Design Philosophy

The first of the modern range of Ferranti high speed resistor transition tap changers appeared in 1958, following some three years of development work. It succeeded the comprehensive range of reactor transition tap changers produced by the Company for many years, which were famous for their reliable, sturdy construction.

Two major factors dictated the change from reactor to resistor transition: the importance of minimum size as transformer ratings increased and land for new substations became more difficult to obtain, and the great reduction in contact wear obtainable by breaking a resistive rather than a reactive load. To take the fullest advantage of the opportunities offered by this new idea, the Company decided to 'start again' with its tap changer range, re-thinking the requirements from the very beginning.

Analysis of figures obtained in collaboration with supply authorities showed clearly that, in all types of tap changer, control circuits formed the 'weak link' in the system. They required frequent maintenance and accounted for the overwhelming majority of faults on supply systems. Simplification of this circuitry was therefore considered to be the first priority.

Working in collaboration with motor manufacturers, a new single, split phase capacitor start and run driving motor was developed. This provides a unit of the highest dependability with characteristics of low starting and stalling currents, and capable of being stalled continuously without harm. In addition to the obvious simplification of the change from a three to a single phase control, this low current characteristic means that complicated protective relays are eliminated and a simple re-wireable fuse covers all requirements. In addition, the automatically controlled tap changer can be switched direct from the contact of the voltage control relay without the need for interposing relays.

By making the motor suitable for oil immersion and running it, and its gearing, totally immersed in standard transformer oil, the need for special lubrication is eliminated, saving both maintenance and the need for the stock of special lubricant. The frictional resistance provided by the oil is sufficient to bring the mechanism to a stop and mechanical or electrical braking is unnecessary. So eliminating another common cause of maintenance trouble.

The timing gear needed for indication and to ensure correct sequence of operation is mechanically coupled direct to the switch and therefore mirrors its actions exactly. Here again the policy is to provide a structure and electrical contacts capable of lasting the lifetime of the associated transformer without attention. The whole of this gear is also immersed in transformer oil to seal the contacts from atmospheric dust or chemical pollution so that regular contact cleaning is not required. The timing and driving gears are in all cases sealed in separate compartments isolated from the main load carrying switches. All prototype timing gears are proved capable of upwards of one million operations without appreciable mechanical deterioration.

The main switch structures are all of rugged construction designed to meet any electrical and mechanical stresses to which they may be subjected. To minimise maintenance requirements the useful contact life is obviously of primary importance. The main current carrying contacts, which do not break load and are therefore subject to frictional wear only, are large relative to the current carried and of high conductivity copper to prevent over heating. These will not normally require attention throughout the working life of the switch. The transitional contacts break on load however and are therefore subject to some arcing erosion. High speed operation and the rapid arc quenching obtained with a resistive load of high power factor gives a considerable improvement but it still left a maintenance requirement incompatible with the rest of the mechanism. The circular transitional contact was thus developed. This automatically indexes round as it makes contact, so that each successive arc is struck from a different surface and the contact erosion is spread over the entire surface of the contact. The useful contact life is increased many times by this type of design.

All switches carrying load are immersed in transformer oil and isolated both from the transformer and other tap changer compartments. This oil will, of course, become contaminated due to the arcing on the transitional contacts and will require renewal at the recommended intervals. Drain and filter valves are fitted to facilitate this operation.

Throughout the range, close attention has been paid to keeping the tap changer to the minimum size compatible with the highest degree of reliability. Normal maintenance has been reduced to routine oil changes and occasional inspection of the various component parts. Attention has nevertheless been paid to accessibility and all parts are convenient to inspect and can be replaced easily and quickly, if required.

FERRANTI

Tap Changers

Series EFGH General Description

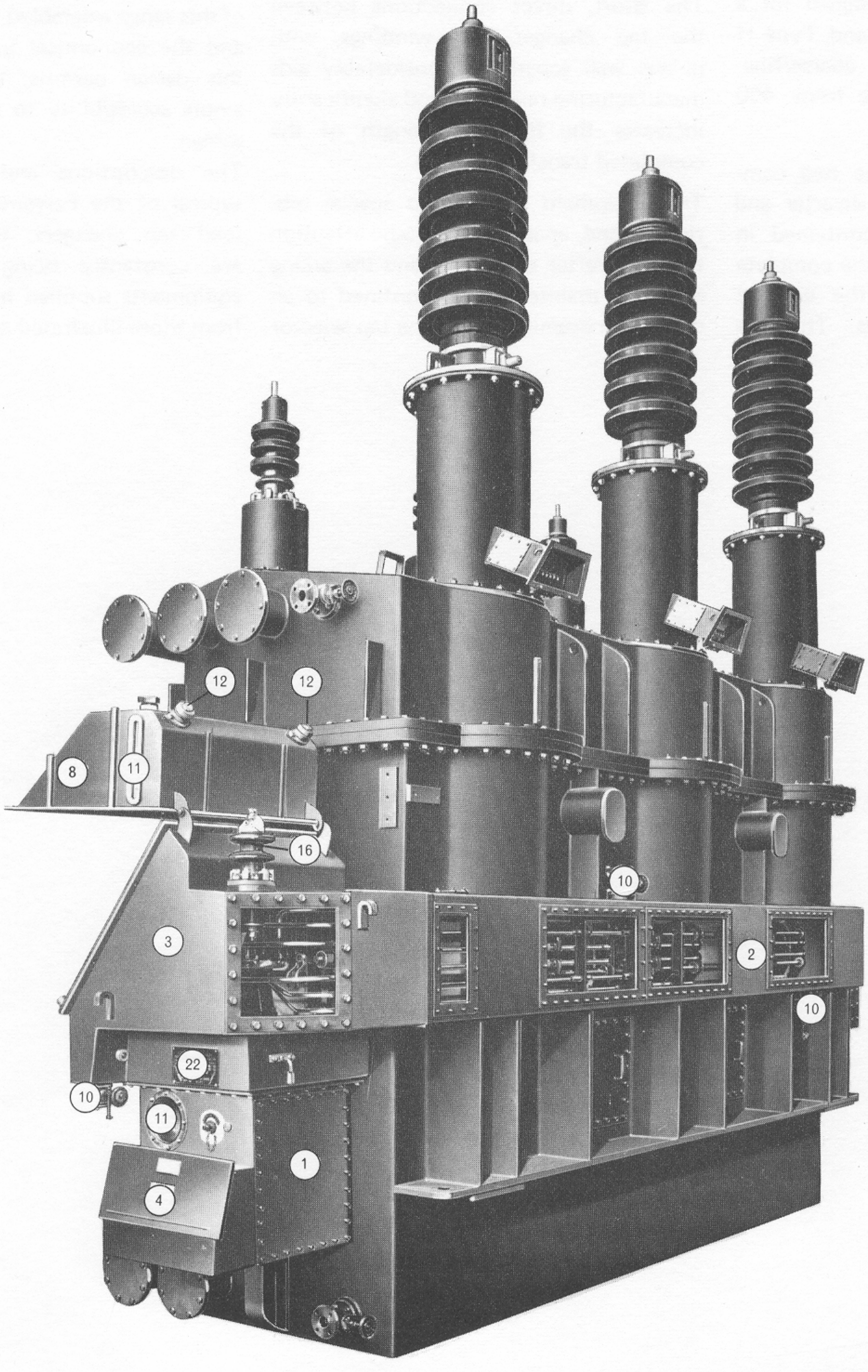

Fig.1 General view of 60 MVA, 132 kV, Transformer fitted with Series EFGH Tap Change Equipment (covers removed)

1 Driving motor and timing gear compartment
2 Tap selector switch compartment
3 Diverter switch compartment
4 Terminal and cable entry compartment
8 Hinged and bolted cover for diverter switch compartment
10 Drain and filter valve
11 Oil level indicator
12 Air release valve or breather
22 Instruction plate
61 Neutral point terminal

This is a range of high speed, resistor transition on load tap changers for operation at the earthed neutral end of star-connected transformers. These tap changers are normally for use on system voltages from 66 kV to 440 kV but can be used on other system voltages or on systems where the neutral is insulated, provided the working and test voltages are kept within agreed limits.

Types E, F and G are designed for a linear tapping arrangement and Type H provides for reversing and coarse/fine. Nominal current ratings are from 400 amps to 2000 amps.

The tap changers are of the two compartment type, that is the diverter and tap selector switches are contained in separate compartments and the complete series is characterised by the unusual arrangement of these units. The tap selector switches are mounted on the side of the transformer tank, each one exactly opposite its respective winding, in a compartment which stretches the whole length of the transformer tank.

The diverter switch compartment (with the driving motor/timing mechanism compartment bolted to it as a combined unit) can be bolted to either end of the tap selector switch compartment.

The short, direct connections between the tap changer and windings, with phases well separated, considerably aids manufacturing reliability and significantly increases the impulse strength of the completed transformer unit.

The equipment requires no special lubrication and, apart from periodic attention to the diverter switch oil and the arcing contacts, maintenance is confined to an occasional examination of the tap selector switches. On the mechanical construction of the tap changers, a run of over 1,000,000 operations was carried out to show that mechanical wear can be neglected during the life of a transformer. The simple but robust construction of the equipment ensures reliable service under the most arduous conditions occuring during the operation of modern electrical power systems.

Figure 1 illustrates a typical tap changer of this range assembled to the transformer and the economical use of space which this design permits, together with the ample accessibility to all parts, is clearly shown.

The descriptions and illustrations are typical of the Ferranti Series EFGH on load tap changers, but improvements are constantly being introduced, and equipments supplied may differ in detail from those illustrated and described.

Series EFGH Driving Motor/ Timing Gear Compartment

This compartment, which is bolted to the underside of the diverter switch compartment and separated from it by a barrier panel, is shown in illustrations Figures 2, 3 and 4.

The control terminal and cable entry part of the compartment contains no oil and connections to the timing gear are made by means of oil-tight terminals mounted on a barrier panel. The main compartment is oil filled and is provided with drain and filter valves, oil level indicator and air release valve.

The driving motor is fixed to a mounting plate which can be adjusted for alignment and the drive is taken through an 'Oldham' coupling to the reduction gear unit. This reduction gear train is illustrated schematically in Figure 5. The worm wheel shaft is extended to accommodate the operating handle which is inserted by removing a screwed plug in the side of the compartment. The operating handle cannot engage with the drive shaft until the auto isolator switch knob is turned to open the switch and so cut-off the supply to the motor. This avoids any possibility of the motor starting whilst the gear is being operated manually. A plate fixed to the compartment side indicates the direction of rotation of the handle and the instruction plate fixed to the side of the diverter switch compartment directly above the handle gives the number of turns necessary for one tap change.

The drive shaft is also extended in the opposite direction to accommodate the mechanical end stop. Figures 6 and 7 show the detailed arrangement and method of operation of this item which is accurately set during the assembly of the tap changer. If the mechanical end stop operates as a result of the motor over-running, the drive can be stalled from full speed without damage.

The main drive shaft passes through the motor compartment into a pocket in the base of the diverter switch compartment. Double oil seals prevent any leakage of oil from the diverter switch compartment into the motor compartment. Tests have

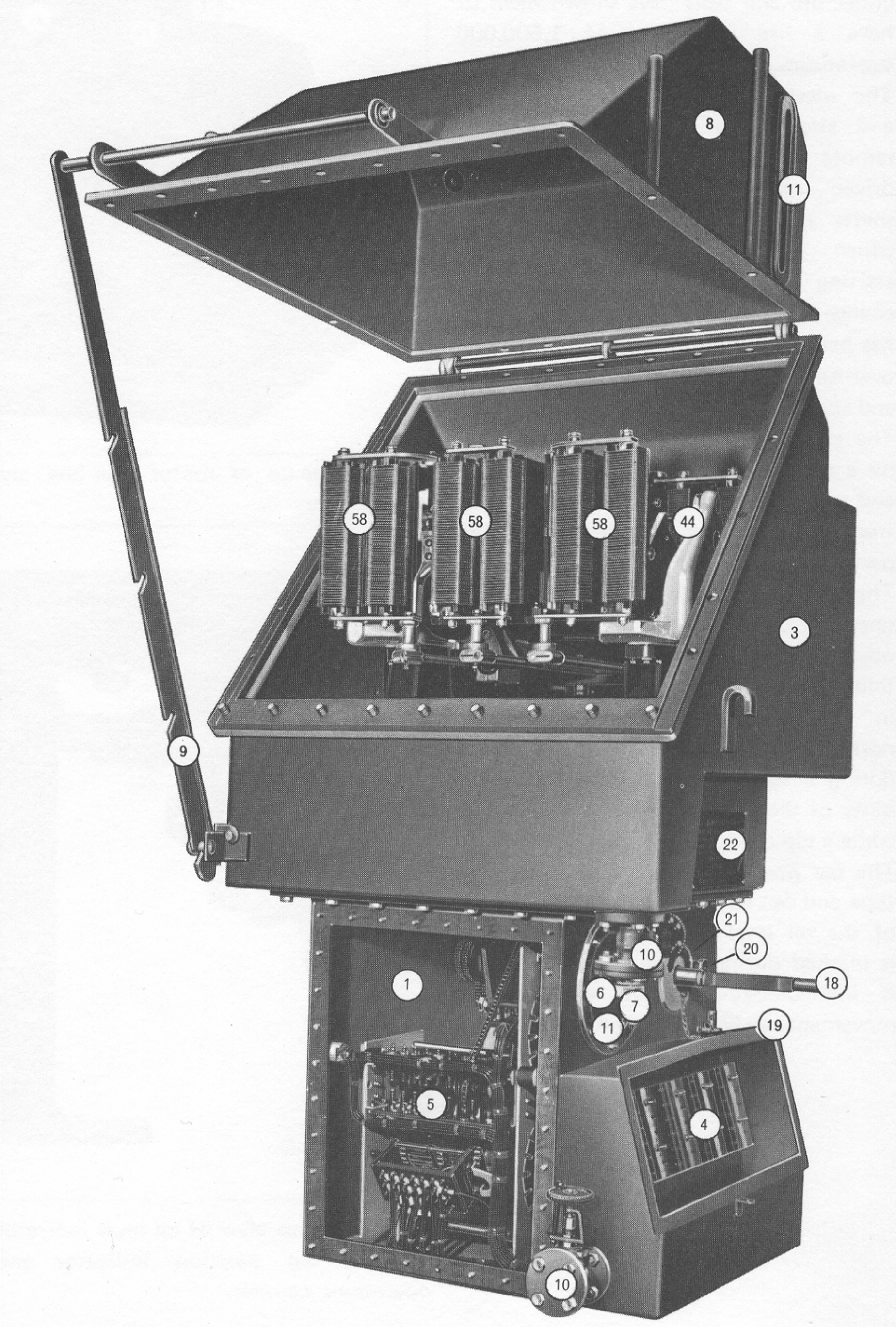

Fig.2 General view of motor gear-box and diverter switch compartment

1	Driving motor and timing gear compartment	10	Drain valve
3	Diverter switch compartment	11	Oil level indicator
4	Terminal and cable entry compartment	18	Hand operation handle
5	Timing gear	19	Hand operation screwed plug
6	Tap position indicator	20	Auto-isolator switch knob
7	Operations counter	21	Direction of rotation plate
8	Hinged and bolted cover for diverter switch compartment	22	Instruction plate
9	Stay and safety catch for diverter switch cover	44	Diverter switch
		58	Diverter switch bridging resistor

shown that these oil seals will withstand transformer oil throughout the life of the equipment.

