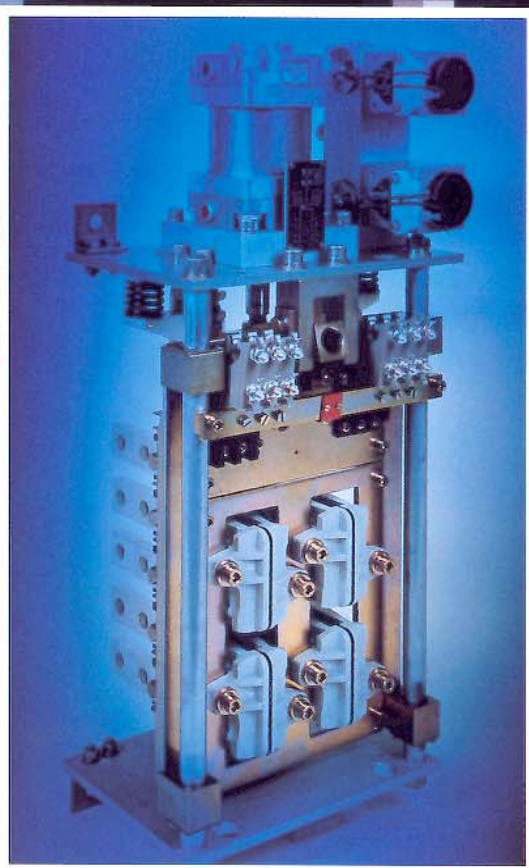


Type BWT and BWU

Changeover Switches
for Traction Motor
Circuits



Type BWT and BWU Changeover Switches for Traction Motor Circuits

Introduction

The different circuit arrangements of the commutator-type motors of electric traction vehicles are set up by changeover switches. These changeover devices may be used as

- direction reversers,
- motoring/braking changeover switches.
- converter or traction motor disconnect switches,

- series/parallel grouping switches,
- power system selector switches or,
- transformer tapchangers.

In every case switching *always takes place in the de-energized state* and there are either two or three switch positions. The switches themselves are not designed as load switches for interrupting currents. They are actuated either by means of an electro-pneumatic or electro-motive drive system or by hand.

The BWT and BWU series of changeover switches were developed to meet the need for an economically priced, modern device which satisfies the technical requirements and constraints (e.g. lack of available space) imposed by modern traction vehicles. In other words, a functionally optimized selector switch was to replace the traditional reversers and motoring/braking switches.

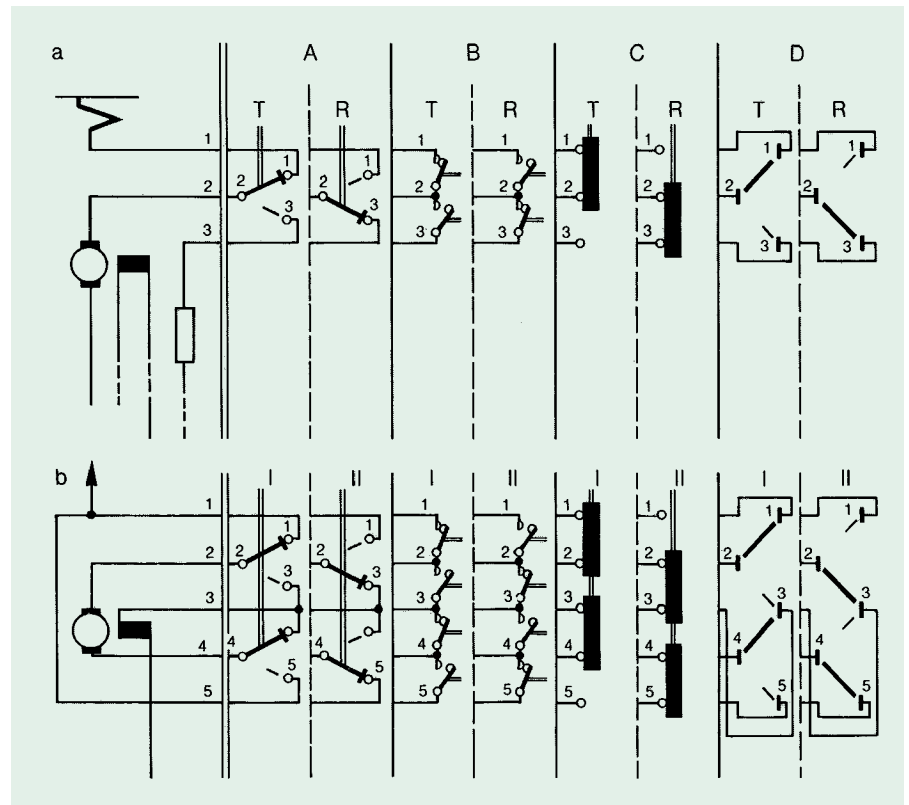
Fig. 1 – Examples of switching functions in an electric traction vehicle

a: Motoring/braking changeover
b: Reversal of direction of travel

A = Rotating selector (reverser)
B = Contactors, cam-switch assembly
C = Type BWT and BWU linear selectors (working diagram)

D = Type BWT and BWU linear selectors (circuit diagram)

T = Position for motoring
R = Position for rheostatic braking
I = Direction of travel I
II = Direction of travel II



Main Functions and Operating Principles of Changeover Switches

Two of the most common uses of the changeover devices are for selecting either the motoring or braking circuit and for reversing the direction of travel. *Figure 1* shows examples of how rotating selector switches, contactors, cam-switch assemblies and linear switches perform these functions. Contactors or cam-switch assemblies are used when it is anticipated that residual currents will have to be interrupted. Contactors of type BMS/BPS are recommended for such applications.

