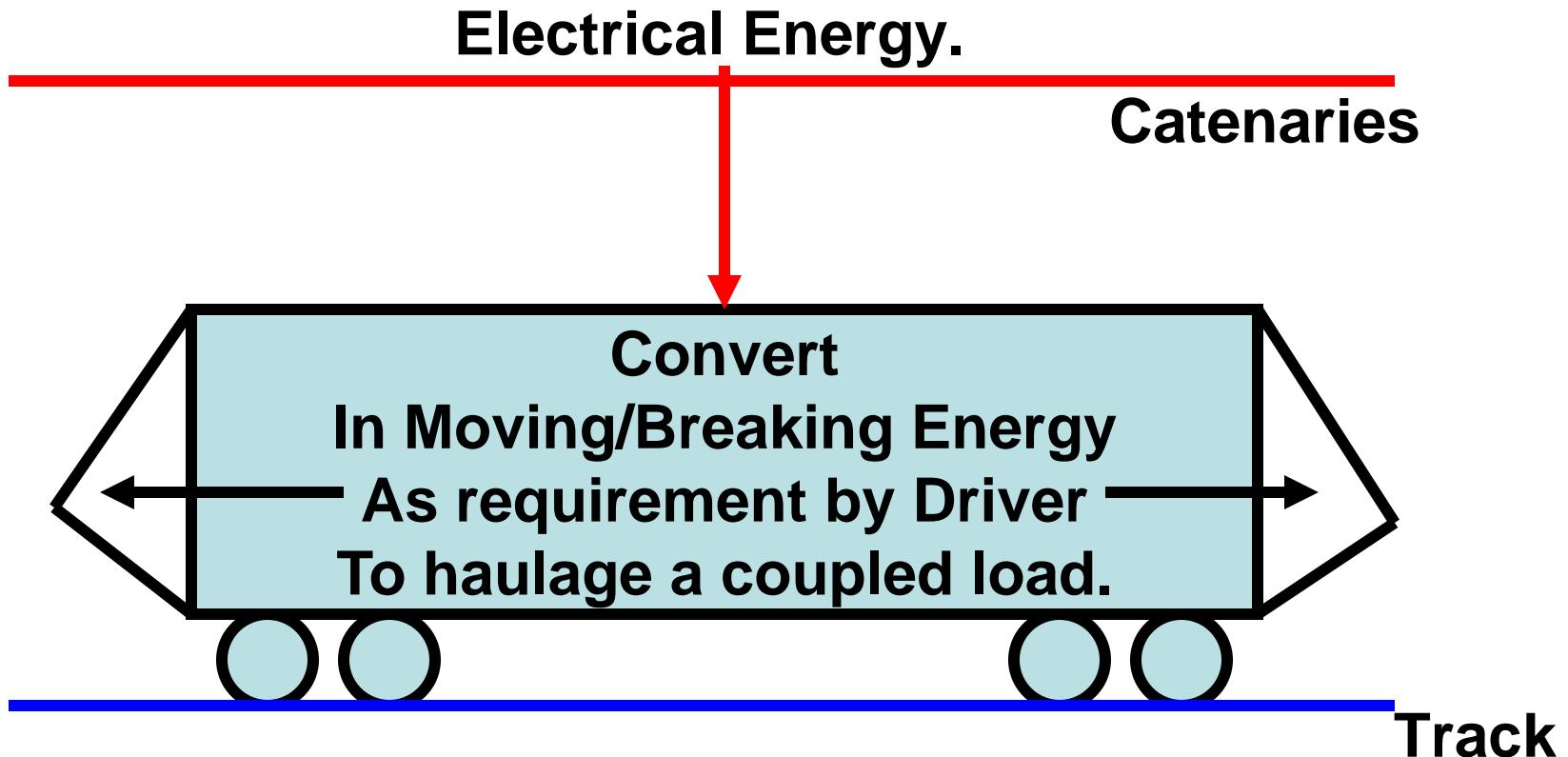


INTRODUCTION OF 3PH LOCO.

PREPARED BY : VINOD KUMAR (ELECTRICAL) RTU,ALWAR

What is an Electric Locomotive.



Available Electrical Energy

For Electric Locomotive.

- 1. 25KV 50Hz AC.
 - Phase connected by top catenary wire.
 - Neutral (Earth) connected by Track.
- 2. 1.5KV DC.
 - Positive connected by top catenary wire.
 - Negative (Earth) connected by Track.

W- Stands for Broad Gauge 1676 mm.

A- Stands for A.C Train

G- Stands for Goods

P- Stands for Passenger traffic

Locomotive working on 25KV 50Hz AC & 1.5KV DC.

- **WCAM1** Mixed Service.
- **WCAM2** Mixed Service.
- **WCAM3** Mixed Service.
- **WCAG1** Goods Service.

Locomotive Working on 25KV 50Hz AC.

- **WAM4 Mixed Service.**
- **WAG5 Goods Service.**
- **WAG7 Goods Service.**
- **WAP1-4 Passenger Service.**
- **WAP5 &7 Passenger Service.**
- **WAG9 Goods Service.**

- ❖ **Locomotive working on.5KV DC.**
- **WCG2 Goods Service.**

WAM4



WAG5



WAG5HB



WAG7



WAP1-4



WAP5

[CLICK HERE TO
VIEW CD CONTENTS](#)



WAP7



WAG9



WAG9H



WAG9H



WAG 9



Type of Service	Freight
Supply System	25 kV, AC, 50 Hz
Class of Loco	WAG-9
Track Gauge	1676 mm (Broad Gauge)
Axle Arrangement	Co-Co
Brake System	Air, Regenerative and Parking
Total Weight	$123 \pm 1\% t$
Axle Load	$20.5 \pm 2\% t$
Overall width of body	3152 mm

WAG 9



Length of cab	2434 mm
Panto locked down height	4255 mm
Traction Motor type	6FXA 6068,3-Phase Squirrel cage Induction Motors
Traction Motor mounting	Axle Hung Nose suspended
Starting Tractive Effort	460 kN
Continuous Power at wheel rim	325 kN
Maximum Regenerative Braking Effort	260 kN
Maximum Service Speed	100 Km/hr
Control System Voltage	110 V DC
Drive System	System 3 phase Drive with GTO Thyristors and microprocessor based VVVF control
Multiple unit operation	Maximum 2 Locos

GENERAL FEATURES OF 3-PHASE AC LOCO.

- **Conventional.**
- Old Technological Features are used: -
- Old DC Series Motor traction drive system Existing.
- DC series motor are more parts (Field & Armature windings,commuter,brushes) since more maintenance.
- **3Ph Loco.**
- Advanced Technological Features:-
- In addition to the provision of latest 3-phase traction drive system.
- The 3 phase induction motor are less parts (Stator & Rotor) since less maintenance.

- **Conventional.**
- Electrical traction control system.
- More wiring, relays and equipments are required for modifications.
- **3Ph Loco.**
- Digital electronics based real time traction control system: -
 - To obtain precise control over tractive effort, speed and other systems.
 - Software controlled system since Functional modifications easy by changing in software.

- **Conventional.**
 - Not Existing & require Manual trouble shooting like Ckt tracing, Relay wedging, bypassing & isolation of defective system.
- **3Ph Loco.**
 - **On-board fault diagnostics system:** -
 - To eliminate/ elaborate trouble-shooting by engine crew and also to help maintenance staff to trace faults. The fault diagnostics system provides for automatic isolation of faulty equipment/ subsystems.

- **Conventional.**
- Simulation mode not existing but LT testing done by put in Loco ground position.
- **3Ph Loco.**
- **Simulation mode of operation:** -
 - To facilitate a complete functional testing of the locomotive without raising pantograph.

- **Conventional.**
- Harmonic filter circuit not Existing but R-C network ckt across Aux. & Power Ckt. Capacitor & ET (Gap less lightening arrester Ckt across Power Ckt.
- **3Ph Loco.**
- An exclusive harmonic filter circuit: -
- To reduce harmonics in the loco current.

- **Conventional.**
- **Rotating Machine Arno Converter:** -
 - To supply 3 phase Aux. Motors. Winding copper & Frictional loss, vibration Existing since less efficiency & more maintenance Existing.
- **3Ph Loco.**
- **Static auxiliary converter:** -
 - To supply auxiliary 3 phase motors. The auxiliary converter, depending on the traction load, operates at an optimum frequency to minimize power consumed by auxiliaries.

- **Conventional.**
- Not Existing.
- **3Ph Loco.**
- **Fire detection and alarm system:** -
 - For detection of the machine room fire & alert Driver by alarm & display a fault message.

- **Conventional.**
- **No more space to provide comfort and relief to crew.**
- **3Ph Loco.**
- **Ergonomically designed and spacious driving cabs:** -
 - To provide comfort and relief to crew.

- **Conventional.**
- **Side Body filters are used:-**More gap between Blower & filter.
- Vaccumized machine Room since more dust are enter in equipments in the machine room.
- **3Ph Loco.**
- **Use of inertial filters:** -Blowers are directly connected to filters.
- Pressurized machine room to prevent entry of dust into sensitive equipment in the machine room.

- **Conventional.**
- Pneumatically controlled Air & Vacuum brake system are existing.
- **3Ph Loco.**
- **Electronically controlled brake system:** -
 - For precise and fast control of braking effort, blending between electrical brake and pneumatic brake on the locomotive.

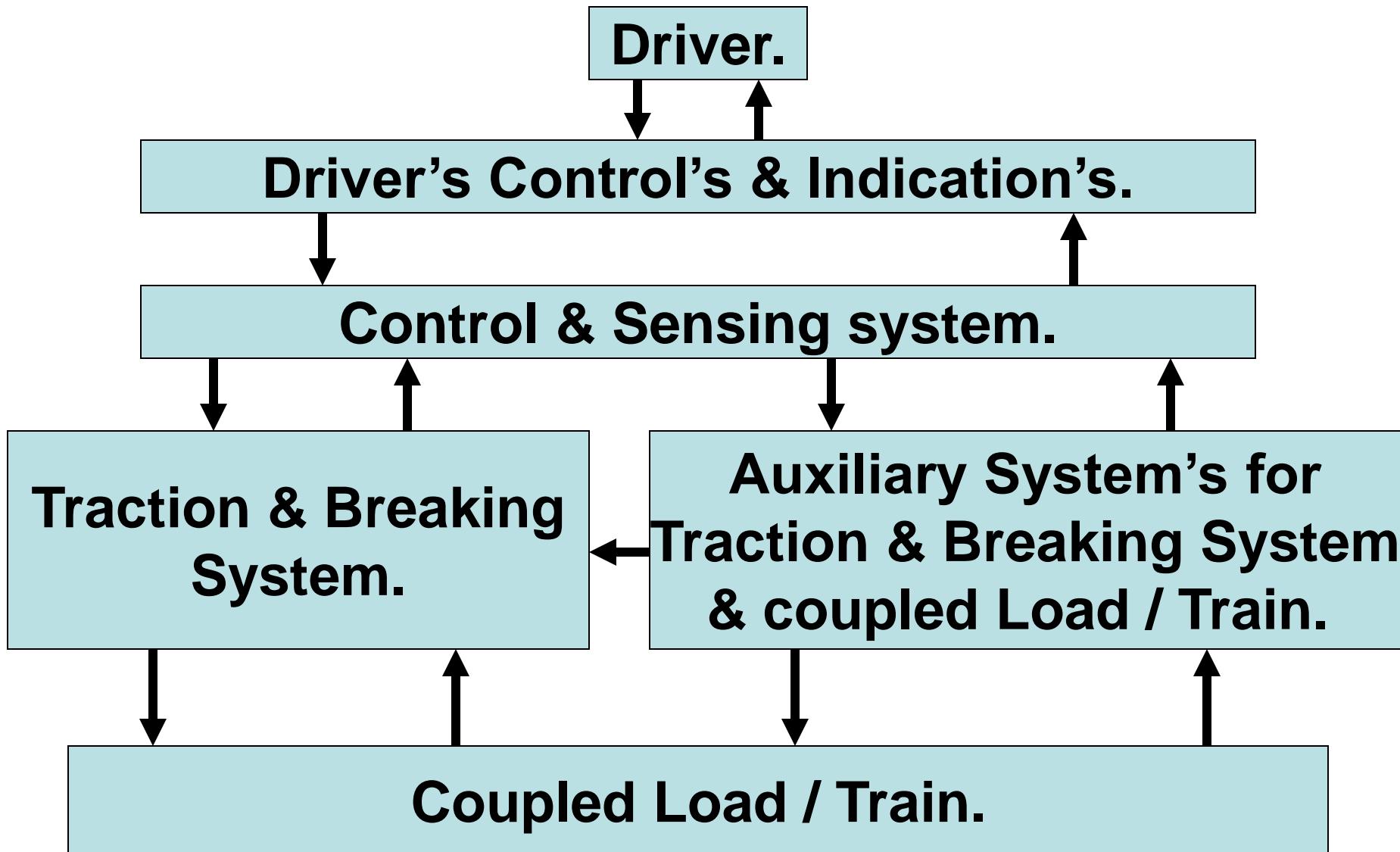
- **Conventional.**
- **Modular Triplet Panel not existing: -**

Pn. Equip. fitted on different locations since more piping.
- **3Ph Loco.**
- **Triplet pneumatic brake panel :-**
- To minimize piping and provide single-place location of all pneumatic equipment.

- **Conventional.**
- Manually operated Hand brake system existing.
- **3Ph Loco.**
- Spring loaded parking brake system: -
 - Spring loaded parking brakes are provided on this loco, these brakes can be operated from loco and remain applied without pressure by spring.

- **Conventional.**
- Not existing.
- **3Ph Loco.**
- **Electronic controlled vigilance system:** -
 - To keep the loco pilot alert Vigilance system is provided, As per this system, loco pilot has to do predetermined task once within 60 seconds, otherwise VCD will apply emergency braking.

Basic Electric Locomotive.



Driver.

- Conventional.**

- Operate the Loco control's as per requirement's.
- Read the Indication's, if found abnormal record it in Log Book.
- Monitor & control different parameter's (TM current & voltage, air Pr., vacuum).

- 3 Ph Loco.**

- Operate the Loco control's as per requirement's.
- Read the Indication's, if found abnormal its already stored in fault memory.
- All parameter monitored & controlled by MICAS S-2 Microprocessor controlled electronic control system. (Diff. voltages, currents, temperatures, frequency, Air pressures).

Driver.

