INSTRUCTION MANUAL

FOR

OUTDOOR METALCLAD

TRANSFORMER MOUNTED

AUTOMATIC

OIL FUSE SWITCH

SO·FS

EQUIPMENT RATED VOLTAGE UP TO 15kV

The successful operation of all switchgear depends largely upon careful erection, systematic inspection at regular intervals and the maintenance of all parts in a satisfactory condition. If the equipment described in this manual receives the recommended attention it will give many years of reliable and trouble-free service.

Since all designs in the Yorkshire Switchgear range are the subject of continuous research and development work, the equipment supplied may differ in minor details from that described. However, we will be happy to supply on request any additional information which may be required. Please quote the unit serial number(s) and, where possible, the contract number, in any enquiry.

Second Edition, November, 1975.

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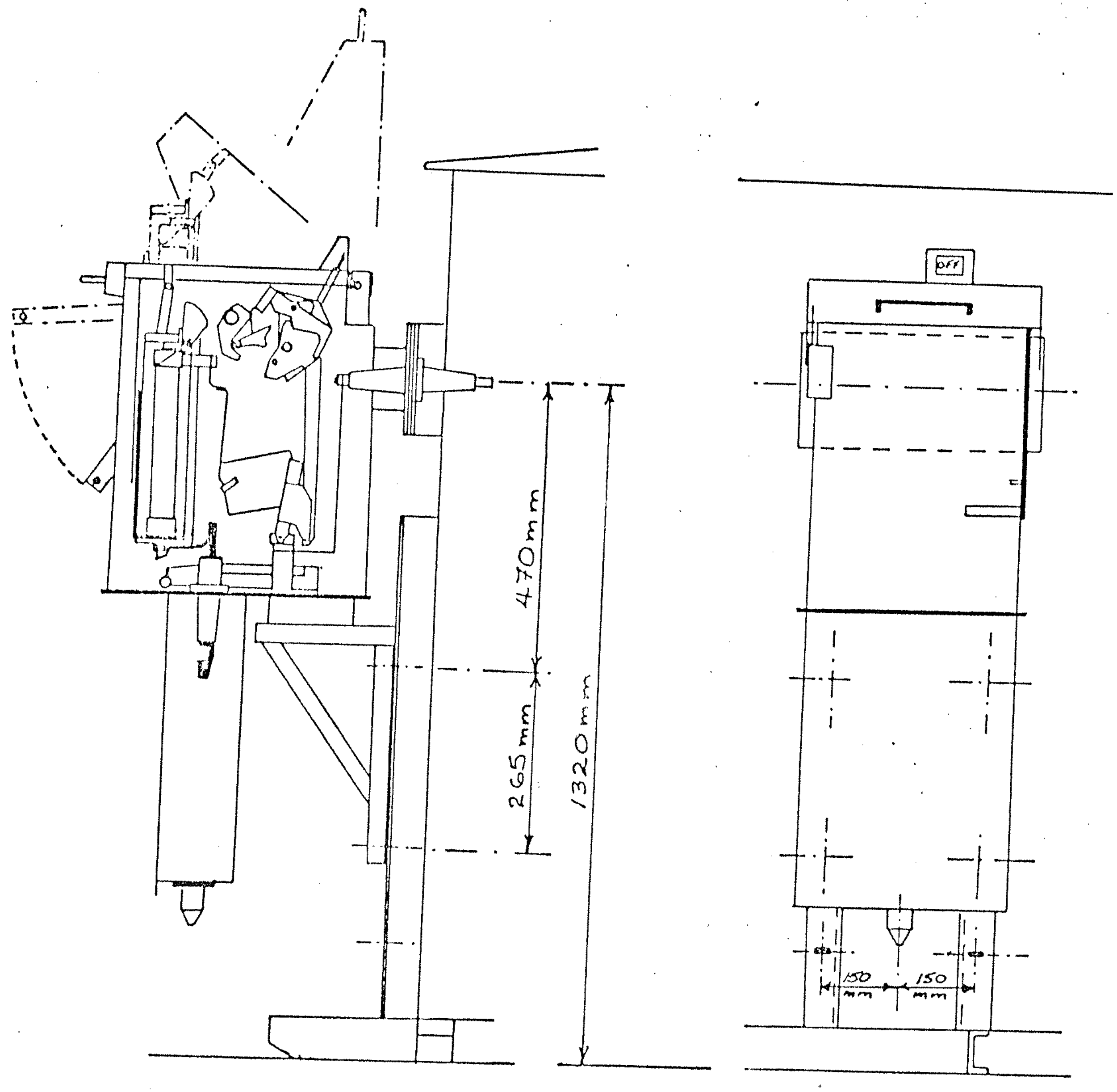


Transformer mounted SO-FS oil fuse switch

1 "SO-FS" TRANSFORMER MOUNTED FUSE SWITCH - GENERAL DESCRIPTION

1.1 Basic Design Concept

1.11 Yorkshire Switchgear's SO-FS outdoor, transformer mounted, metalclad automatic oil fuse switch provides an effective and economic form of short circuit protection for a distribution transformer. It is suitable for system voltages up to 15kV and fault levels up to 500 MVA, the relevant values for any individual unit being indicated on its data plate. See sub-section 1.8, "Technical Specification".

1.12 No SO-FS unit should be employed on a system having a higher voltage or fault level than those indicated on the data plate, without prior approval from Yorkshire Switchgear & Engineering Co. Ltd.

1.13 The main switch (312), fuses (311) and earth switch (315) are housed in a common steel oil tank (323). The main switch handle (303, 313) is at the right hand side of the tank, and the earth switch handle (304, 308) at the left. Robust mechanical interlocks prevent incompatible operations of the two switches.

1.14 The design of the transformer mounted SO-FS has altered slightly since the first edition of this manual was published:

(i) The front of the oil tank (323), which was formerly sloping, is now vertical to give a better internal layout;

(ii) The rigid design of earth switch handle (304/308) has been replaced by a collapsible type to prevent the immediate re-opening of an earth switch which may have been closed onto a fault;

(iii) The 'open' type of fuse carriage (349) has been replaced by a fully enclosed design;

(iv) An inner tank cover (351) has been added to prevent anything being dropped into the tank during fuse changing;

(v) An ON/OFF/EARTH indication (352) has been added, visible through a window in a housing on the cover (324); the original ON/OFF indicator (former 301) on the tank front has been removed.

1.2 Main Switch

1.21 The 250A, load making, load breaking oil switch (312) in series with the HV fuse links (311) gives ON/OFF control of the circuit.

1.22 It has an independent manual spring mechanism to ensure reliable operation irrespective of the operator's effort.

1.23 ASTA Publication No.22 requires that the switch be tested to make and break currents of five times the maximum rating of associated fuses, with the fuses temporarily replaced by solid links.

1.24 Positive ON/OFF indication is given through a weatherproof window aperture (352).

1.25 If a fuse operates on fault the main switch mechanism cannot be reset until the faulty fuse has been replaced.

1.26 See section 2, "DETAILED DESCRIPTION OF SO-FS MAIN SWITCH".

1.3 Fuses

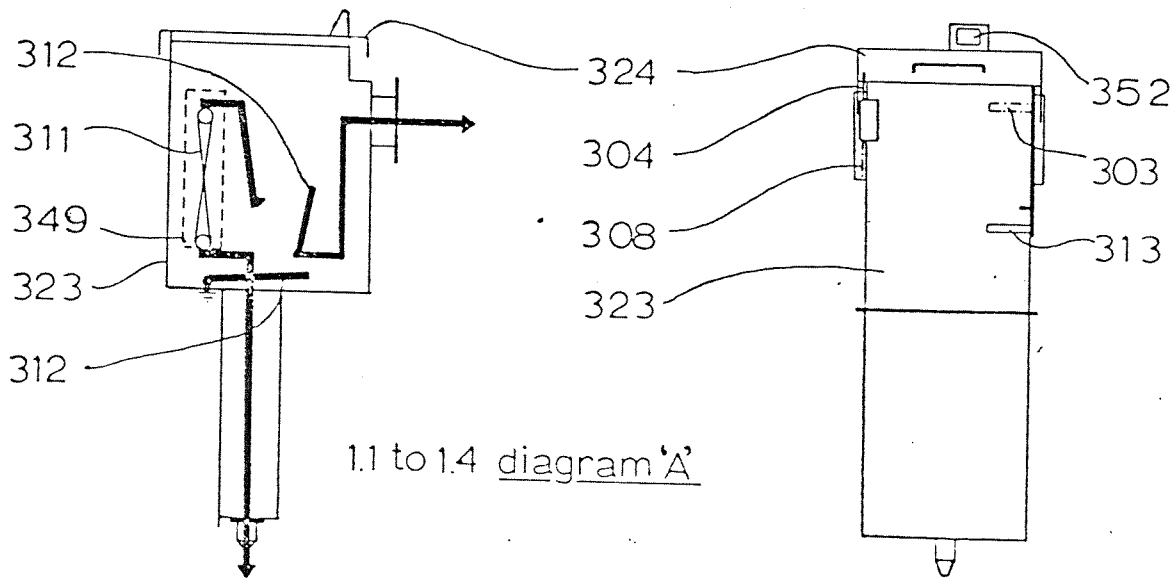
1.31 The oil immersed fuses (311) to BS 2692 are of standard, 359 mm or 254 mm by 64 mm diameter (14.1/8in or 10in by 2.1/2in diameter), barrel size.

1.32 They are clip mounted to a sliding carriage which performs the dual functions of providing easy access for fuse renewal and ensuring that the fuses are fully isolated before becoming accessible to the operator. Kits of conversion parts are available to permit any unit to be modified on site to take the alternative fuse size.

1.33 When a fuse blows on fault a striker pin is ejected from its top end to raise the main switch trip bar and open all three phases on the switch.

1.34 The fuses are only accessible when the main switch is OFF. The cover retaining screws can then be freed and the cover (324) raised through approximately 50°. The carriage is hinged to the bottom side of the cover and rises with it.

1.35 See sub-sections 7.5, 7.6 and 7.7.



1.1 to 1.4 diagram 'A'

1.4 Earth Switch

1.41 A fault making oil switch (315) to BS 2631 controls the earthing of the outgoing transformer terminations.

1.42 As with the main switch, an independent manual spring mechanism ensures reliable operation. The EARTH ON and OFF positions are clearly and durably labelled. The ON/OFF/EARTH indicator (352) confirms the position of the switch blades (315).