For the sake of simplicity, the type BWT and BWU changeover switches are of the linear type. *Figure 2a* shows a

basic circuit diagram of the device with two switching positions and a pneumatic drive, while *Figure 2b* shows the same with an electro-motive drive. It is possible to add a third, neutral position, which may be used, for example, to temporarily isolate individual traction motors. The switch is moved to the neutral position by hand. *Figure 3* shows the circuit diagram of a changeover device with three positions, with electro-pneumatic movement to the central position.

Ratings

The changeover devices of both series are designed for either 1500 V or 3000 V. They differ as regards the dis-

tance between their contacts (the contact travel) and their respective clearances in air and creepage paths. The switch rated 1500 V can also be used for lower voltages.

Despite the many different rated currents possible for traction vehicles, it has been possible to satisfy all current requirements by means of only one contact system dimensioned for 800 A. A rated current of 800 A corresponds to a traction motor power rating of approximately 1200 kW at 1500 V; for higher powers or currents, more contacts have to be connected in parallel. In this case a current distribution factor of 0.8 takes account of the unequal current distribution between the individual branches.

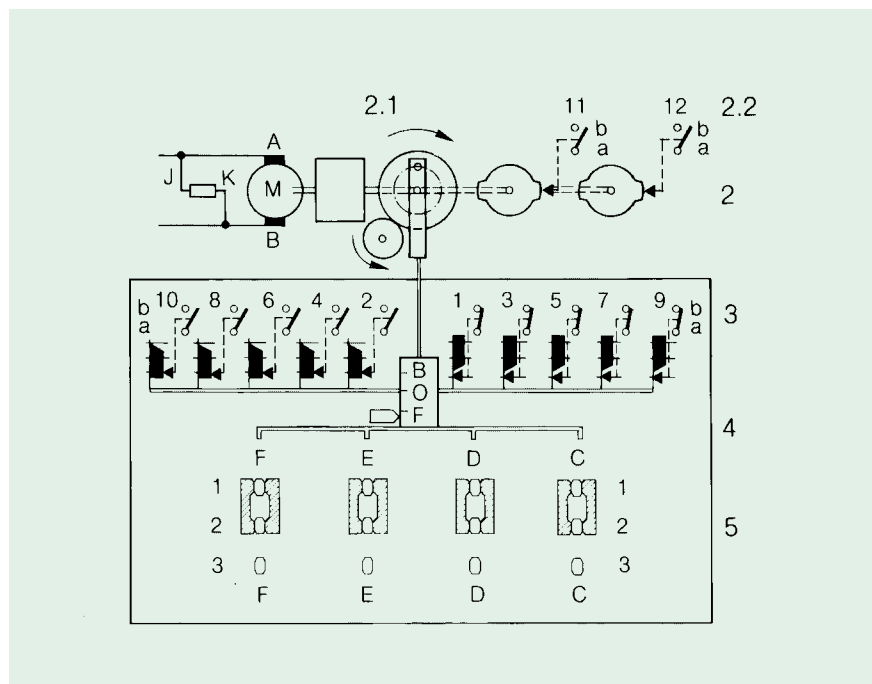
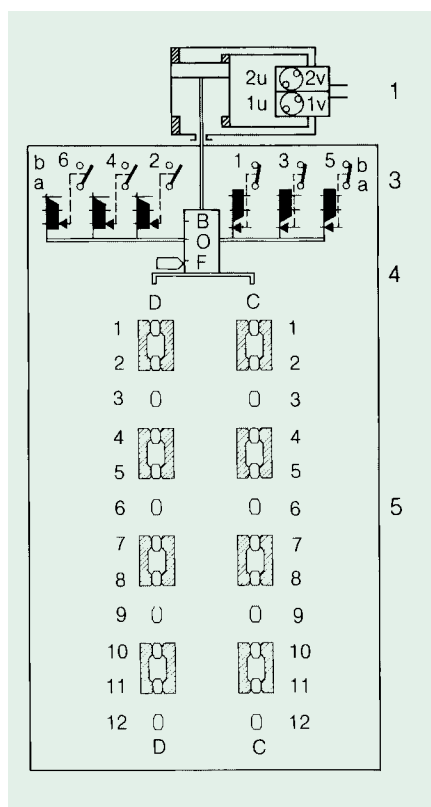
Fig. 2 – Basic circuit diagrams of linear selector with two switch positions.

