भारत सरकार / GOVT. OF INDIA
रेल मंत्रालय / MINISTRY OF RAILWAYS

GENERAL SERVICES

TRAIN LIGHTING

भारतीय रेल
विद्युत इंजीनियरिंग संस्थान
INDIAN RAILWAYS
INSTITUTE OF ELECTRICAL ENGINEERING
नासिक रोड NASIK ROAD - 422 101

PREFACE

The book of “General Services : Train Lighting” was brought out by Institution of Railway Electrical Engineers (IREE) long back. Since, lot of changes and developments have taken place in the field of Train Lighting, it has become necessary to incorporate the changes in this volume. Few additions and modifications in the field of “Train Lighting” has been included in this book.

For bringing out this book Shri Sanjay Swarup, Section Engineer and Shri M.A. Suryawanshi, Raj Bhasha Supdtt. have made substantial efforts, under the guidance of Shri S.M. Khinchi, Senior Professor (EMU) and Shri D. Ramaswamy, Senior Professor (Academics).

I am very glad to note that lot of efforts have been made in bringing out this book of “Train Lighting” in the present form. I am sure that this book will serve the needs of Electrical Engineers working in the field of Train Lighting.

Nasik Road
20th Sept. 2010

A. K. RAWAL
DIRECTOR

TRAIN LIGHTING

TABLE OF CONTENTS

1. SYSTEMS OF TRAIN LIGHTING

1.0 Train lighting is one of the important passenger amenities which influence the image of Railways. Although first train ran on 16th April 1883 from Mumbai CST to Thane, train lighting system through axle driven dynamo pioneered by M/s. J. Stone & Co. came to Indian Railways only by 1930. Dynamo / Brushless alternator driven from axle through flat / 'V' belts, supplies the load when train is in motion and charges the batteries. The batteries supply the load when train is stationary. Following systems for train lighting are presently in use –

1) Axle driven system working on 110 V DC supply.

2) Mid on generation with 415 V, 3 Phase generation AC 110 V utilization.

3) End on generation with 3 Phase 415 V generation and AC 110 V utilization

4) End on generation with 3 Phase 750 V generation and AC 110 V utilization

A decision has been taken that all coaches now being built will have only 110 V system. The coaches operated in 24 V system have already been converted to 110 V system.

1.1 AXLE GENERATION SYSTEM WORKING ON 24 V DC.

Coaches provided with D.C. dynamo/brushless alternator were driven from coach axle through flat belt or V belts on pulleys. The pulleys are mounted on axle as well as dynamo/brushless alternator. The generation equipment used for axle generation are as follows –

a) 60 A and 100 A Dynamos with inherent regulation

b) 100 A (3 KW) and 150 A (4.5 KW) brushless alternators with external regulation for MG & BG respectively.

All D.C dynamos have already been replaced by brushless alternators in view of simplicity in maintenance and superior characteristics for both high and low speeds. No new DC dynamos are being procured and this system is practically non-existent at present. Lead acid batteries of standard capacity 210 Ah, or 320 Ah are provided in each coach depending on the connected load of the coach.

Normally, each coach should be able to meet its own load independently. Emergency feed terminal boards are provided at each end of the coach to enable feeding from the adjoining coaches on either side. This emergency feed is availed of only in case the coach is unable to feed the load due to missing/defective generating equipment, regulator or batteries.

Provision is made for charging the batteries from external source by means of a terminal board.

Incandescent / fluorescent lamps are provided in the coach for lighting purposes. Fixed type Fans 400 mm in II class coaches and 200 mm in I, II & III AC coaches, are provided.

1.2 AXLE GENERATION WORKING ON D.C. 110 V SUPPLY

This system has proved more reliable and capable of meeting future increase in load. It has, therefore, been adopted as standard for all future builds of self generating, coaches. In this system 4.5 KW brushless alternators are driven through V-belts from axle.

Lead acid batteries 11O V, 120 Ah arranged from 3 cell Monoblock units, are provided in the B.G. coaches. Four numbers of emergency feed terminals boxes for B.G. and one number for M.G. coach, are provided on each end wall for interconnecting the coach to adjacent coach to receive power, in the case generation fails. One number emergency terminal box is provided centrally on each side of under frame to facilitate charging of battery from external source. For BG AC coaches, 18 KW / 25 KW brushless alternators are used. Two such alternators are used in AC-2T /AC-3T /Chair Cars and only an alternator is used in First AC coach. Batteries of 800 / 11 00 AH capacity at 10 hr rating are used in I AC / AC-2T / AC-3T /chair car of B.G. Coaches.

A schematic layout for 110 V DC system is at Figure 1.1

Three phase output from 4.5 KW alternator mounted on the bogie of coach is fed to the regulator cum rectifier for rectifying the AC output to DC and regulating the output voltage at different speeds and loads. The output from rectifier cum regulator on the underframe is brought through cables on the coach. The load is fed through four rotary switches (RSW) and fuses connecting circuits LI, L2, F and SPM. LI feeds the essential lighting load like lavatories, gangways, doorways and upto 50% of light in each compartment/bays corridor lights and night lights, L2 feeds remaining lighting loads, F feeds the fan load and SPM feeds emergency feed terminals (EFT).

An external battery charging terminal (BCT) is provided to charge the battery from external charger, if battery is in rundown condition due to failure of alternator.

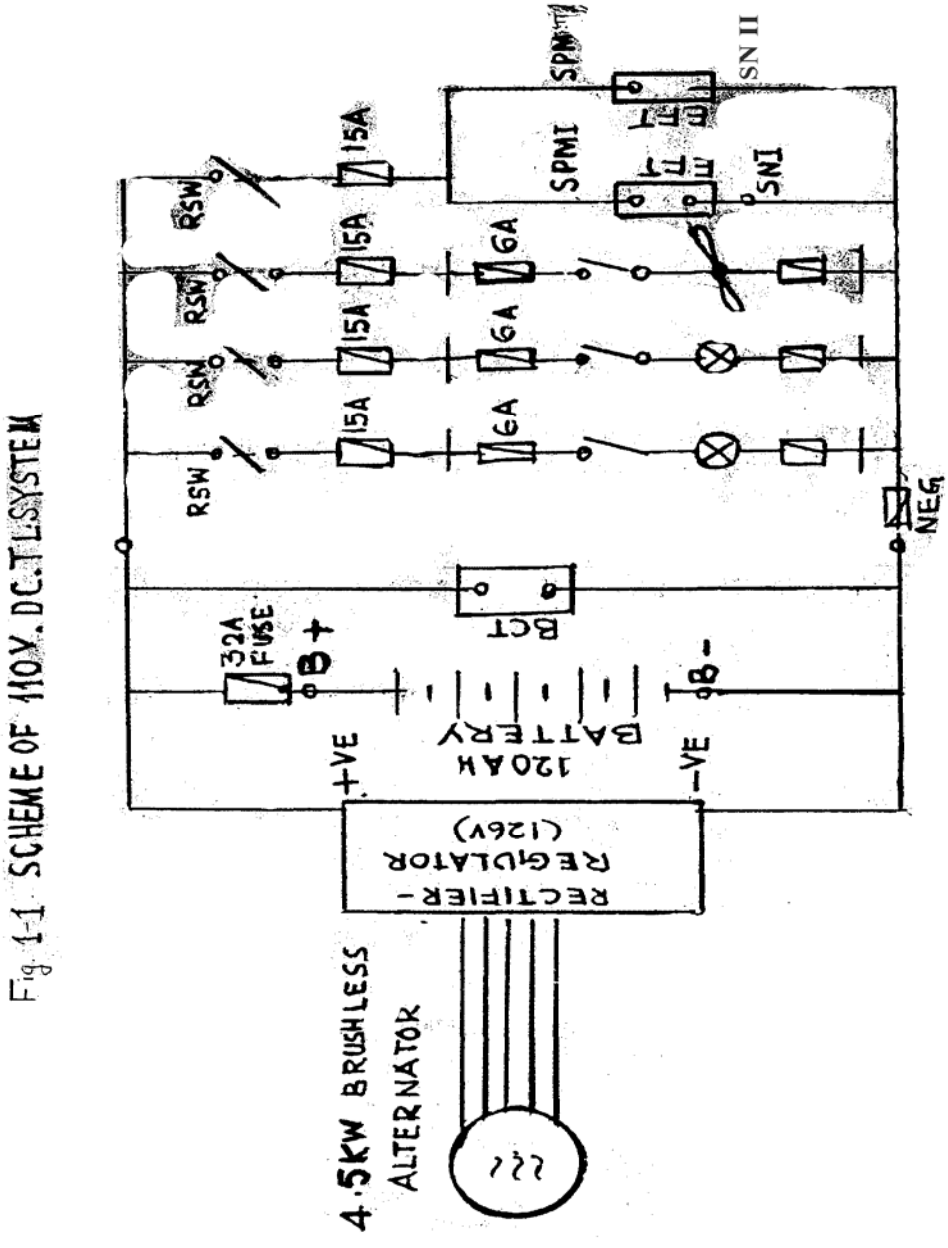


Fig. 1.1

MID-ON-GENERATION

In this system a power car housing DG sets is used in middle of rake. This system is chosen for small branch line slow trains having long halts where batteries are likely to remain undercharged if conventional axle driven system is adopted. Capacity of DG set will depend on composition of rake (usually 30 KVA) and generation is at 415 V, 3 phase, 50 cycle and is stepped down to 110 V, 3 Phase, 50 cycles.. The lights and fans in coaches are operated 110 V AC through feeders on either side of Power Car.

A schematic layout of power car for mid-on-generation is shown at Figure 1-2.

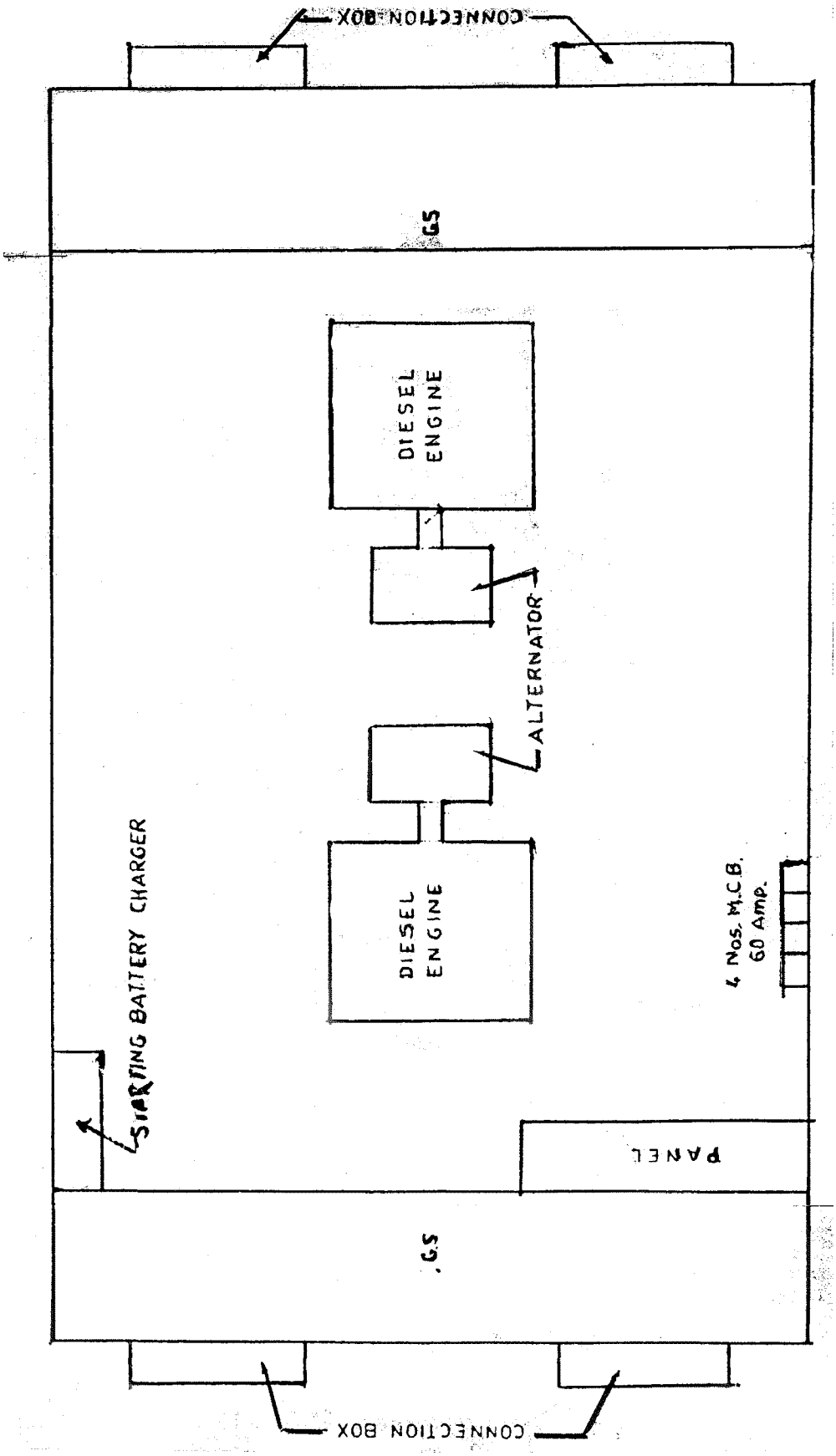


FIG. 1-2 GENERAL LAY OUT OF M.G. POWER CAR

1.3 **END-ON-GENERATION**

Rakes of Rajdhani / Shatabdi express trains having heavy load of air-conditioned coaches, pantry cars with electrically operated cooking appliances, use Diesel Generating Sets housed in coaches known as Power cars to meet the load. Normally 2 power cars, one on either side of rake, generate power at 750 V AC or 415 V AC, 3 phase, 50 cycles. All the coaches of power cars are interconnected with each other through couplers consisting of switchgear flexible cables. Power cars have control panel consisting of switchgear arid protective relays, The power at 750 V/ 415 V is stepped down to 110 V AC for lighting and fan load in the coaches.

A schematic layout of power car for end-on- generation is shown at Figure 1.3 .

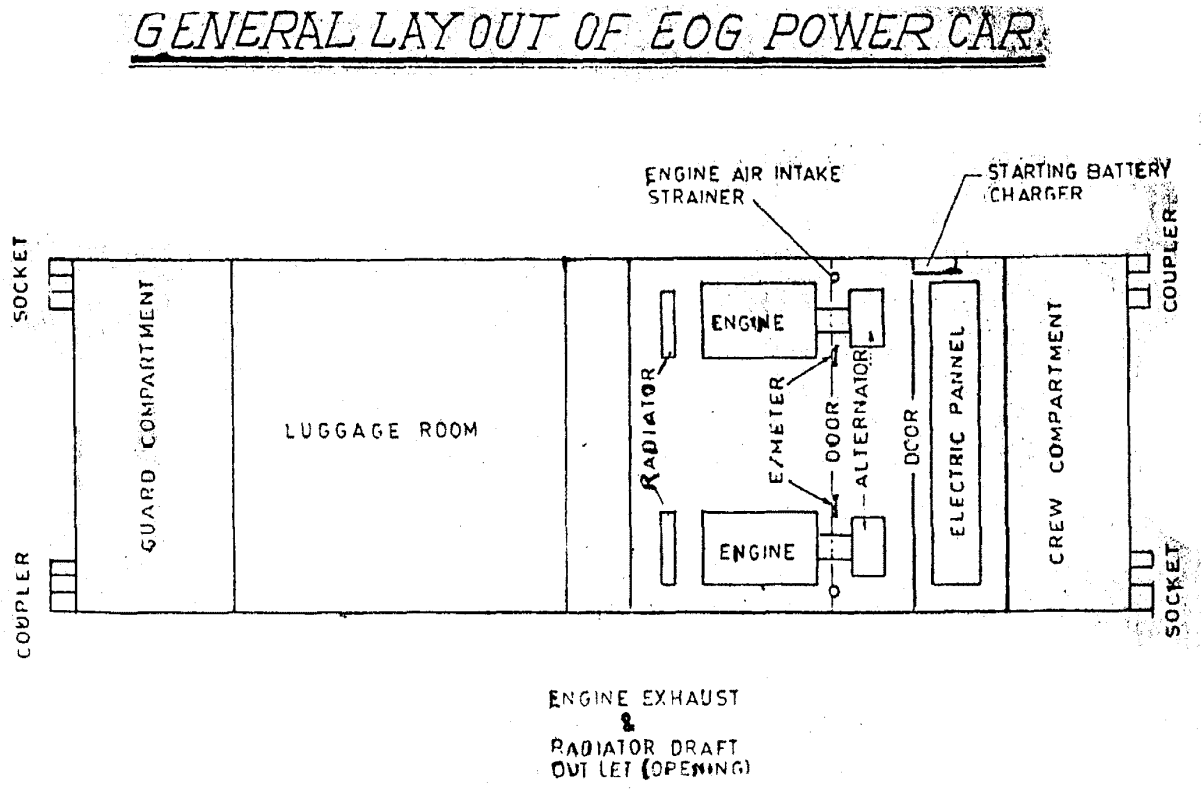


FIG. 1.3

2. D.C. DYNAMOS / BRUSHLESS ALTERNATORS & DRIVES

2.0 INTRODUCT1ON

D.C Dynamos, 32 V used earlier, have been replaced by brushless alternators driven from axle through 'V' belts. No new D.C. dynamos are being procured and old dynamos have been phased out. However for academic purposes the DC Dynamo is being discussed.

2.1. D.C. DYNAMO

2.1.1 The D.C. dynamo used for train lighting is shunt wound, reversible and totally enclosed. When connected to a battery, the generators have inherent self regulating properties due to the utilization of armature reaction through the medium of a third brush and the arrangement of part of the shunt field connected to obtain a. decreasing strength with rising speed. An additional shunt field is connected across the main brushes tending lo improve the characteristics of the generator. The output of the generator is thus at its maximum at low speeds and drops at high speeds making the generator fit for both slow and last trains. In effect, the battery charge in ampere hours over a given period of time is the same for either type of service. Fig.4 shows the assembly and Fig. 5 shows internal connections.

2.1.2 **The following types of old dynamos were in use in the Indian Railways.**

a) Tonum IR *29* S dynamos 60 A capacity.

b) Beni dynamos 60 A capacity.

c) Tonum IR 29 L, dynamos 100 A capacity.

d) Tonum IR 32 L dynamos 120 A capacity.

2.1.3 **Output Adjuster :**

This is variable resistance provided in the body of the dynamo with suitable enclosure to provide easy access and adjustment. The output of the generator will depend upon the strength of the 'B' field circuit while the nature of the characteristic will either be 'flat' or "drooping", depending on the resistance of the 'A' field circuit. In 'Tonum' generators, the output adjuster resistance is designed to get the output at live positions, from 60 to 100 A in steps of 10 A in the case of IR 29 L dynamos and from 72 to 120 A in steps of 12 A in the case of IR 32 L dynamos A fixed resistance (PSR, 0.55 ohms) is included in 'A' field circuit which also forms part of output adjuster resistance. 'Beni' dynamos are also provided with separate resistances for 'A' and 'B' field circuits. While the function of 'B' field resistance is the same as in the case of 'Tonum' generators, the resistance in the 'A' field is provided with three separate settings viz. 'drooping' 'medium' and 'flat' and after the slope of the characteristic curve after the full output is reached. The 'B' field resistance is calibrated in terms of the percentage output of the dynamo from 70 to 100% in steps of 10%.

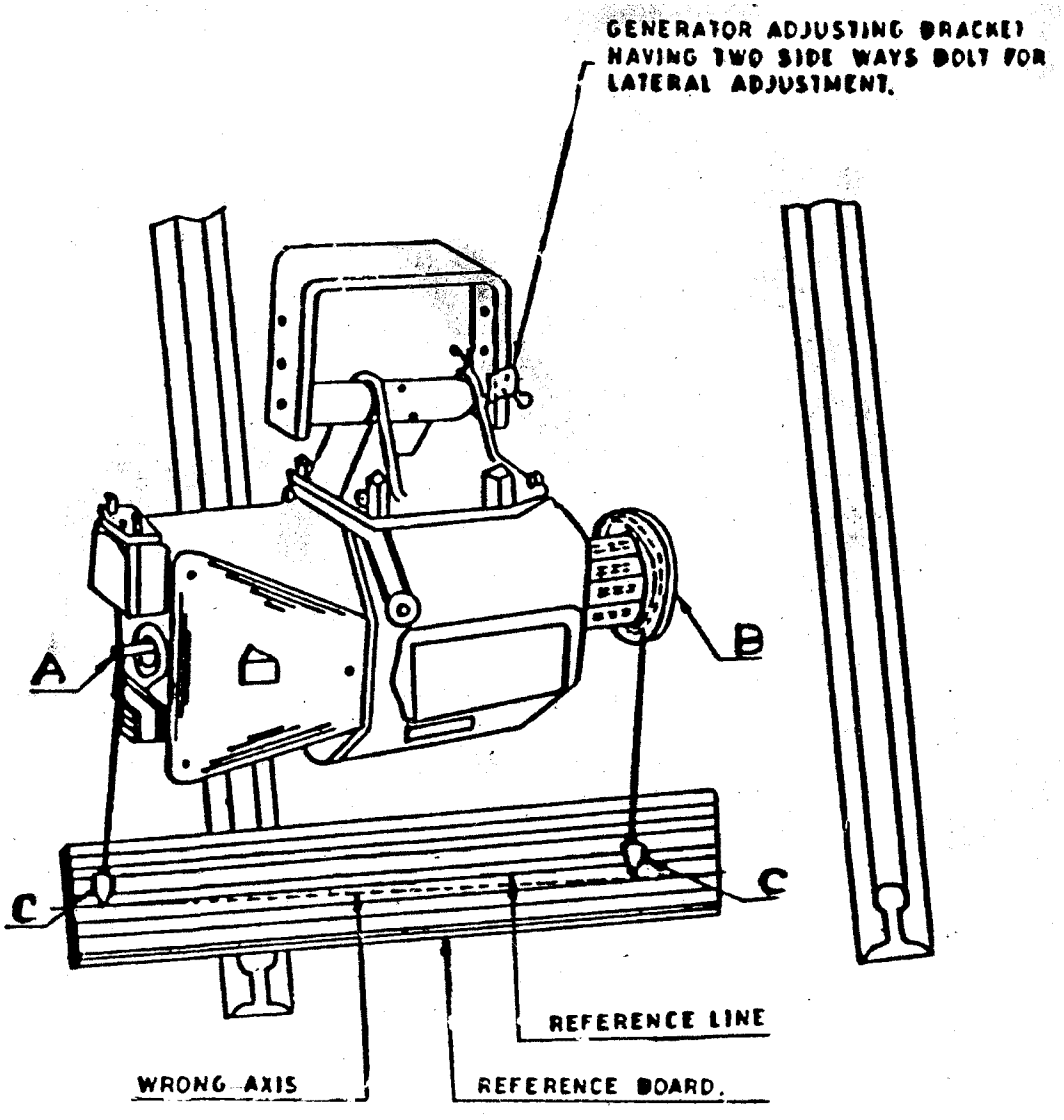


Fig. 4

GAUGE FOR ALIGNMENT OF DYNAMO/ALTERATION

The output adjuster is provided to adjust the dynamo output to the correct value depending on the demand, type of service i.e. fast *or* slow and the ratio of generating lime *to* idle time.

