INSTRUCTION MANUAL

FOR

INDOOR METALCLAD

OIL CIRCUIT BREAKER

UNIT

'SO-HI'

EQUIPMENT RATED VOLTAGES 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, August, 1974

YORKSHIRE SWITCHGEAR & ENGINEERING COMPANY LIMITED,
Meanwood, Leeds, LS6 2BN, England.

Telephone: 0532-757121/7. Telex: 557564

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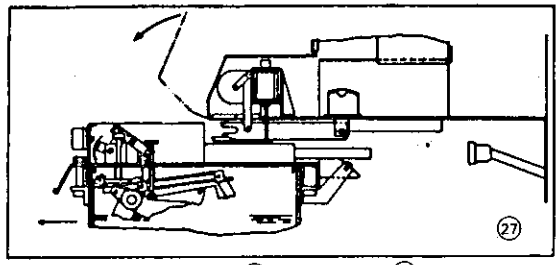
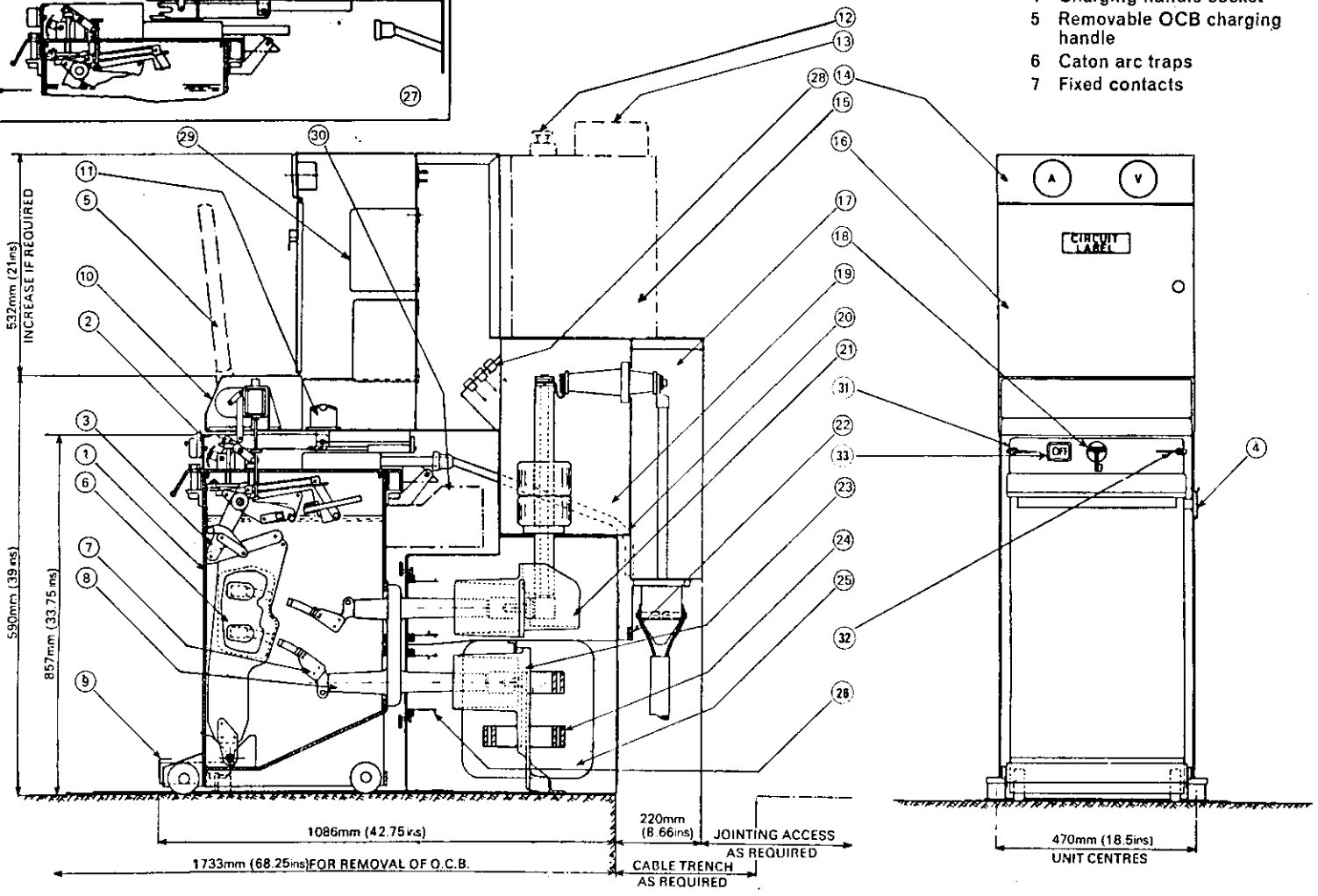




1 Oil circuit breaker tank
2 Hinged OCB tank lid
3 Withdrawable mechanism/ moving contact assembly
4 Charging handle socket
5 Removable OCB charging handle
6 Caton arc traps
7 Fixed contacts
8 Monobloc cast resin oil circuit breaker moulding with flexible isolation contacts
9 Foot operated service lock treadle
10 Hinged cover for access to auxiliary switch, tripping coils and fuses
11 Control, metering and indication fuses
12 Withdrawable HV—VT fuses
13 VT—LV fuses automatically isolated when HV fuses are withdrawn
14 Indication and control panel
15 Oil insulated voltage transformer chamber
16 Relay cabinet
17 Detachable cable box (shown compound filled)
18 OCB interlock knob
19 Air insulated current transformer chamber
20 Oil circuit breaker vent tubes
21 Cast resin circuit insulator moulding
22 Earth bar
23 Cast resin busbar insulator moulding
24 Insulation coated busbars (up to 2000 amps)
25 Air insulated busbar chamber
26 Automatic safety shutters with padlocking facility
27 OCB partially withdrawn
28 Multicore cable fittings (cables routed between panels)
29 Internally mounted relays
30 Power mechanism housing
31 Close lever
32 Trip lever
33 ON/OFF and SPRINGS CHARGED indication

GENERAL ARRANGEMENT OF SO·HI METALCLAD O.C.B. PANEL

1 "SO-HI" OCB - GENERAL DESCRIPTION

1.1 Basic Design Concept

1.11 Yorkshire Switchgear's "SO-HI" is a compact, indoor, metalclad oil circuit breaker unit for voltages up to 15kV and fault levels up to 500 MVA. The type designation of an individual OCB indicates the maximum equipment rated voltage and the maximum symmetrical breaking current, e.g. SO-HI 12/22 would indicate an equipment rated voltage of 12kV and a symmetrical breaking current of 22kA.

1.12 No OCB should be employed on a system having a higher voltage or fault level than those indicated by its designation, without prior approval from Yorkshire Switchgear & Engineering Co. Ltd.

1.13 "SO-HI" circuit breakers comply with the requirements of the issues or revisions of BS116 and IEC56 current at the time of tendering for an order. They are designed for use on 3-phase 50/60 Hz systems having an earthed neutral.

1.14 Each unit has two major components:

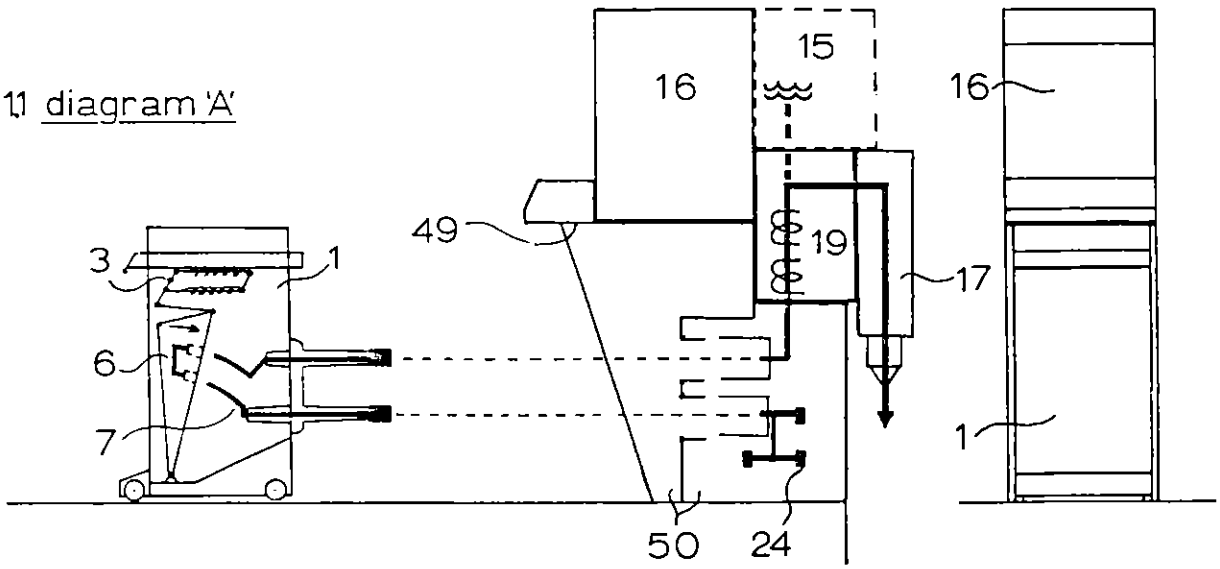
(a) the moving portion, a wheeled oil tank (1) containing the combined operating mechanism and OCB moving contact assembly (3, 6) and OCB fixed contacts (7); and

(b) the fixed portion.

1.15 The basic fixed portion is a standard shell comprising a chamber (50), which houses the busbars (24) and has extended sidewalls, and a top "master plate" (49). To this shell may be added a current transformer chamber (19), rear cable box (17), instrument compartment (16) and oil or resin insulated voltage transformer housing (15) according to the customer's requirements.

1.16 "SO-HI" circuit breaker switchboards may be extended with the SO-FM fault making oil switch and SO-FS oil fuse switch.

1.1 diagram 'A'



1.2 Operating Mechanism

1.21 A hand charged spring, trip free operating mechanism is fitted as standard. Where required an electrically powered mechanism can be provided. Motor charging kits are available for the conversion of units originally supplied for hand charging only.

1.22 The spring mechanism is mounted in the oil tank to reduce maintenance requirements.

1.23 For further details, see section 2, "Detailed Description of Mechanisms".

1.3 The Caton Arc Trap

1.31 "SO-HI" employs a radially operating version of the Caton Arc Trap self-generated oil-blast arc control device combining the following features:

(a) double break operation;

(b) separate main and arcing contacts;

(c) a fully enclosed arcing chamber on each phase;

(d) automatic isolation and cleaning of the arc control system by the opening operation.

1.32 An insulated frame carries the three arc traps, which are pivoted from the bottom of the tank, and the operating mechanism which is directly linked to the arc trap tops.

1.33 For further details, see section 3, "Detailed Description of Arc Control System".

1.4 Isolating and Insulation Systems

1.41 Horizontal isolation of the moving portion eliminates the need for any kind of elevating mechanism, whilst giving a positive, visual indication that the isolated OCB is safe to work on.

1.42 The moving main isolating contacts (88) are mounted on the one-piece resin bushing moulding (8) which also supports the OCB fixed contacts (7) within the tank.

1.43 The fixed busbar isolating contacts (133b) are supported by a resin moulding (23) which also supports the busbars (24) in a trefoil formation and incorporates the tee-off connections and receptacle insulators.

1.44 The unit length busbars themselves (24) are of hard drawn, high conductivity copper with an insulated coating and are jointed at the tee-off connections. Full air clearances and/or creepage distances are maintained throughout.

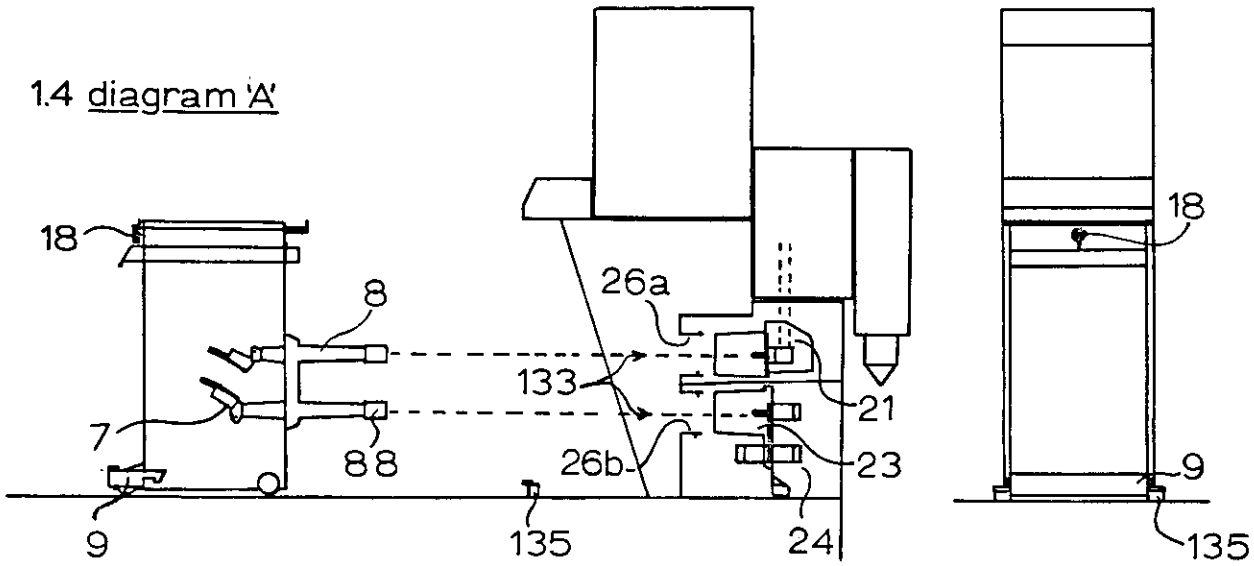
1.45 Another resin moulding (21) supports the feeder fixed isolating contacts (133a). It also supports the bottoms of the current transformer chamber bar primary bushings.

1.46 Independently padlockable feeder (26a) and busbar (26b) safety shutters protect the fixed isolating contacts when the moving portion is withdrawn.

1.47 A two-position interlock knob (18) bolts the OCB moving portion in the SERVICE location, and treadle-released hooks (9) engage anti-jump stops (135) to secure it in this location.

1.48 For further details, see sections 6.1 "To Plug into Service Location" and 6.2 "To Withdraw from Service Location".

1.4 diagram 'A'



1.5 Technical Specification

Certified to BS116: 1952 and IEC56-1/1972-74 and any revisions current at the time of quotation, unless otherwise specified.

Suitable for 3 phase systems with earthed neutral rated up to 15kV.

OCB normal current ratings: 500A, 1250A, 2000A.

Busbar normal current ratings: 800A, 1250A, 2000A.

Fault current ratings:

Specification	Voltage (kV)	Rating (MVA)	Making Current (kA peak)	Breaking Current (kA)		3 Second Short Time Current (kA)
				Symmetrical	Asymmetrical	
BS116	6.6	250	55.8	21.9	26.8	21.9
	11	350	46.9	18.4	22.5	18.4
IEC56	12	415	50	20	21.5	20
	15	520	50	20	21.5	20

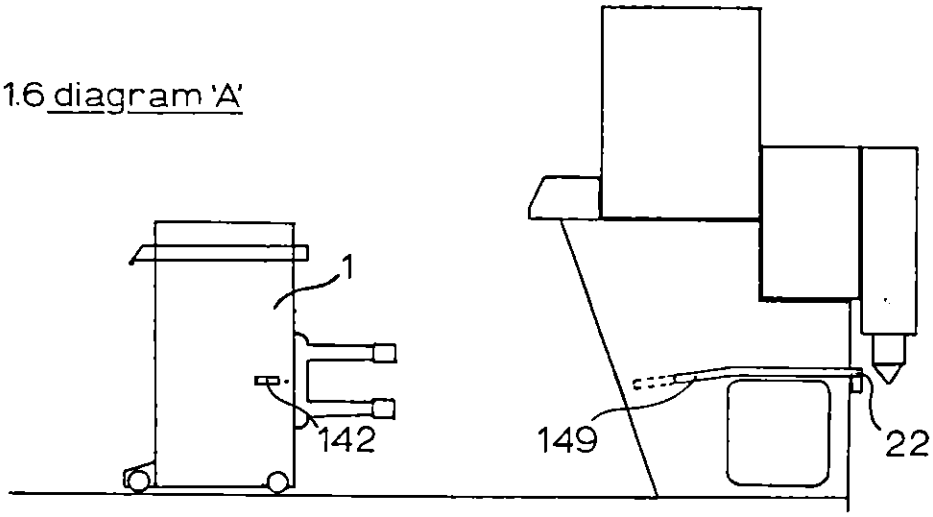
At lower or intermediate voltage values the standard "SO-HI circuit breaker can cater for short circuit currents up to, but not exceeding, those quoted. For details of other ratings, please contact us at our Leeds office.

1.6 Earthing & Testing

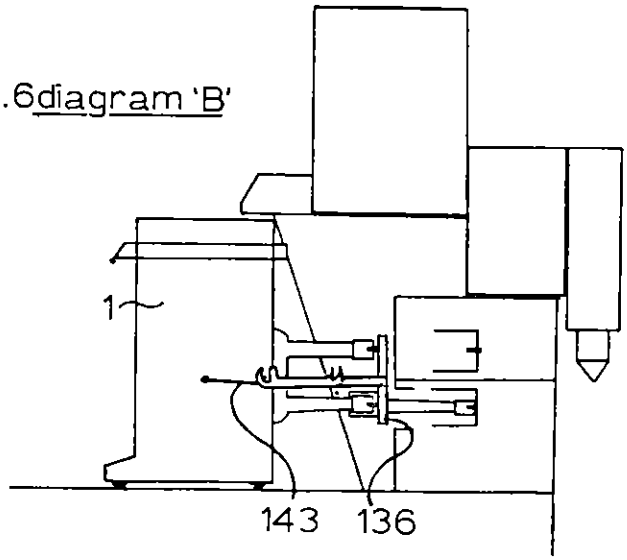
1.61 Earthing of the OCB tank (1) is by two sprung copper contacts (142), one on each side, which engage copper earth bars (149) on the fixed portion side panels. A continuous switchboard earth bar (22) bonds all the fixed portions to the substation earth (diagram 'A').

1.62 Earthing of the circuit or busbar fixed isolating contacts through the OCB is catered for by a light-weight, portable earthing/testing device (136). One man can easily fit it onto the moving portion (1), where it is secured by cam-shaped hook levers (143). The position of the device determines whether the earth is applied to the busbar (diagram 'B') or circuit (diagram 'C') contacts (see section 6.7 "Circuit and Busbar Earthing via the OCB"). The device can also be employed for cable testing (diagram 'D') (see section 6.8 "Cable Testing via the OCB Earthing/Testing Device").

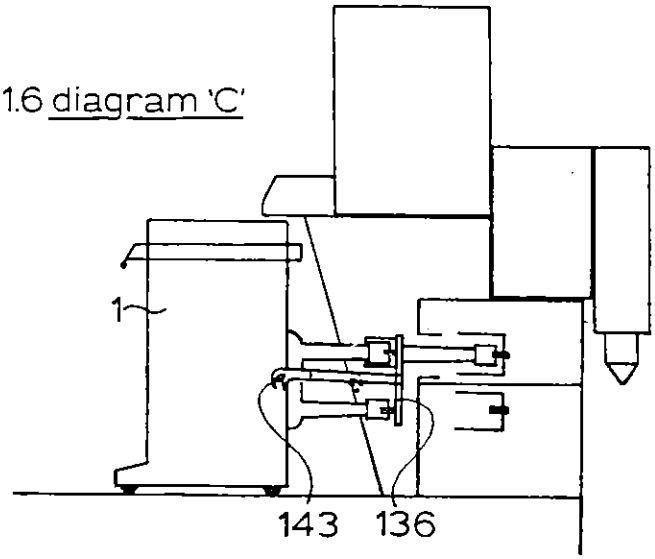
1.6 diagram 'A'



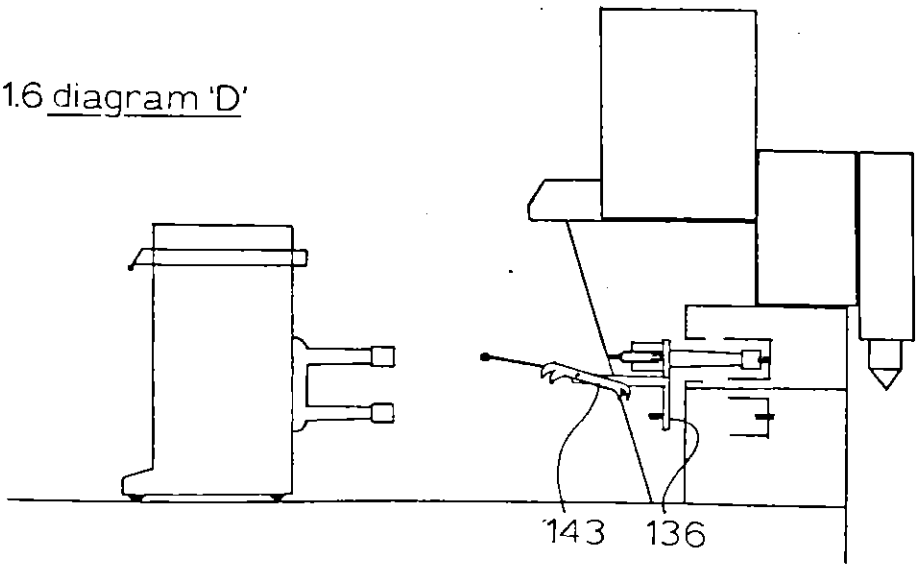
1.6 diagram 'B'



1.6 diagram 'C'



1.6 diagram 'D'



1.7 Interlocks and Padlocking

1.71 Positive mechanical interlocks are incorporated in the design as follows (diagrams 'A' and 'B').

1.72 A moving portion cannot be plugged into or isolated from the fixed portion if the OCB is closed, since in the ON position a rod (36) on the on/off indicator drive rocker (37) interferes with a plate (38) on the service/isolate interlock knob shaft (39) to prevent the knob (18) being turned to ISOLATE. The knob is thus trapped in the SERVICE position, and the rotating bolt (40) which it operates is trapped by a plate on the fixed portion to thwart any attempt to insert or withdraw the moving portion.

1.73 An OCB can only be closed if the moving portion is in the correct service, earth or isolated location, since it is only in these locations that the service/isolate interlock knob (18) can be moved to SERVICE. When the knob is in any other position a projection (41) on its shaft (39) depresses the interlock lever (42) to hold down the OCB trip tappet (43). This means that the opening and closing springs cannot be latched in their charged positions, and the OCB cannot be closed.

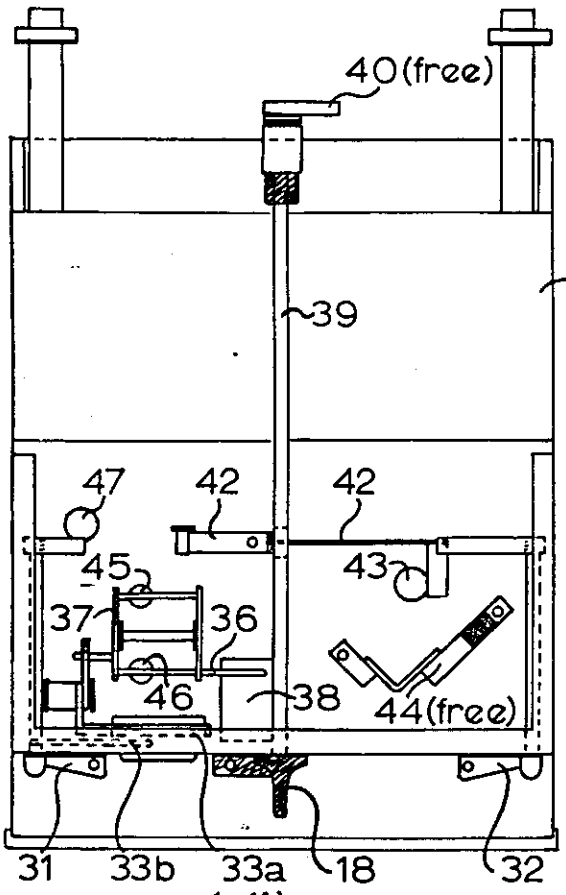
1.74 An "earthing device anti-tripping interlock (44)" on the OCB tank lid can be padlocked to prevent the OCB's being tripped when it is being used to earth the busbars or circuit.

1.75 The service/isolate interlock knob (18) can be padlocked in the SERVICE position to prevent the plugging in or isolation of the moving portion.

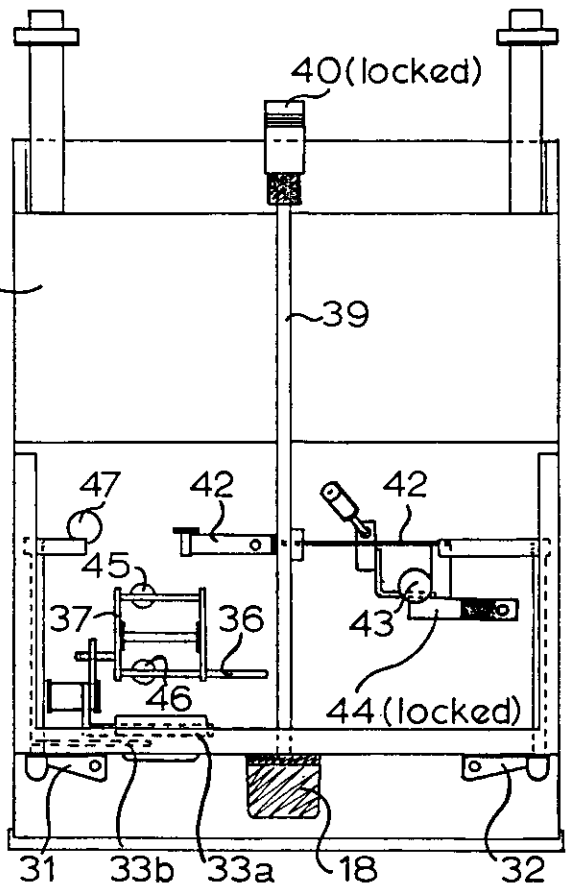
1.76 The charging handle socket (4) can be padlocked to prevent spring charging.

1.77 The trip lever (32) can be padlocked to prevent manual tripping in the SERVICE location.

1.78 When the closing springs are charged an interlock catch on the mechanism is pushed under a protrusion on the tank front wall to prevent the mechanism's removal.



1.7/2.2 diagram 'A'



1.7/2.2 diagram 'B'

2 DETAILED DESCRIPTION OF MECHANISMS

2.1 Principal Features

2.11 A unique design of spring mechanism, mounted on a common frame with the arc control system, is employed. This means that the springs and linkages are in an oil-vapour laden atmosphere and are splashed with oil each time the circuit breaker is operated. The tank venting system forms the only contact with outside air, so that the ingress of moisture or pollutants is virtually eliminated and maintenance requirements are greatly reduced. The common assembly of mechanism and contacts ensures that the linkages between mechanism and circuit breaking system are reduced to the minimum and excessive "play" and friction are eliminated to give more positive operation and more efficient utilization of the spring energy.

2.12 The closing and opening springs are charged simultaneously, and thus do not function in opposition. Mechanism inertia is minimal and lighter springs can be used, whilst smooth, rapid closure and reliable trip-free operation are ensured. The use of hand charging with mechanical or electrical release for local control, or a spring charging motor for remote operation, avoids the need to store a charge for long periods on the closing springs. The closing springs may be left charged on an open circuit breaker but not on a closed circuit breaker.

2.13 One objective of the mechanism design was the standardisation of all circuit breaker moving portions of the same rating, irrespective of control or operational requirements, to allow complete interchangeability. This has been achieved by confining all secondary electrical control, protection and indication circuitry to the fixed portion. A standard system of tappets in the moving portion lid gives mechanical interconnection between fixed and moving portions, i.e. the intelligence between fixed and moving portions is by mechanical means.

2.2 Tappet Operation

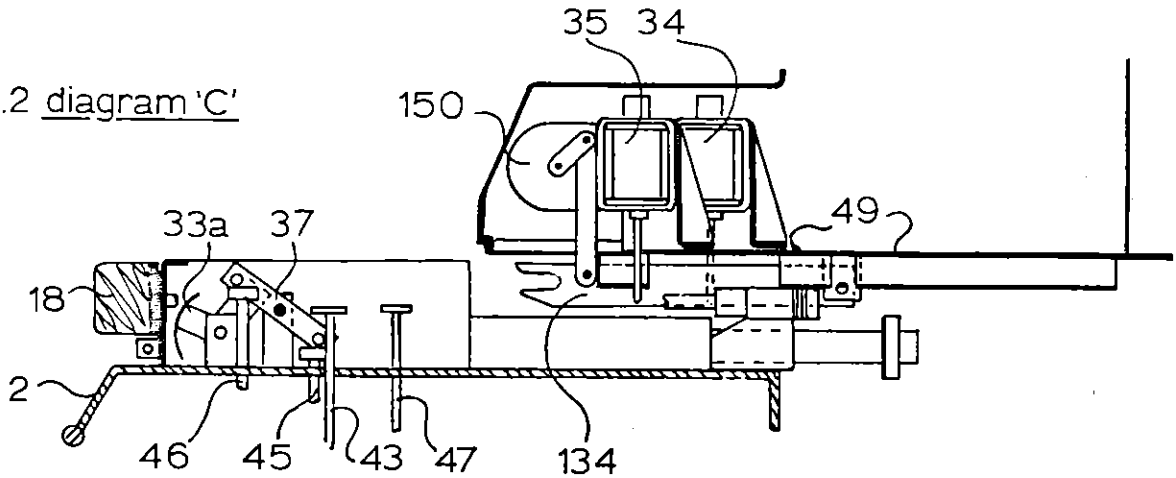
2.21 Two tappets are driven by the operating mechanism. One (45) is raised when the breaker is closed to ON, the other (46) when it is opened to OFF. These tappets in their turn operate a rocker arm linkage (37) which controls the position of the on/off indicator (33a) on the front of the tank lid (2) and also, through a forked lever (134) mounted beneath the fixed portion master plate (49)operates any auxiliary switches (150) required for operation or indication.

2.22 A third tappet (47) is connected to the closing springs release mechanism. Depression of this tappet, either by the operation of a spring release coil (34) on the fixed portion or by manual depression of the close lever (31), releases the charged closing springs to close the OCB.