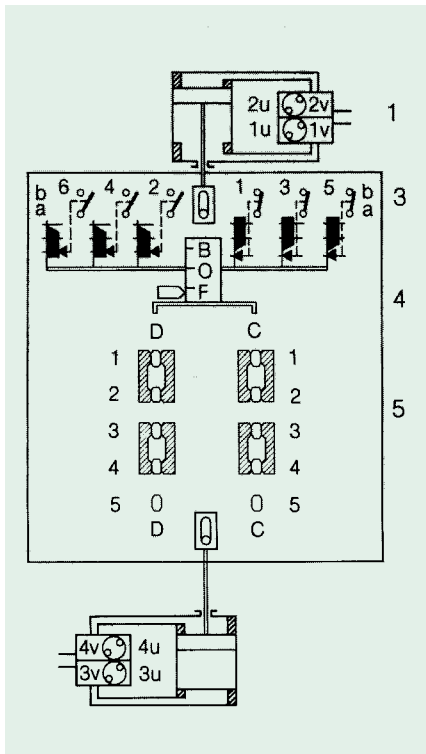
a: Type BWT 15.08/30.08 changeover device with pneumatic drive, 12 levels, 8 contact units and 2 rows of contacts.

b: Type BWU 15.08 changeover device with electro-motive drive, 3 levels, 4 contact units and 4 rows of contacts.

1 = Electro-pneumatic drive with dual-acting air-operated cylinder and two electrically operated valves.
2 = Electro-motive drive with intermediate gearing 2.1 and limit switch 2.2.

3 = Control switches.
4 = Position indicator.
5 = Contact units for main circuits (contact units with linear movement are shown hatched).





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Fig. 3 - Basic circuit diagram of a linear selector with three pneumatically controlled switch positions.

Symbols see Fig.2.

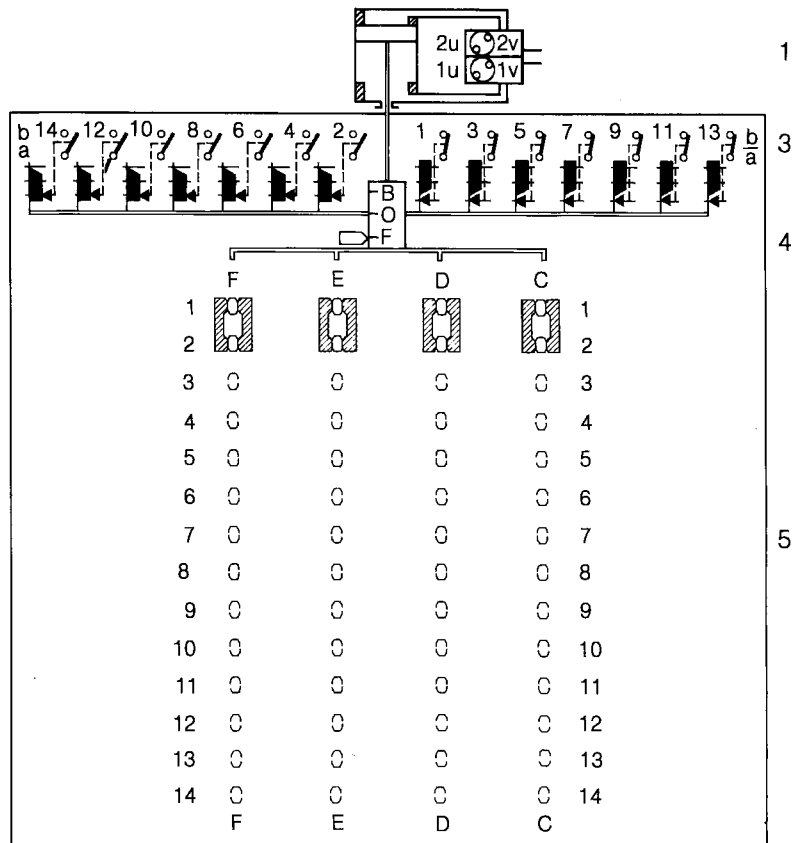


Fig. 4 - Basic circuit diagram of a linear selector with two switch positions.

Type BWU 15.08 changeover switch with a maximum of 14 levels and 5 rows of 4 moving contacts (vertical position).

Symbols see Fig. 2.

