Electrical Advancement in IR Coaches

K.S. JHA
CI/ELECTRICAL

TRAIN LIGTHING OF IR COACHES

Purpose

- **To provide Electric Power for Light , Fan and Air-Conditioning & other Equipments in Railway Coaches.**

Trains lighting Systems

- Self generating –110V DC
- End-on-Generation (power cars) - 750 V, 3-phase,50 Hz
- Head on generation- Hotel load from Locomotive

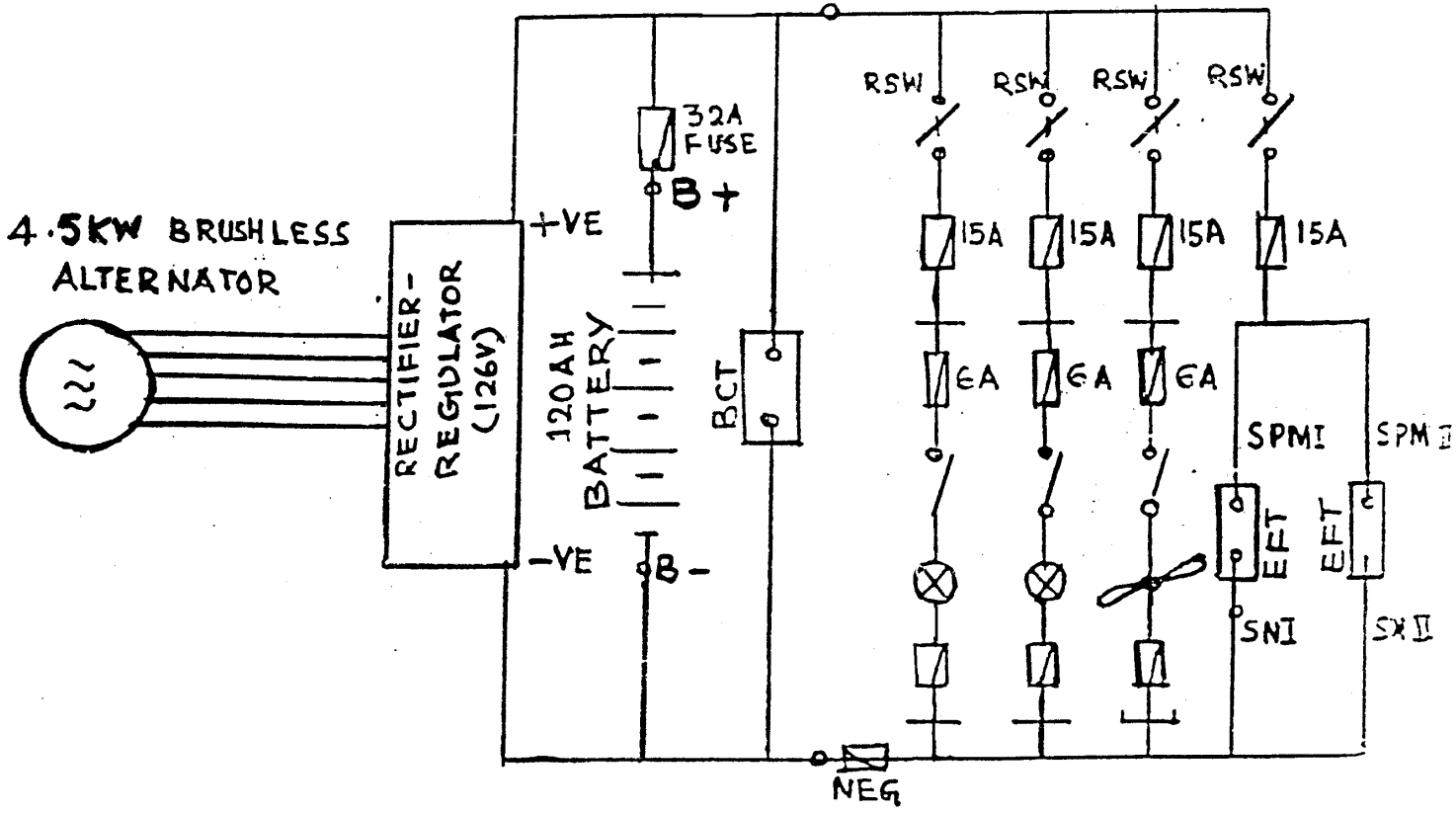
Self Generating

- Each coach is equipped as an independent unit, with a power generating equipment-called **Brushless Alternator**
- **Brushless Alternator is Driven by V-belt from coach axle pulley.**
- The alternator is coupled with a Rectifier and Regulator unit, which provides 110 V,DC at various Speed of the train

Train Lighting Equipments

- Axle pulley & V-Belts
- Alternator
- Rectifier cum regulator unit
- Battery
- Junction box, Rotary Switch, MCBs
- Lights & Fans
- Mobile Charging points