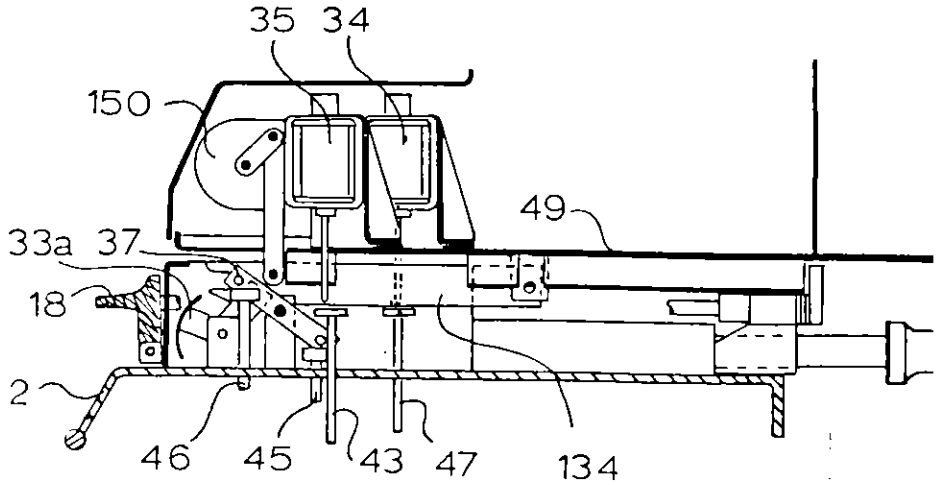
2.23 The fourth and final tappet (43) is connected to the opening springs release mechanism. Depression of this tappet, either by the operation of a trip coil on the fixed portion or by the manual operation of the trip lever (32), releases the charged opening springs to open the OCB.

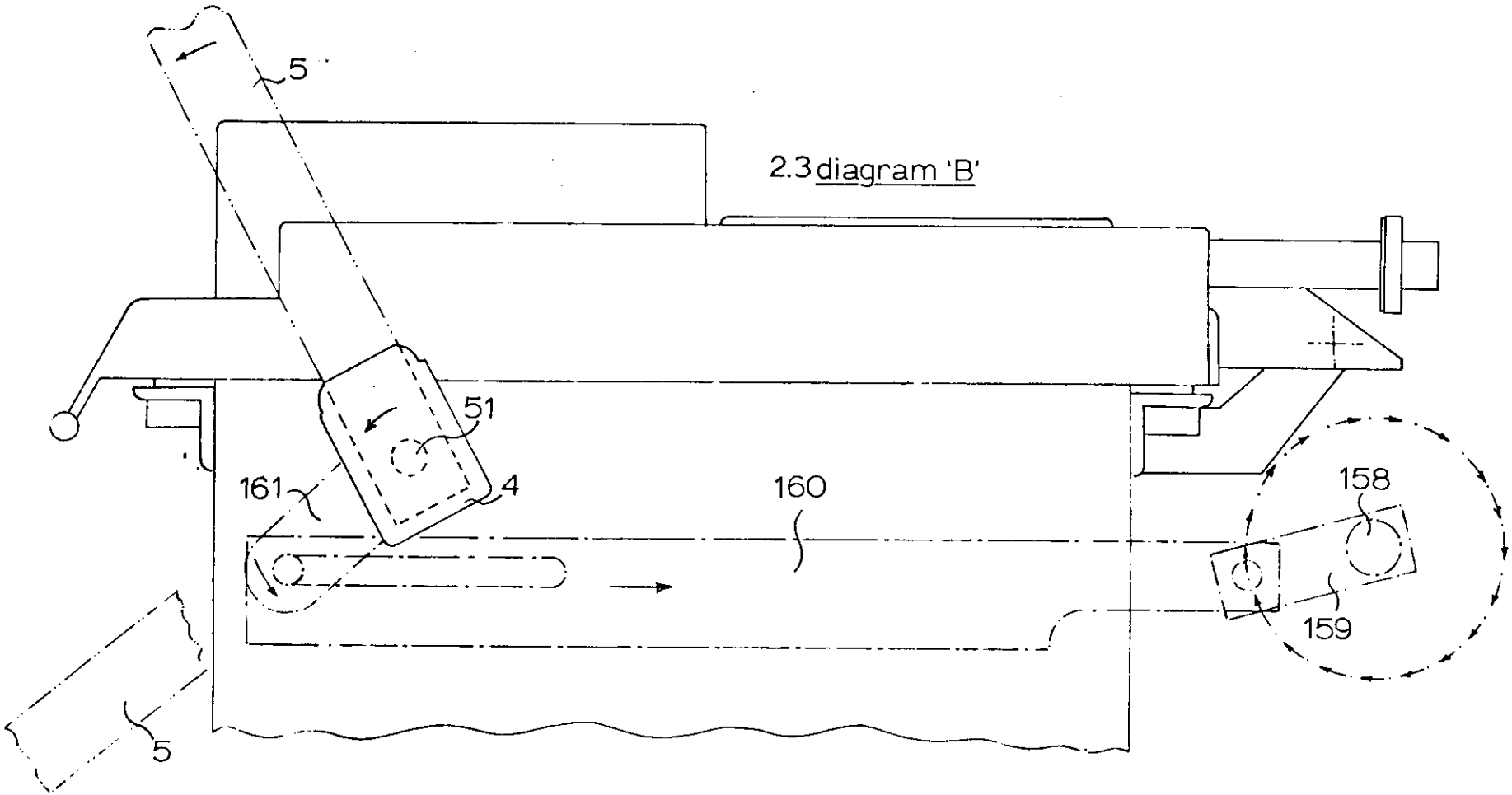
Additionally, when the closing and opening springs are charged but the OCB is open, operation of the trip lever (32) or trip coil (35) or the turning of the service/isolate interlock knob (18) to ISOLATE will depress the trip tappet (43) to discharge both sets of springs without closing the OCB. This should only be done with the charging handle inserted, depressed and held down to contain the charge (see paragraph 6.36).

2.2 diagram 'C'



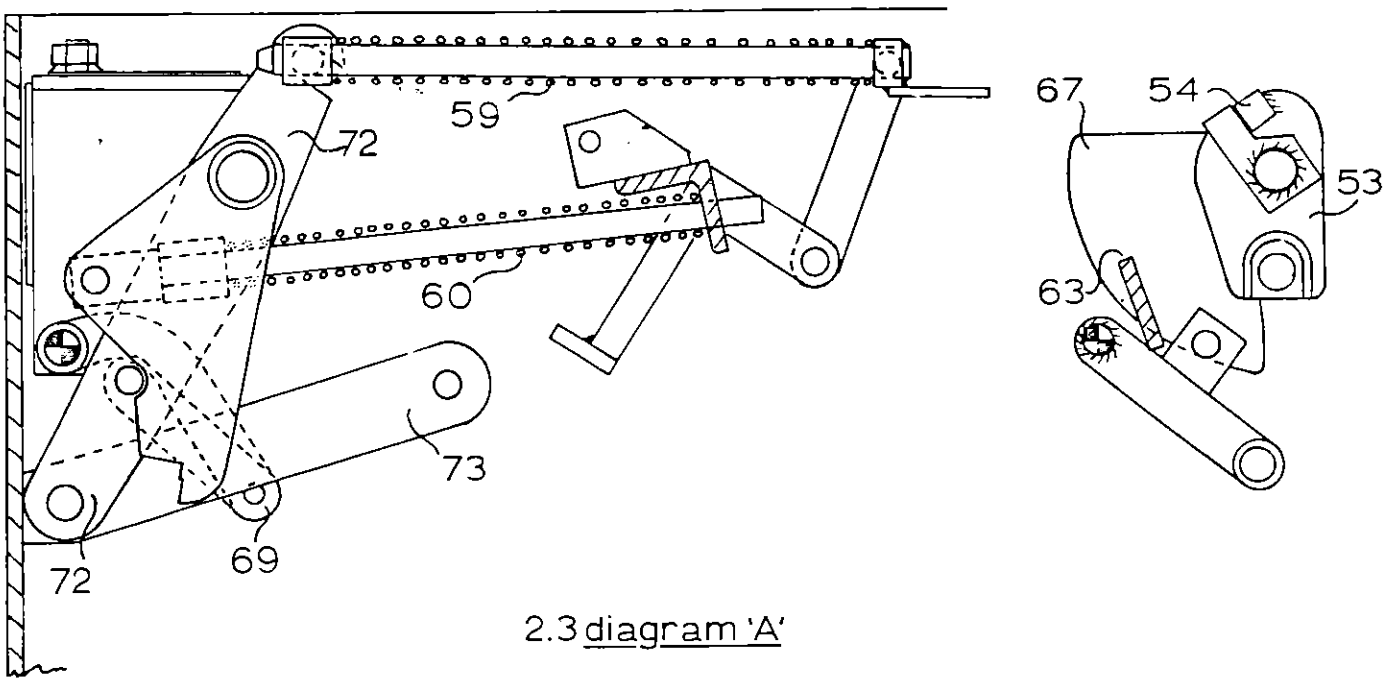
2.2 diagram 'D'




5
2.3 diagram 'B'
51
161
4
160
158
159
5

2.3 Spring Mechanism Operating Sequence

2.31 Diagram 'A' shows the mechanism in the open position with the closing springs (59) and opening springs (60) discharged. The knuckle toggles (69) are latched in the overtoggle position to hold back the lower ends of the main closing levers (72) and thus, through the arc trap operating links (73) to hold open the arc trap moving contact assemblies (not shown here). The initial position of the cam assembly (53, 54, 63, 67) and associated components is also shown.

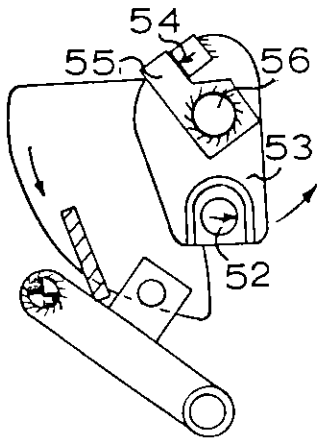


2.3 diagram 'A'

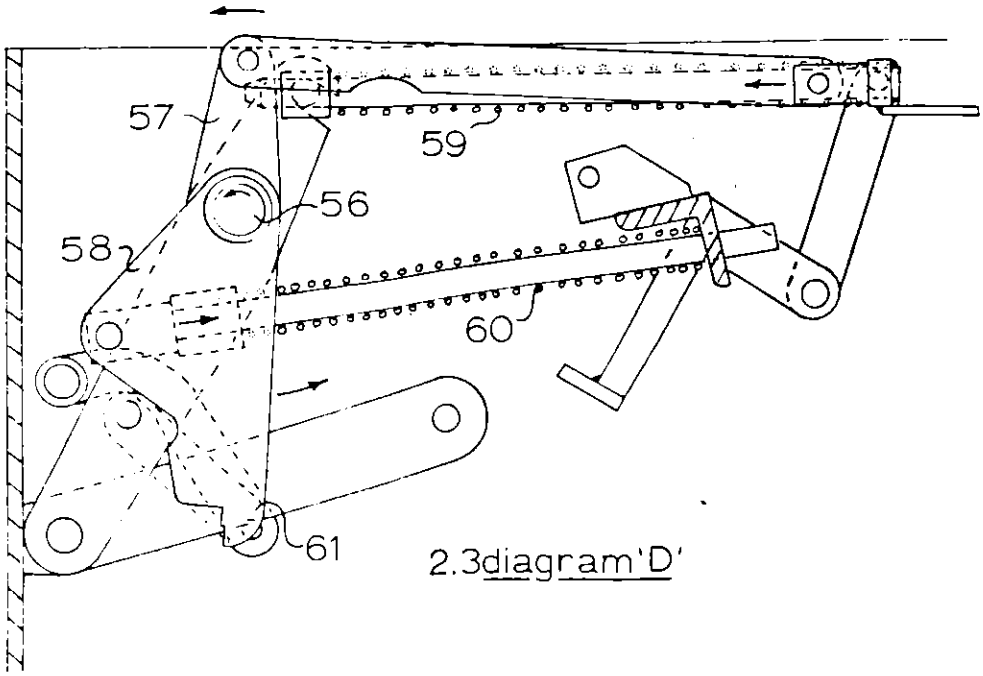
2.32 Diagram 'B' shows the spring charging operation. Either the charging handle (5) is placed in its socket (4) and moved forwards and downwards, or the motor/gear box unit final drive shaft (158) rotates to turn the motor drive arm (159), pulls the drive link (160) which in turn rotates the handle socket drive arm (161). In either case, the charging handle socket shaft (51) is rotated.

2.33 Inside the tank (diagram 'C') a crank pin (52) on the charging handle socket assembly (not shown) moves through an arc. The pin (52) is in engagement with, and drives, a transmission lever (53) which forms part of the cam assembly. A welded block (54), also part of the cam assembly, drives round a driven lever (55) which is welded to the end of the mechanism main shaft (56).

The rotation of the main shaft (56), as shown in diagram 'D', pivots the upper (closing) springs charging lever (57) to compress the closing springs (59) and also pivots the lower (opening) springs charging levers (58) to charge the opening springs (60). The main catch (61) forms an extension to the right hand opening springs charging lever (58) and moves with it.



2.3 diagram 'C'



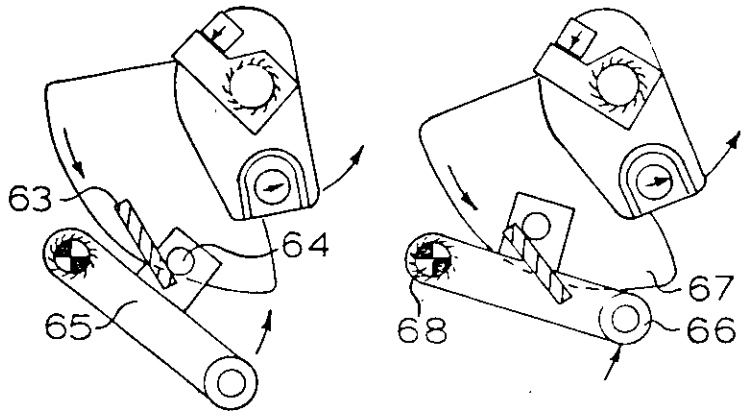
2.3 diagram 'D'

2.34 At an early stage in the charging operation (diagram 'E') a nudging plate (63) on the cam assembly, engages with a pin (64) mounted on the knuckle toggle roller lever (65), which it lifts so that the cam roller (66) runs along the edge of the cam (67) and the knuckle toggle shaft (68) is pivoted.

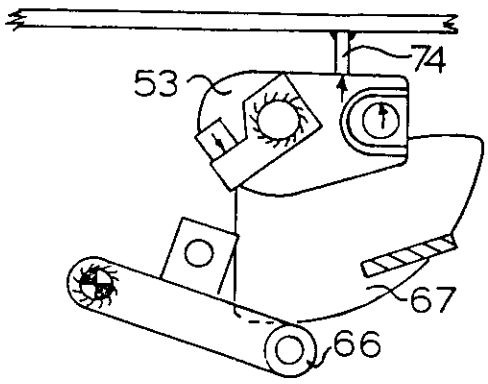
The movement of the knuckle toggle shaft (68) raises the knuckle toggles (69) to the off-toggle position (diagram 'F') so that only the resistance offered by the cam (67) to the roller (66) contains the closing spring pressure (diagram 'E').

2.35 As the charging handle approaches the bottom of its stroke, the main catch (61) pushes past the spring loaded main catch roller (62) which snaps back beneath it (diagram 'F'). By this time the top end of the upper (closing) springs charging lever (57) has pushed an interlock spring catch (not shown) under a protrusion on the front tank wall to prevent removal of the charged mechanism from the tank.

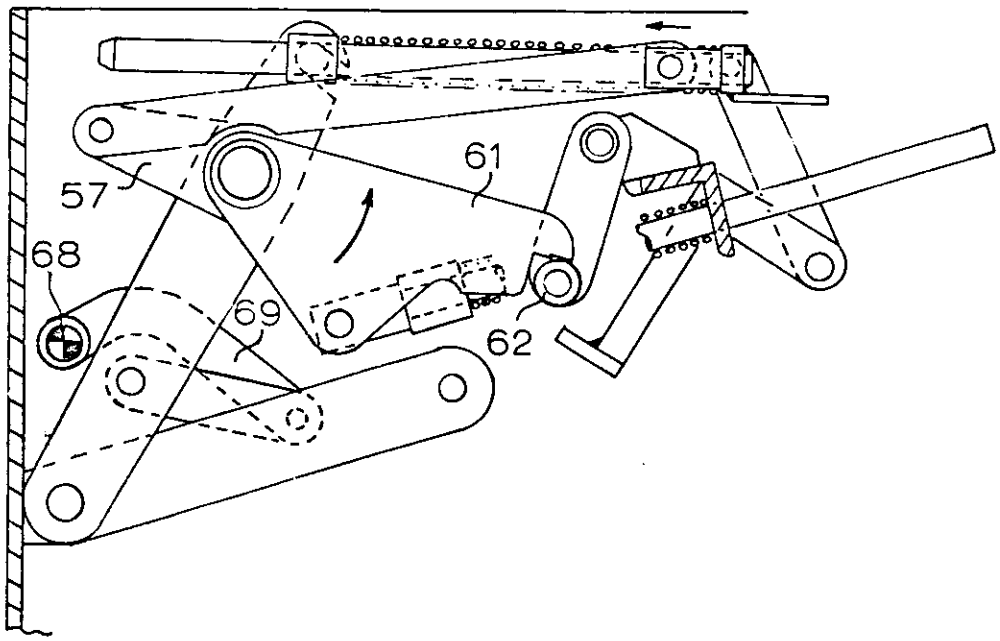
On completion of the charging stroke, the transmission lever (53) on the cam assembly comes up against a positive stop (74) (diagram 'G'). At this point the closing springs pressure is still contained by the resistance of the cam (67) to the roller (66).



2.3 diagram 'E'



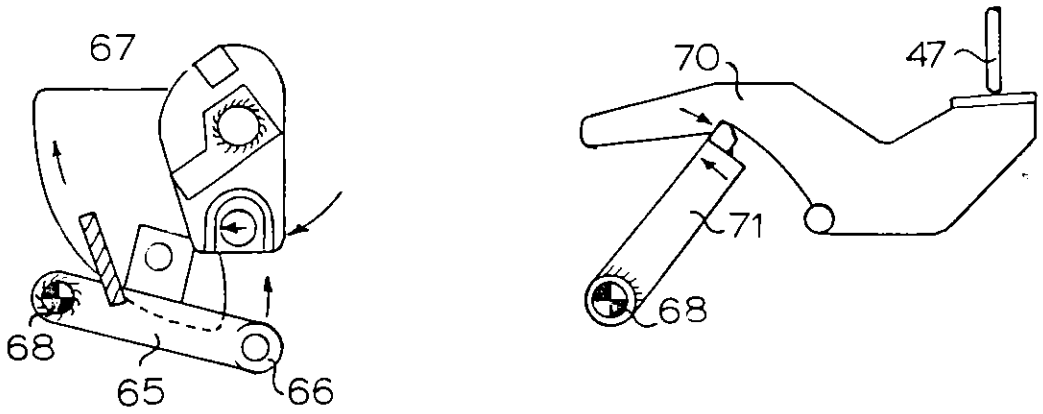
2.3 diagram 'G'



2.3 diagram 'F'

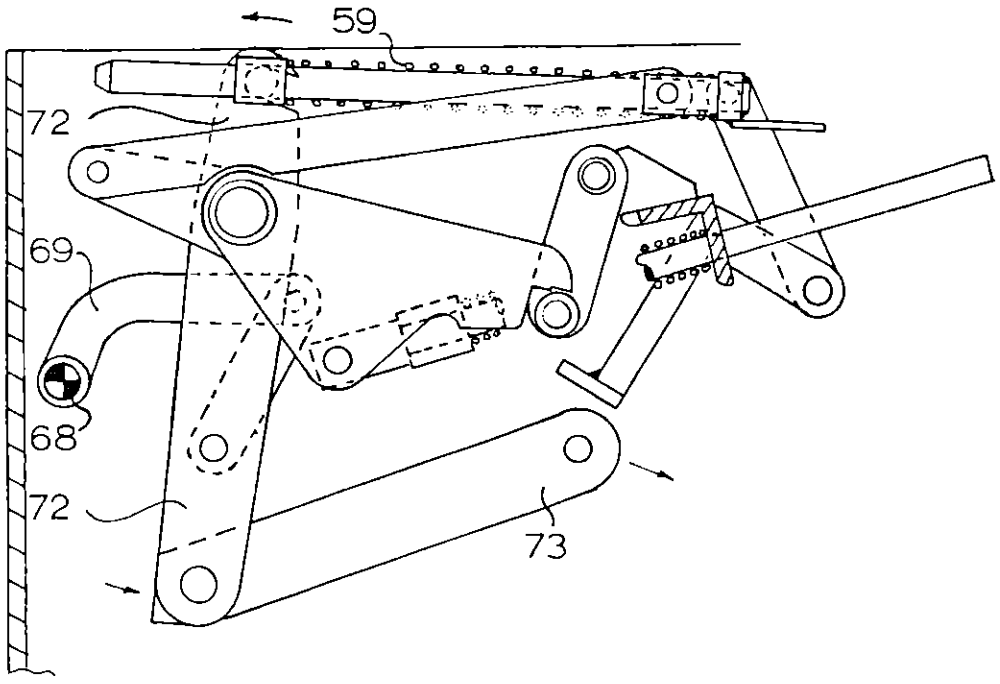
2.36 The operating handle and socket, or motor drive link and handle socket drive arm, are returned to the start position, aided by return springs, and the cam (67) returns to its original position (diagram 'H'), allowing the cam roller (66) and knuckle toggle roller lever (65) to rise, rotating the knuckle toggle shaft (68) slightly further and collapsing the knuckle toggles slightly more. However, this additional rotation of the shaft (68) causes the hold back catch (71) at its left hand end to pivot the closing springs release catch (70) into the "cocked" position by means of a spring loaded linkage (not shown).

In this position, the catch (70) pushes up the close tappet (47) to give a "springs charged" indication, and also contains the closing springs charge by preventing the further rotation of the hold back catch (71). The opening springs charge is contained by the main catch roller (62) which had snapped under the main catch (61) during the latter part of the charging stroke (diagram 'F').



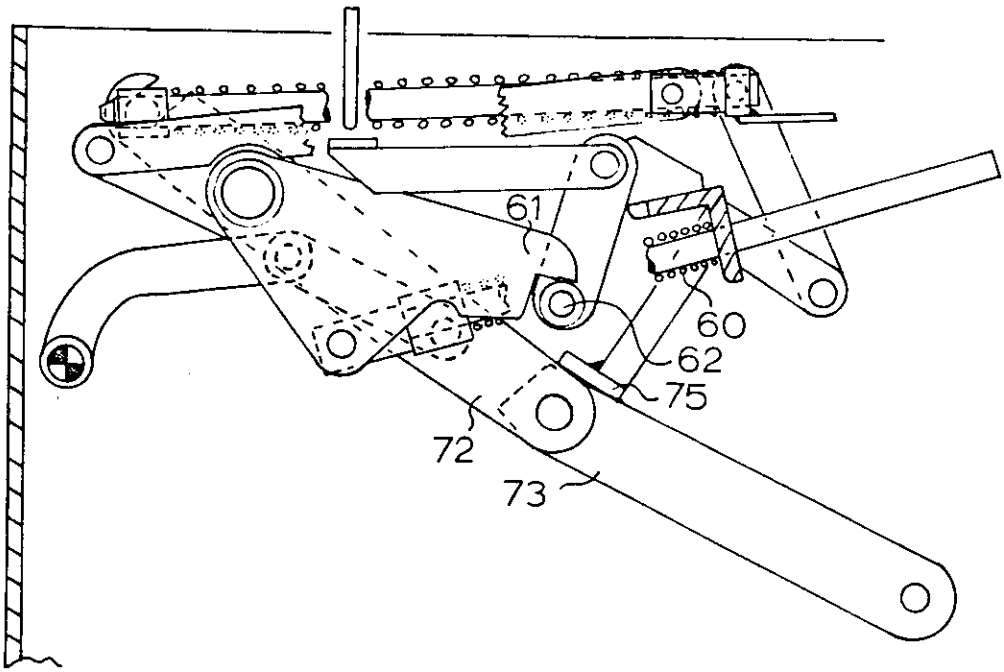
2.3 diagram 'H'

2.37 When the manual close lever (not shown here) is pressed, or the closing springs release coil (not shown here) is energised, the close tappet (47) (diagram 'H') is pushed down and pivots the closing springs release catch (70) clear of the mechanism hold-back catch (71). The knuckle toggle shaft (68) rotates (diagram 'J') as the knuckle toggles (69) rise due to the movement of the main closing levers (72) under pressure from the closing springs (59). This motion is transmitted by the arc trap operating links (73) to push the arc traps (not shown here) firmly into engagement with the fixed contacts.



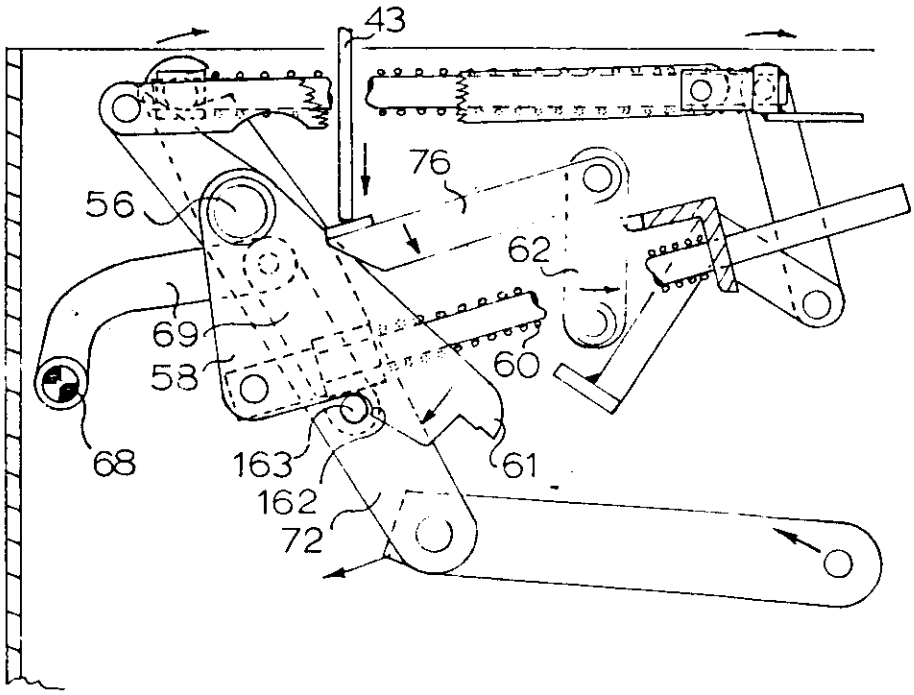
2.3 diagram 'J'

2.38 At the end of the closing stroke (diagram 'K') metal stop pads (75) mounted on the mechanism main frame stop the main closing lever/operating link (72/73) joints just before they reach an "in-line" position. This locks the contact system closed against possible throw-off forces or contact bounce, thus eliminating the need for closing dashpots or additional locking devices, whilst at the same time preventing the linkages' passing into an "over-toggle" position and jamming. The charged opening springs (60) are now held only by the main catch (61) and main catch roller (62).



2.3diagram 'K'

2.39 When the manual trip lever is pressed or a trip coil energised, the trip tappet (43) (diagram 'L') pushes down the mechanism trip lever (76) to pull the main catch roller (62) clear of the main catch (61). The main catch (61) and lower (opening) springs charging levers (58) rotate downwards under the pressure of the opening springs (60), driving the main closing levers (72) down with them due to the engagement between cutouts (162), on the lower (opening) springs charging levers (58), and welded pins (163) on the closing levers (72) behind the pins which secure the toggle links (69). The main closing levers (72) and arc trap operating levers (73) are knocked out of line and the arc traps (not shown here) are pulled away from the fixed contacts. A torsion spring (not shown) at the left hand end of the knuckle toggle shaft (68) snaps the knuckle toggles (69) down into the over-toggle, or locked, position to prevent rebound (see diagram 'A'). Thus the need for opening dashpots or catches is eliminated. A rocker arm (not shown here) on the mechanism main shaft (56) operates the on and off tappets (see paragraph 2.21) in the tank lid.



2.3diagram 'L'

2.4 Motorized Spring Charging System Operating Principles

2.41 When the OCB is open with all springs discharged, the close tappet (47) is down. The tappet switch (112) has one set of contacts open, to break the supply to the remote "springs charged" electrical indication, and one set of contacts closed to make the series circuit through the manual or relay operated switch contacts on the fixed portion or remote control panel which initially energise the incoming supply to the motor (117) and motor relay (115). Since the OCB is OFF, the on/off indicator drive rocker (37) holds the rocker switch (113) closed, also in series with the incoming supply to the motor (117) and motor relay (115).

2.42 When the incoming supply to the motor unit is energised, the motor control relay (115) is energised and operates to close its main contacts in series with the motor (117) which starts to rotate. The motor gear-box transmits this drive to the motor coupling drive disc (107) which rotates clockwise (looking from the right). Drive pins on the disc (107) engage and push round the motor coupling floating drive arm (109) which in turn engages and drives round pins on the motor coupling driven arm or disc (170). The shaft (158), to which the driven disc (170) is secured, transmits the drive to the motor drive arm (159) which pulls the motor drive link (160) to charge the springs as described in section 2.3 "Spring Mechanism Operating Sequence", paragraphs 2.31 to 2.36 inclusive.

2.43 When the motor coupling drive disc (107) has rotated approximately 20° beyond the nominal start position it closes the cam-operated motor switch (114) to lock on a parallel supply to the motor control relay (115) bypassing the manual or relay operated switch contacts on the fixed portion or remote control panel which first energised the incoming supply, and permitting them to be released.

2.44 During the spring charging operation the close tappet (37) rises to give a mechanical "springs charged" indication (33b) and at the same time operates the tappet switch (112). The remote "springs charged" electrical indication circuit is made, and the series circuit through the initiating switch or relay contacts on the fixed portion or remote control panel is broken, to prevent the motor's being re-energised when the closing springs are charged.

2.45 When the motor drive arm (159) has rotated to the 180° position, i.e. is horizontal and pointing towards the fixed portion rear, the mechanism springs are fully charged and the mechanism main catch (61) is at the position of maximum overtravel as described in paragraph 2.35.