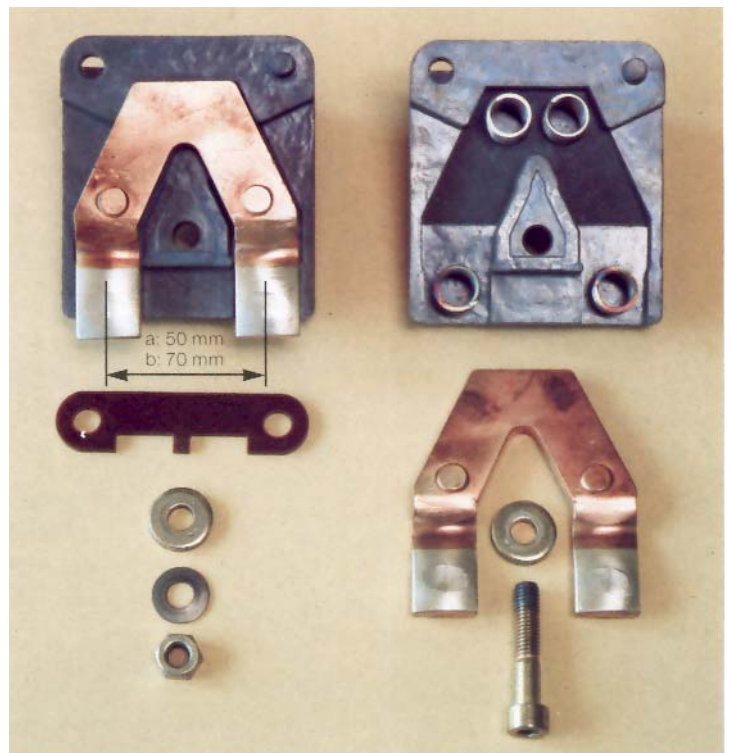
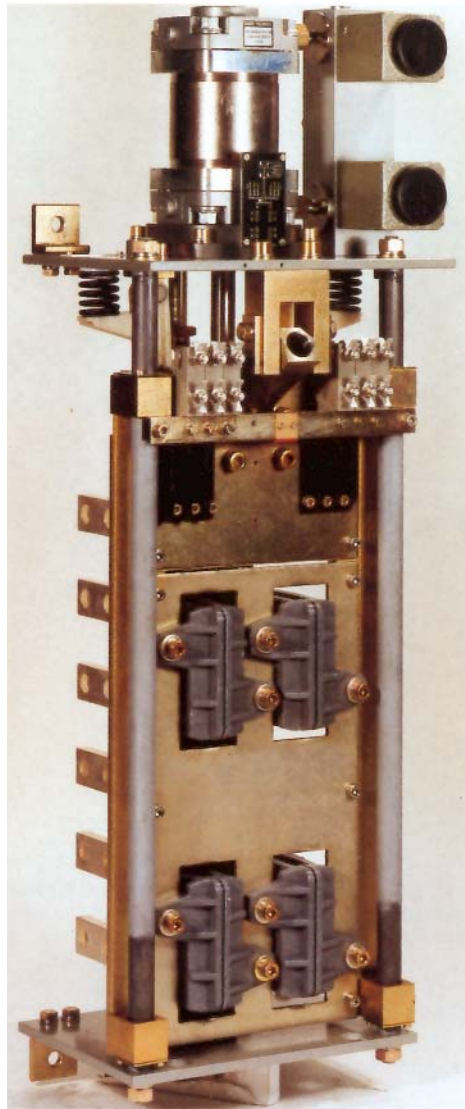


Fig. 5 - Contact unit for a type BWT/BWU changeover switch.

a = Rated voltage 1500 V (50 mm).
b = Rated voltage 3000 V (70 mm).

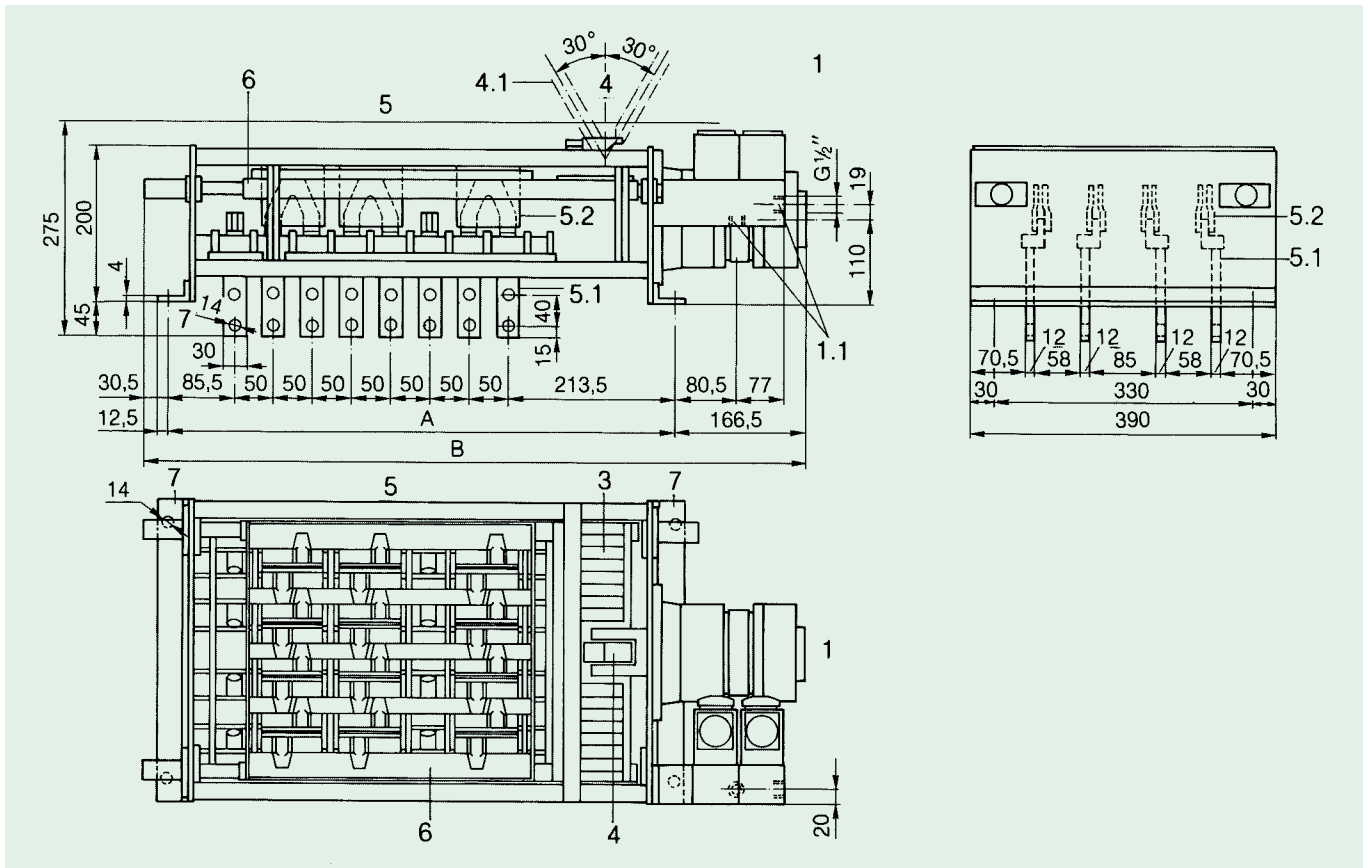
Fig. 6 – Type BWT 15.08 changeover switch with pneumatic drive, used as a direction reverser for two traction motor circuits of shuttle-service motorcoaches operating on Swiss standard gauge railways.