The timing gear is shown in detail in Figures 8 and 9 and is chain driven from a pinion on the main drive shaft.

Each complete sequence of a tap change is timed by means of cam shafts which control all switching operations. The switches are of the open type operating under oil, and tests have shown them to have a life in excess of 1,000,000 operations.

The mechanical tap position indicator and step switch (which operates the remote tap position indicator) are both driven from the cam shafts. The cam shafts also operate the limit switches which are connected in the motor starting circuit to prevent another tap change being initiated after the end step has been reached, and also to prevent the over-run of the motor into the mechanical end stop.

The step switches, which are protected by a perspex cover, are of a rotary type and are specially designed to give trouble-free operation over long periods in this particular application.

The change-over or sense contacts are operated by the cam shaft through the operating arm. These contacts ensure that the tap changer continues to operate in the appropriate direction, and a normally closed contact which opens during a tap change prevents any possibility of the driving motor being reversed while a tap change is in progress.

The tap position indicator is of the disc type and can be seen through the window of the oil level indicator. The indicator is masked during a tap change so that it is immediately apparent whether the movement has been completed or not.

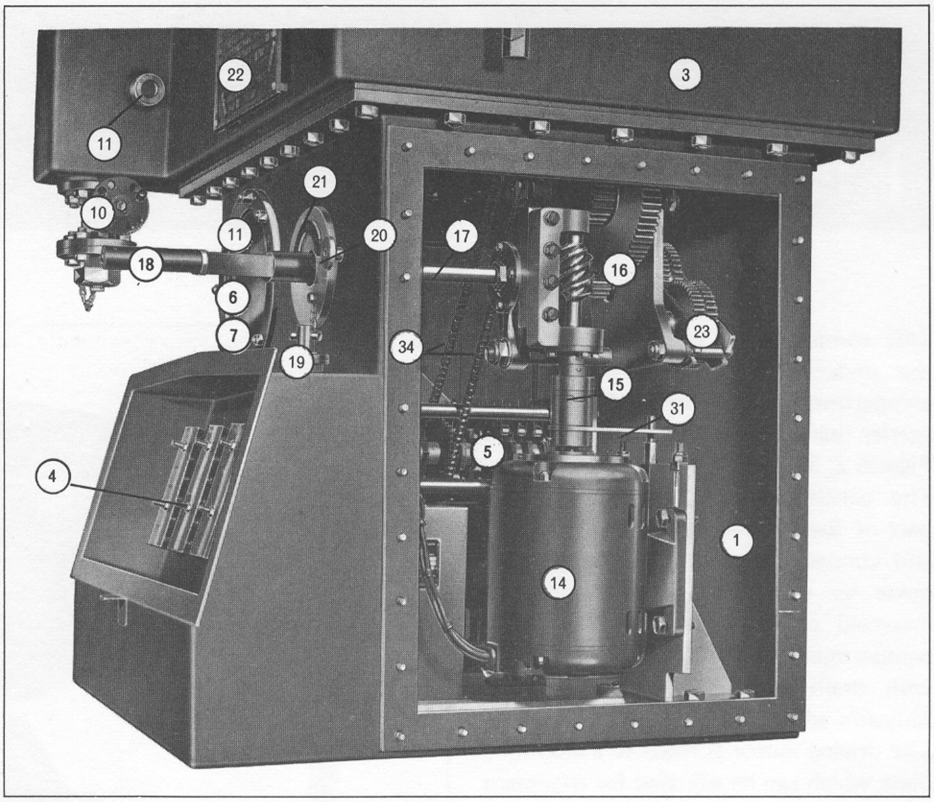

Fig.3 Close-up of motor gear-box and timing gear

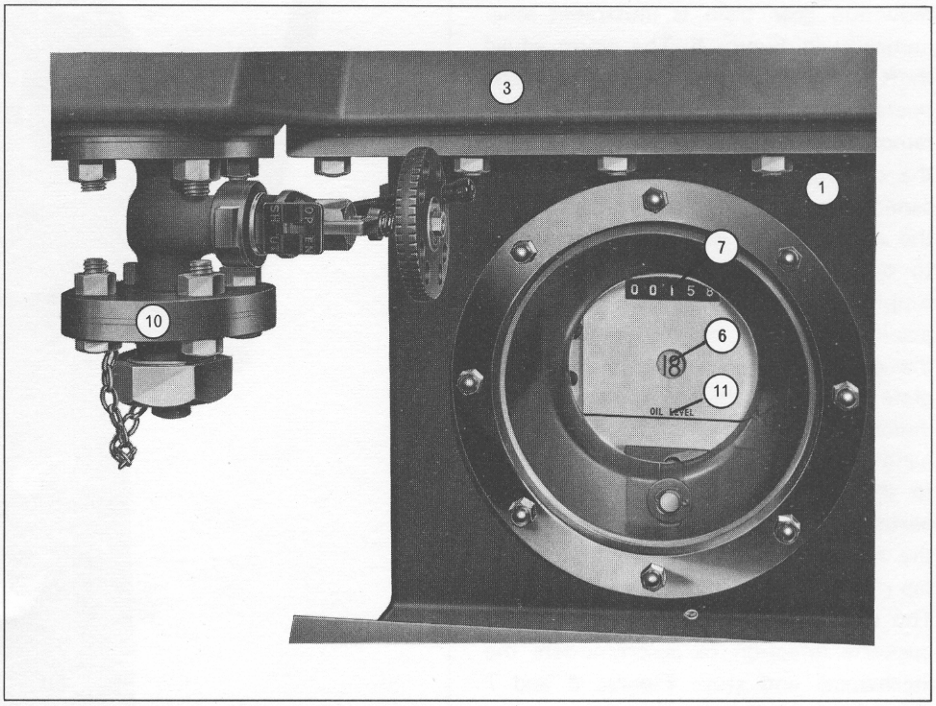

Fig.4 Close-up view of oil level indicator showing tap position indicator and operations counter

1	Driving motor and timing gear compartment	16	Reduction gear unit
3	Diverter switch compartment	17	Worm wheel shaft
4	Terminal and cable entry compartment	18	Hand operation handle
5	Timing gear	19	Hand operation screwed plug
6	Tap position indicator	20	Auto-isolator switch knob
7	Operations counter	21	Direction of rotation plate
10	Drain and filter valve	22	Instruction plate
11	Oil level indicator	23	Mechanical end stop
14	Driving motor	31	Motor damping device
15	'Oldham' type motor coupling	34	Timing gear driving chain

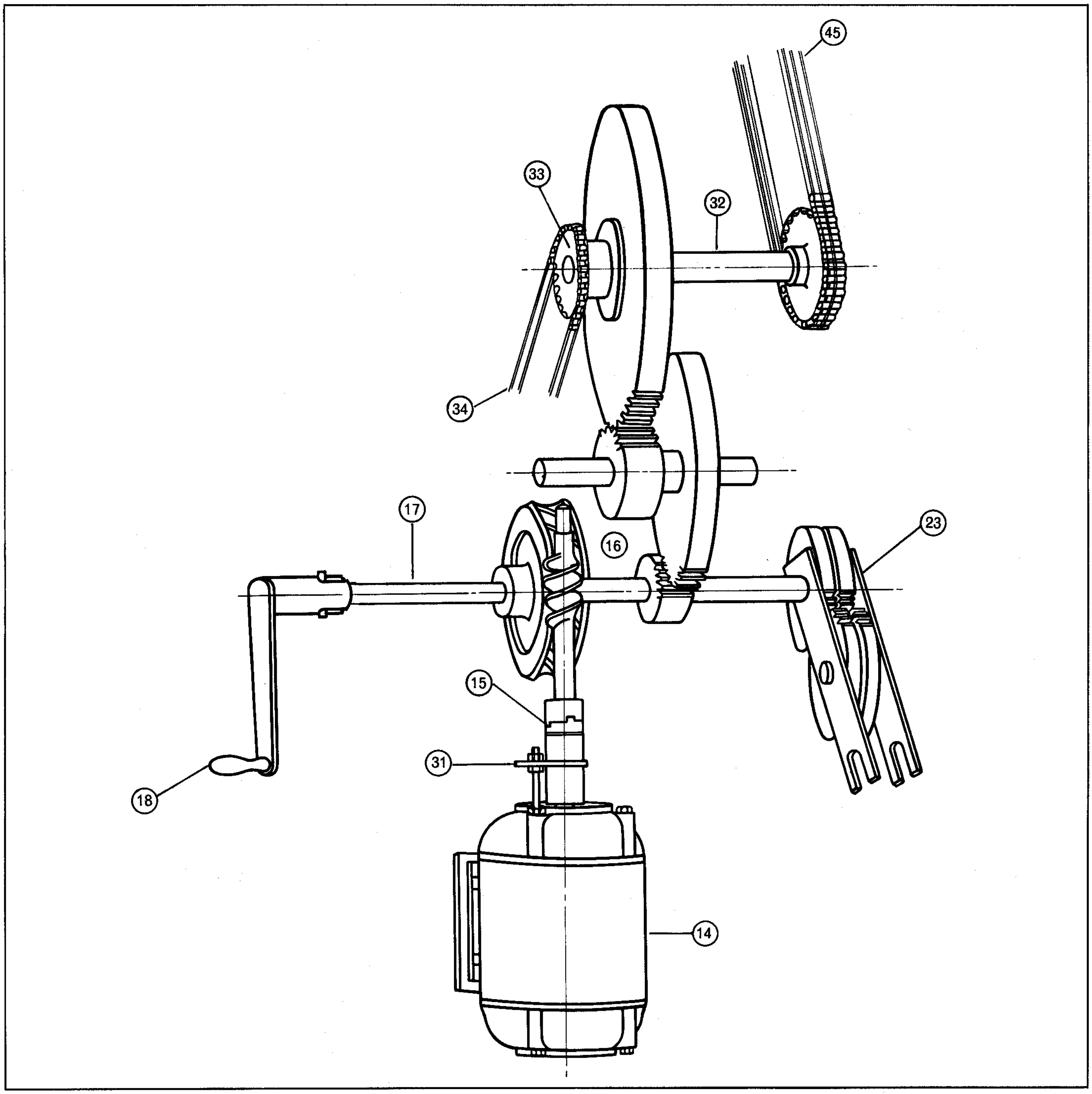

Fig.5 Schematic drawing of driving gear train

14 Driving motor
15 'Oldham' type motor coupling
16 Reduction gear unit
17 Worm wheel shaft
18 Hand operation handle
23 Mechanical end stop
32 Main drive shaft
33 Timing gear drive pinion
34 Timing gear driving chain
45 Driving chain

Fig.6 Exploded view of mechanical end stop

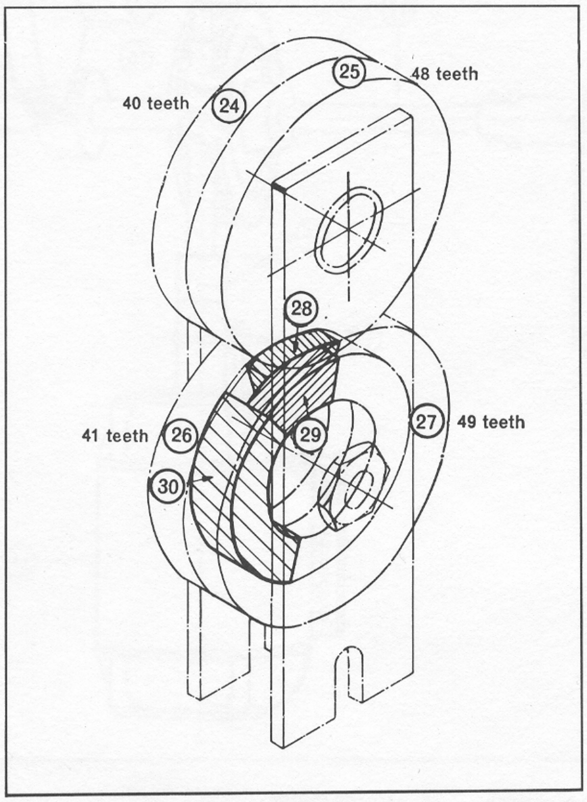

Fig.7 Schematic diagram of mechanical end stop

24, 25, 26, 27 } Mechanical stop pinions
28, 29 } Mechanical stop fixed segments
30 Mechanical stop sliding segment