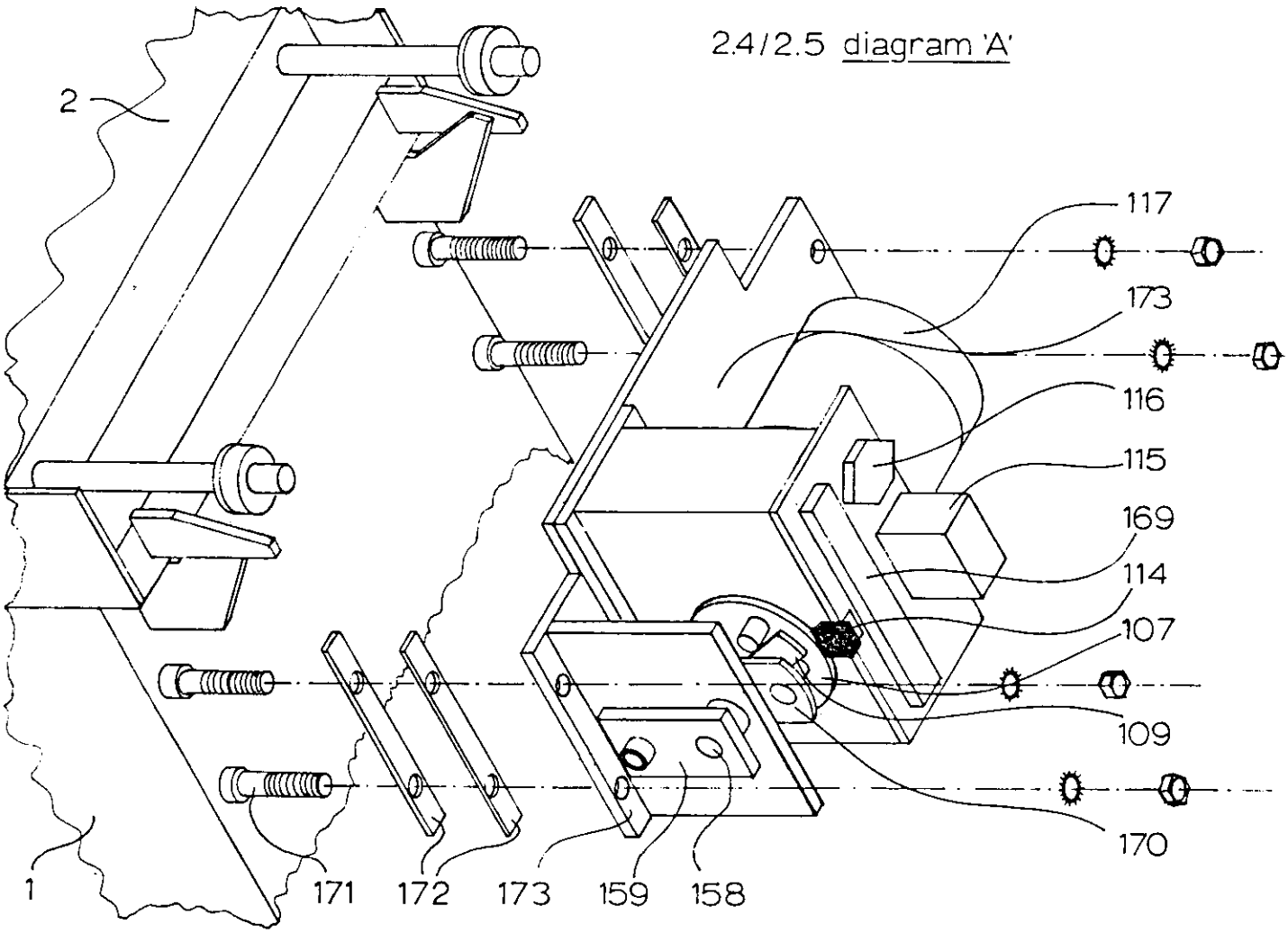
2.46 As the motor (117) continues to rotate, and the motor drive arm (159) passes beyond the 180° position the mechanism main catch (61) settles back onto the main catch roller (62) as described in paragraph 2.36. The initial mechanism springs back pressure, and the continuing pressure from the handle socket return spring, pull the motor drive arm (159) round to its original, forward-pointing horizontal position. During this phase of the operation the motor coupling driven arm or disc (170) will lead the motor coupling drive disc (107) by several degrees of arc, hence the need for a floating drive arm (109).

2.47 When the motor has rotated through approximately 320° from the start position the motor switch (114) re-opens to cut off the motor supply. The motor then coasts to a stop between the 320° and nominal start, 360°, positions.

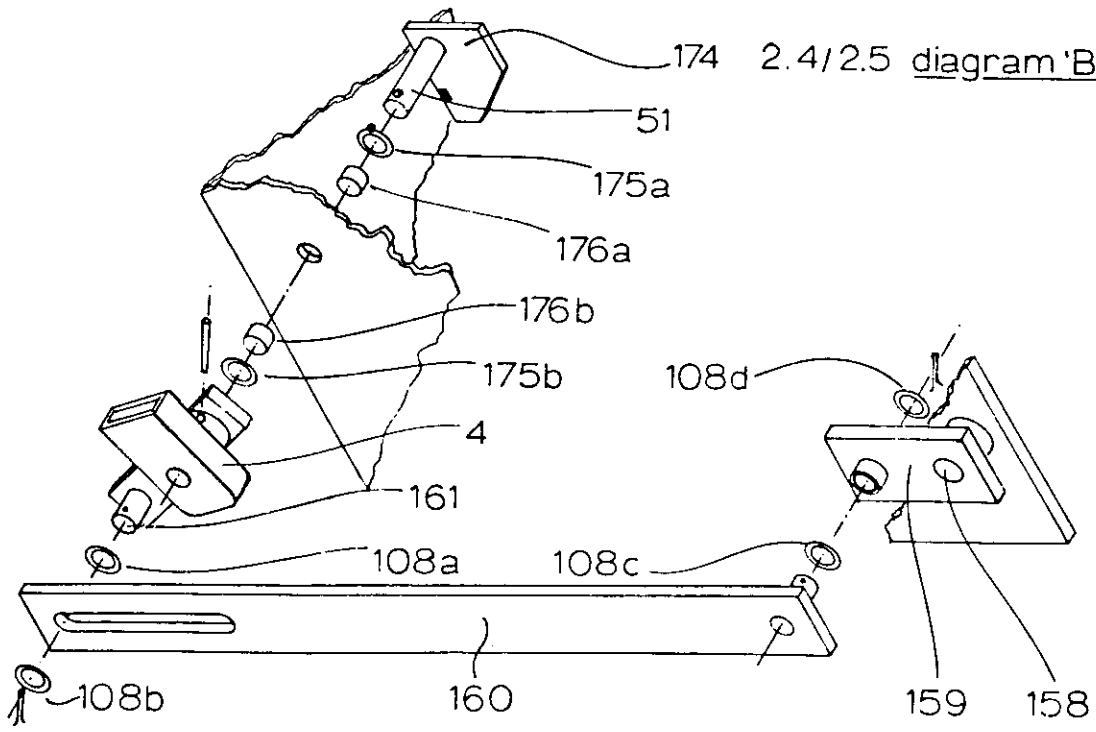
2.48 With the springs charged, the closing springs may be electrically or mechanically released to close the OCB (see section 6.5 "To Close the OCB to ON" and section 2.3, "Spring Mechanism Operating Sequence", paragraph 2.37). The close tappet (37) drops, to return the tappet switch (112) to its original condition. The on/off indicator drive rocker (37) operates and breaks the circuit through the rocker switch (113) to isolate the incoming supply to the motor (117) and motor relay (115) and prevent the motor's being operated until the OCB is re-opened.

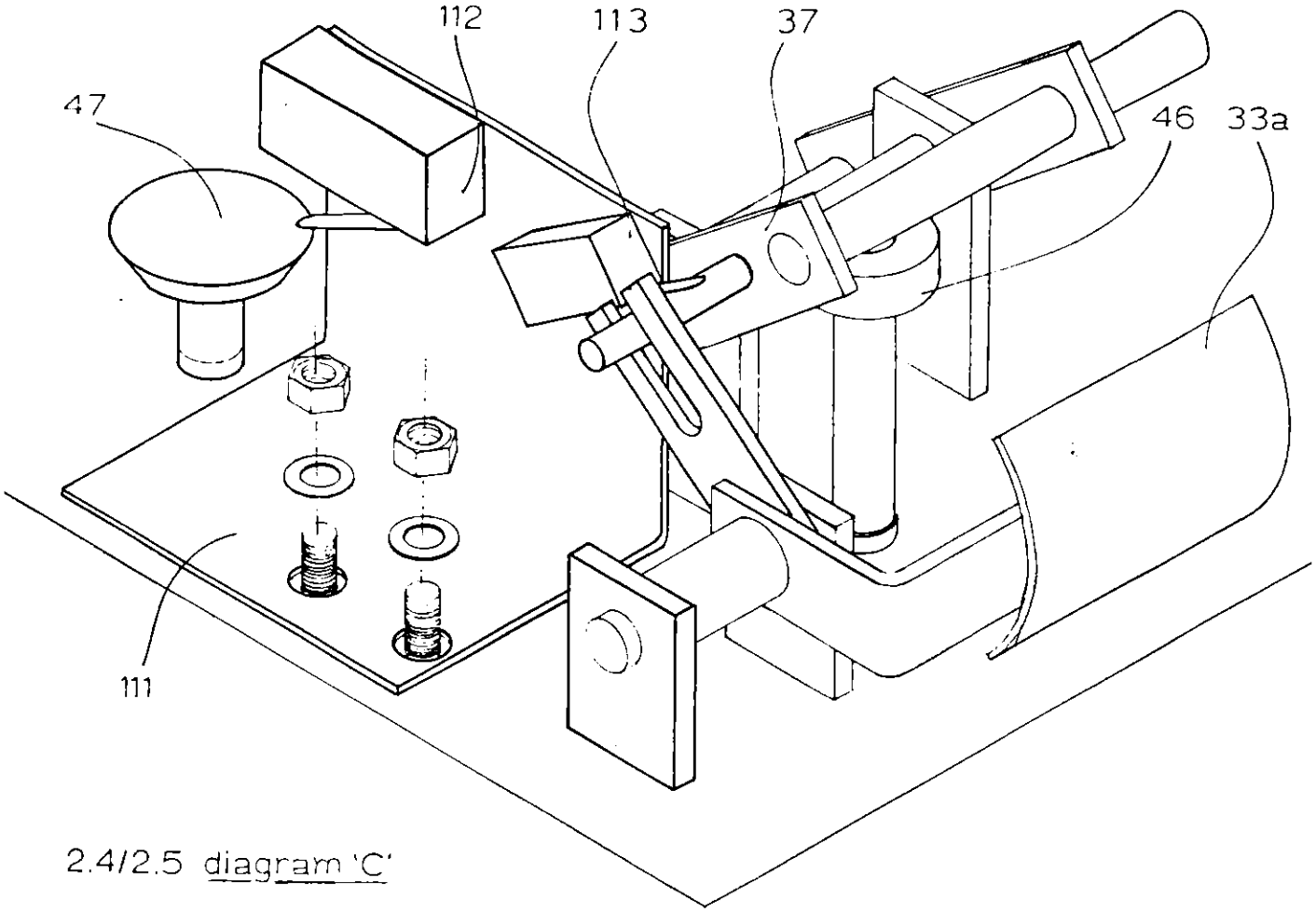
2.49 When the OCB is tripped (see section 6.6, "To Trip the OCB to OFF" and section 2.3, "Spring Mechanism Operating Sequence", paragraph 2.39) the on/off indicator drive rocker (37) returns to its original condition, and so does the rocker switch (113) to permit re-charging.

2.4/2.5 diagram 'A'

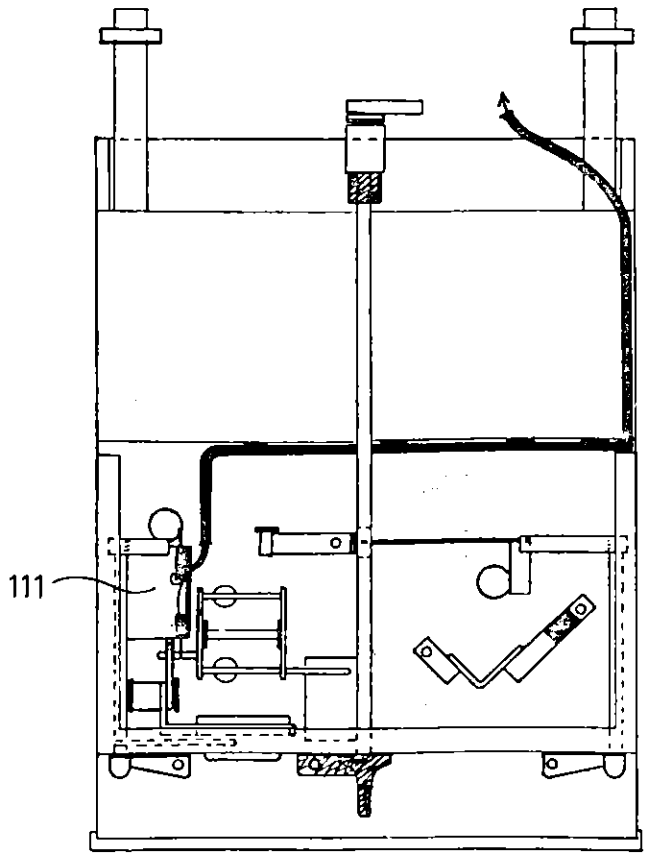


2.4/2.5 diagram 'B'



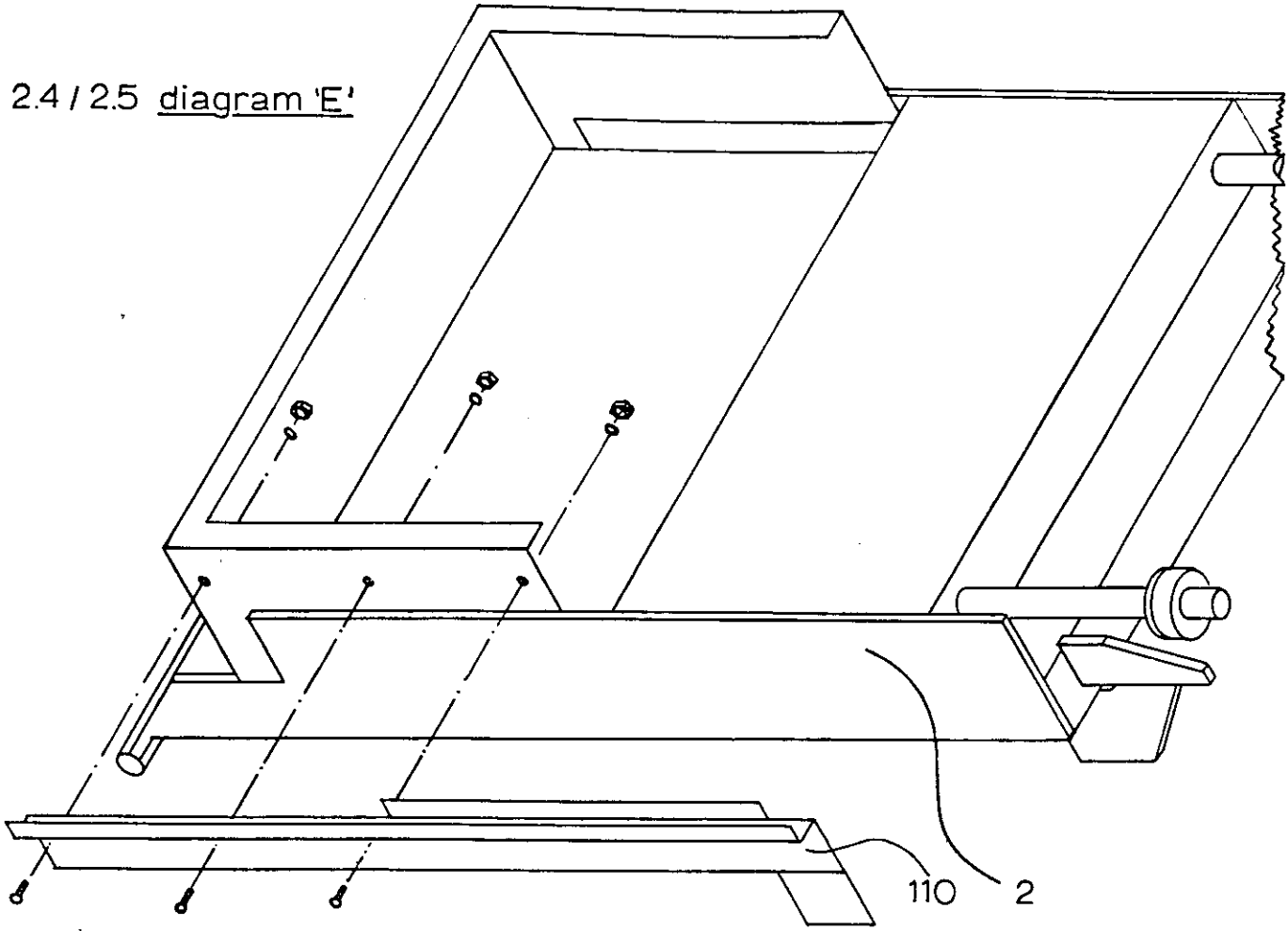


2.4/2.5 diagram 'C'

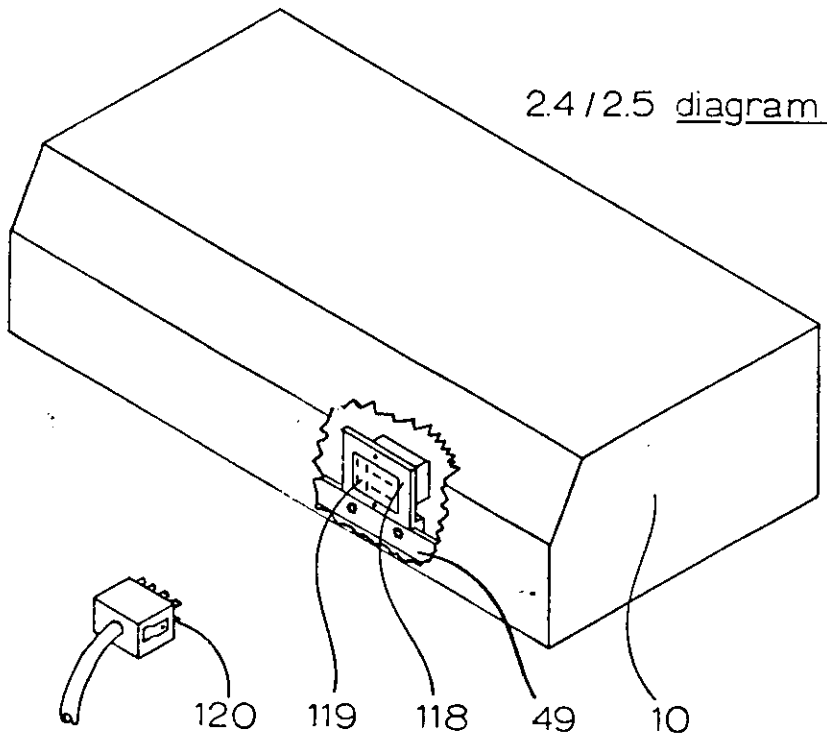


2.4/2.5 diagram 'D'

2.4 / 2.5 diagram 'E'



2.4 / 2.5 diagram 'F'



3 DETAILED DESCRIPTION OF ARC CONTROL SYSTEM

3.1 Principal Features

3.11 As mentioned in the General Description section of this manual, the arc trap combines several features found in conventional plain break, bulk oil and small oil volume circuit breakers to give reliable operation and a long service life with the minimum of maintenance. Notable among the features are the following:

3.12 The use of a double break enables the gas/oil pressure generated by the first arc to be used to extinguish the second and thereby break the current flow.

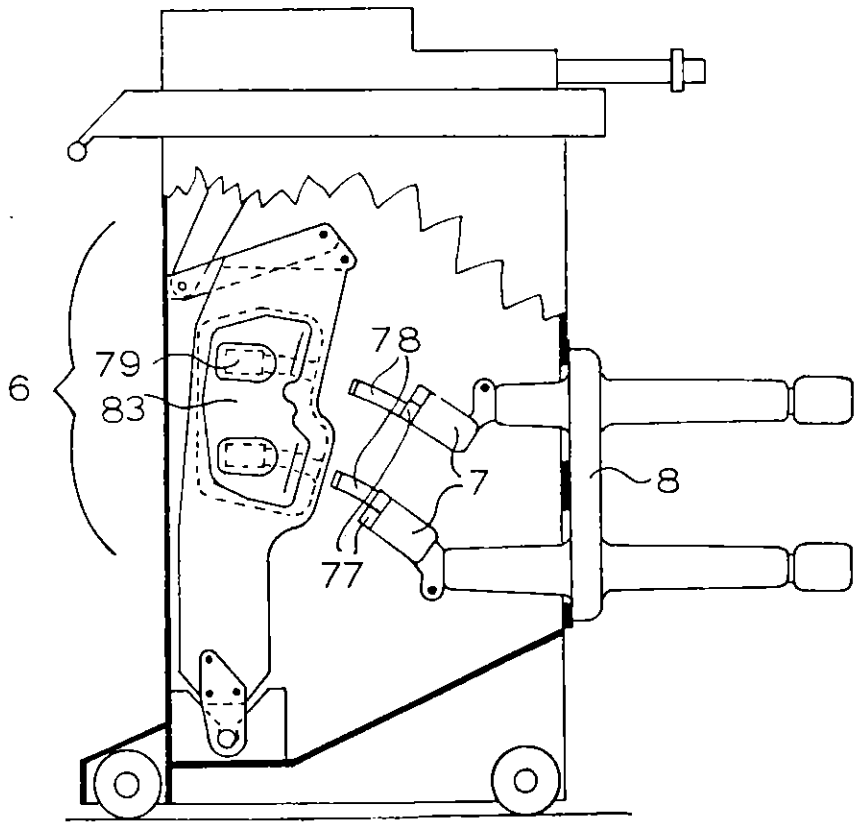
3.13 Separation of the main and arcing contact systems ensures that any pitting or burning of the arcing contacts (minimized by the short arcing times) will not affect the overall contact resistance of the closed OCB;

3.14 A fully enclosed chamber on each phase confines the arcing to a small volume of oil and encourages rapid pressure build up.

3.15 The complete isolation and automatic cleaning of the arc control system in the course of the opening operation results in the few ml of decomposed oil being dispersed in, and replaced from, the surrounding reservoir of clean oil.

3.2 Construction

3.21 Construction of the fixed contact assemblies is as follows (one phase described) (diagram 'A'). Mounted at the extremities of the OCB bushing moulding stems (8) are fixed contact carriers (7), two per phase. These support the OCB fixed main contacts (77), each of which comprises two or more opposed pairs of pivoted, spring loaded fingers. Between the fingers are the rigid, renewable fixed arcing electrodes (78) which extend beyond the fixed main contacts so as to engage the moving arcing contacts (79) within the arc trap (6) when the main contacts have parted. On the "SO-HI" circuit breaker these electrodes (78) are curved to match the radial motion of the arc traps (6).

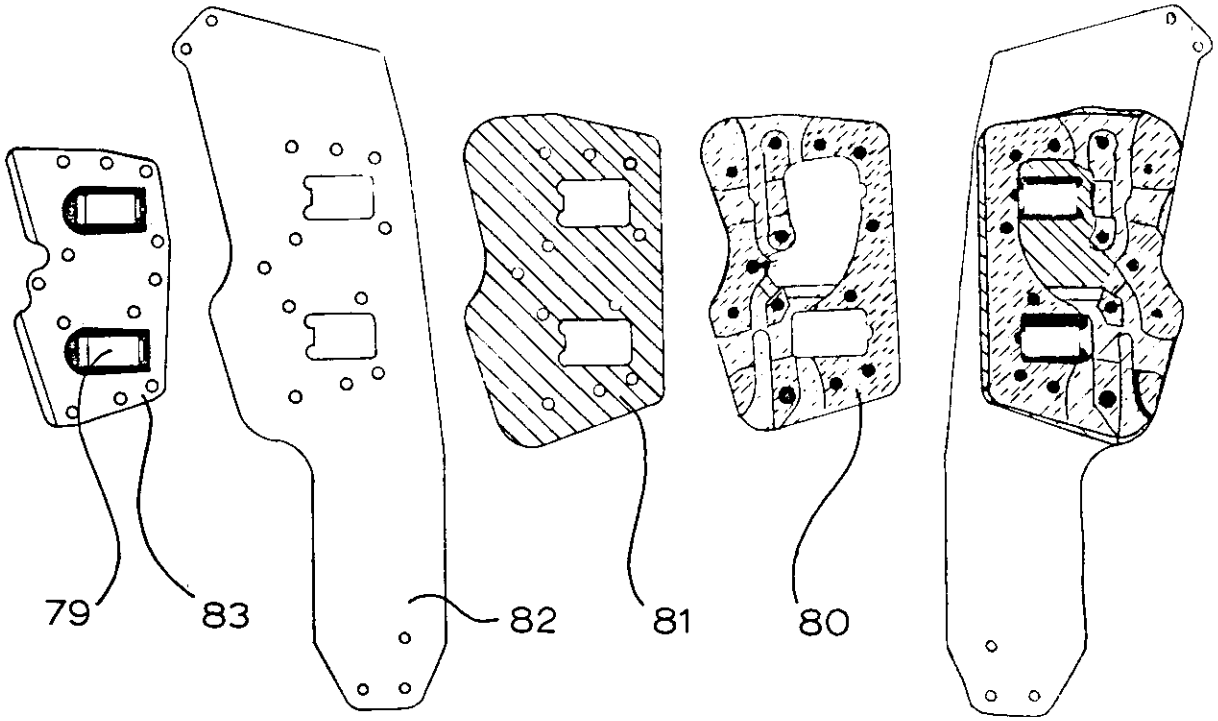


3.2 diagram 'A'

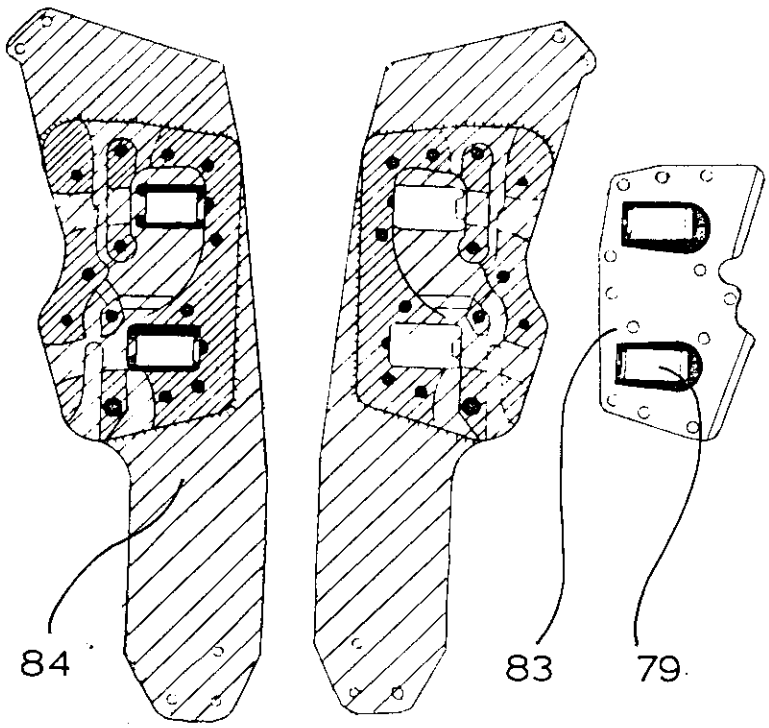
3.22 The arc traps (6) themselves (one per phase) can be regarded as having two basic sections: the metal current carrying parts, and the non-metallic chamber walls and sidearms. Arc traps may have either of two types of construction according to the rating and date of manufacture of the unit.

3.23 In the first type, (diagram 'B'), the arcing chambers are routed from two mating sheets of vulcanized fibre (80), with sidewalls (81) of synthetic resin bonded paper. On the outside of the sidewalls are carrier arms (82) of glass reinforced polyester, the whole assembly being clamped between the formed copper plates (83) which constitute the moving main contacts. The moving arcing contacts (79) within the chambers are spring mounted to the inside faces of the main contact plates (83).

3.25 In the second construction, (diagram 'C'), all the non-metallic components (80, 81, 82) for each side of the arc trap assembly are moulded as a single unit (84) from a suitable resin material. The two halves of the arc trap are then clamped together in the usual way between the moving main contact plates (83).



3.2 diagram 'B'



3.2 diagram 'C'

3.26 Each pair of carrier arms (82) (first type) or housing/carrier arms (84) (second type) is fastened together with spacers at top and bottom. The bottom clamps are welded to the pivoting member of the earthed steel frame which also carries the operating mechanism. The top clamps are linked directly to the operating mechanism.

3.3 Operating Principle of Arc Trap (One Phase Described)

3.31 As opening commences the main contacts (77, 83) separate leaving only the arcing electrodes (78, 79) in circuit. No.1 electrode then parts contact and the resulting arc generates pressure in the gas/oil volume in the arcing chamber, which is fully enclosed because the electrodes block the apertures.