SL Class SG System



BRUSH LESS ALTERNATOR

Ratings of Alternators

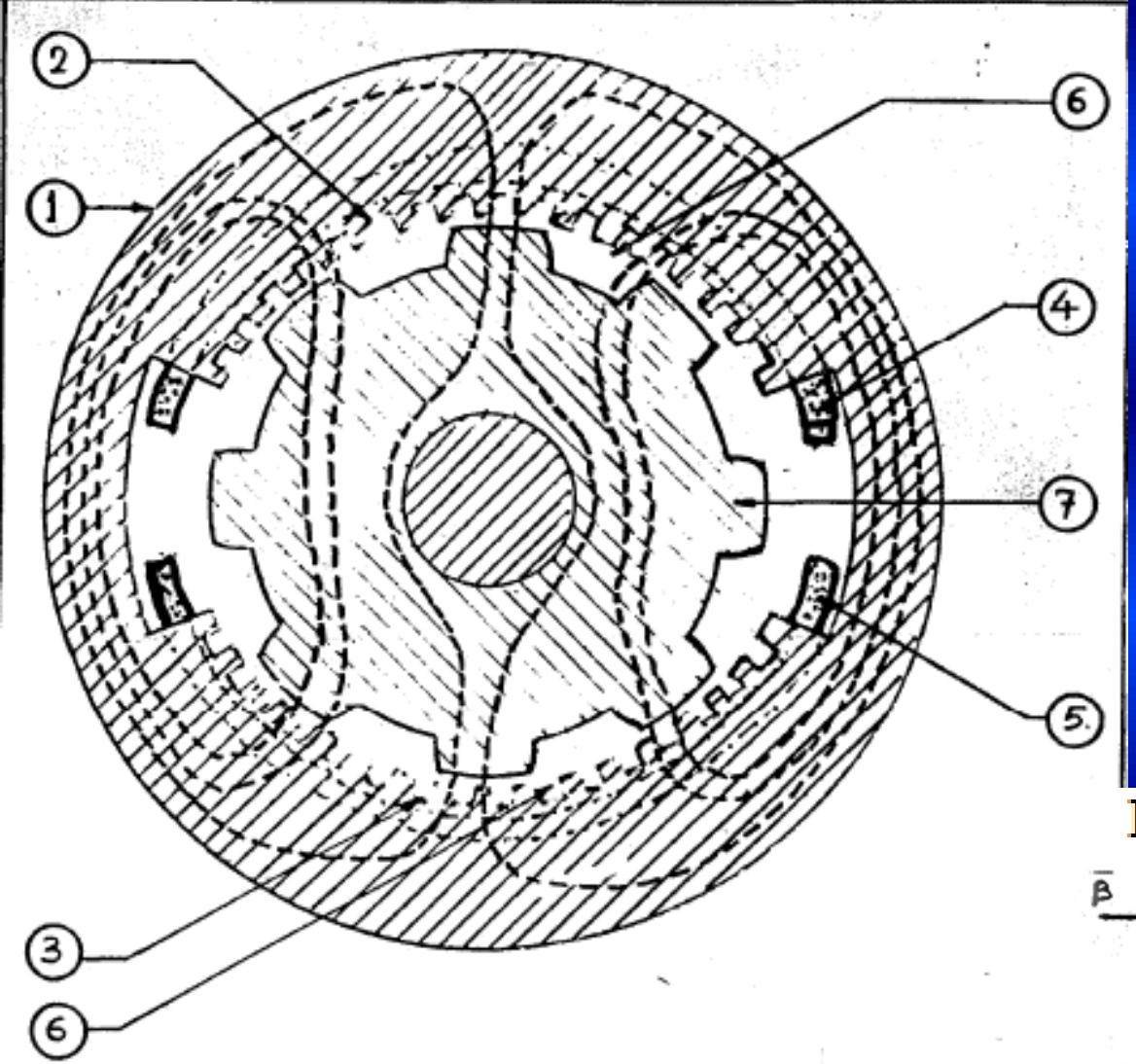
- Train Lighting coaches-

  1. BG:4.5 KW, 110 VOLTS, 4 V- Belts on 1 pulley(Cut In speed-19 kmph)
  2. MG: 3 KW.

- Air-Conditioned coaches-

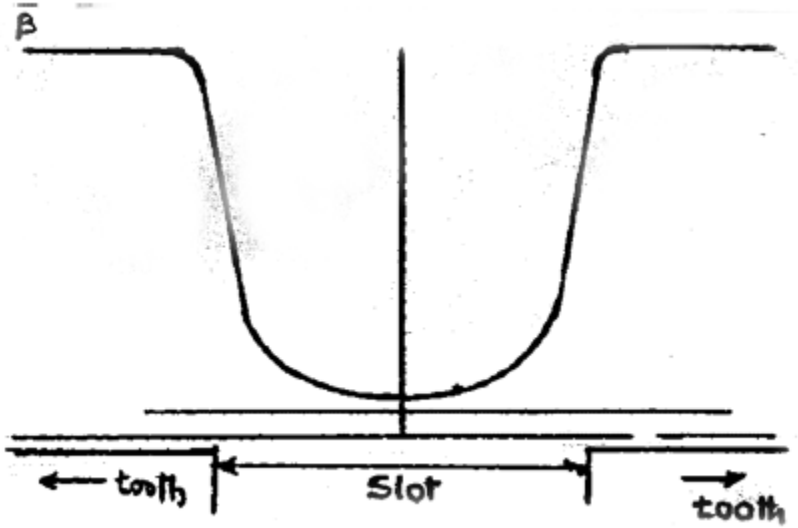
  1. BG: 18KW,22.5 KW or 25 KW,110 Volts, 6+6 V Belts on 2 pulleys (Cut In speed-30 kmph)
  2. MG: 12 KW.

Windings Arrangement



1 - STATOR
2 - NORTH POLE
3 - SOUTH POLE
4 - FIELD COIL
5 - FIELD COIL
6 - ARMATURE WINDING SLOTS
7 - ROTOR.

Flux Density Distribution Curve



Windings Arrangement

- Stator accommodates 02 Sets of winding – AC winding & FIELD winding.
- AC windings are distributed in small slots & connected in Parallel STAR
- Field windings are concentrated in the 2 bigger slots & connected in series.
- Each field coil spans half the total number of slots
- Core of stator will retain a residual magnetism, if excited once with battery.

Operation

- The Rotor resembles a cogged wheel having 8/12 sets of teeth and slots uniformly distributed on the rotor surface.
- This residual flux finds a path through rotor, when rotor rotates, its teeth & slots, flux linked with AC coil will vary.
- This periodically variation induces voltage on AC windings
- The frequency of induced voltage depends on speed of rotor. Magnitude depends on residual flux and strengthen by +Ve feedback from induced voltage.

Capacity of Batteries(110 V)

Type of Coach	Capacity in Ah
110 V BG coaches	120
IInd AC BG coaches (Old)	800
IInd AC BG coaches (New)	1100
IIIrd AC BG coaches	1100
LHB Coaches	70 (24 V)
FC AC COACH	525

Battery Charging at the Terminal Stations

For pre-cooling , AC Coaches are provided with

- One 200A capacity battery charger
- The battery charger takes 440 V, 3 phase supply through special battery charging sockets mounted diagonally one on each end wall.
- The battery charger consists of a transformer and a simple diode bridge rectifier.

RECTIFIER & REGULATOR UNIT

- Function –

1. Rectify 3-ØAC input to DC using Full Wave Diode Rectifier
2. Regulate the generated voltage at the set value.
3. Limiting the out-put current to the set value.

Major Equipments

1. **POWER RECTIFIER** 3-Ø,Fullwave, protected against transient surges by Capacitor.
2. **VOLTAGE REGULATOR --** Induced voltage depends on speed, excitation current & load current. It has 02 input (+feedback) and 1output.
3. **VOLTAGE DETECTOR --** Provides necessary "error signal" for voltage regulation (Zener diode, Potential divider and rheostat)
4. **CURRENT DETECTOR --** Provides necessary "error signal" for Current control.
5. **OVER VOLTAGE PROTECTION --** OVR is set at 150V DC it will over if voltage exceed 150V and open the field circuit causing seizure of generation.

- **02 Nos. of Emergency Feed Terminal (EFT) boxes are provided on each end wall for extending the power from one coach to adjacent coaches ,if required**
- **The load is fed through rotatory switches (RSW) & fuses to the connecting circuits (L1,L2,F and SPM).**
- **L1,L2 feed Lighting loads and & F- feeds fan loads & SPM feeds Emergency Feed Terminals.**

25KVA THREE PHASE INVERTER

OPERATING PRINCIPLE---

- The Input 110 Volt D C Voltage is boosted up to 620V DC, then fed to a 3-Phase PWM Sine-wave Inverter to get 3 - phase Output.
- The three-phase output is passed through harmonics filter.
- The output is protected against short circuits and overloads.

Rating of Fans

SN	TYPE	SWEEP	WATTAGE
A. DC FANS			
1.	SG	400 mm	35 W
2.	MOG	300 mm	29W
B. AC FANS			
1.	EOG	400 mm	60 W

End On Generation System

- **To cater the increased Electrical Power demand for faster train with improved passengers amenities like –**
  - Efficient Air-conditioning,
  - Elegant Lighting
  - Improved Pantry car

  (Cooking Range, Refrigerators, Bottle Coolers)

  in Rajdhani/ Shatabadi Express services, this is introduced.

CONNECTED LOAD FOR RAJDHANI

TYPE OF COACH	No.OF COACH	LOAD IN kW	TOTAL LOAD IN kW
AC III T	08	40.00	320.00
AC II T	06	34.75	208.50
AC FIRST	01	15.75	15.75
AC PANTRY	02	76.75	153.50
AC Power CAR	02	49.00	98.00
TOTAL	19		795.80

