Standard Accessories for Large Capacity Transformer

Fuji Electric Co., Ltd.

CTE 042c

List of Standard Accessories

Contents

This manual covers the accessories for Fuji large capacity transformers (over 15000kVA capacity), and the construction, functions, physical characteristics, etc. of the standard accessories. Optional accessories listed in last page of this manual.

Table 1 List of standard accessories

Type of cooling system	ONAN	ONAF	OFAF	OFWF	Remarks
Nameplate	●	●	●	●	To be installed at high voltage side
Conservator	●	●	●	●	
Dehydrating breather	●	●	●	●	
Bushing	●	●	●	●	
Earthing terminal	●	●	●	●	
Terminal box for auxiliary circuit	●	●	●	●	
No-voltage tap-changer or on-load tap-changer	●	●	●	●	On-load tap-changer includes a motor drive mechanism. No-voltage tap-changer includes manual operating device on the main tank covers.
Pressure-relief device	●	●	●	●	
Buchholz relay	●	●	●	●	
Dial type thermometer	●	●	●	●	
Dial type oil level indicator	●	●	●	●	
Drain valve and vacuum valve	●	●	●	●	
Lifting lug, pulling eye and jacking boss	●	●	●	●	
Cooling equipment					
Panel type radiator	●	●	●	–	
Unit type cooler	–	–	●	–	
Oil to water heat exchanger	–	–	–	●	
Cooling fan	–	●	●	–	
Oil pump	–	–	●	●	
Oil flow relay	–	–	●	●	
Radiator valve	●	●	●	●	

Bushing

The standard specification is an ordinary type bushing, no salt-pollution, brown in colour, and no coordination gap provided for bushing.
Employed by Fuji now as transformer bushings are a solid bushing, condenser bushing and spacer.

Solid bushing (Plain bushing)

The solid bushing has the simplest construction which leaves insulation work mainly to the porcelain tube, and it is being used as the standard part of under 33kV class. Fig. 1 shows the construction. Gap between the center conductor and porcelain tube is kept filled with oil common to the transformer proper.
Fuji is ready to provide high current bushings more than listed Table 2.

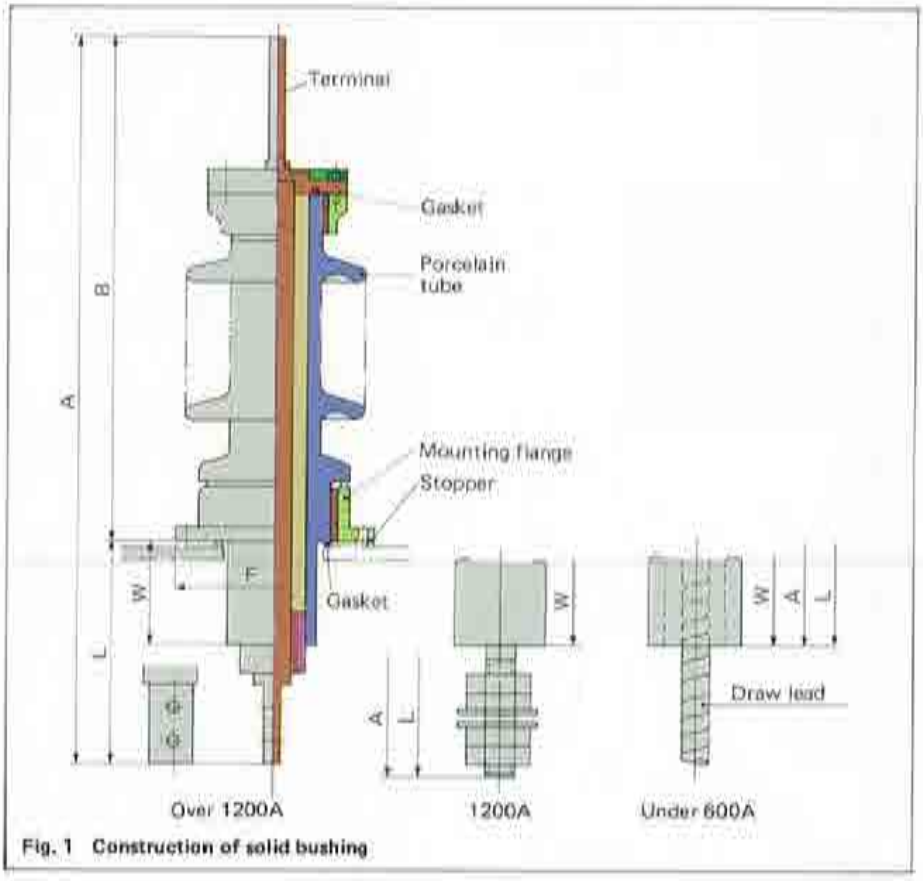


Fig. 1 Construction of solid bushing

Photo 1

Table 2 Dimensional table of solid bushings

Nominal voltage [kV] (BIL)	Rated current [A]	Dimensions [mm] (1) W(2)	A(2)	B	L(2)	Flange dia. F(3)
6.6 (60kV)	600	100 (170)	415	315	100	(133x133)
	1200	100 (170)	520	320	200	(133x133)
	2000	100 (170)	640	390	250	210
	3000	100 (170)	675	430	245	230
	4000	100	675	435	240	250
11 (90kV)	600	120 (200)	495	375	120	(143x143)
	1200	120 (200)	600	380	220	(143x143)
	2000	120 (200)	710	440	270	210
	3000	120 (200)	745	480	265	230
	4000	70 (120)	695	485	210	250
22 (150kV)	600	180 (270)	690	510	180	210
	1200	180 (270)	795	515	280	210
	2000	180 (270)	895	565	330	230
	3000	180 (270)	920	595	325	230
	4000	180 (270)	920	600	320	250
33 (200kV)	600	210 (310)	830	620	210	230
	1200	210 (310)	935	625	310	230
	2000	210 (310)	1030	670	360	250
	3000	210 (310)	1055	700	355	250

Notes:
(1) The dimensions show the bushing using no salt-pollution type porcelain tube. Moreover, for over 22kV, the bushing using a salt-resisting porcelain tube can also be manufactured.
(2) As for the dimension "W" the parenthesized dimensions are also usable according to request for installation of BCT. The dimensions "A" and "L" corresponding to the parenthesized dimensions are omitted.
(3) The parenthesized dimensions in the column "F" mean those of square flanges.

Condenser bushing

1) Oil-impregnated paper-insulated condenser bushing

This is a condenser bushing of which insulating material serving as the main body of internal insulation is composed of oil-impregnated paper.

Fig. 2 shows the construction of this condenser bushing.

The condenser core, after being wound, is made by drying it in vacuum, and deaerating and impregnating with insulating oil, and both air and oil sides are covered with porcelain tube.

The bushing has a sealed in the head chamber and an oil gauge is installed. Moreover, when using this bushing fitted horizontally, it is so constructed as to allow sealing nitrogen with a special conservator put on the mounting flange.

Photo 2 shows BIL 1050kV bushings and Photo 3 shows BIL 1800kV condenser bushing.

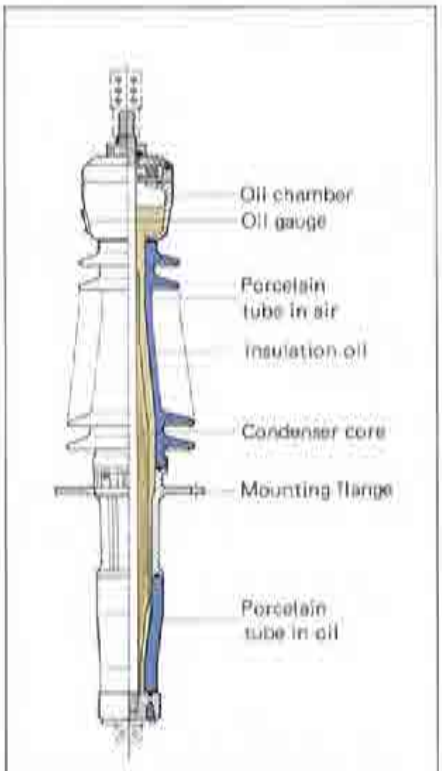


Fig. 2 Construction of oil-impregnated paper-insulated condenser bushing

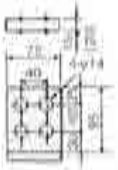
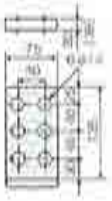
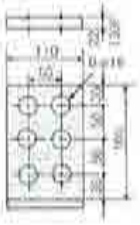
Photo 2

Photo 3

■ Dimension of top terminal

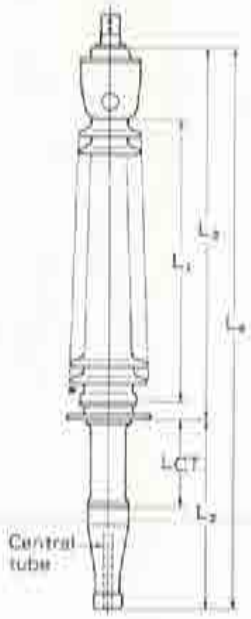
Table 3 shows the dimensions of air-side top terminals of Fuji's standard solid bushing and condenser bushing.