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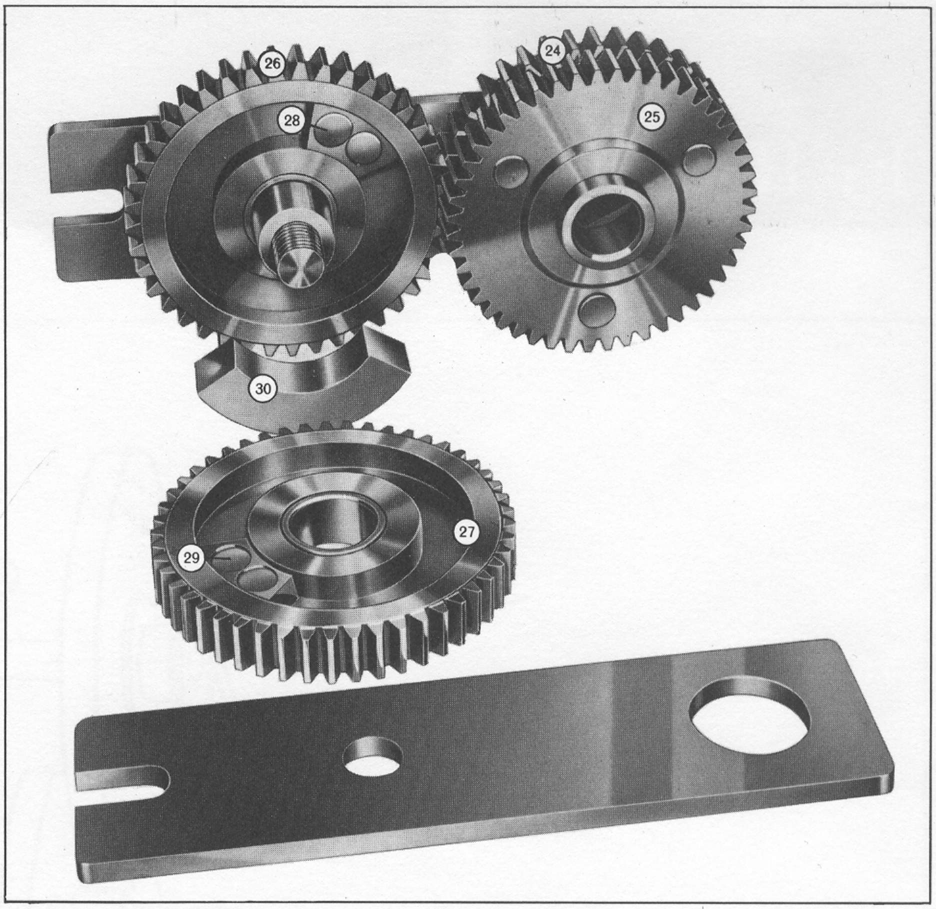

Fig.6 Exploded view of mechanical end stop

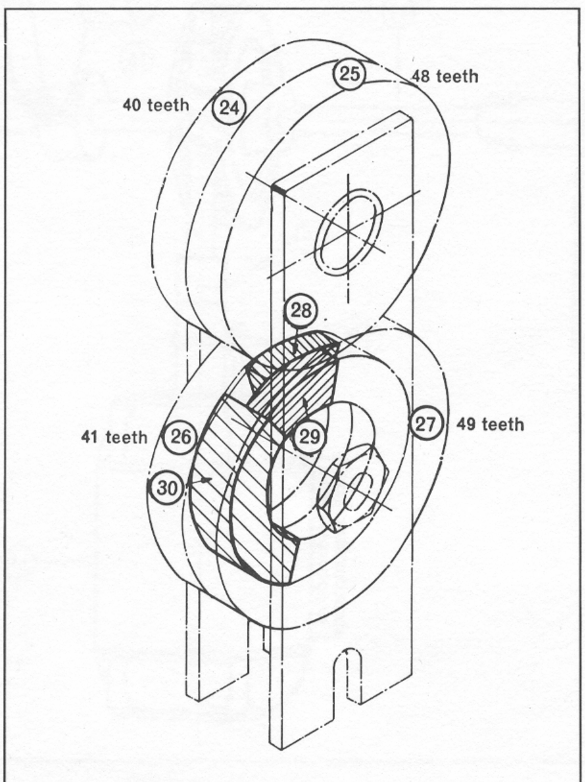

Fig.7 Schematic diagram of mechanical end stop

24, 25, 26, 27 — Mechanical stop pinions

28, 29 — Mechanical stop fixed segments

30 Mechanical stop sliding segment

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Tap Changers

Series EFGH Driving Motor/ Timing Gear Compartment

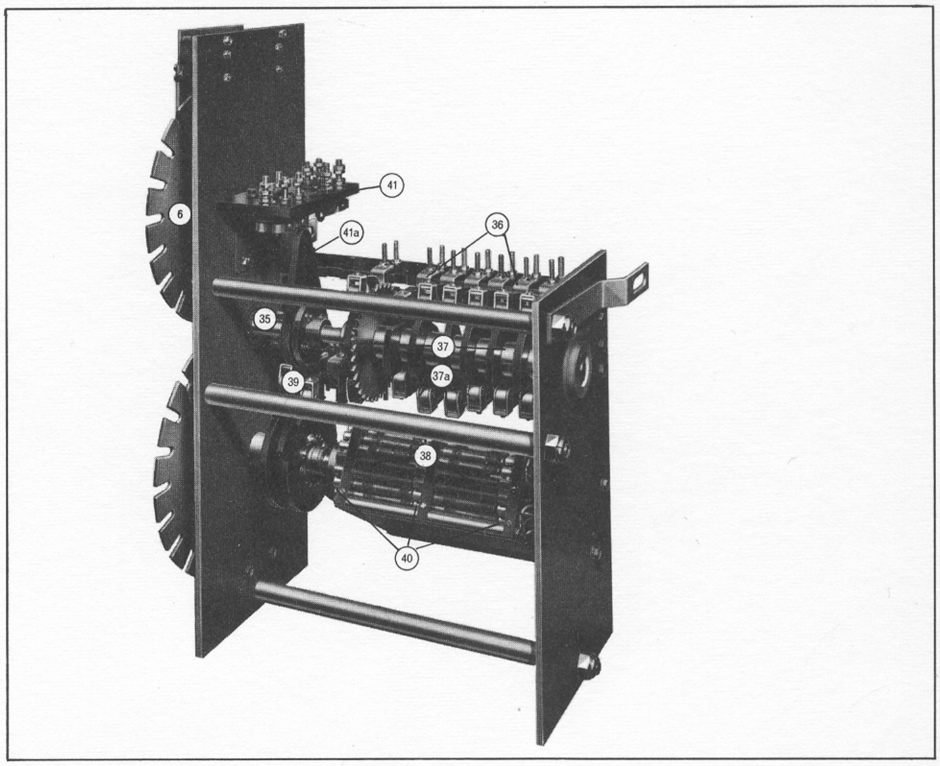

Fig.8 Close-up of timing gear right-hand side

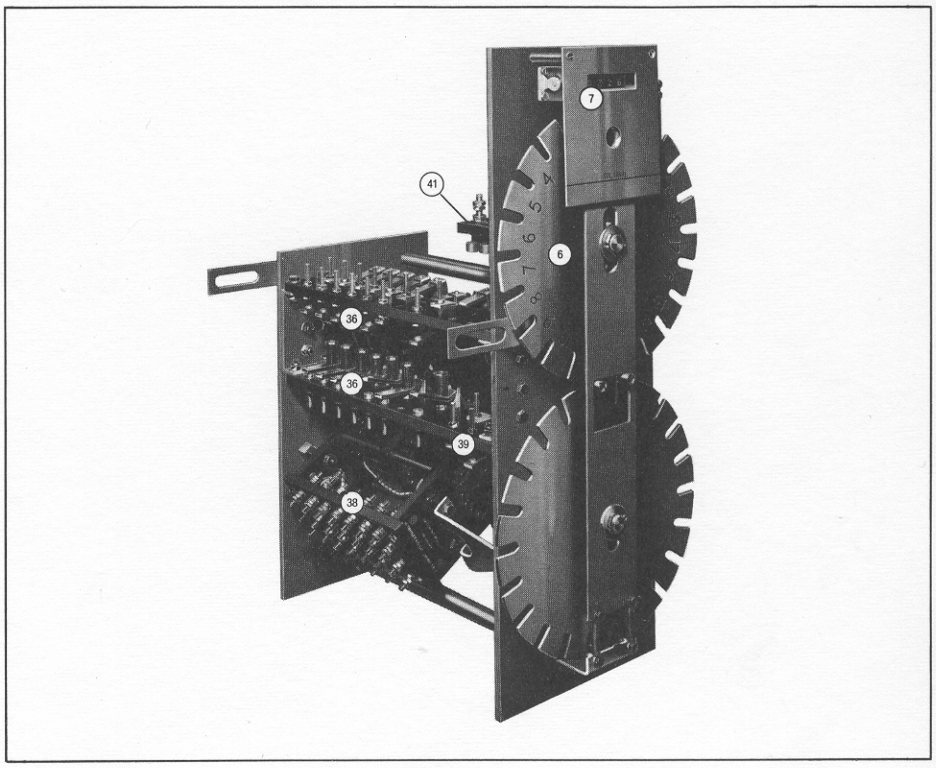

Fig.9 Close-up of timing gear left-hand side

6 Tap position indicator
7 Operations counter
35 Timing gear camshaft
36 Timing gear contacts
37 Timing gear cams
37a Timing gear switch rollers
38 Step switch
39 Limit switch contacts
40 Perspex cover for step switch
41 Changeover directional and sense contacts
41a Directional switch operating arm

Series EFGH Diverter Switch Compartment

A general view of the compartment is shown in Figure 2.

The type of diverter switch fitted to a particular equipment depends upon the rating of the transformer. Figures 11 and 13 show typical arrangements and illustrate the common stored energy toggle mechanism, tripping plate, spring driving bar and springs which operate the moving contact shaft and moving contact arm.

Figure 15 illustrates schematically the mechanical sequence of movements which take place on initiation of a tap change. As the spring driving bar is moved from left to right (or vice versa), the operating springs are gradually extended. When the driving bar approaches the end of its travel, it makes contact with the lug of the tripping plate and on reaching the end of its travel pushes the tripping plate over thus causing the toggle system to collapse suddenly. This allows the springs to drive the moving contact arm from one side of the diverter switch to the other: a dashpot, incorporated in the toggle mechanism, absorbs the shock created by the sudden movement.

The driving springs are designed to provide reliability in service and, whilst fitted at both ends of the diverter switch, those at one end are sufficient to ensure satisfactory operation. Every diverter switch is tested through a substantial number of operations and then is electrically checked by oscilloscope for correct timing sequence.

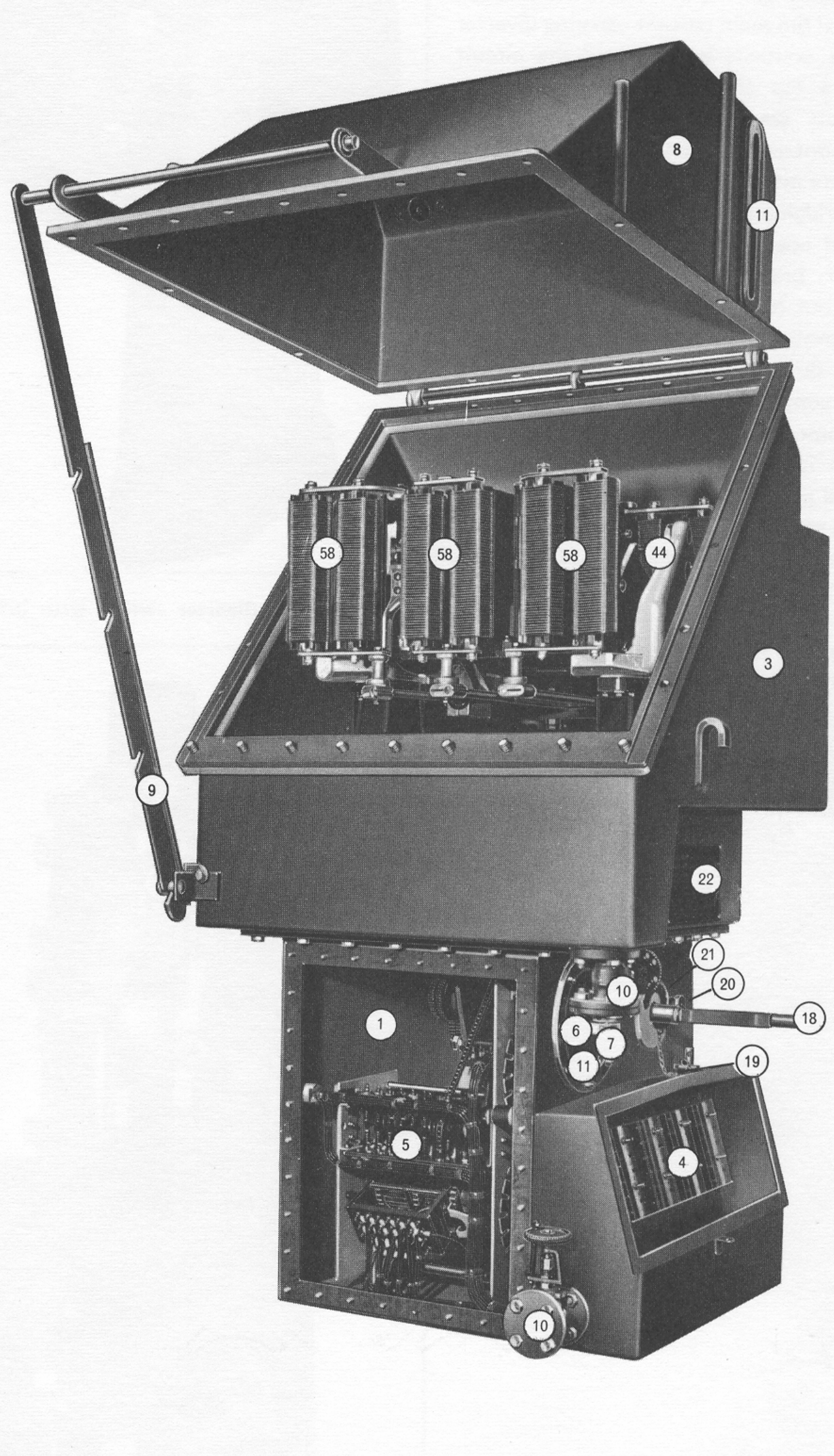

Fig.2 General view of motor gear-box and diverter switch compartment

1 Driving motor and timing gear compartment
3 Diverter switch compartment
4 Terminal and cable entry compartment
5 Timing gear
6 Tap position indicator
7 Operations counter
8 Hinged and bolted cover for diverter switch compartment
9 Stay and safety catch for diverter switch cover
10 Drain valve
11 Oil level indicator
18 Hand operation handle
19 Hand operation screwed plug
20 Auto-isolator switch knob
21 Direction of rotation plate
22 Instruction plate
44 Diverter switch
58 Diverter switch bridging resistor

The arrangement of the self-aligning arcing contacts on both types of diverter switch, is shown in Figures 12 and 14 and the fixed and moving contacts are surfaced with Tungsten Copper. Ratchet or servo devices are incorporated to allow all roller contacts to rotate, thus ensuring even burning all round the periphery, and contact bounce has been virtually eliminated.