Max. traction motor voltage 750 V
 Max. traction motor current 1050 A
 One-hour traction motor current 600 A



Technical data of type BWT/BWU changeover devices (linear selector switches)

Type		BWT 15.08	BWU 15.08	BWT 30.08	BWU 30.08
Rated voltage	V	1500	1500	3000	3000
Max. operating voltage	V	1800	1800	3600	3600
Rated current					
- continuous	A	750	750	750	750
- one-hour	A	800	800	800	800
- 5 minutes	A	1200	1200	1200	1200
Short-time current (1 s)	kA _{mms}	20	20	20	20
Dynamic limit current	kA _{sw}	50	50	50	50
Weight	kg	31 to 55	35 to 115	33 to 63	37 to 110
Ambient temperature	°C		- 30 to + 80		
Mechanical lifetime		3 million switching operations			
Changeover time	s	approx. 0·5			
Drive voltage	Vdc	12 to 220			
Pneumatic drive					
- operating pressure range	MPa	0·4 to 1			
- power requirement at Un	W	8			
Electro-motive drive					
- power requirement at Un	W	approx. 200			
Control switch		BWT: 12 auxiliary contacts; BWU: 14 auxiliary contacts.			
Regulations		IEC Publication n° 7 (1968)			



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Fig. 7 - Assembly drawing of the type BWU 15.08 changeover switch.

- 1 = Electro-pneumatic drive.
- 1.1 = Optional compressed-air connection.
- 3 = Control switches.
- 4 = Position indicator.
- 4.1 = Handle for manual operation.

- 5 = Contact units for main circuits.
- 5.1 = Fixed contacts with main power terminals at rear.
- 5.2 = Contact unit in drive carriage.
- 6 = Drive carriage.
- 7 = Mounting brackets.

- A = Dimension A.
- B = Dimension B.
- n = Number of contact levels.

n	A mm	B mm
3	399	596
5	499	696
6	549	746
7	599	796
8	649	846
9	699	896
10	749	946
11	799	996
12	849	1046
13	899	1096
14	949	1146

The changeover switches of each series differ in the maximum number of terminals they offer:

Type	BWT	BWU
Number of contact rows	2	4
Number of levels	12	14
Number of terminals	24	56
Circuit diagram	Fig. 2a	Fig. 4

The *Table* shows the technical data of the BWT and BWU series of changeover switches.

Modular Subassemblies of the BWT and BWU Series

The two series (for both 1500 V and 3000 V) consist of the following, modular subassemblies:

- Contact modules comprising a linear contact unit and fixed contacts.
- Electro-pneumatic or electro-motive drive or hand.

- Drive carriages of variable length.
- Control switch bank.

The *contact unit* consists of a pair of moving contacts mounted in a block of moulded insulating material. In position, these contact units form electrically conductive bridges which can be moved between any two of three adjacent fixed contacts at different levels. The *fixed contacts* lead directly to the cable terminals in the traction motor circuits. The contact units represent the active elements of the drive carriages. The distance travelled by the carriages is exactly the same as the distance between the contacts. The units are capable of withstanding very high short circuits.

In both series there is a contact unit for each of the rated voltages of 1500 and 3000 V (*Fig. 5*).