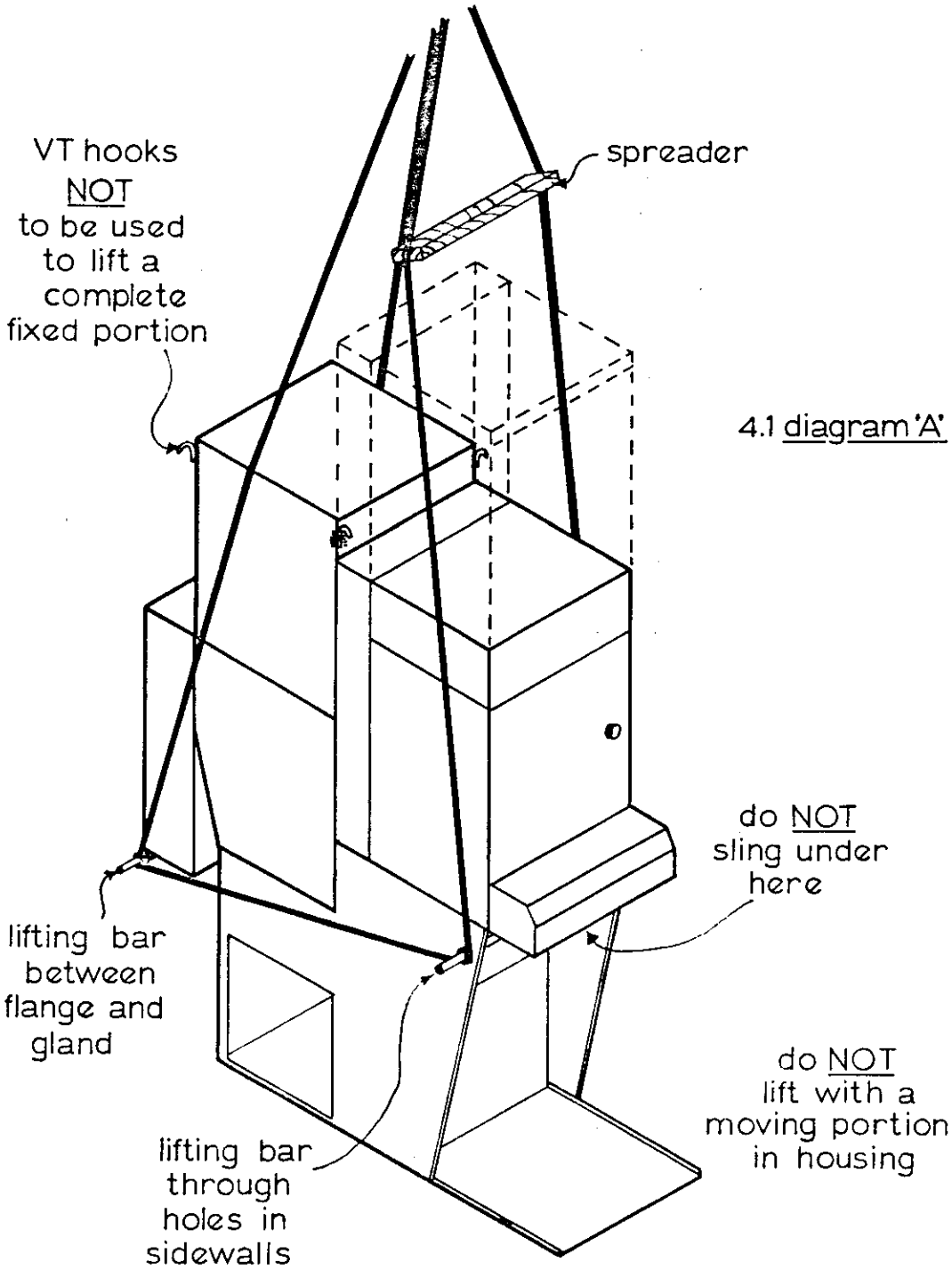
3.32 One quarter cycle after No.1, the No.2 electrode also parts contact, drawing a second arc which is immediately constricted by the gas pressure already generated. As the gap at No.2 electrode widens a high velocity gas/oil stream is forced around and across the No.2 arc, to cool and de-ionize it. At the next current zero the constricting oil is forced into the arc path to sweep away the conducting vapour and interpose a barrier of compressed oil of high dielectric strength.

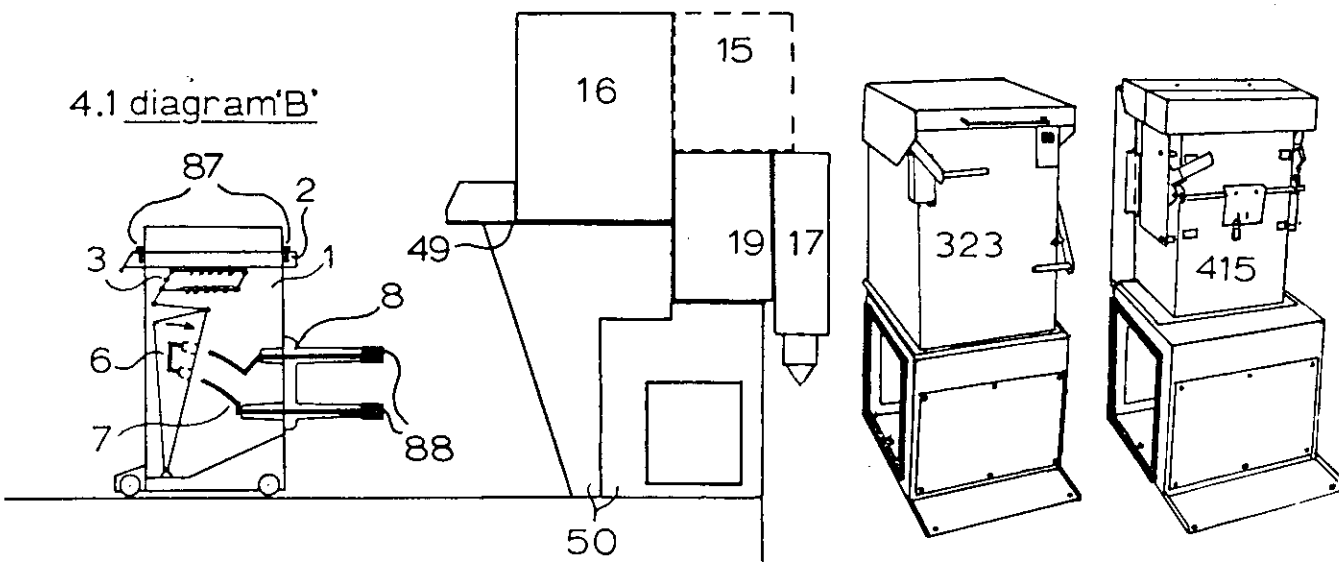
3.33 In ideal conditions, i.e. when the No.1 electrode parts shortly after one current zero, extinction will occur at the next zero, i.e. the first after the drawing of the No.2 arc. Even in the most unfavourable conditions it is rare for more than two current loops to precede total extinction.

3.34 Following arc extinction the arc trap (6) is scoured by the exhausting gases, then flushed and refilled with clean oil from the surrounding reservoir. At the end of its operating stroke the complete arc trap (6) comes to rest in a position remote from the fixed contacts (77, 78) and thus relatively free from electrical stress. This, coupled with the dispersion of any products of arcing in the comparatively large volume of oil in the tank (1), eliminates any risk of breakdown or maloperation due to tracking across "lined up" particles of carbonised oil or insulation.

3.35 When the circuit breaker is fully closed, two parallel contact systems are in engagement, i.e. the main contacts (77, 83) and the arcing electrodes (78, 79). During opening the main contacts (77, 83) break first, leaving the electrodes (78, 79) to carry the whole of the load or fault current. Surface burning or erosion is thus confined to the arcing system. Successive short circuit operations produce slight burning which is fairly evenly divided between the electrodes, though the No.1 set tends to erode marginally more quickly since it carries an arc for a quarter cycle before the No.2 arc is drawn. Due to the very short arcing times, electrode burning is minimal. The majority of arc trap circuit breakers already in service throughout the world have never and will never require anything more than occasional trimming of their electrodes with a file - electrode replacement is rare on all but the most arduous operational duties such as arc furnace control.

3.36 A further advantage of the dual contact system is that the main contacts can be as large as is necessary to suit their current rating without affecting the arcing chamber size.


VT hooks
NOT
to be used
to lift a
complete
fixed portion
spreader
4.1 diagram 'A'
do NOT
sling under
here
lifting bar
between
flange and
gland
do NOT
lift with a
moving portion
in housing
lifting bar
through
holes in
sidewalls


4.1 diagram 'B'
87
2
3
1
8
6
7
88
16
15
49
19
17
50
323
415

4. DELIVERY & ERECTION

4.1 Loading, Delivery and Unloading

4.11 "SD-HI" units may be carried on open trucks if adequately secured and tarpaulined against the weather.

4.12 It is possible for two men to load, unload and erect a SD-HI switchboard 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 manila rope sling, SWL at least twice the total weight of any load to be lifted, looped under main structural components should be used for crane unloading. WARNING. Do not loop the sling under the front of an OCB lid (2) without first ensuring that all four securing screws (87) are tightened fully home.

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 Weights, Oil & Compound Volumes

4.21 These are approximate minimum values only and may be significantly exceeded where numerous auxiliaries (e.g. relays) are employed.

	Equipment	Ref.	Delivery Weight		Volume of Oil or Compound Required		Equivalent Compound Weights						Equivalent Oil Weight	
							BICC G8		BICC G21		BICC G91, G101, Dussek MR3			
			kg	lb	litres	galls	kg	lb	kg	lb	kg	lb	kg	lb
4.22	Moving portion without oil or mechanism/arc traps assembly	1 etc.	122	268	91	20	-	-	-	-	-	-	78	172
4.23	Mechanism/arc traps assembly	6, 3	31	69	-	-	-	-	-	-	-	-	-	-
4.24	Fixed Portion complete but without cable box fluid or voltage transformer	16, 17, 19, 49, 50	204	450	36.5 (cable box)	8	44	96	46	100	38	82	32	70
4.25	Bus section fixed portion add to 4.24	-	98	215	-	-	-	-	-	-	-	-	-	-
4.26	Voltage transformer without oil	15	86	190	91	20	-	-	-	-	-	-	78	172
4.27	Oil Fuse Switch without fuses or compound but with cable box	323 etc.	155	342	100 (switch tank)	22	-	-	-	-	-	-	86	190
					29 (cable box)	6.4	35	76.5	36.5	80.5	30	65	25	55
4.28	Oil switch without oil or compound but with cable box	415 etc.	123	270	45.5 (switch tank)	10	-	-	-	-	-	-	39	86
					29 (cable box)	6.4	35	76.5	36.5	80.5	30	65	25	55

4.3 Storage of Switchgear

4.31 "SD-HI" indoor switchgear must not be left out of doors, even in fine weather, for more than a few minutes unless it is adequately protected by tarpaulins. Even if it is so protected, it must be taken indoors as soon as possible, preferably within 24 hours of delivery.

4.32 If it is to be stored for any length of time before installation it should be kept in a warm, dry room.

4.4 Preparation of Switchroom Floor

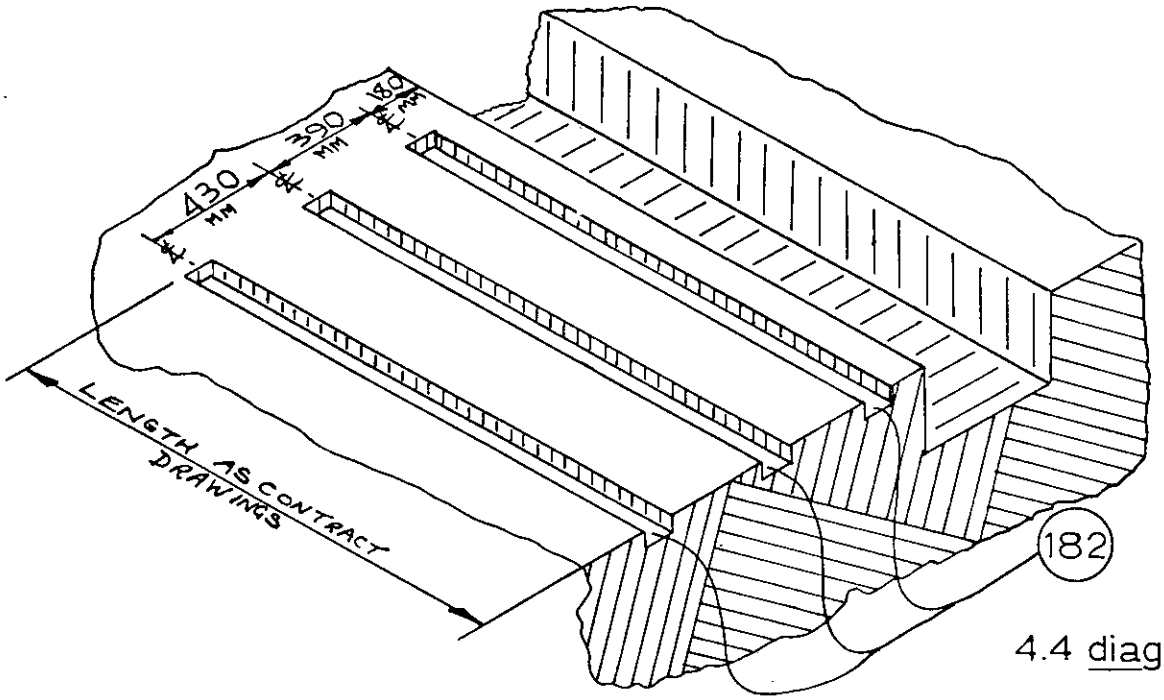
4.41 The "SD-HI", "SD-FM" and "SD-FS" switchgear designs can be erected directly onto a concrete floor and secured with rag-bolts or proprietary fixings. However, this can only be achieved satisfactorily if the floor has a smooth, trowelled finish to within the limits of a nominally flat floor as specified in British Standard Code of Practice CP204: Part 1: 1965, i.e. ± 1/8 in in 10 ft (± 3 mm in 2880 mm). If it is felt that this standard of flooring cannot be guaranteed, we recommend that "Unistrut" channels, reference P3200, with spring nuts reference P1008 be employed to ensure a level foundation, as detailed in the following text. "Unistrut" fittings can be obtained from:

Unistrut Division of GKN Sankey Limited,
43-45, Broadwater Road,
Welwyn Garden City,
Herts.

or can be supplied by ourselves at an additional cost per switchboard panel.

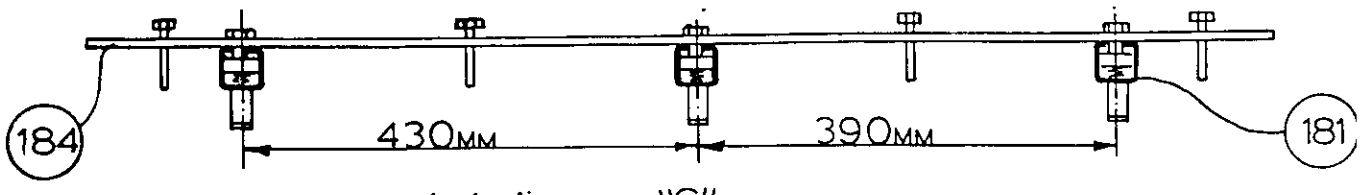
4.42 Foundation details vary from switchboard to switchboard. Reference should always be made to the foundation plan supplied for the individual installation. A cable trench or conduits, of size and layout to suit the cables to be used, will usually be required at the rear of the switchboard. Rear access for cable jointing will also be necessary. Where firewalls are installed they must be extended down into the trench, oversize gaps being left for the installation of cable ducts, busbar trunkings etc. The holes can be filled in to size when all equipment is in position.

4.43 Prepare a sub-floor 40 mm (1.5/8 in) below finished floor level, with chases (182) a further 70 mm (2.1/2 in) deep by 100 mm (4 in) wide as shown in diagram 'B'. Note that for circuit breaker fixed portions three chases (182), at centres of 180 mm plus 390 mm plus 430 mm from the trench edge will be required. All other units require only the first two chases. The length of the chases must be at least the total ultimate length of the switchboard, including any future extensions which may be under consideration.

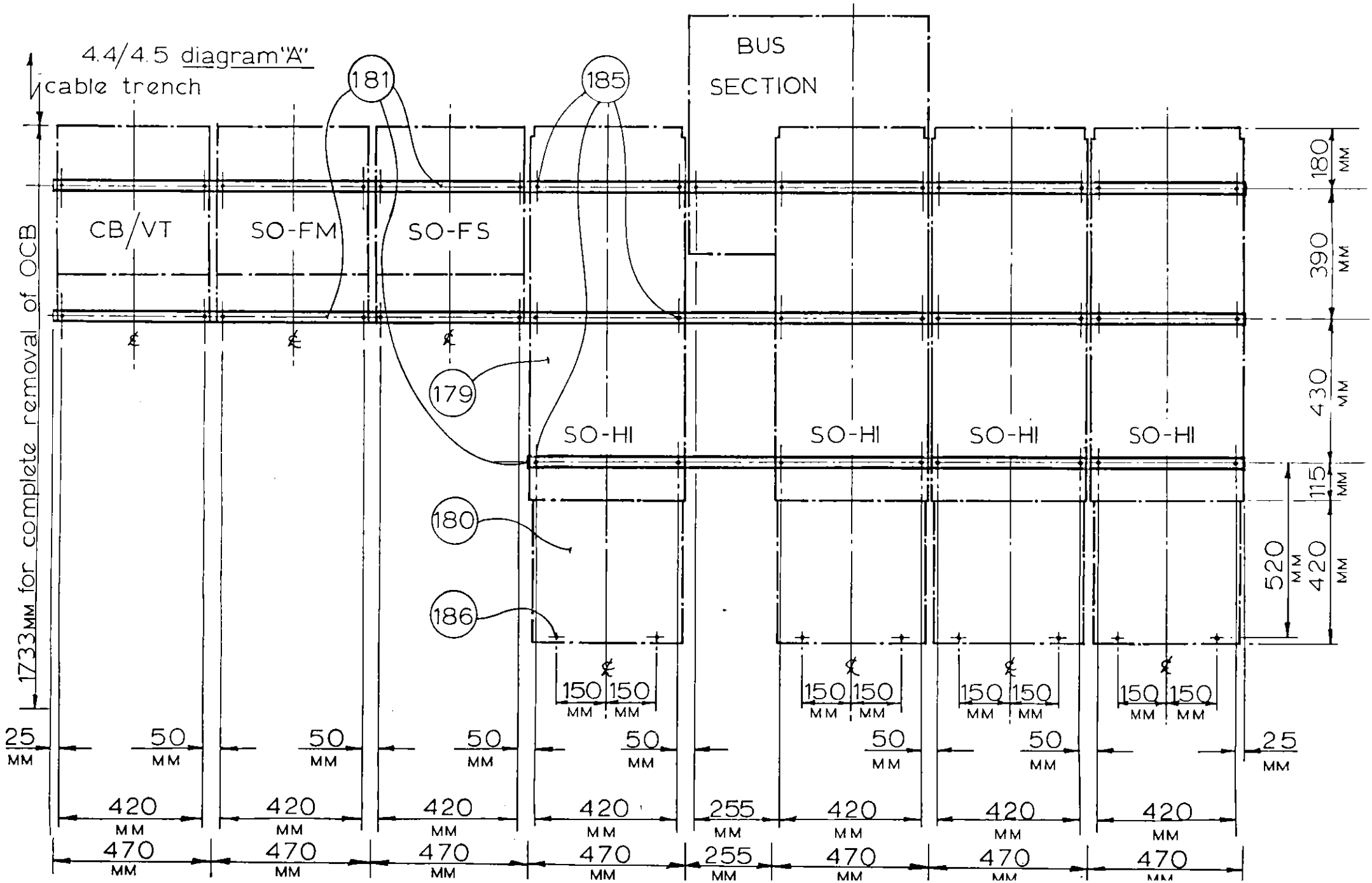


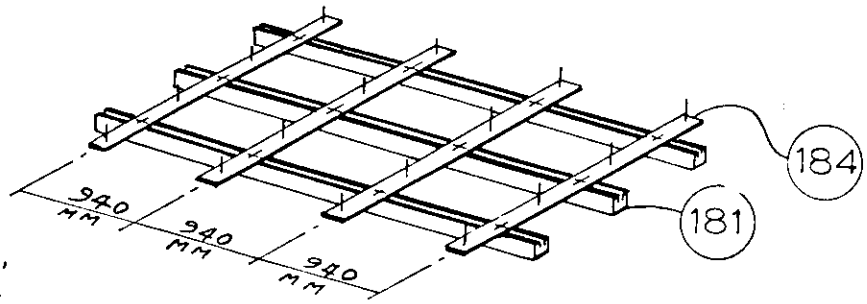
4.4 diagram "B"

4.44 Place the Unistrut runners (181) in their approximate positions in the chases and burn 50 mm (2 in) gaps in the foam plastic filler of approximately 940 mm (37 in) centres, using a blowlamp. Using the spring nuts (183) provided, fix tie bar jigs (184) to the foundation runners (181) at 940 mm (37 in) centres as shown in diagrams 'C' and 'D'.



4.4 diagram "C"


4.4/4.5 diagram "A"
cable trench
181
185
BUS
SECTION
CB/VT
SO-FM
SO-FS
179
SO-HI
SO-HI
SO-HI
SO-HI
180
186
1733 MM for complete removal of OCB
180 MM
390 MM
430 MM
115 MM
520 MM
420 MM
150 150 MM MM
25 MM
50 MM
420 MM
255 MM
470 MM

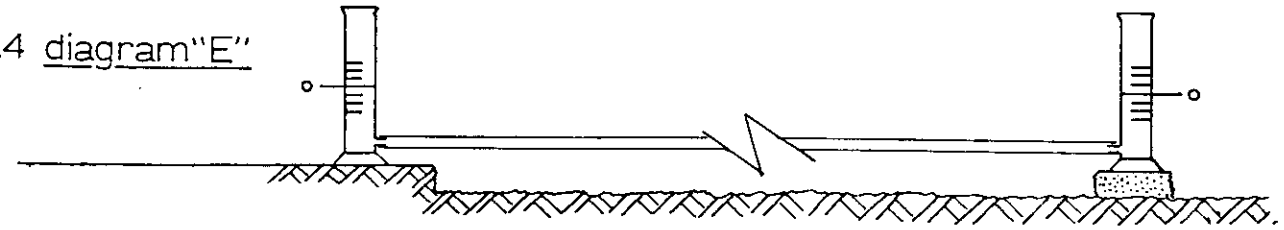


4.4 diagram"D"

4.45 Erect a fixed datum, representing the finished floor level of 40 mm (1.5/8 in) above the prepared sub-floor, half way along the switchboard. Take a water level gauge consisting of two graduated jars connected by a flexible pipe of at least 3/4 of total switchboard length (diagram 'E') and fill with water, taking care to remove all trapped air from the pipe by letting the pipe lie flat on the floor. Place both jars on the datum and note their common reading (on short switchboards a spirit level and long straight edge may be used).

4.46 Check by measuring corresponding diagonals that the Unistrut/tie bar assembly (181/184)is 'square'. Position small pieces of steel plate under the levelling screws, and ensure that the centre of the rear runner is 180 mm from the cable trench edge at both ends. Where two or more lengths of Unistrut are to be butted end to end, they must line up exactly.

4.4 diagram"E"

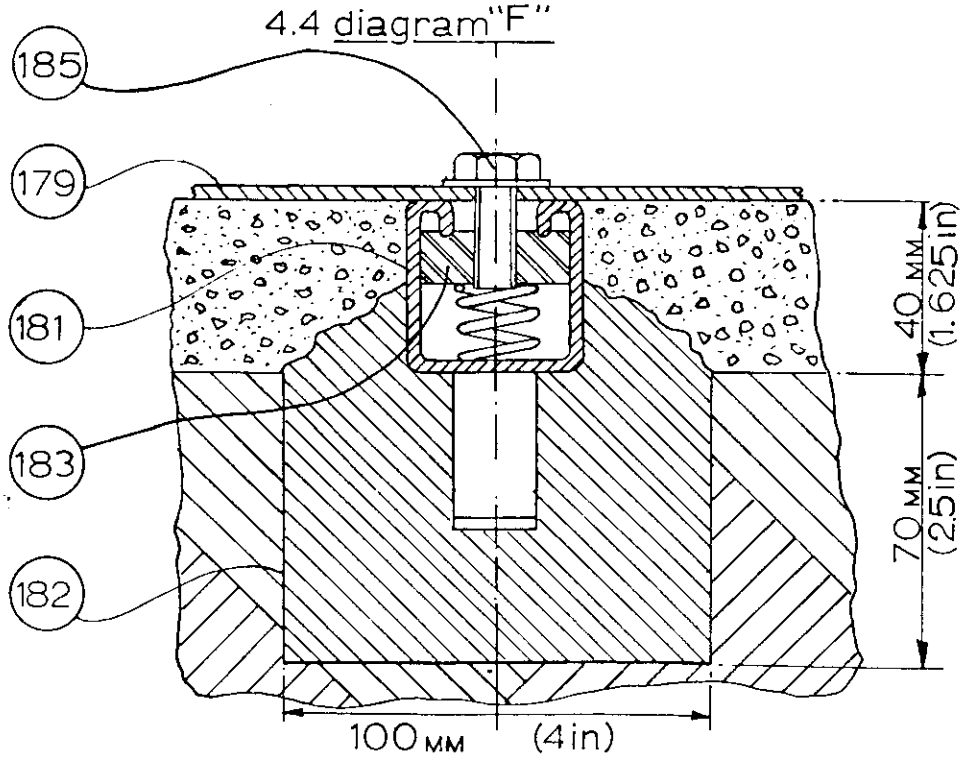


4.47 Leaving one of the water level jars on the datum, place the other on top of each runner (181) in turn along the length of the switchboard, each time adjusting the local jacking screws until the previously noted common water level is attained. This will result in the runners being level over the full length of the switchboard. A tolerance of $\pm$ 0.5 mm is acceptable.

4.48 Grout the Unistrut runners (181) in position, the grout filling the chases and reaching approximately half way up the Unistrut sides (diagram 'F'). When the grout is fully set, remove the tie bars (184) and sprung nuts (183) from the runners.

4.49 Float the finished floor between the runners (181), the level coinciding with the tops of the runners. Take care not to get concrete into those parts of the channels from which the foam has been removed. When the switchboard floor area has set, float the rest of the floor using the finished area as datum.

4.4 diagram"F"



4.5 Erection of Fixed Portions and other Units (Mk II on Unistrut)

4.51 This section was revised in February, 1974, to cover the use of Mk II fixed portions or busbar chambers, with integral baseplates, and "Unistrut" foundation runners. All types of unit, SO-HI OCB, SO-FM oil switch, SO-FS fuse switch, busbar cable box and busbar voltage transformer, are covered.

4.52 Using the foundation plan for the specific switchboard as a guide, burn 50 mm (2 in) gaps in the Unistrut (181) foam plastic filler at the fixed portion fixing points with a blowlamp. Position the 3/8 in sprung nuts (183) in the runners at these points.

4.53 In the case of a CIRCUIT BREAKER fixed portion, unfasten, remove and store the busbar chamber back plate (91), earthing device locating angles (90) and front shutter assemblies mounting plate (92) from each unit. Check that anti-vermin strips (95a, 95b) are fitted at the right hand side of each unit (except the extreme right hand unit on the switchboard). Should the strips not be fitted already (e.g. on an extension at the right of an existing board) appropriate lengths of strip can be supplied for on-site application. The backing material is simply peeled off and the sticky surface applied to the clean painted surface.

4.54 For ANY OTHER type of unit unfasten, remove and store the busbar chamber back plate (346) and front plate (347). Again, check that anti-vermin strips (95) are in position at the top and sides of each right hand busbar aperture except on the extreme right hand unit of a switchboard. See 4.53 above for details of on-site fitting.

4.55 Place all switchgear fixed portions and busbar chambers in position, ensuring by using a long straight edge that their back surfaces at floor level are exactly in line (except for bus sections). Check the unit centres against the contract foundation plan. Bolt all units down using 3/8 in U.N.C. x 1.1/4 in long hexagonal headed screws (185) and standard 3/8 in washers.

4.56 Adjacent CIRCUIT BREAKER fixed portion shells (49, 50) must then be fastened together. Each sidewall (50) has two 7 mm (9/32 in) fastening holes (164) in the offset front edge, and one 11 mm (7/16 in) hole (165) adjacent to the front lower corner of the current transformer (position may change from that illustrated). The smaller holes take 12 mm (1/2 in) long 'O'BA screws, washers and self-locking nuts which are tightened up to hold the offset edges of adjacent panels firmly together. The larger hole takes an 8 mm (5/16 in) diameter screw, washers and nut which are used only to pull the units into position and must not be tightened hard as this will distort the sidewalls.

4.57 CIRCUIT BREAKER fixed portions can then have their removable front aprons (180) fitted to the fronts of their baseplates (179) as follows.

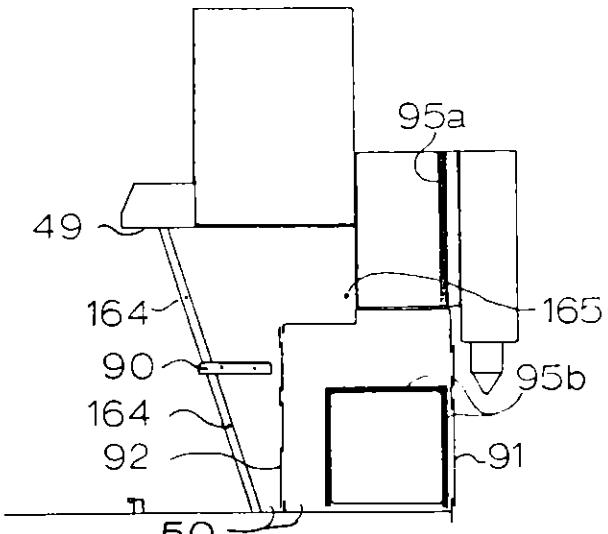
(a) Secure each apron (180) to the front of its baseplate (179) using the three studs and nuts provided.

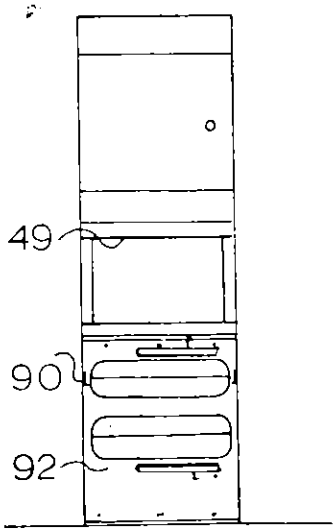
(b) Using the two countersunk holes at the front of the apron as guides, drill two 7 mm (9/32 in) diameter by 50 mm (2 in) deep pilot holes in the floor.

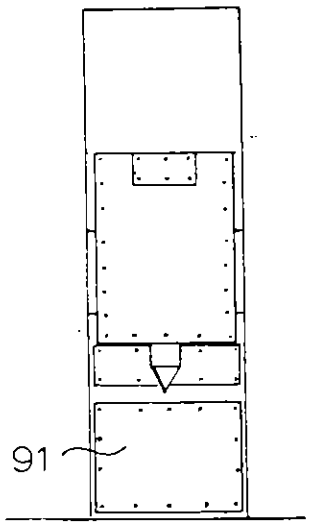
(c) Unfasten and remove the apron and open out the holes in the floor to 9 mm (3/8 in) diameter.

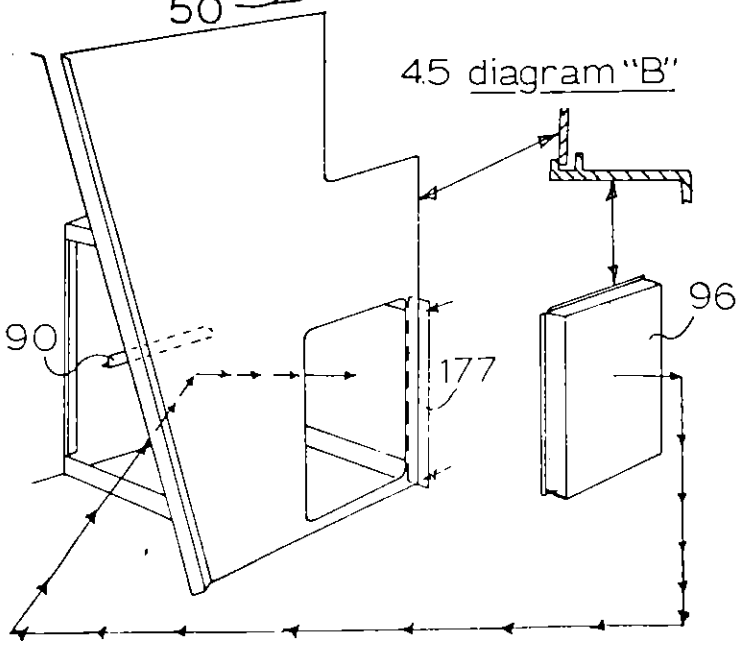
(d) Fit a 'UNI-FIX' plug type P5 in each hole, replace the apron and secure it by the nuts and studs mentioned in (a) above, then drive a No.14 x 1.1/2 in long countersunk Phillips-headed wood screw (186) through each of the front two holes to hold the front of the apron down.