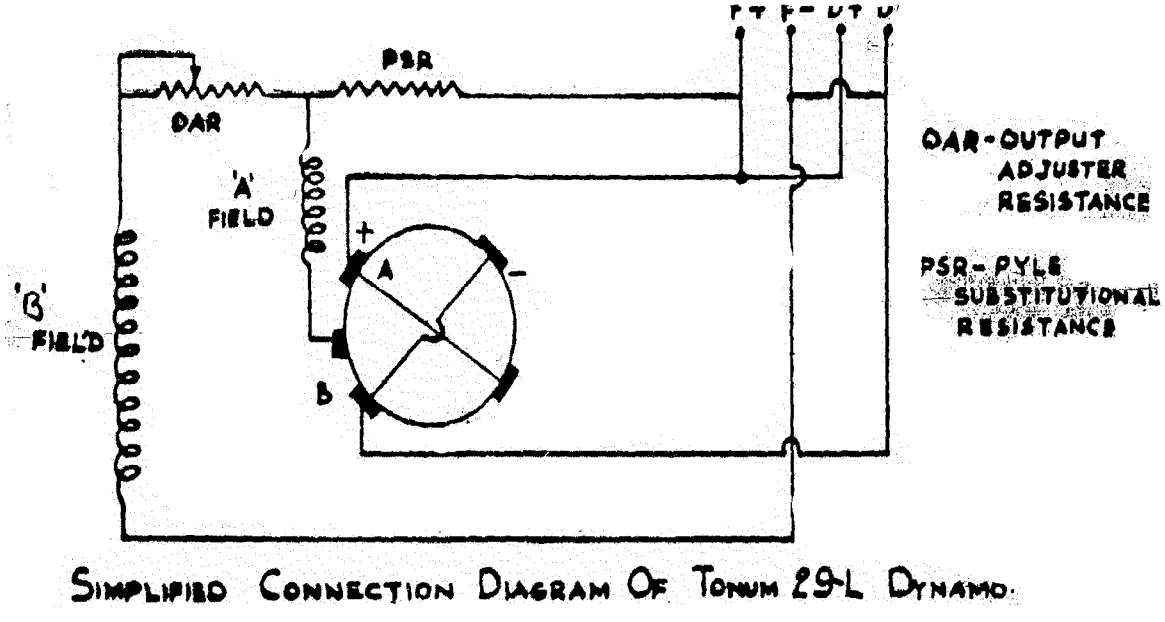


Fig 5

Simplified Connection Diagram of Tonum 29-L Dynamo

2,1.5 **Terminal Assembly :**

The terminal assembly is made up of terminal base of bakelite and terminal pillar studs. The flexible connections from the brush arms and field connections are brought to the field terminal base. Fuses are provided in the positive side and a fink in the negative side on the terminal assembly both for "Main" and "field" connections.

2,1.6 **Silicon Block Diode**

A silicon diode with rated capacity of 150 A for BG and 100 A for MG with working voltage of 50 V and peak transient voltage of 1 00 V with reverse current not exceeding 50 mA and voltage drop of 1.0 V at full load has been provided between Dynamo+ and Battery+. The silicon diode is attached to heat sink The whole assembly is enclosed in a metal frame with louvers to allow free flow of air. With the dynamo voltage above the battery by an amount of the voltage drop across the blocker, the dynamo starts charging the battery.

2.2 BRUSHLESS ALTERNATORS

2.2.1. Brushless alternators are governed by RDSO specification EL/TL/47 Rev'C" for 4.5 KW and 3.0 KW alternators. Approved manufacturers for the alternators are:

KEL (Kerala Electrical & Allied Engineering Industries)

BEACON (Best & Crompton)

SIL (Stone India Limited)

HMTD Engineering

CGL (Crompton Greaves Limited)

Some new makes are also coming up like PIPL, STESALITE, IEC etc

2.2.2 **Inter-changeability of Components**

Regulators of 4.5 KW Alternator for any make will work for any make of 4.5 kW brushless alternator, for same voltage rating.

To achieve simplicity in maintenance, brushless alternators, having no moving contacts or windings on rotors, have been introduced on 110V.

The ratings in use are:-

a) 4.5 KW, 120V BG non-AC coaches

b) 3.0 KW, 120 V for MG non-AC coaches

c) 12.0 KW, 120 V for MG AC coaches / Jan Shatabdi Non AC Coaches.

d) 18.0 KW, 130 V for BG AC coaches (old)

e) 25 KW,130V, alternator for BG AC coaches (new)

2.2.3. **4.5 KW ALTERNATORS (CGL make)**

4.5 KW brushless alternator is of totally enclosed construction capable of developing a constant voltage of 120V/30 V and is used for :-

a) Charging the coach battery;

b) Operation of lights, fans in the coach.

The alternator consists of two sets of windings viz. A.C. Winding and field winding, both accommodated in the stator. The AC windings are distributed in the small slots and field windings are concentrated in two slots. Each field coil spans half the total number of slots (Fig.6)

The Rotor, consists of stacked stamping, resembling a cogged wheel having teeth and slots, uniformly distributed on rotor surface skewing the rotor axis.

The core of the stator which is completely embraced by the field coils will retain a residual magnetism if excited by a battery once. The flux produced by the field coils find its path through rotor. When the rotor is rotated, the passage of rotor teeth and slots alternatively under the field offers a varying reluctance path for the flux produced by the field coils. The flux which varies periodically links with AC coils and induces an alternating voltage in AC coil (Fig. 7). The frequency of induced voltage depends on the speed of rotor. The magnitude depends on the speed of the rotor and level of excitation. The field is controlled through regulator to attain desired output voltage.

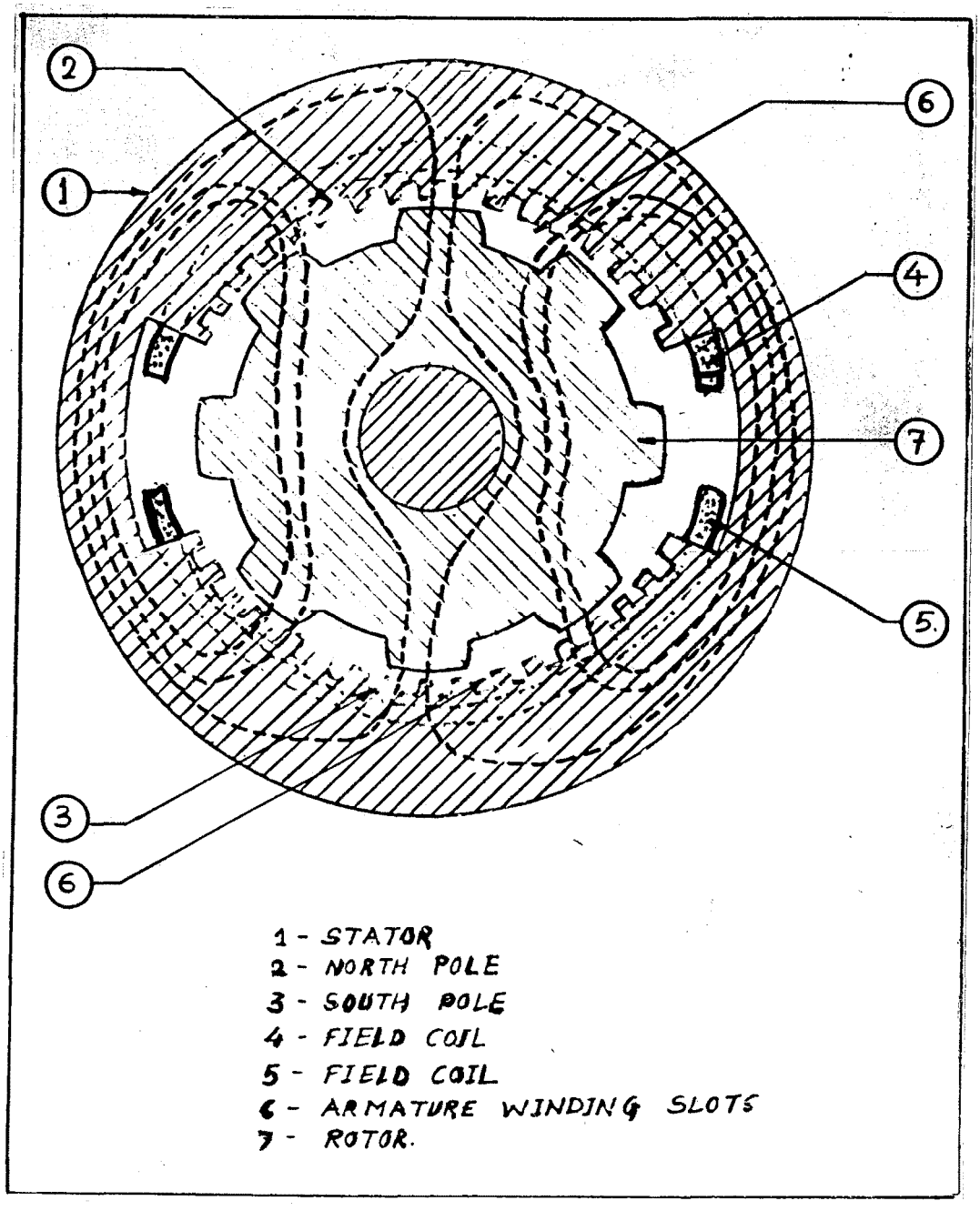

2
6
1
4
7
5
3
6
1 - STATOR
2 - NORTH POLE
3 - SOUTH POLE
4 - FIELD COIL
5 - FIELD COIL
6 - ARMATURE WINDING SLOTS
7 - ROTOR.

Fig. 6

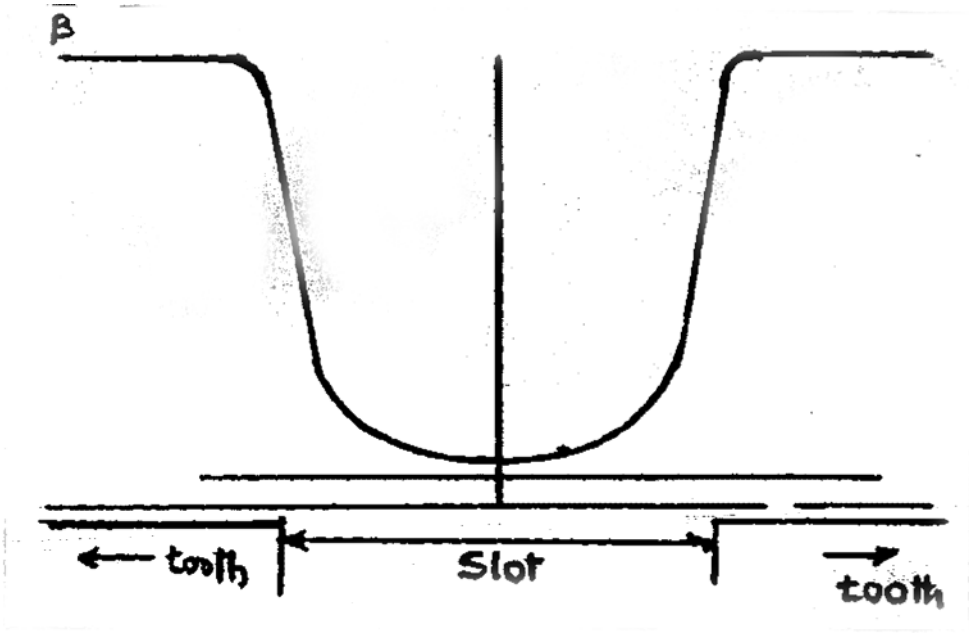


Fig. 7
Flux Density Distribution Curve

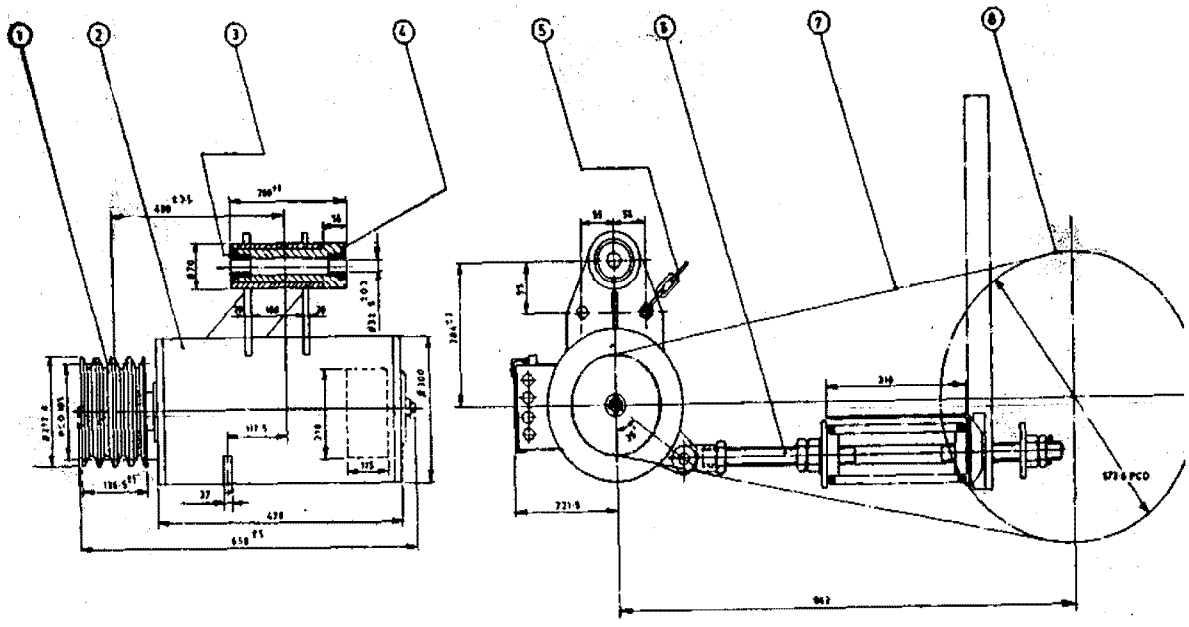
Alternator is mounted on the bogie or suspended from bogie. Bogie mounting is called "Transom-mounting" and suspension from bogie is called "under-frame mounting". While all new 110V coaches have transom mounted alternators, the old under-frame mounted dynamos/alternators have been replaced by transom mounted Alternators at the time of POH.

Two suspension brackets are securely welded to shell. A shell tube machined after welding to suspension bracket houses the suspension bush. This bush is locked in place by two grub-screws. This suspension pin on which hangs the alternator, passes through bush fitted with self-lubricated CAST-NYLON bushes at both the ends which does not require any greasing arrangement. Bush is suitable for use with the suspension pin of 31.75/31:65 dia (Fig.8)

A suitable belt tensioning arrangement is also provided to adjust belt tension as required. A belt tension indicator provided on non-drive end shield serves to indicate the belt tension for under-frame mounted alternator. For bogie mounted alternator belt tension indication is provided by compressed length of spring by indicator plate. (Fig. 9, 10).

Two sets of safety chains are provided to support the alternator and prevent its falling on track while on run, in case of breakage of suspension pin.

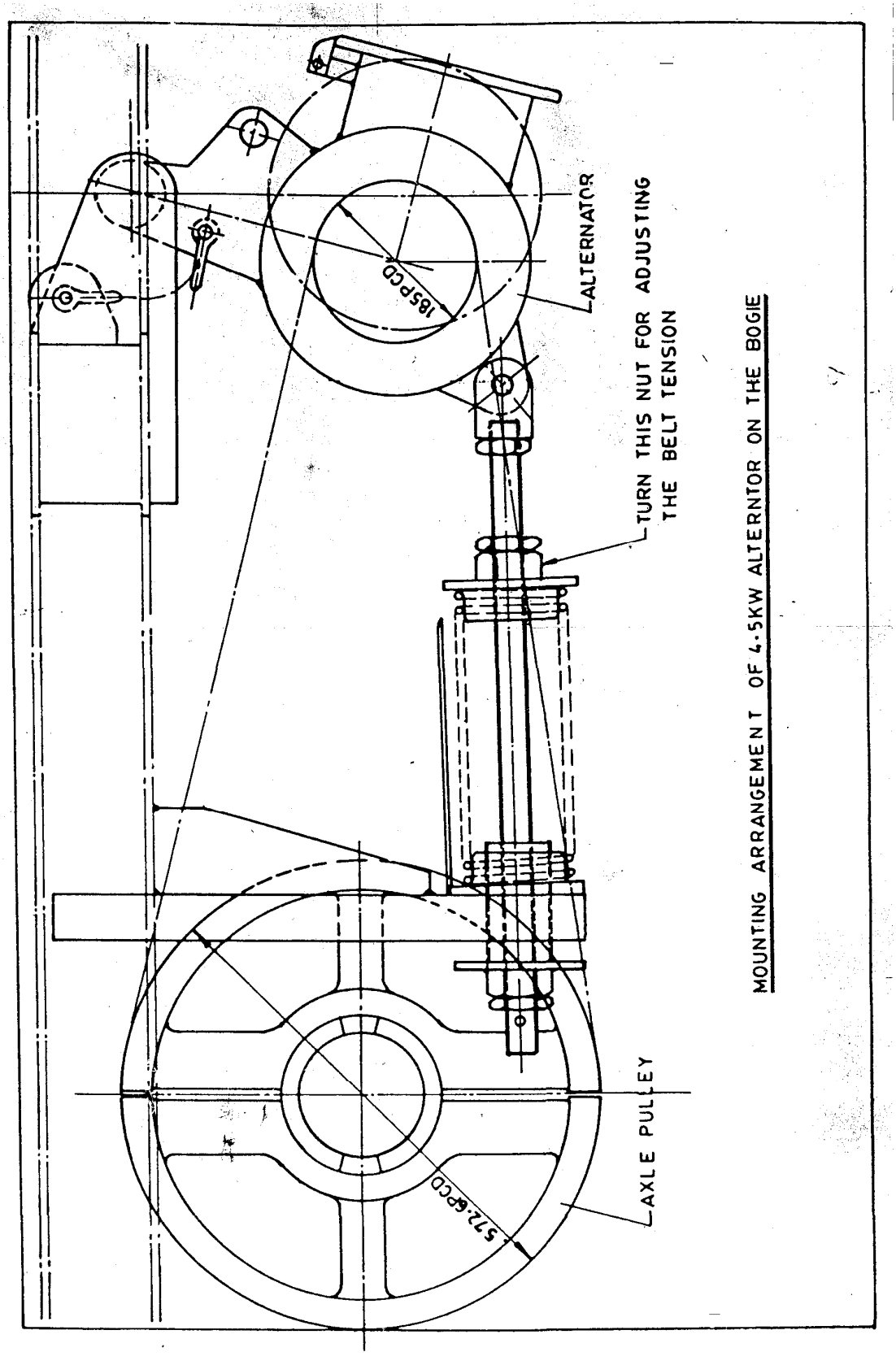
Alternators make use of 140 mm dia flat belt pulley when mounted on under-frame and 185 mm PCD for v-groove pulley in conjunction with an axle pulley of 572.6 mm PCD when mounted on bogie.



NO.	DESCRIPTION	QTY
1.	V BELT PULLEY (ALTERNATOR)	1 .
2.	ALTERNATOR	1
3.	CAST NYLON BUSH	2
4.	SUSPENSION BUSH	1
5.	SAFETY CHAIN	2
6.	TENSIONING DEVICE	1
7.	VBELT	4
8.	AXLE V DEEP GROOVE PULLEY	4

DIMENSION DRAWING OF ALTERNATOR (TRANSOM MOUNTED)

Fig. 8



MOUNTING ARRANGEMENT OF 4.5KW ALTERNTOR ON THE BOGIE

FIG. 9

2.2.3.1. Rectifier-cum-Regulator units for 4.5 KW Alternator (CGL Make)

The Regulator-Rectifier unit has the following functions: -

i) Rectifying 3 phase AC output of alternator to DC using full wave rectifier bridge.

ii) Regulating the voltage generated by alternator at set value.

iii) Regulating output current at set value.

The main rectifier consists of six silicon diodes adequately rated and mounted on aluminium blocks secured on main aluminium heat sinks whose cooling surface is adequately rated and exposed to air at the rear portion of box.

Unit comprises of following main components:- (Refer Fig - 11)

a) Three phase bridge output rectifier consisting of six silicon diodes D1 to D6 mounted on aluminium blocks secured to main heat sink. These aluminium blocks are suitably insulated from the main heat sink electrically by means of MELINEX paper, nylon bushes/washers at the same time ensuring proper conduction and transfer of heat generated during operation.

b) Single phase full wave field rectifier diodes D16 and D17 mounted separately on heat sinks along with free wheeling diode D18 suitable for the same.

c) Two sensing diodes (D19, D20 for current/voltage sensing) with zener diode (Z1) which acts as reference.

d) Current transformer (CT)

e) Main printed circuit board (PCB) with the control circuit and voltage setting potentiometer (P1) and current setting potentiometer (P2).

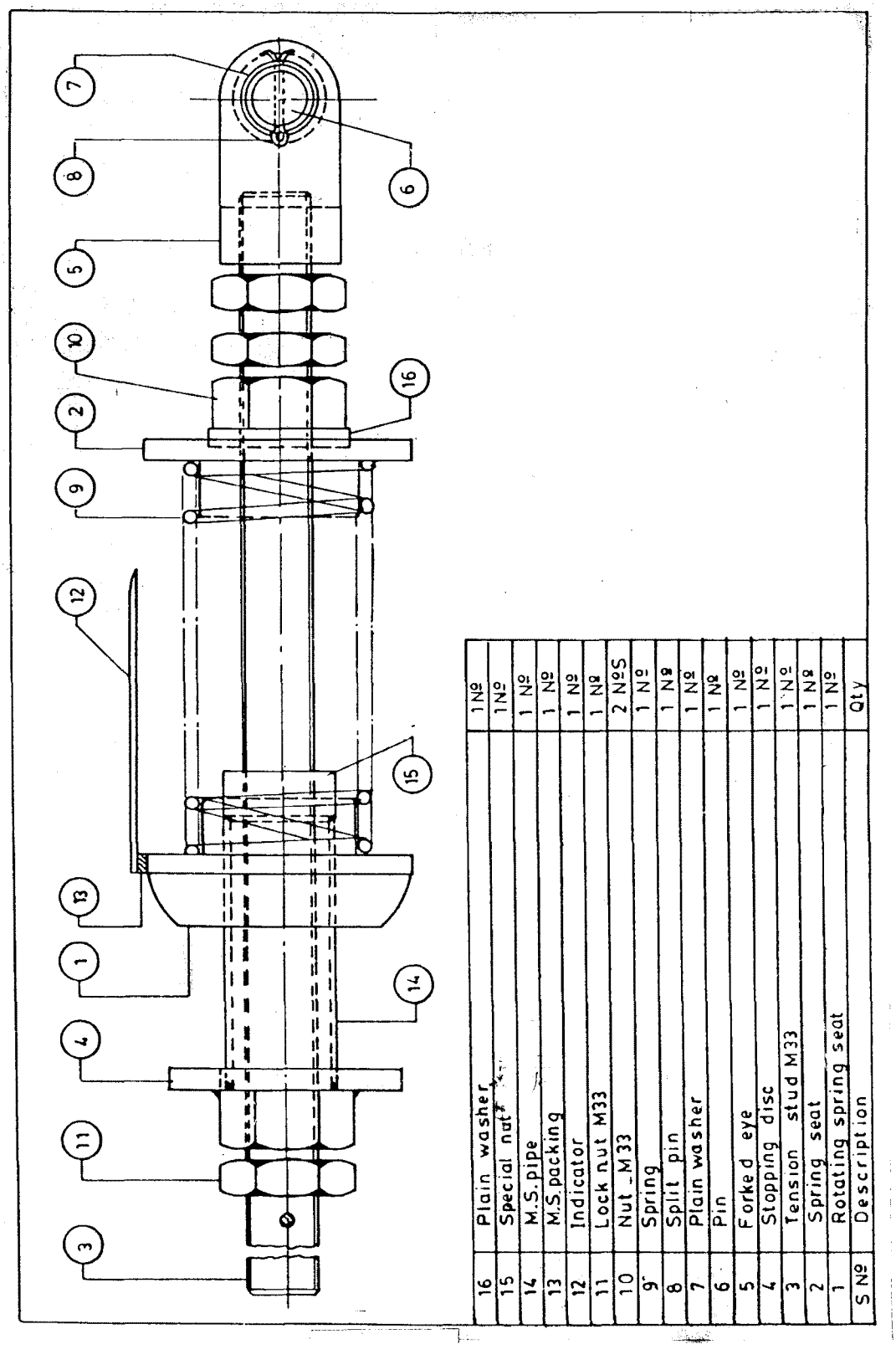
f) Field transformer (FT)

g) Magnetic amplifier (MA)

Diodes D4 to D6 and Dl to D3 make up the positive and negative halves of the main three phase bridge rectifier which receives the three phase AC input from the alternator and gives a DC output of DC + and DC-.