Maximum K W = 0.7 x (800.00) = 560KW

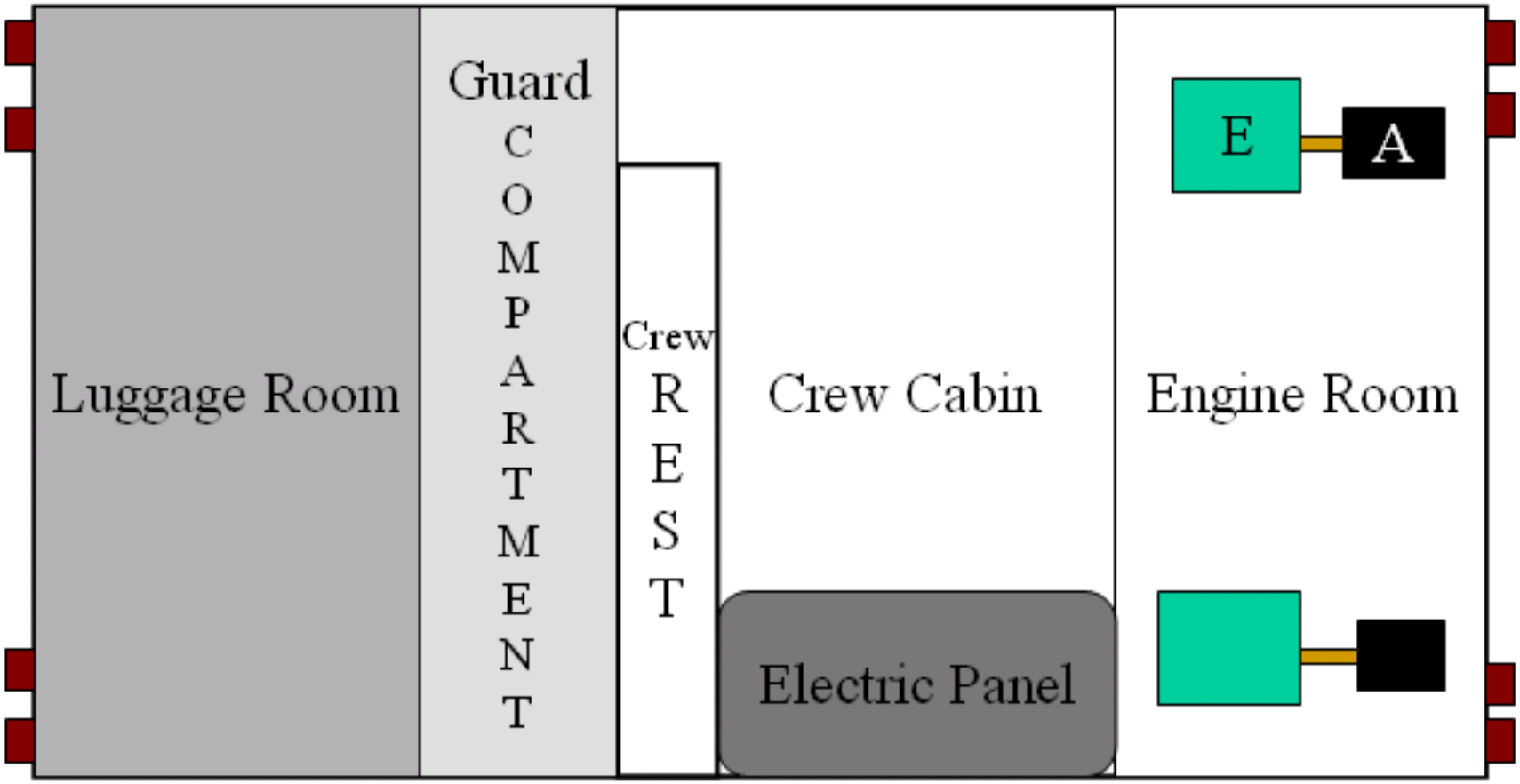
(Assuming Diversity factor = 0.7)

CAPACITY OF ALTERNATOR

- **1. Load on both the feeder = 560 kW**
  2.Load on each feeder = 280 / 0.8 = 350 KVA
  3.Required Output of the Alternator = 350 KVA

420 or 500 KVA Alternator are being used to cater the future load.

POWER CAR


Luggage Room
Guard
COMPARTMENT
Crew
REST
Crew Cabin
Electric Panel
E
A
Engine Room

Supply System of EOG

- **Power supply for air-conditioning, lights and fans is obtained by tapping from one of the two feeders of 750 V, 3 phase, 50 HZ emanating from the Power Car**
  - **Each coach is provided with 50KVA transformer which steps down voltage to 415 V, 3 phase**
  - **All AC equipments i.e. compressor, condenser, evaporator, heater etc. work on 415V, 3 phase**

Supply System in EOG Coaches contd…

- For supply to lights and fans, each coach is provided with a step down transformer of capacity 3 KVA - steps down the voltage from 415 V, 3 phase to 190 V, 3 phase.

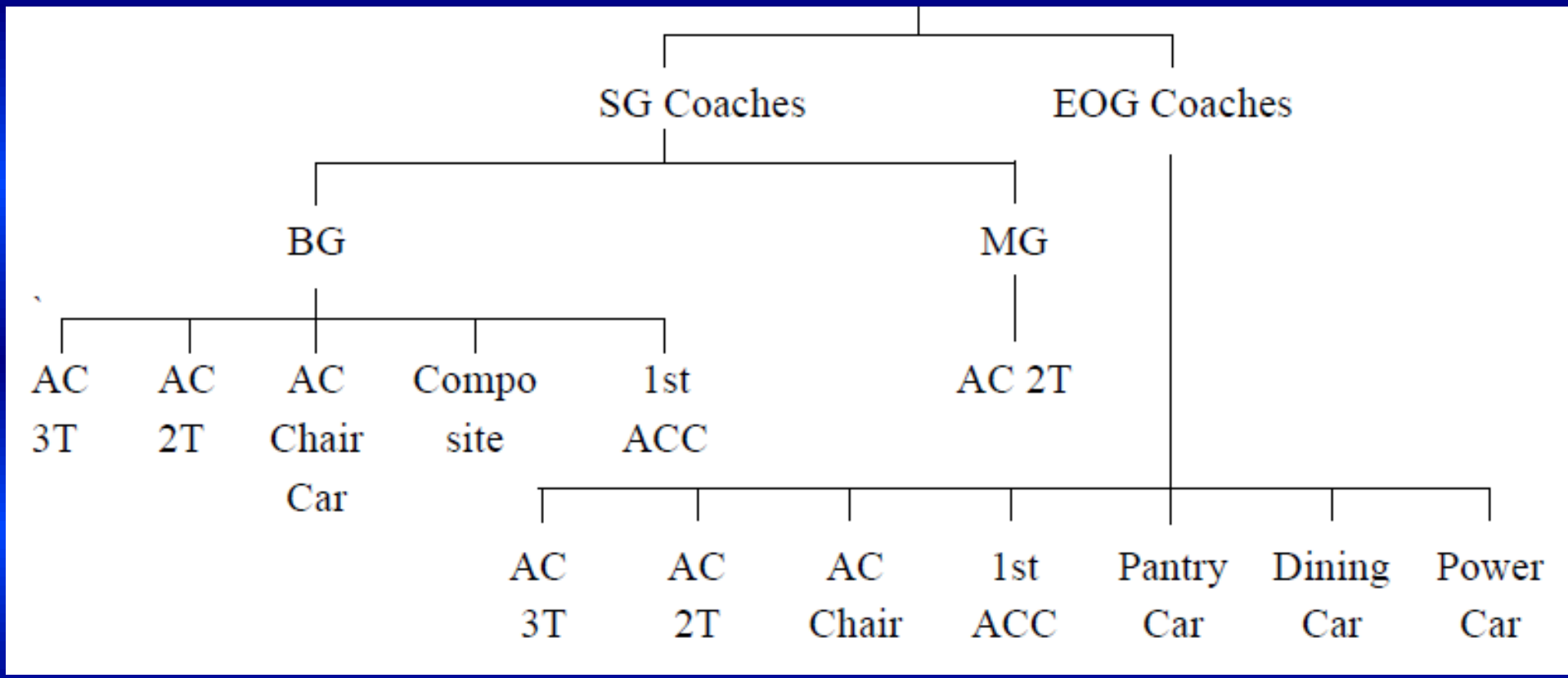
- 110 V a.c. supply is provided for lamps and fans by connecting them between line and neutral of the secondary side of transformer

Supply System in EOG Coaches contd…

- **A 110 V emergency battery of 90 Ah capacity has been provided on the under frame along with a battery charger. The battery supplies the emergency lights provided in the Coach *in* the event of a. c. power failure.**

AIR-CONDITIONING
Of
COACHES

AC COACHES


SG Coaches
EOG Coaches
BG
MG
AC 3T
AC 2T
AC Chair Car
Compo site
1st ACC
AC 2T
AC 3T
AC 2T
AC Chair
1st ACC
Pantry Car
Dining Car
Power Car

Air-conditioning in its primitive stage

- During 1900-1935
  - By providing Khus-Khus in matting
  - By providing ice containers
- First air-conditioned coach – Manufactured in the year 1936 at Matunga Workshop, Mumbai
- Introduction of AC coach in regular service – manufactured by ICF, Chennai in 1965

Air-conditioning – comfort factors

- Factors deciding comfort level
  - temperature
  - humidity
  - draft (velocity of air)
  - purity of air
  - Noise

- Humidity – ratio of the moisture contained in a given quantity to the quantity of moisture required to saturate that quantity at a particular temp. It is termed as Relative Humidity (RH).

Unit of Refrigeration

- Unit of Refrigeration – in ton (TR)
- It refers to the latent heat required to melt a ton of ice at 32 degree F in 24 hours
- 1 ton = 2000 lbs
- Latent heat of Water to freeze -144 BTU/Lb

$$1\ TR = \frac{2000 \times 144}{24} = 12000\ BTU/Hr$$

$$= 3000\ k\ Cal/Hr$$

- 1 TR of Refrigeration capacity?

- 1 TR can cater to apprx.