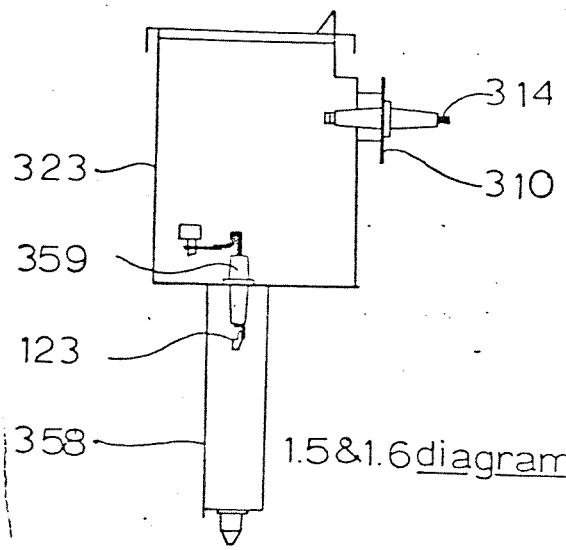
1.43 The rating of the earth switch is based on the assumption that the feed circuit will be an outgoing feed to a transformer. The rear flange connection must not be used to feed into the fuse switch or switchboard.

1.44 The earth switch handle on some units is of a collapsible type to prevent immediate re-opening should a live transformer be earthed in error.

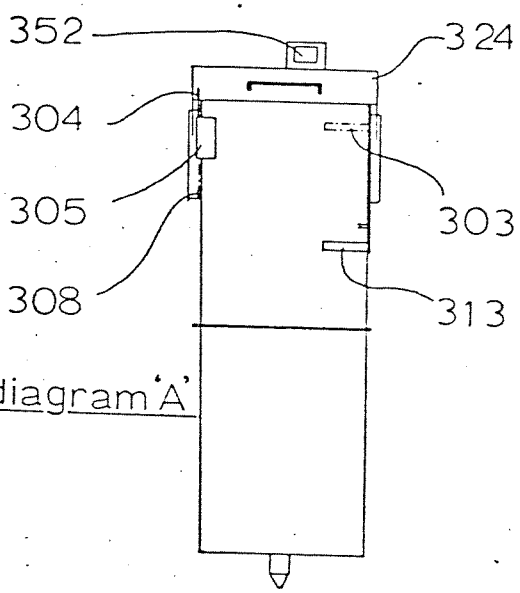
1.45 See also section 3, "DETAILED DESCRIPTION OF SO-FS EARTH SWITCH".-

1.5 Transformer Connections

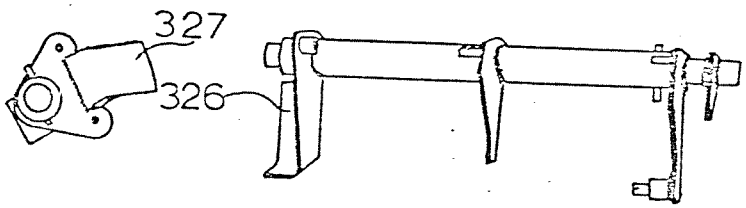
1.51 The transformer circuit leaves the oil tank (323) through bushings (314) at the upper rear of the unit. The flange (310) around the bushings connects to the transformer flange.



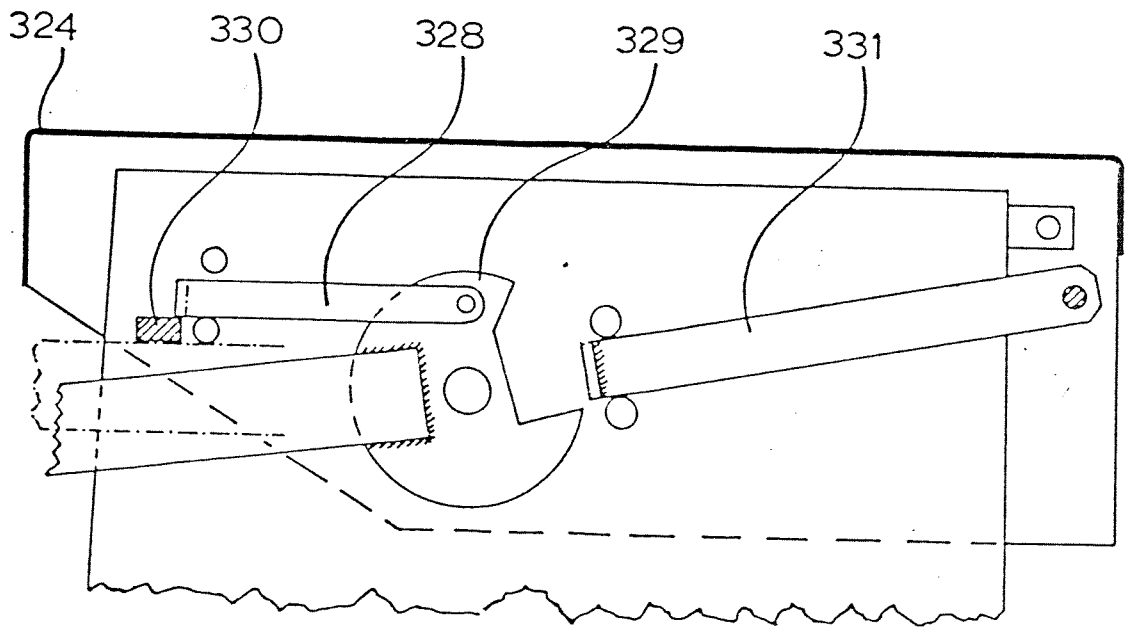
1.5&1.6 diagram 'A'



1.7 diagram 'A'



1.7 diagram "B"



1.7 diagram "C"

1.6 Cable Box

1.61 An incoming cable box (358) is mounted beneath the front of the oil tank (323). Bushings (359) pass from the tank to the box, and carry the cable sockets (123). The cable box is designed to be compound filled.

1.7 Interlocks & Padlocking

1.71 Positive mechanical interlocks incorporated in the fuse switch design prevent dangerous operating practices being undertaken.

1.72 The main and earth switches cannot both be ON (313, 308) at the same time. Two cams, one (326) on the main switch drive shaft and the other (327) on the earth switch mechanism obstruct each other so that one switch must be opened before the other can be closed.

1.73 The tank cover (324) cannot be raised to isolate the fuses and give access to the tank interior until the main switch handle is raised past the OFF to the RESET position (303). A shoot bolt (328), driven by a cam (329) on the main switch handle shaft, engages a catch (330) on the inner right hand side of the cover (324) to prevent its being raised. As the handle is raised to the RESET position (303), the bolt (328) is withdrawn.

1.74 When the cover (324) is open, the main switch (312) cannot be closed to ON (313). A second shoot bolt (331), driven by the cover (324), engages in a cut out in the cam (329) on the main switch handle shaft to prevent the handle being lowered; as the cover (324) is lowered, the bolt (331) is withdrawn.

1.75 A padlockable "remove to earth" hinged interlock plate (305) allows the earth switch handle to be locked in either the EARTH (308) or the EARTH OFF (304) position.

1.76 The trip-free design of the main switch mechanism means that a single padlocking point can be used to lock it in either the ON or the OFF position (313), but not in the RESET position (303).

1.8 Technical Specification

ASTA 22 IEC 282-1: 1968 BS.2631: 1955 BS.2692: 1956

Suitable for 3 phase systems with earthed neutral.

Equipment maximum rated voltage (kV): 15

Normal Current Rating of Main Switch (A): 250

Earth Switch Making Current (kA) peak: 5.4

Earth Switch Short Time (3s) Current (kA): 2.1

Voltage (kV)	Rating (MVA)	Fuse Switch Prospective Breaking Current (kA)	Fuse Switch Prospective Making Current (kA peak)	Maximum Fuse Rating (A)	
				254 mm(10in)	359 mm (14.1/8in)
3.3	125	21.9	55.8	250	-
6.6	250	21.9	55.8	80	135
11	410	21.9	55.8	75	85
15	500	19.3	49.2	-	80 (15.5kV fuses)

2 DETAILED DESCRIPTION OF SO-FS MAIN SWITCH

2.1 Principal Features

2.11 The basic operating mechanism is a well-tried design, which has been successfully employed in other Yorkshi. Switchgear units for a number of years.

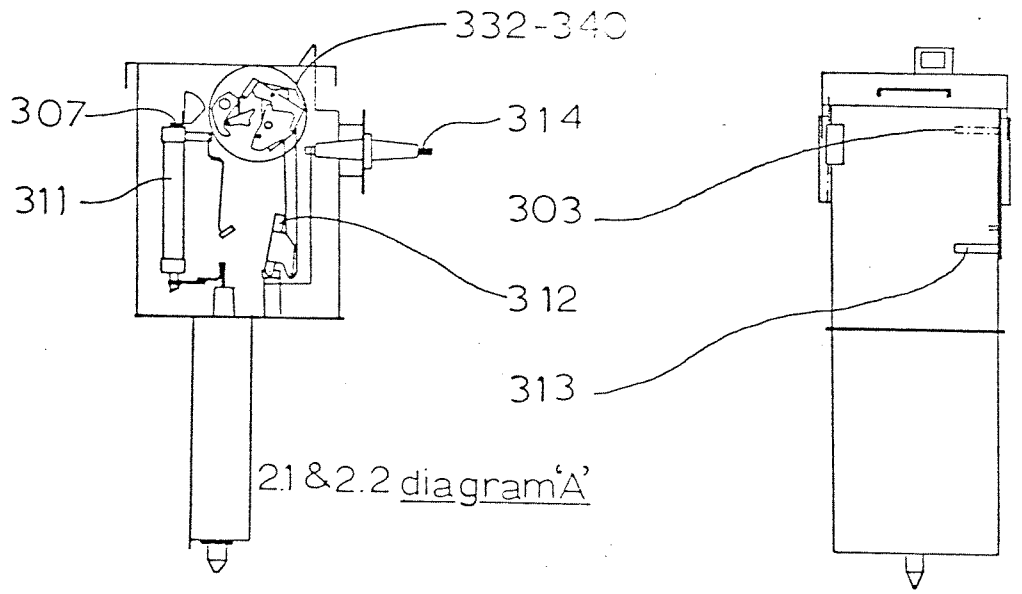
2.12 The main switch itself consists of three copper blades (312), pivoted from mountings which are electrically connected to the transformer terminations (314). In the ON position (313) the blades engage spring contacts in series with the fuses (311).