The current transformer (CT) senses in all three Phases. The secondary of which has a burden resistance (R5) to convert the secondary current into voltage. This AC voltage is rectified by diodes DIG to D15 (bridge configuration) and fed to the P2-R3 voltage divider chain. The voltage output is rectified (using D7& D9 diodes) and fed separately to the R1-R2-P1-R4 voltage divider chain. These two sensed voltages are compared with the reference voltage of the zener diode Z1 and subsequently fed to the control winding of the magnetic

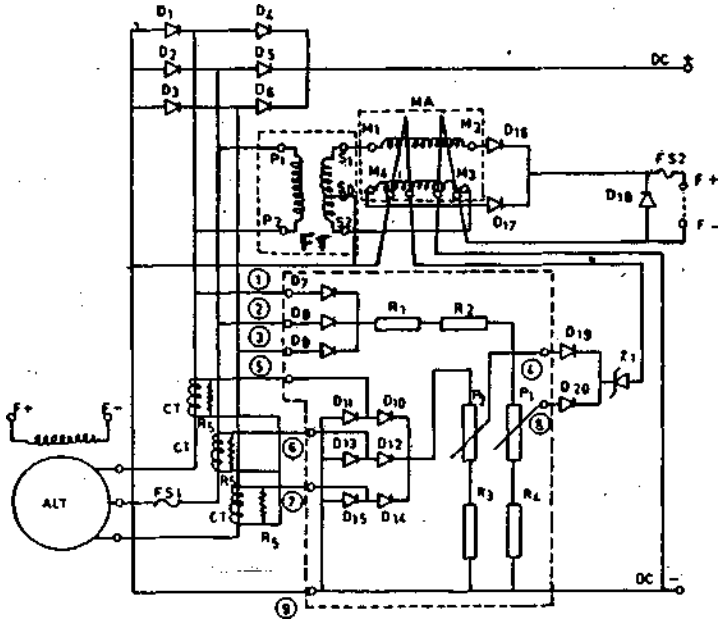
amplifier. This enables magnetic amplifier to act as ON/OFF switch for controlling the alternator field current and in turn the alternator output voltage.



S No	Description	Qty
16	Plain washer	1 No
15	Special nut	1 No
14	M.S.pipe	1 No
13	M.S.packing	1 No
12	Indicator	1 No
11	Lock nut M33	1 No
10	Nut _M33	2 Nos
9	Spring	1 No
8	Split pin	1 No
7	Plain washer	1 No
6	Pin	1 No
5	Forked eye	1 No
4	Stopping disc	1 No
3	Tension stud M33	1 No
2	Spring seat	1 No
1	Rotating spring seat	1 No

FIG 10

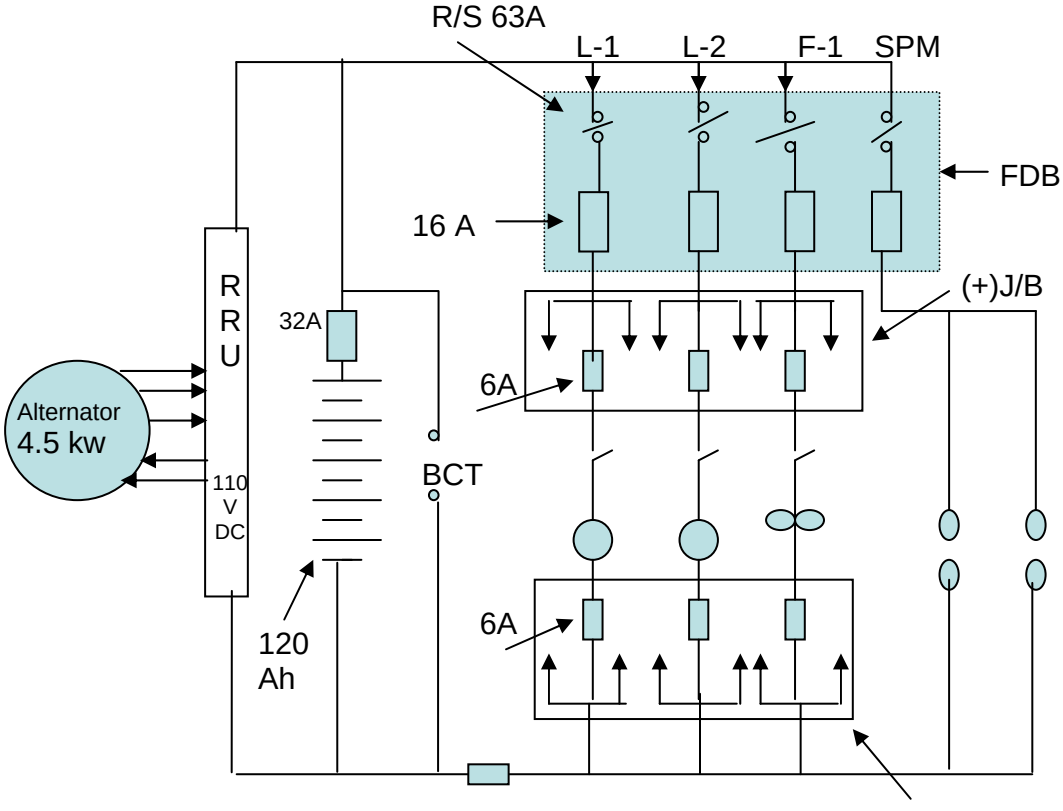
MAGNETIC AMPLIFIER REGULATOR



FS2	6 AMP	6AM P
FS1	125 AMP	32 AMP
P2	500 E, 7.5 W	500 E, 7.5 W
P1	250 E, 7.5	250 E. 7.5 W
R5	200 E, 12 W	1 K4, 12 W
R4	500 E, 12 W	500 E. 12 W
R3	250 E, 12 W	200 E. 12 W
R2	200E.12W	1 K5, 12 W
R1		1 K, 12W
Z1	15V.5W	22V, 5W
D16-D20	4.00 V. 6 A	400 V, 6 A
D7-D15	600 V, 1A.	700V, 1A
D1-D6	400V, 150 A	1000 V, 55 A
COMPONENTS FOR	30 V (3 KW/4.5 KW)	110V (4.5 KW)

FIG. 11

The schematic diagram of electrical connection with a 4.5 kw alternator for Train lighting is as follows



2.2.3.2 CHARACTERISTICS OF 4.5 KW ALTERNATOR & REGULATOR

Output	4.5 KW	
Voltage	120V DC	
Current	37.5 A	
*Cut in speed	350 RPM (Approx 19 KMPH)	
**MFO	600 RPM (Approx 31 KMPH)	
Max speed	2500 RPM (Approx 130 KMPH)	
Mounting	Transom Mounted	
Drive	V belts (4)	
Insulation class		
a) Armature	H	
b) Field	H	
Bearings		
a) Driving End	–	SKF Roller Bearing NU 311 or equivalent
b) Non driving end	–	SKF Ball bearing 6309 or equivalent
Regulator		

Type	–	Magnetic Amplifier
Voltage settings	–	110-140V DC marked in steps of 5V
Voltage regulator	–	within +5% of voltage setting
Current setting	–	37.5 Amps
Current limiting	–	+ 15%
	–	0%
*Cut in :		The minimum speed which the Alternator can pick up speed generation. There will be no output below this speed.
**MFO :		Maximum speed for full output. Although generation picks up at cut in speed, for delivering full output, speed is higher than cut in speed and is called MFO.

2.2.4 **18 / 25 KW Brushless Alternator & Regulator (KEL make):**

Principle of working of 18/25 KW brushless alternator is same as that of 4.5KW Alternator. 18/25 KW alternator is used for AC coaches. The alternator with associated regulator delivers 18/25 KW (at a constant voltage of 135+/- 5% from no load to 133 A) at all train speeds above 50 KMPH. Two machines are used for Ac 2T/chair cars and one machine is used for IAC coach for:-

a) Charging the coach battery consisting of 56 cells of 800 AH capacity (1100 AH in new coaches).

b) Supplying the coach loads like compressors, lights and blowers.

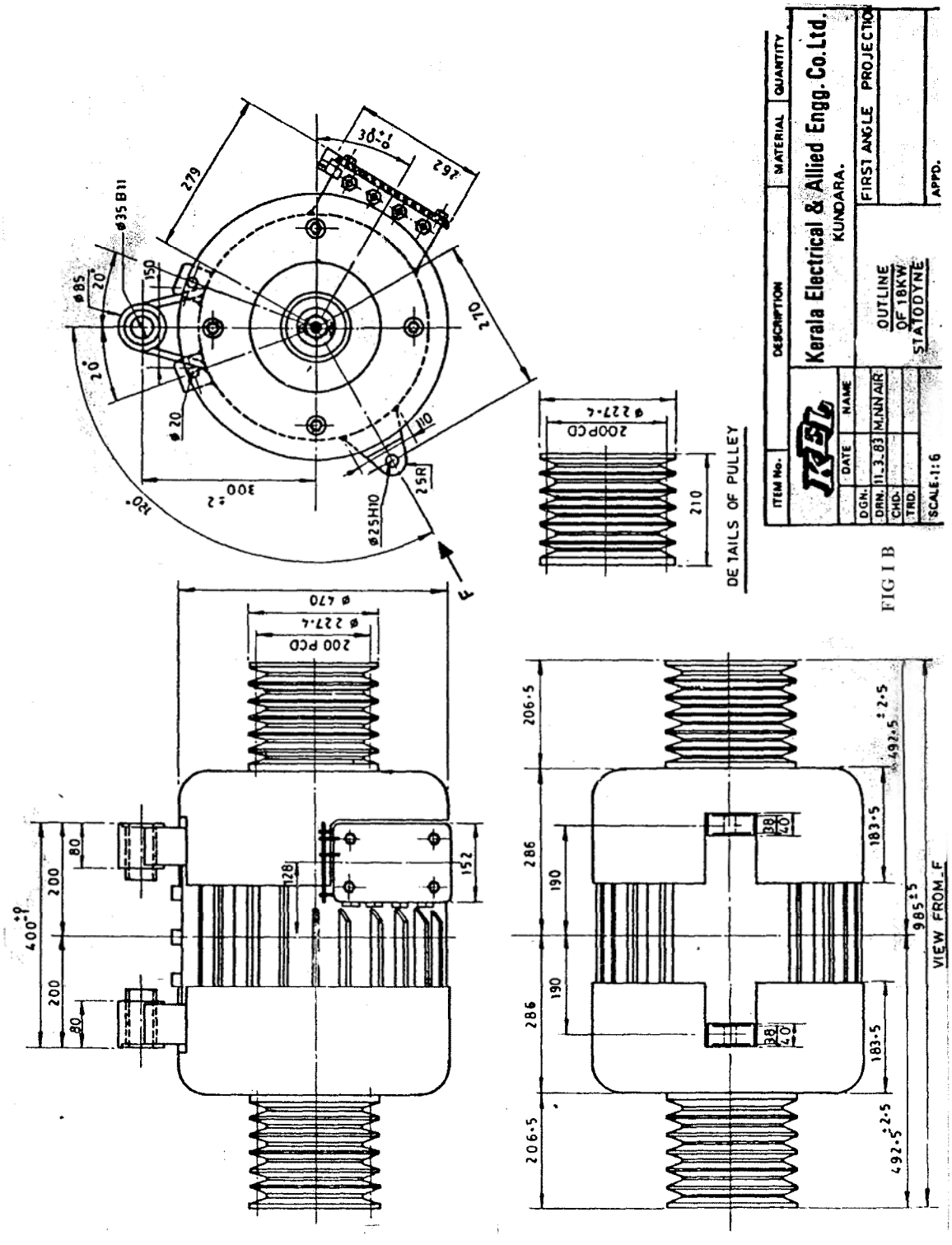


FIG 12

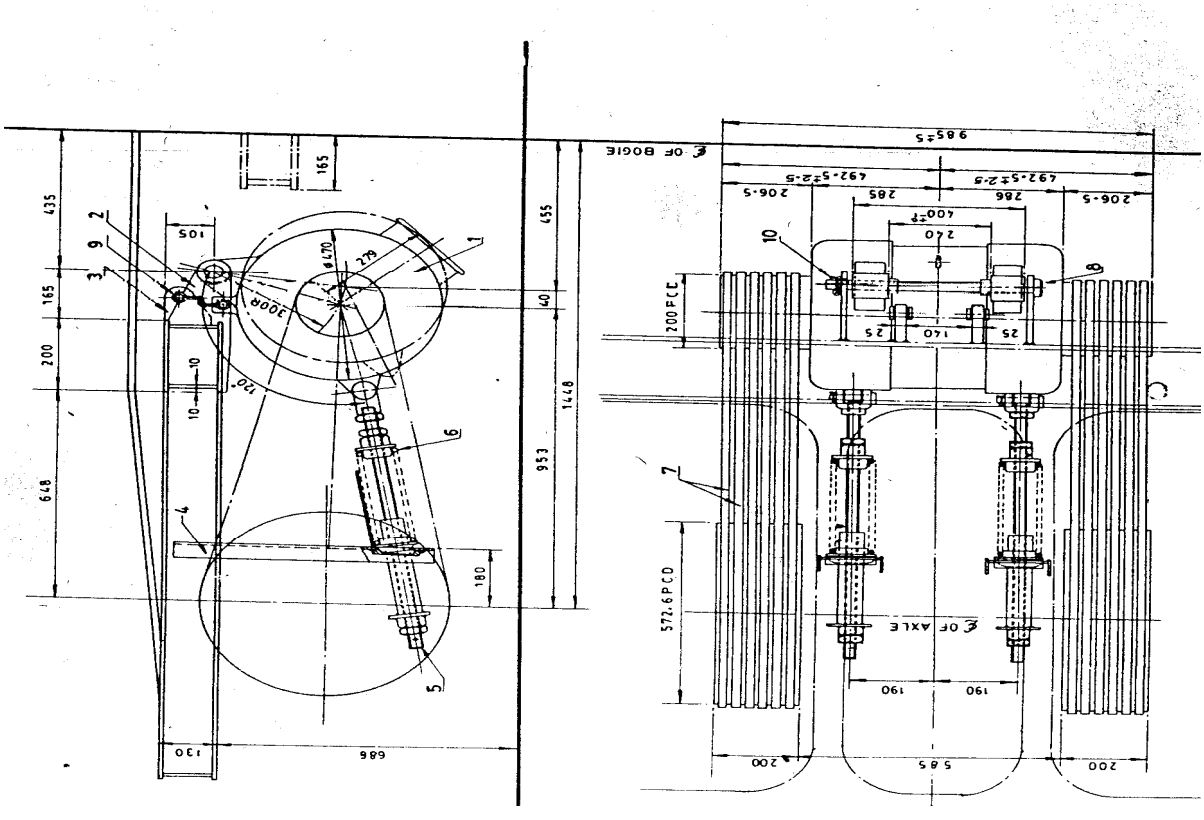
Principle of operation

The brushless alternator is 3 phase Inductor Alternator without any rotating windings, commutator or slip rings. Both the field windings and AC windings are located in the stator. The AC windings are distributed in 60 slots. The field coils are concentrated and forms into two slots. Each field coil spans half the total number of stator slots.

The rotor is made up of silicon steel laminations and resembles a cogged wheel. The teeth and slots are uniformly distributed on the rotor surface (skewing the rotor axis).

The alternator is equipped with two numbers of 200 MM PCD 6 groove V pulley and is driven through an axle pulley of 572.6 mm PCD. V belts type - C-122 are used for drive (Fig. 12 and 13).

FIG 13



ITEM No	DESCRIPTION	MATERIAL	QUANTITY
10	SPLIT COTTER	I S - 226	2 NOS
9	SAFETY CHAIN	I S - 226	2 NOS
8	SUSPENSION HANGER PIN	EN-9	1 NO
7	'V' BELT	I S - 2494	12 NOS
6	TENSION SPRING	I S - 4454	2 NOS
5	TENSIONING STUD	I S - 226	2 NOS
4	SPRING ANCHOR BRACKET	I S - 2062	2 NOS
3	CHAIN BRACKET	I.S. 2062	2 NOS
2	MOUNTING BRACKET	I S - 2062	2 NOS
1	STATODYNE GENERATOR		1 NO

KEL — Kerala Electrical & Allied Engg. Co. Ltd.
KUNDARA.

	DATE	NAME
DSN.		
DRN.	8.6.78	MNNAIR
CHD.		
TRD.		
SCALE 1:8		

SUSPENSION ARRANGEMENT OF 18KW STATODYNE GENERATOR IN I.C.F. A.C. COACHES

FIRST ANGLE PROJECTION

APPD.

Alternator data	
Output voltage	135 V±5% on D.C. side, (97V, 3 phase AC)
Current	140/193 A (Max) on DC side
Cut in speed	550 rpm (30 KMPH with half worn wheels with pulley ratio 200/572.6)
Maxm. speed for full output	930 rpm for 135 A at 135 V (51 KMPH)
Maxm. speed	2800 rpm (156 KMPH)
Class of Insulation	F
Resistance between field terminals.	7.3 Ohm.

Rectifier-cum-Regulator Unit for 18 / 25 KW alternator KEL make (Fig. 14) has the following parts:-

POWER RECTIFIER (RP);-

This consists of six silicon diodes connected in three phase full wave bridge. The three phase output of the alternator is rectified by these diodes to give a DC output at terminals +L and -C. Each diode is protected against transient surge voltage by capacitor Cl. The whole bridge is protected against high frequency surges by capacitor C3. The DC output is filtered by capacitor C2.

CURRENT TRANSFORMERS ; (CT1,CT2 & CT3)

The current transformers are used to sense the load current for the current limiter When the primary winding of each current transformer carries load current, the secondary winding feeds a three phase voltage to the rectifier RT2 in the regulator rack.

REGULATOR RACK

The regulator rack consists of the following parts:

Excitation Transformer (E.T.)

This is a one winding transformer with tapings for input and output. The transformer steps down the voltage for the field coils. The output of the transformer is taken to the field through the Magnetic Amplifier before being rectified by field rectifier diodes.

The transformer has five set of terminals.

Terminals 14 and 15 - Input from Phase 14 and 15 of alternator.

Centre tapping, terminal 19, goes to the -ve terminal for field supply.

Terminals 18 and 161 are the output terminals and go to the respective terminals on the Magnetic Amplifier.

Magnetic Amplifier (MA)

The magnetic amplifier forms the nucleus of the regulator circuit. It works on the principle of saturation of magnetic core. The equipment has six sets of windings.

Two load windings	18-162 and 17-161
* Four control windings	10-11
	26-27
	20-40
	29-30 (Not shown)

* (Of these only 10-11 and 20-40 are used in the circuit 10-11 for voltage and current control, and 20-40 for gain control). The field current passes through the load winding and offers a variable impedance to the field circuit.

Field Rectifier Unit (D3-D4)

The two silicon diodes D4 and D3 acts as a full wave rectifier for the field supply. These diodes conduct alternatively, when the terminals 18 and 161 become positive with respect to the centre tapping 19.

The rectified current from the diodes is taken through the feed back winding 20-40 of the magnetic amplifier. Terminals 20 and 19 form the +ve terminals form the field supply.

Free Wheeling Diode:

In the normal circumstances, this diode D5 has no function. But should there be any reason for a surge from the field circuit, which will have a polarity opposite to that of excitation, this diode will conduct, avoiding creepage of the surge voltage to more important components like Magnetic Amplifier.

Rectifier Bridges (RT1 and RT2)

Each bridge RT1 and RT2 is made up of six silicon diodes, connected for three phase full wave rectification. RT1 supplies the rectified voltage for voltage detector DT1, which is also the voltage developed by the alternator. RT2 rectifies the three voltage developed at C.T. secondary side and supplies to the voltage detector DT2.

Voltage Detector DT1 & DT2

These voltage detectors serve the function of providing necessary "error signal" for voltage regulator and current limiting.

It consists of a network of zener diode, potential divider and rheostat. The voltage drop across each resistance can be adjusted by varying the resistances Rh1and Rh2.

In the case of DT 1 when the output voltage exceeds the rated voltage of the alternator, the voltage drop across R 1 will be sufficient to cause zener break down and this will send a current through the control winding 10-11 of the magnetic amplifier.

Similarly, in the case of DT2, when the current reaches the pre-set present value, the voltage induced in the secondary of the current transformers after rectification by RT2 will

be sufficient to cause conduction of the zener diode and to produce the necessary error signal to Magnetic Amplifier for current control.

Zener diode starts conducting only at a designated voltage (zener voltage). The voltage across the zener will be maintained even if the voltage input to the circuit is increasing. Thus, it serves as a base for comparison.

Blocking Diodes (Dl and D2)

Diodes Dl and D2 are used to block the current from one zener to the other. Diode D1 prevent creepage of current from DT2 to DT l and D2 prevents current from DT1 to DT2. This is achieved by the unidirectional property of diodes.

Working of Regulator:

The three phase output from the alternator is rectified by the bridge connected silicon diodes. The DC excitation to the field is obtained by full wave rectification of alternating current provided through the field transformer and the load windings of the magnetic amplifier.

The voltage induced in the alternator winding is dependent on the speed of revolution of rotor and on the excitation current. In the absence of voltage detector and magnetic amplifier, the voltage of the alternator will rise indefinitely due to the positive feed back limited only by saturation of stator. But as soon as the pre-set voltage is reached, the zener diode in detector DT1 conducts and sends a "Control current" through the magnetic amplifier windings 10-11. The flux produced by the control current is in such a way that it opposes the flux produced by the load windings, thereby increasing the impedance of field circuit. This increase in field impedance reduces the field current and brings back the output voltage to the normal value required,

The current limiting is also achieved in a similar manner. When the pre-determined load current is delivered by the alternator, the secondary voltage of the CT after rectification by bridge RT2 will provide the necessary "error signal" for the magnetic amplifier. In this case also the voltage drop across the resistance R 1 will be sufficient to cause the zener diode in DT2 to conduct. The control current from this also passes through the same control winding 10-11. The effect of this control current is to retain the current at the limited value and to reduce the voltage. For a sustained over-load, the generator voltage will fall to the battery voltage and relieve the alternator immediately, thereby reducing the chances of damage due to the load.

2.2.4.1 **CURRENT Vs VOLTAGE CHARACTERISTICS:**

The equipment is designed to give DC side output upto a maximum current of 140 A. The graph at Fig. 15 shows the machine characteristics at 1500 rpm with a light load on the machine.

The horizontal portion is at constant voltage and shows the end of charged condition. It must be noted that due to the capacitors in the surge protection circuit, the voltage at open circuit conditions will be in excess of nominal voltage. But with a little charging current, the voltage comes back to the nominal value.