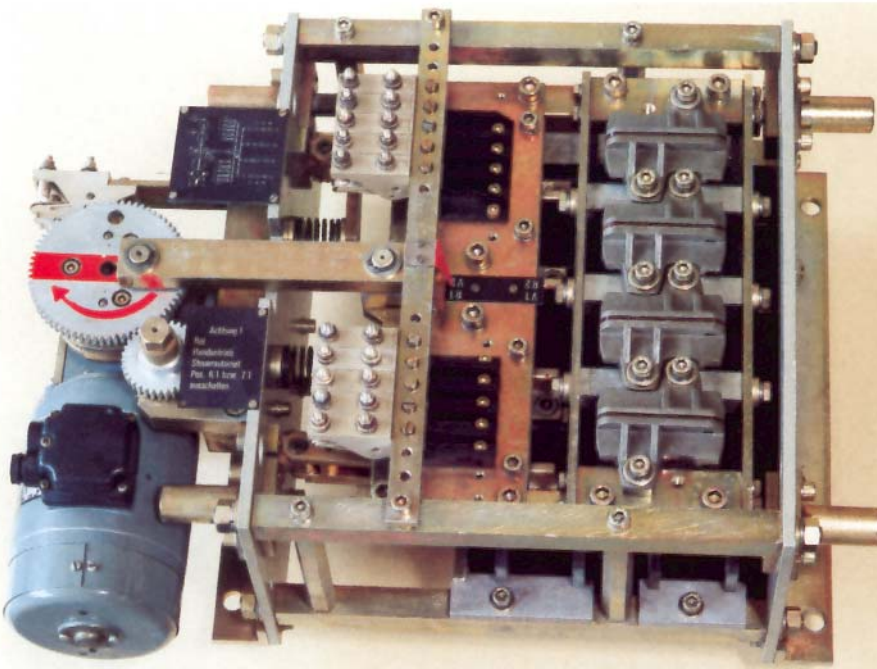


Fig. 8 – Type BWU 15.08 changeover switch with electro-motive drive, used in the traction motor circuit of all-electric two-coach trainsets class Be 8/8 on the Forch line, Zurich (mounted horizontally beneath the coach floor).

Rated traction motor voltage	1200 V
Max. traction motor current	500 A
One-hour traction motor current	350 A

Fig. 9 – Main equipment unit of multi-purpose main-line locomotive Re 4/4 IV of the Swiss Federal Railways for operation with single-phase a.c. at 15 kV/16 $\frac{2}{3}$ Hz.

Main equipment unit for the two dual-excited pulsating current traction motors of the driving bogie. The phase-angle controlled rectifier vehicle has a separately excited rheostatic brake.

Top: Electro-pneumatic contactors of type BPS for

- Motoring
- Braking
- Interpole shunting
- Separate excitation.

Centre:
Primary relay of type MAS-2 for detecting maximum currents.

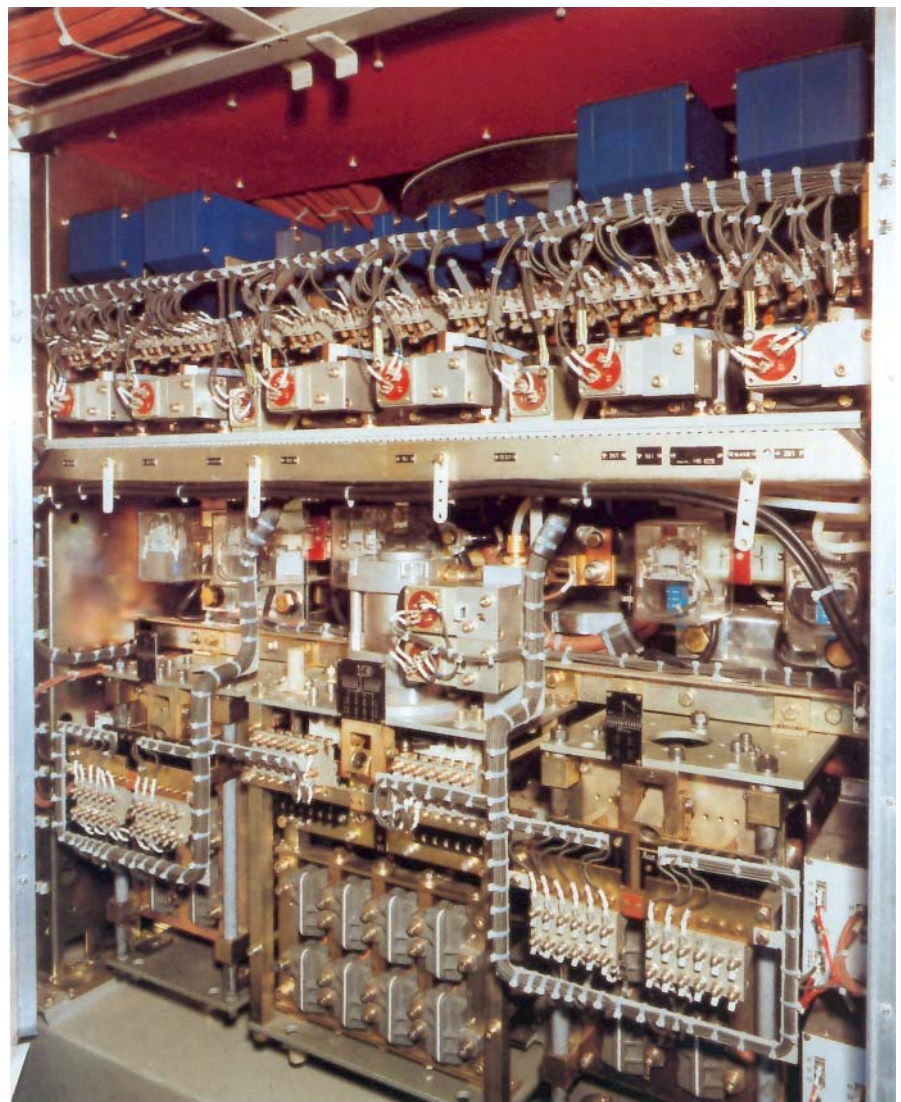
Bottom:
Linear changeover switches of the following types:

Centre: BWU 15.08 electro-pneumatically actuated reverser.

Left and right:
Type BWT 15.08 manually actuated traction motor selector (disconnect switch).