100 SQFT. (Area)

or

1200 CUFT. (Space)

Temperature settings in AC Coach

		Low	Medium	High
• I AC	Cooling	22^0 C	24^0 C	26^0 C
	Heating	17^0 C	19^0 C	21^0 C
• II AC	Cooling	-	23^0 C	25^0 C
III AC	Heating	-	19^0 C	21^0 C

Other settings in AC Coach

- Fresh air requirement
  - Smoking not permitted — 0.35 meter cube/min/ passenger
  - Smoking permitted — 0.70 meter cube/min/ passenger
- Air Velocity
  - up to 0.2m/sec inside the compartment
  - 4 m/sec at the diffuser

Refrigerant

- Freon 12 or Freon 22 (CFC gases)*

- These are chemical Compounds. Freon is the Trade name by DuPONT. In India the Trade name is Mafron.
- To be replaced by non CFC gases by 2000/ 2010 - to reduce Ozone layer depletion.
- R-134 a is being used now **(Non CFC)

◆ *Dichlorodifluoromethane

◆ **Tetrafluoroethane

Capacity of AC Coaches

- As per heat load calculation, Load and Plant capacity of various Coaches

	LOAD	CAPACITY
• AC II tier	8 TR	2 Plant x 5.3 TR
• AC Ist	5.3 TR	1 Plant x 6.7 TR
• AC Chair Car/III tier		2 Plant x 6.7 TR

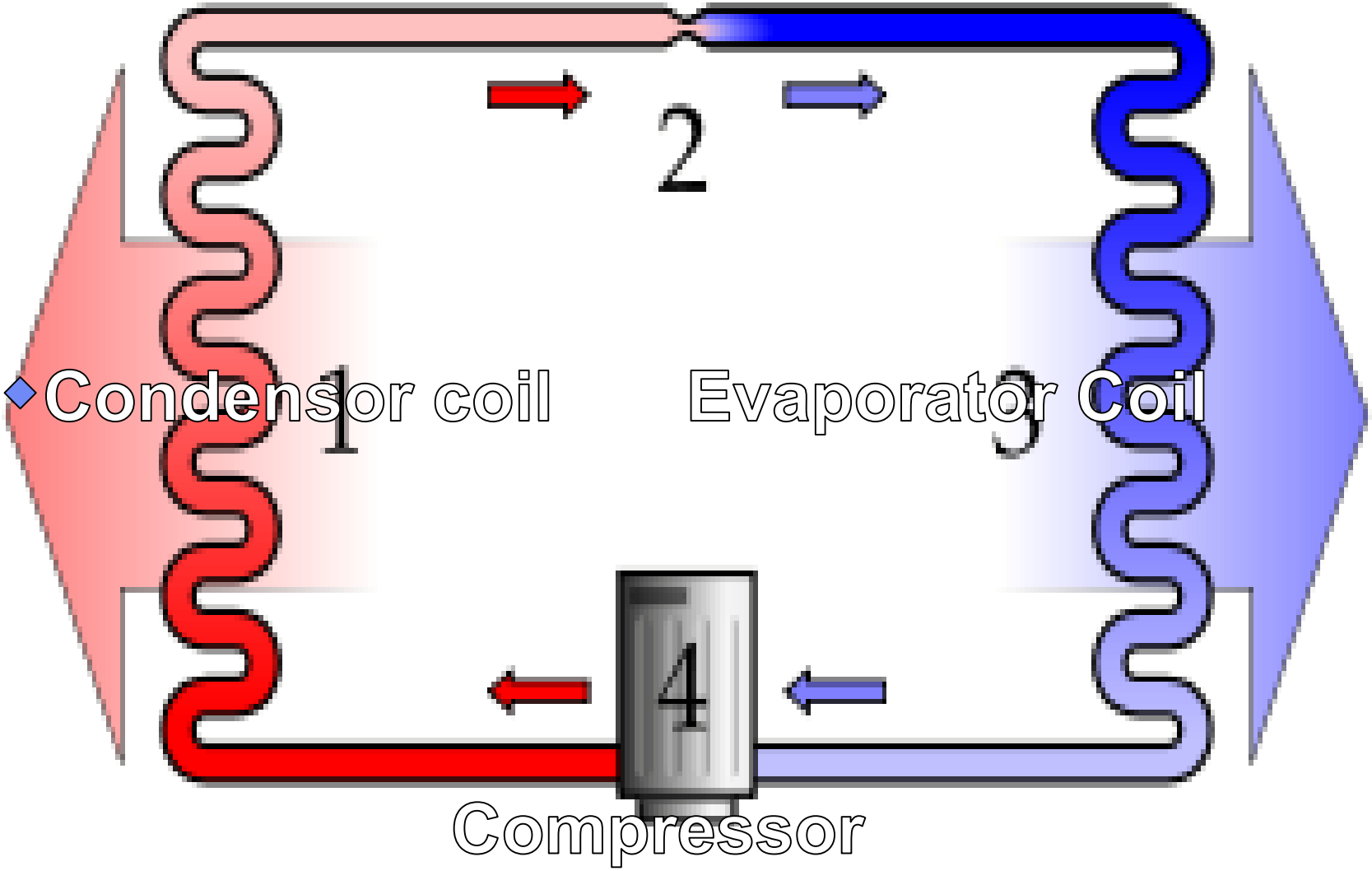
Air- Conditioned Coaches

- Air-conditioned Coaches broadly classified as-
  - Self generating type
    - Power for AC equipments is supplied by axle driven alternators at 110V DC
  - End-on generation type
    - Power from diesel generated sets (DG sets) at both ends at 750 V AC 3 phase 50 Hz.
    - AC equipments operate at 415 V 3 phase 50 Hz. AC