Figures 12 and 14 also show the arrangement of the main current carrying diverter switch contacts which close the circuit after a tap change is complete. These contacts are of the pressure balanced line contact type and the moving contacts are integral with the contact arms.

The bridging resistors are oil cooled, wire wound open type mounted on accessible copper brackets. They are short-time rated but have a liberal margin to cover the continuous operation which may occur due to 'Hunting' when on automatic control.

The common connection from the diverter switch is taken through busbars to the neutral point bushing mounted on top of the diverter switch compartment or, when necessary, by oil-tight through type terminals into the main transformer tank.

Each phase neutral can be arranged to be brought out separately if required.

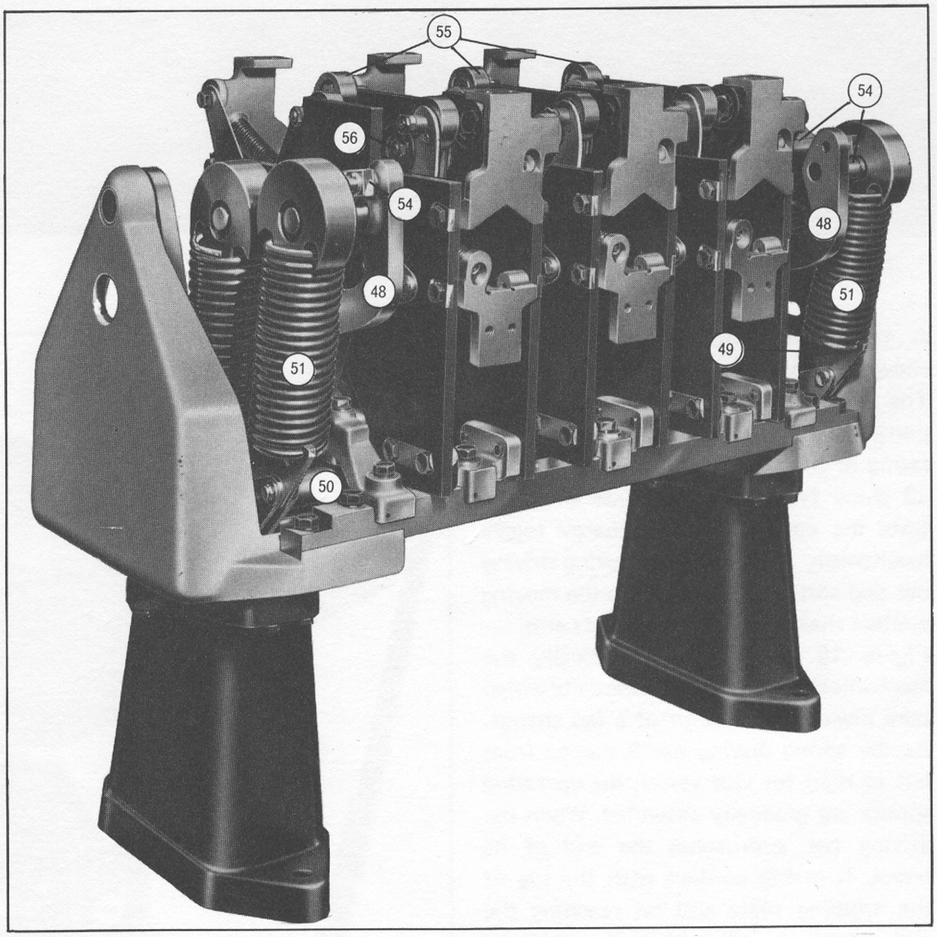

Fig.11 Typical diverter switch with bridging resistors removed

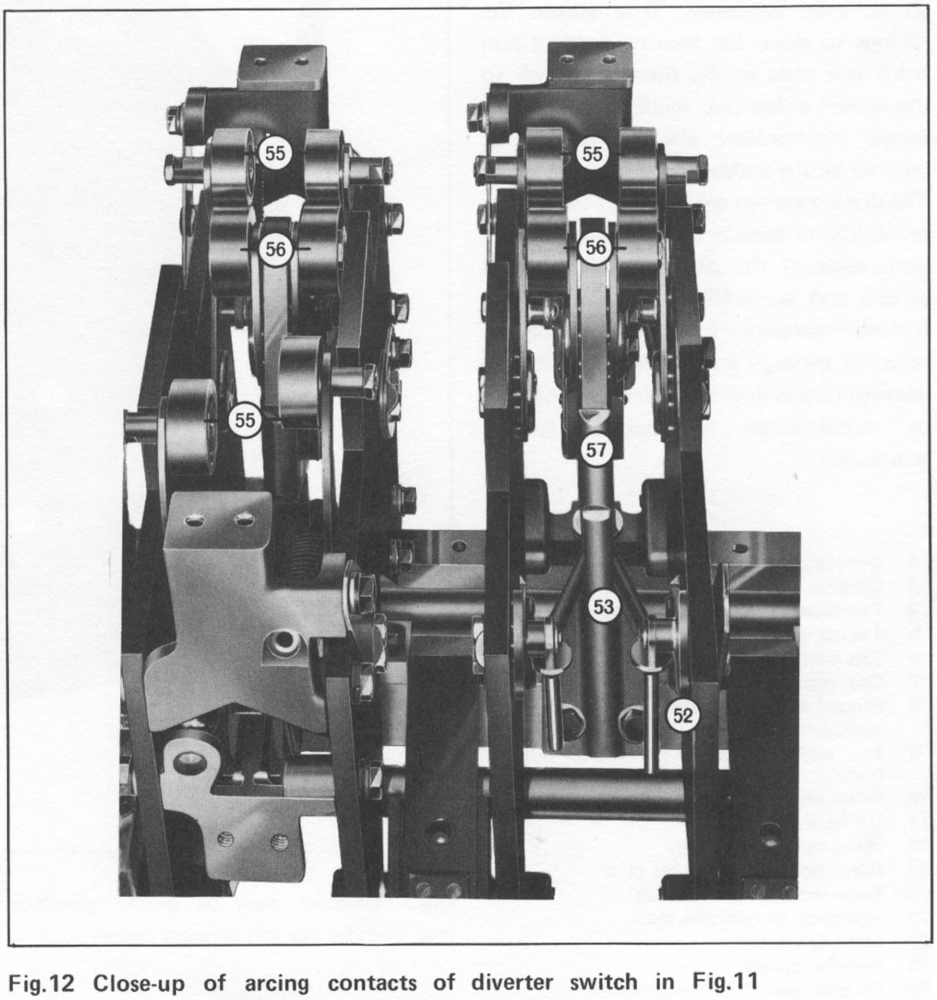

Fig.12 Close-up of arcing contacts of diverter switch in Fig.11

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Tap Changers

Series EFGH Diverter Switch Compartment

48 Diverter switch toggle mechanism
49 Diverter switch tripping plate
50 Diverter switch spring driving bar
51 Diverter switch driving springs
52 Diverter switch moving contact shaft
53 Diverter switch contact arm
54 Diverter switch dashpots
55 Diverter switch fixed arcing contacts
56 Diverter switch moving arcing contacts
57 Diverter switch main fixed contacts
58 Diverter switch bridging resistors
59 Brackets for bridging resistors
60 Neutral point common connection

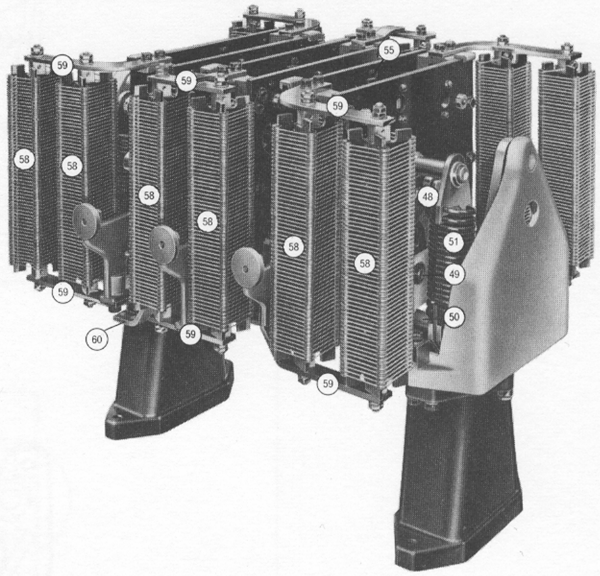


Fig.13 Typical diverter switch

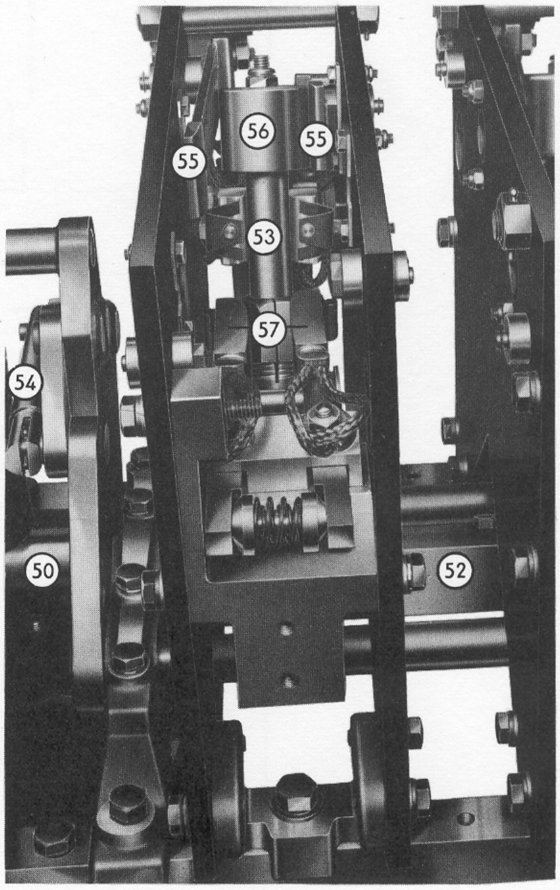


Fig.14 Close-up of arcing contacts of diverter switch shown in Fig.13

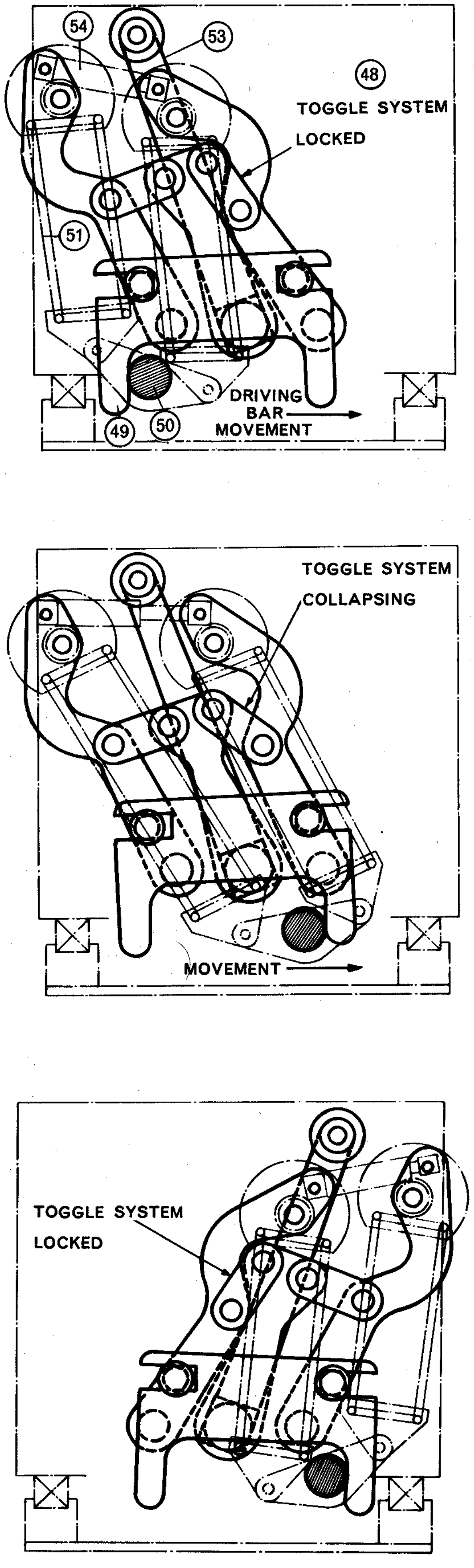


Fig. 15 Schematic drawing of diverter switch operation

Series EFGH Tap Selector Switch Compartment Types EF & G

The tap selector switch compartment is an integral part of the transformer tank, making a substantial contribution to the stiffening of the tank and it is provided by the transformer manufacturer: a general view of the compartment is shown in Figures 16 and 17.

The tap selector switch is illustrated in Figure 19 which shows the assembly of one phase. The switch base, which provides the barrier between selector switch compartment and transformer tank, is a glass fibre filled, synthetic resin, high pressure moulding into which the fixed contacts are mounted. This arrangement excludes the necessity for a separate barrier panel with additional, intermediate connections. Because the tap selector switches are mounted close to their respective transformer windings only very short tapping leads are necessary and an extremely neat arrangement can be effected as shown in Figure 18. On the transformer side of the switch bases, the contacts are tapered to accept a connector which is driven home by an 'Allen' type cap-screw. Reversal of this screw drives the connector off the taper if it should be necessary to remove a tapping lead from a selector switch contact.

Glass fibre mouldings are also used for the bridge pieces which carry the lead screw bearings and busbar supports, the flexible couplings and the moving contact housings The contact housings (Fig. 20) embody self-aligning driving nuts for the lead screws and the sliding contacts for the busbars. The tips of the moving copper contacts are of the balanced pressure line contact self-aligning type, and short flexible links connect the sliding busbars to the main busbars There are two main busbars per phase which are connected to oil-tight through type bushings leading into the diverter switch compartment. As the tap selector switch contacts do not make or break current they consequently give trouble-free service throughout the life of the transformer.