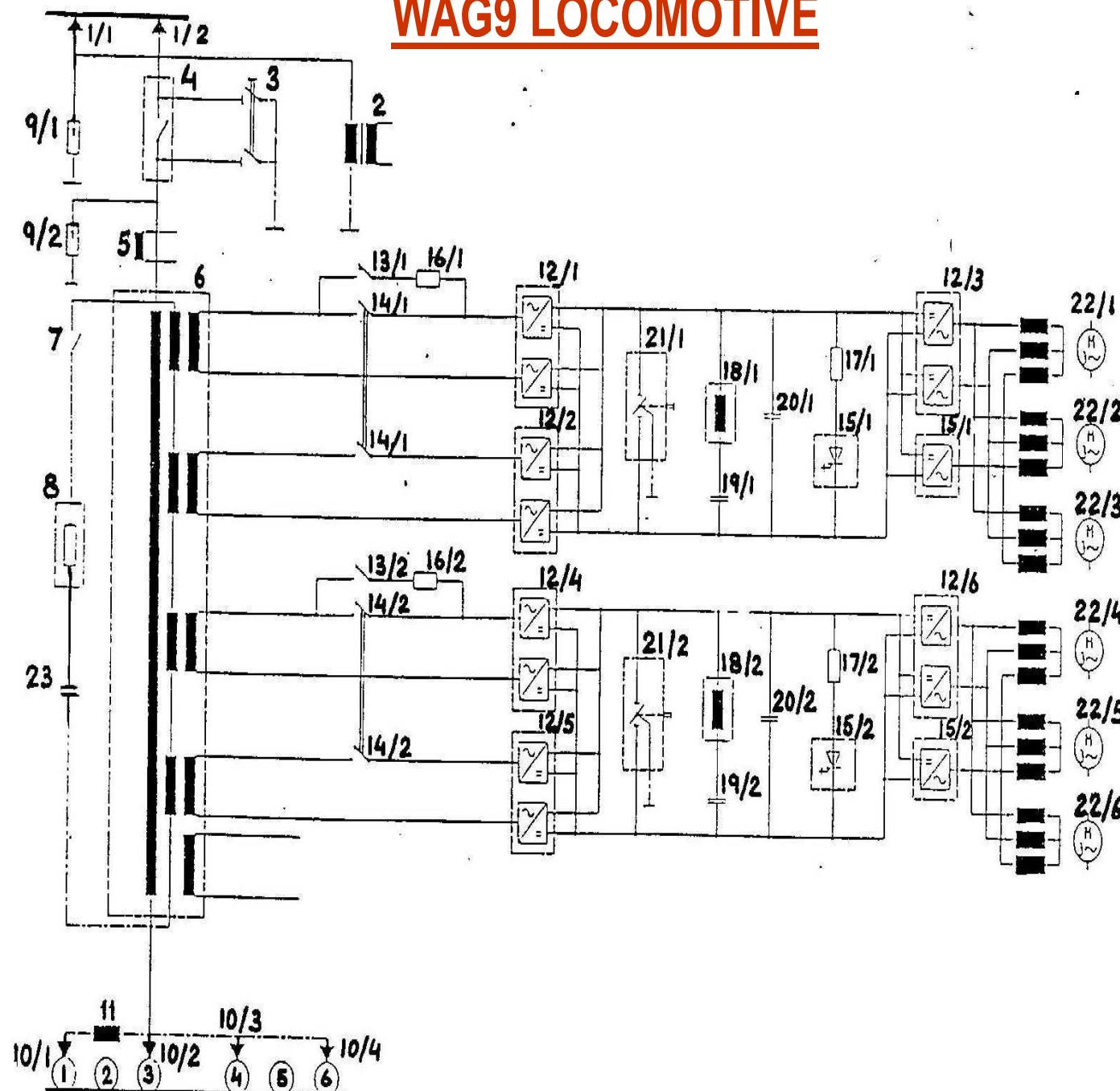
- **Conventional.**
 - No any system existing.
 - Dynamic rheostat elect. Braking existing but less effective.
 - Key set consist BL,ZPT & MPJ Key.
 - Not Existing.
 - Not Existing.
- **3Ph Loco.**
 - Fire detection system existing for detecting fire in machine room.
 - More effective regenerative elect. braking system existing.
 - Key set consist Cab Activation key & Auto Brake Controller Key.
 - Automatic Anti Spin Brake system Existing.
 - Emergency Stop Push Button for fast shutdown of Loco Existing.

Chapter - 1

TECHNICAL DATA

Technical Data	WAP5	WAP-7	WAG9
Type of Service	Passenger	Passenger	Freight
Axle Arrangement	Bo-Bo	Co-Co	Co-Co
Gear Ratio	1:3.65	1:3.6	1:5.133
Gauge	1676 mm	1676 mm	1676 mm
Length over Buffer	18162 mm	20562 mm	20562 mm
Overall Width	3142 mm	3100 mm	3152 mm
Maximum Height with Pantograph Locked	4255 mm	4255 mm	4255 mm
Wheel Diameter New	1092 mm	1092 mm	1092 mm
Worn	1016 mm	1016 mm	1016 mm
Total Weight	78 T	123 T	123 T
OHE Voltage Nominal	25 KV	25 KV	25 KV
Minimum	17.5 KV	17.5 KV	17.5 KV
Maximum	30 KV	30 KV	30 KV
OHE Frequency Nominal	50 Hz	50 Hz	50 Hz
Minimum	45 Hz	45 Hz	45 Hz
Maximum	55 Hz	55 Hz	55 Hz

WAG9 LOCOMOTIVE

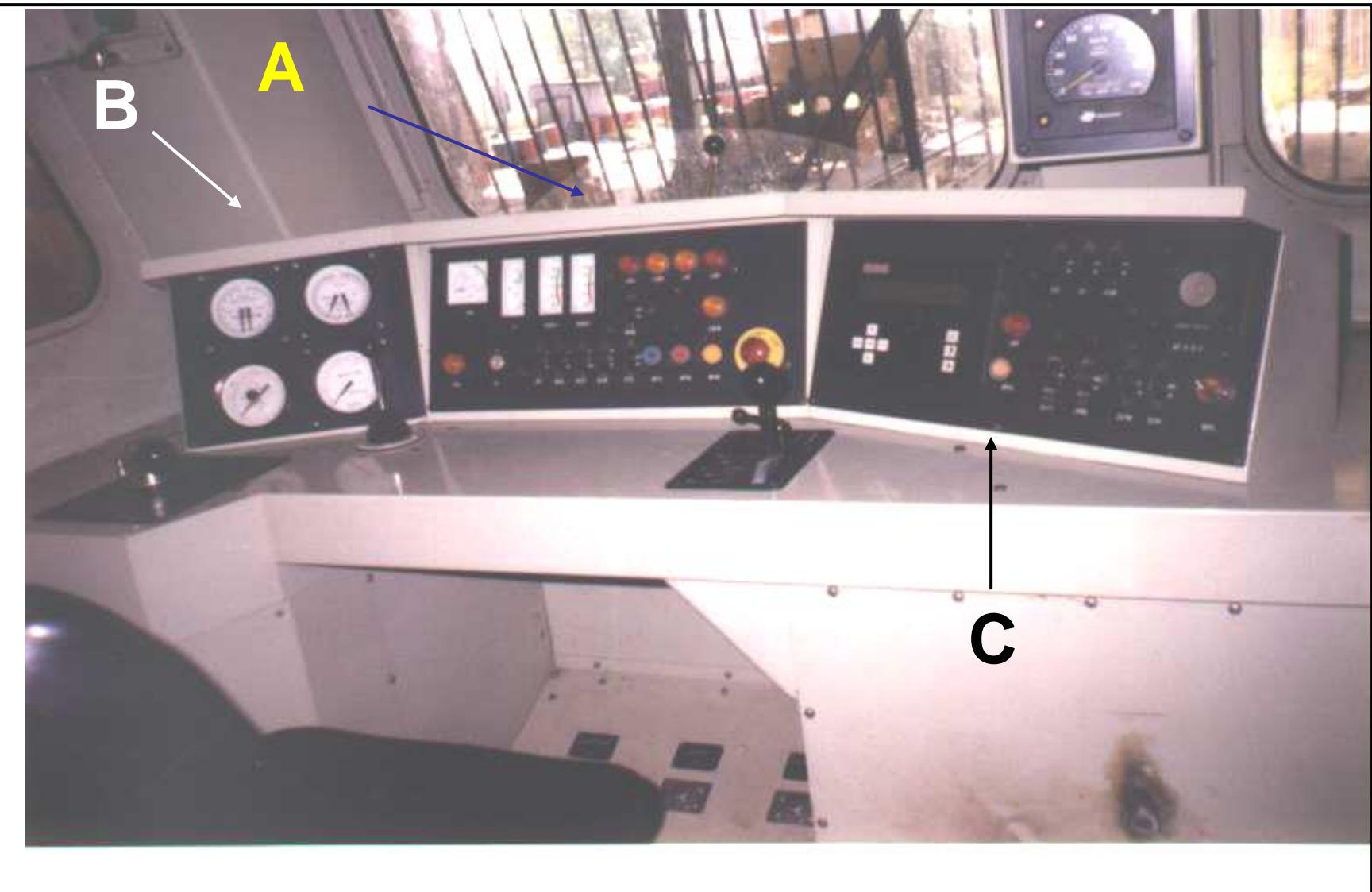


1. Pantograph
2. Primary voltage transformer
3. Earthing switch VCB
4. Main circuit

Traction Power Circuit:

Power from the overhead Catenary is directed to the main transformer, Mounted on the locomotive under frame, via the pantograph. The traction Circuit is split into two separate circuits after the main transformer. The traction converters can conduct current from the Catenary to the traction Motors to provide propulsion, or can act as in the opposite manner conducting, and rectifying, current from the traction motors to the Catenary. This allows the converter to work in both traction and braking mode. During braking the traction motors act as generators feeding power back into the catenary. The traction converters then act to convert the three phases into single phase for the catenary. The traction converters provide continuous and automatic control of both speed and torque of the traction motors according to the driver's demand. The converters are controlled by the converter control electronics, and the locomotive central electronics. Three, 3-phase synchronous traction motors are connected in parallel to each traction converter

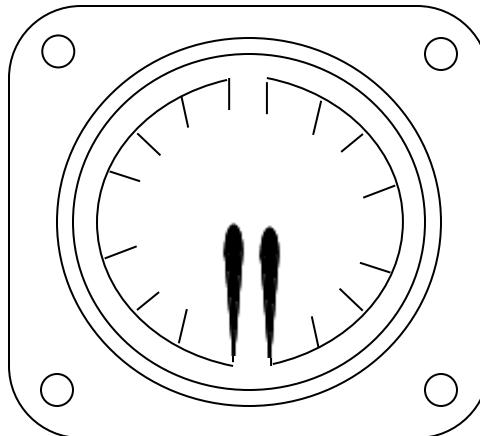
Drivers Cab



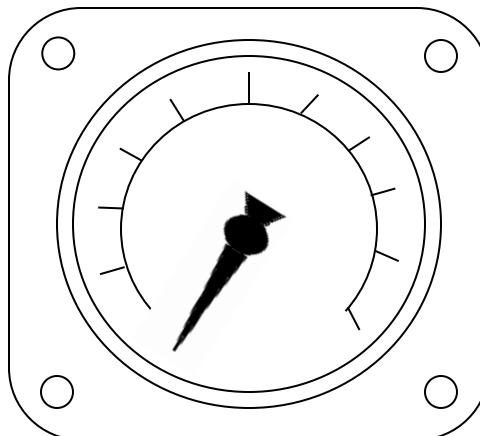


PANEL B

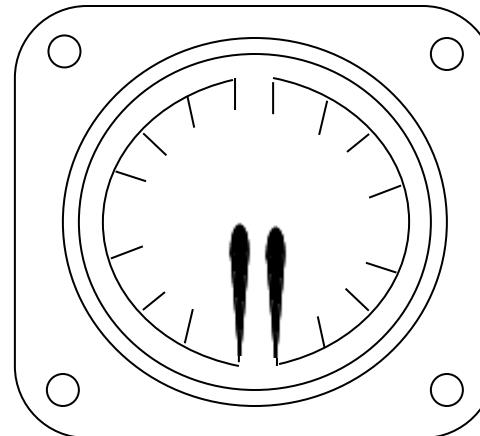
**Pressure Brake
Cylinder Bogie
1+2**



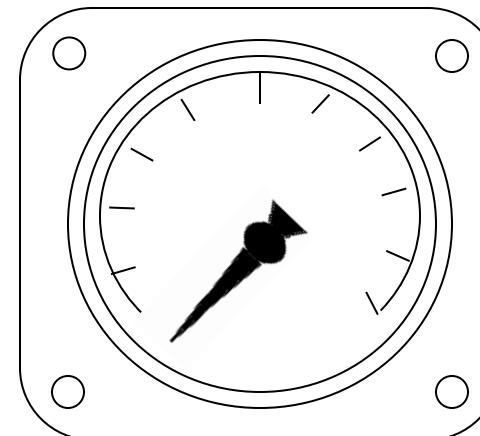
Air Flow Meter



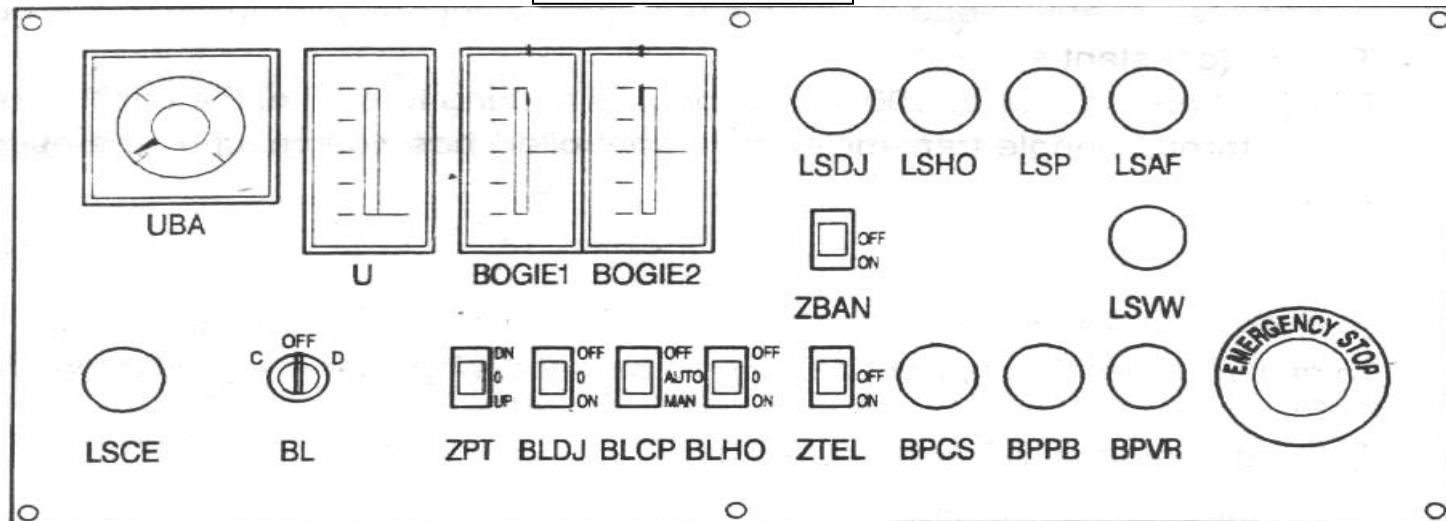
**Pressure Brake
Feed Pipe/Main
Reservoir**