The sloped portion of the graph is the current limited portion. The junction between the horizontal and sloped portion is a curve, which serves to protect the battery even if the generator is loaded on a flat battery

2.2.5 **25 KW ALTERNATORS**

With the introduction of roof mounted package units and inverters in self generating AC coaches (AC 2 tier, AC 3tier), there is increase in connected load. To meet the increased load, Brushless Alternator of 25KW having same external dimensions as 18 KW Alternators have been developed.

In the regulator for optimised alternator, of HMTD make, two magnetic amplifiers have been used (Fig. 16) whereas only one magnetic amplifier has been used in regulator for 18/25 KW alternator.

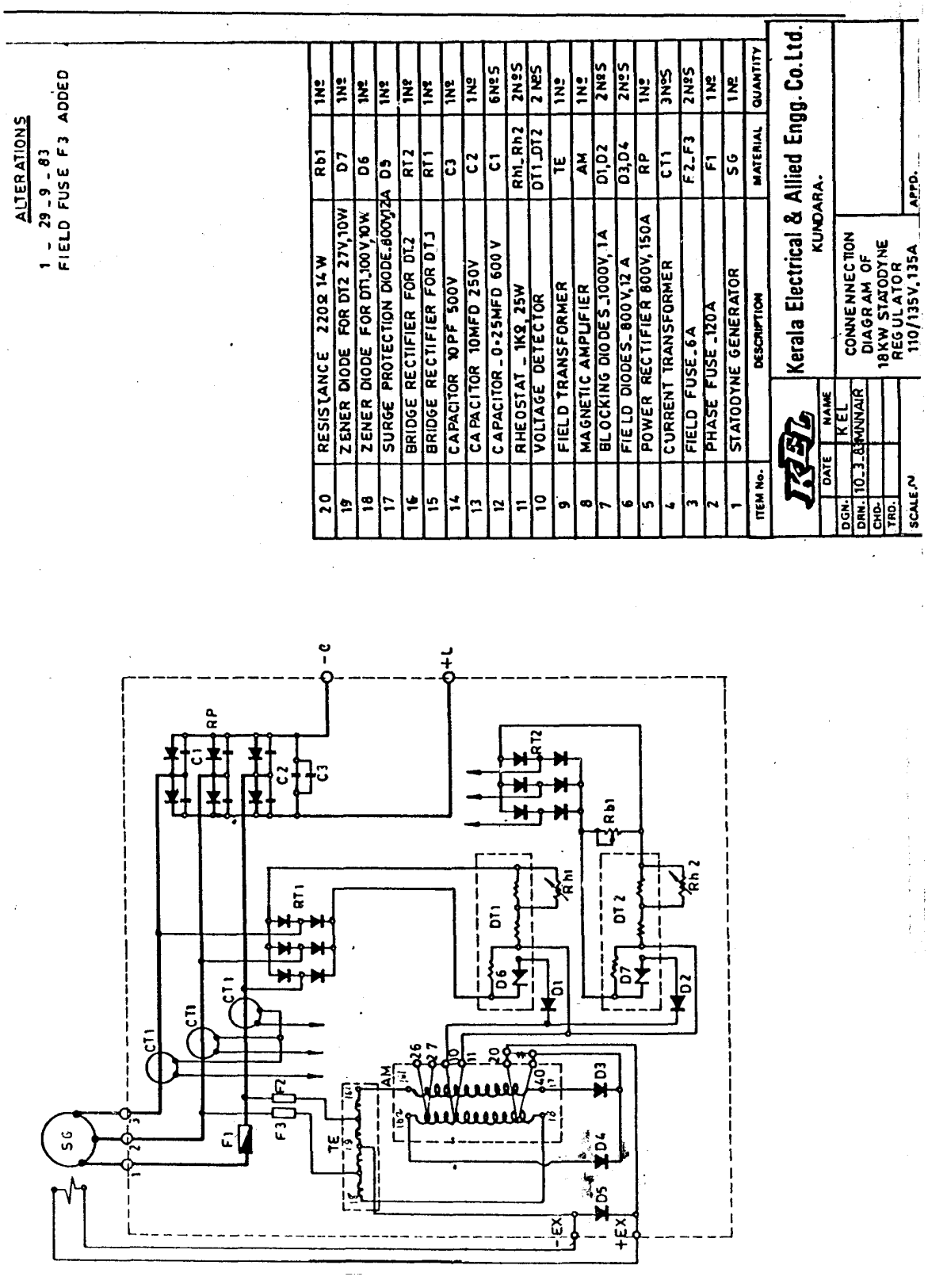

ALTERATIONS
1 - 29-9-83
FIELD FUSE F3 ADDED
20 RESISTANCE 220Ω 14W Rb1 1Nº
19 ZENER DIODE FOR DT2 27V,10W D7 1Nº
18 ZENER DIODE FOR DT1,100V,10W D6 1Nº
17 SURGE PROTECTION DIODE.800V,12A D5 1Nº
16 BRIDGE RECTIFIER FOR DT2 RT2 1Nº
15 BRIDGE RECTIFIER FOR DT1 RT1 1Nº
14 CAPACITOR 10PF 500V C3 1Nº
13 CAPACITOR 10MFD 250V C2 1Nº
12 CAPACITOR_0-25MFD 600 V C1 6NºS
11 RHEOSTAT _ 1KΩ_25W Rh1_Rh2 2NºS
10 VOLTAGE DETECTOR DT1_DT2 2 NºS
9 FIELD TRANSFORMER TE 1Nº
8 MAGNETIC AMPLIFIER AM 1Nº
7 BLOCKING DIODES_1000V,1A D1,D2 2NºS
6 FIELD DIODES_800V,12 A D3,D4 2NºS
5 POWER RECTIFIER 800V,150A RP 1Nº
4 CURRENT TRANSFORMER CT1 3NºS
3 FIELD FUSE_6A F2_F3 2NºS
2 PHASE FUSE_120A F1 1Nº
1 STATODYNE GENERATOR SG 1Nº
ITEM No. DESCRIPTION MATERIAL QUANTITY
Kerala Electrical & Allied Engg. Co.Ltd.
KUNDARA.
DATE NAME
DGN. 10.3.83 KEL
DRN.
CHD.
TRD.
SCALE NONE
CONNENNECTION DIAGRAM OF 18KW STATODYNE REGULATOR 110/135V, 135A
APPD.
-C
+L
RP
C1
C2
C3
RT2
Rb1
Rh1
Rh2
DT1
DT2
D6
D7
D1
D2
D3
D4
D5
RT1
CT1
CT1
CT1
F1
F2
F3
SG
TE
AM
-EX
+EX

FIG. 14

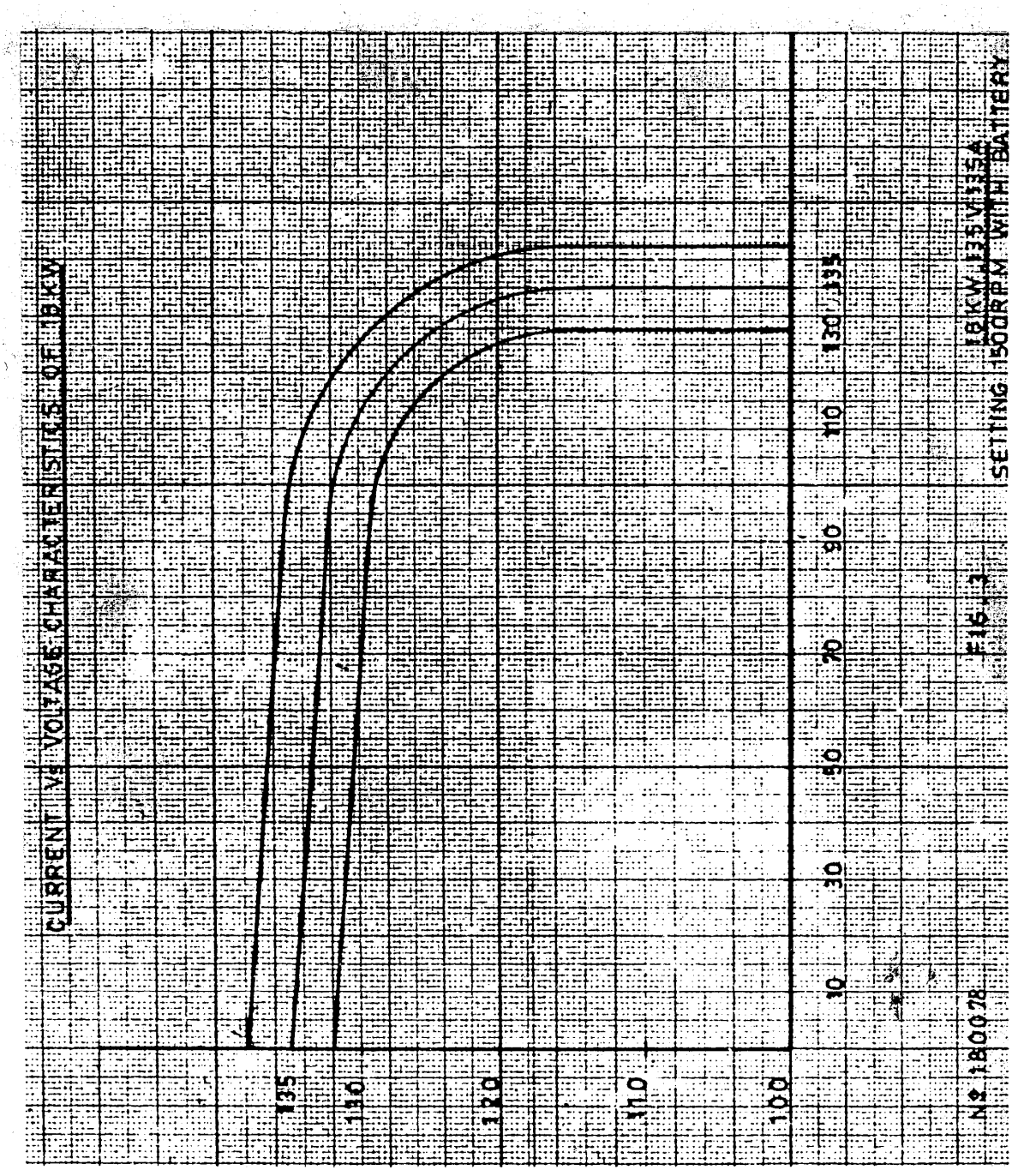

CURRENT Vs VOLTAGE CHARACTERISTICS OF 18 KW
18KW 135V 133A
SETTING 1500RPM WITH BATTERY
FIG. 3
No 18002B
135
130
125
120
115
110
105
100
10
30
50
70
90
110
130
135

FIG. 15

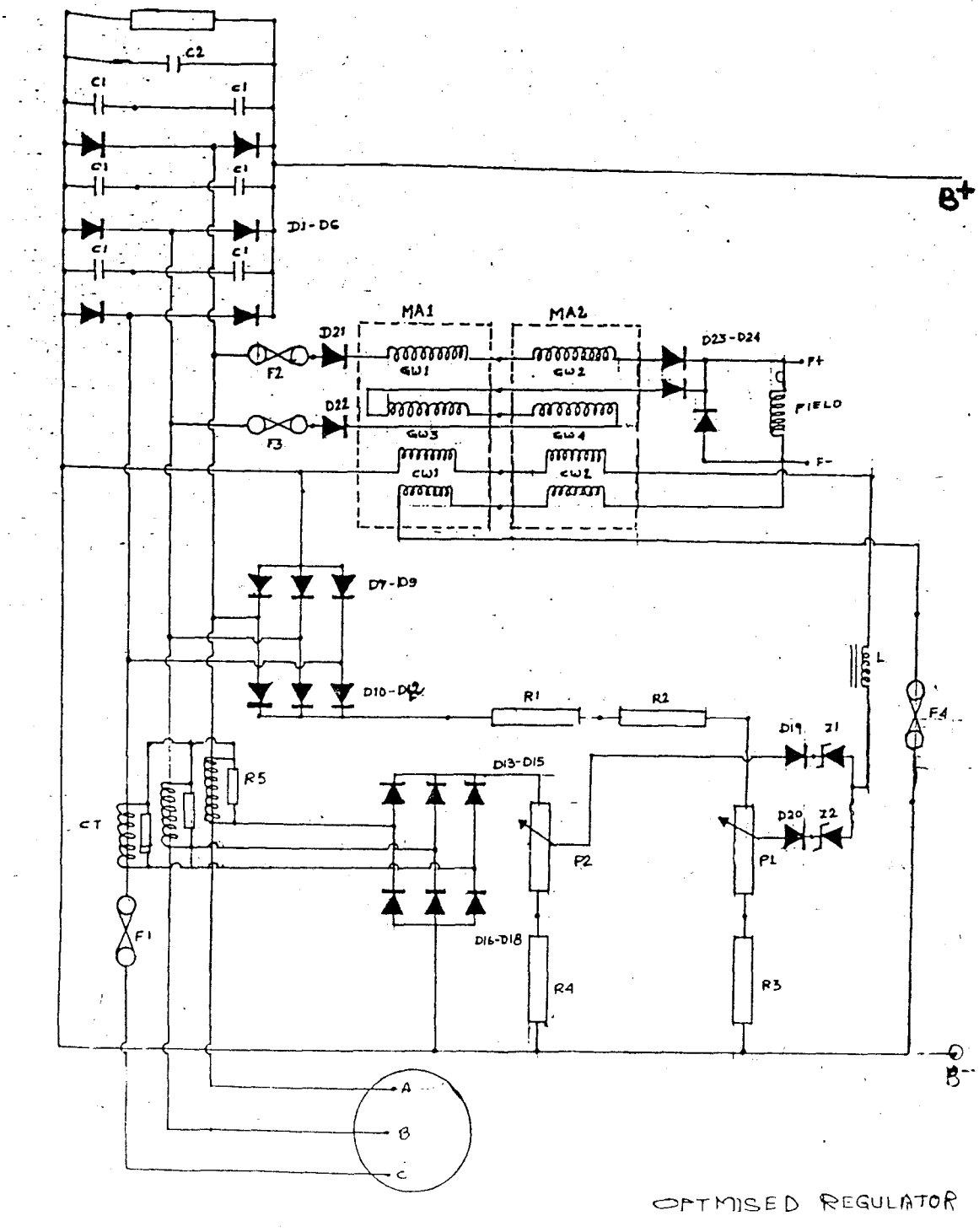

C2
C1
C1
C1
C1
C1
C1
C1
D1-D6
B+
MA1
MA2
D21
F2
GW1
GW2
D23-D24
F+
D22
F3
GW3
GW4
FIELD
F-
CW1
CW2
D7-D9
D10-D12
L
R1
R2
F4
D19
Z1
D13-D15
R5
CT
D20
Z2
P2
P1
F1
D16-D18
R4
R3
B-
A
B
C
OPTMISED REGULATOR

FIG. 16

3. ELECTRONIC RECTIFIER CUM REGULATOR (ERRU)

(25KW AND 4.5 KW)

3.0 Main features of ERRU with UVC:

- Fast and reliable switching devices.
- Alternator identifying facilities and
- Auto setting of parameters such as output DC voltage, battery current, load current which in turn increase the life of battery and the alternator itself.
- Monitoring real time value of alternator voltage, load current, battery AH (IN), AH(OUT) etc., through interface fitted inside the coach.

3.1 Main advantages of ERRU:

- Control circuit is Modular type design.
- Auto identification of alternator ratings and indications.
- Auto setting of parameter of voltage, load current, Battery current, over voltage, over current and current limiting for all the regulator of 4.5 kW, 18 kW and 25 kW.
- UVC is interchangeable with all types of Electronic Regulators from 4.5 kW to 25 kW.
- Close regulation of voltage +/- 2 V over the entire range of load and speed to have uniform charging of batteries.
- Less voltage and current ripple on Battery Charging current.
- Controlled Battery charging current to have longer life of batteries.

- Moulded Hall sensors for current sensing and setting current limit.
- Static over voltage protection and latching **without battery.**

- Isopack Power diodes directly mounted on the heat sinks to have better heat dissipation.

- Moulded PCBs to avoid dust and vibration problems.

- Separate interface unit for monitoring the parameters like DC Voltage, DC current, Battery charging and discharging currents, Amp, Hours etc. and it can be downloaded.

- This interface has facilities to store AH.IN and AH.OUT, generation and non-generation time, total distance traveled by coach and faults occurred in the regulators.

- This interface also has Emergency unit. In case of failure of one control unit, the other control unit will take care of both regulators.

3.2 Rating and Setting :

(A) 25 kW Regulator:

Rating :

Voltage	:	130 V
Full Load amps	:	193 A
1-Hour rating amps	:	222 A
Speed Range	:	800 RPM to 2500 RPM.

Setting :

Normal	:	127V +/- 0.5 V at 97 Amp.
		And at 1500 RPM

Over Load	:	222 Amps at 120 V
Load Current	:	230 Amps (Max)

Battery charging current: 110 Amps (Max.)

(B) 18 kW Regulator:

Rating :

Voltage	:	130 V
Full Load amps	:	138 A
Speed Range	:	800 RPM to 2500 RPM.

Setting :

Normal	:	127V +/- 0.5 V at 70 Amp.
		And at 1500 RPM
Over Load	:	150 Amps at 120 V

Battery charging current: 110 Amps (Max.)

(C) 4.5 kW Regulator:

Rating :

Voltage	:	124 V
Full Load amps	:	38 A
Speed Range	:	550 RPM to 2500 RPM.

Setting :

Normal	:	124V +/- 0.5 V at 19 Amp.
		And at 1500 RPM
Facility available for setting:		120V,122V & 124V
Load Current	:	42 Amp (Maximum)

Battery charging current: 24 Amp (Max.)

3.3 Main Components of ERRU :

The main components of the ERRU are as follows

- Terminal Box
- Power Unit
- Universal Voltage Controller (UVC)
- Static Over Voltage Protection (OVP)
- Emergency Field Extension with interface
- High Reliable Components

1. Half Effect Sensor.
2. ISOPACK Power Diodes.

3.4 Detail of various components of Electronic Regulator

(i) TERMINAL BOX :

The terminal box of the ERRU is having terminals like the conventional two number DC+ and DC-. The wiring in the coach has to be modified as per the drawing No. ER25-050-RIV.2 for 25 kW and ER4.5-W-001 for 4.5 kW, enclosed

in the manual. The terminal box also contains an adopter terminal (female) for taking the control and sensing cable to the interface mounted inside the coach.

(ii) POWER Unit:

The Electronic Regulator is designed with Power unit and Universal Voltage control (UVC) unit, one power unit for all AC coach alternators i.e. 18 kW and 25 kW and another Power unit for non-AC coaches i.e. 4.5 kW Alternator. The Universal Voltage Controller Unit (UVC) is common for all the regulators of AC and non-AC coach alternators. The AC coach regulator can be used for 18 kW and 25 kW Alternator without any change in the setting. The regulator identifies the alternator and makes the setting according to the power of alternator.

(iii) UNIVERSAL VOLTAGE CONTROLLER (UVC) (DRG. NO.:ER25-017):

The UVC controls the field current to maintain the set output voltage of the alternator. The supply is given from one phase of the alternator and rectified using single-phase bridge and given to field coil and the power devices. The gate of the power devices is controlled by a micro controller, which is programmed with all data as per the requirements of the specification.

The phase voltage is fed to the primary of the control transformer and the secondary tapings are fed to the power-supplying module. The micro controller gets the power and information through the A/D converter, multiplexer and isolation amplifier.

The various date and characteristics of 4.5 kW, 18 kW and 25 kW Alternators are fed to the controller and stored. As the train starts moving or as the alternator is driven the micro controller automatically gets the information from the alternator and identifies the same. As the alternator is identified the setting of various parameters for the particular rating of the alternator are set and starts working as per the set parameters.

Hall effect sensors are used for sensing the output load current and battery charging current. The battery charging current is set to limit the charging current as per the battery capacity.

A bunch of leads through conduit are taken from the UVC to the terminal box and then to the interface box mounted inside the coach.

(iv) STATIC OVER VOLTAGE PROTECTION (OVP) :

Static Over Voltage Protection circuit is provided to stop the generation incase of any fault of the components and cause over generation. As the voltage goes beyond 142 Volts for more than 3 seconds the OVP circuit immediately reduces the field current and latches the output voltage at less than 90 Volts. The latching remains even without battery.

The OVP uses a sensing circuit for sensing the output voltage. The sensed voltage is fed to a comparator, electronic relay and a delay circuit. When the voltage exceeds the set value, the delay circuit switches on and the comparator gives a pulse to an electronic relay connected in series with the field circuit. The opening of the electronic relay prevents the output voltage of regulator from rising, above the set value of 142 V. After a pre-set delay time, the signal is latched and the field current is not allowed beyond a level to generate only the latched voltage of 80 to 90 Volts. As and when the fault is removed from the circuit the OVP automatically isolates itself or the latching can be removed through a reset switch provided in the circuit.

(v) EMERGENCY FIELD EXTENSION WITH INTERFACE :

Two regulators are supplied with an interface box, which can be fitted inside the coach. The inter face box is provided to monitor the set parameters. These parameters are displayed using LCD by a scrolling arrangement. The parameters are,

1. DC output current of both the alternators.
2. DC output voltage of both the alternators.
3. Battery current.
4. Battery charging current.
5. Amp hour in.
6. Amp hour out.
7. Total Amp hour in/out.
8. Total kW hr charging and discharging
9. Speed of the alternator.
10. Total distance traveled by the coach.
11. Total generation and non-generation time of both regulators.
12. Last 32 faults
13. Acquisition time.
14. Date and time.

(vi) DATA LOGGER WITH INTERFACE :

A four pin round type connector is provided for collecting datas like output voltage, current, battery current charging and discharging and speed of the alternator from the regulator. Each regulator can be connected to date down loading unit and the above mentioned data can be downloaded at any time.

Data for seven days are logged and stored in the memory and this can be down-loaded using the downloading unit.

(vii) OVP INDICATION AND RESET :

OVP indication and reset is also provided in the same box. The operator can reset incase the OVP operates and disconnects the regulator. All this can be done when the train is in movement.

SETTING OF PARAMETERS :

This interface unit is having facilities to change the parameter of DC output voltage, output current and battery current incase of improper load sharing. This can also be done in running time.

DOWNLOADING UNIT :

A small hand held unit is provided for downloading the data stored in the regulator. And this can be taken in to computer and the data can be retrieved in EXCEL format. Retrieving format will be as per RDSO's specification. Downloading can be done in coach running time but it is advised to do in coach stopped condition.

EMERGENCY FIELD EXTENSION:

The same date logger box contains the emergency field extension incase of the failure of the control circuit of one regulator. This helps the operator to understand the healthy conditions of both the alternators and to provide field extension in case of the control circuit of one regulator is defective.

Note:

- Emergency field extension switches can be operated in running condition and for the safety operate only when the train is in the halt condition.

- Setting of parameters should be done after removing the lock. The locking facility is for preventing the unauthorized operation.
- Data downloading and retrieving in computer require Windows 98 operating system with USB ports.

(viii) HIGHLY RELIABLE COMPONENTS :

High reliable components are added to minimize the failure in the Electronic Regulator. The working principle of these components mentioned below are explained here under.

1. Hall Effect Senor.
2. Isopack Power Diodes.

(1) HALL EFFECT SENSOR :

The Hall sensor is a transformer operating with a balanced magnetic flux principle to measure D.C. – A.C – pulsating current with galvanic insulation between primary and secondary circuits. The primary current produces a magnetic field, which is detected by a Hall effect device and, via an electronic amplifier, is immediately balanced by injecting a current into the secondary winding. The secondary current thus injected is the exact replica of the primary current times the turns ratio. This closed loop current sensing is fed into the main circuit to limit the output current and protect the equipment from over current.