2.13 The trip free, independent manual spring closing mechanism is linked to the blades through bakelised wood (Permali) sections.

2.2 Operating Sequence

2.21 As the main switch handle is raised from the OFF position (313) to the RESET position (303) its shaft rotates clockwise (looking from the right). The internal drive lever (338) which is mounted on the handle shaft also rotates clockwise (looking from the right), pulling on the closing spring assembly and thus causing the twin drive arms (332) to rotate clockwise (looking from the right) with the main switch drive shaft (337).

2.22 The mechanism hammer (333) is moved to the RESET position, where its top end is held by the upper trip roller (334). At the same time the lower roller bracket engages a notched cam (335) on the main switch drive shaft.



2.1 & 2.2 diagram 'A'

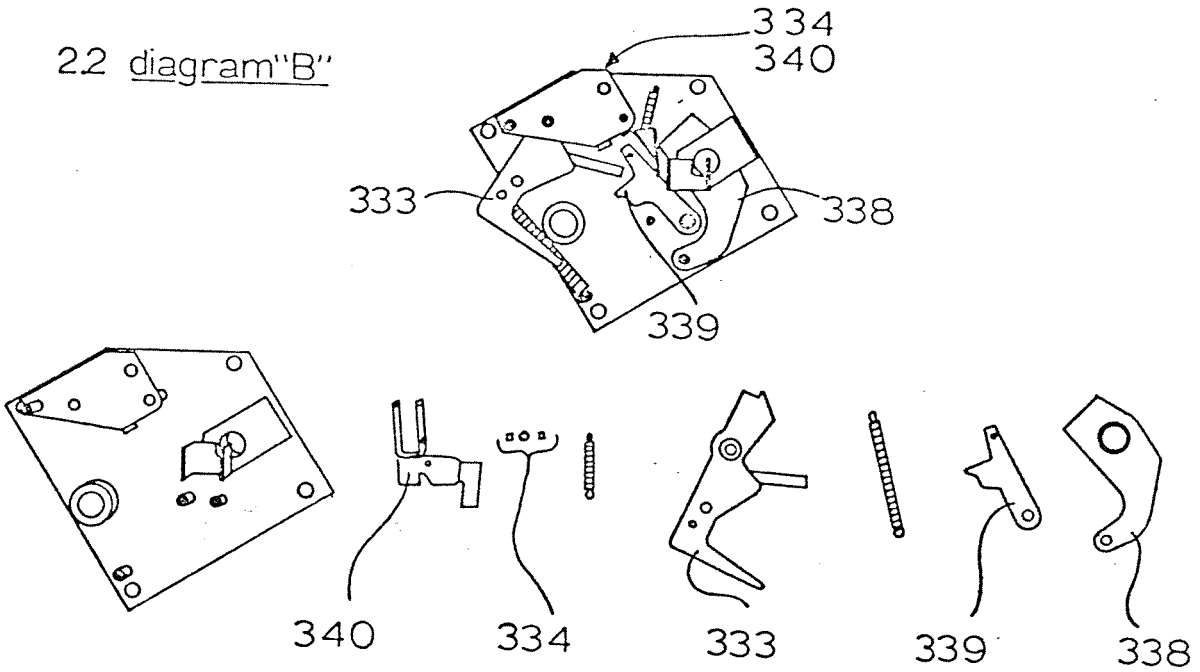
2.23 The main switch handle is then moved downwards to close the switch. The drive lever (338) rotates anti-clockwise (looking from the right) and, through the closing spring assembly (336), pushes the drive arms (332) and main switch drive shaft (337) anti-clockwise (looking from the right). The drive arms (332) are then arrested by the hold back catch (339) (with adequate clearance remaining between the switchblades and contacts) and the continued motion of the drive lever (338) compresses the closing springs (336).

2.24 At the toggle point, the point of maximum spring compression, the drive lever (338) pushes the hold back catch (339) out of engagement, allowing the drive arms and drive shaft (337) to rotate at speed under the pressure of the discharging closing springs (336). This closes the switch blades and compresses the opening springs. At the completion of the closing stroke, the spring loaded hold-in catch engages with the drive arms to prevent slow opening.

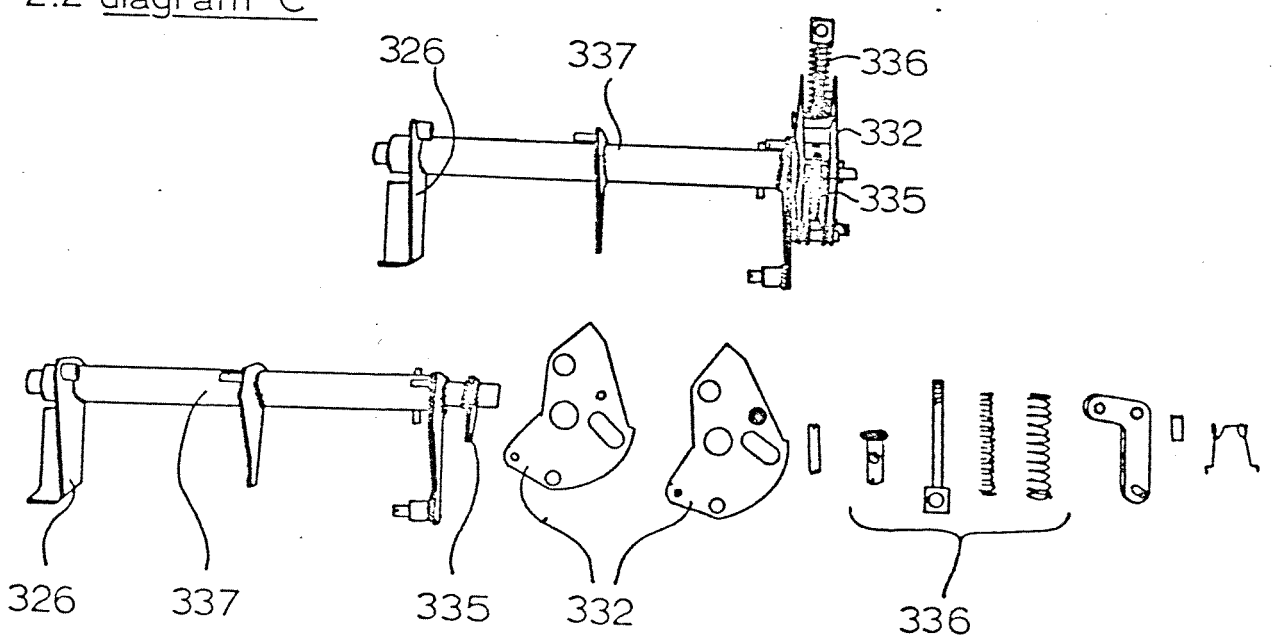
2.25 To trip the main switch, the operating handle (313) is raised slightly. The drive lever (338) rotates clockwise (looking from the right) causing the reverse trip to pivot the upper trip roller arm (340) and release the hammer (333). Since it is spring-loaded, the hammer (333) pivots clockwise (looking from the right) and its tail knocks the lower roller bracket forwards to release the notched cam (335) on the main drive shaft (337). The main drive shaft (337) rotates clockwise (looking from the right) at high speed under the influence of the opening springs. This rotation disengages the hold-in catch (to allow later resetting) and opens the switch blades (312).

2.26 When a fuse blows, its ejected striker pin raises the trip bar (307) and the trip block at the right hand end of the trip bar pushes back a nylon pin. This operates the upper trip roller (334) to open the switch as described in 2.25 above.

2.2 diagram"B"



2.2 diagram "C"



3 DETAILED DESCRIPTION OF SO-FS EARTH SWITCH

3.1 Principal Features

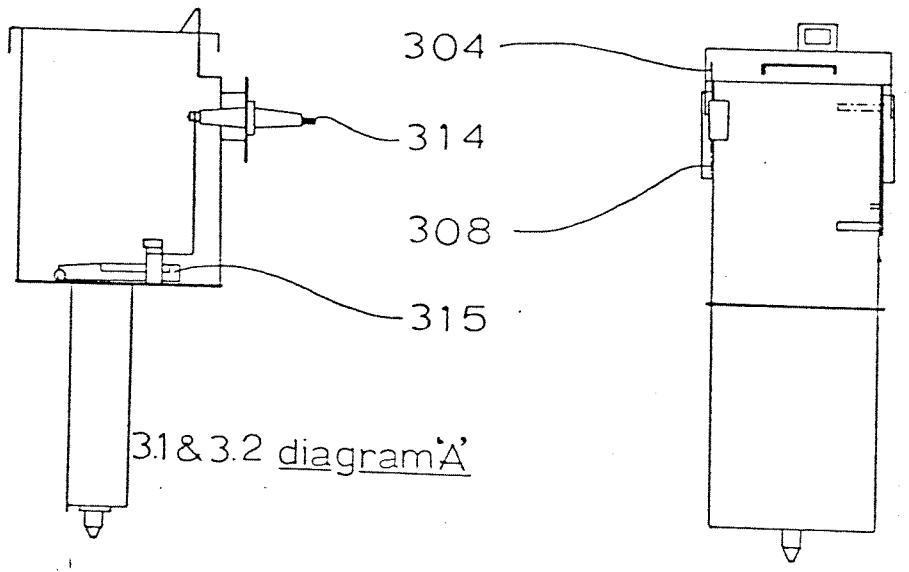
3.11 The earth switch is a fault making, independent manual spring design conforming to BS 2631.

3.12 Two pairs of spring-loaded copper blades (315), bonded to the earthed metalwork of the tank, pivot to engage fixed copper contacts which are electrically connected to the transformer terminations (314).

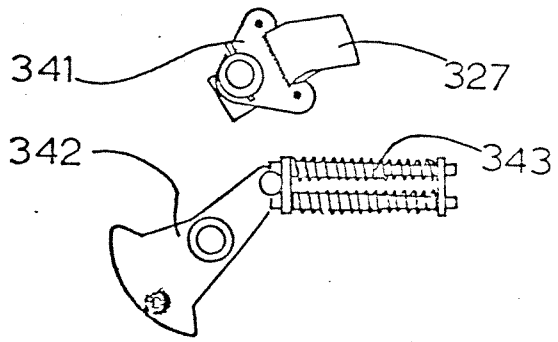
3.13 The mechanism is linked to the moving switch contacts by steel linkages.

3.14 Because the earthing switch is of only 5.4kA peak making current capacity, the rear transformer connection must not be used for an incoming supply (i.e. with normal power flow from transformer to cable box) but can only be used on an outgoing circuit (i.e. normal power flow from cable box to transformer).