The tap selector switch lead screws are driven from the Geneva mechanism which is mounted on the barrier panel between tap selector and diverter switch compartments. The lead screws are coupled to the Geneva mechanism by insulated shafts and flexible couplings and similar shafts and couplings divide the lead screws into

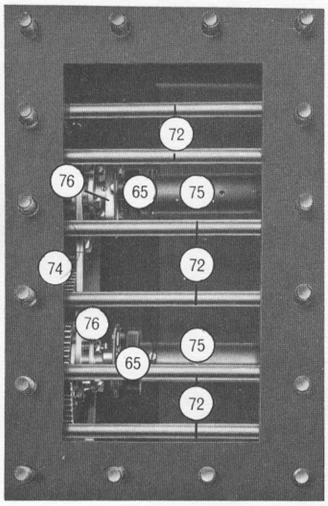


Fig.16 Selector switch driving mechanism

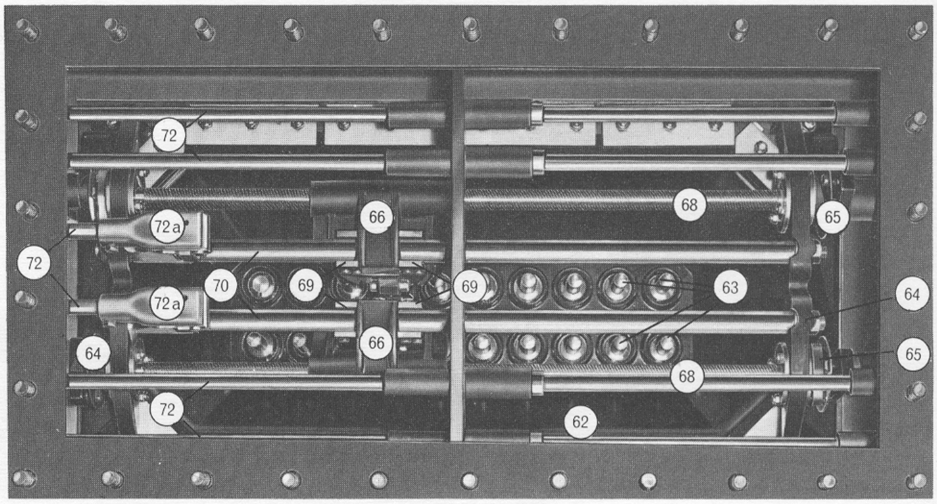


Fig.17 Selector switch general view

62 Selector switch barrier panel
63 Selector switch fixed contacts
64 Bearing bridge moulding
65 Lead screw half coupling
66 Moving contact housing embodying driving nut
68 Lead screw
69 Sliding contact
70 Sliding contact bar
72 Main busbar
72a Busbar coupler
74 Selector switch Geneva mechanism
75 Insulated driving shaft
76 Flexible coupling

sections corresponding to each phase. Figure 21 illustrates, in schematic form, the Geneva mechanism. The Geneva arm is free on the boss of the main gear shaft and receives its motion from the segment and this arrangement provides the 180^{o} lost motion necessary on reversal of direction of the tap changer. Figure 23 shows, schematically, how this device operates and Figure 22 the actual device.

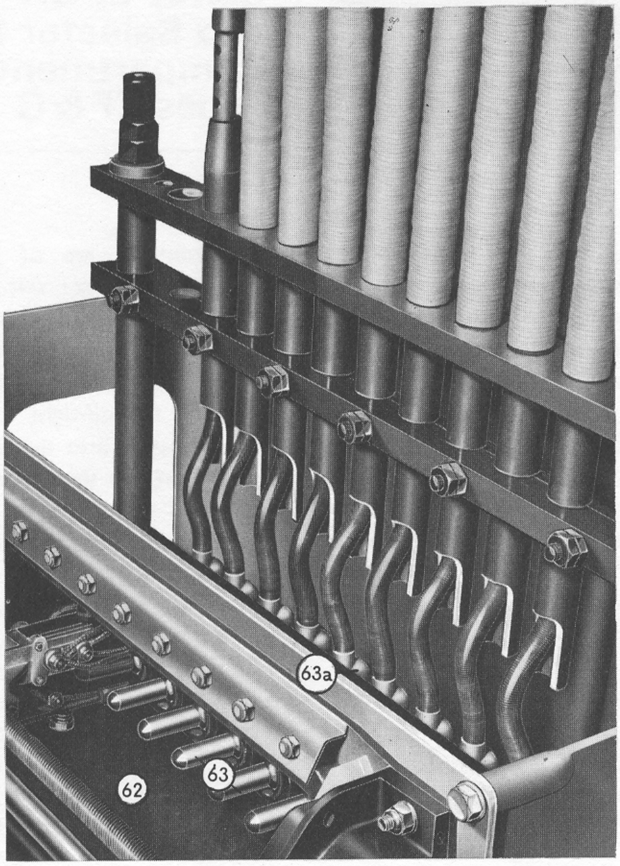


Fig.18 Typical tapping lead arrangement

62 Selector switch barrier panel
63 Selector switch fixed contacts
63a Tapping lead connector
64 Bearing bridge moulding
65 Lead screw half coupling
66 Moving contact housing embodying driving nut
66a Moving contact compression screw
68 Lead screw
69 Sliding contact
70 Sliding contact bar
71 Selector switch moving contact tip
72a Busbar coupler
76 Flexible coupling

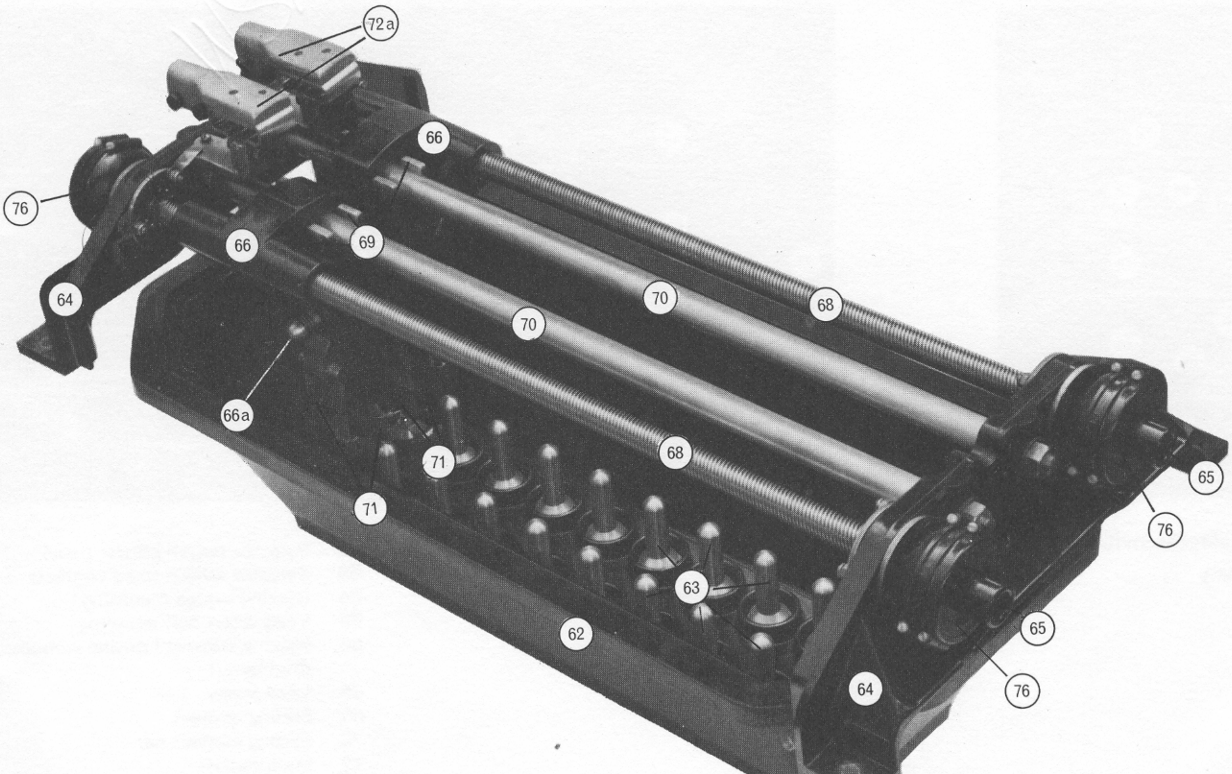


Fig.19 Detailed view of selector switch unit

Series EFGH Tap Selector Switch Compartment Types EF & G

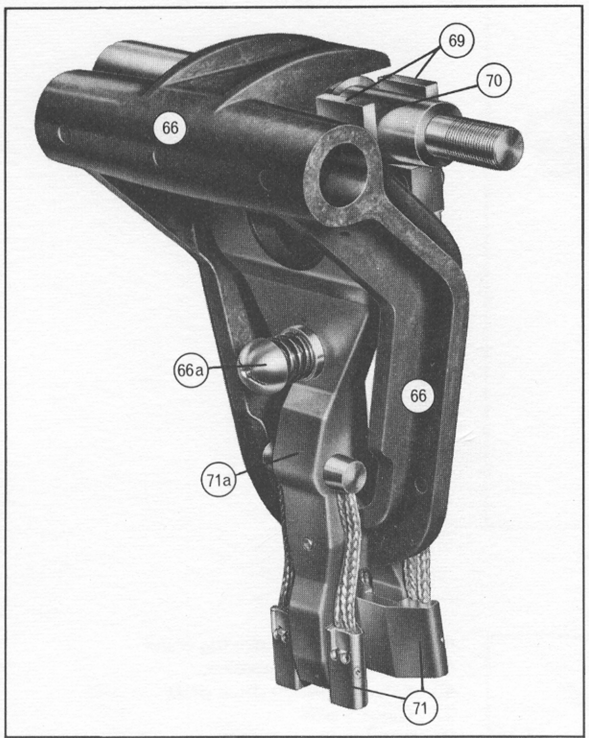


Fig.20 Close-up view of selector switch moving contact arm

42	Diverter switch driving crank
43	Diverter switch insulated coupling rod
45	Driving chain
46	Selector switch drive shaft
66	Moving contact housing embodying driving nut.
66a	Moving contact compression screw
68	Lead screws
69	Sliding contact
70	Sliding contact bar
71	Selector switch moving contact tip
71a	Moving contact arm
74	Selector switch Geneva mechanism
75	Insulated driving shafts
76	Flexible couplings
77	Geneva arm