(2) ISOPACK POWER DIODES :

These diode modules contain two diodes in a single pack and have a base plate, which is ceramic isolated from the power circuit. They can be mounted directly on the heat sinks needing no insulation in between. This results in effective heat transfer to the heat sink and thereby reducing temperature of the device. These modules are tested

for more than 1.5 kV isolation between live terminals and base place. The ratings of devices are as follows –

VRRP	:	1800 Volts peak to peak.
I (avg)	:	350 Amps.

3.5 A list of Do's and Don'ts are listed below from the maintenance and trouble shooting point of view.

DO'S :

1. Check all the connections are tight. If found any loose connection, tighten the connection.
2. Connect the cables in correct polarity.
3. Keep the cover closed.
4. Use proper rating of fuse.

DON'T :

1. Don't disconnect any connectors from regulators and UVC.
2. Don't bypass the protecting systems OVP and fuse.
3. Don't keep the door opened.
4. Don't disturb the setting if not require.
5. Don't press the LCD display.

DO'S AND DON'T IN CIP AND THE DOWNLOADING UNIT

DO'S :

1. Connect all the connectors in proper position.

2. Keep normal position always in the emergency field extension unit.

DON'TS :

1. Don't remove any connector from the CIP unit.

2. Don't damage the LCD display.

3. Don't reverse the power supply connection.

4. Don't keep open the CIP door.

5. Don't keep the downloading unit in high temperature.

6. Don't download when the train is running.

7. Don't disturb the setting if not required.

3.5 PERIODICAL MAINTENANCE INSTRUCTION FOR ERRU

1. Check all the connections are tight. If found any loose connection, tighten the connection.

2. Care must be taken for connecting the terminals in correct polarity. The reverse connection may cause severe damage in regulator.

3. Do not disconnect the connectors from UVC and terminals. If any disconnection is found, connect the connectors in original position. Do not connect any wrong side and wrong connection will cause damage in regulator.

4. Do not keep open the UVC door as well as regulator box and terminal covers. Open door may give chance to enter the dust and

metallic things inside and this may cause any short circuit in the regulator.

5. In case of fuse blown, is suggested to use proper HRC fuse. Do not tie with wire and this wire-fuse will cause any damage in the regulator.

6. Protections are safety for our systems; so do not bypass the protecting systems lie, OVP and fuse.

7. Do not disturb the setting.

8. Store the downloading unit in safe place and do not keep in very high temperature.

9. Do not press the LCD display screen and pressing will cause the damage to the LCD.

10. Use proper tools for opening and removing the units from the regulator.

NOTE : The periodical maintenance above can be done once in a month.

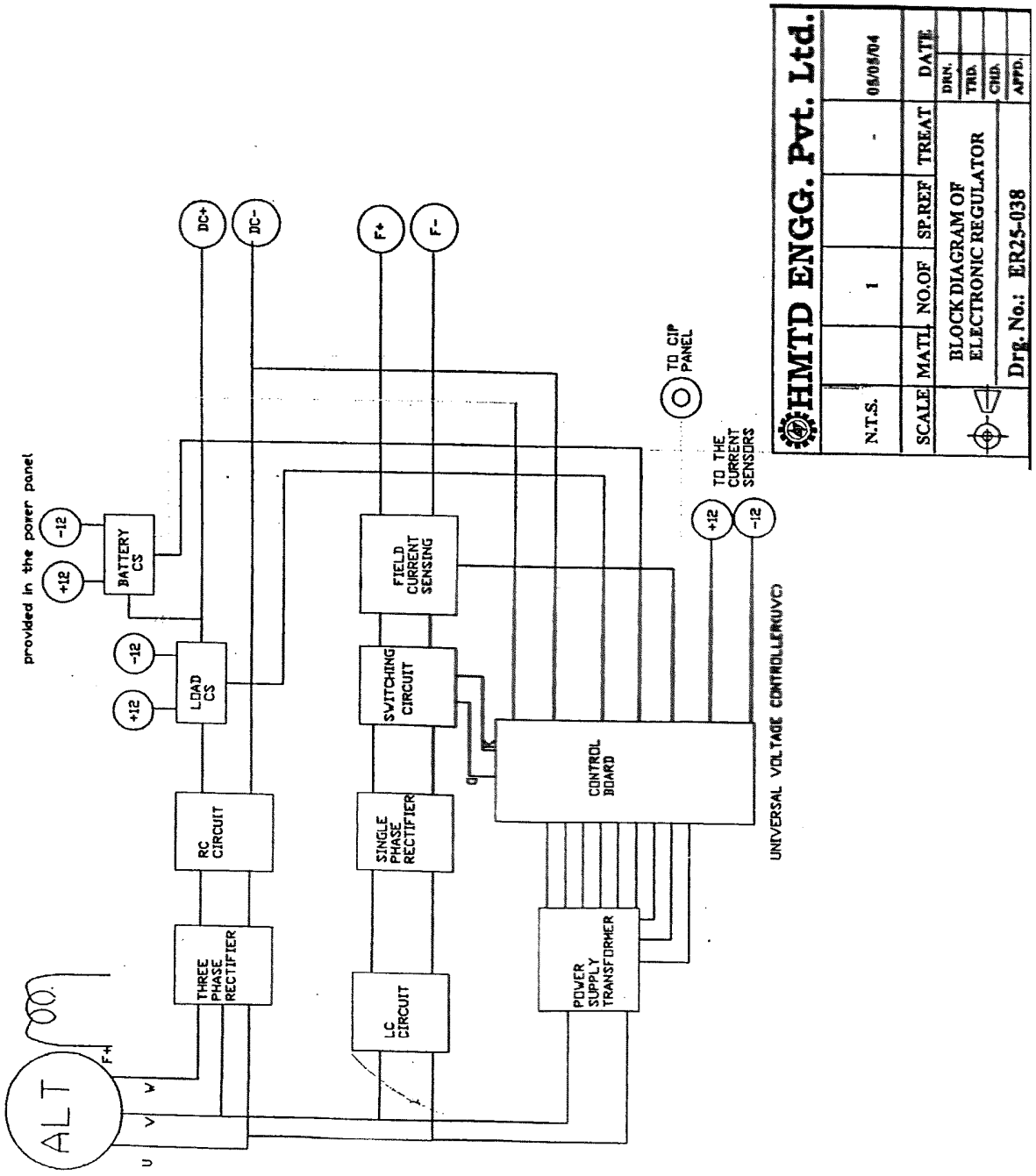
3.6 TROUBLE SHOOTING INSTRUCTIONS FOR 4.5 KW ERRU

Sr. No.	Type of Defects	Probable Cause	Check	Remedy
1.	Regulator output is less (or) no generation.	a. HRC fuse blown.	Check Fuse	If fuse blown, change the fuse.
		b. Field fuse blown.	Check Fuse	If fuse blown, change the fuse.
		c. A loose connection in the field winding (or) open (or) short Ckt.	Remove the field connection from Reg. Check the field connection in the Alternator in between the field winding and check the continuity of Alt field cables. If continuity is OK, check the resistance of field coil.	If a connection between two field is broken, join the two leads by brazing of the leads. If field coil defective, remove the coil carefully and replace it with the new field coil. The resistance of new field coil at $20^{o}C$ is 4.0 ±0.5Ω.
		d. Field winding is earthed.	Check the megger value of the filed coil.	If megger value is less than one MΩ, send the Alt to shop for proper attention of field coil.
		e. Phase winding may be open (or) short ckt (or) earthed.	Check the leads, continuity & resistance of the phase winding.	If the leads are open, braze the leads with coil termination. If the phase winding is short (or) earthed, send the Alt to shop for rewinding.
		f. 3Φ bridge rectifier may be open (or) short ckt.	Check the 3Φ bridge rectifier by using multimeter, after removing the bus bars from 3Φ bridge rectifier.	Replace the 3Φ bridge rectifier, if found defective.

		g. 1Φ bridge rectifier may be open (or) short ckt.	Check the 1Φ bridge rectifier by using multimeter.	If 1Φ bridge rectifier is defective, replace it.
		h. OVP unit is not working.	-	Change the OVP unit.
		i. Power Supply Transformer in UVC may be open (or) short.	Check all winding in transformer after removing the transformer connections.	If Power Supply Transformer winding is defective, replace it.
		j. Inductor L1 may be open.	Check inductor is OK (or) not.	If found defective, replace it.
		k. Field Trans-former may be open (or) short.	Check Field Transformer is OK (or) not.	If found defective, replace it.
2.	Voltage control is high generation.	a. Zener diode Z1 to Z4 may be short.	Check Zeners by using multimeter, after removing the connections.	If found defective, replace it.
		b. Power Supply transformer in UVC may be open (or) short.	Check all winding in transformer after removing the transformer connections.	If Power Supply Transformer winding is defective, replace it.
		c. Gate connection from Control PCB may not be proper.	Check connections are OK (or) not.	If found defective, replace it.
		d. Power supply of Fuse Failure PCB may short.	Check the power supply of Fuse failure PCB.	If found short. Change the Fuse Failure PCB.
3.	Load current limit.	a. Power Supply (+12V & -12V) of load current sensor.	Check all connect-ions from Control PCB to current sensor.	If connections are not proper, rectify it. If connections are OK, change the Control PCB.

		b. Output Section of Load current sensor.	Check voltage between M point of current sensor and grid.	If voltage is nil @ load condition, change current sensor. If voltage is there, change the Control PCB.
4.	Battery current limit.	a. Power Supply (+12V & -12V) of battery current sensor.	Check all connect-ions from Control PCB to current sensor.	If connections are not proper, rectify it. If connections are OK, change the Control PCB.
		b. Output Section of Battery current sensor.	Check voltage between M point of current sensor & grid.	If voltage is nil @ battery load condition, change current sensor. If voltage is there, change the Control PCB.
5.	OVP is tripping.	a. Due to high generation.	Check above all conditions at high generation.	If found defective, replace it.
6.	OVP is not tripping.	a. OVP PCB may be faulty.	-	Change the OVP PCB.

3.7 BLOCK DIAGRAM OF HMTD MAKE ERRU



4. BATTERIES

4.0 Conventional Lead Acid Cells for TL applications are governed by IS 6848.

4.1 Type of cells in use for train lighting and coach air-conditioning are as under :-

Capacity of battery in AH at 27 Degree C at 10 Hr Rate	*Type of coach where generally used*
120	110 V, BG coaches
450	MG AC Coach
525	Jan Shatabdi Non - AC coaches
800	II AC BG Coaches (Old) (Under-slung type)
1100	II AC BG Coaches (new)/AC 3 Tier Coach

4.2 **Principle of Operation :**

In a charged lead acid cell positive active material consists of lead peroxide (PbO2) and the negative of spongy lead (Pb). Dilute sulphuric acid (H2SO4 + H2O) serves as electrolyte.

The overall reactions inside the cell during discharge and charge are represented most -conveniently by a reversible equation as follows :-

$$PbO2 + Pb + 2H2SO4 <=> 2PbSO4 + 2H2O$$

During discharge, the lead peroxide on the positive plates as well as the spongy lead on the negative plates are converted into lead sulphate (PbSO4). In this process, sulphuric acid (H2SO4) is consumed and water (H2O) is formed. Consequently, the specific gravity of the electrolyte falls, the extent of fall being proportional to the ampere-hours taken out. The process causes at first a slow, and then a faster voltage drop, until a permissible lower limit (final discharge voltage) is reached, which depends on the rate of discharge current. The amount of ampere-hours (constant current x time) taken out is called the capacity of the cell at this rate.

The chemical process during charge is the reverse of that during discharge. The lead-sulphate on the positive plates is reconverted into lead peroxide and the lead sulphate in the negative plates into spongy lead. Sulphuric acid is formed and the water consumed. The specific gravity of the electrolyte rises. There is at first a slow, later a faster rise of cell voltage. From 2.4 volts onwards gassing sets in due to a strong decomposition of water into hydrogen and oxygen. Violent gassing is injurious to the plate material. So after reaching this gassing voltage the rate of the charging current must be limited to within safe permissible values.

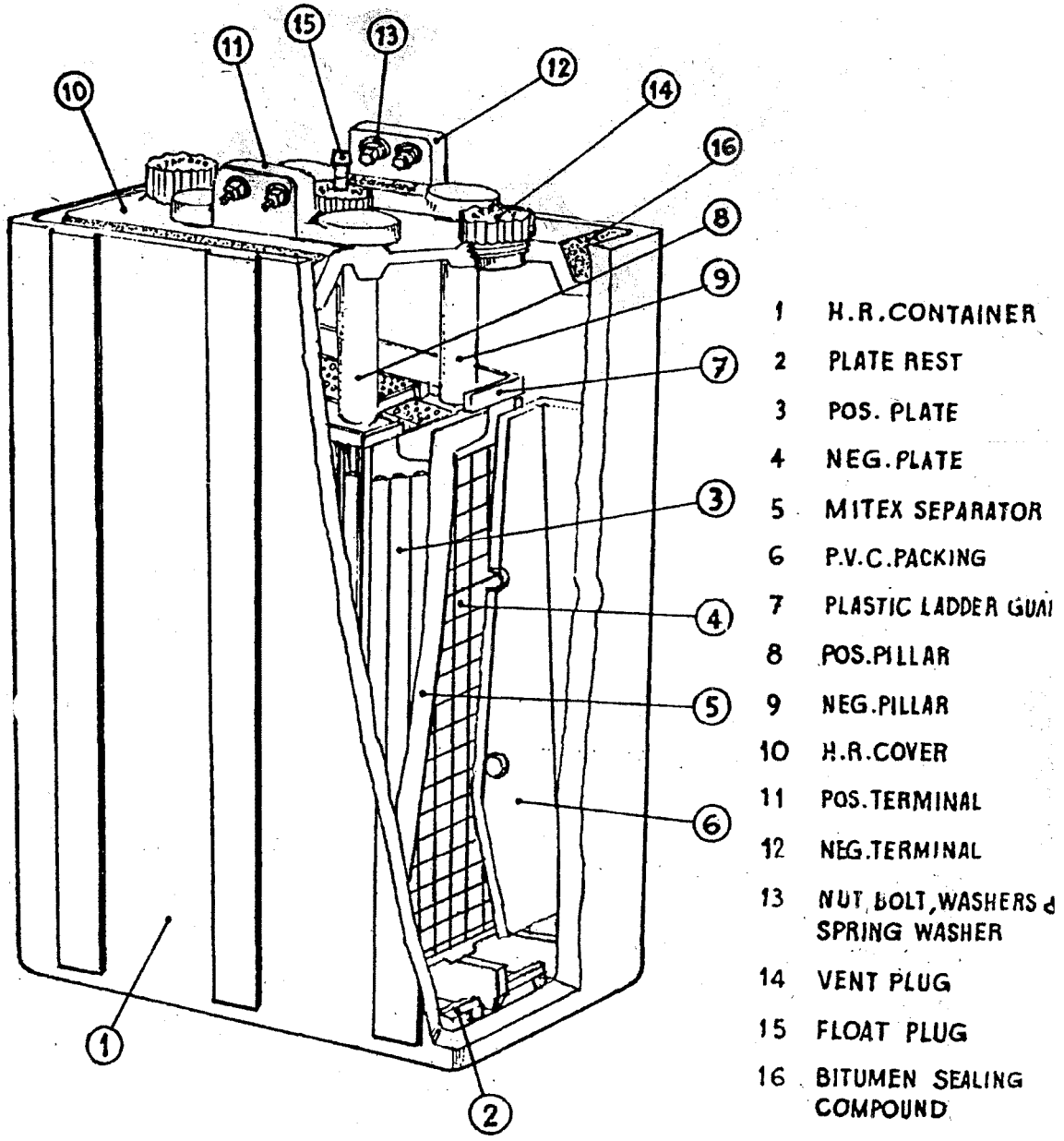

RPg CELL
1 H.R.CONTAINER
2 PLATE REST
3 POS. PLATE
4 NEG.PLATE
5 MITEX SEPARATOR
6 P.V.C.PACKING
7 PLASTIC LADDER GUAI
8 POS.PILLAR
9 NEG.PILLAR
10 H.R.COVER
11 POS.TERMINAL
12 NEG.TERMINAL
13 NUT, BOLT, WASHERS & SPRING WASHER
14 VENT PLUG
15 FLOAT PLUG
16 BITUMEN SEALING COMPOUND

FIG. 1

The nominal voltage of a lead acid cell is 2.0 volts. The true open circuit voltage, however, is dependent on the specific gravity of the electrolyte and varies between 2.02 to 2.05 volts. During discharge the voltage depends on the rate of the discharge current.

4.3 **Constructional Features Main components of lead acid cell are :-**

a) Positive Plates - Usually tubular construction is adopted. Positive plates are made up of a number of tubes which contain active materials. Tubes have a large number of minute pores which allow the electrolyte to pass through pores freely, while preventing any loss of active material.

b) Negative Plates - Usually consist of a lead grid into which active material is pressed. The grids are designed to retain the active material in position.

c) Separators - Synthetic separators are used between positive and negative plates. The separators allow good diffusion of electrolyte.

d) Container - is made of hard rubber with high insulating strength to resist acids.

e) Cell cover - is also made of hard rubber, resistant to acid having vent and level indicator holes.

An exploded view of a cell is Figure 1.

4.4 **Accessories: The following are few accessories of a lead acid cell -**

a) Float,

b) Float guide,

c) Vent plug.

a) **Float ;**

The float stem will have markings to indicate the lowest and highest electrolyte levels permissible. It should be ensured that the electrolyte level is maintained in service by adding pure distilled / de-mineralised water to IS: 1069.

b) **Float guide :**

The float guide is of removable and antisplash type and facilitates unrestricted vertical movement of float stem. During maintenance it is essential to ensure that the float assembly is designed to prevent acid splash in service (IS:6848). Any defective float guides/assemblies should be replaced promptly.

c) **Vent plug :**

This is of the anti-splash type with more than one exit hole. This will allow the gases to escape freely but effectively prevent acid particles or spray from coming out. It should be ensured that the vent plug is tightened fully whenever the plug is opened during maintenance for checking specific gravity of cell or after topping up electrolyte level with distilled water.

4.4.1 It is necessary to procure all these accessories exactly to the approved design of the original manufacturers since any defective supply is likely to affect the life of cell adversely.

4.4.2 External accessories for cells are intercell connectors, end cell connectors and fasteners. These accessories are governed by IS: 6848.

4.4.4 Water intended for storage batteries should conform to IS: 1069 and should be added to bring the level of electrolyte to approximately the correct height just before the charge or during early part of the charge so that gassing will thoroughly mix it with electrolyte. The salient requirements of the battery grade water are as follows :-

Appearance - The same shall be clear, colourless, odourless and free from suspended impurities.

	Characteristics		Limits
1.	pH.		6.5 to 7.0
2.	Non-volatile residue.	maximum	0.001 %
3.	Chloride as Cl	maximum	0.001 %
4.	Ammonia as NH3	maximum	0.001 %
5.	Heavy metals		NIL
6.	Calcium		NIL
7.	Manganese		NIL
8.	Oxidised matters - To pass 'KMNO4' test		
9.	Electrical conductivity at 27 ± 2 degree C in micro mhos/cm maximum value		10000

4.4.5 It should be noted that testing of mere PH value alone would not suffice to assess the quality of water used for replenishing in batteries. It is therefore necessary to undertake periodic chemical analysis at least once in 3 months and keep a record of these results.

4.4.6 In the early days, water intended for storage batteries used to be obtained by coal fired steam boilers or electrical distilled water plants. Demineralising plants are now available in the market and no electrical energy or fuel is required to operate this plant. The inlet water is connected to the plant and the treated water is obtained at the outlet after passing through chemicals provided for the purpose. A continuous monitoring PH meter is also provided in the plant. The whole unit occupies lesser space, is compact and neat. Requirement can be picked up from a wide range of capacities available in the market.

4.4.7 Hydrometer is used to ascertain the specific gravity of electrolyte in a lead acid cell. The specific gravity is the relative weight or density of the electrolyte as compared with a similar volume of pure water. The specific gravity of a cell should be maintained at the value given by the manufacturer in the fully charged condition. This value for fully charged cells at 27 Degree C shall be between 1,210 and 1,220 for cells up to 525 Ah capacity and between 1.245 to 1.255 for cells over 525 Ah capacity as per IS:6848.

4.4.8 Voltmeter is used for taking the individual voltage of cells and the battery as a whole. This voltmeter shall preferably be of a dry cell operated digital type with a range of D.C. from 0 to 200 V.

4.4.9 The rating assigned to the cell or battery is the capacity expressed in ampere-hours (after correction to 27 degrees C) stated by the manufacturer to be obtainable when the cell or battery is discharged at the 10 Hr. rate to the end voltage of 1.80 V per cell.

4.5 MAINTENANCE :

The present and most efficient procedure for the maintenance of lead acid cells is to carry out through overhauls, repairs, rigid tests and quality control during POH work of TL / AC coaches in the workshops. The work in the maintenance depots is confined only to regular and systematic examination, occasional topping up of cells and charging whenever needed.

4.5.1 Train lighting batteries of coaches by the very nature of service conditions cannot be expected to have steady rate of charge/discharge. They are often left to idle for long duration or charged at higher rates. Such strenuous service of these cells therefore calls for systematic and thorough examination while in service, prompt remedial measures of defects/replacement of cells and quality POH work in Shops to achieve the expected life without any loss of efficiency below 80 %.

4.5.2 Running maintenance of storage batteries falls under four categories :-

1. Trip examination,
2. Fortnightly examination,
3. Quarterly examination,
4. Intermediate overhaul.

4.5.3 Trip Examination :

To know the condition of cells during 'Trip Examination' some cells in a battery are treated as 'Pilot' cells. On arrival of train in the maintenance line, disconnection shall be done at inter vehicle connections, Recording of the specific gravity of' ‘Pilot’ cells in each battery shall be done, Pilot cells in coaches should be changed every month and. Marking of Pilot cells should be made as described. Cells are usually provided either in 2 battery boxes of 6 cells each or 1 battery box of 12 cells in coaches with DC-.24 V system. Cell number for marking pilot cells should be reckoned from left to right while facing the battery box. On receipt of coach from POH, the 1st and 12th cells should be marked 'P' in chalk indicating as Pilot cells. This should be changed to 2nd and 11 th after a month, 3rd and 10th in the next month, and so on in the subsequent months. After the cycle is completed, the same cycle should be repeated. The idea of changing the Pilot cells is to ensure that true condition of the battery is reflected, till the cells are sent for next POH and to take prompt remedial action in case of defects. In case of conventional coaches working on DC 110 V system there are two boxes with 28 cells in each. Marking of these cells to indicate Pilot cells shall be done as follows:-

B - I											
1	2	3 4	5	6	7	8 9	10	11	12	13	14
15	16	17 18	19	20	21	22 23	24	25	26	27	28
B - II											
29	30	31 32	33	34	35	36 37	38	39	40	41	42
43	44	45 46	47	48	49	50 51	52	53	54	55	56

Month	**B-I Pilot cells**				**B-II Pilot Ceils**			
After POH	1,	14,	15,	28	29,	42,	43,	56
2nd Month	2,	13,	16,	27	30,	41,	44,	55
3rd Month	3,	12,	17,	26	31,	40,	45,	54
4th Month	4,	11,	18,	25	32	, 39,	46,	53
5th Month	5,	10,	19,	24	33	, 38	47,	52
6th Month	6,	9,	20,	23	34	, 37,	48,	51
7th Month	7,	8,	21,	22	35	, 36,	49,	50

Repeat cycle further.