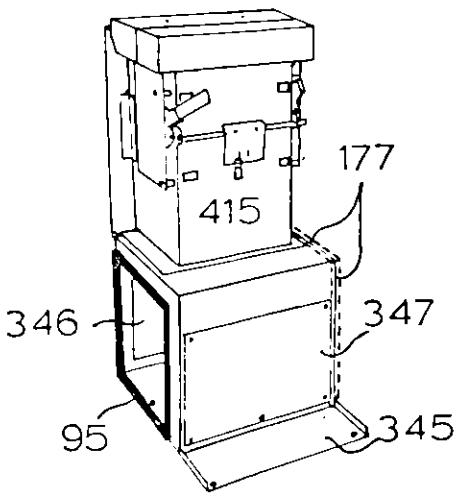
4.58 Fit pieces of clip-on plastic cover to any exposed lengths of Unistrut runner, e.g. where provision has been made for future extensions or adjacent to bus section fixed portions.











4.6 Fitting the Busbars

4.61 The busbars (24) can now be fitted between adjacent units.

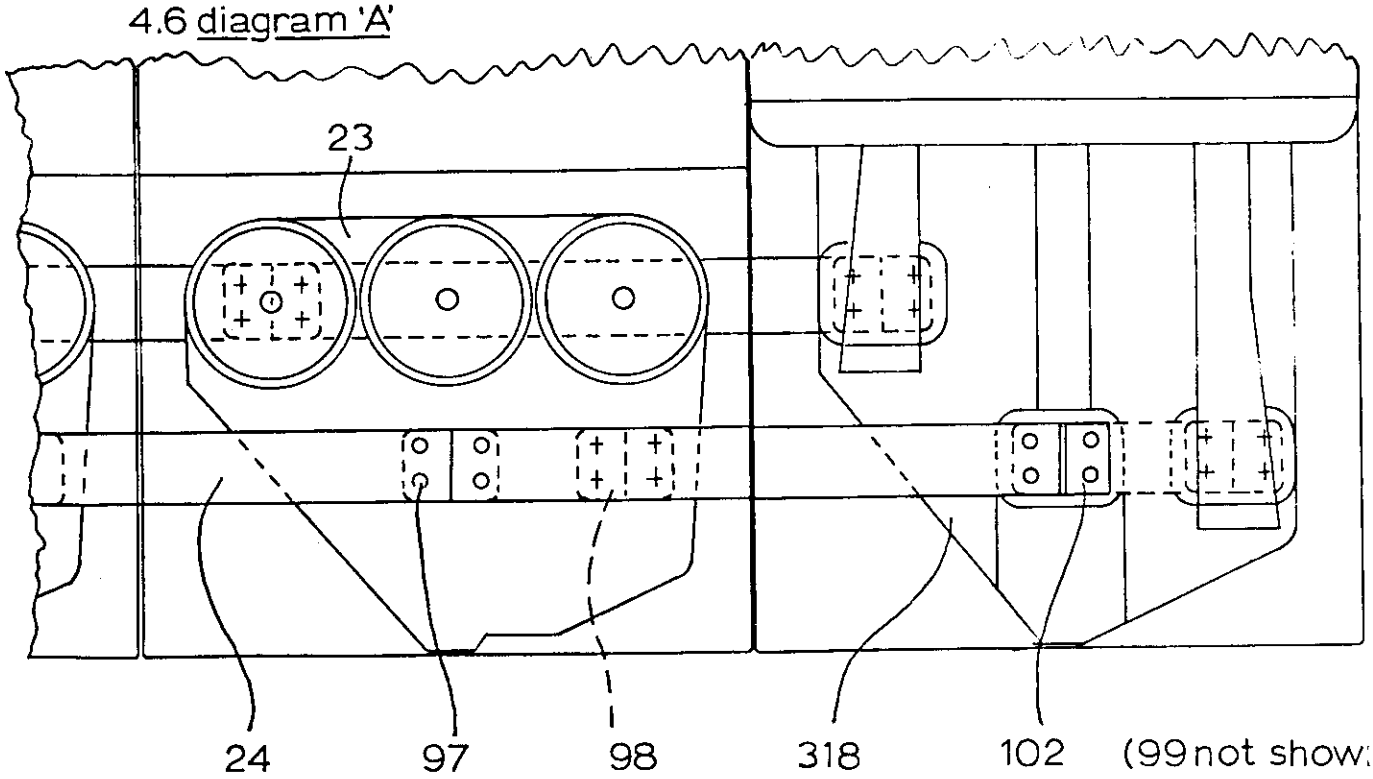
Do not start to fit them until you have read the whole of this section (4.6).

4.62 Unit length, resin coated busbars are employed in the following arrangements:

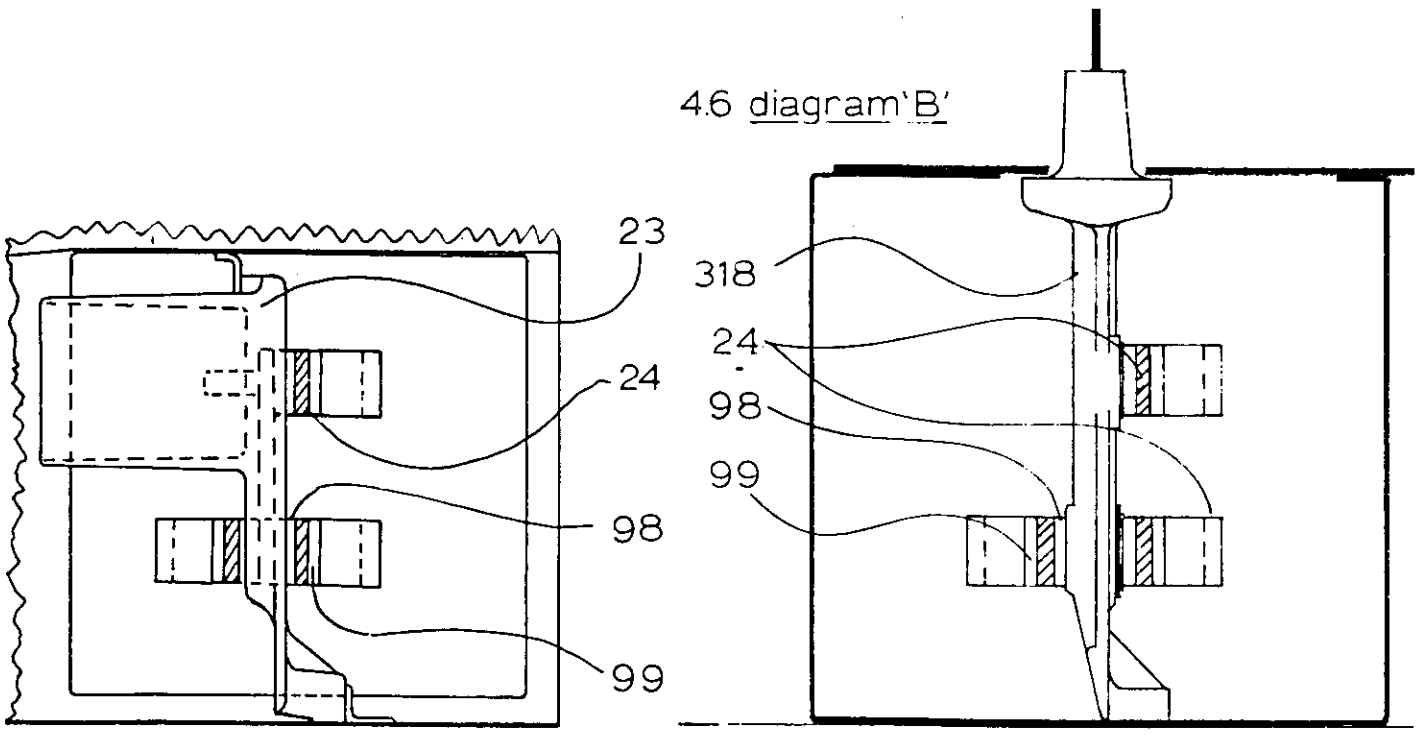
Current Rating	No. Laminations per phase	Size of each lamination
800 A	1	51 mm x 6 mm (2 in x 1/4 in)
1250 A	2	51 mm x 6 mm (2 in x 1/4 in)
2000 A	2	51 mm x 10 mm (2 in x 3/8 in)

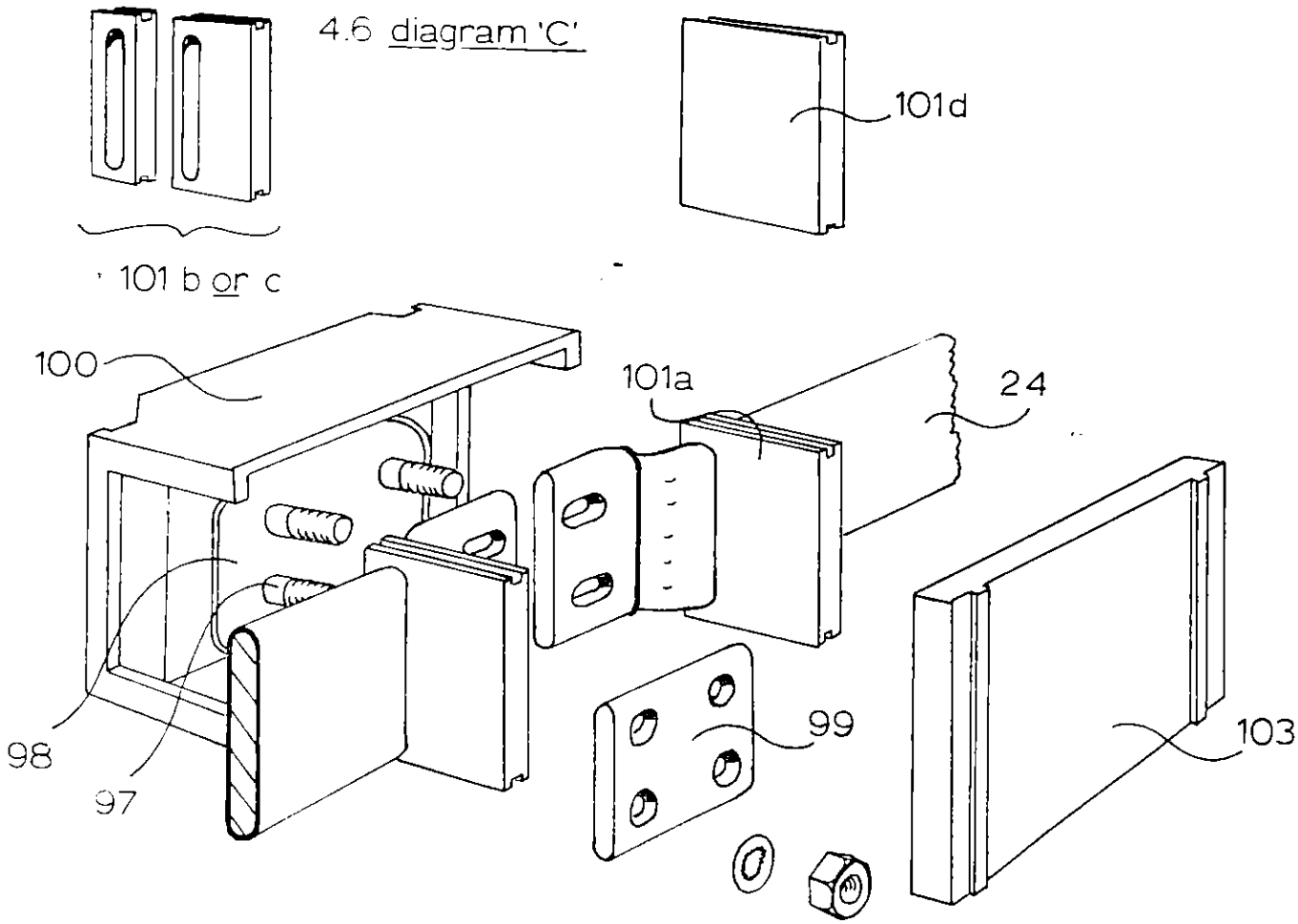
4.63 Each busbar section (24) is secured at each end by nuts and internally toothed washers to two studs (97) protruding from an integral tee-off connection plate (98) in the busbar insulator and support moulding (23). On end panels, busbar packers (102) are fitted to the unused studs (97). Fishplate spacers (99) clamp the busbars (24) in place, carry busbar through currents across the joint and maintain the air circulation spaces between the laminations of multiple busbars.

4.6 diagram 'A'



4.6 diagram 'B'





4.64 Units for line voltages above 12kV, or requiring an impulse level in excess of 75kV are provided with shrouds for the busbar/tee-off connection junctions. These are fitted as follows (one phase described):

(a) The joint box (100) is factory-fitted in position round the tee-off connection plate (98) before the busbars are fitted, and is secured by two fillets, one internal and one external, of adhesive.

(b) The appropriate end pieces (101) are to be fitted at each end of each busbar section. There are four types of end piece:

101(a) Single type for 800 A busbar;
101(b) Double type for 1250 A busbars;
101(c) Double type for 2000 A busbars;
101(d) Single blank type for end panel.

(c) As the busbars (24) are located on the studs (97) the end pieces (101) are slid into engagement with the walls of the joint box (100).

(d) With all busbars and fishplates located and securely fastened, the joint box cover (103) is placed in position and snapped on.

(e) Special clamping arrangements are necessary at end panels of switchboards employing shrouded connections. See the diagrams for details of insulated clamp plates, screws etc.

4.65 Busbar end plates (96) must be fitted to the end panels of switchboards to block off the busbar apertures. The procedure is as follows:

(a) Working through the front of the busbar chamber, place the dished end plate (96) in position so that the bulge protrudes outwards through the sidewall, and the double flange at the top of the plate (96) is engaged on either side of the sidewall (i.e. one flange inside, the other outside).

(b) Secure the plate (96) in position with the screw provided, which passes through a tapped hole in the plate (96) bottom flange and bears against the outside of the sidewall.

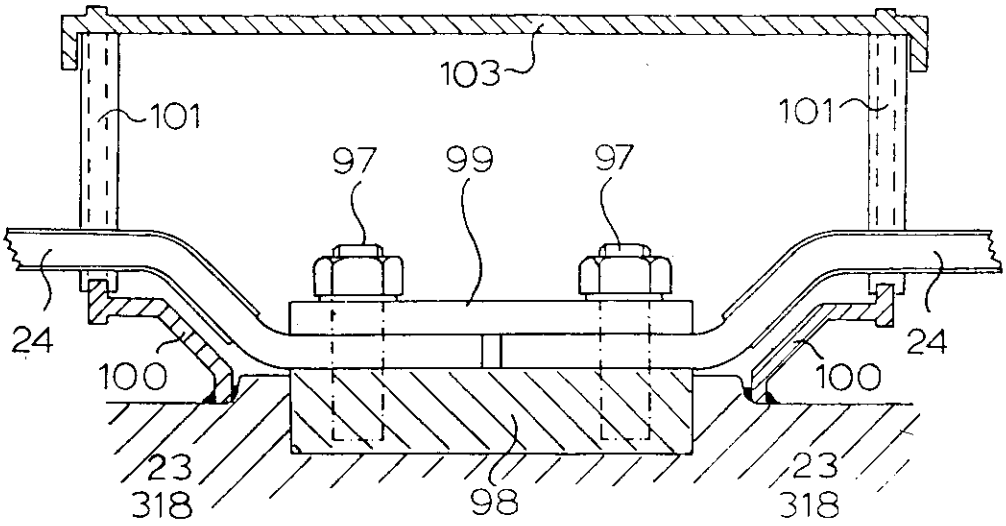
(c) Repeat at the other end of the switchboard.

4.66 Clean the busbars (24) and tee-off mouldings (23, 318) as described in detail in the "Maintenance" section of the appropriate manual. Remove any foreign bodies from the busbar chambers. Replace and fasten tight all busbar chamber back plates (91, 346) and front plates (92, 347). Peel off the backing strips of the unit-to-unit busbar cover plates (177) and stick them in place between adjacent busbar chamber back plates (91, 346) and, in the case of units other than circuit breaker fixed portions, in the spaces between adjacent busbar chamber front plates (346) and across the spaces between adjacent chamber tops.

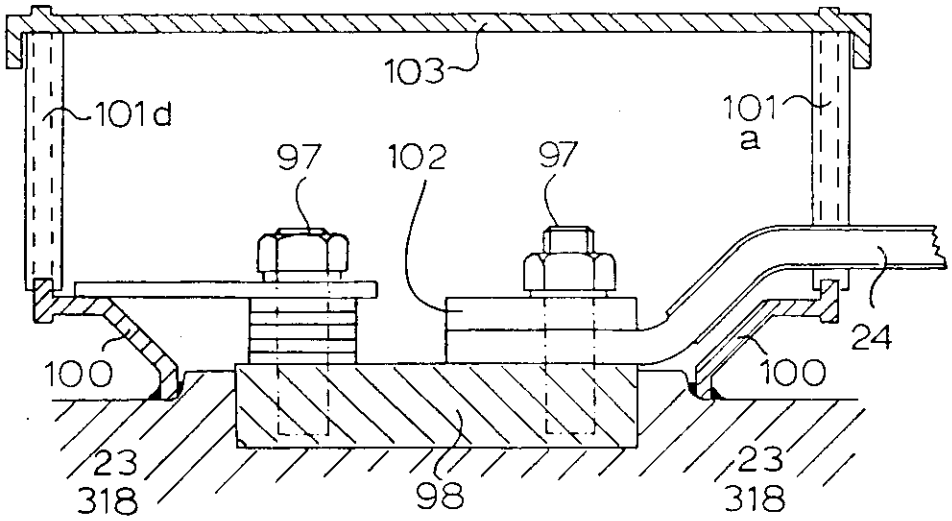
4.67 In the case of circuit breaker fixed portions, replace and secure the earthing device locating angles (90) on the sidewalls (50).

4.68 Fit the inter-unit sections of the main switchboard earth bar along the rear of the busbar chambers, , ensuring that the earth connection from each fixed portion is connected to the main earth bar. Bond the switchboard earth bar to the substation earth according to local practice.

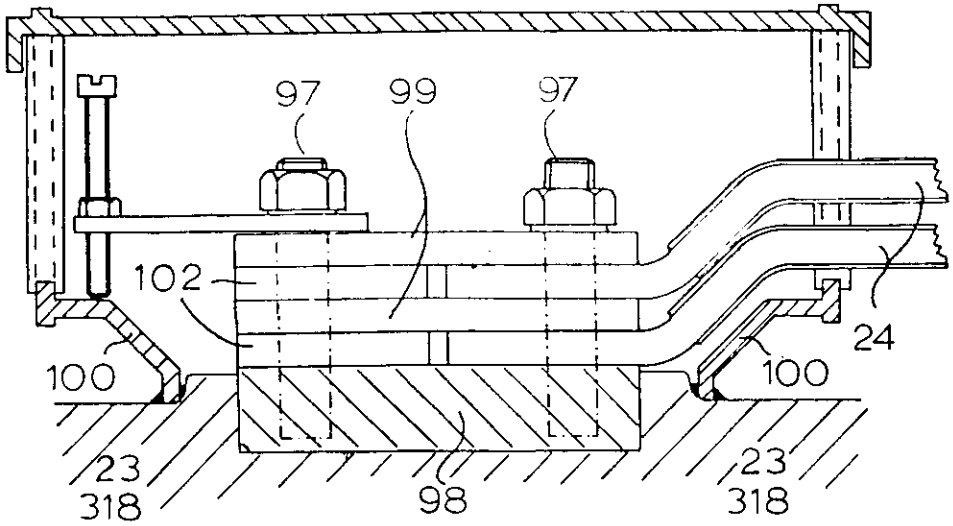
4.69 Note that when a switchboard is to be extended, the new units can be erected whilst the end plate (96) of the original board remains in position. Remember that anti-vermin sealing strips (95) must be placed between the old and new units. When the new equipment is complete, the original switchboard is made dead and the busbars are earthed. The bus chamber back plate (91, 346) of the original end unit is removed, the end plate (96) is moved to the new end unit and busbars (24) are fitted between the adjacent new and original units. The normal completion procedures are then followed.



4.6 diagram 'D' i



4.6 diagram 'D' ii



4.6 diagram 'D' iii

4.7 Jointing Main Cables

4.71 The following method applies to standard compound insulated, bottom entry cable boxes. 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.

4.72 Prepare the cable box (17) as follows:

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

(b) Put pressure plastic around the bottom plate (124) securing studs and along the spaces between them. (A special oil 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 (17) and wipe the insulators with a clean, dry rag.

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

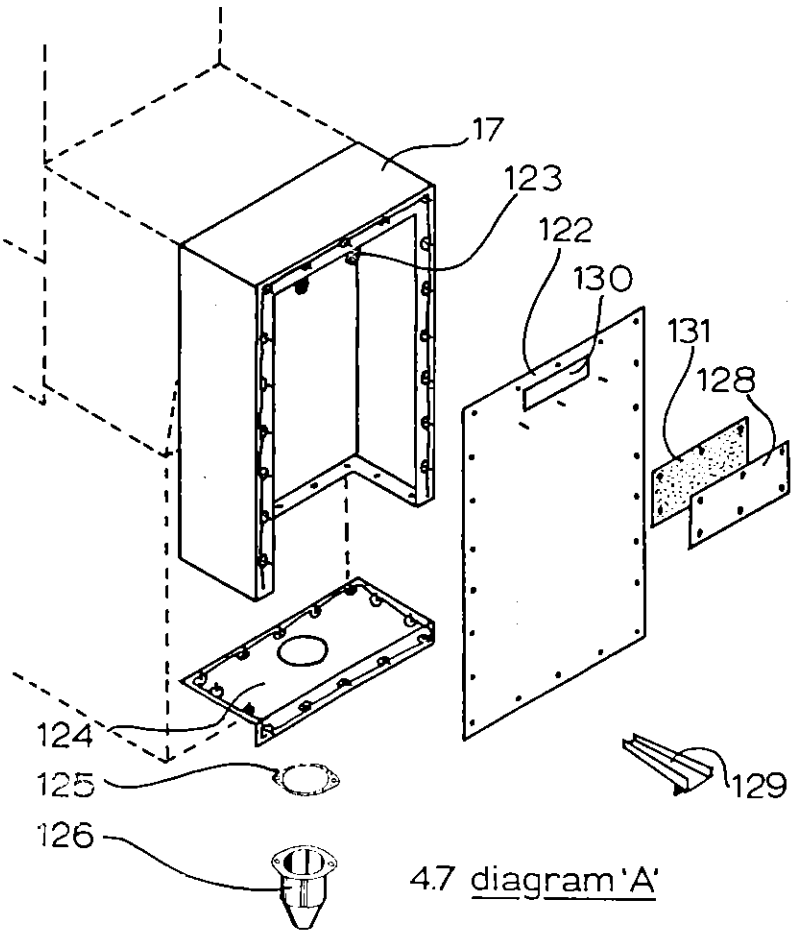
4.73 Prepare the requisite amount of compound, observing the following precautions:

(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 prolonged, direct contact between the flames and any one point on 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.



4.7 diagram 'A'

4.74 Compound the cable box up as follows:

(a) Remove the filler aperture cover (128) from the cable box back plate (122) and pre-heat the box (17), 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 (17) at their respectively correct temperatures, slowly but continuously pour in the compound (using a pre-heated Yorkshire Switchgear compound filler (129) or clean compound tin section) until the compound level reaches the bottom of the filler 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.

4.75 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 (17), cable and floor so that there is no risk of maintenance staff wrongly thinking that the cable box is leaking during future inspections.

IMPORTANT NOTE ON OIL-FILLED CHAMBERS

During the erection and preparation of switchgear, it is important that all oil-filled chambers on both fixed and moving portions (i.e. not only circuit breaker and switch tanks, but also certain voltage transformer, current transformer and connection chambers) be opened, examined and filled to the correct level with switch oil. Some chamber may be already filled with oil, e.g. certain voltage or current transformer chambers, but the oil level should still be checked and carefully topped up if necessary. Look for the label:

NOTE

Before the switchgear is energised, this chamber must be filled to the level shown with switch oil conforming to British Standard 148, and the site tests specified in the relevant British Standards must be completed.

5. PREPARATION & COMMISSIONING

5.1 Preparation of Fixed Portion

5.11 SAFETY NOTE The following text assumes that the switchboard has not yet been commissioned and that there is no possibility of the busbars or circuit cable being ALIVE.

5.12 Before commissioning the switchboard, check the operation of the safety shutters (26) on each panel. First, padlock each pair of shutters in turn and note that when either locking bar (132) is in the padlocked position it is not possible to push open the shutters which it protects. Then remove the padlocks in turn and check that each locking bar springs up or down as appropriate to clear the shutters when it is released.

5.13 Test for automatic operation of the shutters (26) by slowly plugging in and withdrawing a moving portion (1 etc.) as described elsewhere in this manual (sections 6.1 and 6.2).

5.14 Open each pair of shutters (26) in turn to give access to the isolating contacts (133) and receptacles (21, 23) within.

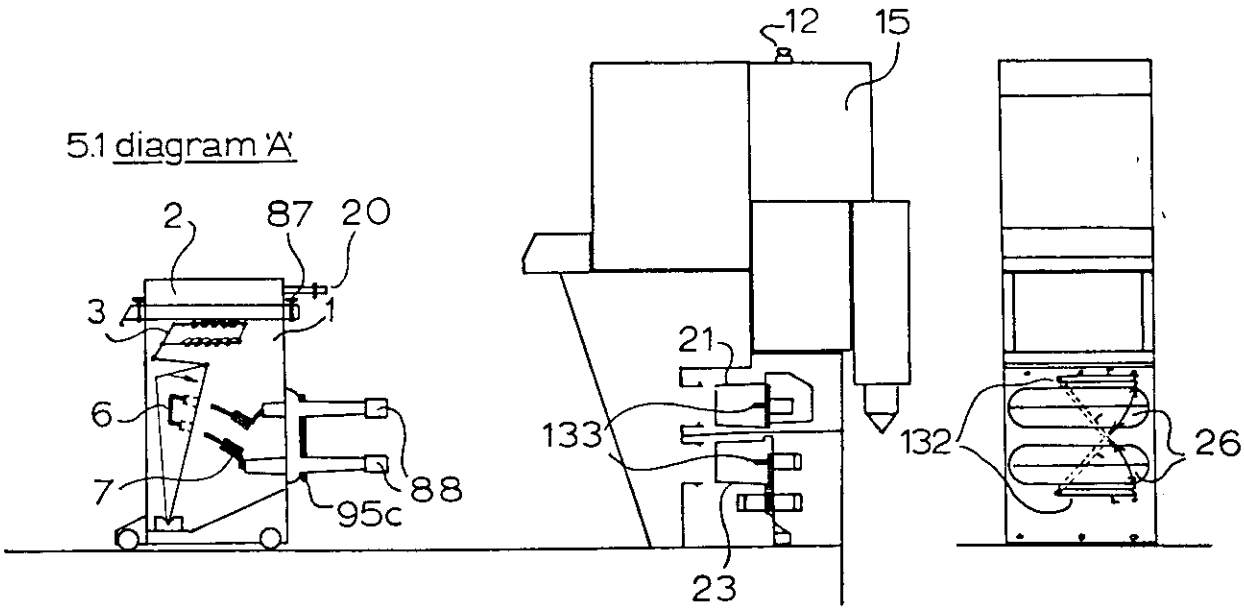
MAKE SURE THAT ALL FIXED CONTACTS (133) ARE DEAD then clean the receptacle insulators (21, 23) and clean and grease the contacts (133) as described under section 7.4 "Isolating Contact & Insulation Maintenance". Release the shutters (26).

5.15 Check all secondary wiring, paying particular attention to the tightness and security of terminations.

5.16 Check the fixed portion section of the mechanical interconnection linkages which interact with the tappets in the moving portion tank lid (see sections 1.4 "Isolating & Insulation Systems" and 2.2 "Tappet Operation").

5.17 Where a voltage transformer (15) is fitted, check that the correct ratings of HV and MV fuses are fitted in the primary and secondary circuits. Clean out the tank and fill it with switch oil of the type used in the OCB, observing the precautions detailed under 5.3 "Oil Filling of Switchgear". Check that the VT shutter closes when the HV fuses are withdrawn (12).

5.1 diagram 'A'



5.2 Preparation of Moving Portion

5.21 Remove all packings, labels etc. from the moving portion exterior. Unfasten the four hexagon headed bolts (87) securing the tank lid (2) and open the lid (see 5.1 diagram 'A').

5.22 Remove any packings from the interior and remove the mechanism/arc trap assembly (3) as described in 7.4 "Routine Maintenance of Moving Portion" in this manual. Check the mechanism/arc trap assembly to ensure that there is no sign of damage or loose connections.

5.23 Check that the inside of the tank (1) is clean and that there is nothing lying loose in the bottom of it. Clean out the tank and fill it up to the marked oil level as described in section 5.3 "Oil Filling of Switchgear". Check that the tank gas vents (20) are not blocked by blowing through them. Replace the mechanism/arc trap assembly (3) and close and fasten the lid (2, 87).

5.24 Clean and grease the self-aligning moving isolating contacts (88) as described in section 7.4 "Isolating Contact & Insulation Maintenance". Check that the anti-vermin seal (95c) is in position.

5.25 Check the condition and operation of the tappets, interlocks and controls on the top and front of the tank lid (2); see sections 1.7 "Interlocks and Padlocking", 2.2 "Tappet Operation" and the whole of section 6 "ROUTINE CIRCUIT BREAKER OPERATION". Plug the OCB into a DEAD fixed portion if possible to check the engagement and operation of the mechanical interconnections in accordance with those sections.

5.3 Oil Filling of Switchgear

5.31 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.

5.32 The oil must be of the correct grade (normally B30), 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.

5.33 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.

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

5.35 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.

5.36 To avoid condensation, 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 switch-room 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 dessicant 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.

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

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

5.39 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. This precaution is particularly important during post-fault maintenance.