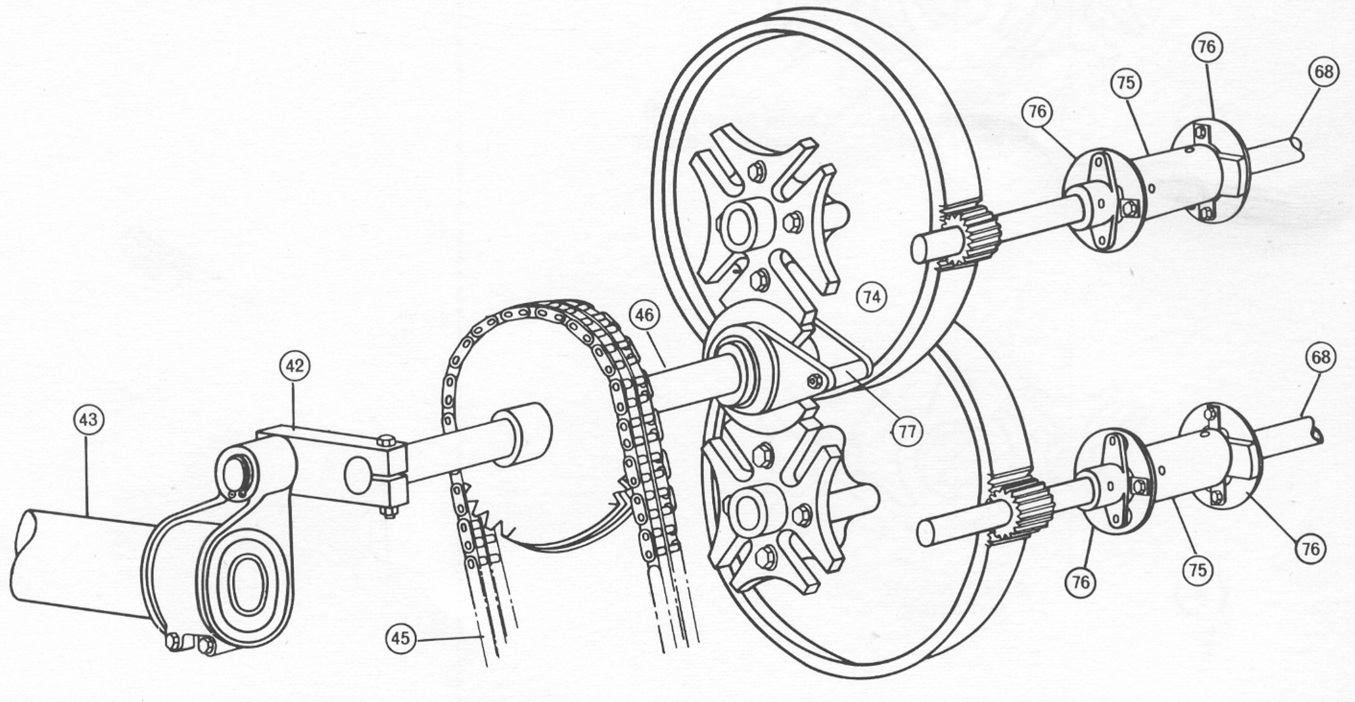


Fig.21 Schematic drawing of Geneva mechanism and drive

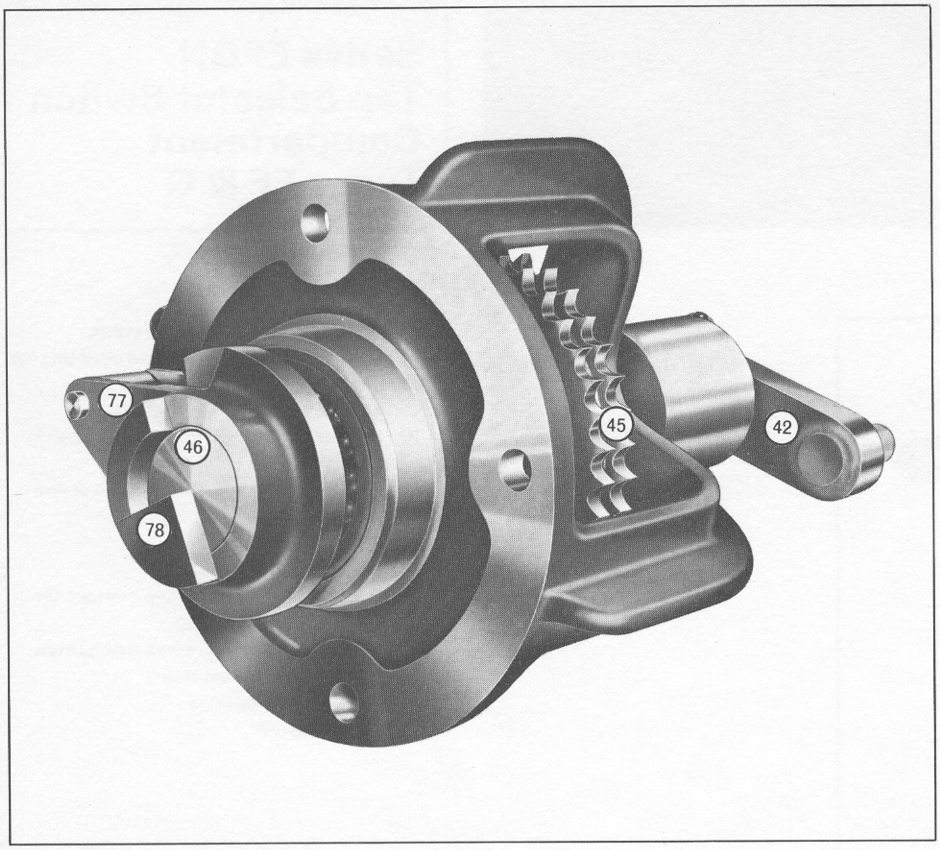


Fig.22 Close-up view of 180° lost motion device

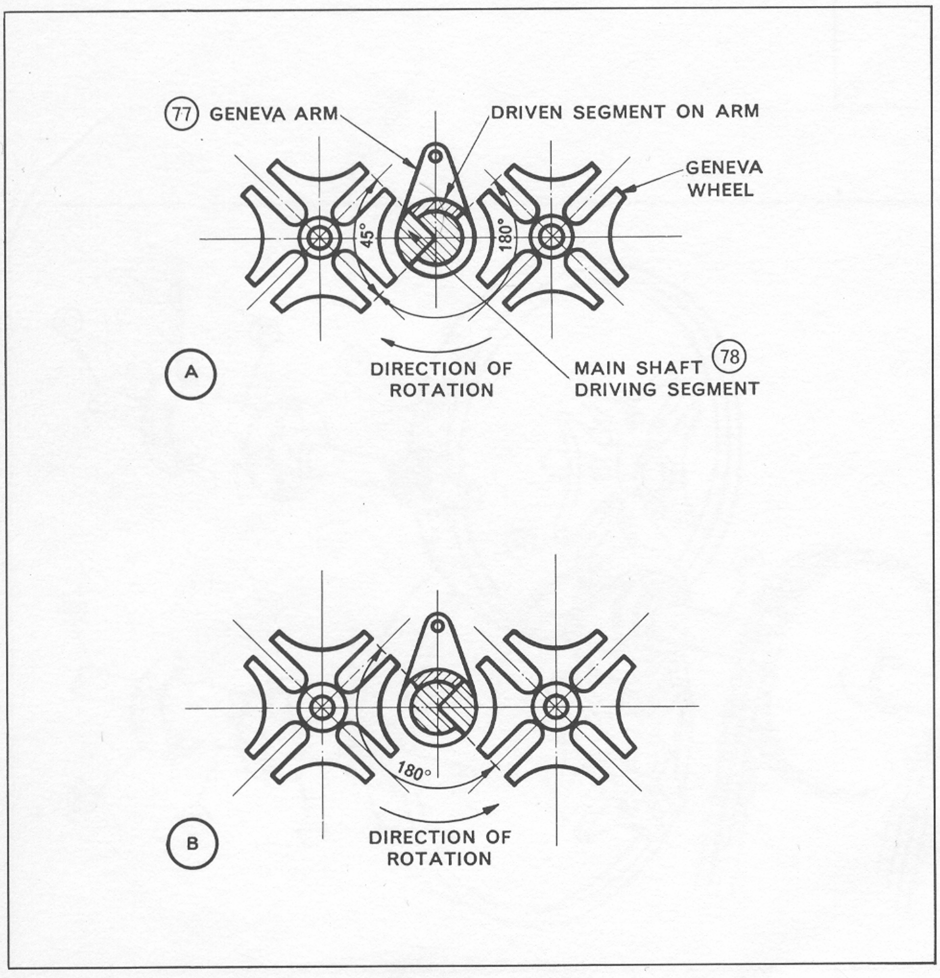


Fig.23 Schematic drawing of 180° lost motion device

42 Diverter switch driving crank
45 Driving chain sprocket
46 Selector switch drive shaft
77 Geneva arm
78 180° lost motion segment

Series EFGH Tap Selector Switch Compartment Type H

The tap selector switch compartment is an integral part of the transformer tank, making a substantial contribution to the stiffening of the tank, and it is provided by the transformer manufacturer: a general view of a typical compartment is shown in Figure 24.

Two forms of tap selector switch can be provided under type H, one is suitable for a reversing tapping arrangement and the other for a form of coarse/fine arrangement. In both cases the switch bases form the oil barrier between the tap selector switch compartment and the transformer tank, thus eliminating the need for separate barrier panels and additional intermediate connections. Because each switch is mounted close to its winding the tapping leads are kept short, making a considerable saving in copper and also significantly increasing the impulse strength of the completed transformer. Each base is a circular epoxy resin casting into which the switch contacts are mounted. On the transformer side of the switch bases the contacts are tapered to accept a connector which is driven home by an 'Allen' type cap-head screw. Reversal of this screw drives the connector off the taper, if it should be necessary to remove a tapping lead from a selector switch contact.

Connections between the tap selector switches and the diverter switch are made by two main bus bars per phase, the bus bars terminating in oil-tight, through type bushings mounted on the barrier plate between the diverter switch and tap selector switch compartments.

Reversing Switch

This version is designated type HR.

On each base are mounted the fixed contacts for the tap connections, arranged in two sets of circular formation, and the fixed contacts for the change-over switch; these contacts are C.C.S. alloy. The moving contacts, of hard drawn copper, are of the line contact, balanced pressure, self-aligning type, mounted on gun-metal carriers.

The drive for the tap selector switches is taken from the Geneva mechanism, which is mounted on the barrier plate separating the diverter and tap selector switch compartments, by means of two sets of insulated shafts and flexible couplings through worm and insulated wormwheel drives to the respective switches. The change-over switches are operated from the top set of insulated drive shafts and couplings by means of an arm lever and peg. The Geneva mechanism is shown schematically in Figure 25 and one phase of the selector switch is shown in Figure 27.

Coarse/Fine Switch

This version is designated type HD and is designed for a form of coarse/fine tappings i.e. four coarse sections and three fine sections.

Each switch base carries the fixed contacts for the tap selector switch (coarse taps) and two change-over switches (fine taps). The tap selector contacts, of C.C.S. alloy, are arranged in two straight rows, one above the other and in each position the top and bottom contacts are connected in parallel: the two sets

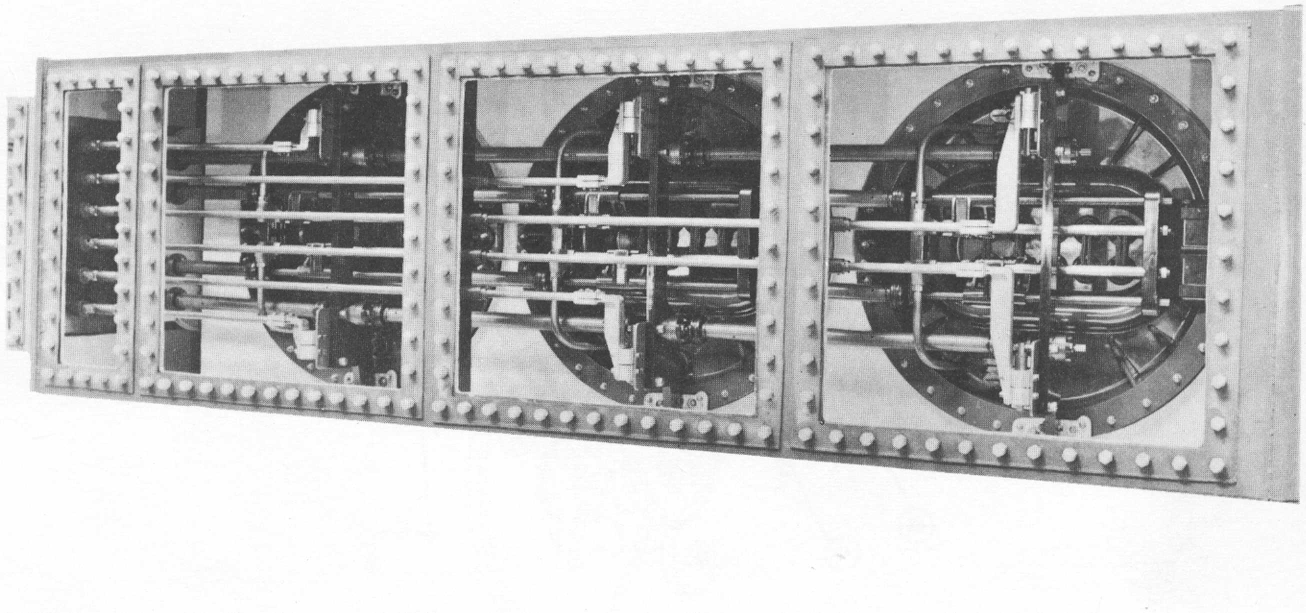


Fig.24 Typical Type H Tap Changer Selector Switch Compartment

of change-over contacts are mounted one above and one below the tap selector contacts, and the common contacts of the change-over switches are connected one to each side of the diverter switch, by means of bus bars.
The moving contacts for the tap selector switches are carried on glass fibre filled synthetic resin high pressure mouldings which embody a self-aligning nut for the lead screw drive and a sliding contact for the collector bus bar; the hard drawn copper contacts are of the balanced pressure, line contact, self-aligning type. The collector bus bars are connected, one to each of the change-over switches, by solid copper connectors.
The drive to the tap selector switches is by lead screws and insulated flexible couplings operated from a double Geneva mechanism which ensures the correct relationship between the tap selector and change-over switches, and the diverter switch. The drive to the change-over switches is by eccentric cams coupled to the Geneva mechanism by insulated shafts and insulated, flexible couplings. The Geneva mechanism is shown schematically in Figure 26 and one phase of the selector switch is shown in Figure 28.

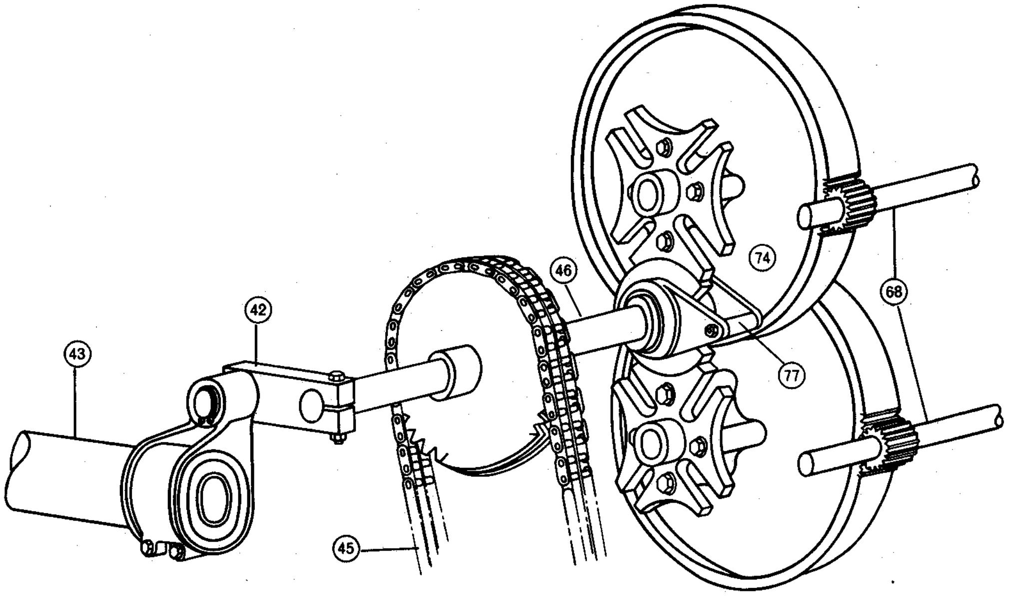


Fig.25 Schematic drawing of Type HR Geneva mechanism and drive

42 Diverter switch driving crank
43 Diverter switch insulated coupling rod
45 Driving chain
46 Selector switch main drive shaft
68 Selector switch drive shafts
74 Selector switch Geneva mechanism
77 Geneva arm