3.15 The earth switch handle on some units is of a collapsible type to prevent immediate re-opening should a live cable be earthed in error.



3.1 & 3.2 diagram 'A'



3.2 diagram "B"

3.2 Operating Sequence

3.21 As the earth switch handle is moved down from the EARTH OFF (304) to the EARTH ON (308) position, a pin on the handle side turns a slotted cam to rotate the earth switch drive shaft. A drive lever (341) on the shaft inside the oil tank moves clockwise (seen from the right). There is some free movement, then a pin on the drive lever (341) engages the driven lever (342) and begins to move it round to compress the operating springs (343).

3.22 When the springs (343) pass the toggle point, or point of maximum compression, they expand at speed, driving the driven lever (342) which, through a slotted link connection and steel linkages, pulls the switch blades (315) home.

3.23 The opening sequence is identical to the above, except that the directions of movement are reversed.

4 DELIVERY & ERECTION

4.1 Loading, Delivery and Unloading

4.11 Outdoor units may be carried on open trucks if the covers are securely fastened.

4.12 It is possible for two men to load, unload and erect a SO-FS transformer mounted fuse switch without the use of lifting or handling equipment. However, for speed and safety the use of a small crane, forklift or other handling device is recommended. The safe working load (SWL) should be at least twice the total weight of any load to be lifted; in the case of a crane, this should be the SWL at the maximum radius required by the site layout.

4.13 A 6 m (20ft) circumference endless manilla rope sling, SWL at least twice the total weight of the switch, should be looped under main structural components of the unit to crane lift it.

4.14 Do not attempt to operate any item of switchgear until the appropriate erection, preparation and commissioning procedures have been completed.

4.2 Delivery Weight, Oil and Compound Volumes

4.21 These are approximate values only.

4.22 Fuse switch without oil, fuses or compound, but with cable box:	155 kg (342 lb).
4.23 Volume of oil tank:	100 litres (22 gall).
Equivalent weight of oil:	86 kg (190 lb).
4.24 Volume of cable box:	29 litres (6.4 gall).
Equivalent compound weight:	30-35 kg (65-76.5 lb).
Equivalent oil weight:	[illegible] kg ([illegible] lb).

4.3 [illegible]

4.31 The switch is supported by a bracket which bolts to angle pieces welded on the transformer tank. The front faces of the angles must be in line with the face of the transformer flange.

4.32 Remove the transformer lid and drain the oil down below the level of the blanked-off HV aperture (see 5.2, "Oil Filling of Switchgear" for precautions to be observed). Remove the blanking plate, but leave the gasket in position on the flange face.

4.33 Fasten the bracket and switch in place so that the switch rear bushings (314) protrude into the transformer tank. Fasten the switch and transformer flanges together.

4.34 Working in the transformer tank air space, connect the transformer HV terminals to the switch bushing conductors and fasten them with the nuts provided.

4.35 Refill the transformer tank to its operating level (see sub-section 5.2 again) and replace the transformer lid.

4.36 Joint the cable as described in sub-section 4.4 and prepare and commission the switch as described in section 5.

4.4 Jointing Main Cables

4.41 The following method applies to standard compound insulated cable boxes (358). However, only slight modifications are required for other cable boxes in our range. Compounds of the bituminous or rosin oil type are extensively used in metalclad switchgear cable boxes and if care is exercised in their use the equipment will function for long periods without further attention.

4.42 Prepare the cable as follows:-

(a) Remove the cable box front plate (122) and note the positions of the cable sockets (123) before removing them. Remove the bottom plate (124), gasket (125) and gland (126) and make off the cable through them in the normal way, taking care that the gasket (125) is refitted between plate (124) and gland (126).

(b) Put pressure plastic around the studs and along the edges of the bottom plate (124). (A gasket rather than pressure plastic is used for oil filled boxes). Re-tighten the bottom plate (124) and gland (126).

(c) Clean out the interior of the box (358) and wipe the insulators with a clean, dry rag.

(d) Put pressure plastic around the front plate (122) securing studs and along the spaces between them. (A gasket rather than pressure plastic is used for oil filled boxes). Refit the front plate (122), nuts and washers and tighten evenly onto the studs.

4.43 Prepare the requisite amount of bituminous compound, observing the following precautions:

(a) Dust, damp or any foreign matter is deleterious to the compound, and a very small percentage of any impurity greatly reduces its dielectric properties. Care should therefore be taken to ensure that all tools, buckets etc., which are used are perfectly clean.

(b) The correct method of taking solid bitumen compound out of the tins is to cut off the ends with a cold chisel, and then split the cylindrical portion from end to end. The compound can then be removed and broken into small pieces before going into the bucket for heating.

(c) Until the compound is fluid, side heating only should be applied, and at all times direct contact between a gas flame cone and the outside of the bucket should be avoided, as this can give rise to a localised hot spot and cause charring of the compound.

(d) The compound should be stirred at regular intervals, preferably with a stirring rod having a built-in thermometer, until the pouring temperature as stated by the manufacturers is reached. The lid should be fitted to the bucket except during stirring.

4.44 Compound the cable box up as follows:

(a) Remove the filler aperture cover (128) from the cable box upper front plate and pre-heat the box, preferably by using radiant heaters, until an inserted thermometer shows an internal air temperature of 38°C (100°F). This removes surface moisture and prevents chilling and consequent voiding of the compound.

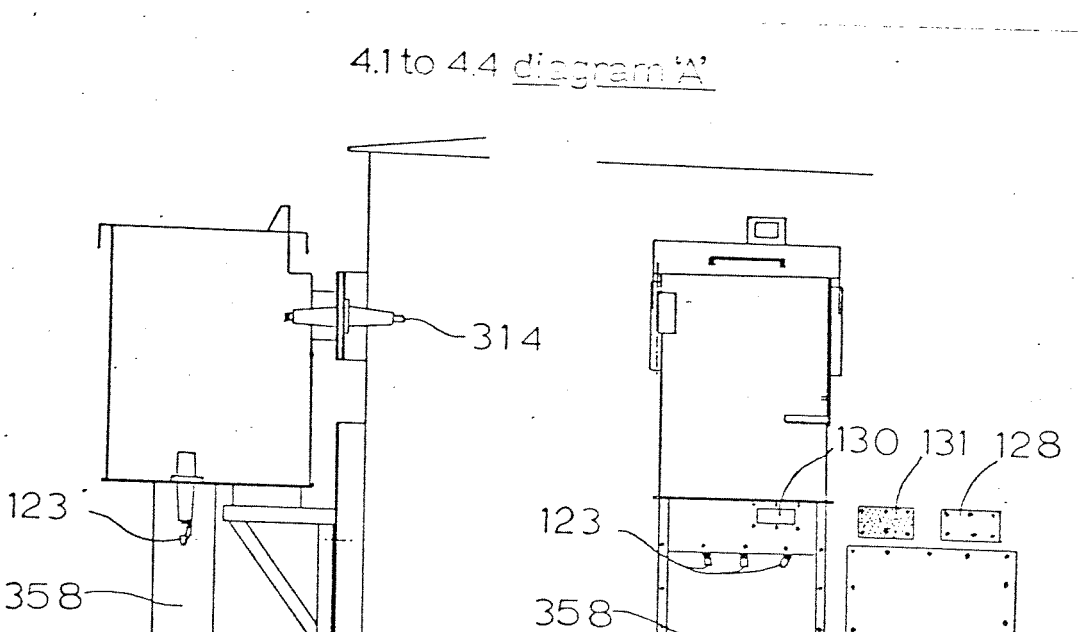
(b) With compound and cable box at their respective correct temperatures, slowly but continuously pour in the compound (using a pre-heated clean compound tin section) until the compound level reaches the bottom of the aperture (130).

(c) Fit the filler aperture cover (128) loosely and leave the compound to cool and settle for two hours. Then check whether the contracted level of the compound is sufficient without topping up. If not, top up with fresh compound whilst the original compound is still warm.

(d) Finally, fit the filler aperture gasket (131) and cover (128), replace the securing nuts and washers and tighten the nuts.

4.45 On completion of topping up, clean the compound buckets and utensils of all compound whilst they are still warm to avoid contamination of future batches. Clean any spilled compound from the cable box, cable and floor so that there is no risk of maintenance staff wrongly thinking that the cable box is leaking during future inspections.

4.1 to 4.4 diagram 'A'



5 PREPARATION & COMMISSIONING

5.1 Preparation of Tank and Mechanisms

5.11 WITH CABLE BOX (358) AND OUTGOING CIRCUIT (314) DEAD, remove all packing materials, wipe down the outside of the switch tank (323) and, with the operating handles in the RESET (303) and EARTH OFF (304) positions, unfasten the cover retaining screws and raise the cover (324). The fuse carriage (349) is hinged to the underside of the cover (324) and will rise with it. The spring loaded carriage retaining clip (350) will snap out to support the lid. Check that the correct fuses (311) are in place. If not, put in fuses of the required rating as described in sections 7.5, 7.6 and 7.7.

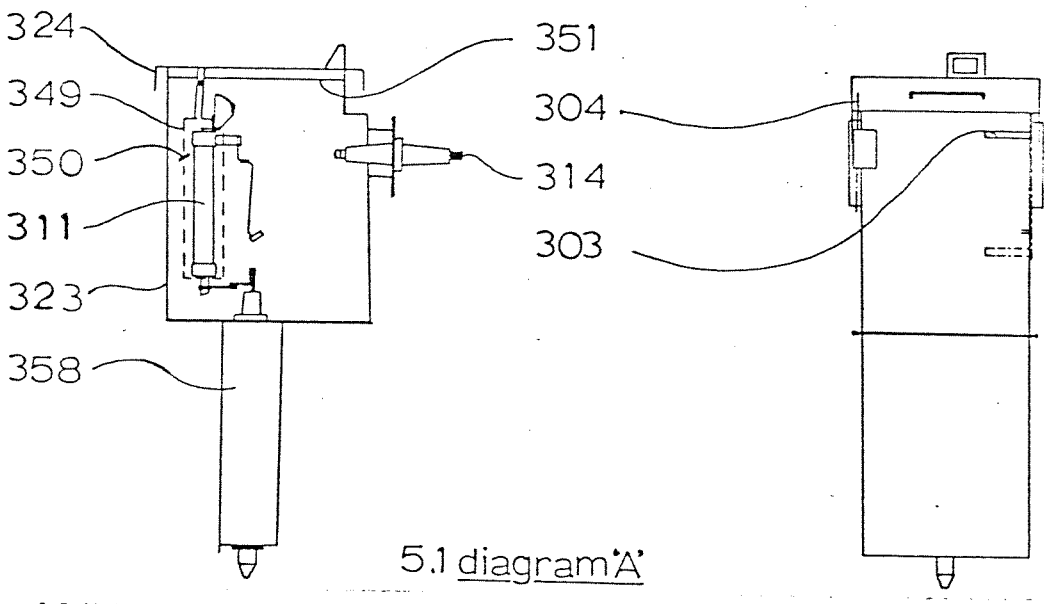
5.12 Unfasten and remove the fuse carriage (349) by removing the split pins at the top of the lift arms and sliding the carriage out of its guides. Remove the tank inner cover (351).