Table 3 Dimensions of flat terminals (Air side) [Unit: mm]

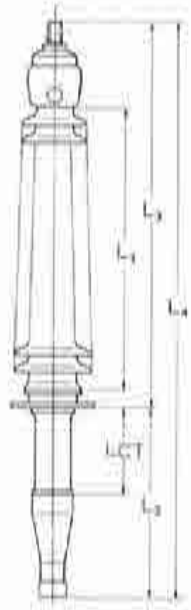
Rated current	Upper 600A~800A	1000~1250A	2000A	3000A~3150A
Dimensions of flat terminals				

Remarks.
(1) These terminals apply to the solid bushing and condenser bushing, provided the thickness of terminal for the condenser bushing is according to the parenthesized dimensions.
(2) The following will not supplied, terminal clamping hex. hd. bolt hex. nut, washer and lock washer (all of them are made of steel and galvanized or given a baked finish).
(3) These dimensions will comply with JEM-1395 (dimensions of solid bushing for transformer).

Table 4 Dimensional table of oil-impregnated paper-insulated condenser bushings

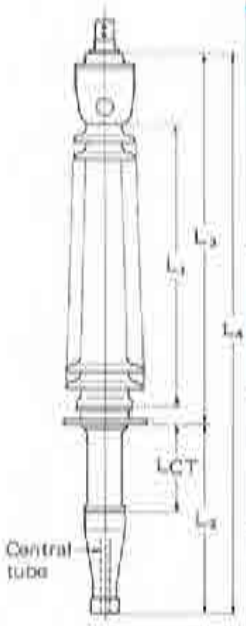


Draw lead type

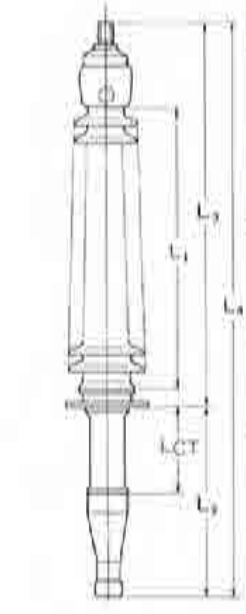


Fixed condutor type

BIL	Un	Um	VAC		In	LCT	FC		Lc and Lcp		L_1	L_2	L_3	L_4	W	
Dry lightning impulse withstand voltage [kV]	Rated voltage [kV]	Maximum line to ground voltage [kV]	Power frequency withstand voltage, 1 min. [kV]		Nominal current of bushing [A]	Space for CT [mm]	Cantilever test load, 1 min. [N]		Min. creepage distance (mm) Total (Lc) (Protected (Lcp))		Top porcelain length [mm]	Length below flange seat [mm]	Length above flange seat [mm]	Total length [mm]	Mass approx. [kg]	
			Dry	Wet			Top	Bottom	Normal type	Anti-fog type					Normal type	Anti-fog type
250	52	30	105	105	800	100	1000	2000	1090 (355)	1196 (486)	480	295	760	1055	23	23
						300						495		1255	25	26
					1250	100	1250	2500				295	870	1165	37	38
						300						495		1365	40	41
					2000	300	2000	4000				500	890	1390	60	60
					2500	300	2000	4000				500	890	1390	75	75
350	72.5	44	160	150	800	100	1000	2000	1580 (540)	1755 (740)	670	325	950	1275	30	31
						300						525		1475	32	33
						500						725		1675	33	34
					1250	100	1250	2500				325	1060	1385	46	47
						300						525		1585	48	50
						500						725		1785	55	55
					2000	300	2000	4000				530	1105	1635	75	75
						500						730		1835	80	80
					3150	300	4000	8000				530	1130	1660	95	95
						500						730		1860	105	105
450	100	58	200	195	800	100	1000	2000	2040 (700)	2820 (1445)	850	380	1130	1510	47	50
						300						580		1710	49	55
						500						780		1910	55	55
					1250	100	1250	2500				380	1240	1620	65	70
						300						580		1820	70	70
						500						780		2020	75	75
					2000	300	2000	4000				585	1285	1870	100	105
						500						785		2070	105	110
					3150	300	4000	8000				585	1310	1895	120	125
						500						785		2095	130	135
550	123	73	250	240	800	100	1000	2000	2565 (880)	3525 (1810)	1060	445	1355	1800	70	75
						300						645		2000	70	75
						500						845		2200	75	80
					1250	100	1250	2500				450	1470	1920	90	95
						300						650		2120	95	100
						500						850		2320	100	105
					2000	300	2000	4000				655	1495	2150	125	125
						500						855		2350	130	135
					3150	300	4000	8000				655	1520	2175	140	145
						500						855		2375	150	155
550	145	88	260	240	800	100	1250	2500	2565 (880)	3525 (1810)	1060	445	1355	1800	75	75
						300						645		2000	75	80
						500						845		2200	80	85
					1250	100	1600	3200				450	1470	1920	95	100
						300						650		2120	100	105
						500						850		2320	105	110
					2000	300	2500	5000				655	1495	2150	120	125
						500						855		2350	130	135
					3150	300	4000	8000				655	1520	2175	140	145
						500						855		2375	150	155
650	145	88	300	285	800	100	1250	2500	3080 (1055)	4235 (2170)	1270	505	1605	2110	100	105
						300						705		2310	105	110
						500						905		2510	105	110
					1250	100	1600	3200				505	1745	2250	125	130
						300						705		2450	130	135
						500						905		2650	135	140
					2000	300	2500	5000				735	1790	2525	155	160
						500						935		2725	160	165
					3150	300	4000	8000				735	1815	2550	175	185
						500						935		2750	185	190
650	170	102	310	285	800	100	1250	2500	3080 (1055)	4235 (2170)	1270	580	1605	2185	105	110
						300						780		2385	115	115
						500						980		2585	115	120
					1250	100	1600	3200				580	1745	2325	135	140
						300						780		2525	140	145
						500						980		2725	145	150
					2000	300	2500	5000				735	1790	2525	155	160
						500						935		2725	160	165
					3150	300	4000	8000				735	1815	2550	180	185
						500						935		2750	185	190



Draw lead type



Fixed conductor type

BIL	Un	Uy	VAC		VSI	In	LCT	Fc		Lc and Lcp		L_1	L_2	L_3	L_4	W	
Dry lightning impulse withstand voltage [kV]	Rated voltage [kV]	Maximum time to ground voltage [kV]	Power frequency withstand voltage, 1 min. [kV]		Wet switching impulse withstand voltage [kV]	Nominal current of bushing [A]	Space for CT [mm]	Cantilever test load 1 min. [N]		Min. creepage distance (mm) Total (Lc) (Protected (Lcp))		Top porcelain length [mm]	Length below flange [mm]	Length above flange [mm]	Total length [mm]	Mass approx. [kg]	
			Dry	Wet				Top	Bottom	Normal type	Anti-fog type					Normal type	Anti-fog type
750	170	102	365	350	–	800	100	1250	2500	3615 (1235)	4960 (2540)	1500	580	1875	2455	120	125
							300						780		2655	125	130
							500						980		2855	130	135
						1250	100	1600	3200				580	1980	2560	155	155
							300						780		2760	160	165
							500						980		2960	165	170
						2000	300	2500	5000				785	2025	2810	185	190
							500						985		3010	195	200
						3150	300	4000	8000				785	2045	2830	210	215
							500						985		3030	215	225
850	245	146	365	360	–	1250	300	1600	3200	4275 (1470)	5870 (3025)	1750	840	2175	3015	230	240
							500						1040		3215	235	245
						2500	300	2500	5000				855	2290	3145	295	305
							500						1055		3345	305	315
						3150	300	4000	8000				855	2315	3170	295	305
							500						1055		3370	305	315
950	245	146	400	395	–	1250	300	1600	3200	4780 (1650)	6570 (3385)	1950	905	2375	3280	250	265
							500						1105		3480	260	270
						2500	300	2500	5000				920	2490	3410	320	335
							500						1120		3610	335	345
						3150	300	4000	8000				920	2515	3435	320	335
							500						1120		3635	335	345
1050	245	146	485	460	–	1250	300	1600	3200	5440 (1885)	7485 (3870)	2200	905	2630	3535	285	300
							500						1105		3735	290	305
						2500	300	2500	5000				920	2745	3665	360	370
							500						1120		3865	370	380
						3150	300	4000	8000				920	2770	3690	360	370
							500						1120		3890	370	380
	300	173	485	460	750	1250	300	1600	3200			2200	920	2660	3580	320	335
							500						1120		3780	325	340
						2500	300	2500	3000				935	2745	3680	395	405
							500						1135		3880	405	415
						3150	300	4000	8000				935	2770	3705	395	405
							500						1135		3905	405	415
1175	300	173	610	610	850	1250	300	1600	3200	6145 (2115)	8445 (4355)	2500	1035	2975	4010	390	405
							500						1235		4210	400	415
						3150	300	4000	8000				1045	3120	4165	475	490
							500						1245		4365	490	510
	362	220	520	610	850	1250	300	4000	8000				1035	3010	4045	440	455
							500						1235		4245	450	465
						3150	300	5000	10000				1045	3155	4200	530	550
							500						1245		4400	540	560
1300	362	220	570	570	950	1250	300	4000	8000	6945 (2420)	9565 (4960)	2800	1100	3310	4410	490	510
							600						1400		4710	510	530
						3150	300	5000	10000				1120	3455	4575	590	610
							600						1420		4875	620	640
1425	420	242	630	630	1050	1600	300	4000	8000	7650 (2655)	10525 (5445)	3100	1250	3780	5030	700	720
							600						1550		5330	730	750
						3150	300	5000	10000				1270	3925	5195	850	870
							600						1570		5495	880	910
1550	550	318	690	680	1175	1600	300	4000	8000	8460 (2950)	11655 (6050)	3400	1400	4120	5520	880	910
							600						1700		5820	920	940
						3150	300	5000	10000				1420	4265	5685	1050	1080
							600						1720		5985	1090	1120
1675	550	318	750	740	1175	1600	300	4000	8000	9165 (3185)	12615 (6535)	3700	1400	4420	5820	930	960
							600						1700		6120	970	1000
						3150	300	5000	10000				1420	4565	5985	1110	1140
							600						1720	4575	6295	1160	1190
1800	550	318	790	790	1300	1600	300	4000	8000	9975 (3480)	13745 (7140)	4000	1470	4720	6190	1000	1030
							600						1770	4730	6500	1040	1070
						3150	300	5000	10000				1490	4875	6365	1180	1210
							600						1790		6665	1230	1260

2) Synthetic-resin-bonded paper-insulated condenser bushing

This is a condenser bushing of which insulating material serving as the main body of internal insulation is composed of synthetic resin paper.

