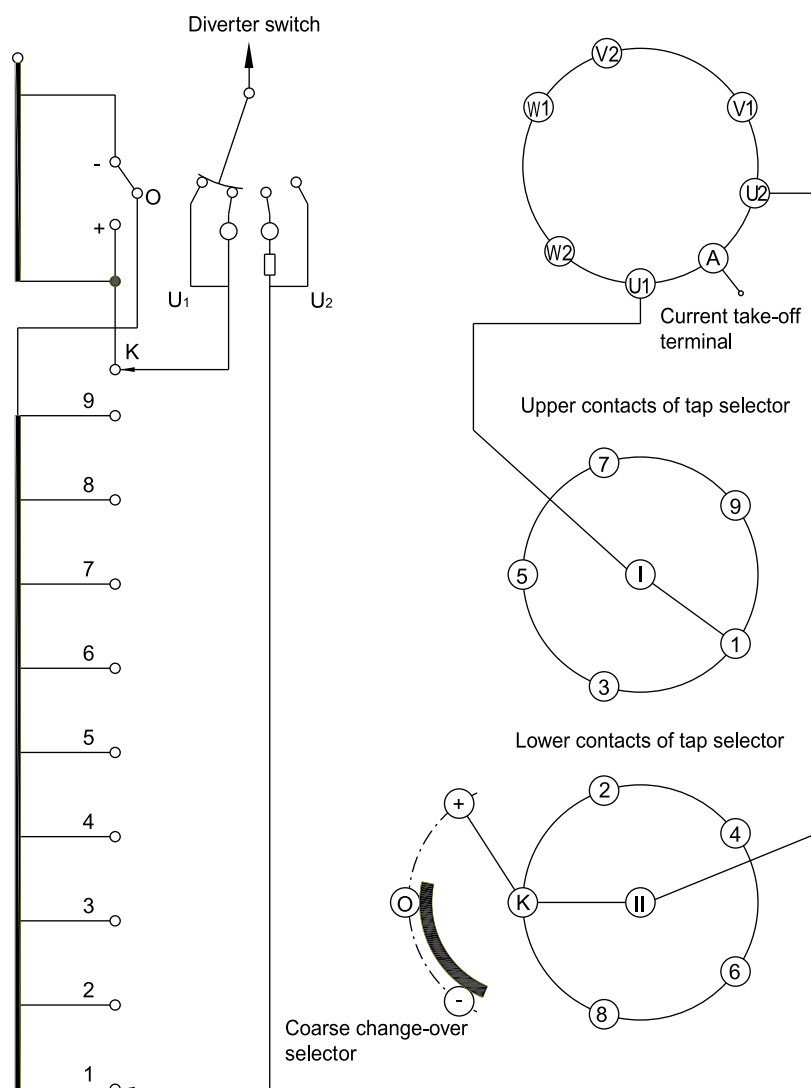
Operation position number	19
Different voltage number	19
Set position ●	10

Change-over selector	O+										O-								
Change-over selector location	1	2	3	4	5	6	7	8	9	K	1	2	3	4	5	6	7	8	9
Display position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19