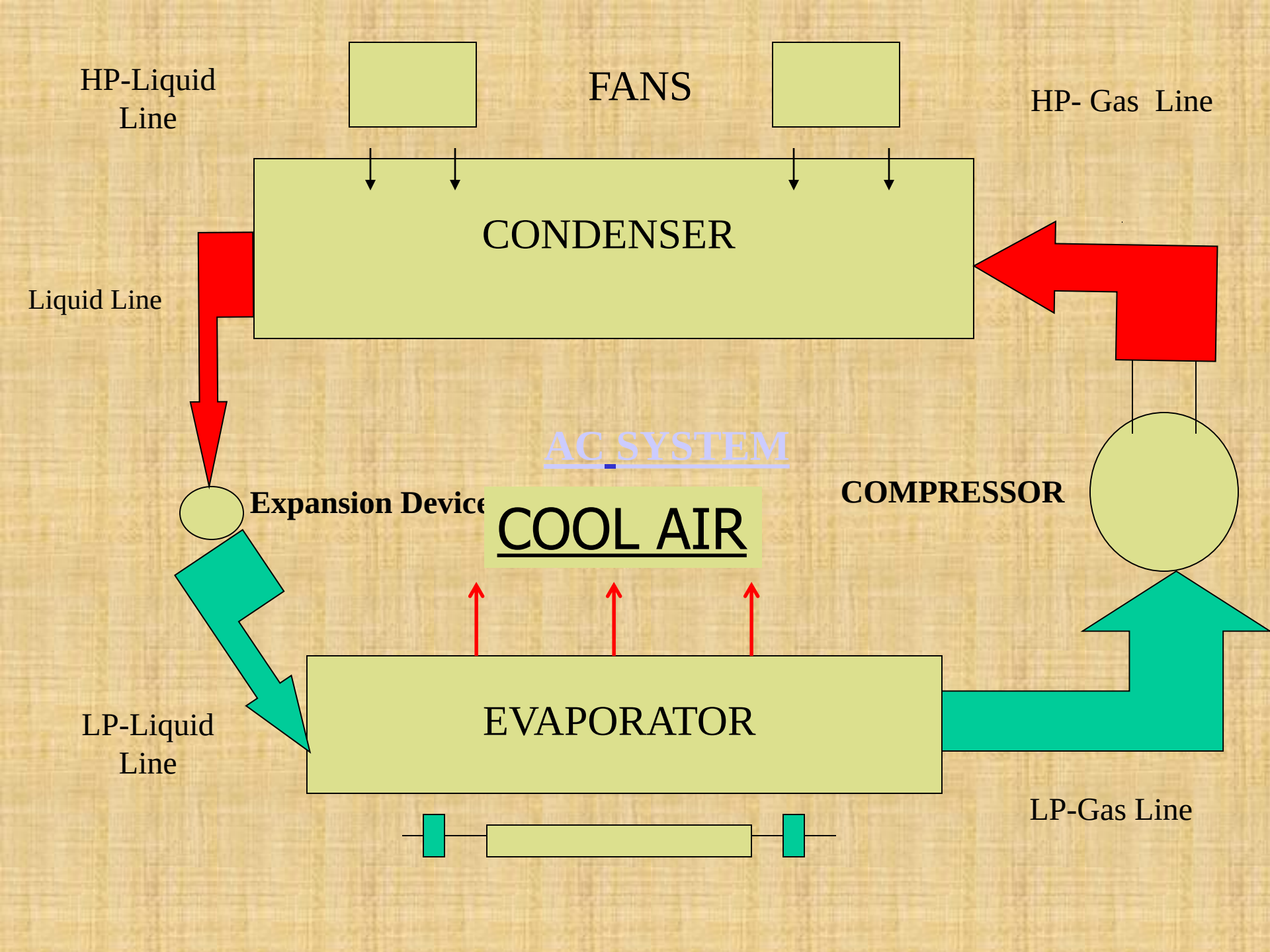
Equipments of AC System

- Compressor – compresses & delivers gas into condensers at **a** high pressure & high temperature
- Condenser – it cools the hot gas and liquidies it under pressure
- Expansion Valve – It controls and regulates the rate of flow of liquid freon under high pressure
- Evaporator –the cooling unit in which liquid freon under low pressure evaporates & in-doing so takes away the latent heat thereby cooling the medium surrounding the cooling coil

- Expansion Valve



- Condensor coil
- Evaporator Coil
- Compressor


HP-Liquid Line
FANS
HP- Gas Line
CONDENSER
Liquid Line
AC SYSTEM
Expansion Device
COOL AIR
COMPRESSOR
EVAPORATOR
LP-Liquid Line
LP-Gas Line

AC system in conventional type Coaches

- In conventional type – AC equipments provided on under-frame
- Operates on 110 V DC supply through 18/25/27.5 KW alternators
- Thermostat senses the inside temperature of the coach
- Battery charger is provided on under-frame for charging the batteries
- Pre-cooling sockets are provided on either side of the coach for pre-cooling purpose

Underslung Type AC System

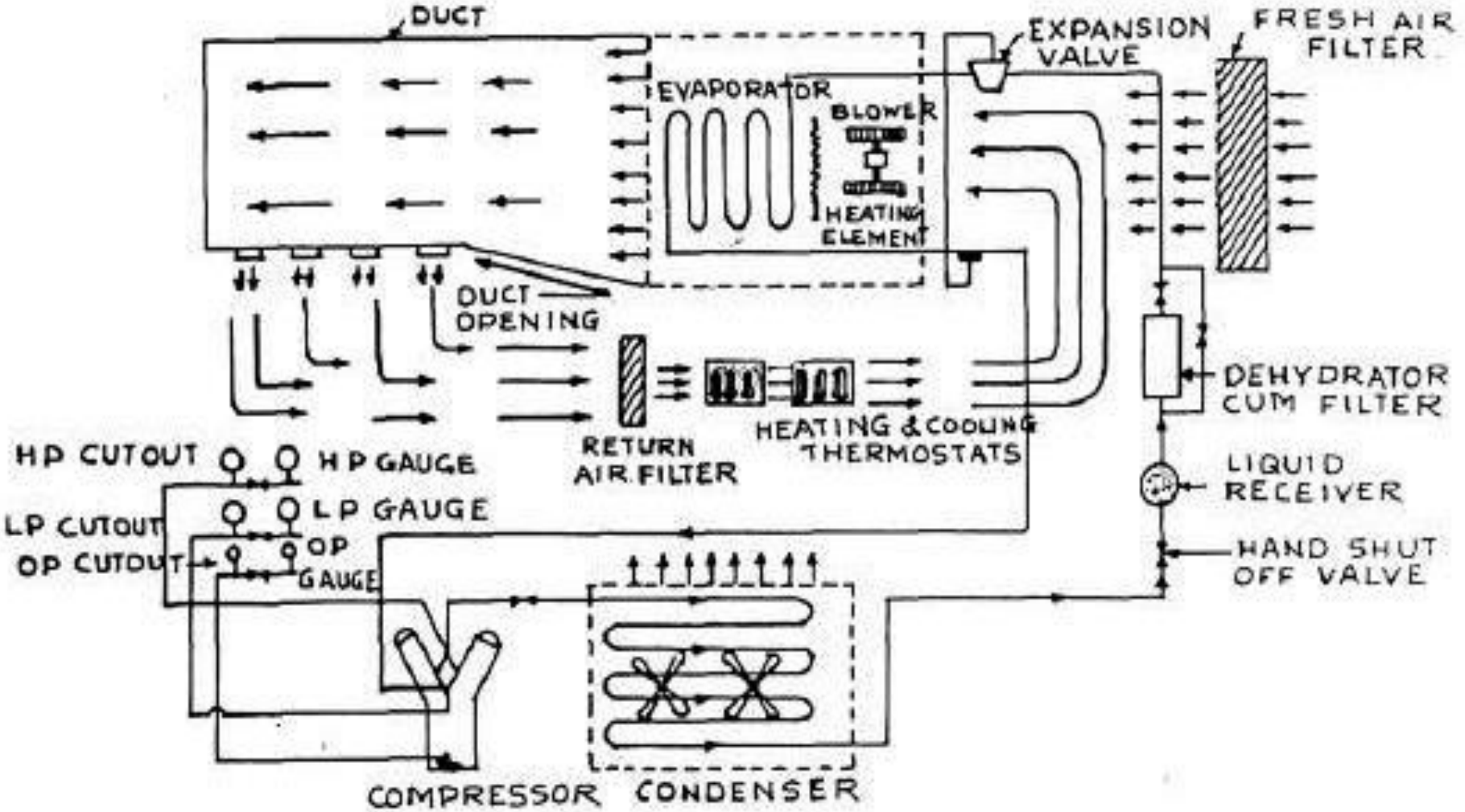


FIG.1 SCHEMATIC DIAGRAM OF AIR CONDITIONING SYSTEM FOR A/C COACHES

Drawbacks of Conventional AC system

- Underslung type system causes problems –
  - Refrigerant gas leakage from pipes and joints
  - Heavy weight - coach tare weight increases
  - Large space occupation by the equipments
  - Maintenance problems - Huge skilled manpower required
  - Consumes more power - Less energy efficient
  - Under-slung equipments get hit by ballast, CRO
  - Accumulated dust affects heat transfer