**Pressure
Brake
Pipe**



Panel A



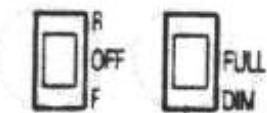
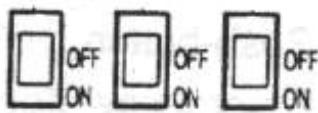
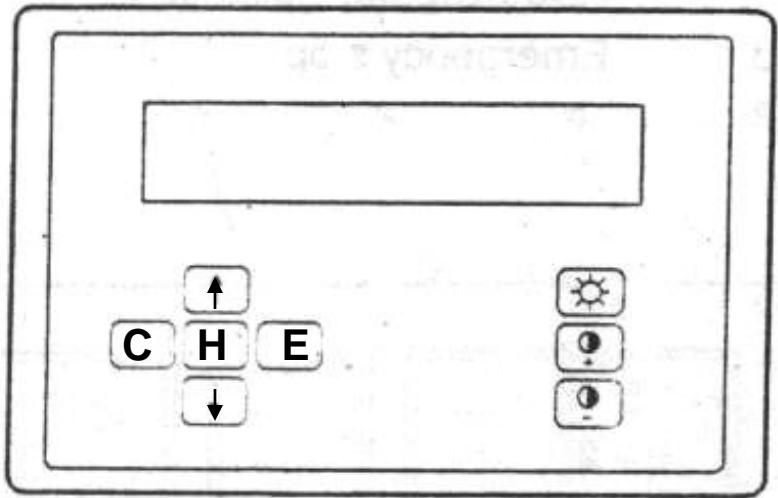
1. UBA Voltmeter Battery voltage
2. U Voltmeter Catenary voltage
- 3 .BOGIE 1 TE/BE meter - Traction / braking effort, bogie 1
- 4 .BOGIE 2 TE/BE meter - Traction / braking effort, bogie 2
- 5 .ZBAN Spring loaded switch – Banking operation “ON” / “OFF”
- 6 .LSDJ Indication lamp, red - Main circuit breaker “OFF”
7. LSHO Indication lamp, yellow - Hotel load “ON” (Inactive on WAG-9)
- 8 .LSP Indication lamp, yellow - Wheel slipping
9. LSAF Indication lamp, red - Train parting
10. LSVW Indication lamp, yellow - Vigilance warning
11. LSCE Lamp, amber - Over temperature CEL
- 12 .BL Key switch - Activation of Driver's cab
- 13 .ZPT Spring—loaded switch - Raise / Lower Pantograph
- 14 .BLDJ Spring—loaded switch –Main circuit breaker “ON” / “OFF”
15. BLCP Spring—loaded switch - Main compressors AUTO mode “ON”/“OFF”

16. BLHO Spring—loaded switch - hotel load “ON”/ “OFF” (Inactive on WAG-9)
17. ZTEL Switch - Max. Traction limitation
- 18 .BPCS Illuminated pushbutton – green-constant Speed control
19. BPPB Illuminated push—button- red - Parking brake
- 20 BPVR Push—button, yellow Resetting vigilance
- 21 Emergency Stop - button – red - Emergency stop

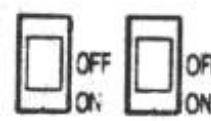
Panel C

1. Screen Display of messages diagnosis
- 2 .LSFI Indication lamp, red - Fault message, priority 1
- 3 .ZLC Switch - Driver's cab lighting
- 4 .ZLI Switch - Instrument lighting
- 5 .ZLDD Switch - Driver's desk illumination
- 6 .B-Z-V-O-F- Buzzer - Warning signal,3 frequencies
- 7 .BPFA Illuminated push - button, yellow - Acknowledgement all fault messages
- 8 .BLPR Switch - Head Light, Bright
- 9 .ZPRD Switch - Headlights, Dim
10. ZLFW Switch - Marker lights, white
- 11 .ZLFR Switch - Marker lights, red
- 12 .BPFL Illuminated push - button, yellow - Emergency flash light

Panel C



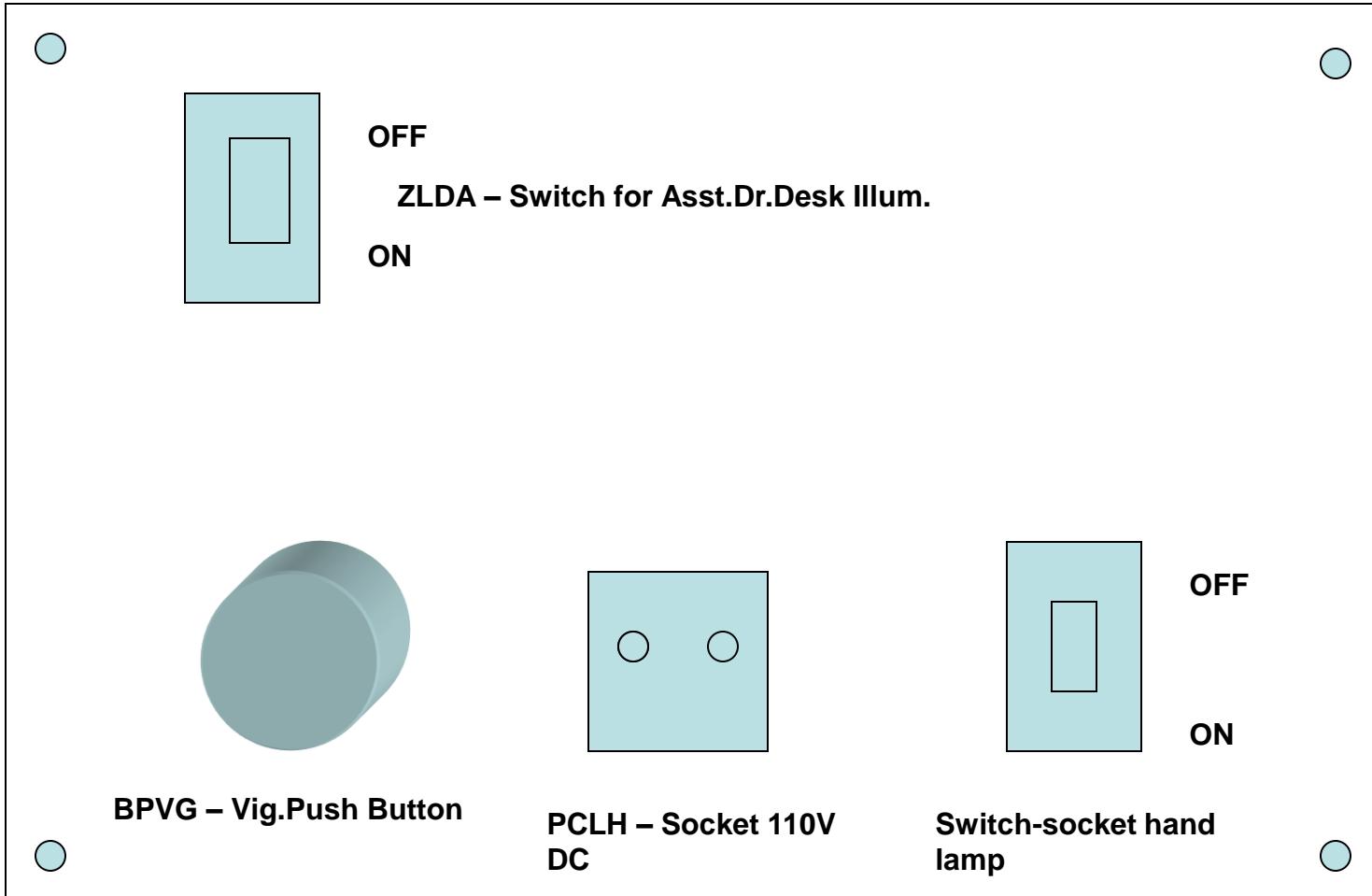
BLPR ZPRD



ZLFW ZLFR



PANEL - D



Master Controller

3 Phase Loco

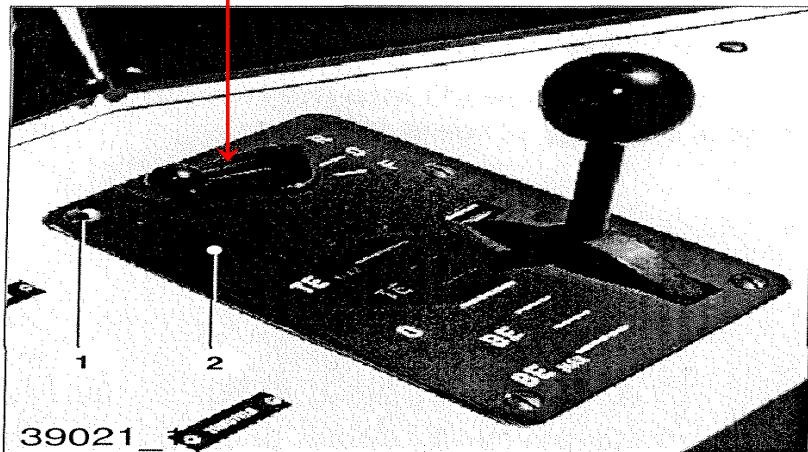


Conventional Loco

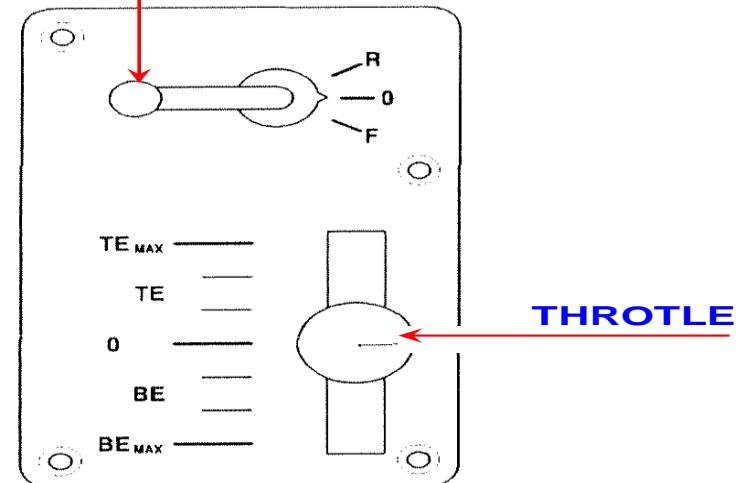


MASTER CONTROLLER

REVERSER



REVERSER



BL KEY

THREE POSITIONS

☞ C - Cooling mode

☞ O - Neutral

☞ D - Driving mode

REVERSER

- ☞ Three positions F, O, R
- ☞ If reverser is on ‘O’, TE/BE can not be moved
- ☞ Mover reverser in ‘F’ or ‘R’ direction

METERS

- ☞ Pressure gauge - FP, MR
- ☞ Pressure gauge - BP
- ☞ UBA, U
- ☞ BP flow indicator, BC pressure
- ☞ TE/BE Meters - Two Nos. (B1 & B2)
- ☞ Angle transmitter fails
 - 0, 1/3 TE, 2/3 TE Tmax
 - 0, 1/3 BE, 2/3 BE, BEmax

PUSH BUTTON SWITCHES

- ☞ **BPCS** Constant speed
 - ☞ **BPPB** Parking brake not > 5 Kmph
 - ☞ **BPVG** Vigilance alarm acknowledgement
 - ☞ **BPFA** Fault acknowledgement
 - ☞ **BPFL** Flasher light
 - ☞ **ZBAN** Switch for banking
 - ☞ **ZTEL** Max. limit for traction (WAP 5 isolated)
 - ☞ **ZLC** Cab light
 - ☞ **ZLI** Instrument light
-

FOOT PEDAL SWITCHES

- 👉 **Sanding**
- 👉 **Loco brake release**
- 👉 **Vigilance acknowledgement .**
- 👉 **VIGILANCE MODE**
 - **Every 60 Sec. acknowledgement.**
 - **Press foot switch for vigilance (Driver side)**
 - **Press foot switch for sanding**
 - **Press BPVR (Driver side) OR BPVG (Asst.Driver)**
 - **Move TE/BE throttle**

DRIVING EQUIPMENTS

- ☞ Master controller
- ☞ TE/BE throttle
- ☞ Operated with the help of angle transmitter
- ☞ $T_{max} - O - BE_{max}$
- ☞ Maximum increase - 20 KN/Sec

2.4.1.1 Roof layout

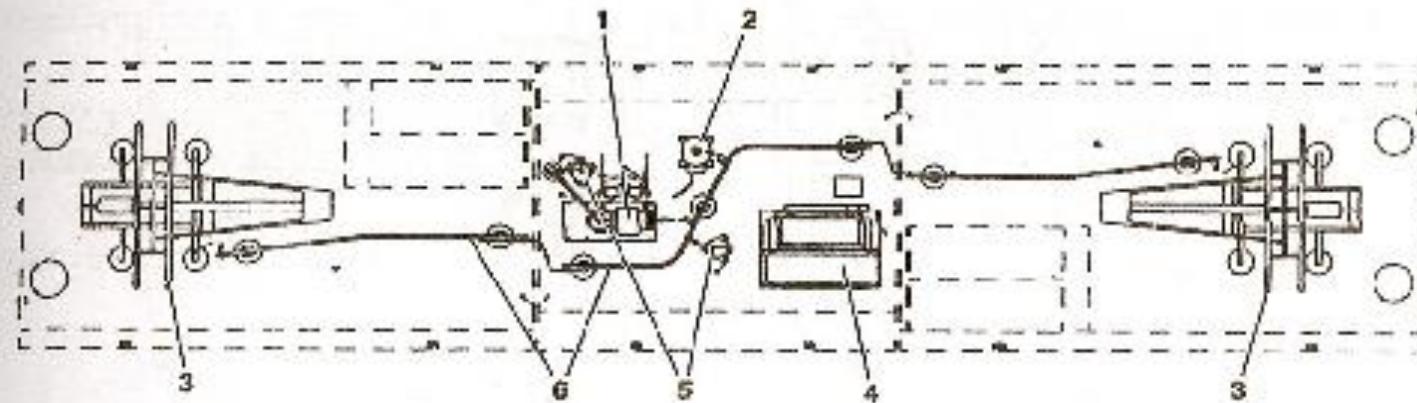


Fig. 2.3 Roof layout

- 1 Main circuit breaker
- 2 Transducers
- 3 Pantograph
- 4 Resistor harmonic filter
- 5 Surge arrestor
- 6 Roof line

Pantograph:

Two pantographs are provided on either end of loco. Design Of pantograph is same as other AC locos. For raising and lowering of pantograph one switch 'ZPT' is provided on panel 'A' having 2 positions, UP and DOWN.