Photo 5 shows the construction of this bushing. The center conductor, insulating paper and condenser film are completely made into one integral piece, and thereon a flange is fitted.

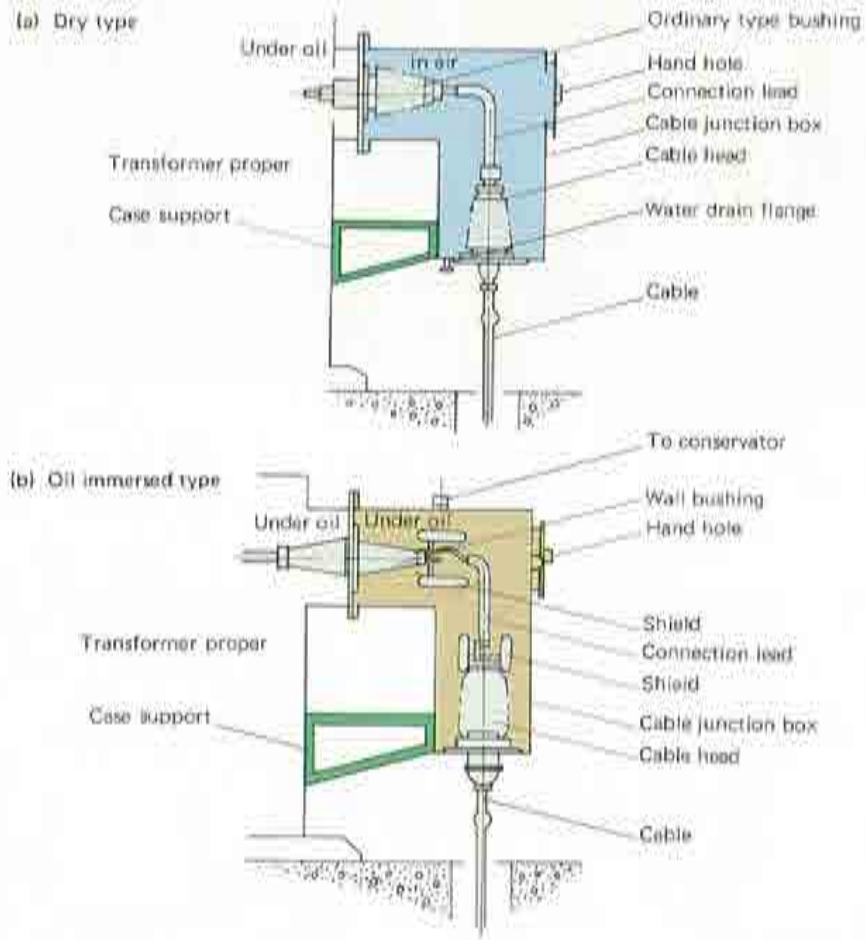
Therefore, this bushing can be assembled for oil to oil or oil to SF_6 connecting construction.

They are employed for an insulation level (BIL) of over 350kV and selected according to the purpose of use.

Photo 4 Oil-filled type cable junction box

Photo 5

Fig. 5 Cross sections of cable junction box



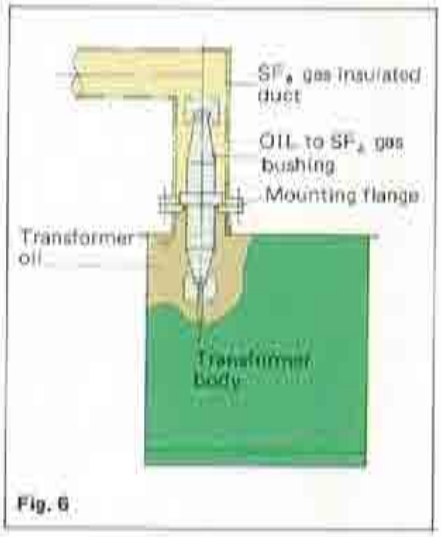


Fig. 6

Spacer

The wall type condenser bushing has been used for some time for connection between a transformer leadwire and a cable or GIS. But with this method the connecting part must be made quite long, and the leadout of leadwires becomes complicated in a place where space is limited such as a pumping-up power station or underground substation. This spacer consists of epoxy molded resin and its interior includes the electrostatic shields for alleviating an electric field. Use of the spacer enables greatly reducing the size of this part. It can be used for the following purposes:

- As a partition between oil-immersed equipment such as cable junction box (corresponding to oil-immersed wall bushing)
- As a partition between oil-immersed and gas equipment such as GIS

Photo 6 Spacer

Photo 7 Long-term energized test status

Fig. 7

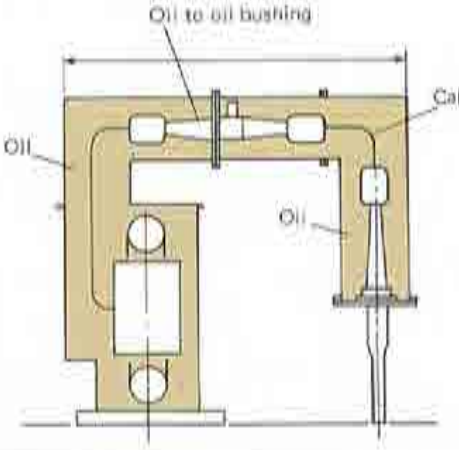


Fig. 8

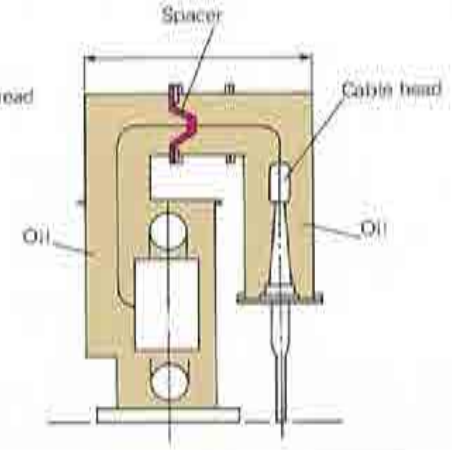
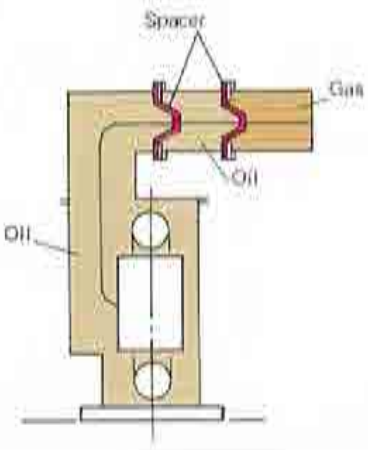


Fig. 9



No-voltage Tap-changer

No-voltage tap-changer is used for changing over taps for voltage regulation after the transformer has been put in no-voltage condition, and it consists of a changeover part and operating device. For the no-voltage tap-changer, the following two types are available; cage and revolving. They are used according to the scope of applications given in Table 6. The contact is made from copper or copper alloy and tinned for preventing copper sulfide from forming due to active sulfur contained in oil, thus permitting stable contact at all times.

Table 6 Applications of various types of tap-changers

Scope of application / Type of tap changer	Nominal voltage	Rated current	No. of taps
Cage type	Under 30kV	Under 1050A	Under 5
Revolving type	Over 30kV	Under 1000A	Under 5

Cage type no-voltage tap-changer

This cage type is used for transformers with nominal voltage class of under 30kV. Photo 11 shows an example of the construction. The fixed contact is installed on insulating shafts arranged on the circumference, and the moving contact is of clip type which holds the fixed contact from both sides and is secured to the insulating rotary shaft at the center. When this rotary shaft is turned, the moving contact shorts two fixed contacts and taps are changed over in turn. Since the cage type is small and the insulation class is low, it is usually installed in the upper space of core.

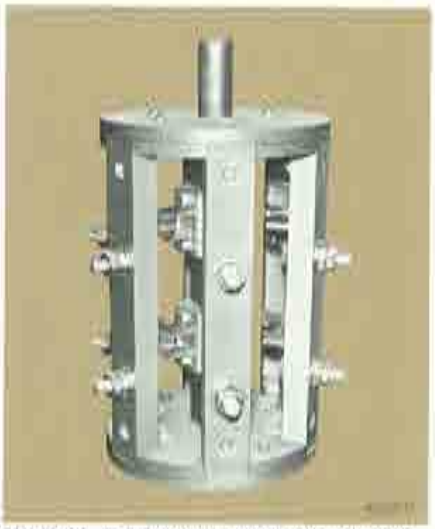


Photo 11 Cage type no-voltage tap-changer

Revolving type no-voltage tap-changer

This revolving type is used for transformers with insulation class of over 30kV. Since the nominal voltage class is high, the contact is cylindrical and the whole unit is made compact, as shown in Photo 13. It is so arranged that the cylindrical moving contact shorts two round fixed contacts with the specified contact pressure by a spring. The outside of each fixed contact is covered with an insulating cylinder in order to raise the insulation strength.
It is installed at the space between winding and tank.