5.4 Testing of Protective Equipment

5.41 All protective equipment should be thoroughly tested before commissioning, since the correct operation of circuit breakers on the occurrence of faults is of prime importance, and as relays are called upon to operate only at infrequent intervals, it is essential that they should function in the correct manner.

5.42 An operational check can be made on current operated relays by either:

(1) Primary Injection; (2) Secondary Injection; or (3) Current Transformer Test Winding, and the following notes are intended to serve as a guide to indicate the application of these methods.

5.43 Protective systems involving relays embodying both current and voltage elements require more complicated testing equipment, and in these cases reference should be made to the manufacturer's literature.

5.44 Prior to any operational check the relays should be examined and any packing pieces removed, and all wiring should be checked to diagram.

5.45 Primary Injection gives the closest simulation of service conditions, since it checks not only the operation of the protective equipment but also the primary and secondary windings of the current transformers (CTs).

The application of the primary injection test to SD-HI circuit breakers can present problems, since the CTs are fitted in the fixed portion. However, if the equipment can be tested before the main cables are jointed, the following procedure can be adopted.

(a) Plug the OCB of the new panel to be tested only into the fixed portion (see section 6.1 "To Plug into Service Location").

(b) Connect one terminal of the primary current test set to the busbar concerned via one of the busbar cover plate openings and the other to the cable box terminations.

(c) In the case of bus section OCBs, access will be required to the two busbar sections involved.

Before carrying out any primary injection testing it is essential to check that none of the CT secondary windings are open circuited, since under this condition all the applied primary ampere turns are employed to magnetise the CT core and dangerously high voltage can be produced.

5.46 Secondary Injection is a useful test for routine operational checks on relay equipment since the bulky heavy current equipment necessary for primary injection is not required. It is not, however, as complete as Primary Injection Testing since it does not check the accuracy of the CT.

If the relays are provided with a bridge type tapping device, or are of the draw-out pattern, secondary injection can readily be carried out by means of split plug type connectors.

5.5 High Voltage Tests

5.51 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 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.

5.52 The first test should be applied thus:

a) all phases to earth with OCB or oil switch closed;

b) between phases with OCB or oil switch closed;

c) across the break of the open OCB or oil switch.

If the equipment available 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 5.51
1	100
2	83.5
3	75
4	70
5	66.6
10	60
15	57.7

5.53 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, particularly of condenser bushings, 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

5.54 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

5.6 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 from the following:

Colour	Colour No. (BS.381C: 1948)
Signal Red (shutters-busbar)	537
Lemon Yellow (shutters-cable)	355
Light Grey	631

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

5.7 Making Alive

5.71 With all circuit breaker moving portions isolated, switch on any auxiliary circuits which may be required for indication and control. Operate the switchgear as follows in accordance with section 6 "Routine Circuit Breaker Operation".

5.72 Plug in an OCB moving portion to the circuit which is to provide the incoming supply. Make that supply alive from the remote end. Close, trip and reclose the local OCB. Check the operation of any indicating or measuring instruments.

5.73 Plug in and close/trip/close at each of the other panels in turn as the circuits are ready for commissioning. Check the operation of instruments at each panel in turn.

6. ROUTINE CIRCUIT BREAKER OPERATION

6.1 To Plug into Service Location

6.11 Check whether the OCB is OFF or ON as shown in the indicator window (33), and whether or not SPRINGS CHARGED is shown in the indicator window (33). If the OCB is ON, trip it as described in section 6.6, "To Trip the OCB to OFF". If the OCB is OFF but with SPRINGS CHARGED, discharge the springs as described in paragraph 6.36.

6.12 With the OCB OFF and springs discharged, set the service/isolate interlock knob (18) to ISOLATE.

6.13 Unlock the busbar and feeder automatic safety shutters (26, 132).

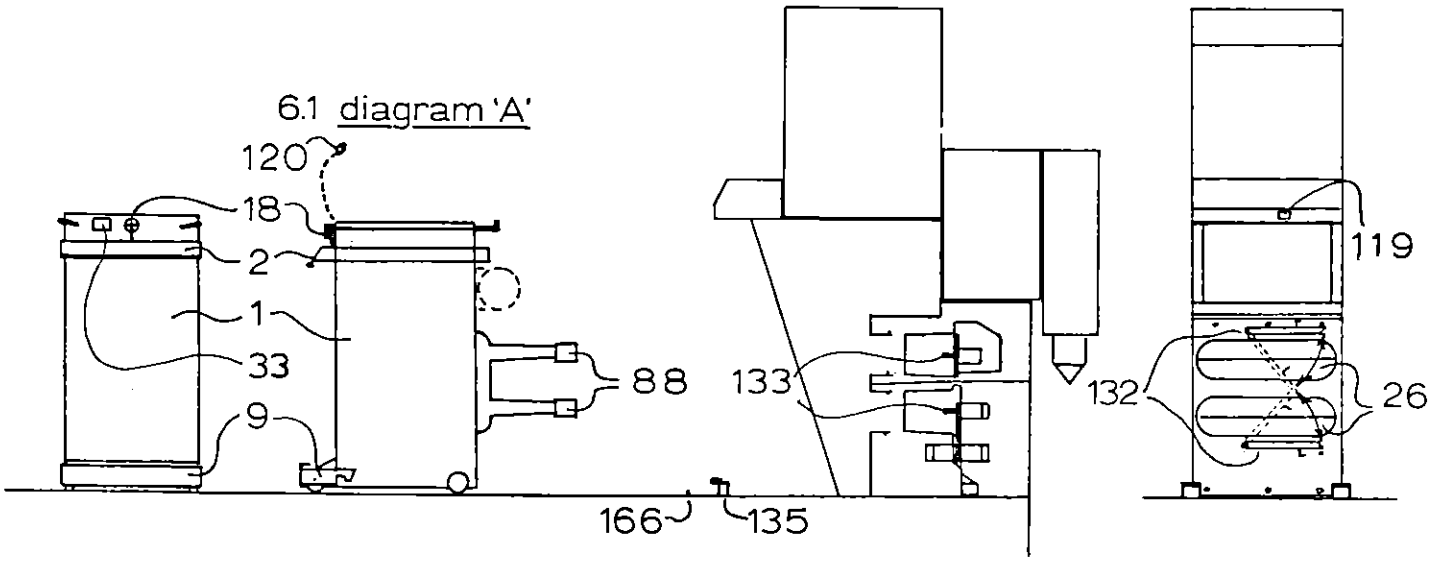
6.14 Place your hands on the beaded lip at the bottom of the tank lid front face (2) and push the moving portion (1 etc.) back towards the fixed portion shutters. The moving isolating contacts (88) on the moving portion will push open the shutters (26) when they reach them. Continue to push until the two hooks of the foot operated service lock (9) have engaged behind the two anti-jump stops (135) on the floor plates when the fixed (133) and moving (88) contacts will be mated.

6.15 On some units the size and/or stiffness of the isolating contact clusters (88) may necessitate the use of the forked operating handle (5) to push the moving portion completely home. Place the slotted hole (about 50 mm (2 in.) from the tip of the flat end of the handle) over the pin which protrudes from the end of the service lock treadle (9). Engage the slot in the end of the handle (5) onto the protrusion (166) on the floor plate (89) (see illustration). Pivot the handle away from you to engage the contact clusters (88) with the fixed isolating contacts (133) and the service lock hooks (9) with the anti-jump stops (135) on the floor plates (89).

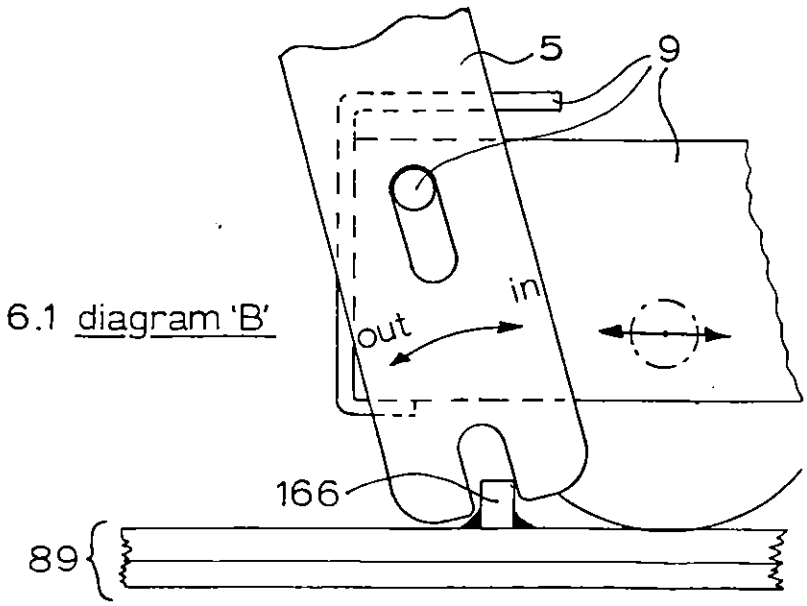
6.16 Set the service/isolate interlock knob (18) to SERVICE. It can be padlocked in this position to prevent withdrawal of the moving portion.

6.17 In the case of a motorized unit, push the jumper plug (**120**) into its socket (**119**) on the fixed portion.

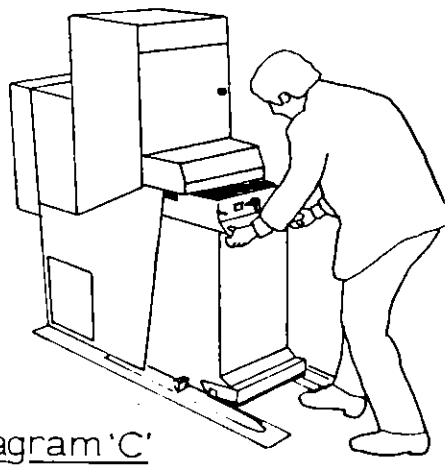
6.1 diagram 'A'



6.1 diagram 'B'



6.1 diagram 'C'



6.2 To Withdraw from Service Location

6.21 Diagrams are as for section 6.1. Check whether the OCB is OFF or ON as shown in the indicator window (33), and whether or not SPRINGS CHARGED is shown in the indicator window (33). If the OCB is ON, trip it as described in section 6.6, "To Trip the OCB to OFF". If the OCB is OFF but with SPRINGS CHARGED, discharge the springs are described in paragraph 6.36.

6.22 With the OCB OFF and the springs discharged, set the service/isolate interlock knob (18) to ISOLATE.

6.23 In the case of a motorized unit, pull the jumper plug (120) out of its socket (119) on the fixed portion.

6.24 Hook your fingers under the beaded lip at the bottom of the tank lid front face (2), depress the foot operated service lock treadle (9) and pull the moving portion (1 etc.) forwards to break the contact clusters' (88) grip and withdraw the moving portion.

6.25 On some units the size and/or stiffness of the isolating contact clusters (88) may necessitate the use of the forked operating handle (5) to break the contacts' grip. Place the slotted hole (about 50 mm (2 in.) from the tip of the flat end of the handle) over the pin which protrudes from the right hand end of the service lock treadle (9). Engage the slot in the end of the handle onto the protrusion (166) on the floor plate (89) (see illustration). Pivot the handle towards you to disengage the contact clusters (88) from the fixed isolating contacts (133), and the service lock hooks (9) from the anti-jump stops on the floor plates.

6.26 Pull the moving portion (1 etc.) clear of the fixed portion and padlock the busbar and feeder shutters closed (26, 132).

6.3 To Charge and Discharge the OCB Springs (Hand)

6.31 The OCB must only be operated with the tank (1) filled with oil to the marked level.

6.32 Ensure that the service/isolate interlock knob (18) is set to SERVICE and the OCB is OFF (33). Do NOT turn this knob (18) to ISOLATE when the springs are charged, as this will discharge both sets of springs simultaneously against no resistance, and could weaken or damage the mechanism.

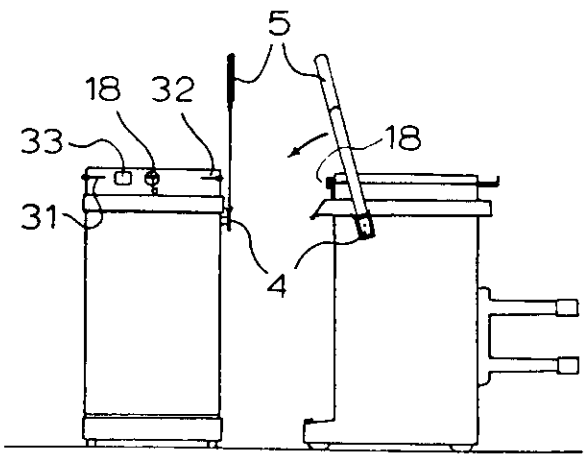
6.33 Check that the operating handle socket (4) at the right hand side of the tank (1) is unlocked and insert the operating handle (5) into it. Push the handle down as far as it will go, to an approximately horizontal position. SPRINGS CHARGED will appear in front of OFF in the indicator window (33). The closing and opening springs are now charged.

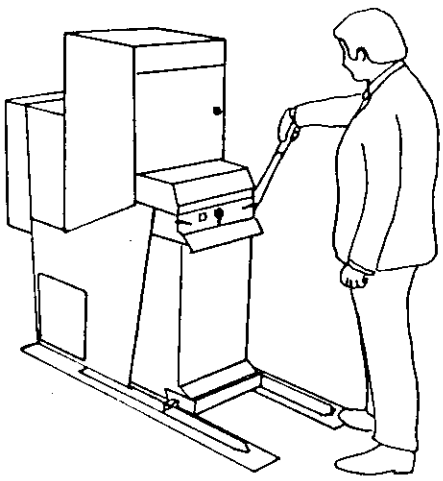
6.34 Raise the operating handle (5) back to the vertical position and remove it from its socket (4). The indication SPRINGS CHARGED should remain in the indicator window (33).

6.35 The operating handle socket (4) can be padlocked if required. Note that a further charge cannot be stored until the OCB has been closed and tripped, or until the springs have been discharged, as described next.

6.36 Should it prove necessary to discharge the springs without closing the OCB, re-insert the operating handle (5) into its (unlocked) socket (4). Push the handle down as far as it will go and maintain pressure. Press the trip lever (32) and allow the operating handle to rise slowly under the pressure of the springs, holding the operating handle firmly to prevent its flying upwards. When the operating handle has reached the top of its stroke it may be removed, and the socket (4) padlocked to prevent re-charging.

6.3 diagram 'A'





6.3 diagram 'B'

6.4 To Charge & Discharge the OCB Springs (Motor)

6.41 The OCB must only be operated with the tank (1) filled with oil to the marked level.

6.42 Ensure that the service/isolate interlock knob (18) is set to SERVICE and the OCB is OFF (33). Do NOT turn this knob (18) to ISOLATE when the springs are charged, as this will discharge both sets of springs simultaneously against no resistance, and could weaken or damage the mechanism. Ensure that the jumper plug (120) is plugged into the jumper socket (119).

6.43 The actual arrangement and labelling of the electrical controls will vary from installation to installation. Basically, however, there are two electrical control systems: the "charge springs" circuit and the "trip/close" circuits. An additional local/remote control facility may be included.

6.44 In every case, the springs must be charged before the breaker can be closed. A second spring charge cannot be stored until the breaker has been taken through a complete close-and-trip cycle or the springs have been discharged as described in paragraph 6.46. Re-charging may be automatic, once the charging circuits have been switched on, or each re-charging cycle may need to be individually initiated from the control panel. This will depend on the electrical control scheme employed. The detailed operation of the electrical and mechanical systems involved is explained in sections 2.3, "Spring Mechanism Operating Sequence" and 2.4 "Motorized Spring Charging System Operating Principles".

6.45 Should the motor supply fail during the charging operation, one of three conditions will apply.

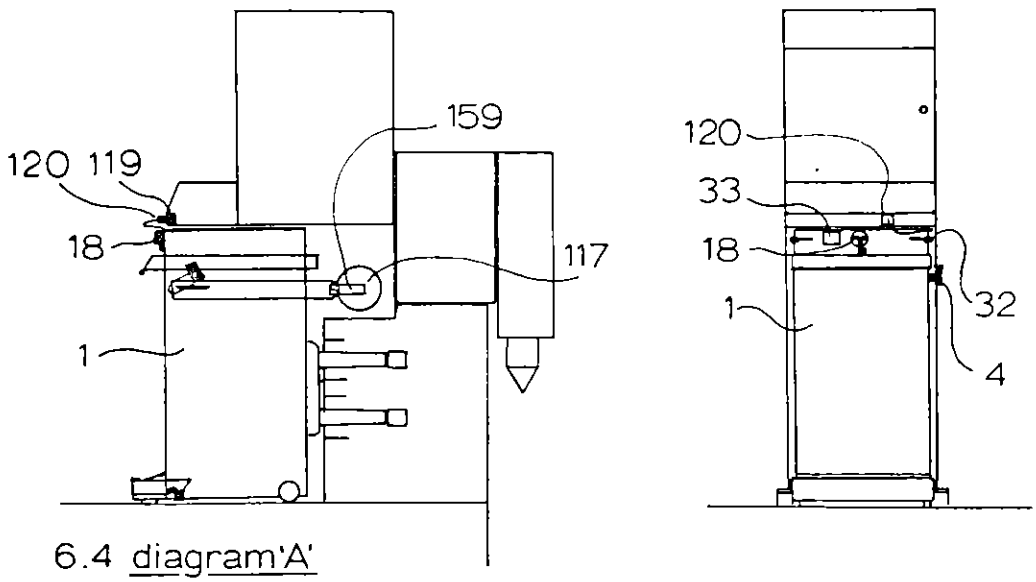
(a) If the motor drive arm (159) has not yet reached the 180° position, i.e. horizontal and pointing to the rear, the springs will simply discharge themselves without moving the arc trap assemblies and drive the motor (117) back to its starting position. No action is required.

(b) If the motor drive arm (159) has passed beyond the 180° position, the springs will be fully charged and latched and the handle socket return spring will pull the motor drive arm (159) round to the starting position. No action is required, but note that the OCB is now ready to close.

(c) If the motor drive arm (159) is left at the 180° position, the springs must be discharged as follows.

6.46 To discharge the springs without closing the OCB, first remove the jumper plug (120) from its socket (119). Insert the manual charging handle (5) into its socket (4). Push the handle down as far as it will go and maintain pressure. If the motor drive arm (159) is in the 180° position (i.e. horizontal and pointing towards the rear of the fixed portion), rotate it anti-clockwise (looking from the right) to the start position (i.e. horizontal and pointing forwards). Press the trip lever (32) and allow the charging handle to rise slowly under the pressure of the springs, holding the charging handle firmly to prevent its flying upwards. When the handle has reached the top of its stroke it may be removed.

6.47 Note that an OCB which is OFF, with the springs discharged, the jumper plug (120) pulled out and the motor (117) in the start position may be operated in every respect as a normal manually charged spring OCB.



6.4 diagram'A'

6.5 To Close the OCB to ON

6.51 Once the closing springs are charged, the OCB may be closed in any one of several ways, as detailed below (see also sections 2.2 "Tappet Operation" and 2.3 "Spring Mechanism Operating Sequence").

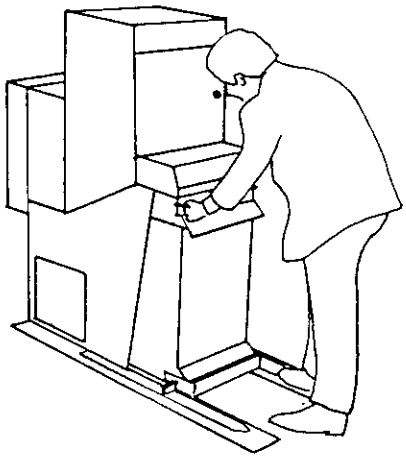
6.52 Manual operation is by the pressing of the close lever (31) (diagram 'A') or, where specified, by the pulling of a lanyard passing through a split ring on the OCB lid (2) front lip and connected at one end to the close lever (31) (diagram 'B').

6.53 Electrical operation is by the making alive of a closing spring release coil on the fixed portion to depress the OCB close tappet on the moving portion. The coil may be energised by the operation of automatic control relays, by the operation of a local or remote close button, or by the operation of a local or remote trip/close switch. For details see section 2.2 "Tappet Operation".

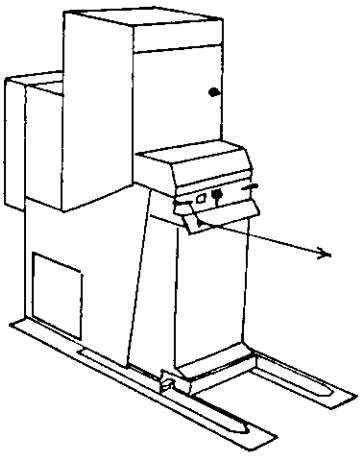
6.54 Whichever of the above descriptions applies, the close tappet is depressed to release the closing springs. The indication in the indicator window (33) will change, SPRINGS CHARGED/OFF being changed to SPRINGS FREE/ON.

6.55 The OCB opening springs are already charged, so that immediate re-opening, either by the operation of the trip lever (32) or by the operation of protective circuits, is possible.

6.56 The manual trip lever (32) can be padlocked to prevent manual tripping of the OCB, for example by unauthorised personnel in a consumer's substation. When the OCB is ON the service/isolate interlock (18) is automatically prevented from being moved to ISOLATE.

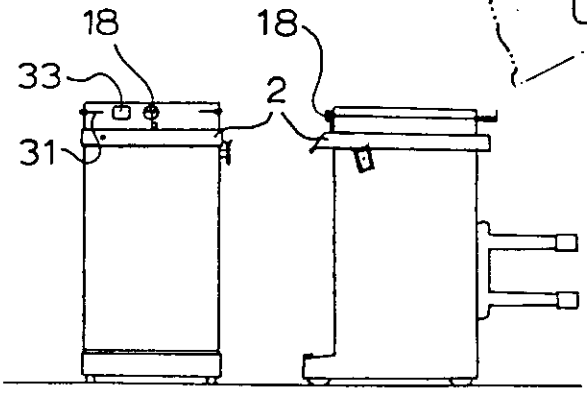


6.5 diagram 'A'

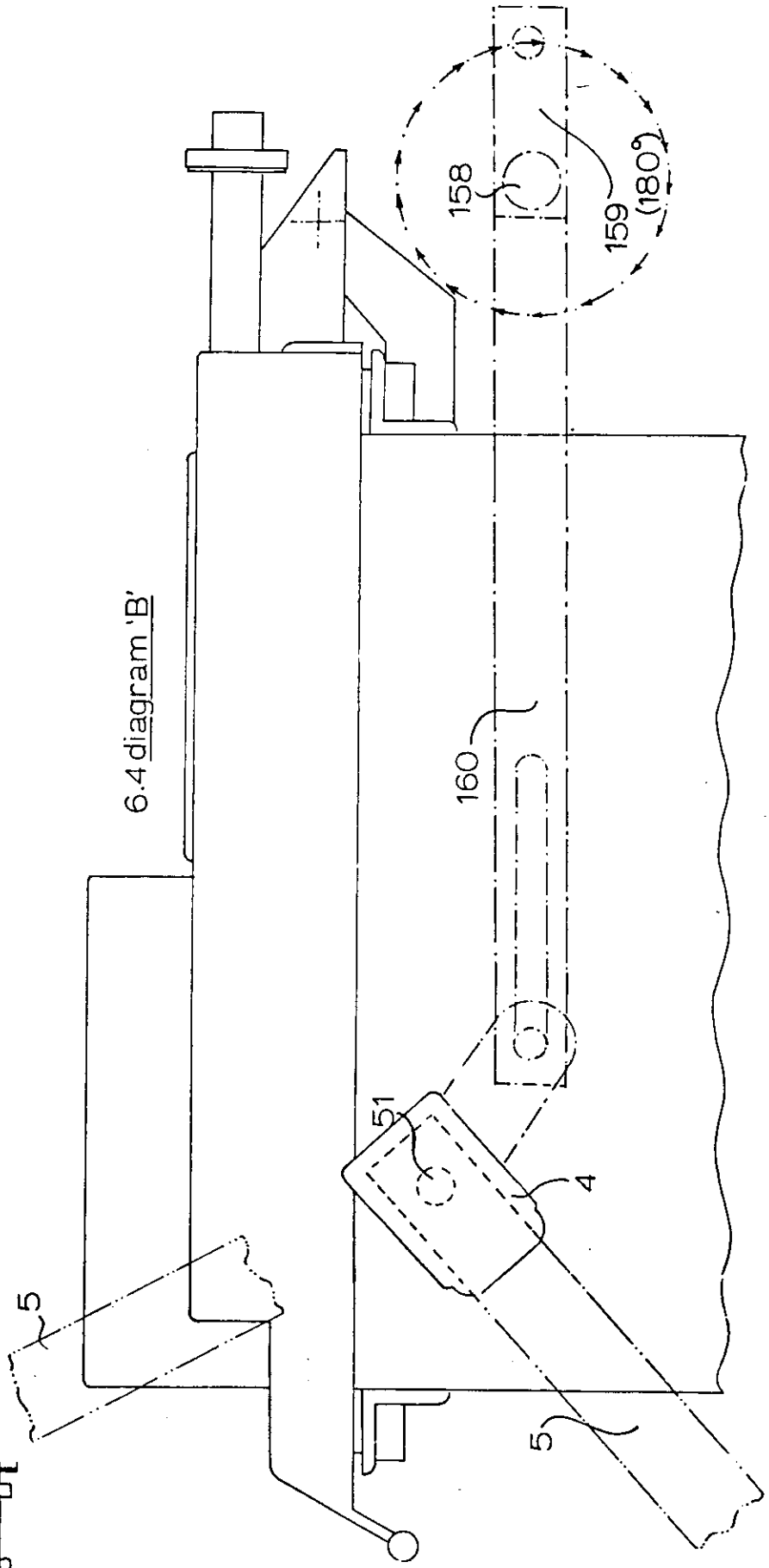


6.5 diagram 'B'

6.5 diagram 'C'



6.4 diagram 'B'



6.6 To Trip the OCB to OFF

6.61 The OCB may be tripped in any one of several ways, as detailed below (see also sections 2.2 "Tappet Operation" and 2.3 "Spring Mechanism Operating Sequence").

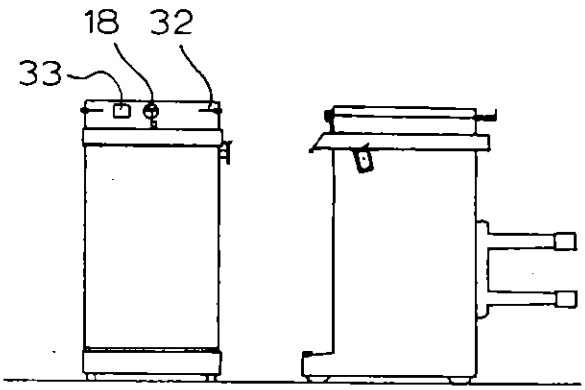
6.62 The first way in which the OCB can be tripped is by the pressing down of the manual trip lever (32) at the right of the OCB lid front plate (2) (diagram 'B').

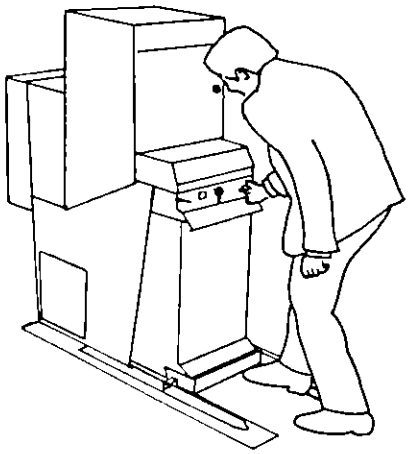
6.63 The second way in which the OCB can be tripped is by the operation of a local or remote electrical trip button or trip/close switch to energise the trip coil on the fixed portion. For details see section 2.2 "Tappet Operation".

6.64 The third way in which the OCB can be tripped is by the operation of a shunt trip coil on the fixed portion due to the blowing of time limit fuses or the operation of protective relays. For details, again, see section 2.2 "Tappet Operation".

6.65 In every case the trip tappet in the OCB lid is depressed to collapse the spring mechanism, and the ON sign in the indicator window (33) is replaced by OFF.

6.6 diagram 'A'





6.6 diagram 'B'

6.7 Circuit and Busbar Earthing via the OCB

6.71 Either the circuit cable or the busbars of a SO-HI unit can be earthed through the circuit breaker by means of a lightweight Portable Earthing/Testing Device (136). Since both the earthing/testing device and the circuit breaker are capable of taking the full short circuit current without stress if an earth is accidentally applied to live contacts, the safety of the operator is assured.

6.72 Before earthing the circuit or busbar ensure that it has been made dead, isolated and locked off from all points of supply. At the panel where the earth is to be applied, the safety shutters (26) of the contacts which are not to be earthed must be padlocked closed (132).

The earthing/testing device (136) can be supplied equipped with additional interlocks to deter an inexperienced operator from attempting to plug it into the fixed portion without mounting it on the moving portion.

6.73 To fit the earthing/testing device (136) to the moving portion for Circuit Earthing: (Diagram 'C')

(a) Stand at the left hand side of the withdrawn moving portion (1) and hold the device (136) with the "CIRCUIT EARTHING" label uppermost and the contact clusters (137) towards the fixed portion. If space is limited, hold the device vertically with the "CIRCUIT EARTHING" label towards you and the contact clusters (137) uppermost.

(b) Rotate the earthing device securing handle (139) anti-clockwise (looking from the left) against its stop.

(c) Offer the device (136) to the moving portion so that the horizontal operating shaft (140) passes between the upper and lower moving portion isolating contact sets (88) and the insulated earthing/testing device spouts (138) envelope the upper moving portion contact clusters (88(a)). Draw the device forwards until the 'U' shaped brackets (141) at each side engage the earthing contacts (142) on the moving portion tank (1) sides.

(d) Rotate the earthing device securing handle (139) clockwise (looking from the left) so that the claw cams (143) engage the bosses (144) on the tank (1) to pull the device firmly into engagement with the moving portion contact clusters (88).

6.74 To fit the earthing/testing device to the moving portion for Busbar Earthing: (diagram 'D')

(a) Stand at the right hand side of the withdrawn moving portion (1) and hold the device (136) with the "BUSBAR EARTHING" interlock flap (145) uppermost and the contact clusters (137) towards the fixed portion. If space is limited, hold the device vertically with the "BUSBAR EARTHING" label towards you and the contact clusters uppermost.

(b) Rotate the earthing device securing handle (139) anti-clockwise (looking from the right) against its stop.