When we press switch down ward (i.e. position UP) and release -panto will up.
When we press switch upward (i.e. position DOWN) and release -panto will lower.

Note:The rear panto will rise automatically.

Selection Of Panto:-

Panto selector switch is provided on Pneumatic Panel in machine Room

Auto - Normal position (only rear panto will raise)

I - Panto of Cab-1 will raise (2 will isolate electrically)

II - Panto of CAB-2 will raise (1 will isolate electrically)

For isolation of both panto pneumatically,there are two COCKS provided on Pn. Panel. PAN-1&PAN-2.Normally these coc should be opened Horizontal).

For isolating particular panto keep that coc on closed position (i.e Vertical)

One circuit breaker(127.12 Circuit breaker Pantograph, VCB Control) is provided for panto circuit in SB-1 cubicle.

Key IG-38 is provided on pneumatic panel to control the air pressure to Panto.For air passage to panto this key should be kept ON (horizontal).

2.4.1.2 Underframe layout

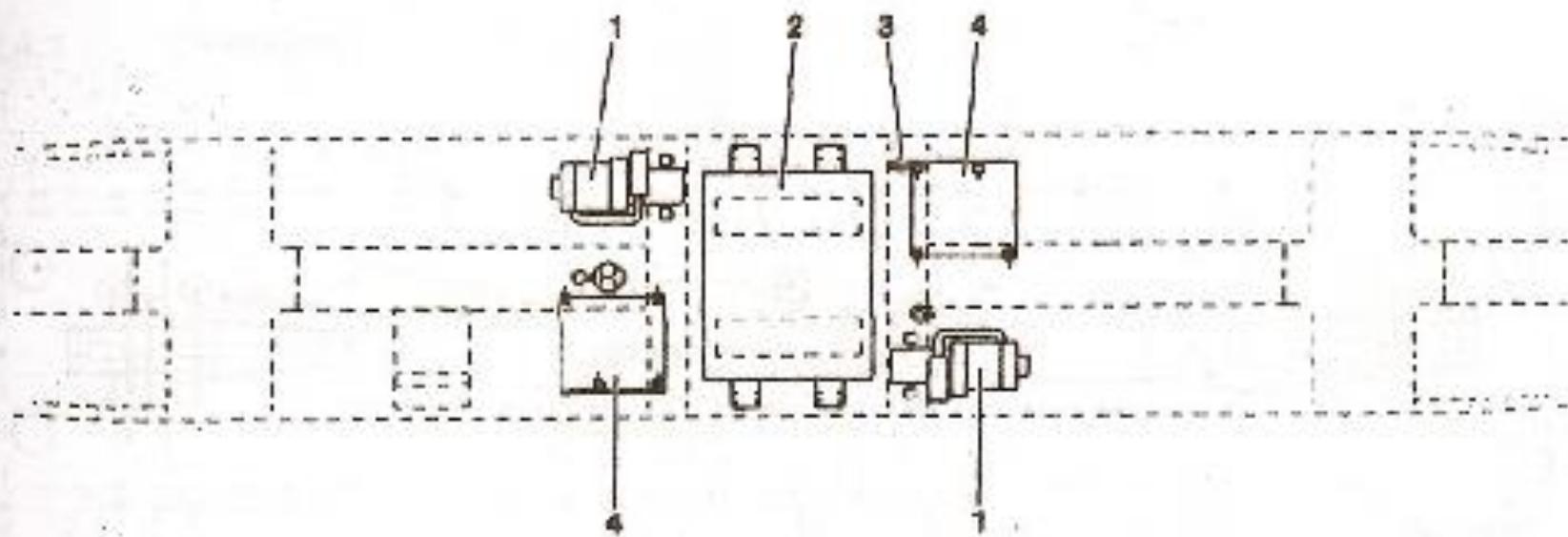


Fig. 2.4 Underframe layout

- 1 Main compressor
- 2 Transformator
- 3 Circuit breaker battery
- 4 Battery box

Battery:

In ABB loco Ni-Cad Battery is used. There are total 78 cells in the batteries which are placed in 2 boxes at either side of the locomotive. Each box contains 39 cells and each battery has 3 cells. Capacity of battery is 199 A-H and output is 110 V. To charge the battery, one battery charger is provided with circuit Breaker no. 110 situated in SB2. Main switch for battery is 112 which is placed In a box provided near battery box no. 2. For control circuit supply 1 MCB no. 112.1 is provided in SB2. To show the battery voltage UBA is provided in either cab.

Technical Specification :(battery)

Cell model = SBL-199

Cell type = Nickel/Cadmium

Number of cells per battery = 3

Number of batteries per battery box = 13

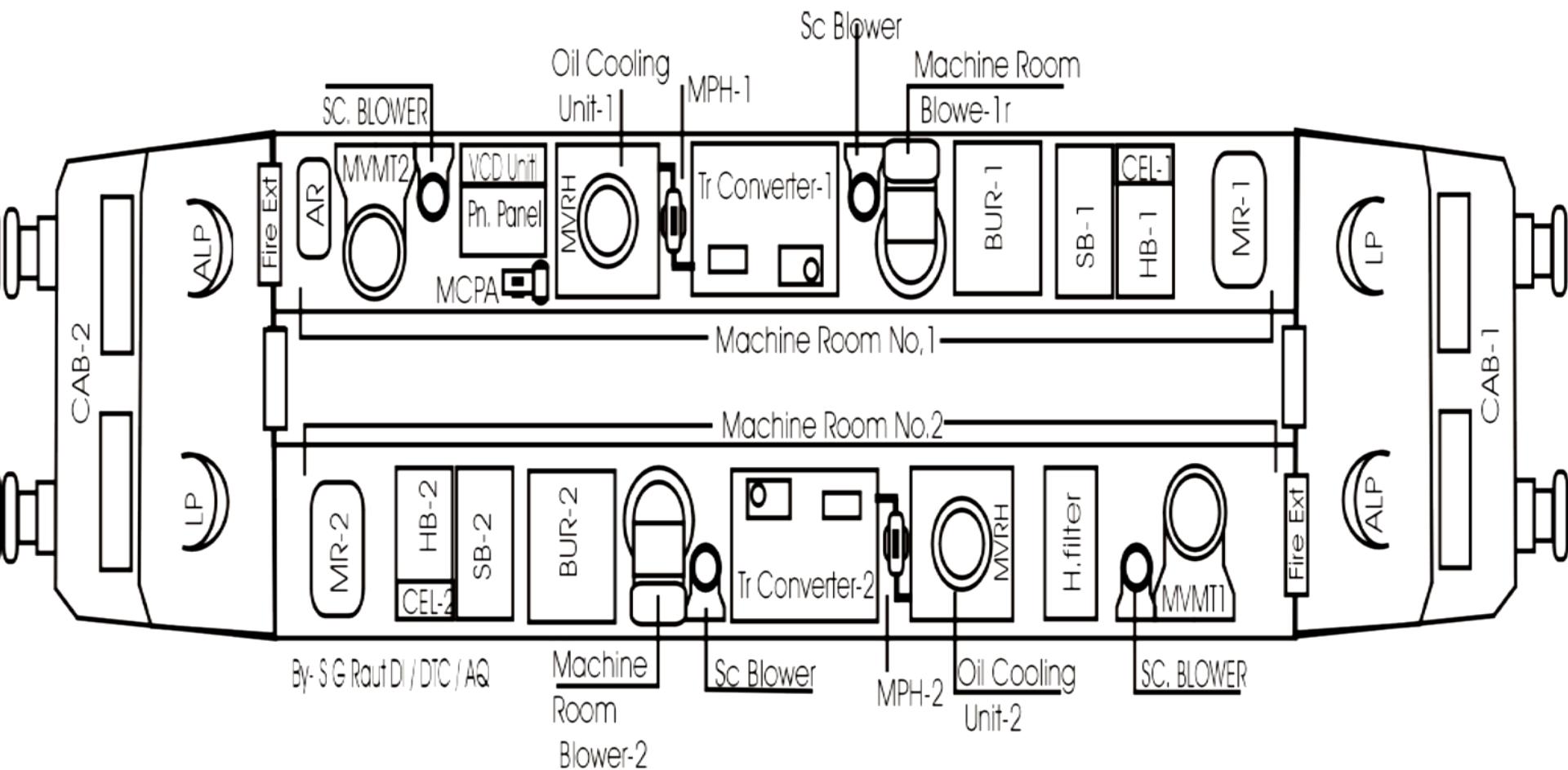
Number of battery boxes = 2

Total nominal capacity = 199 Ah

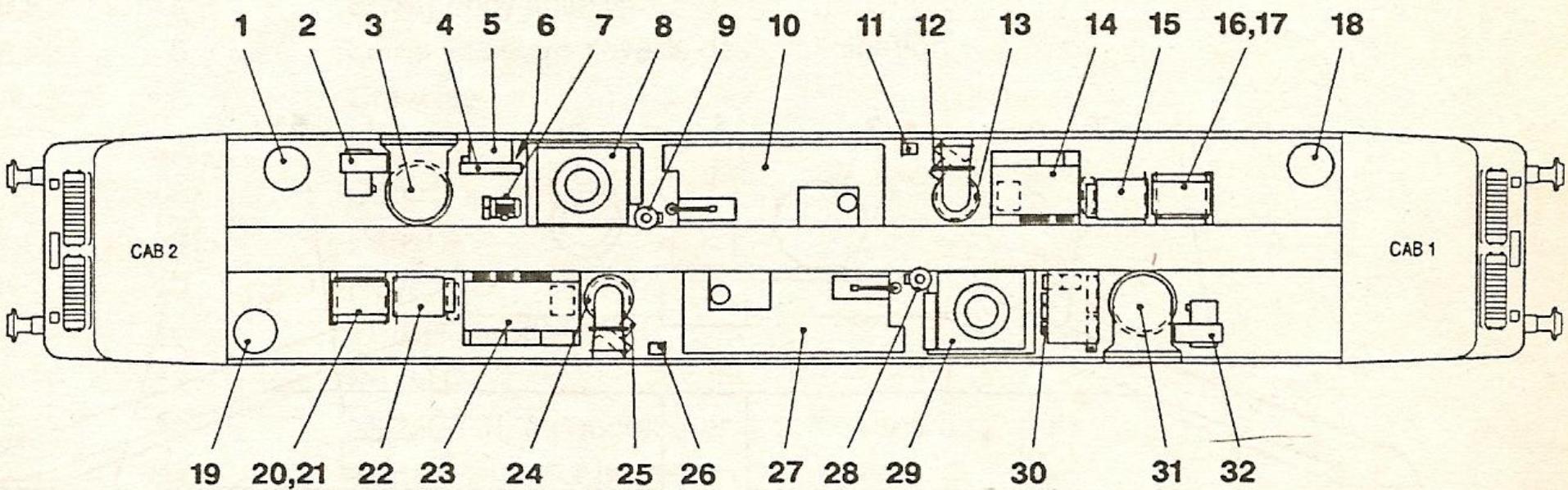
Nominal voltage of each cell = 1.4 V

Total battery voltage = $1.4 \times 3 \times 26 = 110 \text{ V}$

Machine Room Layout WAG9

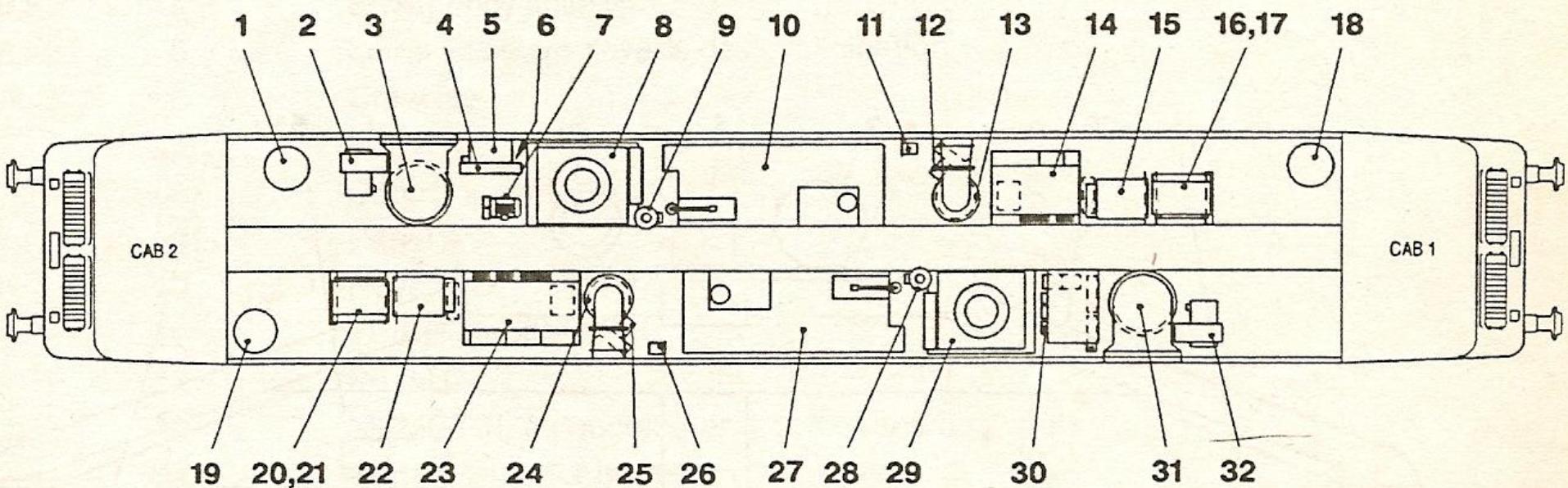


MACHINE ROOM LAYOUT



1. Auxiliary Reservoir
2. Scavenger blower to traction motor blower 2 /oil cooling unit 1
3. Traction motor blower bogie 2
4. Vigilance control equipment
5. Control electronics pneumatic manifold
6. Pneumatic panel
7. Auxiliary compressor
8. Oil cooling unit, transformer/converter 1
9. Oil pump converter 1
10. Traction converter 1
11. Capacitor to Scavenger blower for machine room blower 1
12. Scavenger blower to machine room blower 1