Photo 12

Photo 13 ▶ Revolving type no-voltage tap-changer

Operating device of no-voltage tap-changer

In the no-voltage tap-changer, the tap changing frequency is less than in the on-load tap-changer, and therefore this operating device is fitted atop the transformer cover as a standard. Fig. 11 shows the construction of operating device of cage type and revolving type no-voltage tap-changers. When changing taps, the supplied handle may be fitted onto the operating shaft after removing the operating device cover, and the shaft may be turned to the specified tap position upon loosening the setting bolt. On the operating device, a tap position indication plate is fitted, which bears the same symbol as the tap symbol given on the transformer nameplate. On completion of operation, the setting bolt should be screwed in conforming to the guide hole. Oil-tightness at the shaft thru-part is maintained with an oil seal as shown in Fig. 11. Further, a gasket is provided even at the cover section of operating device to allow transformer operation without any trouble even in case of an oil leak. Thus, a so-called double seal construction is adopted. According to request, it is also possible to arrange so that the tap changing operation can be made on the ground by mechanical device as shown in Photo 15. Moreover, a no-voltage tap-changer should never be operated when the transformer is in excited condition. To prevent the tap changer from working with the transformer excited, it is also possible to arrange so that circuit breaker is not closed while no-voltage tap-changer is in operation, by interlocking with the operating circuit of circuit breaker.

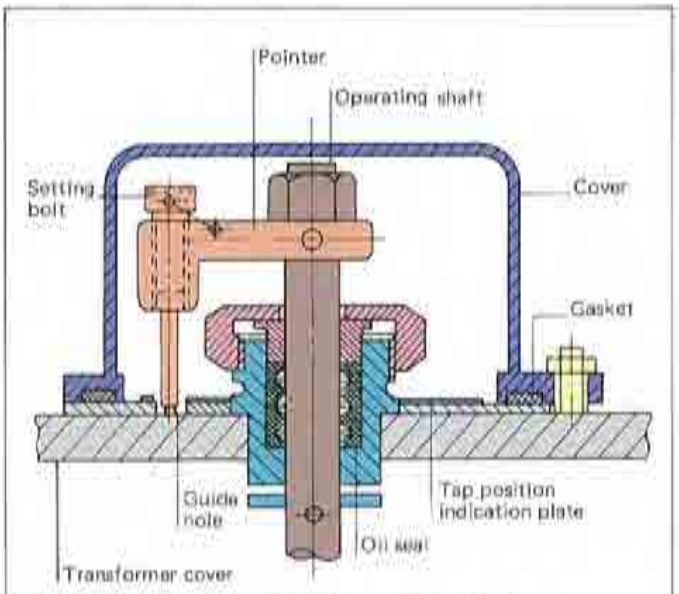


Fig. 11 Operating device of cage type and revolving type no-voltage tap-changers

Photo 14

Photo 15 Mechanical device of operating on the ground.

Cooling Equipment

The cooling systems of oil-immersed transformers are classified as shown in Table 7. Description of the accessories used for ordinary oil-immersed transformers is given.

Table 7 Cooling systems of oil-immersed transformers

- Oil-immersed type
  - Oil natural circulation type
    - Oil-immersed natural-cooled type
    - Oil-immersed forced-air-cooled type
  - Oil forced circulation type
    - Forced-oil natural cooled type
    - Forced-oil forced-air-cooled type
      - Low noise cooler
      - Ordinary noise cooler
    - Forced-oil water-cooled type

Panel type radiator

The self-cooled radiator is generally used for the oil-immersed natural cooled (ONAN) transformers, and in addition, it is used for oil-immersed forced-air-cooled type (ONAF) with cooling fans installed on the radiator, and for forced-oil natural-cooled type (OFAN) or forced-oil forced-air-cooled type (OFAF) with oil pumps combined. This radiator serves to disperse heat produced in the transformer core and/or winding to the atmosphere with the natural convection of oil, convection of air and radiating action.
A panel type radiator is used as a standard for the natural cooled type. The panel type is made by seam-welding sheets and is installed on the transformer tank with the connecting pipe from the header.
Moreover, since a radiator valve is fitted at the bottom of radiator, it is possible to mount and demount the radiator with oil to cover the core and windings in the tank during field assembly. The construction of this panel type radiator is thus simple, eliminating cumbersome procedures in maintenance. The radiator is very dependable and durable and used most widely for oil-immersed transformers.

Oil-immersed forced-air-cooled type improves the heat transfer rate at air side by blowing air forcibly and raises the cooling efficiency, with the cooling fans fitted to the radiator.
The cooling fans are installed on the side or the under of radiator as shown in Fig. 12 and Photo 16.

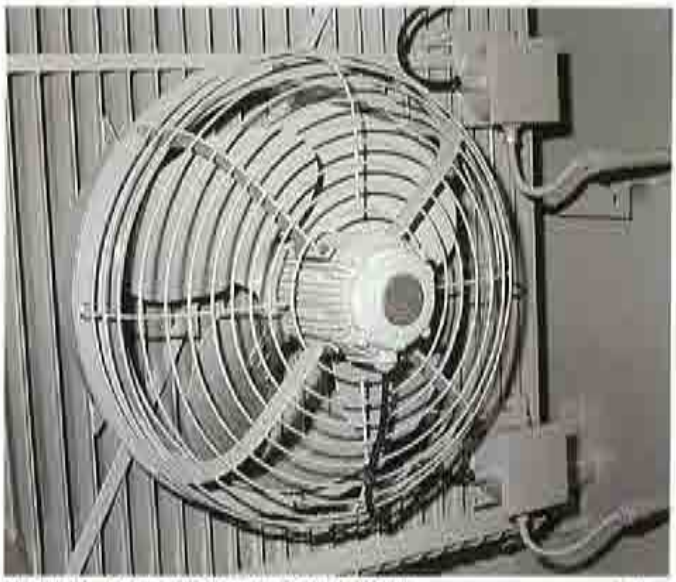


Photo 16 Cooling fan fitted to the radiator

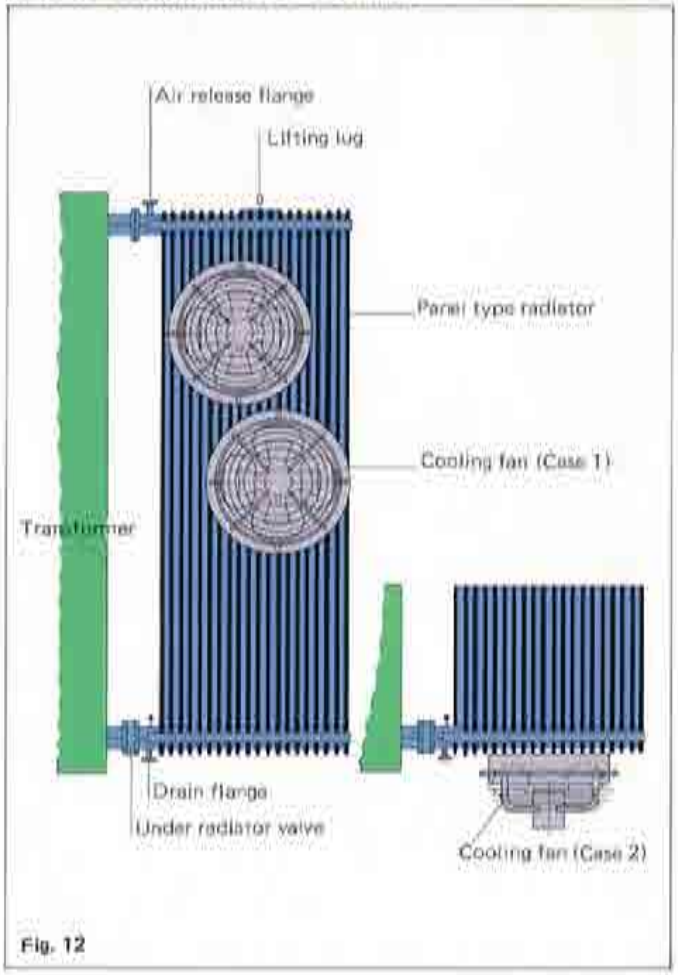


Fig. 12

Photo 17 Separately installed forced-oil self-cooled type radiator

In the oil-immersed forced-air-cooled type for economical operation of the transformer, it is also possible to utilize the natural cooled operation mode when load is low, and actuate the cooling fans by energizing the thermal relay according to the temperature rise of oil when load increases. And where necessary, a step can be taken to divide the cooling fans into a few groups for further raising the operational efficiency. Forced-oil natural-cooled type is mainly used as a separate type cooler for large-capacity transformers with specification for very low noise and an example is shown in Photo 17. That is, with oil convected forcibly through the oil pump and a proper oil velocity ensured in the core and/or winding, heat transfer rate to oil is enhanced and at the same time loss in the piping between transformer and separately installed forced-oil natural-cooled radiator is compensated. In this case however, not much improvement in the cooling efficiency of the radiator itself can be expected since the air side is given a natural cooling. The self-cooled type radiator can also be changed to a forced-oil forced-air-cooled type by combining an oil pump and cooling fans with the radiator. Compared with the forced-oil forced-air type cooler, however, the amount of materials and installing space increase although a great self-cooling capacity is ensured. For this reason, such type is not employed in general except in special cases.