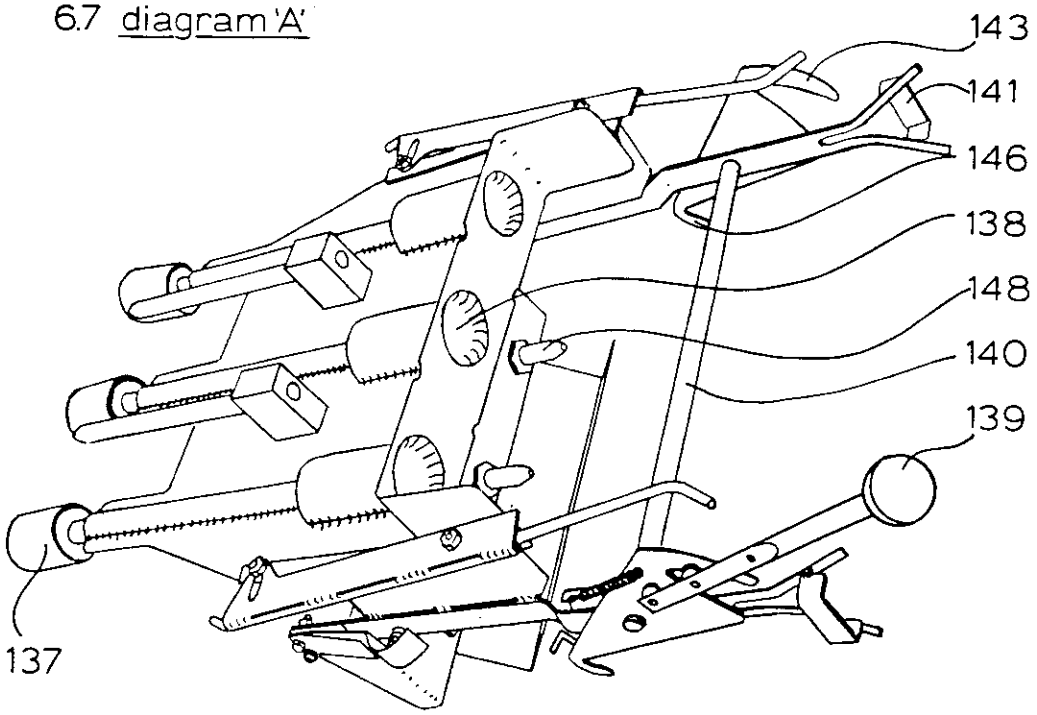
(c) Offer the device (136) to the moving portion so that the horizontal operating shaft (140) passes between the upper and lower moving portion isolating contact sets (88) and the insulated earthing/testing device spouts (138) envelope the lower moving portion contact clusters (88(b)). It will be necessary to lift the red interlock flap (145) carrying the "BUSBAR EARTHING" label in order to clear the upper moving portion contact clusters (88(a)). Draw the device forwards until the 'U' shaped brackets (141) at each side engage the earthing contacts (142) on the moving portion tank (1) sides.

(d) Rotate the earthing device securing handle (139) clockwise (looking from the right) so that the claw cams (143) engage the bosses (144) on the tank (1) to pull the device firmly into engagement with the moving portion contact clusters (88).

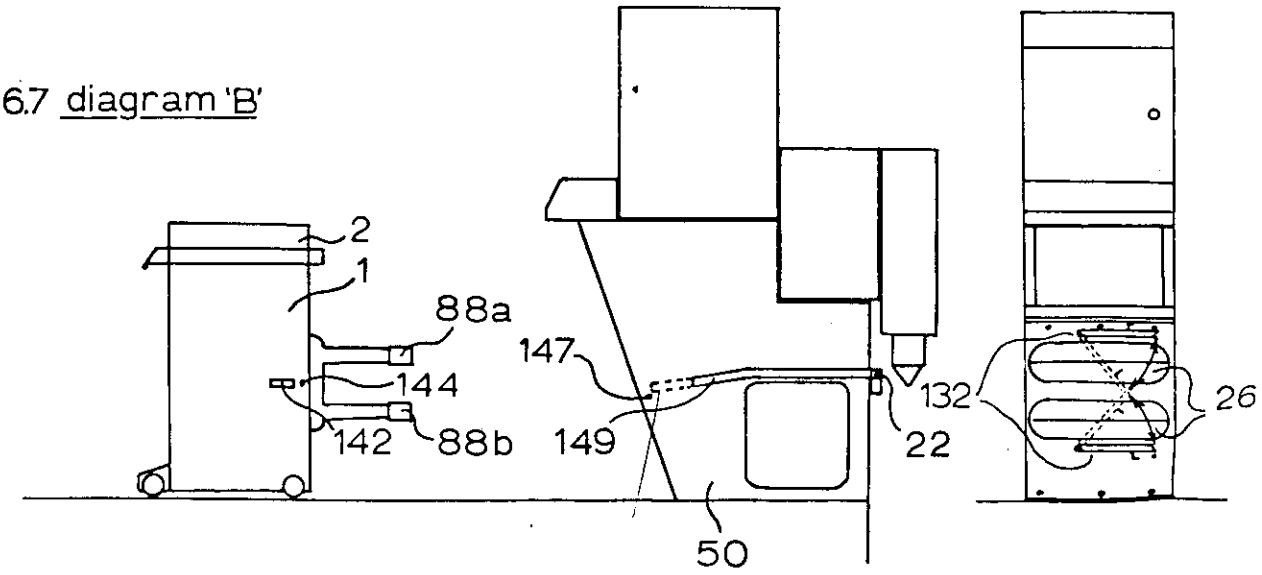
6.75 With the service/interlock knob (18) set to ISOLATE, push the moving portion back towards the fixed portion until the contacts (137, 133) mate fully, when you will be able to set the service/isolate interlock knob (18) to SERVICE.

6.76 Lock off the trip facility by rotating the earthing device interlock (44) on the tank lid (2) clockwise and depressing it so that it engages the trip tappet (43) and passes under the service/isolate interlock lever (42). This prevents the operation of the trip lever (32) or the service/isolate interlock knob (18). Padlock the earthing device interlock (44) in this position. Charge and close the OCB in the normal way to apply the earth.

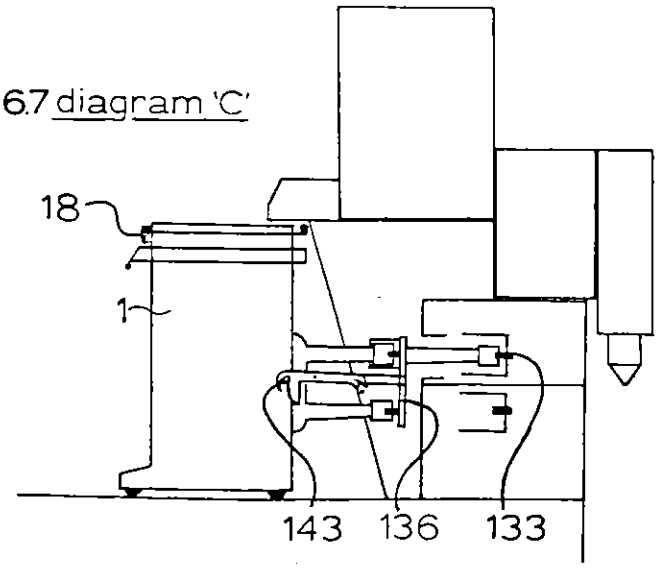
6.7 diagram 'A'



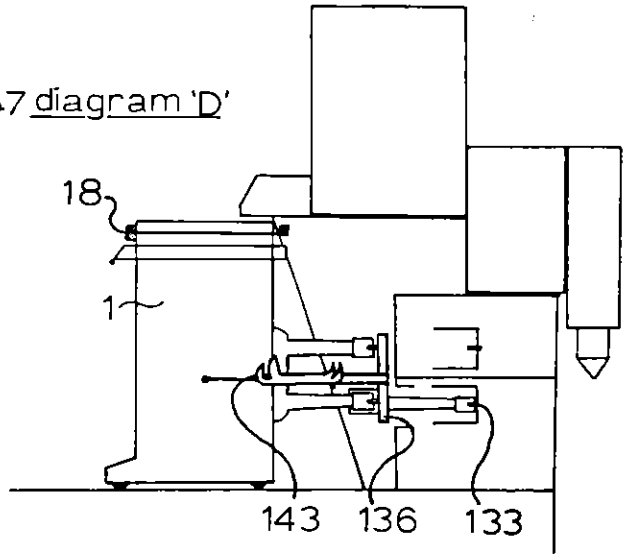
6.7 diagram 'B'

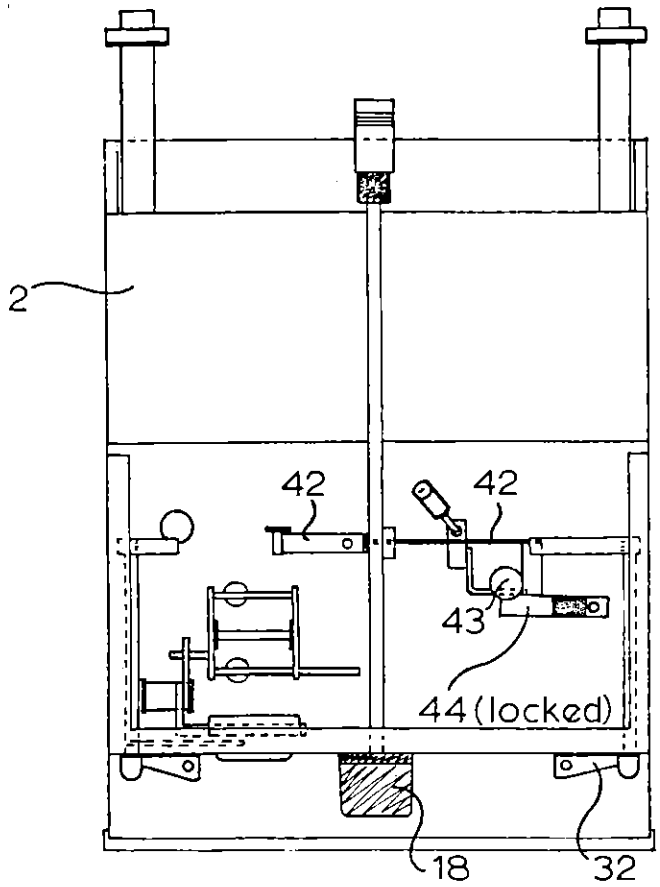


6.7 diagram 'C'



6.7 diagram 'D'





6.7 diagram 'E'

6.8 Cable Testing via the OCB Earthing/Testing Device

6.81 The earthing/testing device (136) can also be used for the continuity or pressure testing of the circuit cable (127). The procedure is as follows:-

6.82 Earth the circuit cable (127) via the OCB as described above (sections 6.73, 6.75, 6.76), then unlock the earthing device interlock (44), pivot it clear, and trip the OCB by pressing the trip lever (32). Set the service/isolate interlock knob (18) to ISOLATE, but before withdrawing the moving portion:-

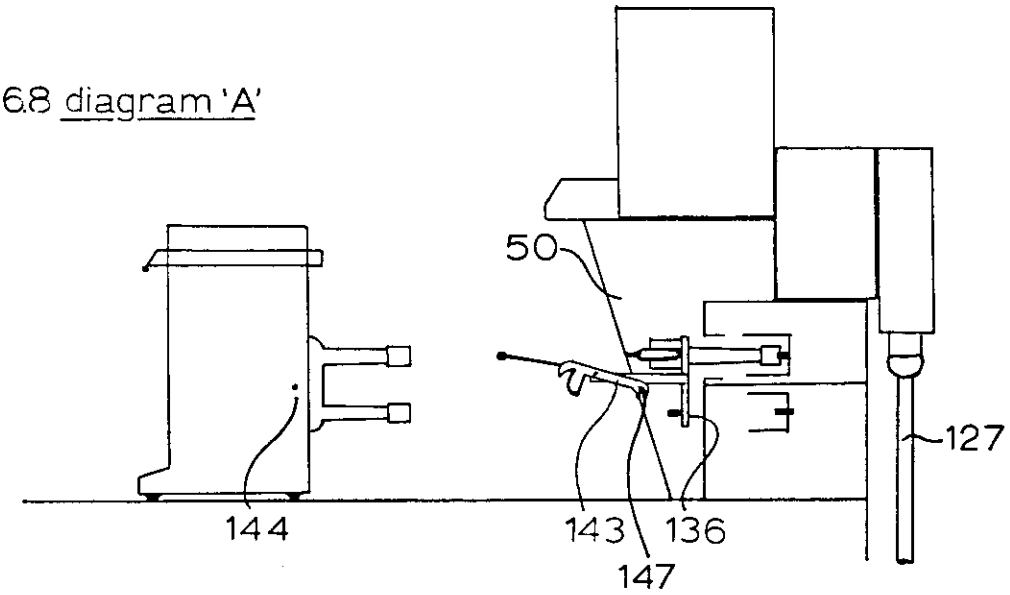
6.83 Raise the earthing device securing handle (139) fully. The tank securing claw cams (146) will clear their corresponding bosses (144) on the moving portion tank (1), and the fixed portion securing hooks (146) will engage with corresponding pins (147) on the fixed portion sidewalls (50).

6.84 Now withdraw the moving portion (1 etc.), leaving the earthing/testing device (136) plugged into the fixed portion.

6.85 The three shrouded upper contacts (138) of the earthing/testing device (136) now give electrical connection to the individual cable terminations for testing purposes. Push-on test connections are available for this. The three lower star point contacts (148) are earthed via the earth bars (149) on the fixed portion sidewalls to provide a reference earth for phasing out, etc.

6.86 On completion of testing, plug in the moving portion (1 etc.) to the device (136) and press down the earthing/testing device securing handle (139) so that the tank securing claw cams (143) again engage their bosses (144) on the tank (1) and the fixed portion securing hooks (146) clear their pins (147) on the fixed portion sidewalls (50).

6.8 diagram 'A'



6.9 Removal of Earthing/Testing Device

6.91 With the OCB moving portion (1 etc.) plugged into and secured to the earthing/testing device (136), remove the padlock from, and disengage the anti-tripping interlock (44) by rotating it anti-clockwise, well clear of the tappet (43).

6.92 Press the trip lever (32) to open the OCB.

6.93 Set the service/isolate interlock knob (18) to ISOLATE and withdraw the moving portion (1 etc.), bringing the earthing/test device (136) with it.

6.94 Operate the earthing device securing handle (139) and remove the earthing/testing device (136), then (a) unlock the locked shutters (26, 132) (if the moving portion (1 etc.) is to be plugged into the service location) or (b) lock the unlocked shutters (26, 132) (if the circuit is to remain isolated).

7. MAINTENANCE

7.1 Frequency of Maintenance.

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

7.12 As indicated in section 1.5 "Technical Specification", "SD-HI" has been successfully certified to BS116 and IEC56. In addition, tests involving repeated interruptions at short intervals of various fault currents have enabled us to produce the graph shown in diagram 'A'.

7.13 In the light of this, and after gaining suitable operational experience on their own systems, users may decide that OCB moving portion post-fault maintenance as such is unnecessary and only routine moving portion maintenance is needed. Instructions for both are included in this manual.

7.14 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.

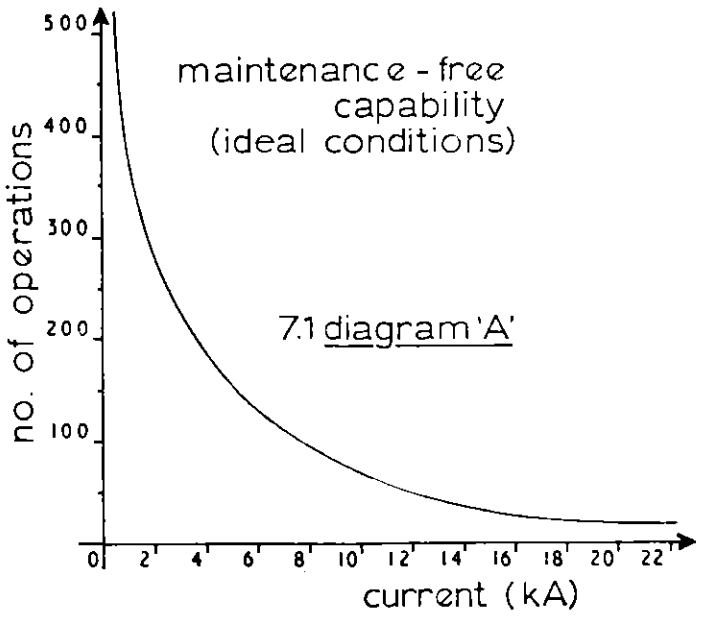
7.15 Where equipment is employed on a particularly arduous duty, such as arc furnace control, which involves multiple operations every day, an initial inspection during the first three months of operation is recommended.

7.16 Users should conform to local practice and regulations; British users are particularly recommended to consult "British Standard Code of Practice for the Maintenance of Electrical Switchgear, CP 1008" for general guidance.

7.17 The unique design of the moving portion, with its easily removable, interchangeable mechanism/arc trap assembly means that, where necessary, the complete assembly can be removed and replaced by a spare in minutes to permit the return of the unit to service. The original assembly can then be inspected and/or serviced in a central workshop as time permits.

7.18 Where operation of a circuit breaker is rare and maintenance requirements minimal, periodic tripping and reclosure between infrequent maintenance outages may suffice to check for satisfactory operation.

7.19 Fixed portion maintenance can be divided into two categories: routine maintenance, undertaken whenever the OCB moving portion is maintained, and occasional maintenance, undertaken only at intervals of several years and involving the making dead of the complete switchboard and associated circuits.



7.1 diagram 'A'

7.2 Routine Maintenance of Fixed Portions

7.21 This consists only of that work which can safely be undertaken with the busbars (24) and circuit cable (127) LIVE and both sets of safety shutters (26) locked closed (132).

7.22 Inspect the general condition of the switchroom to see that it is clean, dry and adequately heated and ventilated. Look for oil or compound leaks from cable boxes (17), listen for any audible discharge, note any unusual smells. Should anything be amiss, investigate the cause and arrange for its correction.

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

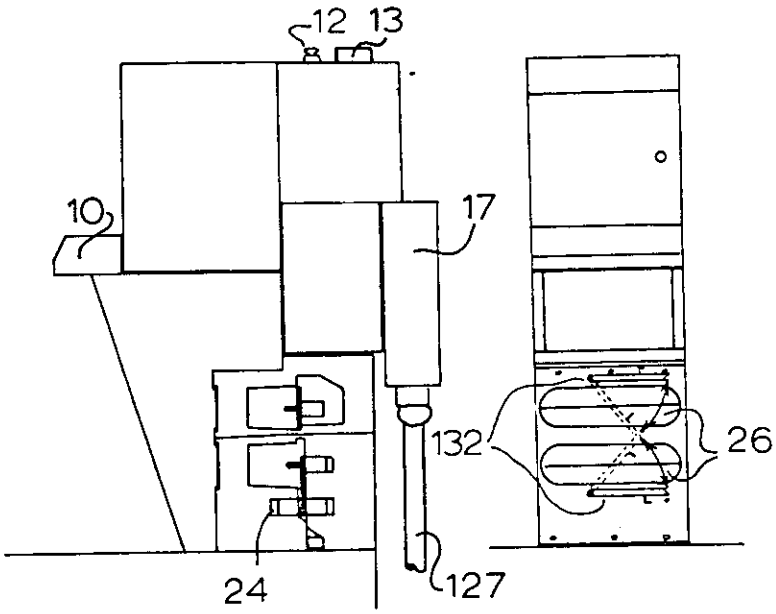
7.24 Unscrew and remove the voltage transformer HV fuses cover (12) and examine the fuses. Note that clean oil drips from them as they are removed from the tank. Similarly, check the LV fuses (13).

7.25 With all secondary circuits disconnected, clean and examine the relays and protective equipment in accordance with the makers' instructions. Note that current transformer terminations must not be open-circuited, since this can give rise to dangerously high voltages. As far as possible, check all secondary wiring terminations. Examine and replace or renew time limit fuses and other secondary circuit fuses and links and inspect and clean their contacts. Clean the auxiliary switch contacts (beneath the drop-down front cover (10)) and smear with petroleum jelly ("Vaseline"). Put all fuses back.

7.26 Clean and lubricate all the moving parts of the mechanical interconnection system (see section 2.2 "Tappet Operation") which are mounted on the fixed portion. Manually operate the tappets of the trip and close coils. See section 7.8 "Lubricating Oil Specification".

7.27 If possible, check the operation of the trip, close and auxiliary systems with a plugged-in moving portion.

7.2 diagram 'A'



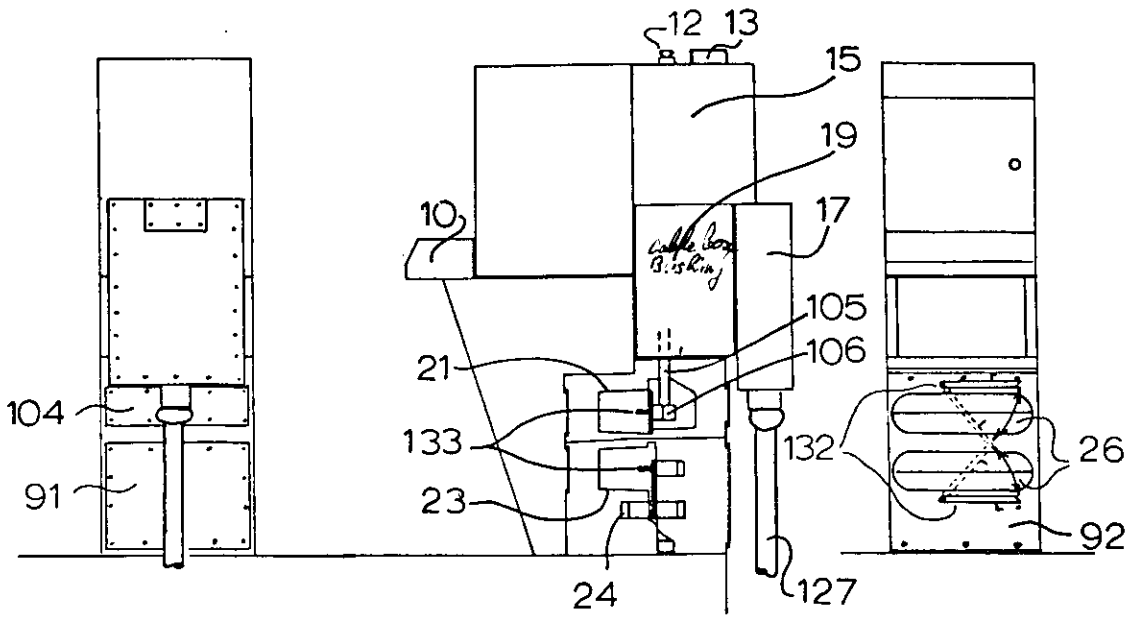
7.3 Occasional Maintenance of Fixed Portions

7.31 This involves the inspection, cleaning and maintenance of equipment in the busbar chamber, circuit connections, current transformer chamber (19), voltage transformer tank (15) and the fixed isolating contact system (21, 23, 133 etc.), in addition to the work covered by routine maintenance.

7.32 UNTIL THE SWITCHBOARD BUSBARS (24) AND ASSOCIATED CIRCUIT CONNECTION (127) OF ANY FIXED PORTION HAVE BEEN MADE DEAD, ISOLATED AND LOCKED OFF AT ALL POINTS OF SUPPLY AND EFFECTIVELY EARTHED, YOU MUST NOT INSERT ANYTHING INTO THE RECEPTACLE INSULATORS OR INTO ANY CHAMBER WHICH HOUSES NORMALLY LIVE METAL PARTS, NOR MUST YOU REMOVE ANY PART OF THE PROTECTIVE METAL CLADDING.

7.33 Padlock each pair of shutters in turn (26, 132) and check that when the locking bar (132) is in the padlocked position, neither of the shutter halves (26) which it protects can be opened. Remove each padlock in turn and check that the locking bar (132) springs up or down as appropriate to clear the shutter halves (26). Check that the shutters (26) can now be pushed open, but spring back when released.

7.3 diagram 'A'



7.34 Remove the busbar chamber back plate (91) and the shutter assemblies mounting plate (92). Check that the circuit and busbar resin mouldings (21, 23) are secure and that the busbars (26) are held firmly in position. On high impulse level equipment with shrouds on the busbar/tee-off connection junctions, check that all shrouds (100 etc.) are securely in position.

Clean the busbars (26) and resin mouldings (21, 23) and clean and grease the isolating contacts (133) as described under 7.6 "Isolating Contact and Insulation Maintenance". Lubricate the shutter (26) mechanisms. Replace the busbar chamber back plate (91) and the shutter assemblies mounting plate (92).

7.35 If the unit has a voltage transformer (VT) (15), check that the lid is fastened down tight to avoid oil spillage and remove the screws which secure the VT housing to the top of the current transformer (CT) chamber (19). Remove the VT. If no VT is fitted, remove the CT chamber top cover. Check the CT terminations and general condition, clean out the chamber using lint-free, non-metallic cloths. Check the insulating screens' condition and replace if necessary. Replace the cover or VT and fasten down. Remove the access plate (104) immediately above the busbar chamber back plate (91) to gain access to the CT bushing (105) bottom connections (106). Check that the connections are secure and clean the connection chamber and insulation as described under 7.6 "Isolating Contact and Insulation Maintenance". Replace the access plate (104).

7.36 Where a voltage transformer (VT) (15) is fitted it should be unlocked and opened and the general condition noted. Top up the oil if necessary. Check the condition of fuses and contacts. Replace the cover.

7.37 Where a compound or oil insulated cable box (17) is fitted, check all round for signs of leakage. Should any be evident the box may require to be broken down and re-made.

In the case of an air insulated box, remove the back plate and check the terminations. Clean the cable box and insulation and reclose the box.

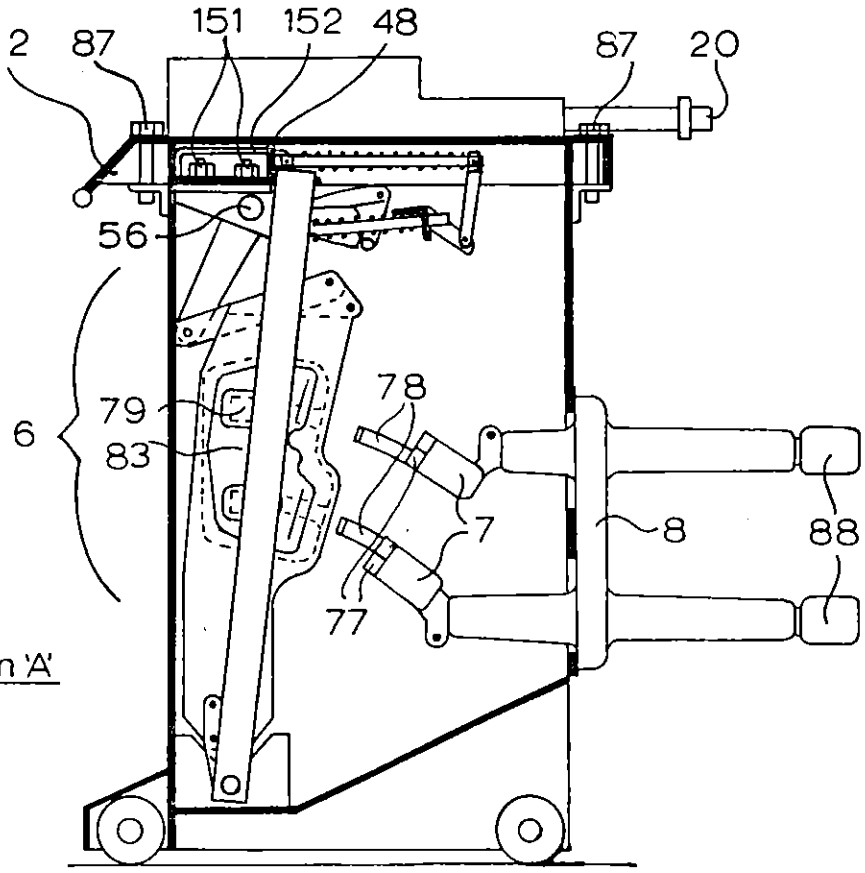
7.4 Routine Maintenance of Moving Portion

7.41 Isolate the moving portion as described in section 6.2 "To Isolate from Service Location". Clean down the outside of the tank (1) and clean and grease the isolating contacts (88) as described in section 7.6 "Isolating Contact & Insulation Maintenance".

7.42 Remove the four hexagon-headed tank lid screws (87) and open the lid (2). Do not operate the spring mechanism with the lid open and oil in the tank - oil will spill all over the floor and you! No naked light should be permitted in the vicinity of open tanks or in any situation in which switch oil is directly exposed to the atmosphere, due to the risk of fire.

7.43 Remove the four hexagonal nuts (151) which hold the mechanism/arc trap assembly in position and lift the assembly out by means of the two handles (152) on the top frame (48). Note that if the springs are charged an interlock is held under the protrusion on the tank front wall to prevent removal.

Rest the mechanism on the support angles at the top of the tank and allow the oil to drip back into the tank, then place the mechanism on a stand (available from Yorkshire Switchgear) or a bench or other clean surface for examination. Check that all fastenings are secure and that no component exhibits signs of wear, slackness or distortion. Examine the operating springs for signs of damage. Check the two taper pins on the main shaft (56) and all other fastenings for tightness. NEVER operate the mechanism in air with the springs fitted - you could cause irreparable damage.