MACHINE ROOM LAYOUT



- 13. Machine room blower 1
- 14. Auxiliary converter box 1
- 15. Cubicle auxiliary circuits 1
- 16. Cubicle control circuits 1
- 17. Central electronics 1 (CEL 1)
- 18. Main reservoir
- 19. Main reservoir
- 20. Central electronics 2 (CEL 2)
- 21. Cubicle control circuits 2
- 22. Cubicle auxiliary circuits 2
- 23. Auxiliary converter box 2
- 24. Machine room blower 2
- 25. Scavenger blower to machine room blower 2
- 26. Capacitor to Scavenger blower for machine
- 27. Traction converter 2
- 28. Oil pump converter 2
- 29. Oil cooling unit, transformer / converter 2
- 30. Filter cubicle
- 31. Traction motor blower bogie 1
- 32. Scavenger blower to traction motor blower 1/oil coo

ENERGIZING THE LOCO

- ☞ **Plug in automatic brake handle**
- ☞ **Turn BL key to 'D' position**
- ☞ **ZPT in up position, close DJ**
- ☞ **If pressure is insufficient to raise PT auxiliary compressor starts.**
- ☞ **Wait till auxiliary compressor stops.**



SELF CHECK BY LOCO

- ☞ BL key to D Node 504
 - ☞ PT raised Node 550
 - ☞ DJ closed Node 570 LSDJ extinguished
 - ☞ Run compressor
 - ☞ Ready for traction Node 590
 - ☞ Release parking brake
 - ☞ If temp. of CEL >70 ° C LSCE will glow
 - ☞ BL key to be kept in cooling mode ‘C’ position
 - ☞ Machine room blower starts
-

IF CREW DOES NOT ACKNOWLEDGE

- ☞ **Alarm sounds**
- ☞ **LSVW glows**
- ☞ **ACKNOWLEDGE - within 8 Sec.**

Otherwise

- ☞ **Penalty brake is initiated**
- ☞ **It can be released only after 160 sec.**
 - Press BPVG
 - Release brake (move A-9 to FS & then to RUN)
 - TE/BE to zero position

Vigilance Control Device (VCD):

The Vigilance Control Device (VCD) for 25 kV AC Tap Changer type Locomotives is a micro-controller based multi-resettable system. It comprises of one main Control Unit and two Driver Indication cum acknowledge Units (one for each Cab). Main purpose of VCD System is to monitor the alertness of the driver inside the locomotive cab and in case the Driver is not alert and does not provide any Acknowledge/Vigilance signals (which are described in the next section) to the System through his Loco control actions or by pressing the Acknowledge/ Vigilance Push switch/Pedal switch, System activates Emergency/Penalty Brake to stop the Loco. If Driver provides any of the Acknowledge/Vigilance signals, during the Vigilance or Warning Cycle it will reset VCD timing cycle.



BRAKE SYSTEM

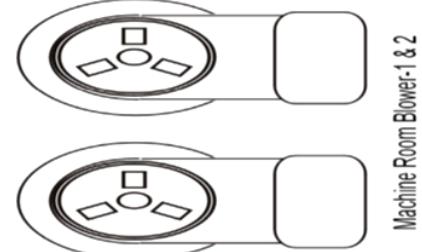
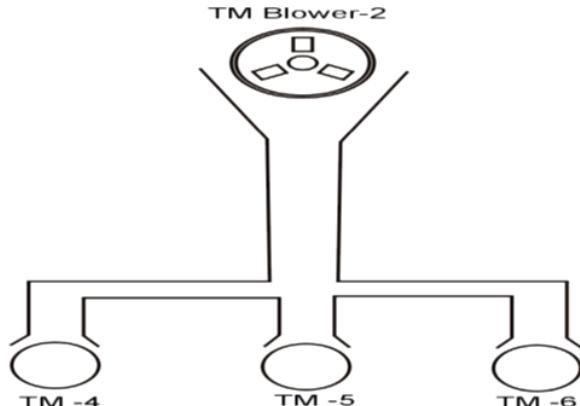
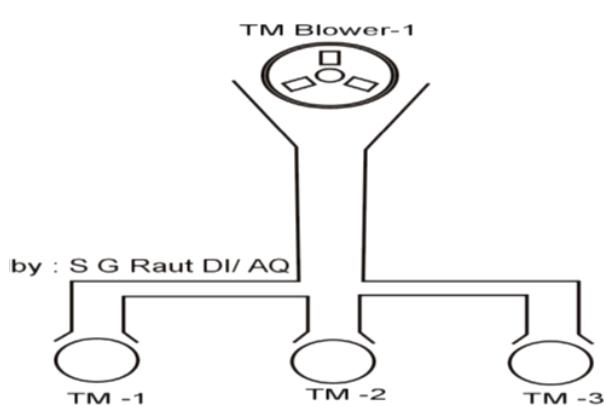
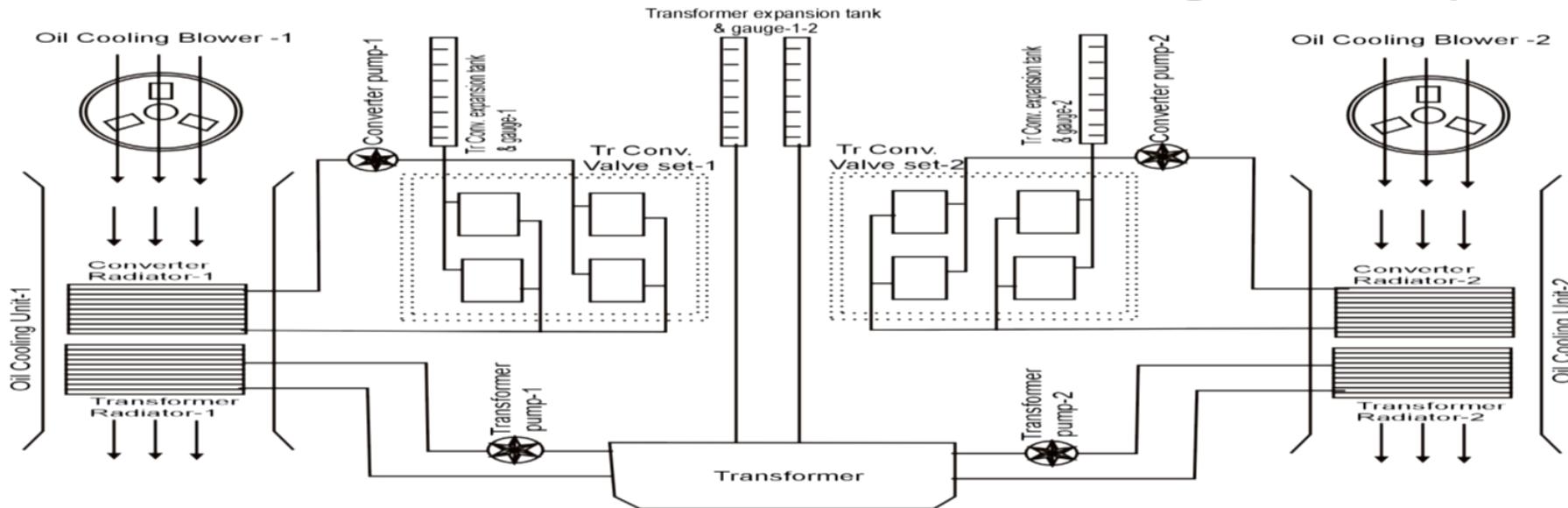
- ☞ **Regenerative brake (through TE/BE handle)**
- **Pneumatic brake actuated automatically, if electrical braking fails**
- ☞ **A 9**
- ☞ **SA 9**
- ☞ **Parking brake**
- ☞ **Anti spin brake**

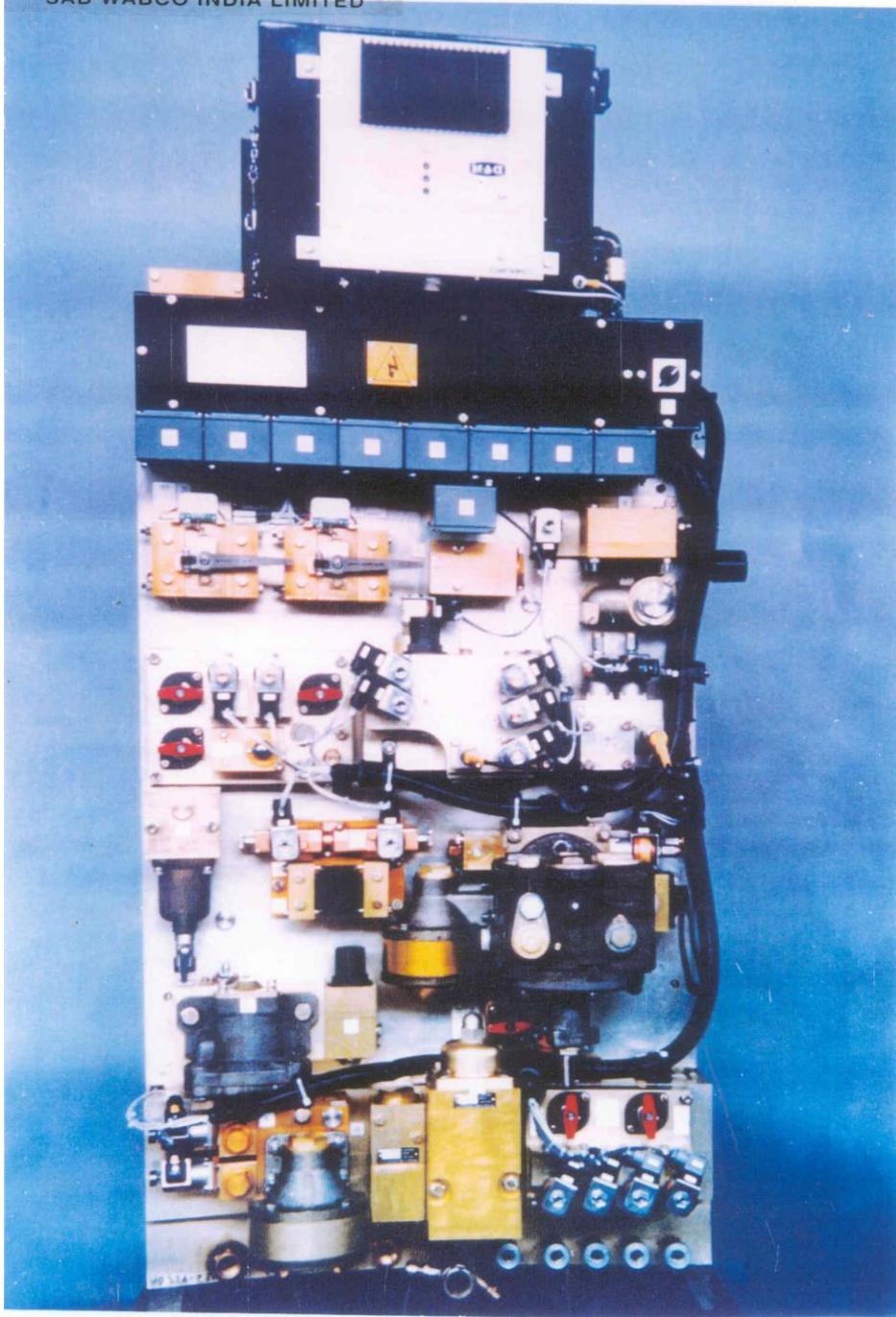
SHUTTING DOWN THE LOCO

- 👉 **Switch off BLDJ**
- 👉 **ZPT to DN position**
- 👉 **BL key to 'O' position**
- 👉 **MCE - Remains in self hold mode for 10 minutes**
- 👉 **During this time driver can change cab or MU can b**

Cooling concept.

cooling conceptt





Power semiconductor devices (Power switches)

- Power switches are the work-horses of PE systems.
- PE switches works in two states only:
 - Fully on (conducting);
 - Fully off (blocking)
- Can be categorised into three group
 - Diode : on and off states controlled by power circuit only
 - Thyristor (SCR) : Latched on by low-power control signal but must be turned off by power circuit. Cannot be turned off by control signal.
 - Controllable switches: Can be turned on and

- Why induction motor (IM)?

- Robust; No brushes. No contacts on rotor shaft
- High Power/Weight ratio compared to Dc motor
- Lower Cost/Power
- Easy to manufacture
- Almost maintenance-free, except for bearing and other mechanical parts

INDUCED E.M.F.

$$E = -N \frac{d\Phi}{dt}$$

N=No.of coil-turns

$$= -N \frac{d}{dt} (\pm_{pm} \cdot \cos \omega t)$$

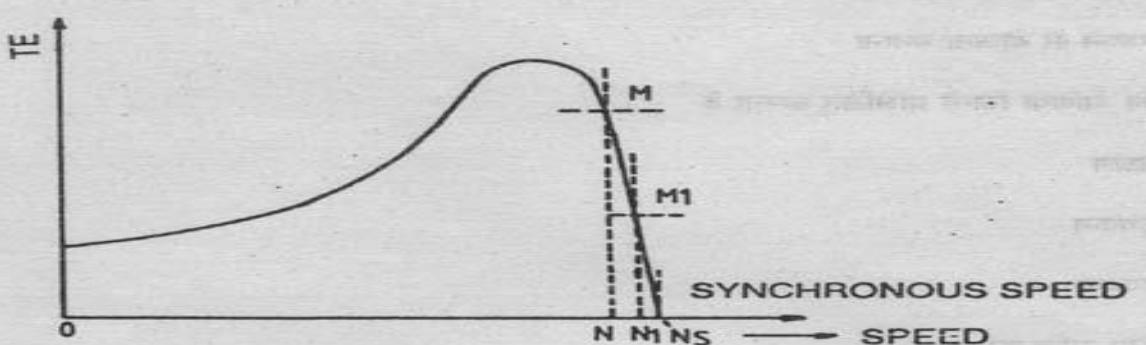
$$= N w \pm_{pm} \cdot \sin \omega t = 2 N.f. \pm_{pm} \sin \omega t$$

$$\frac{E}{f} = (2 N) \pm_{pm} \sin \omega t$$

hence $\Phi \propto V/f$

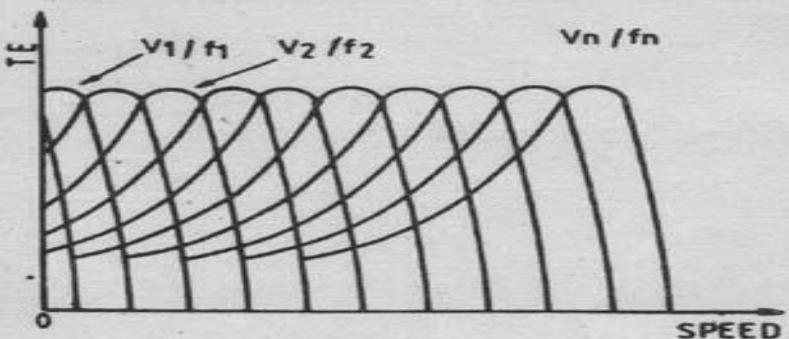
WHY VVVF ?