Air duct

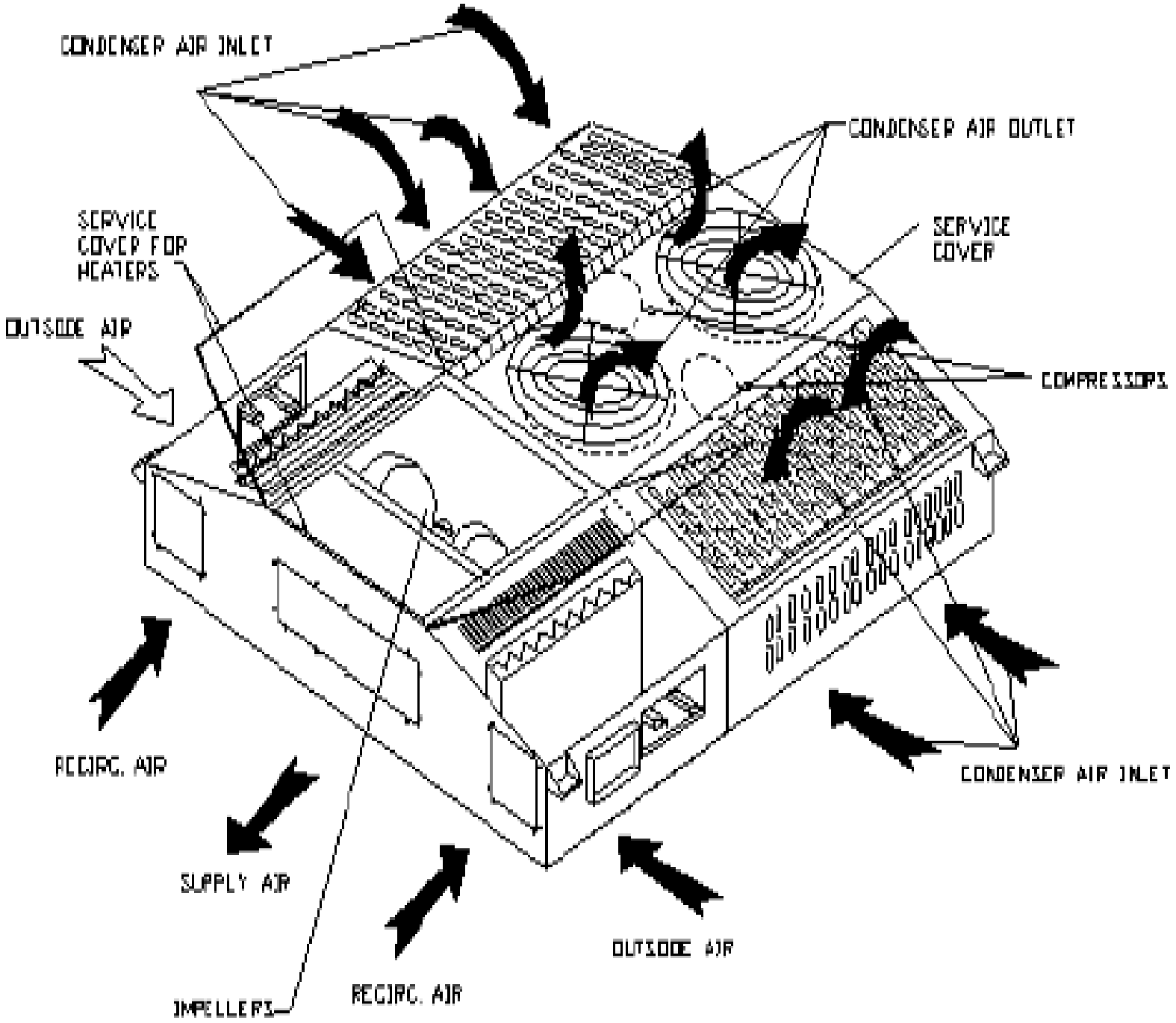
- The air conditioning system includes three air ducts as follows:
- a. Fresh (Inlet) air duct.
- b. Main air duct.
- c. Return air duct.

- Actually there is no separate return air duct provided in A/C coaches. In the case of a.c. two tier coach and A.C. chair car, the return air is drawn through the return air filters directly from the nearest compartment In 1st class A.C. coach, the corridor acts as return air duct and the return air is drawn through return air filters located at the corridor ceiling near the first compartment.

Roof-Mounted Packaged Unit (RMPU)

RMPU of 5.2 TR each was introduced in the year 1992 with 25 KW alternator

- Now a days two high capacity packaged air-conditioning units of 7.0 TR for AC II tier & AC III tier coaches
- For first AC - one unit of 7 TR is used
- Mounted above the toilets on both ends supplying conditioned air in the tapered duct to serve the coach end to end


CONDENSER AIR INLET
CONDENSER AIR OUTLET
SERVICE COVER FOR HEATERS
SERVICE COVER
OUTSIDE AIR
COMPRESSORS
RECIRC. AIR
CONDENSER AIR INLET
SUPPLY AIR
OUTSIDE AIR
IMPELLERS
RECIRC. AIR

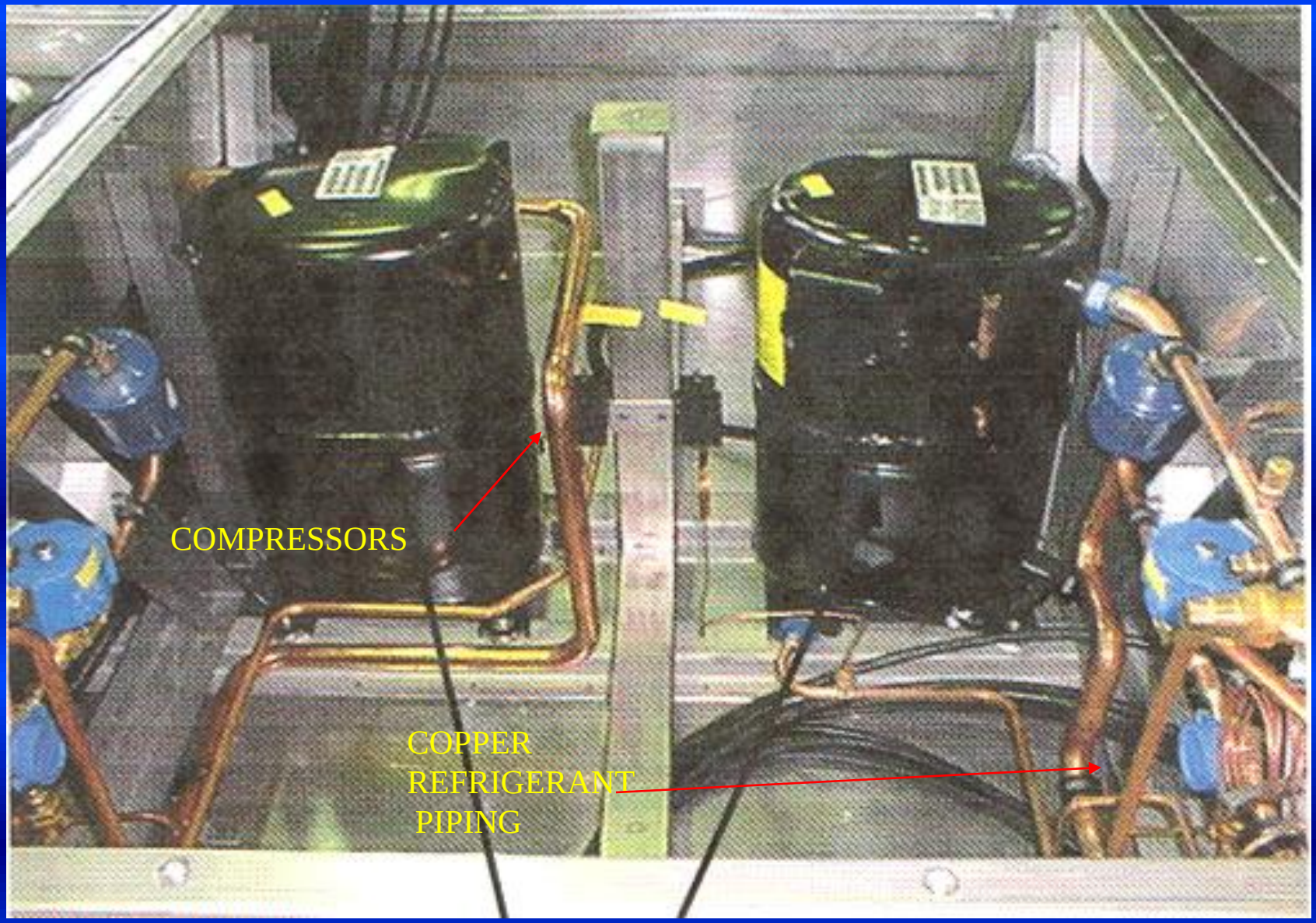
The compact air conditioning unit has two separate cooling circuits consisting of the following components:

- two hermetic refrigeration compressors with oil heaters
- two condenser with Cu pipes and Al. Fins
- two axial fans for cooling the condensers
- two evaporators
- two twin-sucking radial fans for the supply air (driven by the motor)
- three maintenance covers
- two air inlets for circulating air
- one air outlet for supply air
- control and safety devices
- pipelines/fittings
- two mixed air filters

Operating Mode

- **Preheating and cooling operation --**The outside air dampers are closed to facilitate rapid heating up or cooling down of the carriage
- **Normal operation --**In the normal operating mode, the dampers are set to ensure the envisaged fresh air volume of 21 m^3/h per person.
- **Emergency operation ---If** AC system fails due to a failure of the power supply, the adjusting dampers of the circulating air duct close so that the system is operated exclusively with outside air.