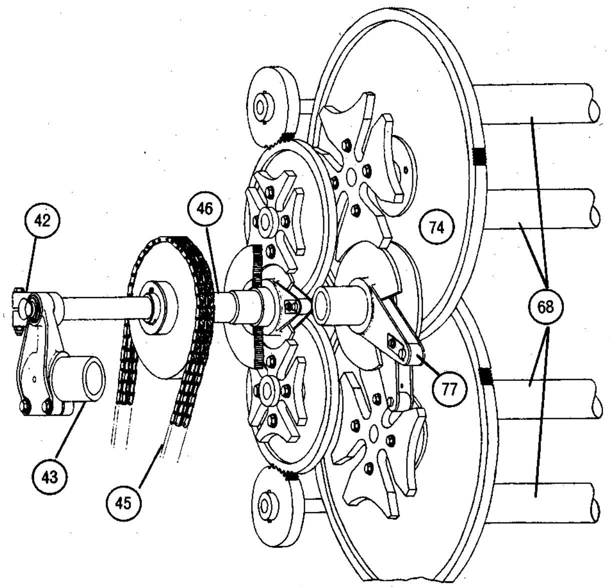


Fig.26 Schematic drawing of Type HD Geneva mechanism and drive

Series E F G H Tap Selector Switch Compartment Type H

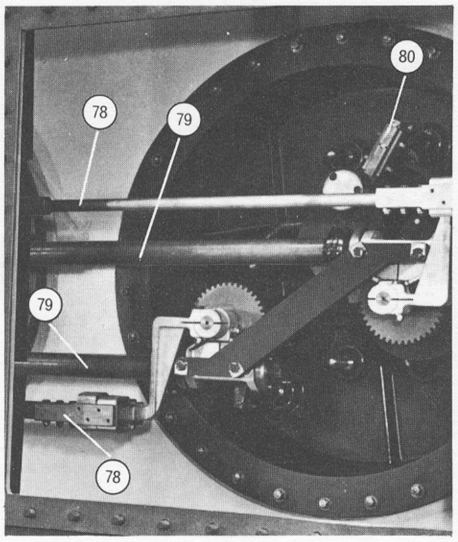


Fig.27 Close-up of one phase of a Type HR selector switch

78 Busbar to diverter switch
79 Drive to selector switch
80 Change-over switch

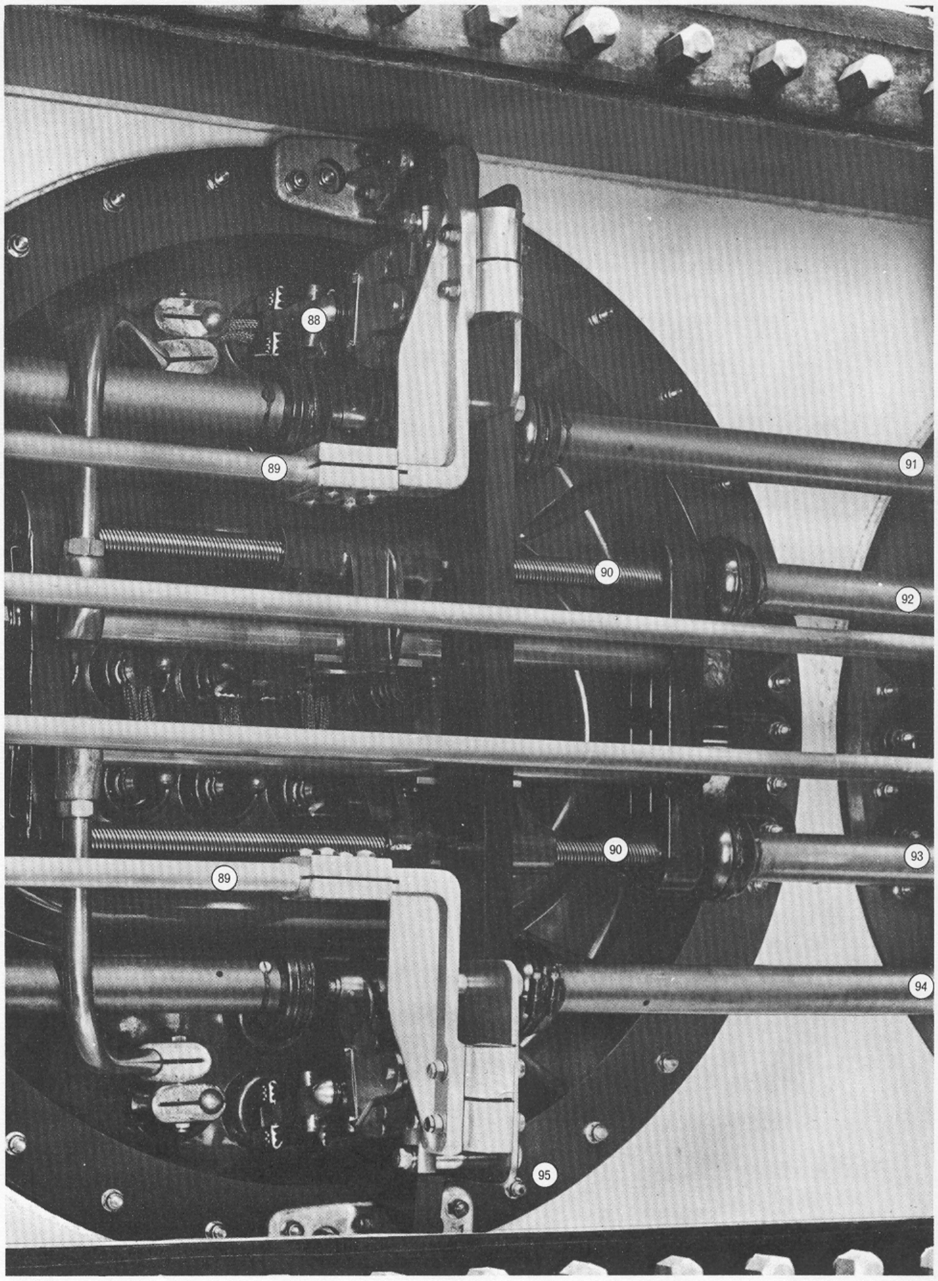


Fig.28 Close-up of one phase of a Type HD12 selector switch

88 Top fine change-over switch
89 Busbar to diverter switch
90 Driving leadscrews for coarse selector, switch
91 Drive for top change-over switch
92 Drive to top coarse selector
93 Drive to bottom coarse selector
94 Drive to bottom change-over switch
95 Epoxy resin selector switch housing

FERRANTI

Tap Changers

Series EFGH Switching Sequence Linear Tappings Types EF&G

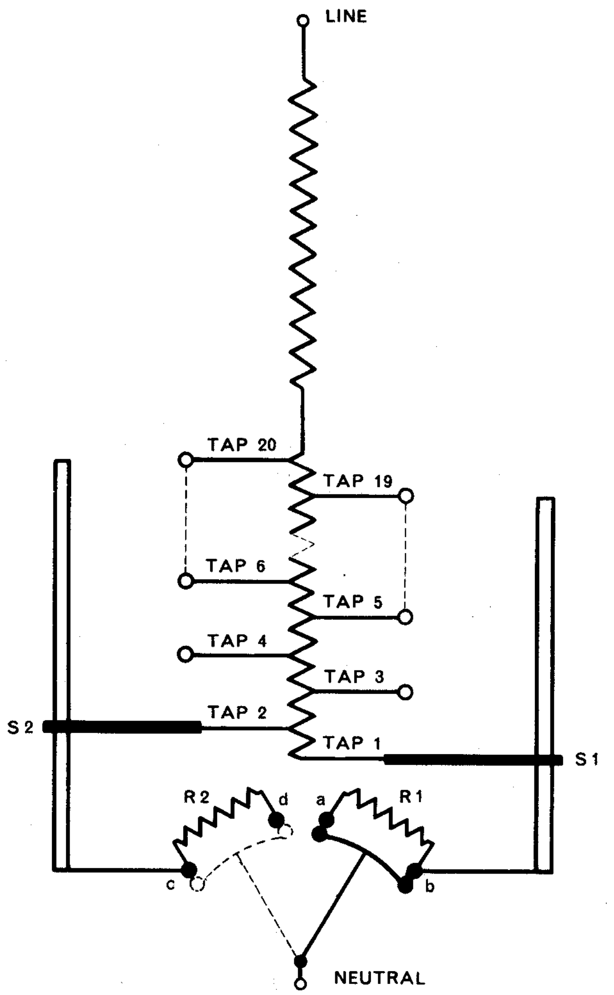
Electrical Switching Sequence

The diagram of connections for one phase of a transformer illustrates the method of operation of the tap changer. In the initial position one selector switch (S1) is on tap 1 and the other (S2) is on tap 2. The diverter switch connects tap 1 to the neutral point of the transformer windings.

The sequence of operations in changing to tap 2 is as follows:

1. As shown contacts ,a, and ,b, are closed and load current flows from tap 1 through contact ,b, — the normal running position for tap 1.
2. As the stored energy mechanism operates, the moving contact starts to travel from one side of the diverter to the other. Contact ,b, is opened and the load current from tap 1 flows through resistor ,R1, to contact ,a.
3. The moving contact continues until contact ,d, closes. Both resistors ,R1, and ,R2, are now connected in series across taps 1 and 2 and the load current flows through the mid-point of these resistors.
4. Further travel of the moving contact opens contact ,a, and the load current then passes from tap 2 through resistor ,R2, and contact ,d.
5. Finally, when the moving contact reaches the other side of the diverter switch, contact ,c, is closed and resistor ,R2, is shorted out. Load current from tap 2 now flows through contact ,c, — the normal running position for tap 2.

The change from tap 1 to 2 as described involves no movement of the selector switches. If a further change in the same direction is required i.e. tap 2 to 3 the selector switch (S1) travels to tap 3 before the diverter switch moves, and the diverter switch then repeats the above sequence, but in reverse order. If the gear is required to change taps in the opposite direction the selector switches remain stationary and the tap change is completed by the movement of the diverter switch only. This is achieved by means of the lost motion device incorporated in the Geneva mechanism.



FERRANTI

Tap Changers

Series E F G H Switching Sequence Reversing Tappings Type HR

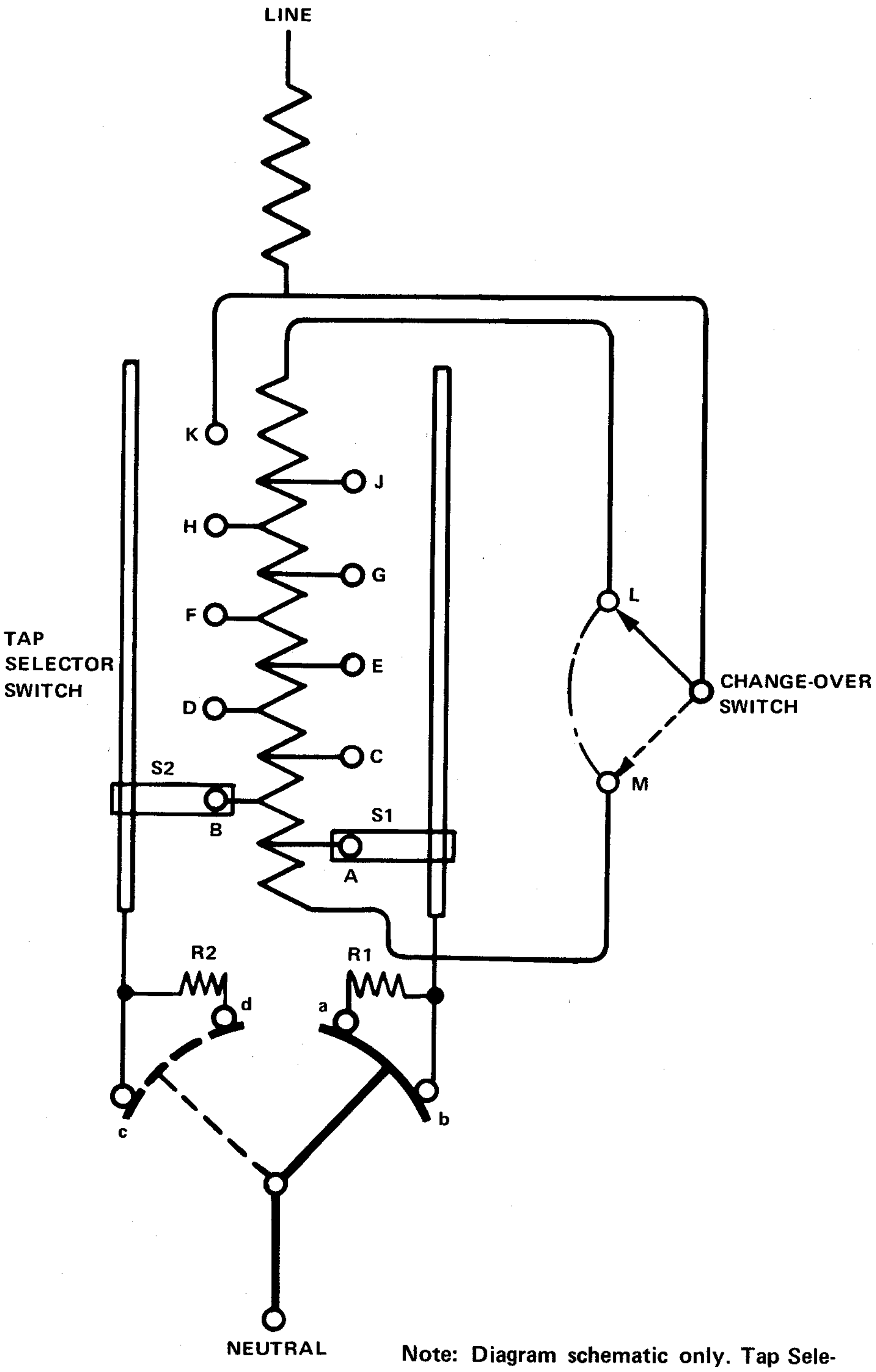
The diagram of connections for one phase of a transformer illustrates the method of operation of the tap changer. In the initial position — tap 1 — one selector switch, S1, is in position, A, and the other, S2, is in position, B, the change-over switch is in position, L, and the diverter switch is in position, a — b. The diverter switch connects tap 1 to the neutral point.

The sequence of operation in changing from tap 1 to tap 2 is as follows:

1. As shown contacts, a, and, b, are closed and load current flows through contacts L, A, and, b. The normal running position for tap 1.
2. As the stored energy mechanism operates, the moving contact starts to travel from one side of the diverter to the other. Contact, b, is opened and the load current from tap 1 flows through resistor, R1, to contact, a.
3. The moving contact continues until contact, d, closes. Both resistors, R1, and, R2, are now connected in series across taps 1 and 2 (selector switch positions A and B) and load current flows through the mid-point of these resistors.
4. Further travel of the moving contact opens contact, a, and the load current passes from tap 2 (selector switch position B) through resistor, R2, and contact, d.
5. Finally, when the moving contact reaches the other side of the diverter switch, contact, c, is closed and resistor, R2, is shorted out. Load current flows through contacts L, B and, c, — the normal running position for tap 2.