- In order to limit starting current, high rotor current, & still obtain high starting torque, we need to keep flux & therefore V/f as constant, because :-
- $I_r \propto \Phi \cdot f_s$ and $\Phi \propto V/f$, gives $I_r \propto (V/f) \cdot f_s$
- $T \propto \Phi \cdot I_r$ gives $T \propto (V/f)^2 \cdot f_s$, Therefore for a given slip-frequency & small slip :-
 - $T \propto (V/f)^2$



SPEED VS TE CHARACTERISTICS OF INDUCTION MOTOR

FIG.11.02



SPEED/TORQUE CHARACTERISTICS WITH V/f CONSTANT

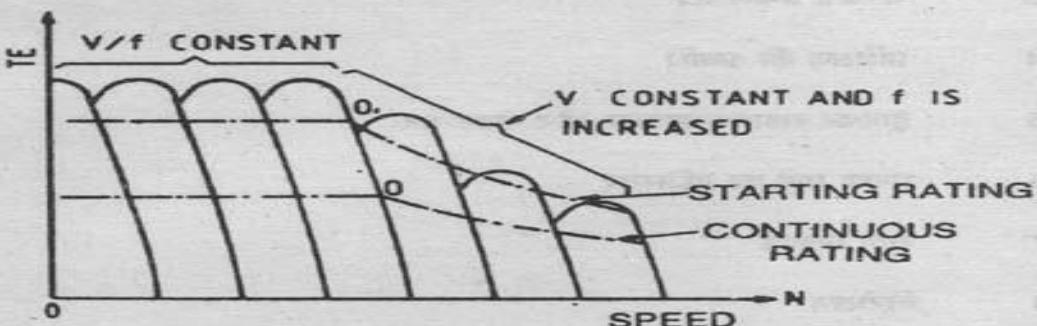
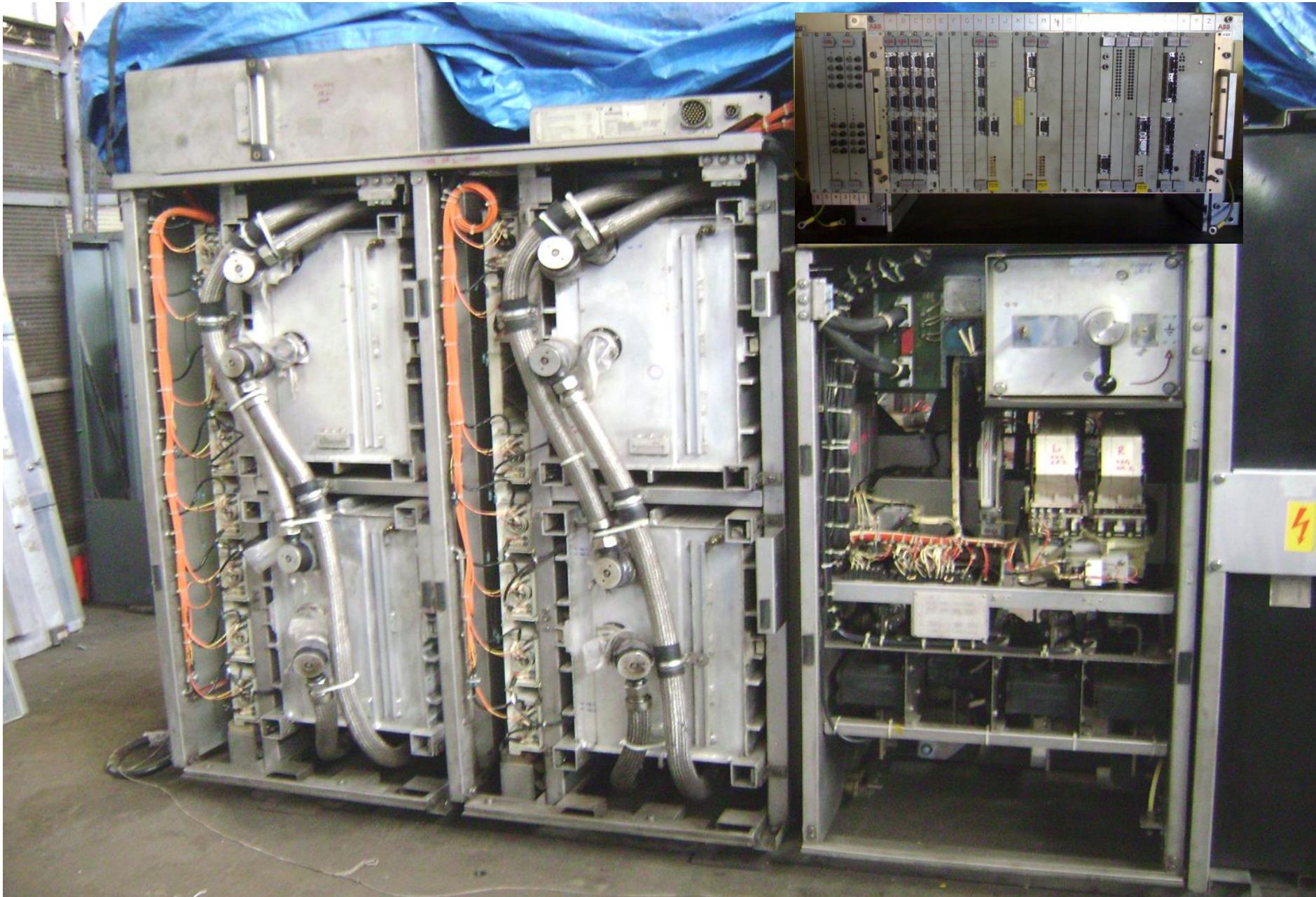
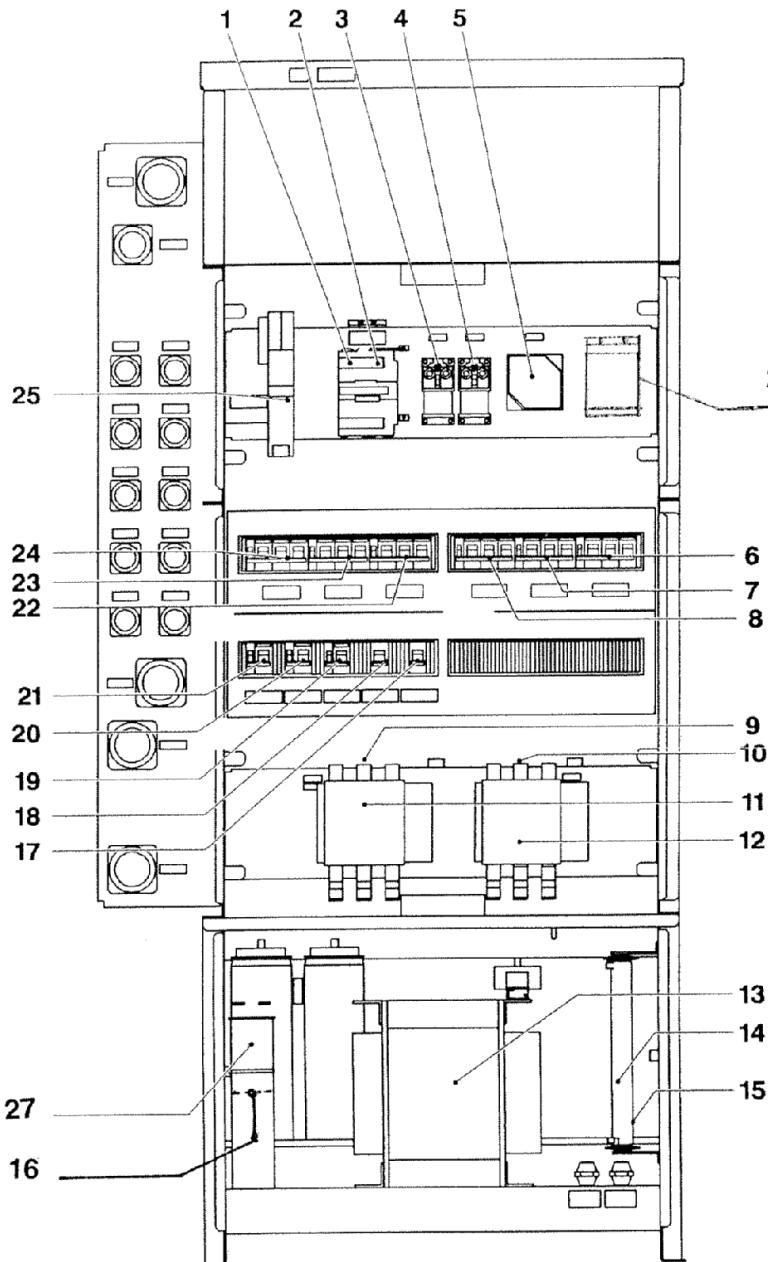