● Drawing is shown at the set position

Appendix 19. SHZV (10193G) operating position table and connection diagram



Operation position number	19
Different voltage number	17
Set position ●	9b

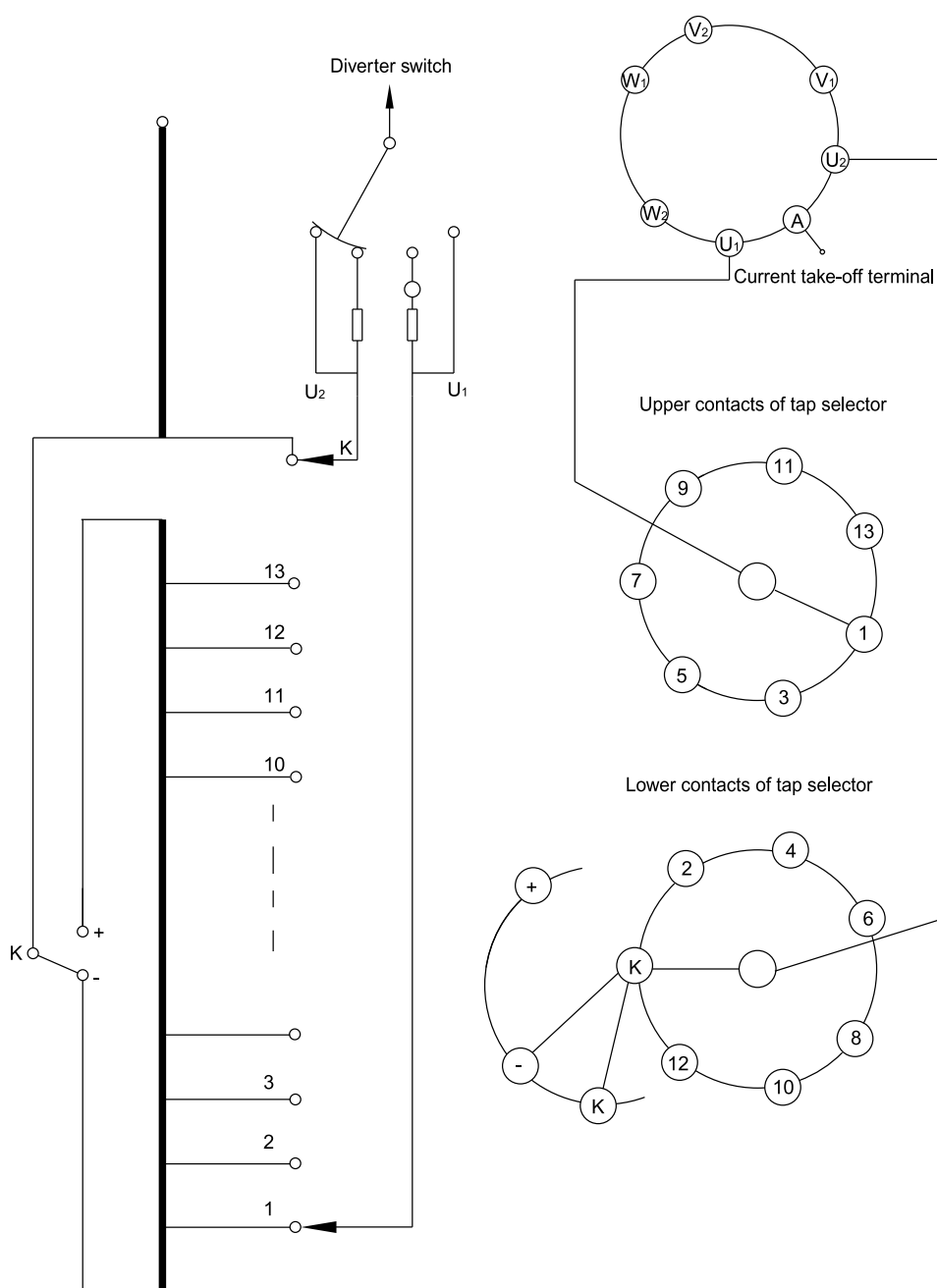
Change-over selector																			
Change-over selector location	1	2	3	4	5	6	7	8	9	K	1	2	3	4	5	6	7	8	9
Display position	1	2	3	4	5	6	7	8	9a	9b	9c	10	11	12	13	14	15	16	17