5.13 Wipe out the tank (323) with a clean, dry, lint-free, non-metallic cloth. Examine the mechanisms, bearings and contacts and check for loose fastenings. Check for foreign bodies in the tank bottom.

5.14 Replace the fuse carriage (349) in its guides and reconnect the lift arms.

5.15 Fill the tank (323) to the marked level with the switch oil (see section 5.2, "Oil Filling of Switchgear"), pouring the oil over those parts of the mechanisms which are above the marked oil level.

5.16 Replace the inner cover (351) and fasten it down. Check the main cover gasket, then close and securely fasten the main cover (324). As far as possible, check the operation of the operating handles and interlocks in accordance with section 6, "Routine Fuse Switch Operation". Leave the handles in the RESET and EARTH OFF positions.



5.1 diagram 'A'

5.2 Oil Filling of Switchgear

5.21 Switchgear is normally despatched without oil and when the equipment is filled on site it is necessary to observe certain precautions to ensure satisfactory operation.

5.22 The oil must be of the correct grade (normally 830), should preferably be used from sealed drums, and must have an electrical strength of not less than that specified by BS 148. Clean oil must not be stored in drums which have held dirty oil.

5.23 All pumps, pipes and other filling utensils must be clean and dry and must have a temperature similar to that of the oil and switchgear. Separate equipment should be used for clean and dirty oils.

5.24 Rubber tubing or any other material which is soluble in oil should not be used.

5.25 All components of the switchgear which are to be immersed in the oil must be thoroughly cleaned with lint-free, non-metallic cloths. Do not use cleaning solvents, which might contaminate the oil.

5.26 To avoid contamination, oil and switchgear should be at least as warm as the surrounding air, and in addition the switchgear should be dry. On indoor equipment, this condition can be obtained by heating the switchroom and allowing the warm air to circulate through the switchgear with the tanks open. All parts inside the chamber or tank will then quickly attain atmospheric temperature. If the substation is very dusty, this method cannot be used, but the same result can be achieved by placing bags of desiccant such as silica gel in the chambers for a period of some hours. Care must, however, be taken to ensure that all of these bags are removed before filling commences. When the equipment is completely dry, no moisture will appear on a mirror held inside the chamber.

5.27 The correct oil level is marked on the inside of the oil switch and fuse switch chambers and on the outside of circuit breaker and voltage transformer tanks. Note that, on the "SO-HI" range, this is the oil level with the mechanism in the tank.

5.28 After filling it is advisable to operate the switchgear several times before applying voltage in order to release any air which may be trapped.

5.29 WARNING: No naked light should be permitted in the vicinity of open tanks or in other situations where switch oil is directly exposed to the atmosphere because of the risk of fire or explosion. This precaution is particularly important during post-fault maintenance.

5.3 Testing of Fuse Operation

5.31 A dummy fuse barrel with a solenoid operated striker pin is available to permit testing of the trip bar mechanism of the main switch.

5.4 High Voltage Tests

5.41 The application of a high voltage pressure test is often called for, for example, before commissioning or after maintenance, according to the local regulations. BS 116 specifies the following values for such site tests for oil circuit breakers:

For service voltages up to 33kV: Twice service voltage plus 2kV (r.m.s.) for one minute:

For small wiring and control circuits: 2kV (r.m.s.) for one minute;

and the same guide may be used for SO-FS pressure tests.

5.42 It is preferable to replace the fuses by conducting links if these are available, but the fuses may be left in place otherwise.

The first test should be applied thus:

(a) all phases to earth with switch closed;

(b) between phases with switch closed;

(c) across the break of the open switch.

If the equipment is not large enough to produce the correct test voltage, a prolonged test at reduced voltage in accordance with the table below may be applied.

POWER-FREQUENCY VOLTAGE TESTS FOR DURATIONS EXCEEDING ONE MINUTE (AFTER ERECTION ON SITE)

Duration of test Minutes	Percentage of one-minute test voltage according to paragraph 5.41
1	100
2	83.5
3	75
4	70
5	66.6
10	60
15	57.7

5.43 D.C. Testing:

The use of D.C. test sets for cable testing is now widespread and the use of this equipment for the pressure testing of switchgear is often convenient. The case against D.C. testing is that the insulation is not stressed in the same manner as when an A.C. voltage, for which it was designed, is applied, but experience has not indicated that initiation of breakdown is more likely with D.C. than with A.C. In the event of a D.C. voltage test being applied to the switchgear, the values must be in accordance with the table below, the duration of test to be 15 minutes.

D.C. TEST VOLTAGES

Rated voltage	Site test voltage
kV	kV
3.3	7.5
6.6	15
11	25
15	34

5.44 Every application of a H.V. pressure test tends to produce a corresponding reduction in the life of the insulation, and the frequency of applying such tests should therefore be carefully considered. For routine tests during the life of the equipment we recommend that test voltages should be in accordance with the table below. If the switchgear includes Voltage Transformers, it is advisable to electrically isolate these and test them separately, particular care being necessary if a VT has a primary neutral and possibly graded insulation.

Age of Equipment	% of Original Site Pressure Test
Under 5 years	100.0
5-10 "	87.5
10-15 "	75.0
15-20 "	62.5
Over 20 "	50.0

5.5 Paintwork

All components are given a high quality protective finish before leaving the works, but the paintwork may be damaged during transport, erection or service. Any scratches or chipped portions of the paintwork should be touched up immediately they are noticed, otherwise the metalwork may rust.

Suitable touch up paint is available from Yorkshire Switchgear, or it may be obtained from any reputable manufacturer. The specification is:

"Glossy Synthetic Air Drying Enamel for Outdoor Use"; outdoor grade paint is employed to avoid the need for periodic repainting. Quote the appropriate colour reference:

Colour	Colour No. (BS 381C: 1948)
Dark Admiralty Grey	632

Or such other colour as may have been specified for a particular installation.

6 ROUTINE FUSE SWITCH OPERATION

6.1 To Close a SO-FS Fuse Switch

6.11 Note that the MAIN switch (313) on the right of the tank is OFF (see indicator window (352)) and the EARTH switch on the left of the tank is set to OFF (304).

6.12 Unlock the MAIN switch handle (313).

6.13 Raise the MAIN switch handle as far as it will go, to the RESET position (303), to engage the closing mechanism.

6.14 Move the MAIN switch handle firmly downwards (313) to close the switch (312). The indication in the tank window (301) should change to ON.

6.15 Lock the MAIN switch handle in this position (313).

6.2 To Trip a SO-FS Fuse Switch

6.21 Note the indication ON in the window (352).

6.22 Unlock the MAIN switch handle (313).

6.23 Raise the MAIN switch handle from the ON position (313), though not as far as the RESET position (303). You will hear the mechanism trip to OFF and see the indication in the window (352) change.

6.24 Lock the MAIN switch handle in the OFF position (same padlocking point as for ON) (313).

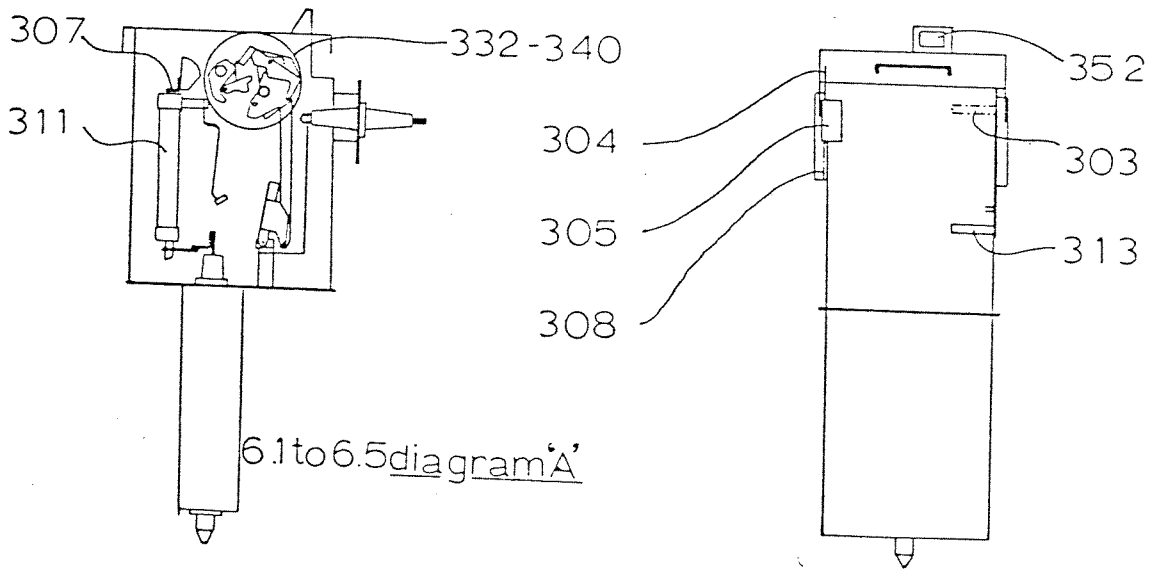
6.3 To Earth the Transformer Circuit

6.31 Note that the MAIN switch (313) on the right of the tank is OFF and the EARTH switch on the left of the tank is set to EARTH OFF (304), (see indicator window (352)). The earth switch handle is of a collapsible type to prevent immediate re-opening should a live cable be earthed in error.

6.32 Unlock the "Remove to Earth" interlock (305) and move it clear of the EARTH switch handle (304).

6.33 Push the EARTH switch handle (304) smoothly but firmly downwards to the EARTH ON position (308).

6.34 Lock the "Remove to Earth" interlock (305) so as to prevent movement of the EARTH switch handle (308).



6.4 To Remove the Earth from the Transformer Circuit

6.41 The right hand MAIN switch handle (313) will be OFF and the left hand EARTH switch will be ON (308), (see indicator window (352)). The earth switch handle is of a collapsible type to prevent immediate re-opening should a live cable be earthed in error.