FIG.11.03

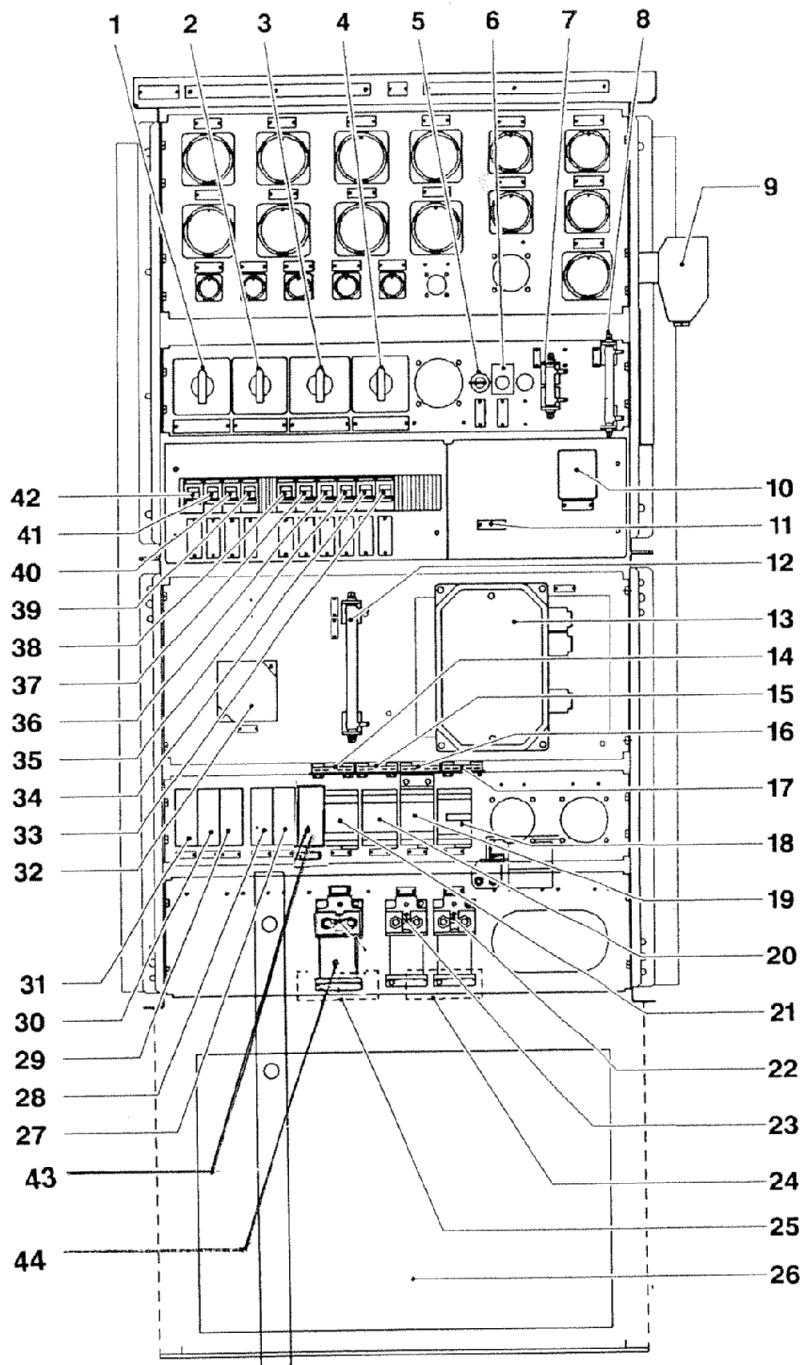
TRACTION CONVERTER



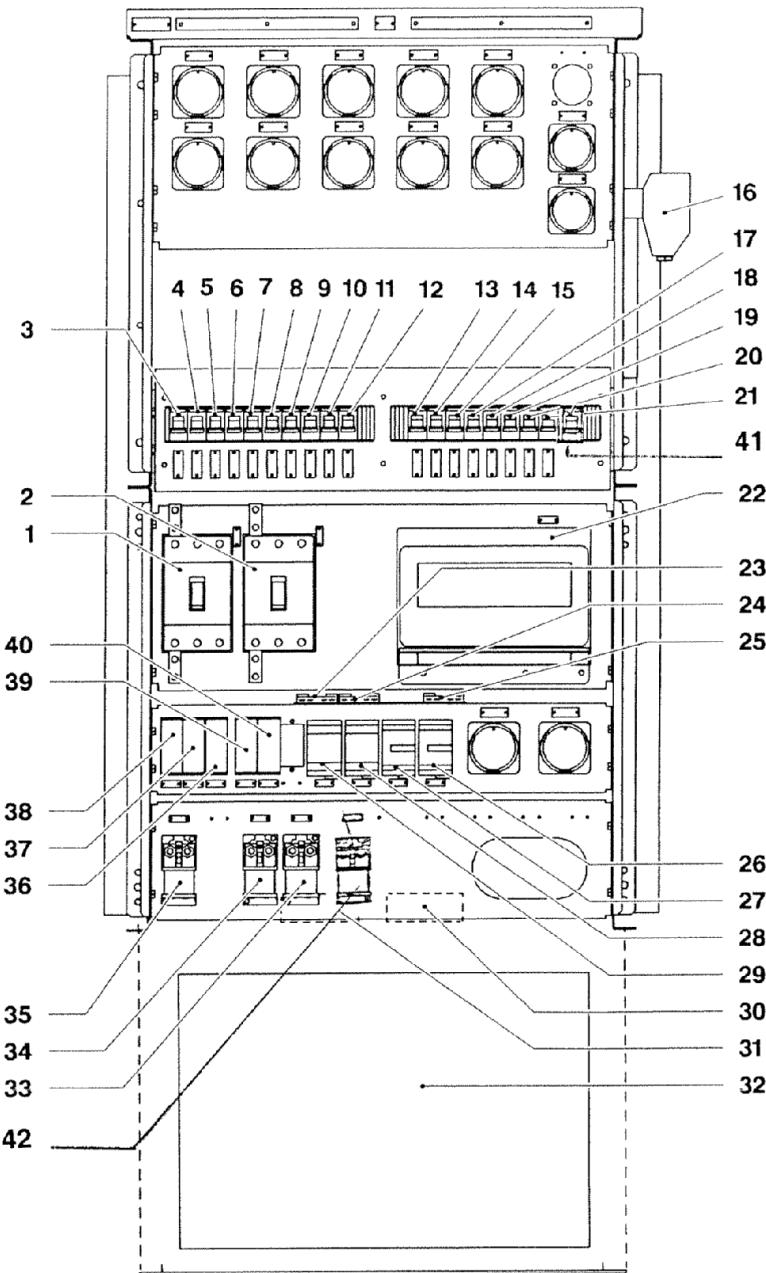
HB1



- 1 Contactor, main compressor
- 2 Snubber circuit to item 47.2
- 3 Auxiliary contactor to item 52
- 4 Auxiliary contactor to item 52
- 5 Earth fault relay 415/110 V
- 6 Circuit breaker, oil cooling unit, transformer/converter
- 7 Circuit breaker, scavenge blower to traction motor blower and oil cooling unit
- 8 Circuit breaker, traction motor blower
- 9 Snubber circuit to item 52
- 10 Snubber circuit to item 52
- 11 Contactor auxiliaries
- 12 Contactor auxiliaries
- 13 Transformer, auxiliary circuits 415/110 V
- 14 Earthing resistor earth fault detection 415/110 V
- 15 Earthing resistor earth fault detection 415/110 V
- 16 Capacitor to MR blower motor
- 17 Circuit breaker, crew fan
- 18 Circuit breaker, cab heater
- 19 Circuit breaker, cab ventilation
- 20 Circuit breaker, scavenge blower to machine room blower
- 21 Circuit breaker, machine room blower
- 22 Circuit breaker, main compressor
- 23 Circuit breaker oil pump converter
- 24 Circuit breaker oil pump transformer
- 25 Fuse auxiliary 415/110 V
- 26 Time relay for MR Blower
- 27 Capacitor to MR Blower (Start up)

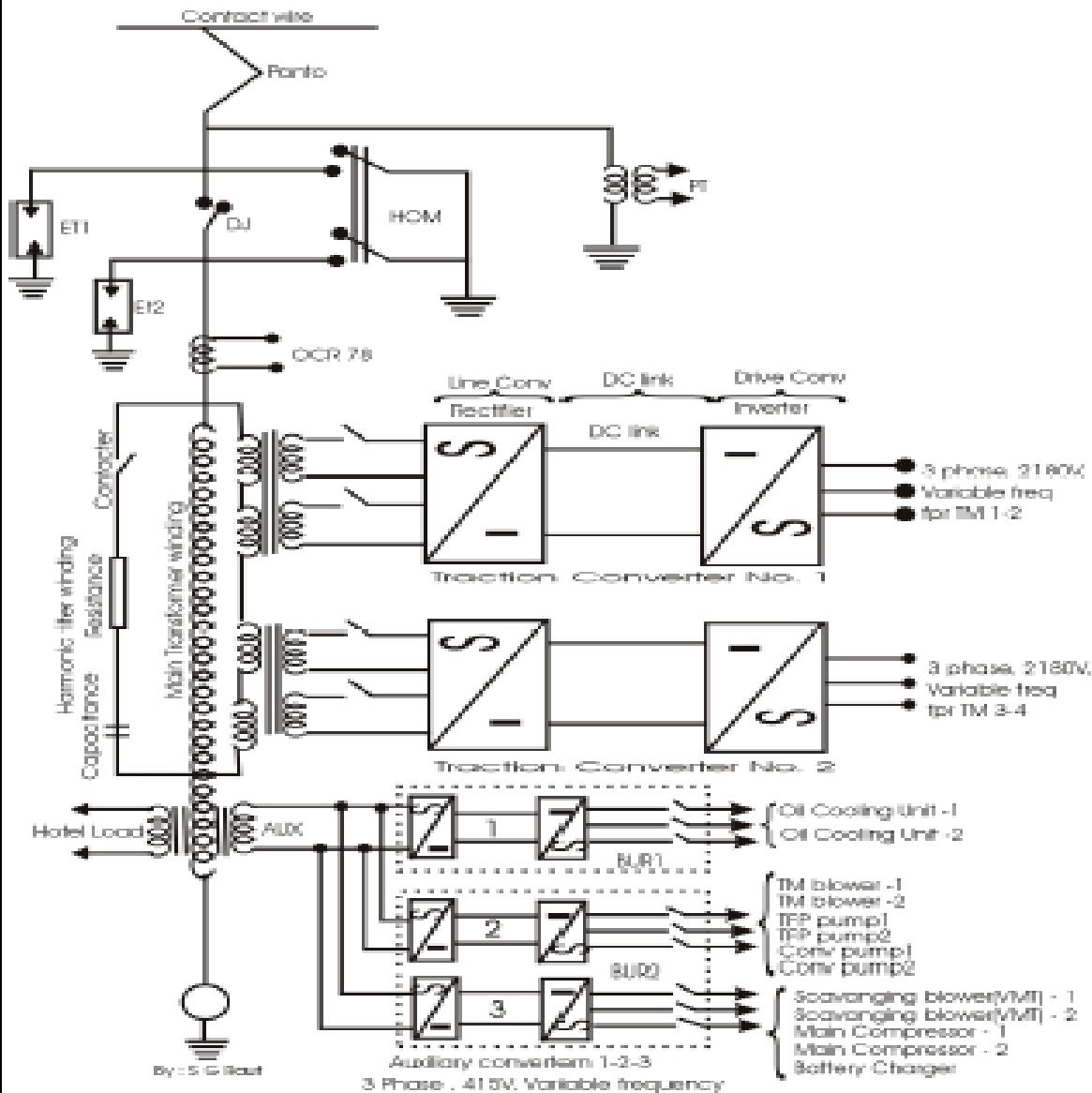


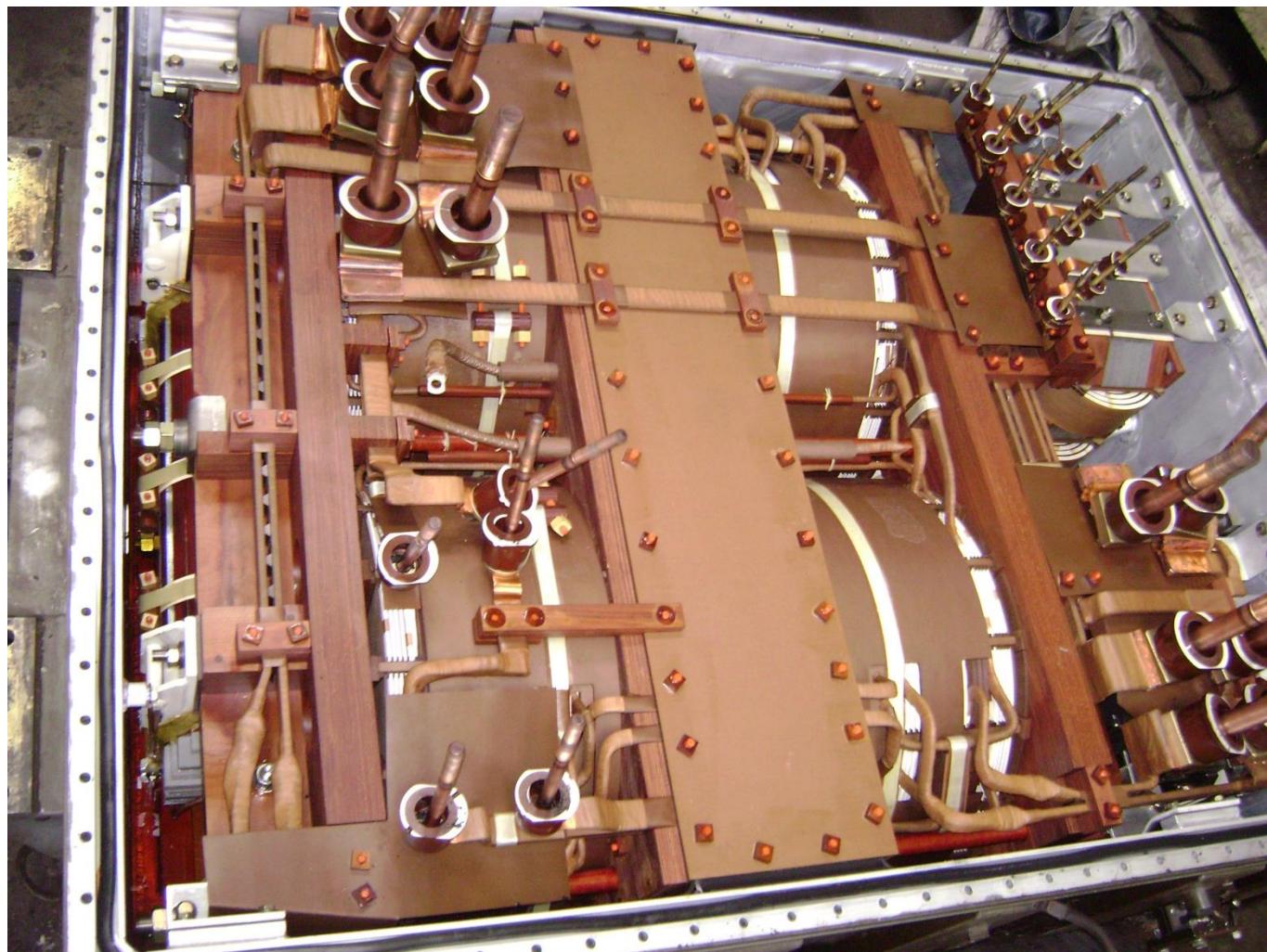
- | | | |
|----|------------------------------|--|
| 1 | Rotary switch | Failure mode operation |
| 2 | Rotary switch | Bogie cut-out |
| 3 | Rotary switch | Configuration |
| 4 | Rotary switch | Vigilance device cut-off |
| 5 | Key switch | Simulation |
| 6 | Illuminated push-button | Configuration |
| 7 | Wire resistor | Earthing screen Train bus |
| 8 | Resistor | Maximum current relay |
| 9 | Thermostat | Control electronics |
| 10 | Relay | Maximum current |
| 11 | Relay | Minimum voltage |
| 12 | Resistor | Earth fault detection, Control circuit |
| 13 | Connecting box | Train bus |
| 14 | Relay | Control electronics "OFF" |
| 15 | Snubber circuit to item 136. | |
| 16 | Snubber circuit to item 126. | |
| 17 | Snubber circuit to item 136. | |
| 18 | Relay | Time delay VCB |
| 19 | Contactor | Auxiliary contactor VCB |
| 20 | Contactor | Power supply cab |
| 21 | Relay Control Electronics C | |
| 22 | Contactor | Control electronics |
| 23 | Contactor | Control circuits "ON" |
| 24 | DC/DC converter | |
| 25 | DC/DC converter | |
| 26 | Rack | Central electronics (CEL1) |
| 27 | Blocking diode | Illumination test |
| 28 | Blocking diodes | |
| 29 | Blocking diodes | |
| 30 | Blocking diodes | |
| 31 | Blocking diodes | |
| 32 | Relay Earth fault | Control circuit |
| 33 | Circuit breaker | Central electronics |
| 34 | Circuit breaker | Central electronics |
| 35 | Circuit breaker | Electronics, auxiliary converter |
| 36 | Circuit breaker | Monitoring |
| 37 | Circuit breaker | Power supply Gate Units |
| 38 | Circuit breaker | Electronics traction converter |
| 39 | Circuit breaker | Lighting front |
| 40 | Circuit breaker | Power supply 24V/48V |
| 41 | Circuit breaker | Pantograph/VCB Control |
| 42 | Circuit breaker | Driver's cab |
| 43 | Blocking diode | Head light |
| 44 | Contactor | Head light |



- | | | |
|----|-------------------------------|-------------------------------------|
| 1 | Circuit breaker | Output battery charger |
| 2 | Circuit breaker | Control circuit locomotive |
| 3 | Circuit breaker | Commissioning 1 |
| 4 | Circuit breaker | Vigilance control |
| 5 | Circuit breaker | Pneumatic panel |
| 6 | Circuit breaker | Commissioning 2 |
| 7 | Circuit breaker | Auxiliary compressor |
| 8 | Circuit breaker | Driver's cab |
| 9 | Circuit breaker | Power supply 24V/48 V |
| 10 | Circuit breaker | Marker lights |
| 11 | Circuit breaker | Lighting front |
| 12 | Circuit breaker | Lighting machine room |
| 13 | Circuit breaker | Electronics traction converter |
| 14 | Circuit breaker | Power supply Gate Units |
| 15 | Circuit breaker | Monitoring |
| 16 | Thermostat | Control electronics |
| 17 | Circuit breaker | Electronics auxiliary converter |
| 18 | Circuit breaker | Electronics auxiliary converter |
| 19 | Circuit breaker | Central electronics |
| 20 | Circuit breaker | Central electronics |
| 21 | Circuit breaker | MEMOTEL speedometer |
| 22 | Fire detection equipment | |
| 23 | Snubber circuit to item 130.1 | |
| 24 | Snubber circuit to item 211 | |
| 25 | Snubber circuit to item 126.7 | |
| 26 | Contactor | Power supply driver's cab |
| 27 | Safety relay | Control electronics "ON" |
| 28 | Relay | Temperature control,
electronics |
| 29 | Auxiliary contactor | Pantograph |
| 30 | DC/DC converter | |
| 31 | DC/DC converter | |
| 32 | Rack | Central electronics (CEL2) |
| 33 | Auxiliary contactor | Wheel flange lubrication |
| 34 | Auxiliary contactor | Wheel flange lubrication |
| 35 | Contactor | Auxiliary compressor |
| 36 | Blocking diodes | |
| 37 | Blocking diodes | |
| 38 | Blocking diodes | |
| 39 | Blocking diodes | |
| 40 | Blocking diodes | Illumination test |
| 41 | Circuit breaker | Electronics auxiliary converter |
| 42 | Auxiliary Contactor | Head Light |