TOP VIEW OF COMPRESSORS



Comparison of RMPU with Conventional under-frame AC system

	RMPU	Conventional AC
Weight	900 Kgs (2 units)	2700 kgs
Installation time	4 hrs	4 days
Refrigerant	R – 22*	R – 134A
Refrigerant charge	2.85 Kgs	15 Kgs
Danger due to cattle run over / flood	Nil	Heavy
Down time for repairs	4 hrs.	Very long time

- * MONO CHLORO DIFLORO ETHANE

Recent Modification

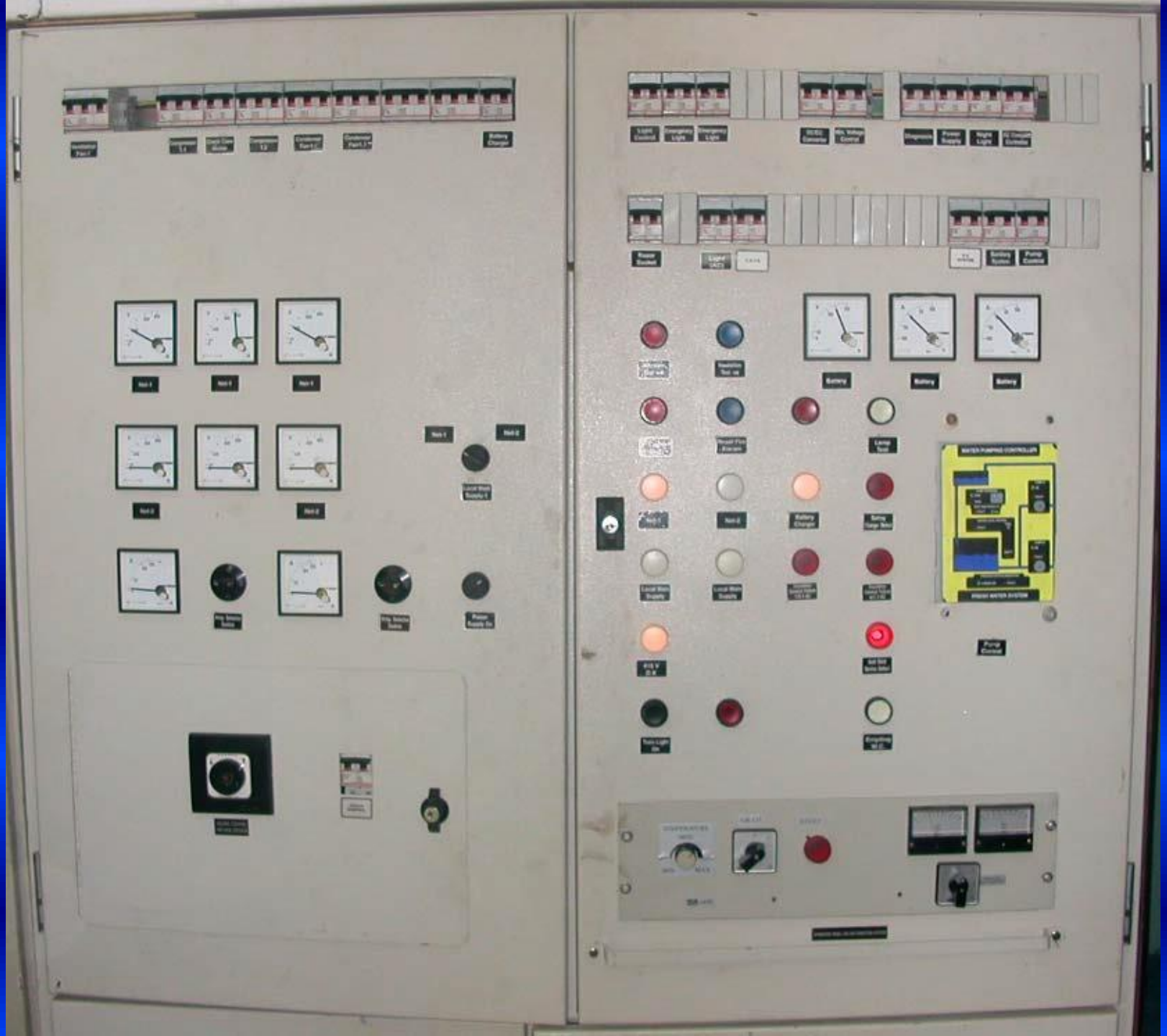
- The art of technology employed in this unit is that two nos. of RMPU are controlled by single Microprocessor Controller there by reliable, durable, high on cooling side, low on energy consumption because they consist of 4 hermetically sealed compressor (two in each unit) with microprocessor-based controllers.
- Only 2 compressors function under normal temperature conditions.
- The other 2 acts as stand-by and works only during peak seasons. Microprocessor Controller rotates the operation of all 4 compressors so that wear and tear is equally uniform. Compressors are started in sequence with time delay to reduce the peak demand of electricity during start up.
- To ensure perfect cooling comfort during monsoons, a special dehumidification package has been installed using compressor and heating cycles.

Linke Hoffman Bosch (LHB) coaches

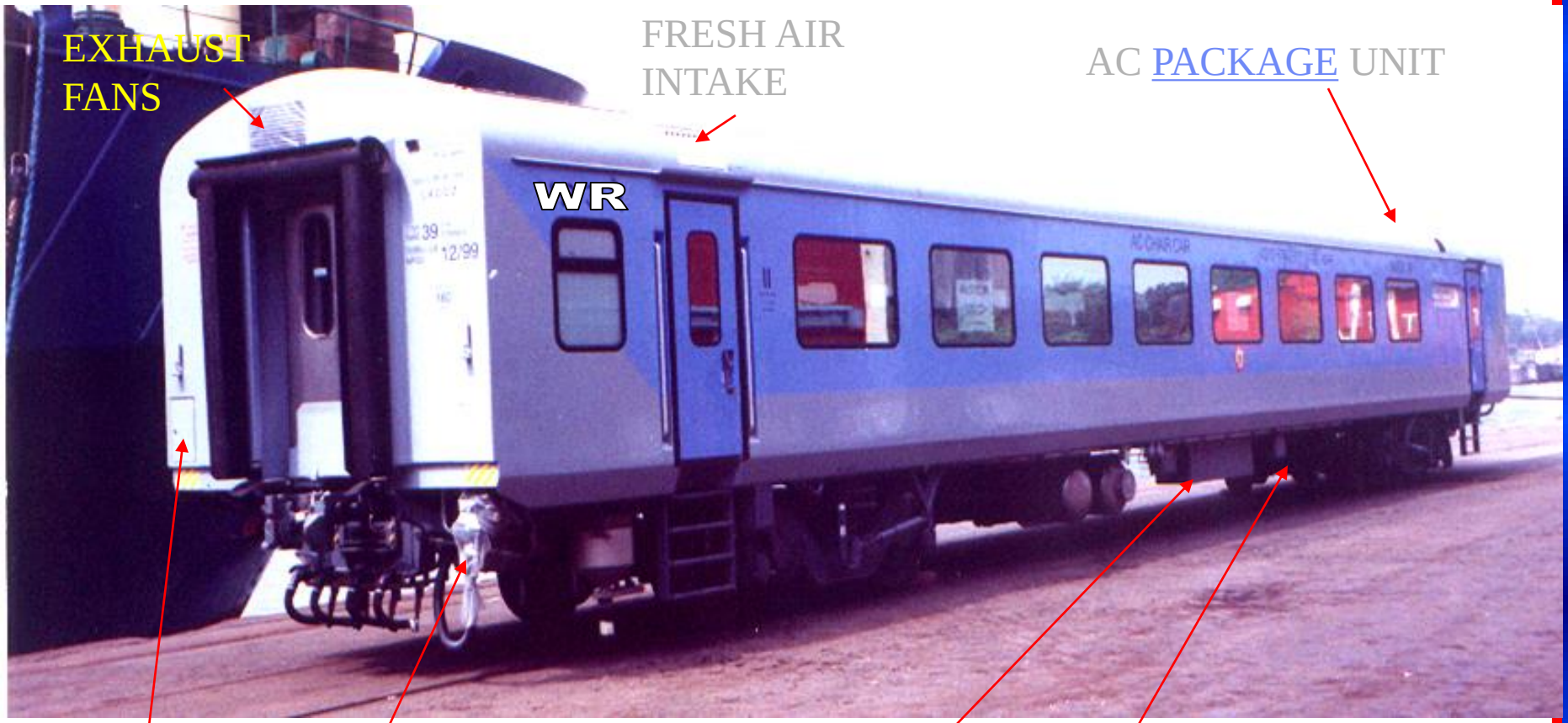
- Latest state of the art coaches provided in Rajdhani / Shatabdi Exp. Trains with modern passenger amenities
- Technology transfer from M/s Alstom – LHB of Germany
- Being manufactured at Rail Coach Factory, Kapurthala from the year 2003 onwards