6.42 Unlock the "Remove to Earth" interlock (305) and move it clear of the EARTH switch handle (308).

6.43 Pull the EARTH switch handle (308) smoothly but firmly upwards to the EARTH OFF position (304).

6.44 Lock the "Remove to Earth" interlock (305) so as to prevent movement of the EARTH switch handle (304).

6.5 Fuse Operation on Fault

6.51 If any fuse (311) blows to clear a fault, a striker pin is ejected from its top end. This raised the main switch mechanism trip bar (307) to trip the switch (312) and prevents the mechanism's (332-40) being reset until the faulty fuse (or fuses) has (or have) been replaced.

6.52 See section 7.5 "Post-Fault Maintenance and Fuse Renewal" for details.

7 MAINTENANCE

7.1 Frequency of Maintenance

7.11 Wide variations in operating duty and environment make it impossible to specify a uniform frequency of maintenance for all switchgear installations.

7.12 However, all equipment should be inspected prior to commissioning and again during the initial 12 months guarantee period, particular attention being paid to the tightness of fastenings and fixings. It should then be possible to assess future maintenance requirements.

7.13 Users are particularly recommended to consult "British Standard Code of Practice for the Maintenance of Electrical Switchgear, CP1008".

7.14 Since the SO-FS unit is non-isolatable, ALL MAINTENANCE OTHER THAN EXTERNAL CLEANING AND FUSE RENEWAL REQUIRES THAT THE CABLE AND TRANSFORMER BE MADE DEAD. However, by careful planning, consumer outages can be reduced to the minimum.

7.2 Maintenance of Tank and Mechanism

7.21 With the switch still alive, inspect the general condition of the transformer bay to see that it is clean, dry and adequately heated and ventilated. Look for oil or compound leaks, listen for any audible discharge, note any unusual smells. Should anything be amiss, investigate the cause and arrange for its correction.

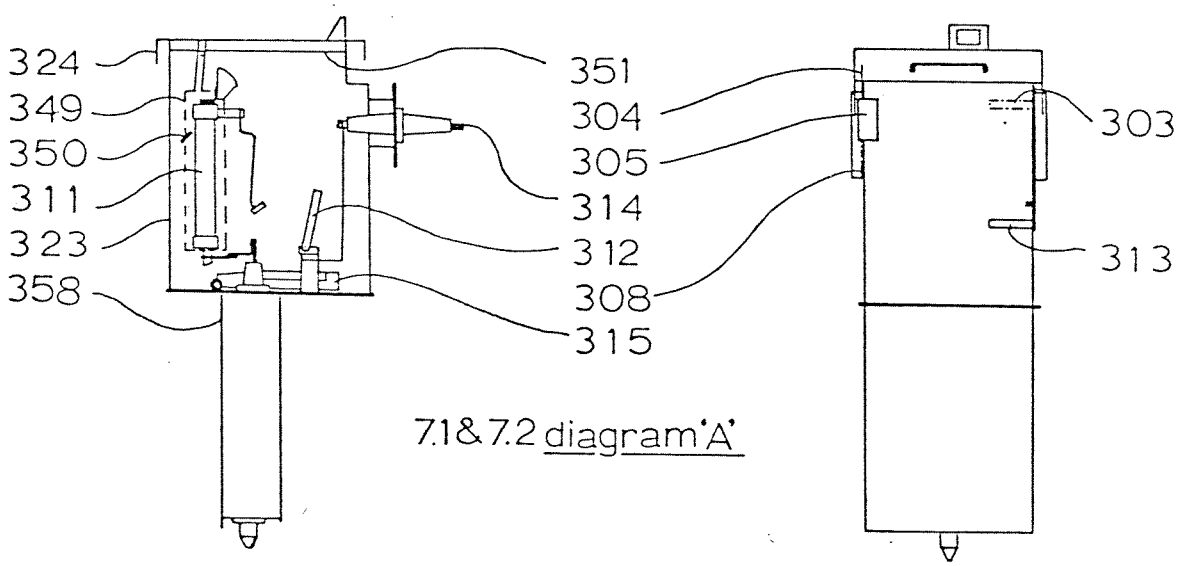
7.22 Clean down the outside of the unit with cloths having no loose fibres or metallic threads. Do not use synthetic cloths in conjunction with cleaning solvents.

7.23 WITH THE INCOMING CABLE AND THE TRANSFORMER MADE DEAD, LOCKED OFF AT ALL POSSIBLE POINTS OF SUPPLY AND EFFECTIVELY EARTHED, unlock the MAIN switch handle (313) and raise it fully to the RESET position (303). Note that the switch cannot be locked in this position, so that maintenance will normally need to be followed by a closing operation to ON (313).

7.24 Unfasten the screws securing the switch fuse cover (324) and raise the cover, which will bring the fuse carriage (349) with it.

WARNING: No naked light should be permitted in the vicinity of open tanks or wherever switch oil is exposed to the atmosphere, due to the risk of fire.

Disconnect the fuse carriage lift arms from the cover (324) and remove the carriage (349) from its guides. Inspect the fuse links (311) for signs of mechanical or thermal damage and replace any that show such signs. Inspect all contacts on the fuse carriage (349) for signs of burning or wear. Smooth with a file or replace any that require attention. Check all fittings and fastenings for tightness.

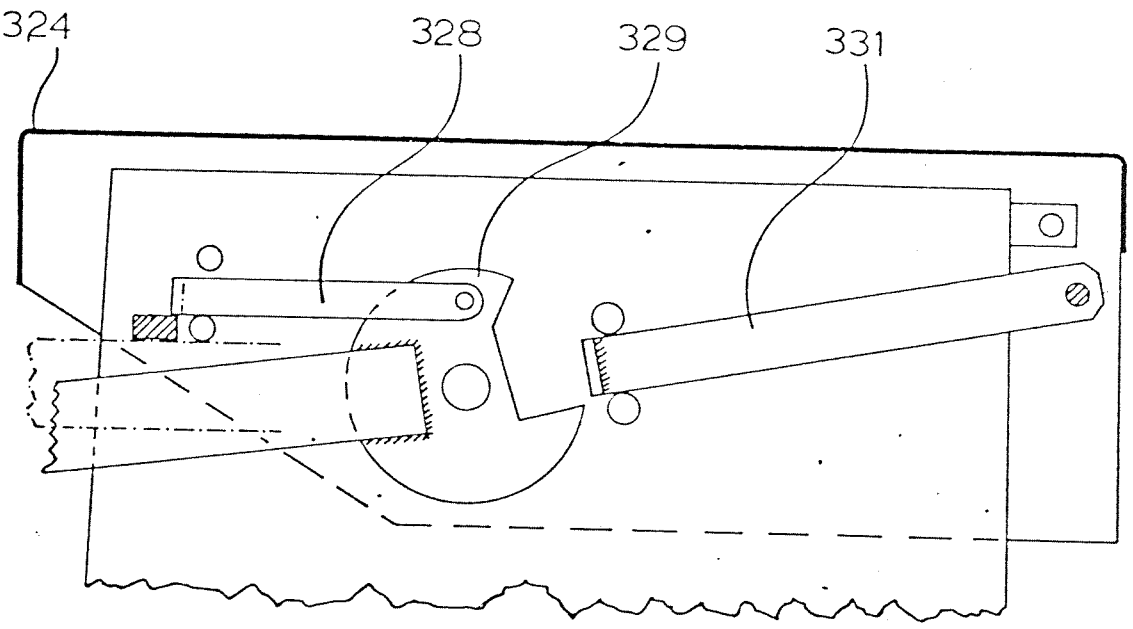


7.1&7.2 diagram 'A'

7.25 Remove the inner cover (351). Sample and test the switch oil as described in section 7.3, "Switch Oil Sampling and Testing". If the oil is clear, it will be possible to carry out the rest of the routine inspection with the oil still in the tank (323). Should the oil be murky, or fail any of the tests prescribed, or should the inspection show that maintenance work within the tank is necessary, then the tank (323) must be emptied and later refilled. See section 5.2, "Oil Filling of Switchgear" for the precautions to be observed.

7.26 Examine the mechanisms and contacts (312, 315 and mating fixed contacts) within the oil tank (323). Any contact burning or pitting may be corrected with a file or glass-paper (not emery or carborundum) or, in serious cases, replacement of the contacts may be necessary. Any filings must be removed from the tank before it is refilled. Look for loose fastenings and tighten any that are found. Examine the bakelised wood ("Permali") operating links for signs of splitting, damage or carbonisation and replace if necessary. Check the operation of all mechanisms and interlocks as far as possible. Remove any foreign bodies from the tank bottom.

7.27 Re-fill or top up the tank (323) to the marked oil level (see section 5.2, "Oil Filling of Switchgear"). Pour oil over all those parts of the mechanism which are normally above oil level. No other lubrication is necessary within the tank. Replace the inner cover (351) and fasten it down. Replace and secure the fuse carriage (349). Inspect the gasket on the cover (324) for signs of ageing or deterioration, and replace if necessary. Close and fasten the cover (324). Operate the EARTH (304, 308) and MAIN (303, 313) switches several times.



7.2 diagram "B"

7.28 Lubricate all external pivot points on the cover (324), handles (304, 308, 303, 313) and interlocks (305, 328, 329, 331) with a good quality oil (see section 7.4, "Lubricating Oil Specification") and touch up any damaged paintwork (see section 5.5, "Paintwork").

7.3 Switch Oil Sampling and Testing

7.31 Users are recommended to consult "British Standard Code of Practice CP1009, Maintenance of Insulating Oil" or any locally applicable standard for more detailed information on this subject. The following procedures are based on those advocated in CP1009.

7.32 First, remove a sample of oil for testing. Use a pipette-type 'thief' tube, keeping the upper end sealed with your thumb until the lower end is about 100 mm (4 in) from the bottom of the tank. Release the upper end and allow the oil to rise up the tube. Re-seal the top with your thumb, remove the tube and transfer the oil sample to a clean, ground - glass-stoppered sample jar of about 1 litre (2 pints) capacity. The first two samples should be used to flush the thief tube and sample jar. Fill, seal and label the jar, giving details of the time and date, the location and the serial number of the unit. The oil may be tested on site if facilities are available, or at a central laboratory.