The change from tap 1 to tap 2 as described, involves no movement of the selector switches, S1, and, S2, or the change-over switch. If a further change in the same direction is required i.e. from tap 2 to tap 3, the selector switch, S1, travels to position, c, before the diverter switch moves and then the diverter switch repeats the above sequence, but in the reverse order — from contact, c, to, b.

For continuing changes in the same direction, the above sequence is repeated



Note: Diagram schematic only. Tap Selector Switches are rotary type.

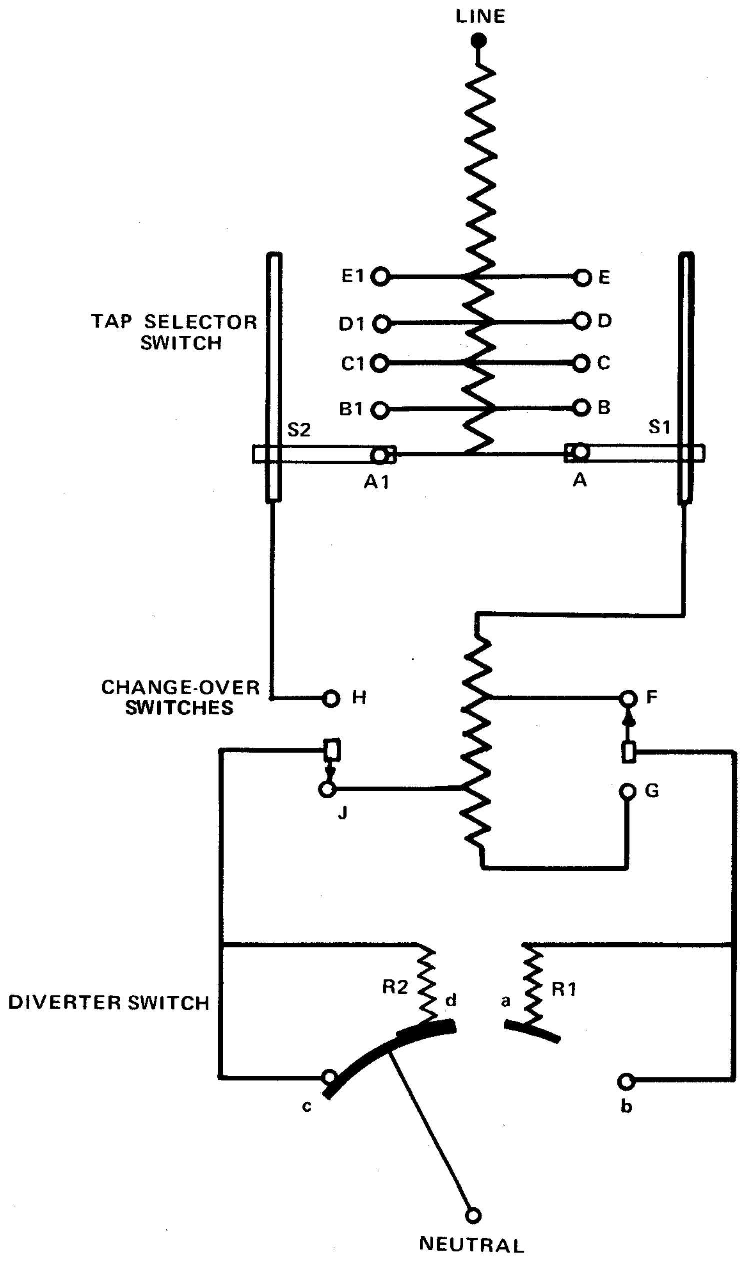
until selector switch, S2, reaches position, K, (tap 10). From this position, another tap change in the same direction causes selector switch, S1, to move from position, J, back to position, A, and the change-over switch to move from position, L, to, M, before the diverter switch moves from position, c, to, b. The load current then flows via contacts, M, A, and, b, — the running position for tap 11. Another change in the same direction results in selector switch, S2, moving on to position, B, again and the diverter to, c, — the load current flows through, M, B, and, c, — the normal running position for tap 12. These sequences would continue, so long as the changes called for were in the same direction, until all positions had been traversed twice.

If a tap change is called for in the reverse direction, the selector switches, S1, and, S2, and the change-over switch remain stationary and the tap change is completed by the movement of the diverter switch only. This is achieved by means of the 180° lost motion device incorporated in the Geneva mechanism.

FERRANTI

Tap Changers

Series E F G H Switching Sequence Modified Coarse/ Fine Tappings Type HD



The diagram of connections for one phase of a transformer illustrates the method of operation of the tap changer. In the initial position (tap 1) the selector switches (S1 and S2) are in positions, A, and, A1, respectively, the change-over switches are in positions, F, and, J, and the diverter switch is in position, c — d. The diverter switch connects tap 1 to the neutral point of the transformer windings.

The sequence of operations in changing from tap 1 to tap 2 is as follows:

1. As shown, contacts, c, and, d, are closed and load current flows through contacts, A, J, &, c, — the normal running position for tap 1.
2. As the stored energy mechanism operates, the moving contact starts to travel from one side of the diverter to the other. Contact, c, is opened and the load current from tap 1 flows through resistor, R2, to contact, d.
3. The moving contact continues until contact, a, closes. Both resistors, R2, and, R1, are now connected in series across taps 1 and 2 and the load current flows through the mid-point of these resistors.
4. Further travel of the moving contact opens contact, d, and the load current then passes from selector position, A, through, F, resistor, R1, and, a.
5. Finally, when the moving contact reaches the other side of the diverter switch, contact, b, is closed and resistor, R1, is shorted out. Load current now flows through contacts, A, F, and, b, — the normal running position for tap 2.

The change from tap position 1 to tap position 2, described above, cuts out one fine tap section without movement of either selector switches, S1, S2, or the change-over switches. When a further tap change is called for in the same direction i.e. from tap 2 to tap 3 the change-over switch on the, c — d, side of the diverter, moves from, J, to, H, before the diverter switch moves, and then the diverter switch repeats the above sequence, but in reverse order. This movement cuts out another fine tap section and load current flows through contacts, A1, H, and, c, — the normal running position for tap 3.

The next tap change in the same direction involves the movement of selector switch, S1, from position, A, to position, B, change-over switch on the, a — b, side of the diverter from position, F, to, G, and diverter switch to position, b, — selector and change-over switches operate before the diverter switch. This movement cuts out the first coarse section and brings in all three fine sections. Load current flows through contacts, B, G, and, b, — the normal running position for tap 4.

For another tap change in the same direction the change-over switch on the, c — d, side of the diverter moves from, H, to, J, and the diverter from, b, to,

c. Load current flows through, B, J, and, c, – the normal position for tap 5.

A change from tap 5 to tap 6 involves the movement of the change-over switch on the, a – b, side of the diverter to move from, G, to, F, and diverter from, c, to, b. The load current flows through, B, F, and, b.

To change from tap 6 to tap 7 involves the movement of selector switch, S2, from, A1, to, B1, and change-over switch on the, c – d, side of the diverter from, J, to, H, and the diverter from, b, to, c. Load current flows through, B1, H, and, c.

Continuing changes in the same direction result in the above sequence of operations being repeated until all taps have been included.

If the tap changer is required to make a tap change in the opposite direction, the selector switches, S1, S2, and both change-over switches remain stationary and the tap change is completed by the movement of the diverter switch only. This is achieved by the 180° lost motion device incorporated in the Geneva mechanism.

Further changes in the reverse direction involve sequential operations of the selector switches, change-over switches and diverter switch as described above but in the reverse order.

FERRANTI

Tap Changers

Series EFGH Type E Specification

The Ferranti Type E on load tap changer is intended for use on three phase, a.c. systems operating up to a maximum voltage of 72.5 kV. This tap changer has separate selector switch and diverter switch compartments, and is designed for operation at the neutral end of the transformer windings.

The technical characteristics are as follows:

Maximum number of steps	19
Maximum working voltage per step	1500 kV
Nominal current	EC4–400 amps EC6–600 amps
Period for complete tap change	7–8 seconds
Diverter switch transition time	3–3½ cycles
Maximum short circuit test	EC4–4000 amps for 5 periods of 3 seconds duration EC6–6000 amps for 5 periods of 3 seconds duration
Maximum full wave impulse voltage withstand:	
(a) Tapping in use to earth	350 kV of either polarity
(b) Between selector contacts	150 kV of either polarity
(c) Remote unselected fixed contact to earth	550 kV of either polarity
(d) Across the tapping range	550 kV of either polarity
Maximum power frequency test:	
(a) To earth	140 kV r.m.s. for 1 minute
(b) Between selector switch contacts	50 kV r.m.s. for 1 minute

At normal temperatures the selector switch pocket can withstand the application of full vacuum to the transformer without pressure equalisation. If the transformer is processed with the selector switch housings in position the pressure between the switch pocket and the transformer must be equalised. Detailed information on processing will be supplied on request.

FERRANTI

Tap Changers

Series EFGH Type F Specification

The Ferranti Type F on load tap changer is intended for use on three phase a.c. systems operating up to a maximum voltage of 145 kV. This tap changer has separate selector switch and diverter switch compartments, and is intended for operation at the neutral end of the transformer windings.

The technical characteristics are as follows:

Maximum number of steps	19
Maximum working voltage per step	Type FC4 – 1750 volts r.m.s. Type FC6 – 2750 volts r.m.s.
Nominal current	Type FC4 – 400 amps Type FC6 – 650 amps
Period for complete tap change	7 – 8 seconds
Diverter switch transition time	3 – 3½ cycles
Maximum short circuit test	Type FC4 – 4000 amps for 5 periods of 3 seconds duration Type FC6 – 6500 amps for 5 periods of 3 seconds duration
Maximum full wave impulse voltage withstand:	
(a) Tapping in use to earth	200 kV of either polarity
(b) Between selector contacts	150 kV of either polarity
(c) Remote unselected fixed contact to earth	550 kV of either polarity
(d) Across the tapping range	550 kV of either polarity
Maximum power frequency test:	
(a) To earth	70 kV r.m.s. for 1 minute
(b) Between selector switch contacts	50 kV r.m.s. for 1 minute

At normal temperatures the selector switch pocket can withstand the application of full vacuum to the transformer without pressure equalisation. If the transformer is processed with the selector switch housings in position the pressure between the switch pocket and the transformer must be equalised. Detailed information on processing will be supplied on request.

FERRANTI

Tap Changers

Series EFGH Type G Specification

The Ferranti Type G on load tap changer is designed for use on three phase a.c. systems of 275 kV nominal voltage. It can be used on nominal voltages up to 400 kV, provided the working and test voltages are not exceeded. This tap changer has separate tap selector switch and diverter switch compartments and is intended for operation at the neutral end of the transformer windings.

The technical characteristics are as follows:

Maximum number of steps	19
Maximum working voltage per step	2750 volts r.m.s.
Nominal current	GC6–650 amps GC12–1200 amps
Period for complete tap change	7–8 seconds
Diverter switch transition time	3-3½ cycles
Maximum short circuit test	GC6–6500 amps for 5 periods of 3 seconds duration GC12–12,000 amps for 5 periods of 3 seconds duration
Maximum full wave impulse voltage withstand:	
(a) Tapping in use to earth	200 kV of either polarity
(b) Between selector contacts	150 kV of either polarity
(c) Remote unselected fixed contact to earth	550 kV of either polarity
(d) Across the tapping range	550 kV of either polarity
Maximum power frequency test:	
(a) To earth	70 kV r.m.s. for 1 minute
(b) Between selector switch contacts	69 kV r.m.s. for 1 minute

At normal temperatures the selector switch pocket can withstand the application of full vacuum to the transformer without pressure equalisation. If the transformer is processed with the selector switch housings in position the pressure between the switch pocket and the transformer must be equalised. Detailed information on processing will be supplied on request.

FERRANTI

Tap Changers

Series EFGH Type HR Specification

The Ferranti HR on load tap changer is similar in layout to the 'F' and 'G' types except that the selector switch is designed for a reversing mechanism. The tap changer is for use at the neutral end of transformer windings operating up to a maximum of 440 kV.

The technical characteristics are as follows:

Maximum number of steps	18
Maximum working voltage per step	2750 volts r.m.s
Nominal current	HR12–1200 amps HR20–2000 amps
Period for complete tap change	7–8 seconds
Diverter switch transition time	3–3½ cycles
Maximum short circuit test	HR12–12,000 amps for 5 periods of 3 seconds duration HR20–16,000 amps for 5 periods of 3 seconds duration
Maximum full wave impulse voltage withstand:	
(a) Tapping in use to earth	250 kV of either polarity
(b) Between selector switch contacts	350 kV of either polarity
(c) Remote unselected fixed contact to earth	350 kV of either polarity
(d) Across the tapping range	350 kV of either polarity
Maximum power frequency test:	
(a) To earth	100 kV r.m.s for 1 minute
(b) Between selector switch contacts	100 kV r.m.s for 1 minute

At normal temperatures the tap changer can withstand the application of full vacuum to the transformer without pressure equalisation. If the transformer is processed with the tap changer in position the pressure between the selector pockets and the transformer must be equalised. Detailed information on processing will be supplied on request.

FERRANTI

Tap Changers

Series EFGH Type HD Specification

The Ferranti HD12 on load tap changer is similar in layout to the 'F' and 'G' types except that the selector switch is designed for a coarse/fine mechanism. The tap changer is for use at the neutral end of transformer windings operating up to a maximum of 440 kV.

The technical characteristics are as follows:

Maximum number of steps	19
Maximum working voltage per step	2750 volts r.m.s.
Nominal current	1200 amps
Period for complete tap change	7–8 seconds
Diverter switch transition time	3–3½ cycles
Maximum short circuit test	12,000 amps for 5 periods of 3 seconds duration
Maximum full wave impulse voltage withstand:	
(a) Tapping in use to earth	300 kV of either polarity
(b) Between selector switch contacts	200 kV of either polarity
(c) Remote unselected fixed contact to earth	700 kV of either polarity
(d) Across the tapping range	650 kV of either polarity
Maximum power frequency test:	
(a) To earth	100 kV r.m.s. for 1 minute
(b) Between selector switch contacts	100 kV r.m.s. for 1 minute

At normal temperatures the tap changer can withstand the application of full vacuum to the transformer without pressure equalisation. If the transformer is processed with the tap changer in position the pressure between the selector pockets and the transformer must be equalised. Detailed information on processing will be supplied on request.