Forced-oil forced-air-cooled unit type cooler

Some times, forced-oil forced-air unit cooler are emploied for large capacity transformer. This is because it provides greater reduction in weight and installing space than the oil-immersed natural cooled type. The forced-oil forced-air-cooled type cooler is a kind of heat exchanger which uses air as a cooling medium and cools the transformer oil circulating in the radiator tube by blowing air upon the tube forcibly through the cooling fans. Fig. 13 shows the construction. Herein, the cooler of ordinary noise level is described; for one of low noise level, refer to the separate data. For the radiator tube, a finned one is usually used.

Temperature difference between air and oil depends on the flow rate of air and oil. However, lessening the temperature difference simply by increasing the flow rate will cause loss in the auxiliaries and increase in noise. To improve the characteristics of cooler, the heat transfer rate of air and oil may be raised. This rate is determined chiefly by the flow velocity of air and oil, and therefore it can be selected properly from the relation with noise.

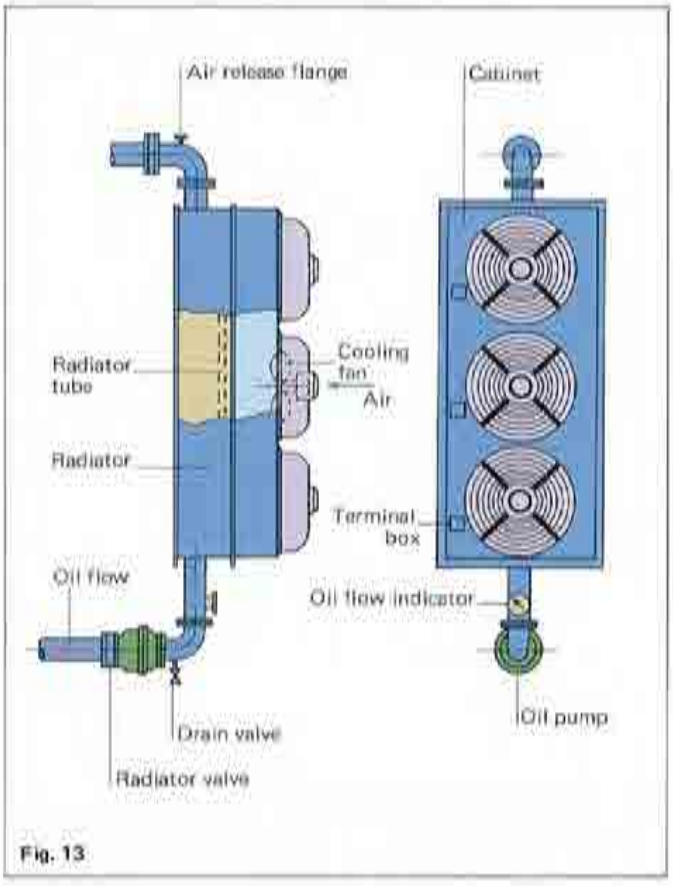


Fig. 13

Parts of unit type cooler

1) Fin tube

For the forced-oil forced-air type cooler, Type EF radiator using fin tube (Photo 18) is employed as a standard. This fin tube is made by putting a steel pipe and many tapered disc fins together into an integral unit, and it has superior heat transfer property and durability. The tube is made of the material for boiler steel tube to facilitate the welding and assembly work, and each fin is made of corrosion resisting aluminum.
The radiator tubes are arranged in the form of an equilateral triangle (zigzag) and welded directly on the top and bottom headers. Since the fins are made of alminum, proper counter-measures are taken for singular corrosion or electro-corrosion at the ends of steel pipe and fins. In particular, the fin surface is provided with a tough oxide film by a forming treatment for ensuring a great corrosion-proofing effect.

Photo 18 Fin tube

2) Cooling fan

Photo 19 shows the external view of cooling fan. The impeller is given a proper twist in order to reduce noise without decreasing air volume. The impeller is coupled directly with a three-phase induction motor and kept dynamically and statically balanced with the motor. A weather-proof, totally-enclosed motor is employed taking outdoor use into account, and therefore there is no possibility of ingress of moisture into it. The bearing used is also of dust-proof and water-proof type, and lubrication-free and grease sealed.

Photo 19 Cooling fan

3) Oil pump

Fig. 14 shows the construction of oil pump. In this centrifugal pump, the impeller with many curved vanes installed in the casing is rotated by a three-phase induction motor and energy is given to the transformer oil through the centrifugal action of pump. The transformer oil is sucked up from the center by rotation of the impeller, given kinetic energy and pressure energy, flows out of the edge of impeller and is fed out via the spiral chamber installed outside the impeller.
As the motor remains immersed in oil, cooling of motor and lubrication of bearing are done together by the oil, thus eliminating the need for periodical lubrication of the bearing.

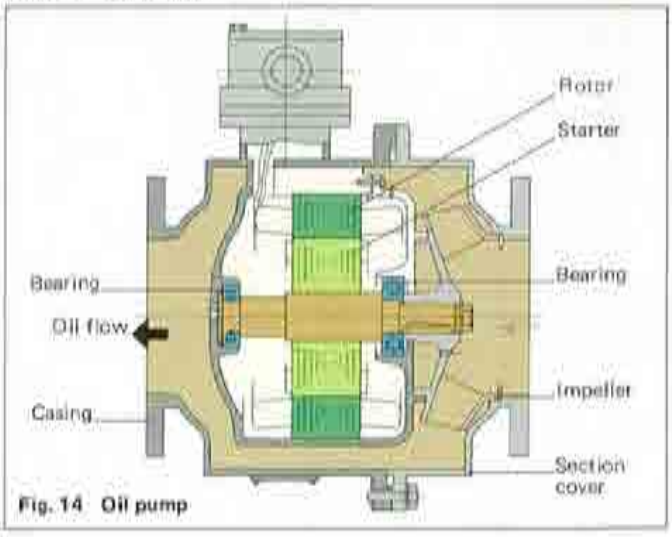


Fig. 14 Oil pump

4) Oil flow indicator

The oil flow indicator shows whether the oil pump is operating or stopped and also shows oil flowing condition and it is fitted in the vicinity of oil pump. Photo 20 shows the external appearance of oil flow indicator. The blade installed in the measuring passage is turned by oil flow, and the turning angle of this blade is indicated through the magnetic coupling. Because of using this magnetic coupling, there is not through part in the shaft, and no possibility of oil leak. The needle indicates "Stop" or "Run". A microswitch is provided which turns to "Close" when the needle is at "Stop". The terminals are fitted in a terminal box mounted on the side of indication section.

Photo 20 Oil flow indicator

Oil to water heat exchanger

The feature of this type of heat exchanger is that both fluid at high temperature side (oil) and that at low temperature side (water) are liquid, and the unit can be made most compact. Photo 21 shows a 500MVA power transformer made compact as a result of employing this type of heat exchanger. The consists of a shell drum, heating tube, tube plate, partition and oil guide, as shown in Fig. 15. Cooling water is flowed inside the heating tube and oil is run to the shell drum side. For preventing thermal stress arising from temperature difference between oil and water from being generated between shell drum and heating tube, a slide system has been employed as a standard, which permits one end of tube plate to move freely in axial direction without securing to the shell drum. For the heating tube, a phosphorus-deoxidized copper seamless tube is used as a standard.

The tube plate, too, is so selected as to comply with the material of heating tube, and both are fitted securely to each other with an expanding system.

At present vertical and horizontal type coolers are available and are used depending on the installing conditions of transformers.

If the quality of cooling water used is improper, the heating tube corrodes and the service life is seriously shortened. Therefore, Fuji has provided a standard for the quality of cooling water and always examines it before the cooling water is used. It is therefore requested to consult with Fuji when planning to employ such a cooler.

The correct maintenance and checks of the cooler are very important in terms of improving cooling efficiency and securing reliability. Fuji therefore recommends checking and cleaning at least once every 6 to 12 months.

The same oil pump and oil flow indicator as used for the forced-oil forced-air-cooled type are attached as a standard.

Photo 21

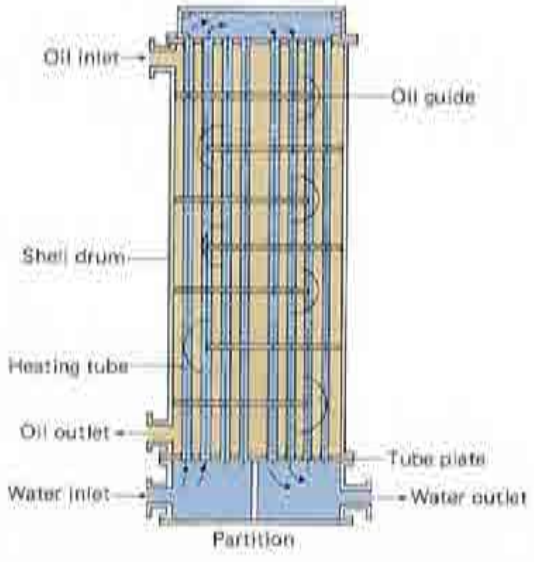


Fig. 15 Sectional view of oil to water heat exchanger

Oil Preservation System

Conventional type conservator

Insulation oil sealed in the transformer changes volumentrically according to variation in its temperature arising from changes in the atmospheric temperature and/or transformer load. The oil reservoir space necessary for this volumetric change is a conservator.
This is conventional type conservator as shown in Fig. 16.
According to request, it is also possible to supply the rubber bag or diaphragm-seal type conservator.