7.33 If it is not possible to carry out the detailed tests (described later in this section) on site, examine the oil by sight and smell. Moisture may be visible as droplets, or as cloudiness in the oil. Cloudiness can also be due to suspended solids. Solid sludge or impurities will be readily visible. A dark brown colour suggests the presence of dissolved asphalts. Green indicates the presence of copper soaps and means that rapid deterioration is imminent. An acrid smell may indicate volatile acids liable to cause corrosion, whilst an odour of petrol or acetylene may indicate a low flash point due to the effects of a fault. If the oil exhibits any of these symptoms to a marked degree it should be removed and reconditioned or discarded and the switch should be examined to determine the cause.

7.34 Oil may be subjected to an electric strength test as follows.

A glass cell, minimum internal dimensions 55 mm (2.1/4 in) x 90 mm (3.3/4 in) x 100 mm (4 in) high, is placed on a thick porcelain dish or other insulator.

Two polished brass spheres of 12.7 to 13 mm (0.5 to 0.511 in) diameter are placed 4 $\pm$ 0.02 mm (0.157 $\pm$ 0.001 in) apart in a horizontal arrangement with their axis at least 40 mm (1.37/64 in) above the bottom of the container, which must be scrupulously clean.

The cell is filled with oil at room temperature ($15^{\circ}C$-$25^{\circ}C$) and the voltage across the sphere electrodes is gradually raised to 30kV, 25-200 Hz, and maintained at that value for one minute.

If a sustained arc does not develop between the electrodes, then the oil is satisfactory in respect of electric strength.

7.35 Suitable moisture tests are the gentle boiling of a small sample of oil over a bunsen flame, or the plunging of a dully red-hot steel rod into a quarter litre (1/2 pint) of oil. In either test, a crackling sound indicates the presence of moisture and the failure of the sample. Two samples out of three should be crackle-free if the oil is to be passed as suitable.

7.36 The presence of dissolved sludge may be detected by diluting a sample of the oil with petroleum spirit and filtering it to see if any sludge is precipitated.

Other tests are best performed only in the laboratory, under controlled conditions.

7.37 Should the oil need to be replaced, clean the tank, mechanisms and contact systems and refill with clean oil, observing the precautions detailed under 5.2, "Oil Filling of Switchgear".

7.38 Whilst the tank is empty, check the mechanisms and contact systems as described in sections 7.25 and 7.26.

7.39 Top up the oil to the marked level in the tank. New oil may be added to old oil, provided that both comply with the requirements of British Standard BS 148 and the old oil is in reasonably good condition.

7.4 Lubricating Oil Specification

7.41 The following lubricating oil specification has been specially developed to suit the requirements of those mechanical components of electrical switchgear which are not within the oil tank. However, any reputable make of oil having an approximately similar specification should be satisfactory. In case of difficulty, please consult our Head Office.

7.42

Specific Gravity	0.893
Pour Point	- 15°F (- 26°C)
Closed Flash Point	500°F (260°C)
Viscosity Redwood	1400 at 70°F (21°C) 172 at 140°F (60°C)
Viscosity Index	96
Additives	2% MoS_2 + tackiness agent.

7.5 Post Fault Maintenance and Fuse Renewal

7.51 Post fault maintenance is limited to the replacement of fuses (311), since the essence of oil fuse switch design is that fault current interruption is confined to the element within the fuse barrel. The tripping of the main switch mechanism serves merely to interrupt the load current on the healthy phases and isolate the outgoing circuit.

7.52 Since the MAIN switch (313) must be set to RESET (303) before the cover (324) can be opened, fuses (311) should only be changed when the MAIN switch (303) can be switched ON (313) immediately afterwards. It cannot be locked in the RESET position (303).

7.53 The fuses (311) can be changed without the use of tools. Fuses are to BS 2692: 1956, of oil-immersed type with striker pins and of barrel size 63 mm (2.1/2 in) diameter by 359 mm (14.1/8 in) or 254 mm (10 in) length, according to which contact cup design (325) is fitted. Kits for conversion to take the alternative fuse sizes are available from Yorkshire Switchgear's head office.

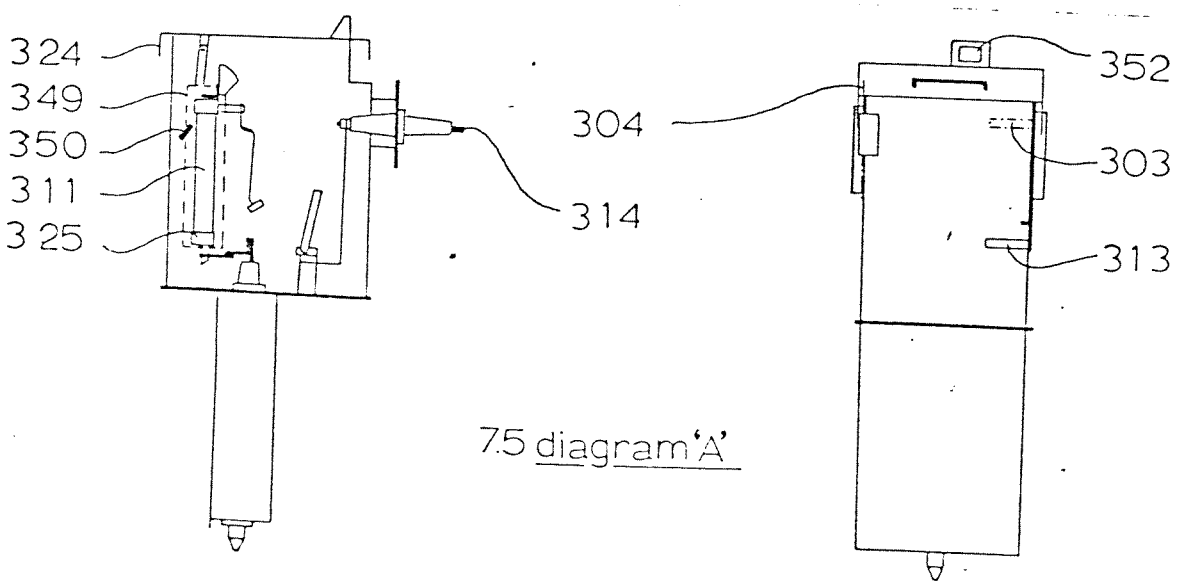
7.54 Note that the right hand MAIN switch (313) is OFF and the left hand EARTH switch is OFF (304) as shown in the indicator window (352). Unlock the MAIN switch handle (313) and raise it to the RESET position (303).

7.55 Unfasten the screws securing the cover (324) and raise the cover and fuse carriage (349) until the carriage retaining clip (350) springs forward to support the weight. The fuses are now accessible; Raise the mechanism trip bar (307) and the hinged contact clips of all three fuses. Remove and destroy or discard all three fuses, since any which have not blown may nonetheless have suffered some damage during the fault.

7.56 Insert the bottom contact (i.e. the end without a striker pin, as indicated on the fuse body) of each new fuse (311) in turn into its retaining cup (325) in the fuse carriage (349). Press each fuse down firmly to ensure that it is satisfactorily seated. Secure the hinged clips over the tops of the fuses and lower the trip bar (307) across the tops of the fuses.

7.57 Release the spring loaded retaining clip (350) on the carriage and close the cover (324). Fasten the cover retaining screws.

7.58 Push the right hand MAIN switch handle (303) down (313) to re-close the main switch. The indication in the window (352) will change to ON. Lock the handle (313) in this position.



7.5 diagram 'A'

7.6 Changing from 254 mm (10 in) to 359 mm (14.1/8 in) Fuses

7.61 Note that the following text applies where the existing fuse carriage (349) is re-used but fitted with replacement fuse retaining cups (325b).

7.62 With the fuse switch (312) OFF and in the RESET position (303, 352), unfasten and raise the fuse switch cover (324). This will lift the fuse carriage (349) with it. Disconnect the links which suspend the fuse carriage from the lid and lift the carriage out of the tank.

7.63 Unfasten the twelve nuts and screws which secure the three fuse retainers/lower contact cups (325a) and the three fuse contact support plates (354). (N.B. Where an enclosed type of fuse carriage is employed, its front cover will need to be removed first). Remove and discard or store the plates, fuse retainer/cups (325a) and contacts (355) and the twelve sets of nuts and screws.

7.64 Using the nuts and screws provided and the existing holes in the carriage (i.e. the holes which formerly secured the fuse contact support plates), fit the replacement fuse retainers/contact cups (325b) which are supplied complete with the shorter design of fuse contact (356) for 359 mm (14.1/8 in) fuses.

7.65 Check that the three pairs of spring contacts (357) which extend from the bottoms of the contact cups (325b) are equally spaced at 119 mm ± 1 mm (4.11/16 ± 1/32 in) to ensure correct contact alignment and engagement. In the case of an enclosed carriage, replace the front cover.

7.66 Replace the carriage (349) in its guides in the tank. Re-connect the links between the carriage and switch cover (324).