LHB Coaches

- Aesthetically superior Interiors
- Very low noise
- Fire retardant materials
- Modular toilets with controlled discharge
- Light weight



GENERAL FEATURES OF LHB COACHES



SALIENT FEATURES OF LHB

- **HIGHER SPEED POTENTIAL-160KMPH**
- DISC BRAKING.
- COACH LENGTH INCREASED BY 1.7 **MTS-54 BERTHS IN AC-II AGAINST 46 IN OTHER AC-II.**
- COACH WEIGHT REDUCED FROM 48T TO **40.3T**
- EACH COACH HAS **60 KVA 415/240,3 PH TRANSFORMER** (ICF-50 KVA)
- **70Ah,110V VRLA EMERGENCY BATTERY**
- **MICRO PROCESSOR CONTROLLED AC PLANT**
- TEMP. CONTROL IN **7 STEPS** (20-25/17-19^{0}C)
- **FASTER PRE-COOLING(FLAP** DOOR CLOSES AT 28^0 C)


सामान ब्रेक और जेनरेटर कार
LUGGAGE BRAKE & GENERATOR CAR
गार्ड
GUARD

GARIB RATH Trains

AC Sleeper coaches having 75/81 berths (in place of 67 in Rajdhani Sleeper Coaches). Chair Cars having 102 chairs (in place of 72 in other AC Chair Cars)

Power Cars are equipped with 02 nos. DG Sets each having 490 BHP engine & 500 KVA, 750 volts alternator. An independent A.C. Unit of 1.5 ton capacity is provided in Guard compartment.

Four berths are provided in each Power Car for handicapped passengers. Luggage portion, however, is not available in these power cars.


विकलांगों के लिए परे
FOR DISABLED WR
068511
1 - 4
TO SLEEP
2909 डा.
गरीब रथ
2910 आ
CONTACT :
D.S. MITTLE & SONS
23521888
BASE
BOOKED TO
CPO/BDTS

All Garib Rath Coaches are equipped with 02 nos. RMPUs. Each RMPUs is having 2 sealed compressors of 3.75 ton capacity.

Electronic Temperature Controllers are used in these coaches with temperature settings as 25^0 C to 27^0 C during summer and 19^0 C to 21^0 C during winter. Temperature setting for summer in other A.C. Coaches is 23^0 C to 25^0 C.

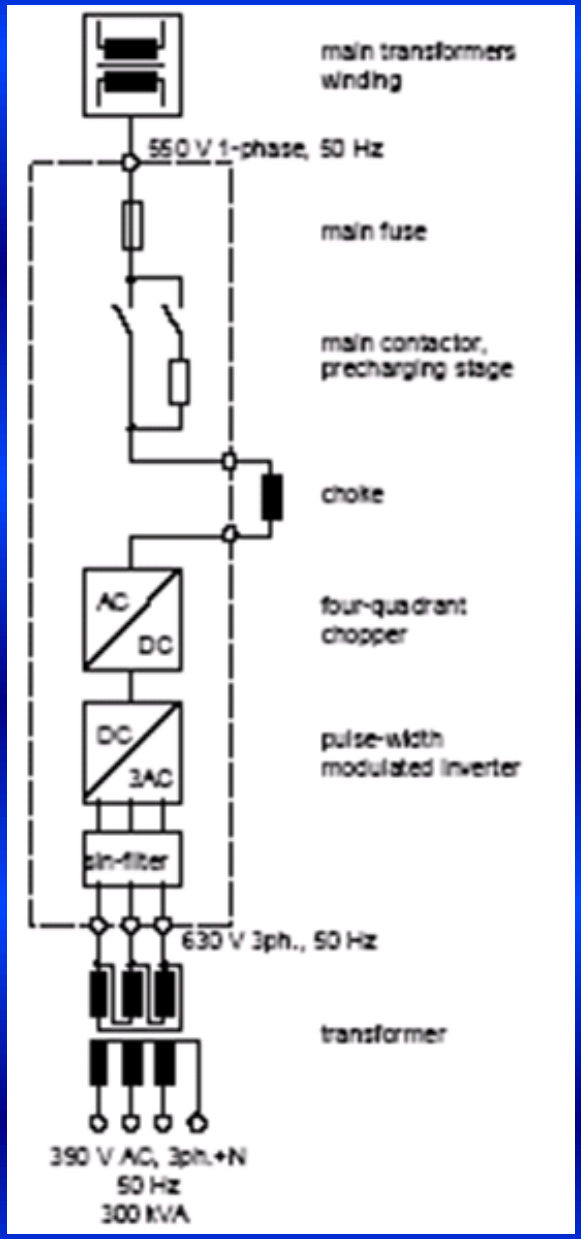
Instead of using two transformers - one for 415 volts power circuit and another for 110 volts lighting circuit, Garib Rath coaches are equipped with a single transformer of 50 KVA having one 47 KVA tapping of 415 volts and another 3 KVA tapping of 110 volts.

Head On Generation scheme

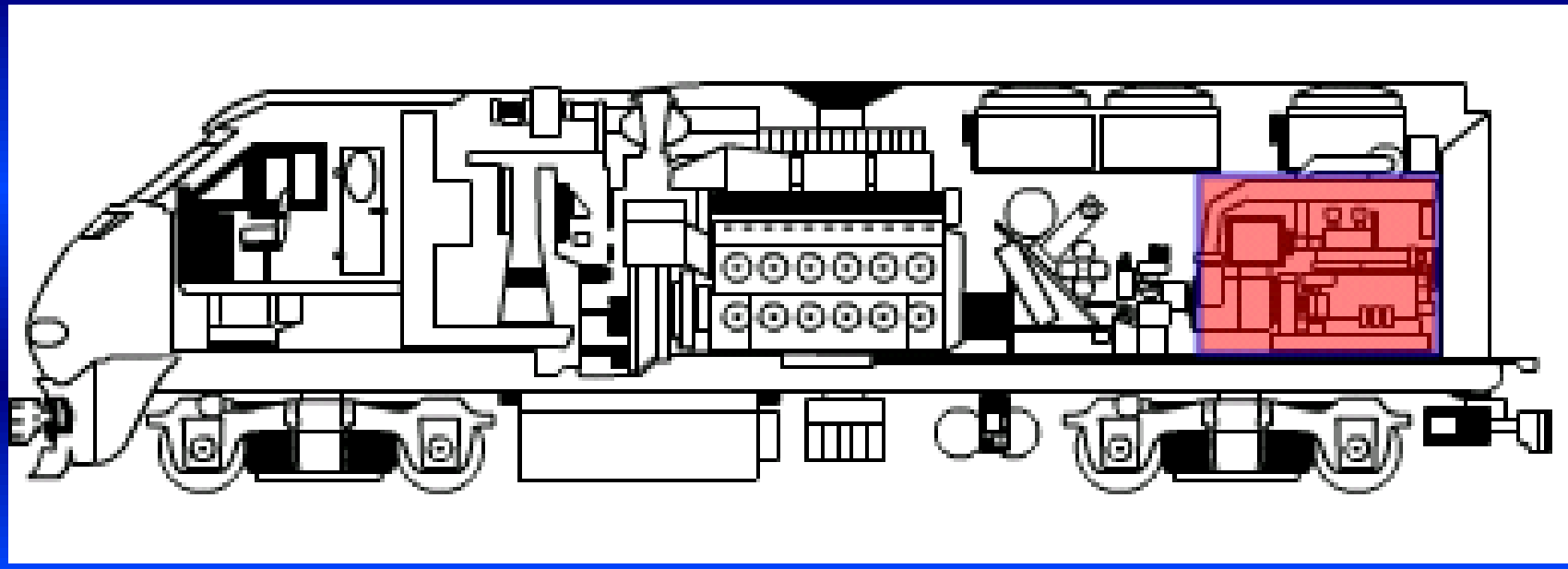
- Hotel load power taken from Electric / Diesel Locomotives for train lighting purpose.
- Power supply to the coaches in Europe is fed from the equipments mounted in the Pantry Car with a pantograph overheads and hence the name "Hotel Load"

Head On Generation scheme

Electric Locomotive



Diesel Locomotive



THANK YOU