Max. traction motor terminal voltage 1120 V
Armature/main field current of
traction motor one-hour 1130 A
max. 1170 A

External field current of
traction motor one hour 200 A
max. 260 A



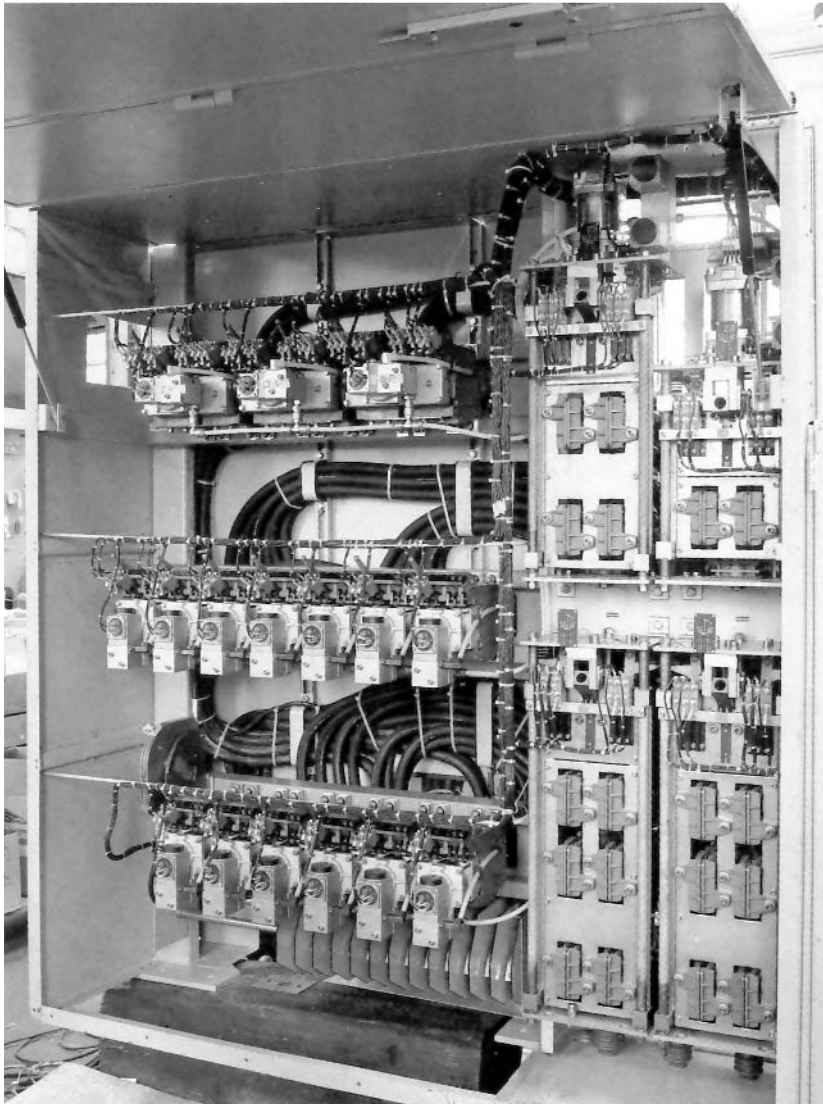


Fig. 10 – Main equipment unit of class 250 multi-purpose main-line locomotive of Red Nacional de los Ferrocarriles Españoles (RENFE) for operation with d.c. at 3 kV.

Main equipment unit for the d.c. series-wound dual traction motor (single-motor bogies) of the contactor-controlled vehicle. The locomotive is driven by pulsating current motors with rheostatic brakes separately excited via converters.

Left:
Bank of electro-pneumatic contactors of type BPS (with arc chutes raised).

Right:
Linear changeover switches of the following types.

Top left:
Type BWT 30.08 electro-pneumatically actuated motoring/braking selector switch.

Top right:
Type BWT 30.08 electro-pneumatically actuated direction reverser.

Bottom:
One type BWT 30.08 manually actuated traction motor selector (disconnect switch) for each half of the traction motor.

Max. traction motor terminal voltage	3600 V
Armature/main field current of traction motor	one-hour 870 A max. 1000 A

External field current of traction motor	one hour 500 A max. 500 A
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Solid silver plates are used as the contacts for 800 A. The fixed contacts are always silver-plated, irrespective of the rated current.

The *electro-pneumatic drives* consist of dual-acting compressed-air cylinders, each with two electro-pneumatically operated valves. They are of the same design for both 1500 V and 3000 V, but have different travels which can be adapted to other contact distances in accordance with the rated voltage.

The length of the drive carriages is varied according to the number of terminals and fixed contacts, there being two at each level for type BWT and four for type BWU. These are therefore the only components which vary according to the installation.

Standard type F switching devices, which are used throughout the entire range of traction equipment (e.g. electro-pneumatic and electro-magnetic contactors, tapchangers) are used as *control switches* for the auxiliary contacts.

Figure 6 shows a fully assembled changeover device of type BWT 15·08.

Design and Mode of Operation of Changeover Switches

The drawing in *Fig. 7* shows the main design features of a changeover switch.