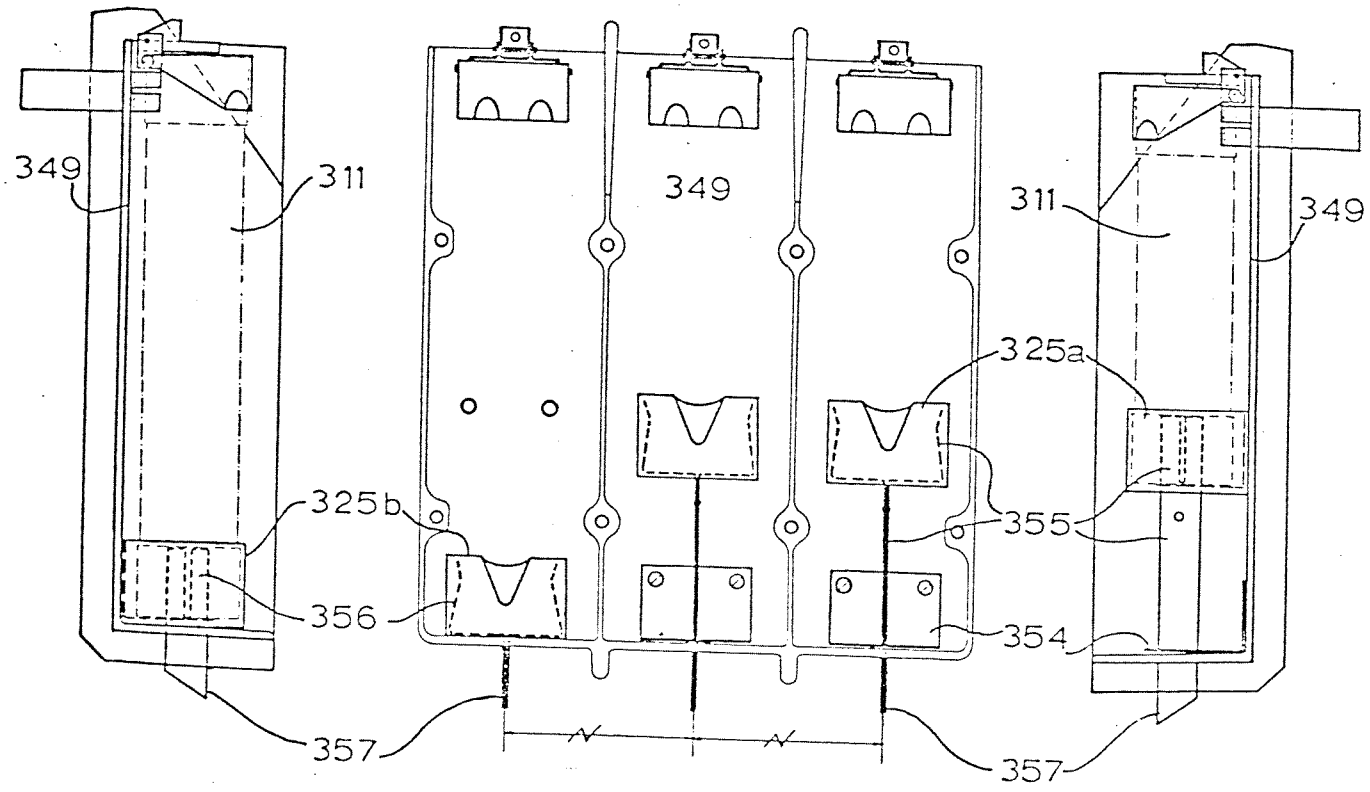
7.7 Changing from 359 mm (14.1/8 in) to 254 mm (10 in) Fuses

7.71 Note that the following text applies where the existing fuse carriage (349) is re-used but fitted with replacement fuse retaining cups (325a).

7.72 With the fuse switch (312) OFF and in the RESET position (303, 352), unfasten and raise the fuse switch cover (324). This will lift the fuse carriage (349) with it. Disconnect the links which suspend the fuse carriage from the lid and lift the carriage out of the tank.

7.73 Unfasten the six 'O'BA nuts and screws which secure the three fuse retainers/lower contact cups (325b). (N.B. Where an enclosed type of fuse carriage is employed, its front cover will need to be removed first). Remove and discard or store the fuse retainer/cups (325b), contacts (356) and the six sets of 'O'BA nuts and screws.

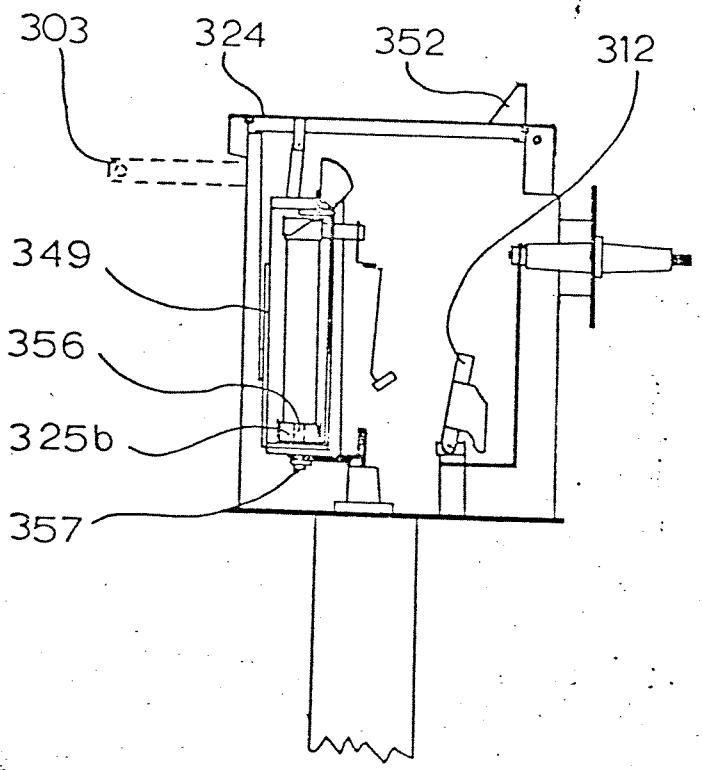
7.74 Using the nuts and screws provided and the existing holes in the carriage, fit the replacement fuse retainers/contact cups (325a) which are supplied complete with the longer design of fuse contact (355) for 254 mm (10 in) fuses and the fuse support plates (354).



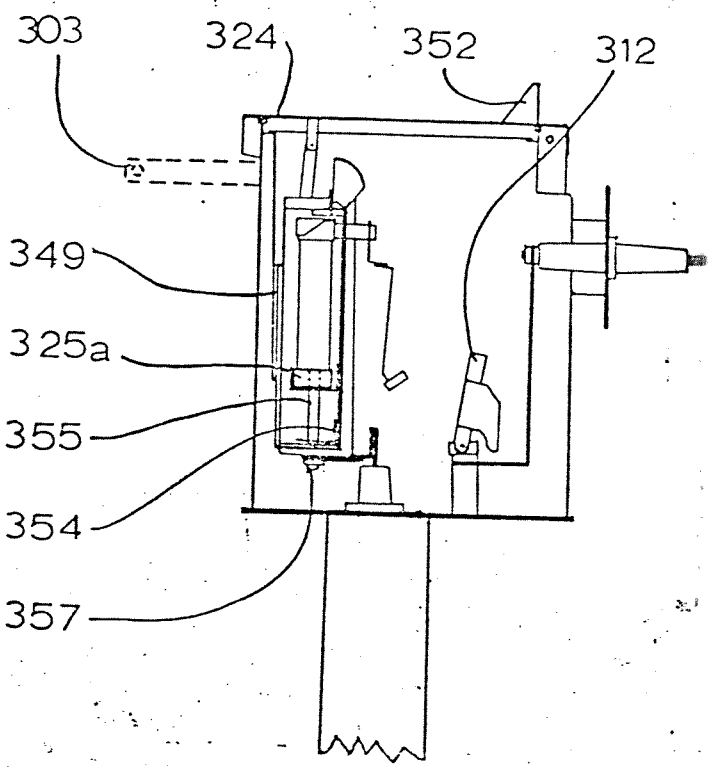
7.6&7.7 diagram'A'

7.75 Check that the three pairs of spring contacts (357) which extend from the bottoms of the contact cups (325a) are equally spaced at 119 mm ± 1 mm (4.11/16 in ± 1/32 in) to ensure correct contact alignment and engagement.

7.76 Replace the carriage (349) in its guides in the tank. Re-connect the links between the carriage and switch cover (324).



7.6/7.7 diagram 'B'



7.6/7.7 diagram 'C'

8 SPARES AND TOOLS

8.1 Spare Parts

8.11 Service experience with earlier designs of fuse switch has shown that the need for the replacement of any part of a SO-FS fuse switch will very rarely arise.

8.12 In view of this factor, of the wide variety of duties and environments to which units may be subjected and of the detailed variations in equipment between individual installations, it is our policy to recommend spare parts on an individual contract basis rather than to issue a general list of recommended spares.

8.13 Should any part be required which was not initially provided as a spare, the enquiry should include the serial number of the unit, the information quoted on the data plate and, where possible, the original contract number. Where relevant, references to illustrations and part key numbers used in this manual may assist in the identification of the component to be renewed, e.g.:

8.14 SO-FS fuse switch, serial no. 0100234, 250 MVA 11kV 90/100 amps, 150 MVA 6.6kV 135/50 amps, 3 phase, peak kilo-amps 33.4, 50/60 Hz.

Trip bar assembly, key no. 307, as illustrated in 7.5 diagram 'A' in Instruction Manual for Outdoor Metalclad Transformer Mounted Automatic Oil Fuse Switch SO-FS Equipment Rated Voltage up to 15kV, Second Edition, November, 1975.

8.15 Whilst not all of the information quoted will always be directly relevant or essential, it may help to distinguish between designs having minor detail variations.

8.2 Tools

8.21 The only tools required for this equipment are:

5/16 in BSW socket wrench,

1/4 in to 5/8 in [illegible] adjustable spanners and open ended spanners,

plus normal workshop tools such as screwdrivers, pliers, drifts, hammers, files, etc.

KEY TO ILLUSTRATIONS (SJ-FS fuse switch for transformer mounting)

122 Main cable box front plate on (351)
123 Cable sockets in (351)
124 Cable box bottom plate on (351)
125 Gasket for (126)
126 Gland for main cable (127)
127 Main cable
128 Filler aperture cover for (130)
130 Filler aperture in (122)
131 Filler aperture gasket for (130)
301
302 Main circuit label
303 Main switch RESET position
304 Earth switch OFF position
305 "Remove to Earth" interlock
306 Oil level
307 Trip bar
308 Earth switch ON position
309 Compound level
310 Flange around (314)
311 Fuse barrel
312 Main switch blade
313 Main switch ON/OFF position
314 Bushing connection to transformer
315 Earth switch blade
323 Oil tank
324 Main cover
325 Lower fuse retaining cups (a) for 254 mm fuses (b) for 359 mm fuses
326 Switch interlock cam on main switch drive shaft (337)
327 Switch interlock cam on earth switch mechanism
328 Front interlock shoot bolt driven by (329)
329 Cover interlock cam on main switch handle shaft
330 Cover interlock catch inside right side of (324)
331 Rear interlock shoot bolt driven by (324)
332 Main switch twin drive arms
333 Main switch mechanism hammer
334 Main switch upper trip roller
335 Main switch drive shaft notched cam
336 Main switch closing spring assembly
337 Main switch drive shaft
338 Main switch handle internal drive lever
339 Main switch hold back catch
340 Main switch upper trip roller arm
341 Earth switch mechanism drive lever
342 Earth switch mechanism driven lever
343 Earth switch operating springs
349 Fuse carriage
350 Fuse carriage retaining clip
351 Tank inner cover
352 ON/OFF/EARTH indication on top cover
353
354 Fuse contact support plates
355 Fuse contacts (long type) for 254 mm fuses
356 Fuse contacts (short type) for 359 mm fuses
357 Spring contacts protruding from (325) bottoms
358 Incoming cable box
359 Cable box bushings