● Drawing is shown at the set position

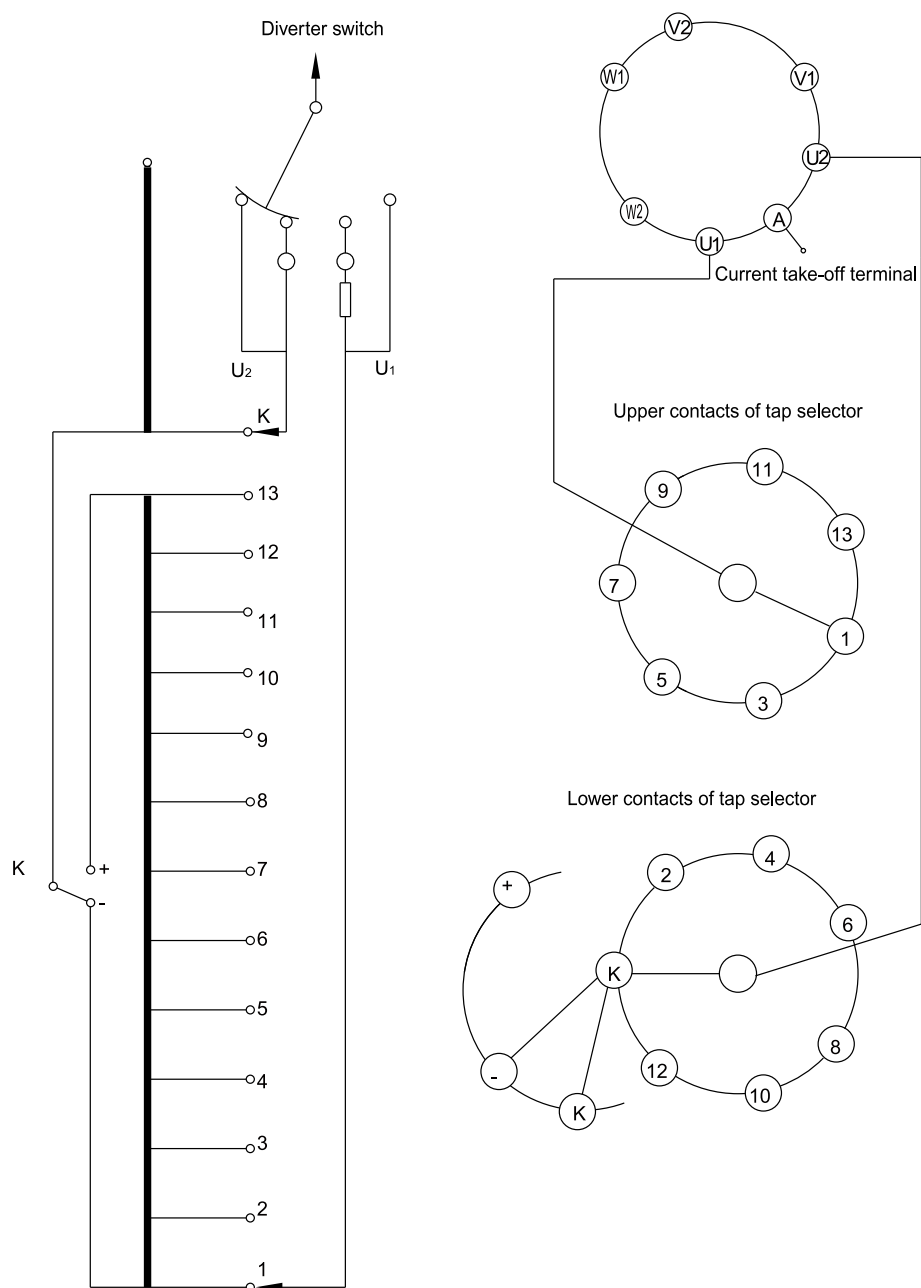
Operation position number	27
Different voltage number	27
Set position ●	14

Change-over selector																											
Change-over selector location	1	2	3	4	5	6	7	8	9	10	11	12	13	K	1	2	3	4	5	6	7	8	9	10	11	12	13
Display position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27