4.5.4 Replace vent plugs after taking specific gravity and ensure that they are tight. "SWITCH ON" lights and fans in each coach and take the voltage readings across the set of 56 cells. "SWITCH OFF" all lights and fans.

Tap the floats of each cell and check for correct electrolyte level as indicated in the float stem. Replace missing/defective floats. In case of low level, replenish with pure battery grade water. If any cell needs too much water for replenishing, watch for crack in the cells and also check the voltage on load which should not be less than 1.80 V. In case of any defect, remove the cell and replace by a spare one preferably of the same make and lug date or a lug date as close to the one already in the coach. Use special containers provided with automatic siphoning device to RDSO drawing No. SKEL 611 for topping up battery grade water. Check tightness of packing and use additional packing if required.

4.5.5 Coaches with discharged batteries which show less than 22 V on load should be put on charge at double the normal rate of charges and continued as long as possible till gassing starts or till the specific gravity rises to the fully charged value which should be between 1.210 and 1.220 for the cell up to 525 Ah or as recommended by the manufacturers and which is stenciled on the battery box. Use the battery charging terminals provided in coaches for charging purposes. Never skin the insulation of cables near end cell connections for this

purpose. Check up correct polarity and connect the charging cables. Use a clip-on d. c. ammeter of 0-100 A range to check up the battery charging current. Note down the rate of charging and the number of hours of charge.

4.5.7 Check the specific gravity of Pilot cells and the total voltage of battery on load at the end of charge and record.

4.5.8 Keep vent plug tight. Ensure that washer is available for vent plugs.

4.5.9 The person in charge of battery maintenance should record all the readings mentioned above in his diary and this information should be transferred to the register maintained for various trains.

Check anti-theft rods and provision of nuts both inside and outside the battery box on either side. Replace if found missing. Secure battery box cover finally after all works are completed.

4.5.10 FORTNIGHTLY EXAMINATION :

In addition to the instructions contained under "Trip Examination" the following works shall be carried out.

. 1. Clean the interior of battery box.

2. Clean the cell tops and deposit of sulphate, if any, in intercell and end cell connections.

3. Remove sulphated intercell connections, clean the connecting surface with a piece of cloth and replace by spare ones. Use fresh fasteners. Sulphated inter cell connections and fasteners should be soaked in kerosene oil, cleaned with warm water and kept ready for use. Intercell connections should be provided with both small and large strips and four fasteners each with one hexagonal nut, one spring washer to IS:3063 and 2 steel punched washers to IS:2016.

4. Remove end cell connectors, clean the connecting surface both in cell and connector thoroughly and provide them back. Check for proper crimping of terminal. In case strands of connecting cable are found cut at the crimping end, cut wire at the crimping end and re-crimp with a new intercell connector. End cell connector conforming to IS:6848 only should be provided. Tinned copper crimping sockets with a single hole, if any, provided as a stop gap measure should be replaced by standard end cell connector. Provide end cell connectors with both the fasteners each with one spring washer to IS:3063 and one punched steel washer to IS:2016.

5. Tap float guides and check for free movement, Look for elongated holes in float guides and replace such guides. Replace deficient floats promptly.

6. Check whether vent plugs are of the antisplash type and replace if required. Check for blockages of holes due to dirt. Cleaning of blocked holes is

necessary to ensure free passage of gas from the cell.

7. Check the "make" of cells and the lug date. Different "makes" of cells if found mixed together should be replaced by a single "make" of cells. If it is not possible to do this during one 'Fortnightly Examination' this should be noted down and attempts made to replace the same during the next Fortnightly Examination'.

8. Check whether cell packing is tight and provide additional packing, if necessary. Use only hard wood coated with acid resistant paint for cell packing. Never use untreated wood or plywood for packing of cells. If any cells are found cracked, replace them promptly

9. Check up provision of anti-theft rods and provision of nuts, both inside and outside the battery box on either side. Replace deficient rod and nuts.

10. Apply petroleum jelly on intercell connections and end cell connections.

11. Check battery fuses and replace overheated/incorrect size fuses by correct size.

12. Check battery box fixing nuts for tightness.

13. Record Specific Gravity of individual cells. "Switch ON" full load of the coach and record individual voltage of cells and total voltage. "Switch off' load. If the specific gravity is less than that painted on the battery box, charge the cells as specified under "Trip Examination" after topping up with battery grade water, if required. Use battery charging terminals, provided on coaches for charging purposes. Charging should be continued till the specific gravity rises, to the value mentioned in battery box, in "Pilot" cells. In case pilot cells show no appreciable improvement, check specific gravity of adjacent cells. If the specific gravity does not improve in spite of charging, replace the battery by another set and send the unloaded battery to Depot/Shop for treatment at the earliest. Cells should be handled with due care while unloading and in transit to avoid breakages. Facilities should be created in Depot for treatment of cells which do not pick up charge. Sulphation will be the main cause for this and the cells can be sent to shops for treatment if the facilities are not available in the depots.

14. On completion of charging, record the specific gravity of individual cells. If there is any wide variation in the specific gravity/voltage of cells, disconnect and replace those cells showing low specific gravity/voltage by spare ones. In case there are more than $l/3^{rd}$ of total cells with low specific gravity, the entire set should be replaced. Cells showing reverse voltage, zero volts should be withdrawn and replaced by charged cells.

15. Record individual voltage of cells and the total voltage on full load of the coach.

16. Change the marking of the "Pilot" cell as given in Para 6.3.3.

4.5.11 QUARTERLY EXAMINATION

In addition to the instructions contained under "Fortnightly Examination" give an equalising charge as given below :

1. Switch OFF load. Charge the cells at 50% of normal rate of charge i.e. at l/20th of the rated capacity of cells. Record hourly cell voltage and specific gravity readings.

2. Terminate charging when 3 successive readings are constant. Record specific gravity and no load voltage of each cell 15 minutes after terminating charge. Specific gravity should be between 1.210 and 1.220 for cells upto 525 Ah The voltage should not be less than 2.1 V. If there is wide variation in the specific gravity and voltage readings, such cells have to be sent to shops for treatment.

4.5.12 INTERMEDIATE OVERHAUL

4.5.13 Instructions given under "Quarterly Examination" should be followed.

4.5.14 Facilities required in major depots for battery maintenance.

1. Test benches for accommodating 8 to 10 sets of cells (12 per set)

2. Single phase battery chargers - 10 Nos.

3. 3 Phase battery charger 100A capacity with 3 panels of 40A rating and provision for adjustment of current from 0 to 40 A with ammeter & voltmeter for treatment of sulphated cells.

4. De-mineraliser of suitable capacity.

5. Storage tank for battery grade water.

6. Panel for discharging batteries.

7. Solar distilling plant.

8. Diesel engine operated trolleys to transport cells

9. A small workshop to attend to minor repairs like building up of lugs, cleaning of sulphated intercell & end cell connectors and fasteners, cannibalization of broken cells, patch repairs to battery box etc.

4.6.0 INITIAL FILLING AND FIRST CHARGE

4.6.1 ELECTROLYTE:

The cells are supplied in dry uncharged condition. These require diluted battery

grade Sulphuric Acid of Specific Gravity as laid down by the manufacturers (1.18 - 1.22), corrected up to 27 degree C, as electrolyte for Initial Filling. This can be prepared by mixing concentrated battery grade Sulphuric Acid (as per IS:266) of sp. gravity. 1.835 with Water of approved quality approved quality (as per IS; 1069).

It is important that the acid and the water should preferably be free from harmful impurities like Iron, Arsenic, Ammonia, Nitrates and Chlorides, but in any case below the specified limits as per IS:266 & IS: 1069.

TABLE -I

MIXING PROPORTIONS, TO PREPARE ELECTROLYTE FOR INITIAL FILLING USING 1.835 SP.G. AGID.

To get approx. 100 Ltrs. of Electrolyte of Sp. Gr.	Take To Mix Water in Liters	Ltrs Acid
1.180	86	17
1.220	82	21

4.6.2 The diluting and mixing of 1.835 acid, should preferably be done in Lead Lined tanks. However, this may be done in Ebonite boxes or Polythene tanks if adequate precautions are taken to regulate the rate of the acid addition to a safe level, which does not generate excessive heat.

4.6.3 Take the estimated quantity of distilled or de-ionised water in the tank and to this go on adding the estimated quantity of concentrated acid at a slow rate, while keeping the mix well stirred, say with a plastic or wooden ladle. After complete mixing allow the acid to cool down to the ambient temperature.

It may be noted that while preparing dilute acids, concentrated acid should always be poured in to water and never water in to acid.

4.6.4 Do not allow the acid to come in contact with skin, clothing or any other material which it might damage. If some acid should, however, get spilled on the skin, rinse promptly with clear water and wash with soap. Bicarbonate of soda solution (1/2 kg. to 5 ltrs of water) will neutralise the acid spilled on clothing or other materials. Apply until bubbling stops and then rinse with clear water.

4.6.5 In our country, the standard temperature for measuring sp. gravity of any electrolyte is 27 degree C. As such, if the electrolyte temperature differs from this reference temperature while taking sp. gravity readings with a hydrometer, the readings require correction. For every 10 degree C above 27 degree C, add 0.007 or seven points to the sp. gr. reading on the hydrometer and for every 10 degree C below 27 degree C, subtract 0.007 or seven points from the readings.

TABLE – II
RELEVANT DATA FOR INITIAL FILLING & CHARGE

This data is normally supplied by manufacturers. Data for 'Standard' MAKE 'RPG' cell is shown below:-.

Cell Type	Electrolyte for Initial filling		First Charge		For Cell Electrolyte Final Sp. Gr. (27 Degree C)
	Ltrs/Cell Approx Qty	Sp. Gr (27 degree C).	Current Amps.	Duration Hrs,	
RPg-210	7.00	1.180	11.0	80	1.215
RPg-320	11.00	1.180	16.0	80	1.215
RPg-400	10.50	1.180	20.0	80	1.215
RPg-525	11.50	1.180	25.0	80	1.215
RPg-800	12.00	1.220	40.0	80	1.250
3RPg-120M/TL	2.40	1.180	06.0	80	1.215

4:6.6 INITIAL FILLING:

3.6.6.1 Remove the vent / filler plugs and fill the cells, with the previously prepared and cooled electrolyte, till the lower marking on the float indicator stem just appears above the float plug.

3.6.6.2 The approximate quantity and sp. gravity of the electrolyte for initial fillings are given in Table II.

3.6.6.3 After filling, allow the cells to rest for a period of around 16 - 24 hours.

3.6.6.4 During the rest period there will be some fall in the level of electrolyte. Restore this with some more electrolyte, before putting the cells on first charge,

3.7.6.5 Now the cells are ready for first charge.

4.6.7 FIRST CHARGE :

4.6.7.1 The recommended first charge current is given in Table II.

4.6.7.2 Select a D.C. source of 50% higher voltage and current capacities as compared to the battery voltage and maximum current requirement. Connect the positive of the source to the positive of the cell battery as marked on the terminals and negative of the source to the negative of the cell / battery also as marked on the terminals.

4.6.7.3 Now charge the cells at the specified rate for 80/100 hours as indicated in Table II.

4.6.7.4 During the charging it is not advisable to allow the temperature of the electrolyte to exceed 50 degree C. So, should it cross 45 degree C, reduce the charging rate to half the value and increase time proportionately. If the temperature continues to rise towards 50

degree C, stop charging immediately, and recommence only after the electrolyte has cooled down below 50 degree C. The total charge input should equal Time x I (where I is the specified charging current).

4.6.7.5 While charging, there will be some fall in the level of electrolyte due to loss of water by gassing. Restore this at intervals, say 24 hrs. by adding required quantity of approved quality of water into the cells.

4.6.7.6 It is necessary to start adjusting the sp. gravity of electrolyte to 1.215 ± 0.005 (with RPg-800, 1.250 ± 0.005) corrected to 27 degree C, at about 10-hours prior to the completion of charge; so that the adjustment is complete before the completion of charge.

If the sp. gr. is higher than specified, withdraw some electrolyte from the cells and replace with equal quantity of water. Charge for about one more hour. Check the sp. gravity and repeat, if necessary.

If the sp. gr. is lower, withdraw some (say 100 ml) electrolyte and replace with concentrated acid of sp, gr. 1.400. Charge for about 15 minutes. Check the sp. gravity. Repeat, if necessary.

NOTE : After adjustment of the sp. gravity of the electrolyte the cells must be gassing freely for a minimum period of two hours of charging. This helps in proper mixing of the electrolyte

4.6.7.7 After standing on open circuit for neither less than 12 hours nor more than 24 hours from the completion of a full charge, the battery shall be discharged through a suitable resistance at a constant current I = 0.10 x C10 amperes, and the discharge shall be stopped when the closed circuit voltage across the battery terminals fall to 1 .80 volts per cell (Refer IS:6848-1979).

3.6.8 The battery shall be charged at the normal charging

4.7 FEATURES AFFECTING LIFE OF LEAD ACTD BATTERIES :

Life obtained on Railways in case of conventional lead acid cells and batteries is not very encouraging and varies from 3 to 4 years. Life of lead acid cells is affected due to the following features :-

a) <u>Necessity for frequent topping up cells:</u>

There are practical constraints in frequent topping up of cells in rake considering the unhygienic surroundings, enormous quantities of distilled / demineralised water required, manpower requirements for completion of topping up process in limited time, difficulties in attending cells in rear row, spilling of electrolyte. Lapses in topping up the cell, however, seriously affect the life and performance of cells.

b) <u>Leakages of electrolyte on lid and on container body:</u>

During transit/handling/storage some cells develop fine cracks in container

body and result in leakages in services later on. Cases of spillage of electrolyte while topping up the cells also occur. These leakages/spillage result in undesirable leakage currents and even self discharge of cells.

c) Failure of one cell in Monoblock unit: Cases of failure of one cell in 3 cell Monoblock unit have been occurring frequently.

d) Undercharging/Overcharging :

In case of unforeseen detentions, failure of regulator/alternator, undercharging occurs. In day time, in winter, or in SLRs, the cells are likely to get overcharged if voltage settings in the regulator is not properly adjusted. These features affect the life of battery.

4.8 LOW MAINTENANCE BATTERIES

In the low maintenance version, modifications have been made in the chemical composition of grid-structure of plates to reduce water losses in service. While grid structure of conventional lead acid battery contains antimony more than 3.5%, in that of Low maintenance version has a lower antimony content of 1.8 to 3.5 %. Reduction of antimony content helps in reduction in loss of water in the electrolyte in service. Antimony is added to give strength to lead spines. Selenium is added to compensate the reduction of antimony content.

These batteries should not require topping up earlier than 9 months, as laid down in RDSO Specification No.EL/TL/55 (Revision 'B'). The batteries are provided with microporous vent-cum-filling plug, which allows free escape of gases evolved during service but does not allow electrolyte to come to surface of lid. A sealed float guide is provided to reduce the water loss. These batteries have been provided on some ac coaches.

4.9 VALVE REGULATED LEAD ACID (VRLA) BATTERIES / SMF BATTERIES

To overcome problems of frequent topping up, and leakage of electrolyte, sealed maintenance free lead acid batteries, termed as SMF (VRLA) batteries have been developed and are now used in most of the ac coaches. These batteries are governed by RDSO specifications EL/TL/59. Electrolyte in these batteries is in immobilised form and these can be used in any position - horizontal or vertical.

The batteries are supplied by manufacturers duly charged and no initial charging is required. Such a battery requires no topping up and maintenance except periodic cleaning of terminals. It has self sealing vent plug which normally does not open out in service.

4.9.1 Valve Regulated Lead Acid (VRLA) Batteries

These batteries are also called Sealed Maintenance Free (SMF) Batteries

Mechanism

Safety Valve :

When the internal pressure increases abnormally, the safety valve opens to release gas from the cell to restore the normal pressure.

Flame Arresting Vent Plug :

Provides with the explosion-proof filter constructed of aluminium oxide.

Container & Lid :

Made of Polypropylene Co-polymer.

Positive Plate :

With lead-calcium-tin alloy grid providing lower corrosion and less self-discharge rates.

Separator :

Made of high Absorbent Glass Mat woven with excellent porosity (AGM type).

Negative Plate :

With lead-calcium-tin alloy grid providing lower corrosion and less self-discharge rates.

Electrolyte :

Dilute sulphuric acid without any impurity.

4.9.2 Recombination Principle

The charge and discharge reaction of the lead acid battery can be expressed by the following equation :

Anode	Electrolyte	Cathode	Discharge	Anode	Electrolyte	Cathode
PbO_2	+ $2H_2SO_4$	+ Pb	Charge	$PbSO_4$ +	$2H_2O$	+ $PbSO_4$
Lead dioxide	Sulphuric acid	Spongy lead		Lead sulphate	Water	Lead sulphate

In a conventional flooded battery, towards the end of charge major part of the energy supplied by charging is dissipated by electrolysing the water in the electrolyte generating Oxygen at the positive plate and Hydrogen at negative plate. These gases are lost in a flooded system through the vent holes causing steady depletion of water and therefore requiring periodic topping up.

In a VRLA system the design is such that negative plates are never fully charged-even when the positive plate is fully charged and hence almost no Hydrogen gas generates from the negative plate although Oxygen is generated from positive plate. This Oxygen gas generated at the positive plate migrates towards the negative plate and reacts with the freshly formed spongy lead and turns into lead monoxide. The lead monoxide in turn reacts with the Sulphuric Acid to turn into lead

Sulphate resulting in the negative plate to be partially discharged.

To summarize the Oxygen evolved at the positive plate is absorbed by the negative plate without being released to the outside. The negative plates being always in a state of partial discharge never generate Hydrogen. This completely prevents loss of water.

This recombination principle may be expressed as a :

Negative plate (charged)	02 gas generated from the positive plate	Negative plate	Electrolyte (discharged)	Negative Electrolyte
Pb + (H20)	1/2 0 2 → (PbO)	→ (PbO)	+ H_2SO_4 →	$PbSO_4$ +
Spongy lead Water	Oxygen gas	Lead Monoxide	Sulphuric acid	Lead Sulphate

4.9.3 Some features of VRLA Batteries :

The Pure Lead-Tin range offers the customer the highest energy density of any lead acid battery anywhere. The battery is constructed around a complex thin plate, pure lead-tin grid which packages more power in a smaller space. The plates being made of high purity lead last longer, offering excellent life. The proven benefits o this superior technology are high performance, quick recharge capability, high energy density and a long service life. The 6V & 12V monoblocks are available in capacities ranging from 12Ah to 150Ah.

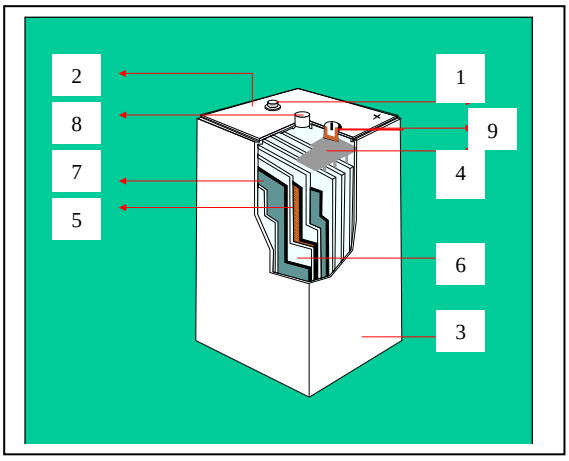
Benefits

- Maintenance-free and spill-proof. This enables flexible mounting
- Wide operating temperature range (-40C to +50C)
- High energy density (gravimetric and volumetric)
- Good charge retention leading to long storage life
- Low internal resistance ensures quick recharge
- Excellent high rate capability permits use of smaller capacity batteries
- Superior raw materials for good performance and life
- Excellent deep discharge recovery characteristics
- UL recognized plastic components

4.10 Comparison of VRLA Batteries & Flooded Batteries

Valve-regulated batteries (VRLA) With robust dry fill gel technology or AGM glass mat technology. Both systems are maintenance-free	**Flooded Batteries** With high-performance tubular plates or compact block batteries with grid plates
• No liquid electrolyte- no spilling • No insulation faults due to wet batteries • No wet, sticky or corroded battery boxes • No risk of excessive or insufficient topping-up. • Reduced risk of fire caused by neglecting to top-up. • Full capacity from charge retention (no standby capacity reduction) • Proof against deep-discharge in accordance with DIN 43 539 T5 • Very low self-discharge, long storage period • High mechanical strength and resistance against vibration and shock due to the VRLA design. • Can be recycled easily and completely	• Classic, robust lead-acid battery technology with liquid electrolyte. • High operational safety even under rough conditions. • Water top-up systems for group or individual topping-up available. • Full capacity from charge retention (no standby capacity reduction) • High mechanical strength and resistance against vibration and shock due to proven design. • Can be recycled easily and completely.

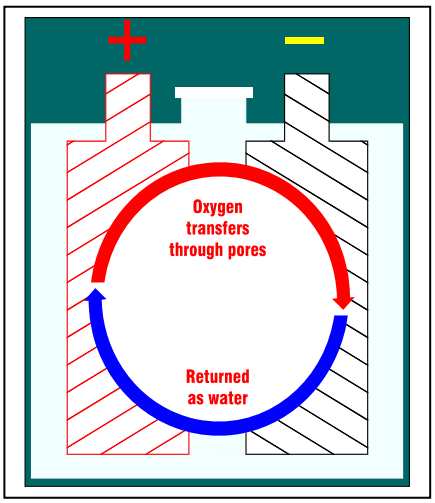
Construction of VRLA Cell



1. Terminal Post -ve.
2. Jar & Cover - Polypropylene.
3. Jar to Cover - Hermetic Sealing.
4. Bus bar
5. Separator: Spun Glass microporous matrix (Totally absorbed electrolyte)
6. Positive Plate - Hybrid Grid Alloy
7. Negative Plate - High surface area to enhance oxygen recombination.
8. Vent Plug
9. Terminal Post +ve.

OXYGEN RECOMBINATION PRINCIPLE

Oxygen Formed during charge



Oxygen Combined Indirectly with Hydrogen

5. CARRIAGE FAN

5.1 GENERAL

400 mm, 300 mm and 200 mm sweep carriage fans are used on Indian Railways in SG, MOG, and EOG coaches where the system voltage could be DC 110 V or AC 110 V. As a passenger amenity item, carriage fans have to be maintained in such working condition as to obtain good air flow and trouble free service for ensuring maximum passenger satisfaction.

5.2 SPECIFICATION

Railway carriage fans are either of the fixed or swiveling type and conform to specification IS: 6680. Performance requirements of these fans are as follows:

PERFORMANCE DATA

Requirement	D.C. Fan sizes			A.C. Fan sizes		
	400 mm	300 mm	200 mm	400 mm	300 mm	200 mm
Minimum Air in m3/min	50	37	20	65	30	14
Maximum Electrical Power input in Watts	35	29	18	60	40	28
Maximum Weight in kg.	15	14.5	10	15	14.5	10

5.3 Such design performance of the carriage fan can be maintained in service only by efficient maintenance of its vital accessories such as carbon brushes, brush holders, springs, commutator, bearings, regulator and its resistance etc. Parts when replaced should be to correct specifications to ensure efficient performance of fans.

ACCESSORIES

5.4 **Regulator** : This shall conform to IS:6680. The regulator is provided for regulating fan speed in upper class coaches. It should be ensured that the fan is capable of starting up from rest with the regulator at the lowest speed step when 85 % of the rated voltage or the lowest voltage of the voltage range of fan is applied.

5.5 **Fuse Protection** : Tinned copper fuse of 35 SWG is provided as protection for each fan. This safeguards the fan from surges and short circuit and isolates the circuit in case of faults in the sub-circuit.