7.4 diagram 'A'

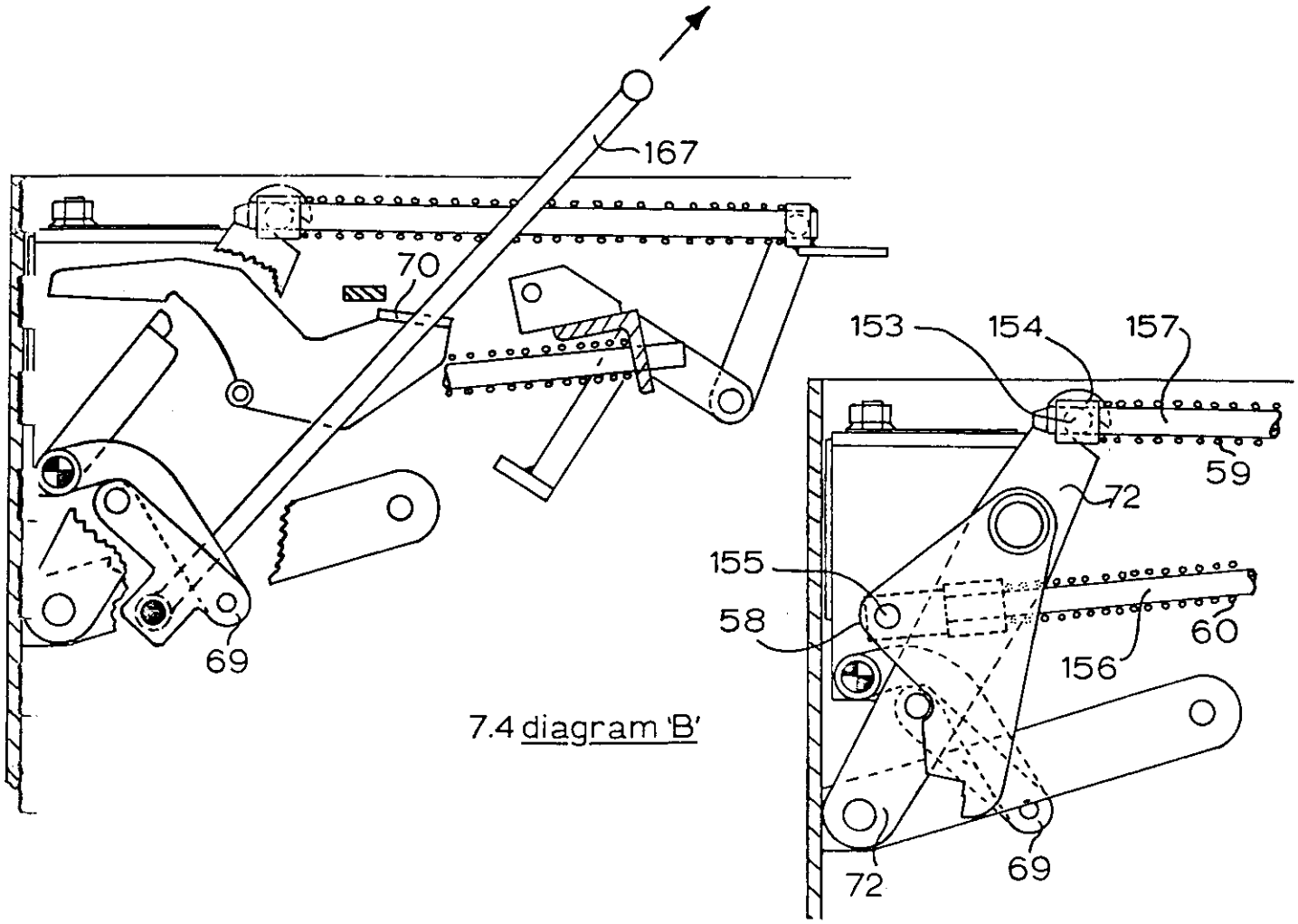
7.44 Whilst the mechanism is out of the tank, examine the fixed main contacts (77) and arcing electrodes (78) in the tank and sample and test the oil in accordance with section 7.7, "Switch Oil Sampling and Testing". If the oil is clear, it is unlikely that the electrodes will have been pitted, and a visual inspection through the oil will suffice. Should the oil be murky or otherwise require to be changed, the opportunity can be taken to examine the contacts and electrodes whilst the tank is empty. Due to the use of separate main and arcing contact systems, it is unlikely that the former (77) will be burned - simply check that the screws are secure and the springs operative (see section 3, "Detailed Description of Arc Control System"). Unless the OCB has been severely and repeatedly overloaded it is unlikely that the arcing electrodes (78) will require more than a rub with a fine file or fine glasspaper (do not use emery or carborundum). In the 15 years or so that the Caton Arc Trap has been in service, the number of electrodes requiring replacement has been negligible. If replacement is necessary we recommend that the mechanism/arc trap assembly (3) also be withdrawn from service and either returned to us or dismantled for the fitting of new moving arcing contacts (79). Also, where a circuit breaker is required to perform a particularly arduous duty or for repeated full load operations, we recommend that tungsten copper arcing tips be specified for the electrodes (78) and contacts (79).

7.45 Wash the mechanism/arc trap assembly with clean switch oil before returning it to the tank. Since all fixed contact assemblies are jig built to be completely interchangeable there should never be any problems with contact alignment. However, whenever the fixed contacts (77) or arcing electrodes (78) have been disturbed, the alignment must be checked as follows:

With the mechanism/arc trap assembly securely fastened (151) in the tank, hook the ring of the knuckle toggle collapsing tool (167) over the pin on the left hand straight knuckle toggle link (69). Pull upwards on the tool and press down on the horizontal end of the closing springs release catch (70) to pivot the arc trap assemblies (6) towards the closed position. There will be resistance to closure due to contact spring pressure, but any untoward sticking or mis-alignment should be readily discernible. If serious misalignment is evident, adjust or replace the affected assemblies. With the alignment correct, remove the tool (167).

Should it ever prove necessary to replace a closing spring (59), remove the split pins at each end of the closing springs retaining bar (153) and raise the closing spring assembly through 90° relieving the residual spring pressure. The closing spring block assemblies (154) can then be unhooked from the main closing levers (72), and removed from the spring shafts (157), freeing the closing springs (59); replacement is the reverse of this procedure.

Should it ever prove necessary to replace an opening spring (60), remove one of the split pins which secure the opening springs pin (155) through the two lower (opening) springs charging levers (58). Remove the pin (155), taking care to note the arrangement of blocks, washers etc. on it; this permits the removal of the springs (60) and their shafts (156).



7.4 diagram 'B'

7.46 Whilst the tank is open, clean the underside of the lid (2) and examine the bottom ends of the tappets (43, 45, 46, 47) in the lid for wear or damage (see section 2.2 "Tappet Operation"). The ON/OFF tappets (45, 46) are secured by socket headed screws through their top collars, the TRIP and CLOSE tappets (43, 47) simply by the positioning of the operating levers above them. Also check that the gas vents (20) are clear by blowing through them.

7.47 When work in the tank is completed, close the lid and fasten it down. Check all fastenings on the tank top linkages and controls for tightness and examine the components for wear or distortion, (see sections 1.7 "Interlocks and Padlocking" and 2.2 "Tappet Operation"). Lubricate all bearings lightly (see section 7.8 "Lubricating Oil Specification"). Charge, close and trip the OCB several times (see section 6 "Routine Circuit Breaker Operation") to check the operation of controls and indication.

7.48 Should the OCB springs fail to latch at the end of the charging stroke, withdraw the moving portion, check that the earthing device interlock (44) is swung fully clear of the trip tappet (43) and interlock lever (42). Plug the moving portion back in, set the interlock knob (18) to SERVICE and try again. If the springs still fail to latch, the mechanism/arc trap assembly must be removed and replaced by a new unit. The faulty assembly must then be examined for worn, broken or distorted parts which must be replaced.

7.49 After an oil change a moving portion should preferably not be plugged into the fixed portion until the air bubbles have had time to rise, i.e. after an hour or so. However, this precaution is not essential where supplies must be quickly restored. If possible, operate the moving portion several times in the plugged-in service position to check the mechanical interconnection between fixed and moving portions and, where possible, employ any electrical close and trip circuits to check their operation.

7.5 Post-Fault Maintenance of Moving Portion

7.51 Due to the combination of features discussed in section 3 "Detailed Description of Arc Control System", electrode and contact burning and oil deterioration are minimal, even after fault operations. In service, a variety of factors will determine the necessity for post-fault maintenance, not least the magnitude of the fault or faults and the severity and number of normal operations since the last routine maintenance.

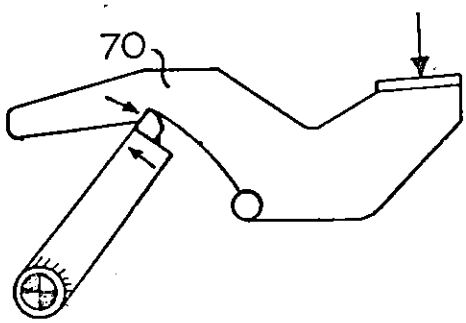
7.52 Post-fault maintenance will normally be identical to routine maintenance except that the oil will be changed and the contacts and tank linings will be more closely examined as a matter of course, whether or not there is obvious evidence of distress.

7.53 No naked light should be permitted in the vicinity of open tanks or in any situation in which switch oil is directly exposed to the atmosphere, due to the risk of fire. This precaution is particularly important during post fault maintenance.

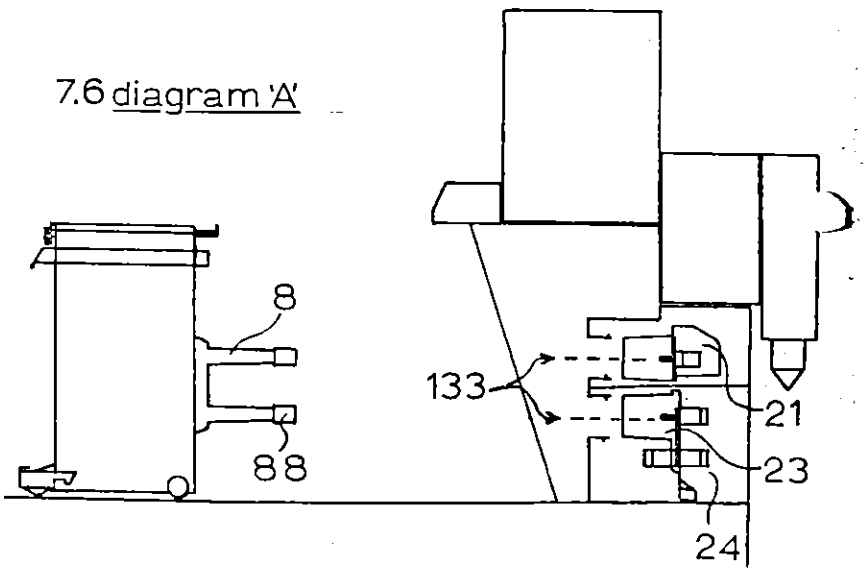
7.6 Isolating Contact & Insulation Maintenance

7.61 Remember, no attempt should be made to service the (male) fixed isolating contacts of a fixed portion, and no hand or tool should be inserted into the receptacle insulator orifices of a fixed portion until the associated busbars and feeder or feeders have been made DEAD, ISOLATED and locked from all points of supply, and EARTHED.

7.4 diagram 'C'



7.6 diagram 'A'



(a) Remove any solidified grease from the male and female contacts (88, 133) with the aid of inhibited 1.1.1 trichloroethane and a lint-free non-metallic non-synthetic cloth. Do not use any abrasive materials.

(b) Apply a thin uniform film of petroleum jelly "Vaseline" to the inside and outside surfaces of the female contacts (88) and to the male contacts (133) so that none is transferred to the epoxy insulation.

SO-HI SUPPLEMENT, MARCH 1983

YORKSHIRE SWITCHGEAR & ENGINEERING CO. LTD.

TYPE SO-HI OIL CIRCUIT-BREAKER SWITCHGEAR EQUIPMENT

Recommended Maintenance Procedure for Isolating Contact Assemblies

This recommended action is not a comprehensive maintenance procedure for Yorkshire Switchgear type SO-HI Oil Circuit-Breaker Equipment. It covers only routine maintenance work to be performed on the isolating contact assemblies.

CIRCUIT-BREAKER MOVING PORTION

Moulding Stem

1. Remove the isolating contact assemblies from the moulding by removal of the single M6 screw inside the cluster as shown in Drg. No. 8303BR. (M8 for 800A and 1200A sizes).

2. Remove any old grease and loose dirt from the stem ends with a rag and inspect. The radius at the end of the stem should be smooth and not suffer from severe dents or irregularities.

3. Using 3M's "Scotchbrite" very fine (red coloured) abrasive pad lightly abrade the entire surface area of each stem removing any hard baked oxide and corrosion deposits.

4. Apply an even layer of a recognised contact grease (e.g. Electrolube type 2G) over the radius at the end of the stem. The hole at the stem end should be lightly greased.

Contact Assemblies

5. Remove any old grease and loose dirt from either end of the contact assembly with a rag, and inspect. The seating areas of the fingers should be smooth and should not have dents or irregularities at either end of the contact, otherwise the entire assembly should be replaced.

6. Using the abrasive pad lightly abrade the contact areas of the fingers at both ends of the assembly.

7. Apply an even layer of the contact grease over the contact areas which have been cleaned.

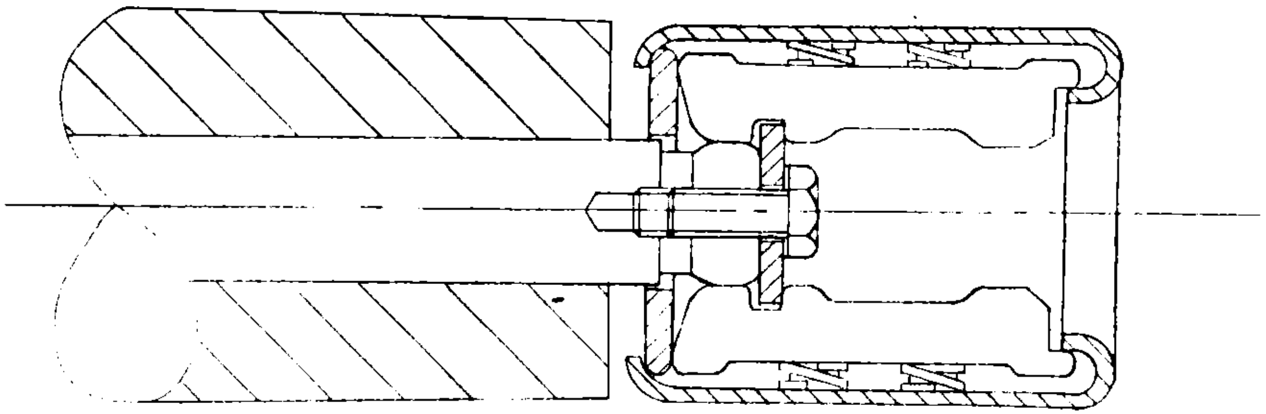
CIRCUIT-BREAKER FIXED PORTION

CAUTION: ENSURE THAT THE FIXED PORTION BUSBARS AND FEEDER CABLE ARE DEAD, ISOLATED AT EVERY POSSIBLE SOURCE OF SUPPLY AND SUITABLY EARTHED BEFORE EXAMINING THE CONTACTS.

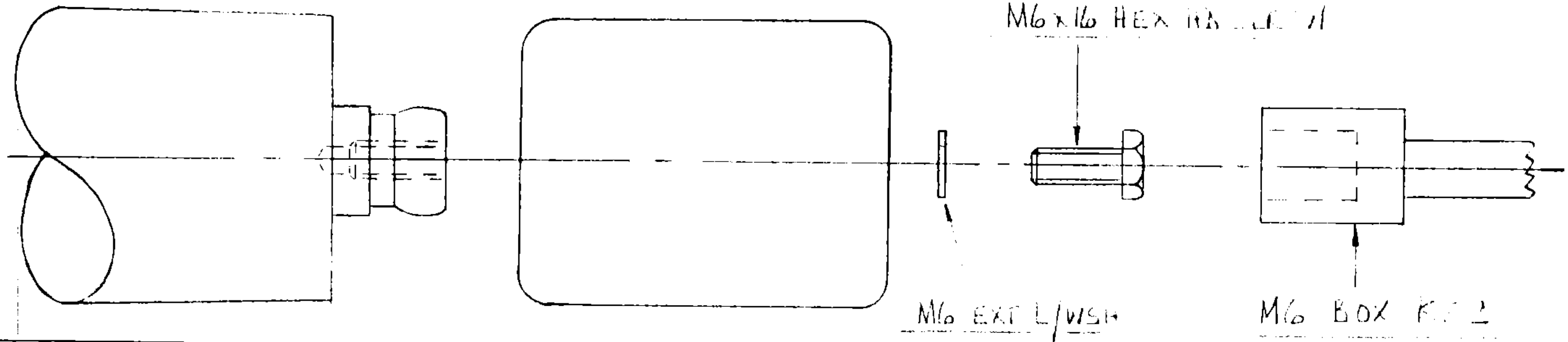
Isolating Contact Plug

8. Where corrosion is found on contact assemblies and moulding stems it is likely that there will be deposits on the plug contact on the fixed portion of a unit. Unless the deposits are heavy it is unlikely that the performance will be impaired.

   Isolation and replacement of the moving portion several times during maintenance will itself, to some extent, result in cleaning of the plug contact. However, the contact system may be further improved by cleaning the plug with "Scotchbrite" and smearing with contact grease.



ISOLATING PLUG ASSEMBLED ONTO STEM



REV	APPROVED	DATE	REV	APPROVED	DATE

GENERAL TOLERANCES (EXCEPT WHERE STATED) — DIMENSIONS IN WHOLE MMS UP TO 500 MM ± 0.5 ABOVE 500 ± 1.0; DIMENSIONS INCLUDING TWO DECIMAL PLACES ± 0.15

ALL DIMENSIONS IN MILLIMETRES — ALL SYMBOLS ISO — REFERENCE — SCALE — ISSUE

TITLE: 630A ISOL PLUG ASSY.

DRAWN — DATE — APPROVED — DATE 16.8.83 — TRACED — DATE

©

CODE No A4 8303.BR.

YORKSHIRE SWITCHGEAR
LEEDS ENGLAND

(c) Clean all accessible insulator surfaces, including fixed portion mouldings (21, 23) and busbars (24) using inhibited 1.1.1 trichloroethane and a lint-free, non-metallic, non-synthetic cloth. Provided that the insulator is dry and has been cleaned effectively, a surface resistivity of not less than 40,000 M-ohms will be obtained. Inspect the insulators for signs of damage (minor surface scratches are unimportant).

7.62 NOTES: (a) Inhibited 1.1.1 trichloroethane may be obtained commercially as:

(i)	Genklene	(made by I.C.I. Ltd.)
(ii)	Inhibisol or Chlorethene NU	(made by the Penetone Co. Ltd., Bassington Industrial Estate, Cramlington, Northumberland).

(b) Surface resistivity has dimensions of resistance only. It is the resistance across the opposite sides of a square of insulation surface of any size. For a typical receptacle or bushing insulator, the surface circumference and length are approximately equal. Hence the resistance between the contact and a ring placed near the flange may be expected to be of the order of 40,000 megohms.

(c) Should insulator damage be found, remove unit from service and inform Yorkshire Switchgear.

7.63 All of the foregoing (sections 7.61 and 7.62) applies equally to the male and female contacts of earthing and testing devices.

7.7 Switch Oil Sampling and Testing

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

7.72 First, remove a sample of oil for testing. Use a pipette-type 'thief' tube, keeping the upper end sealed 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, 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 OCB moving portion. The oil may be tested on site if facilities are available, or at a central laboratory.

7.73 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 re-conditioned or discarded.

7.74 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^{o}-25^{o}C) and the voltage across the sphere electrodes is gradually raised to 30kV, 25-100 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.

7.75 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 present of moisture and the failure of the sample. Two tests out of three should be successful if the oil is to be passed as suitable.

7.76 The presence of dissolved sludge can 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.

7.77 Should the oil need to be replaced, clean the tank and mechanism/arc trap assembly and refill with clean oil, observing the precautions detailed under 5.3 "Oil Filling of Switchgear".

7.78 Whilst the tank is empty, check the tank linings for signs of damp, delamination, burning or other damage. Replace if necessary.

7.79 Top up the oil to the marked level with the mechanism 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.

7.8 Lubricating Oil Specification

7.81 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, consult our Head Office.

7.82 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.

.9 Main Circuit Resistance Measurement and Opening & Closing Time Tolerances

.91 Due to the use of separate main and arcing contact systems in Caton Arc Trap circuit breakers, any contact erosion is confined to the arcing electrodes and thus has a negligible effect on the overall, closed-contact, circuit resistance.

.92 A routine visual inspection (see Sections 7.4 "Routine Maintenance of Moving Portion" and 7.5 "Post-Fault Maintenance of Moving Portion") is of far more use in determining contact erosion which is almost invariably so slight as to require nothing more serious than trimming with a file.

.93 However, if suitable equipment is available, a resistance test may be applied across the upper and lower moving main isolating contacts: the value should not exceed 150μΩ per phase.

.94 Due to the design of the "SO-HI" moving portion, it is virtually impossible to determine the mechanism closing speed of an operational circuit breaker in the substation.

.95 The determination of the opening time is also difficult without the use of sophisticated test devices which are not normally available to maintenance teams.

.96 For these reasons we do not recommend the measurement of operating speeds and times as a useful or significant part of routine test procedures.

8. SPARES & TOOLS

8.1 Spare Parts

8.11 As discussed elsewhere in this manual, service experience with earlier designs of Arc Trap circuit breaker, coupled with extensive certification and endurance tests, have shown that the need for the replacement of any part of a "SO-HI" circuit breaker 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-HI DCB moving portion, serial No. 070014, 11000 V insulation, 6.6/11kV service, 400A, 3ph., 50 Hz, 250/350 MVA.

Rotating interlock bolt, key No. 40, as illustrated in 1.7/2.2 diagram 'A'.

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 Special Tools

8.21 The only special tool required is the knuckle toggle collapsing tool (167) whose use is described in paragraph 7.45.

8.22 At the time of writing this manual, the Company is involved in a programme of metrication of fasteners. Both Imperial and Metric fastener and spanner sizes are therefore quoted.

8.23 Open-ended and ring spanners:

Imperial:	4BA	2BA	0BA	1/4 in	5/16 in	3/8 in	1/2 in	5/8 in
Metric dia.:	M4	M5	M6	M6	M8	M10	M12	M16
Metric A/F:	7 mm	8 mm	10 mm	10 mm	13 mm	17 mm	19 mm	24 mm

8.24 "Allen key" -type socket wrenches: 3/32 in A/F or 2.55 A/F.

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

9. KEY TO ILLUSTRATIONS (SO-HI Circuit Breaker Unit)

1. Oil circuit breaker tank
2. Hinged OCB tank lid
3. Removable mechanism/OCB moving contacts assembly
4. Charging handle socket
5. Removable OCB charging handle
6. Caton arc traps (moving contact systems)
7. OCB fixed main and arcing contact carriers
8. Cast resin tank bushing moulding
9. Foot operated service lock treadle
10. Hinged cover over operating coils and auxiliary switches
11. Control, metering and indication fuses
12. Handles for withdrawal of voltage transformer primary fuses
13. Cover for voltage transformer secondary fuses
14. Panel for electrical meters and controls
15. Voltage transformer housing
16. Relay cabinet door
17. Cable box
18. Interlock knob
19. Current transformer chamber
20. OCB tank vent tubes
21. Cast resin circuit insulator and support
22. Earth bar
23. Cast resin busbar insulator and support
24. Insulation coated busbars
25. Busbar chamber
26. Automatic safety shutters (shown open), (a) feeder, (b) busbars
27. Moving portion in partially withdrawn position
28. Multicore cable fittings
29. Internally mounted relays
30. Power mechanism accommodation
31. Manual close lever
32. Manual trip lever
33. (a) ON/OFF and (b) SPRINGS CHARGED indication
34. Closing spring release coil
35. Trip coil
36. Interlock rod
37. ON/OFF indicator drive rocker
38. Interlock plate
39. Interlock knob shaft
40. Rotating interlock bolt
41. Interlock projection on (39)
42. Interlock lever
43. OCB trip tappet
44. Earthing device anti-tripping interlock
45. "ON" indication tappet
46. "OFF" indication tappet
47. OCB close tappet
48. Mechanism/arc trap assembly main frame
49. Fixed portion master plate
50. Fixed portion busbar chamber with extendec sidewalls
51. Charging handle socket shaft
52. Crank pin on (51)
53. Transmission lever on cam assembly
54. Welded drive block on (53)
55. Driven lever at right hand end of (56)
56. Mechanism main shaft
57. Upper (closing) springs charging lever
58. Lower (opening) springs charging levers
59. Closing springs
60. Opening springs
61. Mechanism main catch
62. Main catch roller
63. Nudging plate (on cam assembly)
64. Pin mounted on (65)
65. Knuckle toggle roller lever
66. Cam roller on (65)
67. Charging mechanism cam
68. Knuckle toggle shaft
69. Knuckle toggles
70. Closing springs release catch
71. Mechanism hold back catch
72. Main closing levers
73. Arc trap operating links
74. Stop limiting travel of (53)
75. Closing lever stop pads
76. Mechanism trip lever
77. OCB fixed main contacts
78. OCB fixed arcing electrodes
79. Arc trap moving arcing contact
80. Arc trap vulcanized fibre laminations
81. Arc trap synthetic resin bonded paper side walls
82. Arc trap carrier arms
83. Arc trap moving main contacts
84. Moulded arc trap/carrier arm (half)
85. Arc trap bottom clamps
86. Arc trap top clamps
87. Tank lid securing screws
88. Moving isolating contacts (a) feeder, (b) busbars
89. Fixed portion floor plate
90. Fixed portion earthing device locating angles

91. Fixed portion busbar chamber backplate
92. Fixed portion front shutter assemblies mounting plate
93. Foundation anchor bolts.
94. Fixed portion floor plate sidewall securing studs
95. Anti-vermin sealing strips
96. Busbar end plate
97. Busbar securing studs
98. Busbar tee-off connection plates
99. Busbar fishplate spacers
100. Busbar joint box
101. Busbar joint box neoprene end piece
    101(a) Single type for 800A busbars
    101(b) Double type for 1250A busbars
    101(c) Double type for 2000A busbars
    101(d) Single blank type for end panel
102. Busbar packer for use on end panels
103. Busbar joint box cover
104. Bushing connection chamber plate
105. Current transformer bushings
106. Metal contact pads for (105)
107. Motor coupling drive disc
108. Spacing washer
109. Motor coupling floating drive arm
110. Cable channel
111. Switch mounting plate
112. Tappet switch operated by (47)
113. Rocker switch operated by (37)
114. Motor switch operated by (107)
115. Motor control relay
116. Rectifier in motor supply
117. Spring charging motor
118. Jumper socket mounting bracket on (49)
119. Jumper socket on (188)
120. Jumper plug for (189)
121. Pilot cable
122. Main cable box back plate on (17)
123. Cable sockets in (17)
124. Cable box bottom plate on (17)
125. Gasket for (126)
126. Gland for main cable (127)
127. Main cable
128. Filler aperture cover on (122)
129. Compound filler (optional extra)
130. Filler apertures in (122)
131. Filler aperture gasket
132. Locking bar for (26)
133. Fixed isolating contacts (a) feeder, (b) busbar
134. Forked mechanical interconnection lever
135. Anti-jump stops
136. Earthing/testing device
137. Contact clusters on (136)
138. Insulated spouts and contacts on (136)
139. Securing handle on (136)
140. Horizontal operating shaft on (136)
141. "U"-shaped brackets on (136)
142. Earthing contacts on OCB tank (1) sides
143. Tank securing claw cams on (136)
144. Earthing/testing device bosses on (1)
145. "BUSBAR EARTHING" interlock flap on (136)
146. Fixed portion securing hooks on (136)
147. Earthing/testing device pins on fixed portion sidewalls (50)
148. Star point contacts on (136)
149. Earth bars on fixed portion sidewalls
150. Auxiliary switches
151. Mechanism securing nuts
152. Mechanism lifting handles
153. Closing springs retaining bar
154. Closing spring block assemblies
155. Opening springs pin
156. Opening spring shafts
157. Closing spring shafts
158. Motor/gear box unit final drive shaft
159. Motor drive arm
160. Motor drive link
161. Handle socket drive arm
162. Cut out on (58)
163. Welded drive pin on (72)
164. 7mm (9/32 in.) dia. holes in fixed portion side sheet front edge
165. 11mm (7/16 in.) dia. hole in fixed portion side sheet
166. Protrusion for contact making/breaking on (89)
167. Knuckle toggle collapsing tool
169. Terminal block
170. Motor coupling driven arm or disc
171. Charging motor mounting studs
172. Charging motor packing strips
173. Motor unit baseplate
174. Drive crank on (51) inside tank
175. Spacing washer
176. Bearings for (51)
177. Unit-to-unit busbar cover plate
178. Motor unit electrical components mounting plate
179. Circuit breaker fixed portion Mk II baseplate
180. Removable front apron in front of (179)
181. Unistrut channels, section P3200
182. Floor chases to take (181)
183. Sprung nuts engaged in (181)
184. Tie bar jigs for (181)
185. Hex-headed screws to engage (183)
186. Wood screw to hold down (180)

SO-HI RECOMMENDED SPARES - 400 AMP

One or more, 3 phase set of fixed and moving arcing contacts, I.M. No. 78 and 79.
Code No. 510613900

Price f.o.b. U.K. Port.

One or more, 3 phase set of fixed and moving main contacts, I.M. No. 77 and 83.
Code No. 510613600

Price f.o.b. U.K. Port.

One or more, 3 phase set of arc traps, I.M. No. 6.
Code No. 510613000

Price f.o.b. U.K. Port.

ALTERNATIVELY

One or more, 3 phase set of arc traps and mechanism complete assy, I.M. No. 3.
Code No. 510615700

Price f.o.b. U.K. Port.

One or more, O.C.B. 6 pole moulding, I.M. No. 8.
Code No. 111060100

Price f.o.b. U.K. Port.

One or more, flexible isolating plug cluster, I.M. No. 88.
Code No. 1PS02108S01A0.

Price f.o.b. U.K. Port.

One or more, trip and closing coils, I.M. No. 34 and 3 .
Trip Coil Code No.
Closing Coil Code No.

Price f.o.b. U.K. Port.

One or more, 3 phase resin circuit moulding, I.M. No. 21.
Code No. 112063500

Price f.o.b. U.K. Port.

One or more, 3 phase resin busbar moulding, I.M. No. 23.
Code No. 112060100

Price f.o.b. U.K. Port.

SO-HI RECOMMENDED SPARES - 800 AMP

One or more, 3 phase set of fixed and moving arcing contacts, I.M. No. 78 and 79.
Code No. 510613900

Price f.o.b. U.K. Port.

One or more, 3 phase set of fixed and moving main contacts, I.M. No. 77 and 83.
Code No. 510613600

Price f.o.b. U.K. Port.

One or more, 3 phase set of arc traps, I.M. No. 6.
Code No. 5110613000

Price f.o.b. U.K. Port.

ALTERNATIVELY

One or more, 3 phase set of arc traps and mechanism complete assy, I.M. No. 3.
Code No. 510615700

Price f.o.b. U.K. Port.

One or more, O.C.B. 6 pole moulding, I.M. No. 8.
Code No. 111060200

Price f.o.b. U.K. Port.

One or more, flexible isolating plug cluster, I.M. No. 88.
Code No. 1PS02108S02A0.

Price f.o.b. U.K. Port.

One or more, trip and closing coils, I.M. No. 34 and 3 .
Trip Coil Code No.
Closing Coil Code No.

Price f.o.b. U.K. Port.

One or more, 3 phase resin circuit moulding, I.M. No. 21.
Code No. 112063600

Price f.o.b. U.K. Port.

One or more, 3 phase resin busbar moulding, I.M. No. 23.
Code No. 112060200

Price f.o.b. U.K. Port.