- Drawing is shown at the set position

Appendix 21. SHZV (14273W) operating position table and connection diagram



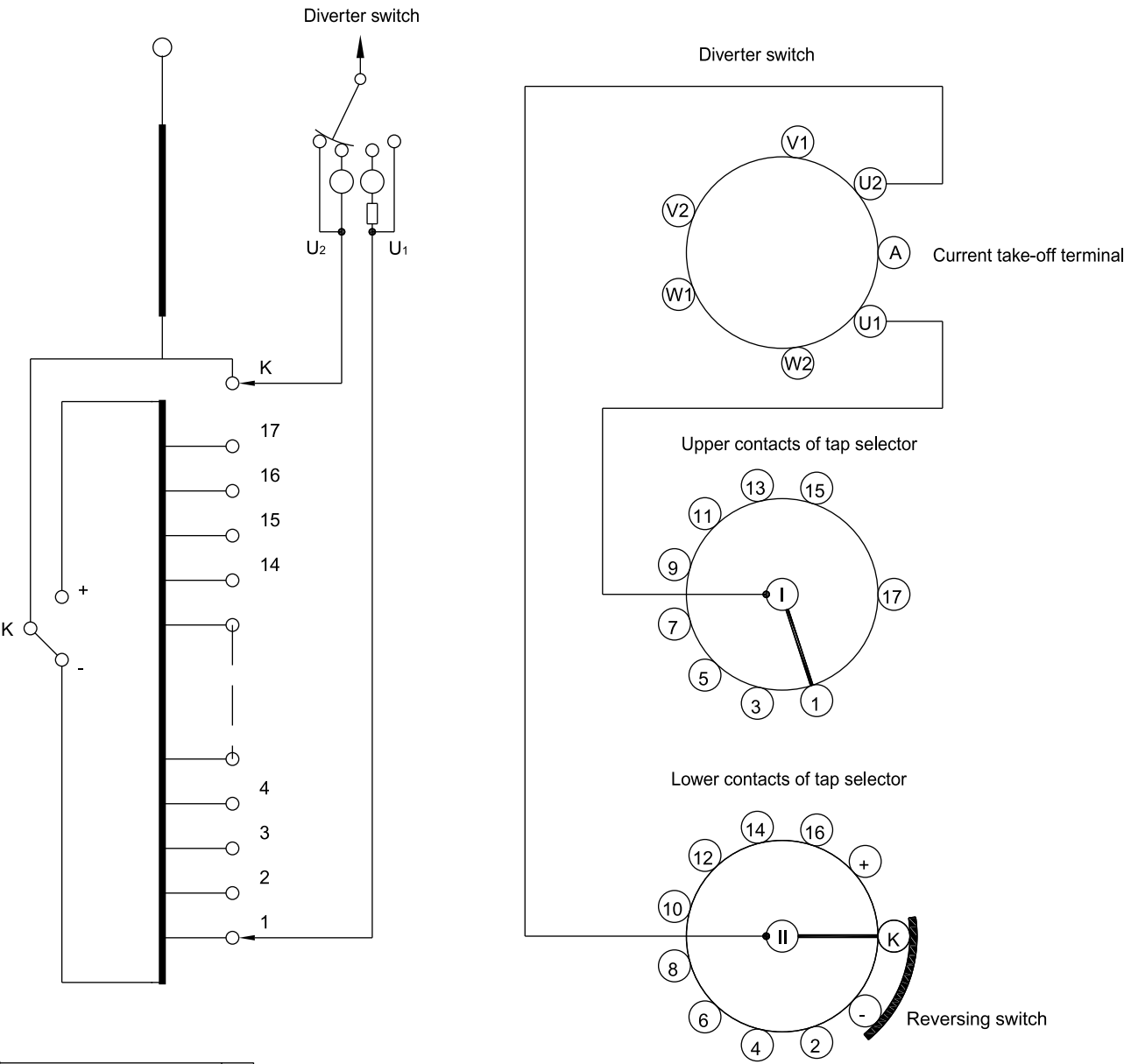
Operation position number	27
Different voltage number	25
Set position ●	13b

Please connect terminal 1 and "-", 13 and "+" in the same phase.

Change-over selector	← K+ →													← K- →													
Change-over selector location	1	2	3	4	5	6	7	8	9	10	11	12	13	K	1	2	3	4	5	6	7	8	9	10	11	12	13
Display position	1	2	3	4	5	6	7	8	9	10	11	12	13a	13b	13c	14	15	16	17	18	19	20	21	22	23	24	25