Photo 22

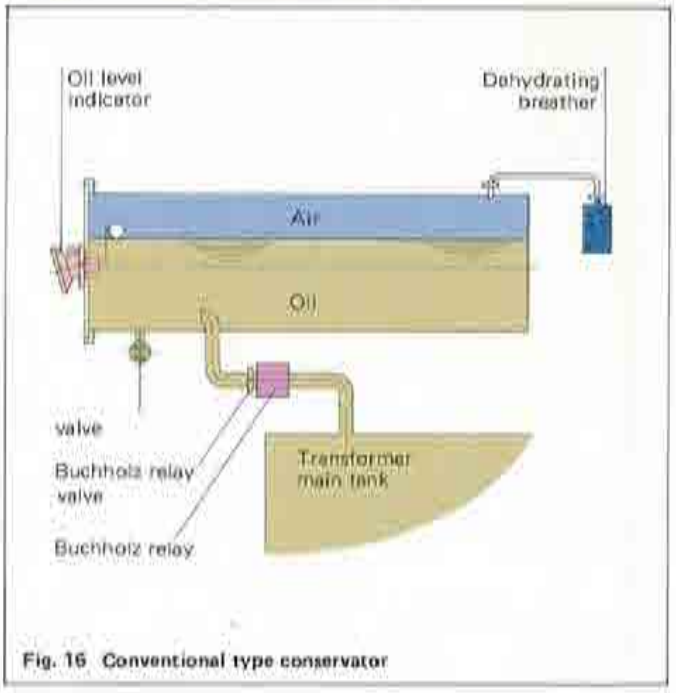


Fig. 16 Conventional type conservator

Oil Level Indicator

One side of the conservator, a dial type oil level indicator is installed. Fig. 17 illustrates the configuration of dial type oil level indicator. It is so constructed as to put a float on the oil surface, transfer the up-and-down movement of the float to the rotary shaft through a lever, transmit the rotation via magnetic coupling in oil-tight condition and move the pointer on the scale plate. As the oil level indicator for large-capacity transformers is installed at a high position, the scale plate is kept tilted downward slantwise for enabling easy reading from the ground. The scale plate does not indicate the total amount of oil in the transformer proper but the rate of rotating angle of the float arm with a dial scale of 0 to 10. An alarm contact is provided as a standard which closes at a certain lower limit of oil level.

Photo 23

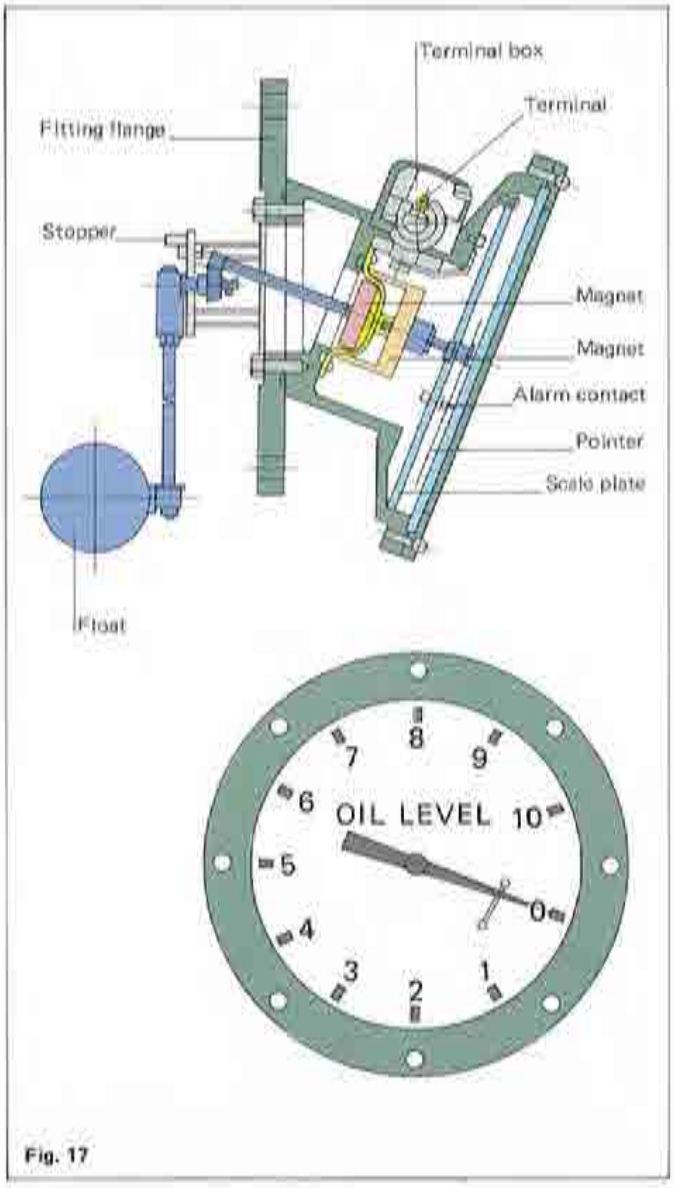


Fig. 17

Buchholz Relay

Photo 24

If any trouble occurs in the transformer, the insulating materials are decomposed and gas is generated. If the trouble is minor, generation of gas is slow, and gas turns to bubbles, which rise in oil and accumulate at the top space in the tank cover. On the other hand, if the trouble is major, gas is generated suddenly, oil pressure in the tank increases sharply and oil flows toward the conservator or pressure relief vent. A Buchholz relay is installed in the course of piping between conservator and tank aiming at catching gas passing through the piping or locating abnormality in the transformer with the detection of unusual oil flow.
Of late, it has become a serious problem for system operation that relays malfunction due to vibration as the transformer capacity becomes increasingly larger. This Buchholz relay uses a microswitch and its anti-vibration performance is far greater than that of the conventional mercury switch type. (Table 8)

Table 8 Anti-vibration performance of Buchholz relay [m/s²]

Testing device	Gravitational acceleration at which no malfunction occurs	
	Horizontal direction	Vertical direction
Sinusoidal oscillations on vibration table 10Hz continuously	Up to 39.2	Up to 19.6
Impact testing device	Up to 245.2	Up to 176.5

Construction, operation and characteristics

Fig. 18 shows the construction of Buchholz relay.

1) In case of slow gas generation (No. 1 float operation)
Bubbles which have gone up to the top space in the tank are collected into the upper chamber of Buchholz relay through a gradient piping from the cover and hold down the oil level in this chamber. In this case, No. 1 float A turns with D as a fulcrum and lowers together with oil level. When the volume of gas collected reaches 300 to 350cc, the microswitch S_1 works interlocked with the float A and the contact closes. This No. 1 contact is usually used for alarm circuit. Part of the side face of Buchholz relay case is a transparent scale plate, by which the volume of gas can be known while observing the oil level.

2) In case of unusual reduction in conservator oil level (Operation of No. 1 and No. 2 floats)
If the conservator oil level lowers unusually although there is no trouble in the transformer. No. 1 float A operates first and then No. 2 float B turns likewise with E as a fulcrum and lowers together with oil level. The moment the oil level reaches nearly the center height of connecting pipe, the microswitch S_2 interlocking with No. 2 float closes. The No. 2 contact is ordinarily used for the operation interrupting circuit.

3) In case of generation of sudden oil flow (No. 2 float operation)
If a sudden oil flow occurs from the tank to conservator, No. 2 float B operates as abovementioned, and when the oil flow velocity reaches 0.85 to 1.15m/sec, the contact of microswitch S_2 closes.
Buchholz relay operates in three ways as mentioned above, and as an auxiliary function, a float locking unit is provided which fixes the floats in transit. This unit functions to sink 2 floats simultaneously and fix them at the specified position by turning one operating shaft running through the relay cover. It is also usable for the operational check of No. 1 and No. 2 contacts of the relay which is in operation.

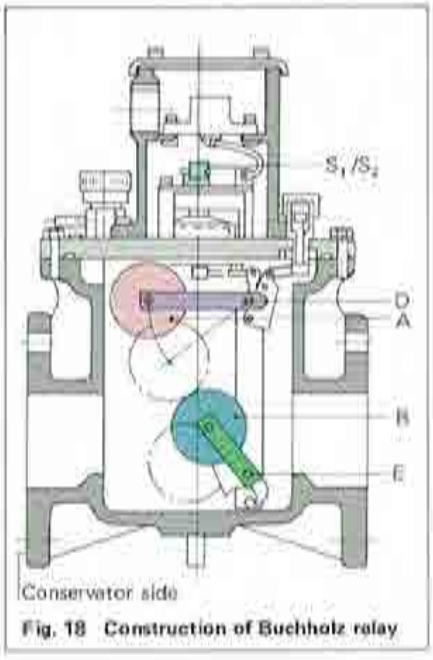


Fig. 18 Construction of Buchholz relay

Cautions on use

(1) In a nitrogen-sealed type transformer, there is a case where nitrogen separates from insulation oil and accumulates in the relay when any change comes about in pressure or temperature. It results in No. 1 float working, and therefore the Buchholz relay is not used as a standard, instead, a sudden gas pressure relay is employed.
(2) When Buchholz relay and sudden gas pressure relay or sudden oil pressure relay are used together on request irrespective of the type of transformer, it can be so arranged as to use Buchholz relay only for No. 1 float and the sudden gas pressure or oil pressure relay for No. 2 one.
(3) In a forced-oil self-cooled transformer, oil flow is generated on occasion inside the conservator connecting pipe due to variation in oil pressure caused during start-up or stop-page of the oil pump, and it results in No. 2 float working. In such a case, a step such as use of a time limit lock or countermeasures on construction will be necessary.