Contact System

The contact system was designed with knife-type contacts to ensure that it

would be capable of withstanding high short-circuit currents. Springs set the contact pressure to 46 ± 5 N. Exact operation with greased contacts guarantees resistance to mechanical wear. Such contact systems, however, have no breaking capacity, i.e. the contacts are only capable of interruptions in which there is no arc. The upper current limit is 500 mA; this demonstrates the suitability of type BWT and BWU changeover devices as selector switches.

Drives

The switch is normally actuated by a rugged, dual-acting air-operated piston, the cylinder of which has builtin end-dampers. Two electro-magnetically actuated valves are mounted directly on the operating mechanism, which they control. The valves have been designed for a 100% duty cycle and can therefore be kept energized for any length of time. Both end positions of the selector switch are notched. A handle can be inserted for manual operation or, if required, to set the switch to the contactless, neutral position. As shown in Fig. 3, movement to the neutral position may also be electro-pneumatically controlled or the position may be provided with a notching facility.

The electro-motive drive is intended particularly for all-electric vehicles, i.e. those without a supply of compressed air (Fig. 8).

Installation, Maintenance

Changeover devices of types BWT and BWU must be installed in special compartments or boxes to protect them from moisture and brake dust. Up to 8 levels, the changeover device can be installed in either position. Beyond that, we advise the vertical position (Fig. 8).

The switch design ensures good access to all parts of the apparatus which might require maintenance or operation. These include contacts, cable connections, compressed-air connections, control wires and the manual operating mechanism. Features important for quick assembly and maintenance of the apparatus are the rear-mounted power terminals and the front arrangement of all contact units.

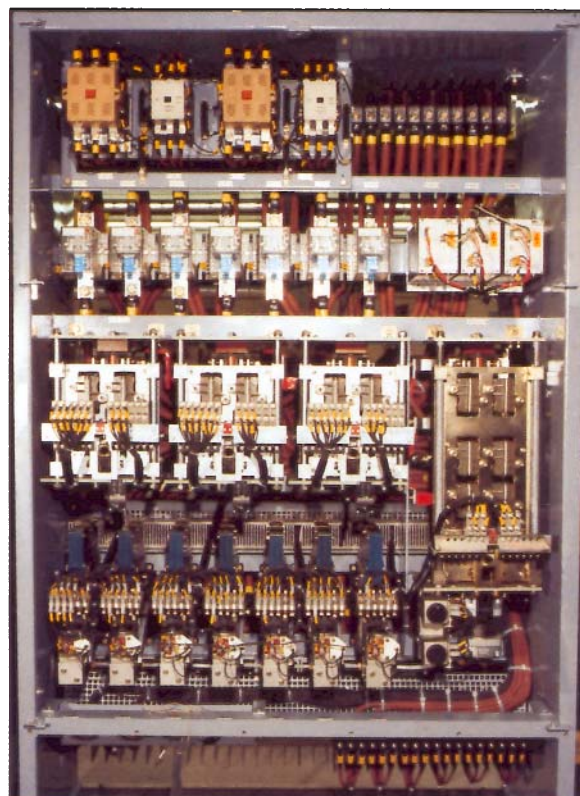


Fig. 11 – Main equipment unit of class EL 1 main-line locomotive of the National Railways of Zimbabwe (NRZ) for operation with single-phase a.c. at 25 kV/50 Hz.

Main equipment unit for the three dual-excited pulsating current motors. This traction vehicle with sector-controlled rectifier has separately excited rheostatic brakes.

Top half:
Various monitoring and protection equipment.

Centre:
Linear changeover switches of the following types:

On left:
One type BWT 15.06 manually actuated selector switch for each traction motor.

On right:
Type BWT 15.06 electro-pneumatically actuated direction reverser.

The moving contacts of the contact units can be taken out by simply removing two screws. To carry out the periodic overall inspection of the moving and fixed contacts, it is sufficient to remove only four screws (six for the fixed contacts), after which the drive carriages can be lifted off. There is no need for any additional dismantling in order to remove the electro-pneumatic or electro-motive drives for maintenance, etc.

Bottom:

Bank of type BPS electro-pneumatic contactors for:

- Motoring
- Braking
- Separate excitation.

Max. traction motor terminal voltage	850 V
Armature/main field current of traction motor	one-hour 590 A max. 735 A

External field current of traction motor	one hour 290 A max. 375 A
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Type Tests

Type tests were carried out on representative changeover switches of types BWT and BWU to confirm the technical data. These were carried out in accordance with IEC recommendations¹ and comprised:

- Function testing in accordance with operating conditions.
- Verification of dielectric strength.

¹ IEC 77

- Heat tests
- Mechanical tests involving up to three million switching operations without maintenance
- Surge current tests in accordance with the Table

The results of the tests came up to all expectations. Despite the lighter and more compact design of the newly developed changeover devices, it has been possible to achieve the high reliability for minimum wear required for traction applications, in which switching is frequent. Previous experience has shown that when switches are assembled and maintained according to instructions and operating conditions are acceptable, there is practically no contact wear at all.

Summary

The changeover devices presented in the above perform the switching duties required in traction motor circuits. The compact, space-saving modules are designed for specific functions (*Fig. 9 to 11*). Special features are the linear positioning, which permits a transparent power cable layout and the high short-circuit withstand capability of the selector switches, which ensures high operational security. The modular concept and the ease with which the contact units can be replaced assure rational production and shorten the time needed for inspections and maintenance.