● Drawing is shown at the set position

Appendix 22. SHZV (18351W) operating position table and connection diagram



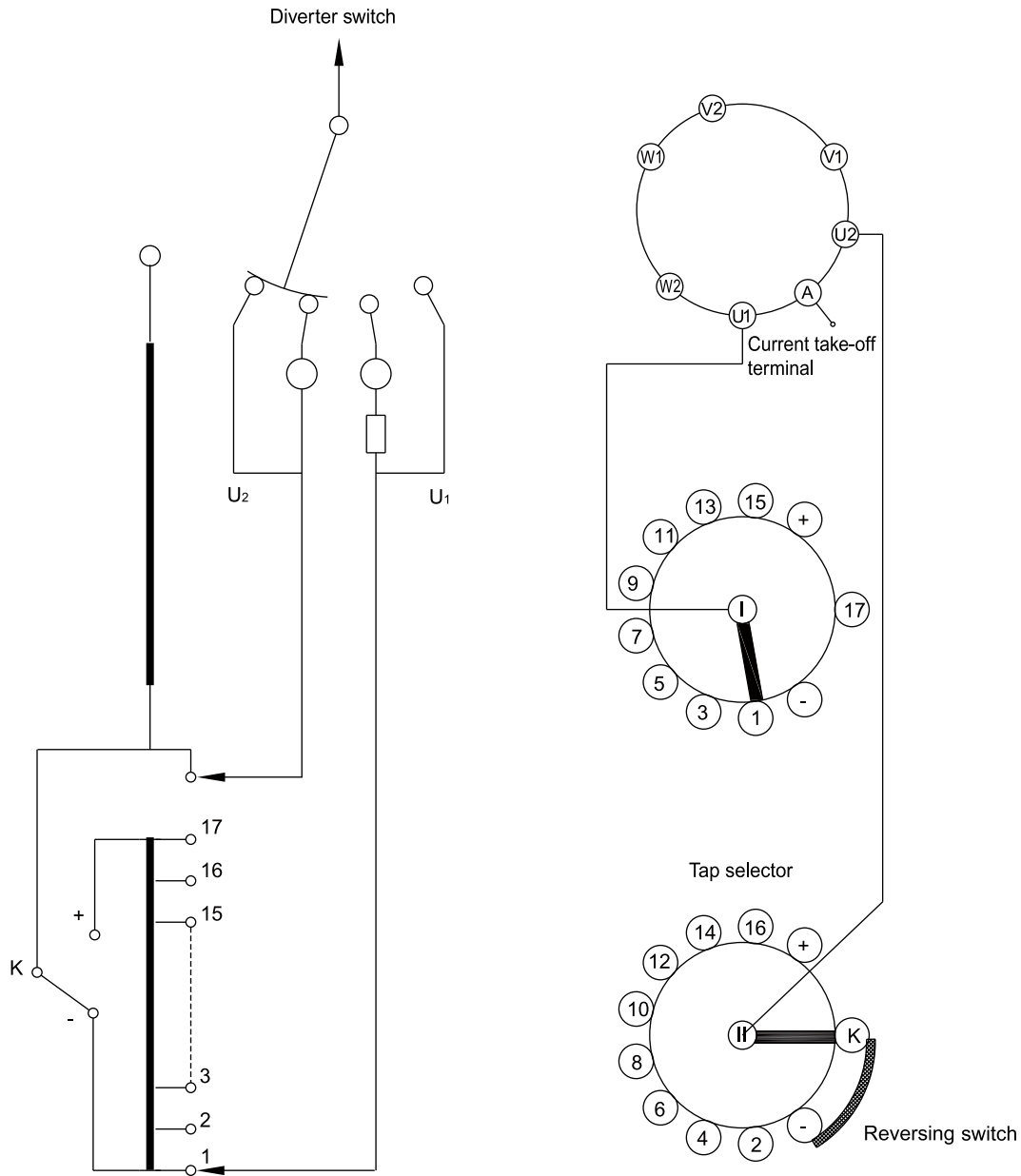
Operation position number	35
Different voltage number	35
Set position ●	18

Change-over selector	<div><div></div><div>K+</div><div></div><div></div><div>K-</div><div></div></div>																																		
Change-over selector location	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	k	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Display position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35

Note: It is suitable for cage tap selector structure only

●Drawing is shown at the set position

Appendix 23. SHZV (18353W) operating position table and connection diagram



Operation position number	35
Different voltage number	33
Set position ●	17b

Change-over selector	<div><div><div>←</div><div>K+</div><div>→</div></div><div><div>←</div><div>K-</div><div>→</div></div></div>																																		
Change-over selector location	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	K	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Display position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17a	17b	17c	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33

Note: It is suitable for cage tap selector structure only

● Drawing is shown at the set position

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