Thermometer

Dial type thermometer

Use mainly for transformers are a dial type thermometer.
The former is used for measuring the temperature of insulation oil, and its heat sensitive element is usually installed onto the maximum oil temperature section of the tank cover and the indicator part is provided on an easy-to-see place at the side of tank.
Fig. 19 shows the configuration of dial type thermometer. This is of liquid pressure type and consists of a heat sensitive element, intermediate flexible pipe and indicator part. The interior of heat sensitive metallic cylinder is filled with sealed gas or liquid, and variation in the volume or pressure arising from temperature change is transmitted to a Bourdon tube fitted to the indicator part through the capillary tube in the intermediate flexible pipe. In this Bourdon tube, variation in pressure is converted to a mechanical movement, the needle is moved by expanding the movement and temperature is indicated on the dial scale. The standard scale plate has graduations of 0 to 100°C.
Further, a dial type thermometer with a scale of −20 to +100°C is available on request for use in cold areas.
The thermometer sufficiently withstands shock and vibration caused in transit and/or oscillation in the transformer operation.
The dial type thermometer is fitted with one alarm contact ("NO" contact) as a rule, and the setting of this alarm temperature is adjustable.
Also, a maximum temperature indication pointer can be provided at request. This pointer can of course be reset easily by an outside control knob. As a pocket is provided for the heat sensitive element, when replacing the metallic cylinder, the element can be removed and re-installed without lowering the oil level in the transformer proper.

Photo 25

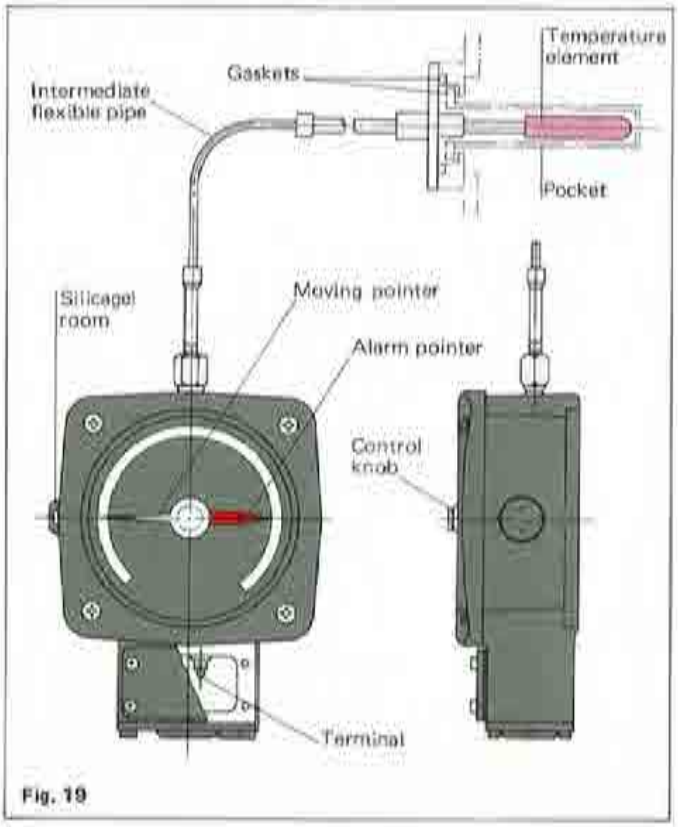


Fig. 19

Pressure Relief Device

Application

The pressure relief device play a vital role in the protection of transformers. Transformers are filled with an insulating and cooling liquid. Should a fault or short circuit occur, the arc instantaneously vaporizes the liquid causing extremely rapid buildup of gaseous pressure. If this pressure is not relieved adequately within several thousandths of a second, the transformer tank will rupture spraying flaming oil over a wide area. The damage and fire hazard possibilities of this consequence are obvious, and it is imperative that measures be taken to prevent them.
Some installations employ conventional slow-acting pressure relief devices as the means to prevent the disastrous effects of a fault or short circuit; but it is most important to note that these conventional devices do not respond quickly enough to relieve an instantaneous pressure buildup. The design of the pressure relief device, however, is such that the sensing and relief of dangerous pressure increases are accomplished immediately. Full valve opening occurs within 2 milli-seconds.

Photo 26

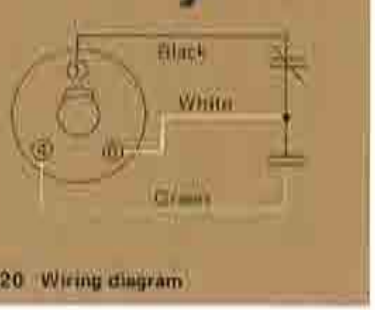


Fig. 20 Wiring diagram

Design and operation

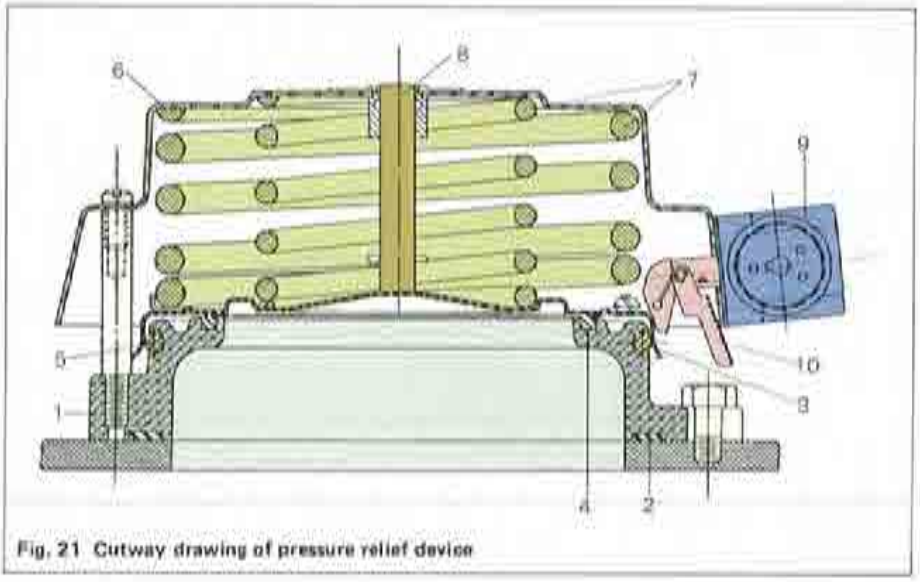


Fig. 21 Cutway drawing of pressure relief device

The pressure relief device is essentially a spring-loaded valve having a unique means of providing instantaneous amplification of actuation force. In the Fig. 21, the unit is shown mounted on the transformer by lugs on flange (1) and sealed by mounting gasket (2). Valve disk (3) is spring-loaded and sealed agains gasket rings (4) and (5) by springs (7). Valve operation is effected when the pressure acting against the area defined by gasket ring (4) exceeds the opening pressure established by springs (7). As disk (3) moves upwards slightly from gasket ring (4), the transformer pressure then quickly becomes exposed to the disk area of the diameter of gasket ring (5), resulting in a greatly increased force, and causing immediate full opening of the valve corresponding to the closed height of the springs (7). The transformer pressure is rapidly reduced to normal values and springs (7) return valve disk (3) to the closed position. A minute bleed port to outside from the volume entrapped between gasket ring (4) and gasket ring (5) prevents inadvertent valve operation in the event that foreign particles on gasket ring (4) present an imperfect ring-to-disk seal.
A bright color-coded mechanical indicator pin (8) in cover (6), although not fastened to valve disk (3) moves with it during operation and is held in the valve-open position by an O-ring in the pin bushing. This pin is clearly visible from a great distance, indicating that the unit has functioned. Pin (8) may be reset by manually pushing it downward until it rests on valve disk (3).
The relief device can be provided with a sealed, weather-proof alarm switch assembly (9) mounted on the cover. The switch assembly includes a single-pole, double-throw switch having a 3 conductor cable for connection to a remote alarm or signal device. Actuated by movement of valve disk (3), the switch is manually reset by arm (10).
Relief pressure settings:
The normal operating pressure for most installation is 0.085 MPa.

Dehydrating Breather

The configuration of the dehydrating breather is shown in Fig. 22. The atmospheric air goes in and out automatically via silicagel in the dehydrating breather according to defference between tank internal pressure and atmospheric pressure. The silicagel is contained in a steel plate cylinder, and a window is provided through which the moistened condition of the silicagel can be checked visually. In order to prevent the silicagel from absorbing moisture from the atmosphere by contacting it at the port opened to the air, the silicagel is kept shut off from the atmosphere by sealed oil.
For the dehydrating breather, blue-coloured globular silicagel used. When the silicagel get moistened, it turns pink, and therefore if discolouration of the silicagel is recognized through the inspection window, the silicagel must be exchanged. The moisture absorbing ability of the silicagel can be recovered by drying with heat until the colour turns blue again. Thus, this silicagel can be used repeatedly. To facilitate maintenance of the dehydrating breather, the inspection window is provided at a position which provides easy observation of the discoloured condition of silicagel when about 70% of the silicagel has become moistened.