5.6 **Gimbal ring** : This shall conform to IS:6680.

This is provided in upper class coaches in swiveling type fans, so that the passenger can keep the fan angle to any position desired by him for comfort.

5.7 MAINTENANCE

The aim in maintenance is to reduce or compensate for the wear-and-tear in operation so that the installation continues to function well and give good service. Preventive maintenance covers the following four basic aspects:-

1. Systematic checking of the carriage fan while in service.
2. Localisation of defect, rectification and restoration of normalcy, if necessary, by replacement of the defective/Worn-out parts.
3. Analysis of the basic cause of failure and taking remedial action to avoid/minimise recurrence.
4. One of the basic causes of passenger complaints is excessive noise of fans and steps should be taken to minimise the noise level. The acceptable level of noise shall be less than 80 db.

5.8 RUNNING MAINTENANCE

The nature of defects in carnage fans mainly come under the following categories.

1. Excessive noise and vibrations.
2. Excessive sparking/blackening of commutator and excessive wear of carbon brushes.
3. Inadequate air delivery.
4. Poor insulation.

Remedial action to be taken in respect of the defects mentioned above is explained in the following sections.

5.9 EXCESSIVE NOISE AND VIBRATIONS

Excessive noise and vibration may be due to the defective bearings, loose cage guards, loose fan blade rivets, incorrect blade angle and profile and wrong balancing of blades.

a. Bearing should be of standard quality. Radial ball bearings with designation "10BC02-6455" to IS:6455 are prescribed for use on Railways carriage fans. The nominal dimensions of ball bearings are 10 mm (ID), 30mm (OD) and 9 mm (Width). These bearings shall be with normal tolerance and normal radial clearances to IS:5692 and IS:5935 respectively.

b. As an alternative, sintered bush bearings to grade I.B-1 of IS:3980 are also used on the blade end of the fans. These bearings shall have nominal dimensions with tolerance of 9.589 (± 0.118 mm) (ID), 15.989(± 0.21mm) (OD) and 20.6 (± 0.165mm) length. Lubrication pad is provided with sintered

bush bearing to ensure required lubrication at the bearing. Procedure/ instructions to be followed, during the removal and fitment of sintered bush bearing and its lubrication at the bearing.

c. Mishandling of the fans during storage, maintenance or due to vibrations in service would cause the cage wires come out of its fixations. This will create abnormal noise with vibration and consequent passenger complaint.

d. Proper care should be taken in handling the fans and in case any wire of the cage guard is found loose out of it's fixation, it should be repaired or the cage guard be replaced. Besides, the tack welding of the radial ribs should be checked and attended.

e. Fans blades should be checked for loosening of rivets and for any distortion in profile, correct blade angle and balancing to minimise excessive vibrations and noise of the fans.

f. Fans should also be checked for wrong balancing. The static balancing could be observed/checked by revolving the blade at slow speed and checking position of stops of blade. Prior to the above checking, the fan blade should be checked for any distortion in profile of blade angle. An unbalanced fan blade should be rejected and replaced with good one.

5.10 EXCESSIVE SPARKING/BLACKENING OF THE COMMUTATOR :-

Excessive sparking at the commutator may result because of

1. Improper spring pressure, carbon brushes grade and carbon brush bedding on commutator.
2. Improper commutator surface condition.
3. Defective winding and commutator connection.

5.11 The following are the approved grades of carbon brushes used on Railway carriage fans.

1. EG 3(1) of M/s Assam Carbon
2. L 16 (I) of M/s Electro Carbonium.
3. SOI 159 of M/s Sintered Graphite, Kanpur. The carbon brushes which reach the wear limit mark (wearing length 10 mm) should be replaced by a good one of the same grade. New brushes must be bedded to commutator over the whole area of contact. Polishing paper can be drawn between the brush and commutator until the brush assumes the correct curvature. Carbon brush springs should be checked for correct tension and should be replaced if found to have lost its temper or damaged by mishandling.

5.12 The commutator surface should be smooth and clean to avoid excessive wear and sparking at the commutator. Cut during commutator turning should be restricted to minimum so as to obtain maximum life from commutator.

5.13 Defective winding can be because of open/short circuit of winding and connections at commutator. If there is excessive sparking without other causes mentioned above, the fan should be dismantled and armature taken out for checking of insulation by megger and connections by drop test and armature and field repaired or1 replaced as may be necessary.

5.14 INADEQUATE AIR DELIVERY

Inadequate air delivery can be because of low speed or incorrect profile or blade angle.

1. For low speed, check for any mechanical jamming of fan or excessive blackening of commutator.
2. Fan blades are likely to get distorted losing their profile and blade angle if handled or stored roughly without care or tampered with in service. The corrugated depression has been introduced on fan blades to stiffen the blade to certain extent to prevent its distortion in service but it is very necessary that fans and blades are handled with care during transport and fans are stored properly to avoid their deformation/damage due to excessive loads in storage.
3. Fan blade profile shall be checked for any distortion or bending particularly where blades are riveted to blade carrier. Distortion or bend noted shall be corrected by gently pressing the fan blade as required.
4. Blade angle can be checked and maintained within acceptable limits by keeping the total maximum blade off-set at two extremes of blade width parallel to fan axis to 32 mm. It can be checked and maintained easily using simple fixture and shall be done every time fan is taken for repairs in sick line or during POH in shops. All the four blades of fan shall be adjusted for blade angle to obtain optimum air delivery.

5.15 POOR INSULATION

Poor insulation of fans may result in focal heating and damage to insulation. Fans shall, therefore, be meggered with 500 V megger and ensured that the fans are having the required insulation value. The insulation value of new fans shall not be less than 2MΩ. This insulation value of fans in service may deteriorate for ingress of moisture, deposition of carbon dust and ageing of insulation etc.

The fan with insulation value less than 1 MΩ is not permissible to be in service. These fans shall be dismantled; armature/field with poor insulation shall be taken out of motor and following operations be performed.

1. Clean the armature/field with the help of a hard brush in petrol to remove all dust and carbon deposits accumulated on armature.
2. Heat the armature in a heating chamber for two hours at 90 degrees C.
3. Dip the armature/field in thermosetting impregnating varnish suitable for class "E" thermal class.
4. Cure the varnish by heating the armature in heat chamber according to curing schedule prescribed by the varnish manufacturer.
5. Measure the insulation resistance by 500 V megger. If the resistance is less than 2MΩ even now, discard the armature/field and use a new one. The defective armature/ field shall be rewound with proper winding wire.

If sufficient facilities are not available for heating and impregnations, send the defective fans for attention to shops.

5.16 TRIP ATTENTION

Following scheme is prescribed for all trains primarily or secondarily maintained at a depot.

1. Switch on each fan individually. Check starting of fan when switched on. In upper class coaches, check fan for starting in the lowest position of regulator and also for variation of speed. If the fan does not start, short the switch terminals with a small piece of wire temporarily. If the fan starts, this will indicate that the controlling switch/regulator is defective. Replace defective switch/regulator.
2. If the fan does not start when the switch terminals are shorted proceed as follows.
    a. Test for supply at the connector terminals near the fan with switch on, if there is no supply, the wiring is defective and has to be attended.
    b. Open dust cover in case of swiveling fans and remove fan body fixing screws in case of fixed fans. Remove carbon brushes. Check carbon for condemning size, proper bedding, correct spring tension and correct grade of brush (RDSO SKEL 3722). Check for free movement of brush in brush holder (RDSO SKEL 2680). Replace defective brushes/springs. Ensure proper bedding.
    c. If the commutator is dirty, clean the surface with flint paper of 2/0 size.
    d. If the commutator surface is grooved or the segments are found pitted in one or more locations, replace the fan by an overhauled fan. The defective fan can thereafter be rectified by replacement of the defective armature by a good one. If spare armature is not available

send defective fan to shop for attention.

e. If the fan is noisy, check for loose blades/fan guards and tighten, if the noise is due to bearings, replace the fan fey a good one.

3. Check the individual fuse for fans and ensure it is of correct size (35 SWG tinned, copper)
4. Clean fan body and guard thoroughly.
5. In swiveling and bracket fans, free movement of fan for keeping at the desired angle as also the fan remaining at this angle should be ensured.
6. In swiveling and bracket fans, ensure that the fan dust cover is promptly replaced, after attention and also that the nylon cord provided to prevent loss of fan dust cover is available in position.
7. The MCB controlling the fan circuit shall be checked for correct rating (35 A) and proper functioning and replaced if found defective. Any temporary fuse used shall be of 22 SWG tinned copper only,
8. Note down the total number of fans in each coach and the number, of fans found defective on arrival. Defective fans shall include fans which require push start. Note down the total number of fans in the entire rake and the number of fans found defective. Such records may be maintained for each train, rake-wise. The aim is to achieve cent percent working of fans.
9. All fans as per scale laid down for the various types of coaches shall be available in the coach. In case it is necessary to remove any fan for attending to major defects and no spare fan is available, a Deficiency Label shall be affixed near the fan point. In case no Deficiency Label is available, Theft Memo shall be issued to the security branch.
10. Deficiency of fans shall be promptly made good when noted by any Depot irrespective of whether the train is primarily maintained or not except in case of recurrent large scale deficiencies of foreign Railway's coaches. The depot/ Rly entrusted with primary maintenance shall be advised by message whenever the deficiency is made good or when large scale deficiencies are noted on arrival.

5.17 FORTNIGHTLY EXAMINATION (FNE)

In addition to the items listed under “Trip Attention" the following works shall be carried out during Fortnightly examination (FNE)

1. The fan body, guards and blades shall be thoroughly cleaned with cloth.
2. All fans shall be opened and condition of commutator, brushes and brush gear shall be thoroughly checked and action taken where necessary as given under "Trip Attention".

3. Fan fixing studs to carriage body shall be checked and tightened, wherever necessary. Availability of all the three fixing studs shall be ensured.
4. Voltage shall be checked at the following location with coach load "ON" and recorded,
    a. at the battery terminals,
    b. at the junction box, and
    c. at three fan points at random,

    The voltage drop with respect to voltage at the battery terminals with full load “ON" shall not exceed 1.5 V in the 110 V system.
5. All the switches controlling the fans shall be checked thoroughly and replaced, where necessary.
6. Fan regulators in Upper class coaches shall be checked for smooth operation from one position to the other. In case the regulators are not regulating the fan speed, it shall be checked and replaced, where necessary.
7. Fan blades shall be replaced if found bent, or if there is no proper air discharge on examination.

5.18 SAFETY ASPECTS

1. The fan shall be provided with a close mesh guard for protection of users against injuries, as specified in IS 6680.
2. To prevent an earth fault in the coach, fans are insulated from the coach body by providing an insulating pad while fixing (RDSO SKEL 3838).
3. The fan base is fixed to the coach body by using hexagonal head screws washers and flat washers. This shall receive special attention since there have been cases of fans dropping in service and causing injury to occupants.
4. The lead from the fan shall be taken in such a way that the wires do not rub or get damaged by the swiveling motion of the fan body.

5.19 ANTI-THEFT MEASURES

1. The inspection dome cover shall be provided with locking arrangements as per RDSO Modification Sheet No/RDSO/TL/MS/5 and RDSO Drawing NO. SKEL 3056.
2. Secure commutator end shield and bearing caps screws by filling the slot of screw heads (3 Nos.) by solder.
3. Fix split pin, as per IS:6680 by passing through the hub of the blade and the armature shaft to prevent easy removal of armature.
4. Secure screws (2 Nos.) holding the commutator end shield to the field

magnets by sinking them further inside and plugging the screw head pockets with solder as per IS:6680.

5. Use aluminum field coils instead of copper field coils as per IS:6680.
6. Use aluminum/zinc alloy or cadmium plated/zinc passivated mild steel brush holder as per RDSO's Drg. NO.SKEL 2680.

5.20 DEVELOPMENTS

Developments in this field are :-

1. Use of one ball bearing and one sintered bush bearing instead of both end ball bearings.
2. Introduction of BLDC fans.
3. Bulk inverters for fans & limited lights for passenger coaches.

5.21 In spite of the very arduous duty to which these fans are put to cent percent trouble free service is possible with careful and sustained maintenance. Investigations confirm that failures occurring in carriage fans are mainly due to introduction low grade materials and inadequate preventive maintenance.

5.22 A Comparison of features of 110 V D.C 400 mm permanent magnet fan and conventional fan is at table 4-1.

5.23 RDSO specification ELPS/SPEC/TL/02 (Provisional) covers 2.5 KVA (at 110 V AC) Bulk inverters for inverting an input voltage of 110 V to 140 V DC. to 110 V AC (± 5%) for fans and limited tube lights in a coach. The inverters will be tried on coaches.

TABLE 4-1

	FEATURE	**EXISTING DESIGN**	**Permanent Magnet Type**
1	Weight	15 Kg	4 Kg
2	Power Input	38 Watts	30 Watts
3	Air Delivery	50 Cum/Min	70 Cum/MIN
4	Starting Voltage	85 Volts	10 Volts
5	Bearing	Open Type Ball Bearing	Shielded Ball Bearings
6	Blades	Mild Steel	Flame Retard Ant Plastic Blade
7	Commutator	Large Dia	Small Dia
a	Temp. Rise	65°C	40°C
9	Finish	Enamel Paint	Epoxy Power Coating

6. CARRIAGE LIGHTING

6.1 GENERAL

Carriage lighting is provided from . .

a. Axle driven generators in conjunction with storage batteries on D.C. 110 V system..

b. Diesel generator sets with step down transformers on A.C. 110 V in MOG system,

c. Diesel generator sets with step down transformers on A.C.110V in E.O.G system.

6.2 LEVEL OF ILLUMINATION.

The level of illumination to be attained in various types of "coached shall be as follows:

Class of coach	**Minimum illumination level..**
First class	30 Lx
	60 Lx
Second class	16 Lx
	40 Lx
Postal	40 Lx
Dining/Pantry	30 Lx
Lavatories Corridor in first class	16 Lx.
Lavatories and Corridor and other class	11 Lx.

6.2.1 The level of illumination shall be measured on a horizontal plane 840 mm above floor level and 500 mm from back of every seat. Average illumination shall be obtained by dividing the sum of illumination at each seat by the number of seats. While conducting the test, the windows and doors shall be closed to avoid outside lights influencing the readings. Degree of uniformity of illumination, which is ratio of level of illumination at the least favorable seat (minimum level) to the average level of illumination shall not be less than 1:3.

6.2.2 In the corridors, the value of illumination level shall be taken on a vertical plane along the centre, of the corridor at a point 840 mm above the floor level and between each compartment door with lights inside the compartment switched on and windows on the corridor side as well as compartment side closed.

6.2.3 Indoor ways and vestibules, the reading shall be taken adjacent to the door or vestibule at height of 840 mm from floor level.

6.2.4 In lavatories and toilets readings shall be taken in the centre of the compartment at a height of 1500 mm above the floor level.

6.3 WATTAGES OF LAMPS :

The wattages off incandescent and fluorescent lamps to be used in various classes of compartments are as under.

a.	Ceiling light fittings in I, II&III AC, II Sleeper, postal vans and dining cars on DC 110 V sys.	18 W, 2 ft. long fluorescent lamps with inverters.
b.	—Do— on AC: MOG system in I class and II class	18 W fluorescent lamps with inverters.
c.	—Do— in I class, II class and dining cars on dc: 110 V system including Lavatories corridors and passages.	2 ft. 18 W twin tube fluorescent with inverters.
d.	Ceiling light fittings in II class lavatories and passages of all coaches and reading lights in I class working on : 110 V	18 W fluorescent lamps with inverters.
e.	Reading light fittings in I&II AC coaches working on dc: 110 V	15 W Pygmy incandescent lamps. (Halogen Lamps used in LHB coaches)
f.	Night light fittings with blue globes in all coaches wording on dc: 110 V	15 W Pygmy incandescent lamps

6.4 SCHEDULE OF FITTINGS AND THEIR CONTROL

The electrical fittings to be provided in various classes of coaches are given below for general guidance.

Class of Coach.

Fittings	**I & II AC**	**II & II Sleeper**	**Postal**	**Dining Car**	**Guards Compartment**
Reading lights	*Yes	No	No	No	No
Night lights	*Yes	*Yes	No	No .	No
Individual switch ceiling lights.	"Yes	*Yes	No	Yes	Yes
Individual switch for night light.	*Yes	*Yes	No	No	No
Side lights	No	No	No	No	Yes
Step lights	No	No	No	Yes	No
Tail light	No	No	No	No	Yes

* Provided in coaches with sleeping accommodation.

5.5 SPECIFICATION OF FITTINGS USED.

a.	Ceiling light fitting size	…	Drg. No. IRS.EA 199 alt.3
b.	Night light fitting	…	— do —
c.	Sidelight fitting	…	Drg.No.SKEL.3048

d.	Step light fitting	…	Drg.No.CA/EF 637
e.	Tall light fitting	…	Drg. No.SKEL 3461 Alt.l
f	Fluorescent ceiling light	…	To 15:2418-1977
g	Lamp holder	…	To 15:1258-1979 (Second Rev)
h.	Reading light	…	Drg.No.WGFAC7-2-011 Alt. h
i.	Toggle switch	…	Drg. No. ICF/SK-7-4-002 Alt. b
j.	Inverters for fluorescent lamps working in dc:110 V	…	TO IRS Specn.No.E.47-78 Amendment. 1
k.	T.L. lamps	…	To 15:897-1982 (Second Rev.)
l.	Glass globe (clear) for ceiling light fitting	…	To type 'A' size 130 Fig 4 of IS: 5870-1970 amendment no-1
m.	Do--(for 110 V lamps)	…	To type 'A' size 120 fig2 of 15:5870-1970 Amendment No. 1

6.6 LIGHTING CIRCUIT

6.6.1 The lighting circuit cable (LC) form the under frame to junction box in the roof is divided into two circuits through miniature circuit breakers of 35 A capacity for each of the circuits LI + and L2 +, Circuit LI + feeds the essential lights which fulfill the minimum lighting requirements in a coach satisfactorily. These include lighting in the lavatories, gangways, doorways and upto 50% of lights in each compartment /bays, corridor lights and night lights. Circuit L2 + feeds all the lights other than essential and includes reading lights in I& II class AC coaches.

6.7 MAINTENANCE:

The transparency or reflecting power of all exposed-surface, and lamps and-fittings would deteriorate due to the formation of a film of dust or dirt. This would, result in reduction of the level of illumination to very low levels within a comparatively short period. Proper maintenance is therefore necessary to keep up the initial illumination values.

The level of illumination will very much depend upon the reflecting properties of the interior surfaces of the coach. It is important that the coach interior is finished in light colors and maintained well for good illumination.

6.7.1 TRIP ATTENTION

a) Switch on each lamp. If the lamp does not glow, check up lamp and replace, if fused. If the lamp is alright, check up control fuse and replace. If the fuse is alright, check up plunger or loose connection and rectify defect. If the switch is alright, check up lamp holder for stuck up plunger or loose connection and rectify defect. If there is no defect in the lamp holder, check up for supply at the holder terminals and if the wiring is found defective, mark the coach "Sick" and arrange for attention in maintenance lines.

b) Note down the coach number, total number of lights in each coach and the number defective/missing lights on arrival.

c) Replace switch covers and Rise covers promptly, if any of them are missing, promptly replace them.

d) If any dome cover is open or not secured properly, rectify defect, if any and secure.

e) Replace broken glass domes.

f) In case of berth lights in first class, check up for free movement of shutters. Replace defective berth lights.

g) Clean side lamp glasses and red shield inside the lamp in SLRs. Check up for free movement of operating handle and oil, if necessary.

h) Clean tail lamp glass and the reflecting surface inside.

i) In case of fluorescent light, check up holders, starters, inverters and fitting wiring and rectify defect/replace component. Replace faded and broken covers promptly.

j) Check up MCBs for light circuits LI & L2 in junction box for proper operation and replace defective MCBs. Watch for loose connections in MCBs to bus bars and rectify. Ensure that MCBs are provided separately for LI and LII circuits.

k) Check up tightness of terminal connections in 100 A HRC fuse for negative circuit in junction box and rectify defect, if any,

1) Remember that fuses & MCBs are safety devices provided for isolating the supply in case of faults. Never by-pass or use incorrect fuses as this may result in serious failures.

m) Take care to see that surfaces such as ceiling, paneling, seats, etc. are not dirtied while attending the fittings.

6.7.2 Fortnightly examination (FNE)

In addition to the items listed out under "Trip Examination" proceed as follows.

a) Open each fitting with the dome key and clean the dust in the fitting both inside and outside. Ensure free operation of locking mechanism and replace defective fitting. Clean glass domes with wet cloth first and then with a clean dry cloth.

b) Replace rusted, fittings and fittings with poor reflecting surface.

c) Check up wattage of lamps and replace by correct wattage

d) Check up whether switches are marked to indicate lighting control 'L', night light control ‘NL’, side lamps in guards compartment as 'SL', tail lamps as ‘TL-Rear', ‘TL- Front' luggage room as 'LRL'. If not stencil legends with fluorescent paint.

e) Check up all lighting circuit fuses in each coach for correct sizes and replace if necessary. Stencil the size of fuses near the locations, if not already done.

f) Mark inspection covers for Distribution fuse boards as ‘DFB’ if not already done.

g) Switch on full load and record voltage at battery terminals, junction box and extreme light point. The drop should not exceed 1.5 V at any point.

h) Thoroughly clean metal guards for roof light fittings in luggage rooms and paint, if necessary.

i) Provide spare fuse wire for use in the branch circuits on the bobbin located on the distribution fuse board.

6.7.3 Enroute attention

a) If there is total darkness, check up functioning of MCBs and replace if necessary. Sometimes staff inadvertently connect both LI and L2 circuits to one MCB and this may lead to tripping of MCB. Provided individual MCBs or connect them independently through ruses of correct size.

b) Test for supply in the junction box. If there is no supply, check up battery fuse and replace.

c) If battery fuse in intact, it is possible that battery is completely drained. Provide emergency feed from adjacent coach after switching off L2 circuit in both the coaches. Advise appropriate station by XR message for attention.

d) In case few lights are not glowing, check up DFB and replace fuse. If the fuse is alright, check up individual lamps and replace fused lamps.

e) In case coaches arrive with dim lights, check up and replace missing belt in generating equipment, Provide emergency feed from adjacent coach switching off L2 circuit in both coaches. Advise appropriate station by XR message for attention.

7. MAINTENANCE SCHEDULES

7.1 SCHEDULE "A"- TRAIN PASSING STATIONS SCHEDULE

Take position at the end of the platform in which the train will be entering the station and observe the condition of the under frame mounted electrical equipments and roof as the train is passing to detect.

a. Deficiency of belt.

b. Loose axle pulley,

c. Infringement with moving dimension.

d. Coaches in dim/dark condition.

7.1.1 Deficiency of belt:

If no belt is available, provide connection from adjacent coaches through emergency feed terminals for the affected coaches duly switching off one light circuit in each coach which feeds the supply and the one which receives the supply. Inform by special message through control and confirm by a wire to the next TL maintenance station to replace missing belts, giving coach numbers.

7.1.2 Loose axle pulley:

Exhibit danger signal in the affected coach and tighten axle pulley bolts after positioning the pulley. If it is found not possible to tighten the axle pulley, secure or remove the axle pulley depending upon the condition for safety of operation. Remove alternator belt, load the axle pulley, if removed, in the same train and inform terminal station by wire for attention. Provide through connections from adjacent coach duly switching off one light circuit in each coach.

7.1.3 Infringement with moving dimension:

Exhibit danger signal in the affected coach and remove infringements. Advise primary maintenance depot and the terminal station for attention as needed by a wire.