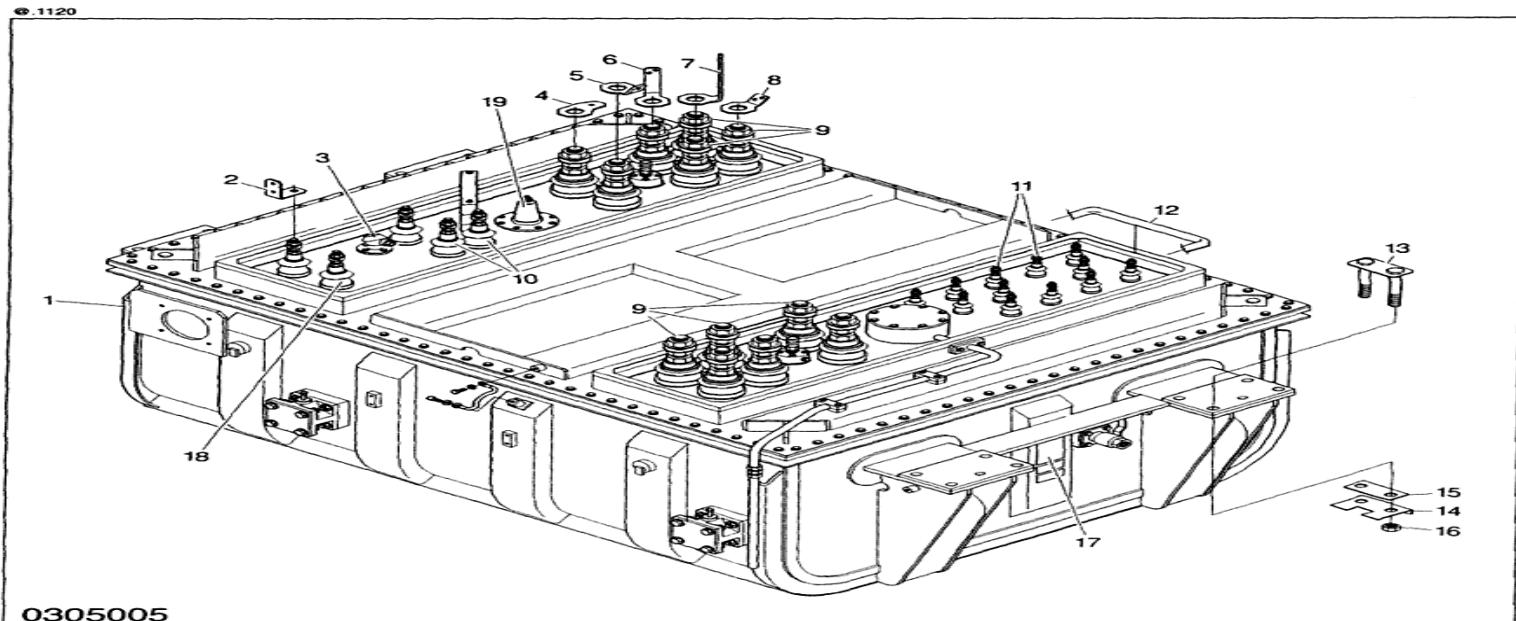
6.3 Traction Power Circuit (VVAP-5)





3.5 Transformer

Overview



1	Transformer general arrangement	11	Smoothing reactor bushing
2	Connection angle	12	Profiled joint
3	Thermometer	13	Fixing plate
4	Connection angle	14	Locking tab
5	Connection angle	15	Jacking plate
6	Connection angle, short	16	Hex. nut
7	Connection angle, long	17	Rating plate
8	Connecting plate	18	BUR bushing
9	Traction-Converter bushing	19	High voltage bushing
10	Filter bushings		

Difference in
3 Phase loco
transformer
and
conventional loco
transformer

S.No.	Criteria	Three Phase Transformer	Conventional Transformer
1	Capacity	Capacity – 6500/7450 KVA	Capacity 3900/5400 KVA
2	Fitting Arrangement	TFP fitted in under frame	TFP fitted partially in under frame and partially in the super structure.
3	TFP tank body	Non magnetic aluminum material	Magnetic material (Iron)
4	GR/CCR	Not existing	Existing
5	Oil pump	4 Nos.	1 No.

S.No	Criteria	Three Phase Transformer	Conventional Transformer
6	Oil pipe line	Stainless steel non magnetic	Magnetic Iron material
7	Conservator and breather	Conservator 2 Nos.	Conservator and breather – 1 No. each
		Breather 2 + 2 Nos.	
8	Radiator	2 Nos. double two in one.	Single radiator
9	Oil cooling blower	2 Nos.	1 No.
10	No. of bushing	29 Nos.	7 or 9 Nos.

S.No	Criteria	Three Phase Transformer	Conventional Transformer
11	Thermostat	01 No.	Not existing
12	Gate Valve	4 Nos.	Not existing
13	Filteration cock/drain cock	1 No. each	Not existing
14	Tank Cover	3 Nos.	1 No.
15	System of oil circulation	circulation in 3 different eqpts. i.e. TFP and convertors	circulation in TFP only.
16	Input supply from DJ	Through CHT bushing	Condenser bushing or CHT bushing

Introduction To T.M

Model	TAO 659	HS 15250 A (Hitachi)	3 Φ A.C Induction T.M.6FXA 7059 – WAP5 6FRA 6068-WAG9/ WAP7
Make	CLW	CLW	ABB/ Crompton /CLW
KW Capacity	585Kw	630Kw	1150 Kw -WAP-5 850 Kw -WAG9
Voltage	750 V	750 V	2180 V (CONT)
Current	840 Amp	900 Amp	370-540A-WAP5 270-393A-WAG9/WAP7
Speed RPM	1060	895	1585-3174-WAP5 1283-2584-WAG9/WAP7,
Poles	6	6	4 Pole - WAP 5 6Pole – WAG9 / WAP7
Weight	2250 Kg	3000 Kg	2150 Kg – 6 FRA 6068 1990 Kg – 6 FXA 7059
Weight Of Arm/Rotor	850 Kg	1010 Kg	790 Kg (ABB)
Application	WAM 4 /WAG5/	WAG7/WAP4/ WCAM 3.	WAP5/WAG9/WAP7

Introduction To T.M

Model	TAO 659	HS 15250 A (Hitachi)	3 Φ A.C Induction T.M.6FXA 7059 – WAP5 6FRA 6068-WAG9/ WAP7
Class of Insulation	H	H	C- 200
Frequency	-	-	65-132 HZ WAG9/WAP7 80-161 HZ WAP5
Axle Arrangement	Co-Co	Co-Co	Co-Co – WAP7/WAG9 Bo-Bo – WAP5
Suspension of TM	Axle Hung Nose Suspended	Axle Hung Nose Suspended	Fully Suspended.
Bearings	Cylindrical Roller Bearing	Cylindrical Roller Bearing	Cylindrical Roller Bearing
Bearing No	CE 318 PE 328	CE 324 PE NU 330	DE – NU 2236 E/C4 NDE – NJ 320 E/C4

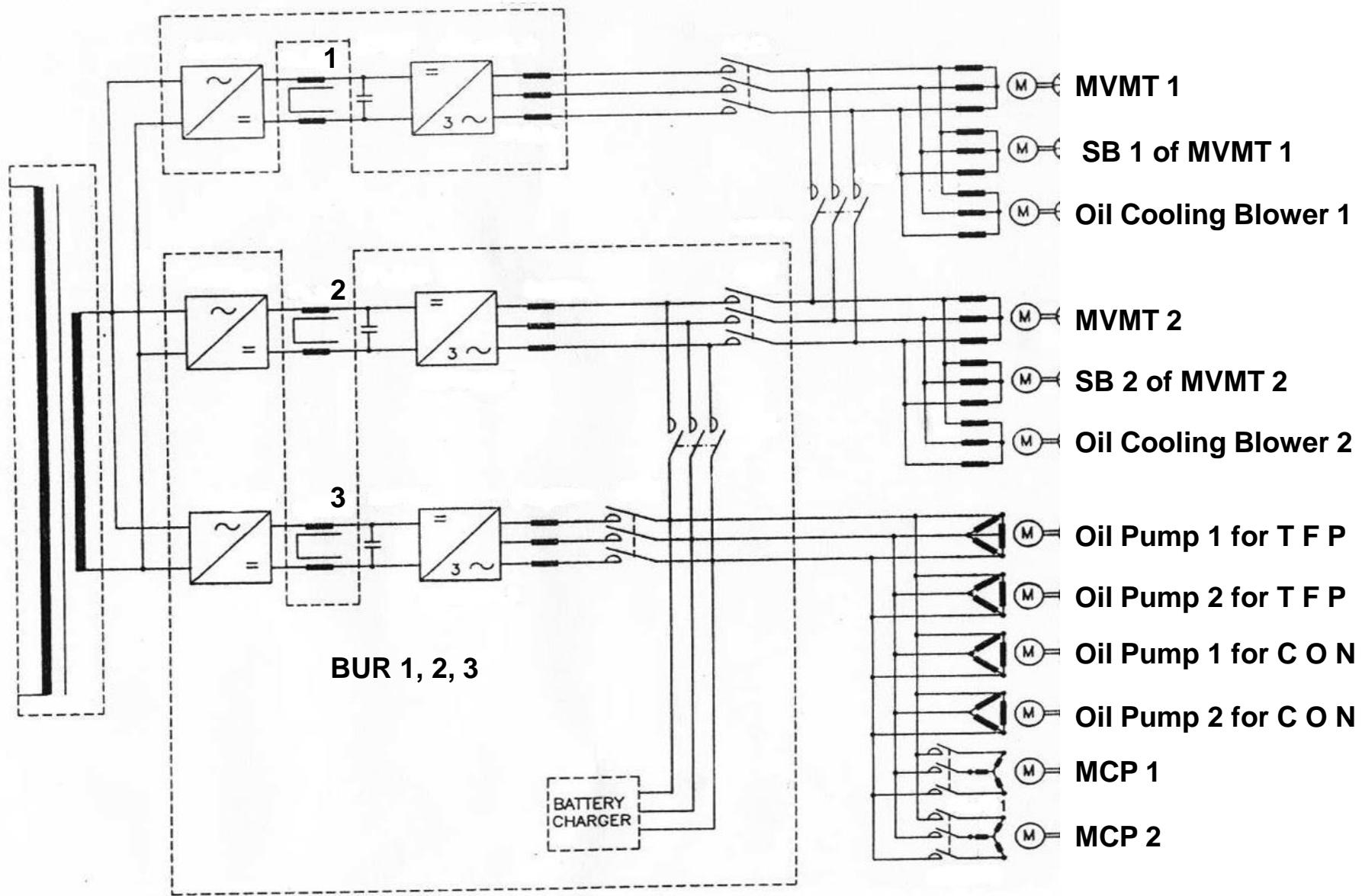
SALIENT DATA OF MAJOR EQUIPMENTS OF WAG – 9 LOCOMOTIVE

- **AUXILIARY MACHINES** :- 3-Phase Auxiliaries :-
- Fed from VVVF Aux.Converter (BUR 1,2 & 3)
- Frequency changes between $50/3$, $50 \times 2/3$ & 50 Hz
- 2 nos. TM Blower Motors
- 2 nos. Scavenger Blower Motors for TM Blowers
- 4 nos. Oil Circulating Pumps
- 2 nos. Oil Cooler Blower Motors
- 2 nos. Main Compressors

SALIENT DATA OF MAJOR EQUIPMENTS OF WAG – 9 LOCOMOTIVE

- **AUXILIARY MACHINES** :- 1-Phase Auxiliaries :-
- i) Operating on 415 V :-
- 2 nos. Machine Room Blowers
- 2 nos. Scavenger Blower Motors for Machine Room
- 2 nos. Cab Heaters
- ii) Operating on 110 V :-
- Cab Heater Fans
- Crew/Cab Fans

Auxiliary Power Circuit Diagram - 3Φ



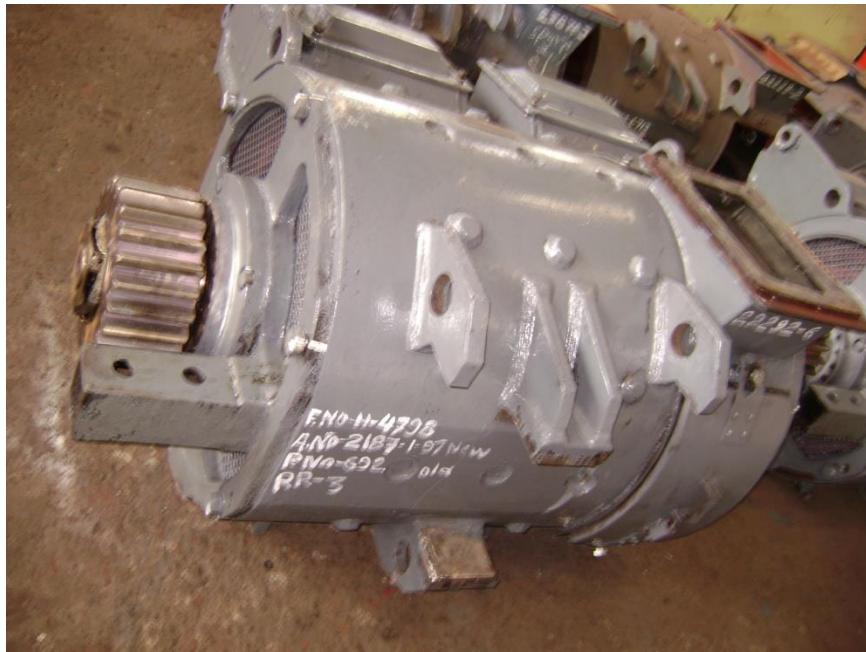
*COMPARISON OF
3 PHASE AC INDUCTION & DC
SERIES MOTOR AS TRACTION
MOTOR*

COMPARISON OF 3 PHASE AC INDUCTION & DC SERIES MOTOR AS TRACTION MOTOR

- 1. REDUCED MAINTENANCE (COMMUTATOR BHRR & CARBAN BRUSH ETC. IS NOT EXIST.**
- 2. HIGHER SPEED (UPTO 2584 RPM)**
- 3. SENSITIVITY OF WHEEL DIA DIFFERENCE**
- 4. RATING (HIGHER HP IS 3 PHASE INDUCTION MOTOR.**
- 5. REDUCED CURRENT LOADING (CURRENT, TEMP & failure WILL BE LESS.**
- 6. REGENERATIVE BRAKING UP TO ZERO SPEED**
- 7. WHEEL SPINNING & SLIPPING**
- 8. DIRECTION REVERSED.**
- 9. PRODUCTIVITY IS HIGHER (DUE TO LESS MAINTENANCE SCHEDULE.)**
- 10. SMALL SIZE COMPARE TO POWER OUT PUT.**

TRACTION MOTOR

Conv. Loco



DC Series Motor

3 Φ Loco



3 Φ Ind. Motor

TRACTION MOTOR

Conv. Loco



3 Φ Loco



Armature

Rotor

O/H Of Stator

Stator









THANK YOU