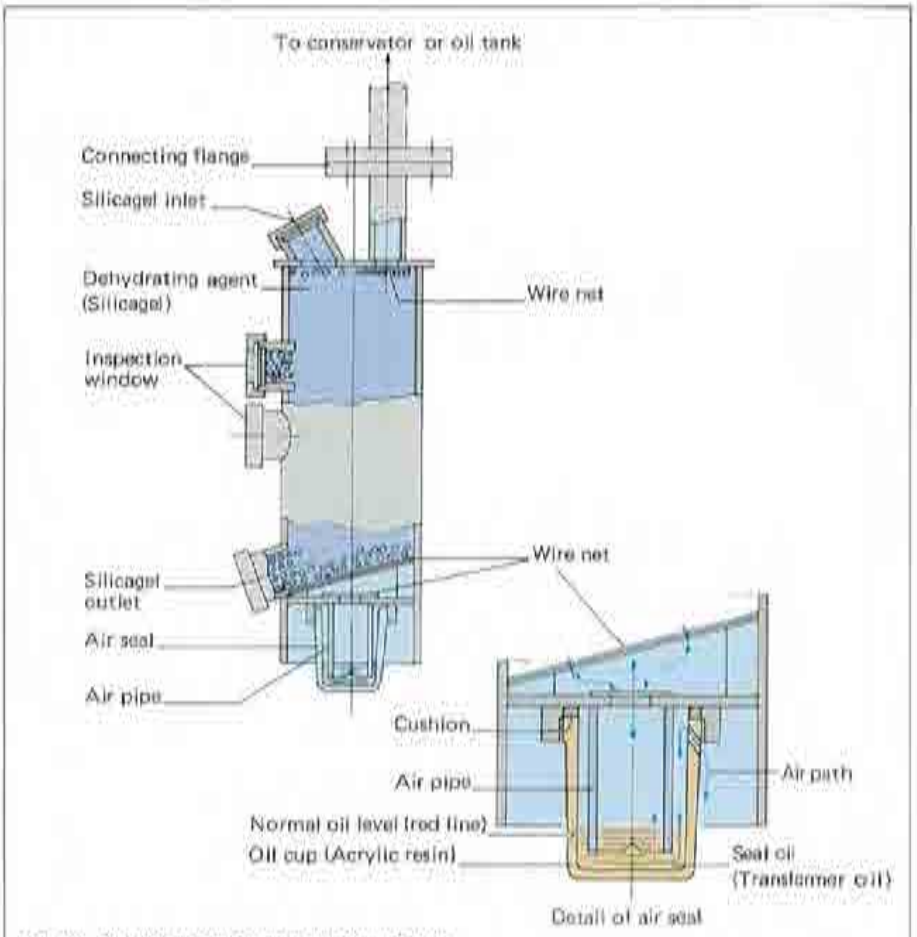


Fig. 22 Dehydrating breather of typical type

Photo 27

Photo 28

Bellows type valves

The bellows type valve is generally used for oil-drain of main tank, conservator and other oil-immersed fitting if applicable of the transformer. Each valve hold the oil-filling valve or vacuum valve at the installation.
Fig. 23 shows the construction of bellows type valve.

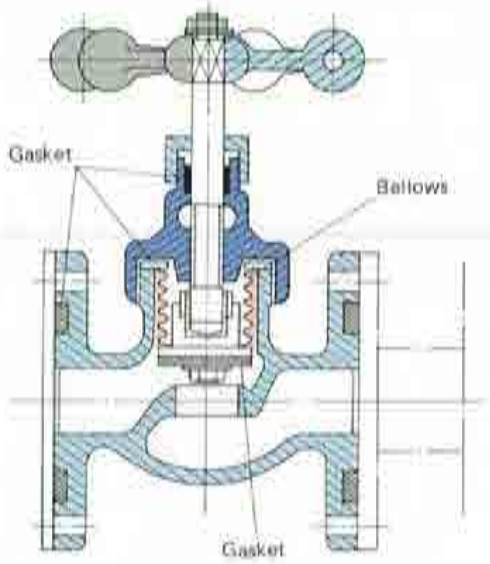


Fig. 23 Construction of bellows type valve
The size will comply with JIS Standard

Photo 29 Outer view of bellows type valve

Flap type valve

Flap type valve is installed between main tank and panel type radiator, unit type cooler or oil to water heat exchanger and between conservator and Buchholz relay. It is operated with standard attached tool, locked by shaft clamp plate. The open or close condition of the flap is indicated on the shaft clamp plate as shown in Fig. 24.

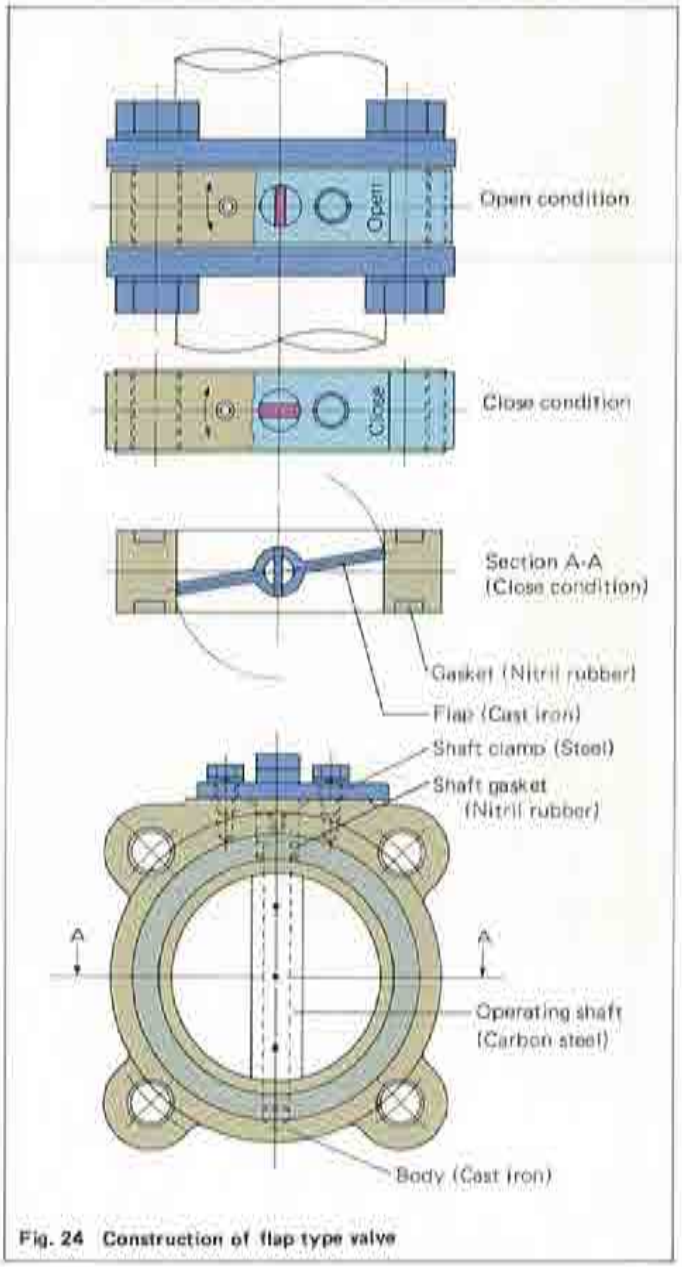


Fig. 24 Construction of flap type valve

Earthing terminal

Earthing terminal as shown in Fig. 25 is attached for grounding of main tank.

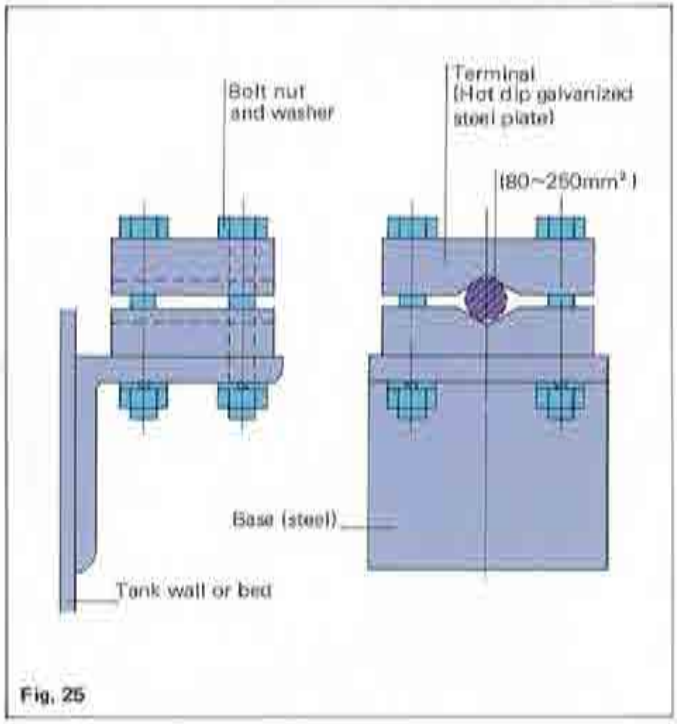


Fig. 25

Photo 30

List of optional accessories

Bank number plate
Rubber bag type conservator
Diaphragm-seal type conservator
Nitrogen seal conservator and its accessories
Main circuit terminal
Bus duct flange
Air and/or oil filled HV cable junction box
Winding temperature indicator
Resistance bulb
Diaphragm type pressure relief device
Sudden pressure relay
Oil flow relay for on-load tap-changer
Ladder
Anti vibration pad
Wheel
Anchor volts
Bushing type current transformer
Cooler control cubicle
On-load tap-changer control cubicle
Oil-purifier for on-load tap-changer
Dummey insert for on-load tap-changer

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