7.1.4 Coaches in dim/dark condition:

Check up junction boxes of coaches with no lights and replace fuses/ switch on tripped MCBs. If the fuses and MCBs are intact, provide through connections from adjacent coaches, duly switching off one light circuit in the coaches feeding the supply and the one receiving supply. Advise terminal station/primary maintenance depot by a wire.

A defective generating equipment should not be interfered with. Belt shall be removed and noted label affixed on such equipment. Advise terminal station. Contact the train guard and /or XL fitter accompanying the train and obtain the particulars of any defect or complaints and attend to same. In case major defects cannot be rectified with the scheduled time of halt, accompany the train and rectify defects. Advise by message to the next maintenance station for further attention required.

A blown fuse should only be replaced by correct size fuse as stenciled near the equipment. If a fuse blows repeatedly, a noted label shall be affixed and the terminal station

advised by a wire. Enter enroute condition of coaches, indicating name of station and also attention given.

7.1.5 Fire in coaches:

In case of fire in coach, the coach should be electrically isolated in the following manner,

a. Disconnect inter vehicle connections, if any.

b. Remove battery fuses.

c. Remove alternator belts

d. Remove alternator regulator field fuses.

7.1.6 SCHEDULE “B” - ROUND TRIP SCHEDULE:

7.2.1: General:

Immediately after arrival of train in the platform, feel the body of alternator with the palm and ascertain whether it is 'cold', 'warm' or 'very hot'. Check whether the belts are in case of 'cold' condition. Record condition of lights and fans i.e. whether the lights are 'dim' or 'dark' and whether fans are working. In case the train is not received at the station by the maintenance staff. The information regarding the arrival condition mentioned above is observed by the train receiving staff shall be passed on to the maintenance staff at the earliest for their guidance while doing the maintenance works.

7.2.2 Maintenance lines:

As soon as the rake is berthed in the maintenance lines and before commencing the work, a standard caution board shall be clamped to the rail on either side of the rake by the Electrical Supervisor/Electrical fitter incharge of the maintenance of the rake. Rail locks shall be used on either side of the rake, in addition, wherever this is feasible. Check the report received from platform receiving staff and concentrate first on attending to defects in these coaches. Proceed as follows in respect of other equipments.

7.2.3 Axle Pulley:

Check axle pulley for breakage of any part, i.e. flange etc, any cracks or other abnormalities. Replace/repair the pulley on condition basis.

Check for any sign of shifting or looseness of axle pulley on the axle by observing the white band mark provided on the pulley face and the axle at the time of fitment of axle pulley. Check the correct gap between the two halves of the axle pulley. Replace axle pulley if the gap is less than that specified.

Axle pulley to drg. No	Gap between two halves	
	Max	Min
SKEL 3723	4.5 mm	3.0 mm
SKEL 1476	4.0 mm	1.0 mm
IRS EA - 140 M	3.0 mm	1.0 mm

In case the gap between two halves is less than the minimum of 3 mm in the case of pulleys to drg No. SKEL 3723, it indicates incorrect profile of machining of the axle pulley and pulley seat on the axle and the same should be checked. Axle pulley with gap less than 3 mm shall not be permitted and also no packing of any kind shall be provided under the pulley to maintain this gap. Gap shall be checked with the help of ‘Go' and 'No Go' gauges.

In the case of pulleys to drg. No. SKEL 1476 and IRS EA-140 M, if the gap between the two halves is less than 1 mm, the axle pulley shall be replaced and the grips provided on the removed axle pulley shall be replaced and re-machined to form matching set. Check for tightness of axle pulley by tapping (the holding bolt) with light (1kg.) hammer. If it gives a clear metallic sound, the pulley is tight. Dull sound indicates loose bolt and the bolt should be tightened. In case of difficulty in tightening the bolt in site, the coach shall be marked sick and called to the sick line for thorough attention. Under no circumstances, a coach with loose axle pulley bolt shall be permitted to work on line, as this is a safety hazard. Loose bolts shall be tightened to a torque of 30 kgm.

Check availability of check nuts proper locking and use of split pins in all fixing bolts.

Check for signs of misalignment of generator. Shine on axle pulley surface will indicate riding of belt and if it is on one side close to the pulley flange and belt has frayed edges on one end, it indicated misalignment which should be checked and adjusted.

7.2.4 Alternator pulley:

Check for any breakage, crack or looseness of Alternator pulley. Replace/repair pulley on condition basis.

Check castle nut on Alternator pulley for availability and soundness of split pin, Replace, if necessary. Never reuse a removed split pin as this is likely to break and result in the pulley working out, which is a safety hazard.

Check for riding of belt on the pulley by observing the shine on the pulley surface and adjust for any misalignment of Alternator.

7.2.5 Tensioning Gear:

Check the tensioning gear for its unrestricted movement and locking arrangement. If the movement is found jammed, the same should be attended to and threads and links lubricated with grease after thorough cleaning.

Replace tension rod, if the threads are found worn out.

Check availability of split pin on tension rod and replace, if found missing.

Check for existence of tension springs. Ensure that the lock nut is tightened whenever tensioning is done.

7.2.6 Alternator:

First attend to alternators in coaches, which have arrived "cold" as noted or reported by train receiving staff. Proceed as follows :

- Check up field fuse. If found blown, replace.
- Check up connections in alternator and rectifier regulator for tightness. If this is alright, remove belt from alternator.
- Use testing machine for testing alternator in situation. Connect the portable dc 110V equipment to the battery and couple the machine with the castle nut of alternator pulley after removing the split pin. Check up voltage in alternator terminals, regulator terminals, DC output terminals in regulator and dc terminals in alternator. Provide a new split pin for pulley castle nut on completion of work.
- Check up condition of safety chain and availability of split pins in safety chain bolts.
- Check up alternator suspension bracket and tension gear for any damage and replace, if necessary.
- Adjust tension with the help of tensioning rod and alternator tension spring. Check up and tighten loose bolts in terminal box covers.
- Remember that alternator requires very little maintenance, while in service. Check availability of split pin for alternator castle nut.

7.2.7 Rectifier regulator:

Clean regulator externally. Open regulator terminal cover and watch for signs of overheating in any terminals. Check up for loose connection and tighten. If the terminal board is found affected due to heat, replace it.

7.3 SCHEDULE “C” - FORTNIGHTLY SCHEDULE:

Alternator :

In addition to the works mentioned in schedule B, carry out the following.

Check up tightness of terminal connections in alternator, blocking diodes, alternators and rectifier regulators. Use proper tools for checking tightness.

Thoroughly clean externally the alternator and regulator.

Open inspection covers of alternator and regulator cover. Blow dust with a portable blower. Secure back covers tightly.

Lubricate all moving parts in suspension brackets.

7.4 DO'S AND DONT'S OF ALTERNATOR / REGULATOR:

Do not energise field from battery in case of failure of field circuit diodes in regulator. Apart from non regulation, this may result in damage to field windings.

Do not reverse F+ and F- connection.

When measuring continuity of alternator field winding, it is most important to observe proper polarity i.e. positive connected to F+ as otherwise the alternator will not self excite.

Do not use megger for checking diodes and transistor. Use only a multimeter or a transistor tester.

Do not change generator pulleys as the mating surface may get reduced.

Whenever the pulley is removed from the shaft, check key & key way for wear. If the key & key way are good, tape key to the shaft to that the right key is used while re-fixing the pulley.

Use the correct flat washer as per drawing while fixing the castle nut of alternator pulley. Incorrect washer is likely to result in play between pulley and castle nut, loose pulley and consequent damage to shaft.

Use proper tools for tightening connections. Loose connections will lead to heating at terminals and result in failure of alternator/regulator.

Use heat sink compound while replacing diodes and power transistors.

Ensure that DC+ and DC- are connected to battery positive and battery negative respectively. Wrong connections will damage main diodes.

Do not meddle with potentiometer settings in regulators as this will adversely affect regulation. Regulator shall be tested in test arm and the voltage settings shall be made to 122 V and current setting to 37.5 A for 4.5KW alternators.

7.5 FORTNIGHTLY SCHEDULE OF MAINTENANCE FOR PRIMARILY MAINTAINED COACHES:

A) ALTERNATORS:

1. Remove belt and clean alternator externally.
2. Check suspension gear and lubricate.
3. Check safety chains for breakage and availability of split pins in all fixing bolts.
4. Clean the threads of belt tension adjustment gear and lubricate threads, check availability of split pin in the belt tension rod.
5. Open alternator terminal cover and check up terminals for over heating and terminal base for any charring marks. Replace defective terminal boards. Check up for loose connections and tighten up with box spanner of correct size.
6. Check up clamp provided for outgoing cables from alternator below alternator terminal box for proper grip on cables, and to prevent movement on run. Check and ensure proper fixing of flexible pipes and end fittings.

B) ALTERNATOR REGULATOR:

1. Clean regulator externally.
2. Open terminal cover and check up terminals for overheating and terminal base for any charring marks. Replace defective terminal boards.

3. Open regulator front cover and blow out dust with 110V DC electric blower. Check up field fuse and replace by correct size. Watch for any visual defects.

4. Secure regulator front cover and terminal cover properly

5. Couple a portable 110 volts DC machine to the alternator pulley castle nut after removing .the split pin and the belt. Check for output in alternator terminals, regulator A.C. terminals and D.C. terminals to ensure that generation is alright. In case of no output D.C. side of regulator, remove regulator and replace by regulator of the correct type, tested in test bed.

C) AXLE PULLEY :

1. Watch for shifting of axle pulley by observing the white band on either side of pulley. Position pulley properly, if found shifted and tighten nuts with torque wrench.

2. Check tightness of nut and also availability of check nuts and split pins in all fixing bolts.

D) BATTERY:

1. Clean battery box externally. Remove battery box front door or open the top half (where the bottom portion is tack welded) and clean the inside portion of front cover. Check for availability of anti-theft rod. Replace, if deficient.

2. Clean cell top thoroughly.

3. Remove sulphated inter-cell connections. Clean the inter cell connection strip and the lugs and reconnect by using a fresh fastener. Ensure use of flat and spring washers for connections. The old fasteners can be taken to the repair shop of the depot, cleaned thoroughly removing sulphation and kept ready for re-use.

4. Remove end cell connections, clean the connectors and the lugs thoroughly and reconnect. Replace deficient end cell connectors. If strands are found cut in end cell connections cut cable near the connector, use an end cell connector and reconnect.

5. Remove vent plugs and check up ventilating holes for blockage & remove blockages. Replace non-standard vent plug. Ensure that washers are available for vent plugs.

6. Tap floats and check up free movement of floats. Watch for worn-out holes in float guides and replace. Replace defective floats.

7. Check individual voltage and specific gravity of cells with full load 'ON' and record. Replace broken/defective cells.

8. Check for loose connection in battery fuse terminals and correct size of fuse. Check for availability of bushes in cable entry holes of battery box and replace, if necessary

9. Watch for low level of electrolyte in cells and top up with pure distilled water only.

10. Apply petroleum jelly on all inter cell and end cell connections.

11. Check tight packing of cells and use additional packing if found necessary.

12. Charge cells, if necessary at normal rate or boost rate of charge. Record specific gravity of pilot cells on completion of charge.

13. Enter date of FNE and station in the front cover inner side of battery box.

E) JUNCTION BOX:

1. Open front door. Check all connections in MCB-cum-fuse panel for tightness. Check - availability of terminal lugs for all cables injunction box and provide if necessary by terminal lugs of correct size.

2. Check MCBs for lights, fans and EFTs for correct capacity and proper operation. Replace defective MCBs. If MCBs are not readily avail able, provide rewirable fuses of appropriate ratings purely as a stopgap measure. Check up negative fuse and replace if necessary by HRC fuse. If rotary switches are provided instead of MCBs, check for proper operation. Check up HRC fuses provided with rotary switches for correct rating and replace, if necessary.

3. Close front door and secure properly by the lock.

F) LIGHT FITTINGS:

1. Open fitting with dome key and clean glass dome with a dry clean cloth both inside and outside. Replace dome if found broken.

2. Check up lamp holders for loose connections. Check up lamps for correct wattage. Replace defective holders and fused lamps. Secure fitting with dome key after completing the work.

3. In case of side lamps in Guard's compartment, check rotating handle for free movement and lubricating, if necessary. Clean lens on both sides of tail lamp and red shield with clean cloth.

4. Clean fixed tail lamp lens.

5. Ensure provision of 15 watts lamps and blue glass domes for all night fittings.

G) FANS :

1. Clean guard and body of fan externally. Open guard mesh and clean fan blades. Check fan blade fixing screw for tightness.

2. Remove body fixing screws in fixed fans/dust cover in swiveling fans and check up carbon brushes for correct grade, length and bedding. Check carbon brush springs for tension by the feel of hand. Replace defective brushes and springs. Bed the new brushes before providing in fans.

3. Check commutator for grooving/pitting marks and replace fans if necessary. Clean dirty commutator with flint paper of zero grade.

4. Check up fixing bolts of fans for tightness.

5. Check up connections for tightness in the connectors provided in fan base. Check up insulation of flexible leads from the connectors to the fans and replace if necessary

6. In the case of swiveling type fans check up gimbals rings for tightness and easy movement of fans for positioning in the required direction.

7. In first class coaches and inspection carriages check regulator and resistance for proper control of speed in the different positions. Replace defective regulators and fan resistances.

8. Replace missing dust covers of swiveling type fans.

9. Check fans for noisy working of bearings, slow working and sluggish starting and replace defective fans

10. Secure close mesh guard properly after the work is completed.

11. Ensure that fans start immediately on switching ON. A fan which requires a push start is considered as defective, and should be rectified during FNE.

H) SWITCHES:

Check each switch of lights and fans for proper fixing and operation. Replace defective switches. Switches should be provided in the locations intended for them and provided for operation by passengers.

I) DISTRIBUTION FUSE BOARDS AND FUSE CUT-OUTS:

1. Check distribution fuse boards and fuse cut outs for lights and fans for tightness of connections and provision of correct size of fuses in the fuse terminals. Replace missing distribution fuse board covers promptly.

J) CALL BELLS IN SALOONS:

Check call bells and indicators for proper operation. Check connections in call bells pushes and call bells & tighten up if necessary.

K) REFRIGERATORS:

1. Check up DC contactors for proper operation and clean dirty contacts (in case of DC refrigerator).
2. Clean refrigerator both internally and externally.
3. Check control fuses and replace overheated fuses.
4. Check compressor belts in case of open type compressor and adjust tension.
5. Check up functioning of thermostat and proper cooling.

L) EMERGENCY FEED TERMINALS (EFTs):

1. Check up supply and marking of polarity in EFTs.
2. Replace missing EFTs and those without wiring nuts.

M) GENERAL

1. Check up earth in coach with test lamp. Trace out fault in case of defect and rectify.
2. Record results of fortnightly examination.
3. Check proper alignment of belt by watching the same on alternator pulley and axle pulley and correct alignment.
4. After putting on the belt over the alternator, use belt tension gear for tightening of belt and ensure that the alternator is proper.

7.6 CHECK LIST FOR INSPECTION OF PASSENGER COACHES:

Train No. Date:

1.0	Functional aspects.
1.2	Correct wattage of lamps Postal & AC coaches – II class coaches and corridors and bathrooms of AC coaches - Night lamp
1.3	Cleanliness of glass domes and proper locking of dome covers.
1.4	Provision of blue glass domes for night light fittings
1.5	Availability & proper functioning of berth lights in I&II class Air Conditioned coaches
1.6	Condition of Lights whether bright or dim
1.7	Full availability of fans.
1.8	Working of fans when switched on without need for push start.
1.9	Noiseless working of fans.
1.10	Cleanliness of fans.
1.11	Free and firm movement of gimbals-ring in swiveling fans.

1.12 (Use of EG3/L16 grade brushes in fans and a use of correct springs (By random check)

1.13 Cleanliness of fan commutator. (By random check)

1.14 Proper working of switches for lights and fans.

1.15 Existence of switch board/fuse panel covers.

1.16 Availability & working of emergency feed terminals,

1.17 Visual examination of the terminals of alternators/ regulators, and end cell connectors.

7.7 "16 POINT ACTION PLAN" (Issued by Railway Board for maintenance of TL & AC coaches)

1. CESEs of the Railways to interact with their counterparts in other Railways to advise the unusual occurrences and obtain feed back.

2. All the AC coaches to be pre-cooled before placement of rakes on platform. This is the time when passengers require maximum and immediate comfort level. Pre-cooling cum emergency leads should be provided in all SG AC coaches (1 in each coach) and power cars (2 in each power car).

3. No train to leave the Primary Depot with EFTs or equipments in isolated condition.

4. Defects in the coaches to be noticed immediately after arrival of train and remedial action taken accordingly. Escorting staff should report at secondary maintenance depot and advise the status of coach and should sign the register with Depot and Depot staff to sign the Log Book with Escorting Staff.

5. All AC coaches from Primary depot should go with both Alternators working. If an Alternator cannot be replaced/repaired at the secondary maintenance depot, decision to send coach with one Alternator to be taken at officer's level. Second Alternator to be fully functional with full generation and the coach/rake to be properly pre-cooled.

6. AC coaches should go from Primary Depot with 6+6 belts on the Alternators and minimum 5+5 from Secondary Depot. Adequate facilities to be built up for changing the belt on rake itself.

7. The knowledge of all the ACCIs & ACCAs should be checked regularly regarding operation of the AC coach equipment as well as handling of the situation in case of failure of the equipment. ACCIs/ACCAs MUST maintain the log book and enter all the unusual occurrences. Training of AC staff of one week duration to be standardised by the Railways.

8. Drive system for generation testing and Regulator setting to be introduced for alternators at all Primary Depots.

9. Unit Exchange Spares (UES) should be available in all depots. Each depot should have authorised holding of UES. Register should be available for each major UES at all the depots.

10. All the major depots should carry out failure analysis of major equipments and the information should be sent to RDSO periodically.

11. The power supply system for pre-cooling to be augmented in view the increasing number of AC coaches in the depots. Railways to examine and take corrective action.

12. Railways to revise their EACs (Estimated Annual Consumption) of the material because of increasing AC Coach holding.

13. Cleating of alternator field and phase wires to be properly checked at primary depot.

14. Full load and no load voltage of each cell of SMF batteries to be recorded (weeded out weak cell) every month for subsequent 3 months and if there is no abnormal variation in voltage, it should thereafter be recorded once in 3 months.

15. Working of thermostat should be monitored and recorded in log book. If thermostat is not found in working condition, the same should be attended/replaced by primary depot.

16. Working of WRA should be checked on arrival of train at primary/secondary depot and its working should be ensured before placement of rake at the platform.

8. END - ON - GENERATION

8.0 With the increase in demand for faster trains having limited halts and improved passengers amenities - air conditioning, fluorescent lighting, catering from pantry cars, Rajdhani/ Shatabdi Express services have been introduced on many routes.

Rajdhani Express trains, were initially introduced on NDLS - Howrah, New Delhi-Bombay Central routes. These trains operate at 130-140 kmph. To reduce the resultant noise and dust problems, all the coaches including the service coaches like pantry-car of the trains occupied by operating personnel like Guard and the crew in the power car ore sealed and hence air-conditioned. Since the power required for operating air-conditioning load., cooking ranges/ refrigerators/ bottle coolers in pantry cars is considerable, use of power cars equipped with Diesel generating sets is the only way, at present.

8.1 CONNECTED LOAD OF TYPICAL RAJDHANI SERVICE (MUMBAI CENTRAL - NEW DELHI) IS AS UNDER :

Sr. No.	Type of Coach	No. of Coaches	Load in KW	Total load in KW
01.	A.C. 3 T	8	40.00	320.00
02.	A.C. 2 T	6	34.75	208.50
03.	A.C. First	1	15.75	15.75
04.	A.C. Pantry	2	76.75	153.50
05.	A.C. Power Car (working)	2	49.00	98,00
		Total 19		795.75
				Say 800,00

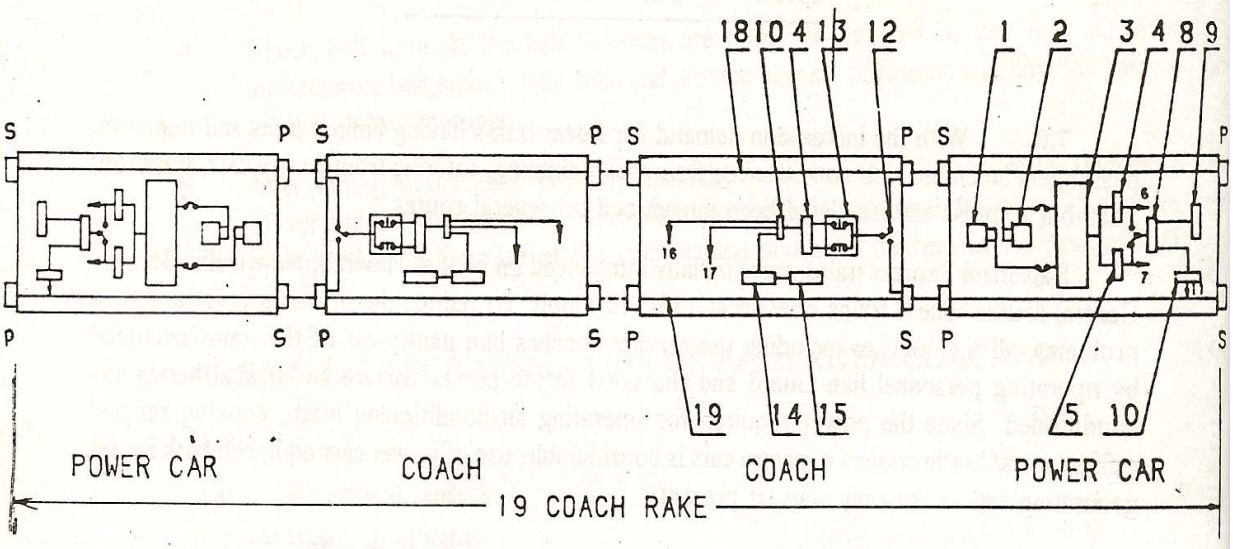
Assuming a diversity factor of 0.7,

Max demand KW = 800 X 0.7,

= 560 KW

8.2 Old rakes of Rajdhani express working in EOG system were provided with three power cars having generation & supply voltage at 415 V, 3 Phase.

SCHEMATIC DIAGRAM OF 750 VOLTS EOG SYSTEM



P - I.V.COUPLER PLUG 750 VOLTS
S - I.V.COUPLER SOCKET 750 VOLTS
1 - D.G.SET-A, 750 VOLTS, 250 KW
2 - D.G.SET-B, 750 VOLTS, 250 KW
3 - POWER CONTROL PANEL
4 - 750/415 VOLTS, 50 KVA STEP DOWN TRANSFORMER-I
5 - 750/415 VOLTS, 50 KVA STEP DOWN TRANSFORMER-II
6 - RADIATOR FAN-1, EXAUST FAN 1 & 2
7 - RADIATOR FAN-2, EXAUST FAN 3 & 4
8 - MAIN FUSE DISTRIBUTION BOARD
9 - A/C CONTROL PANEL
10 - DISTRIBUTION TRANSFORMER 415/190 VOLTS
11 - LIGHT AND FAN PANEL
12 - FEEDER CHANGEOVER CONTACTOR

13 - SYSTEM VOLTAGE SELECTOR CONTACTOR BOX
14 - EMERGENCY BATTERY CHARGER
15 - EMERGENCY BATTERY BOX
16 - AC LOAD
17 - LIGHT AND FAN
18 - THROUGH FEEDER A, 750 VOLTS, 3 PHASE
19 - THROUGH FEEDER B, 750 VOLTS, 3 PHASE

FIG. 7-1

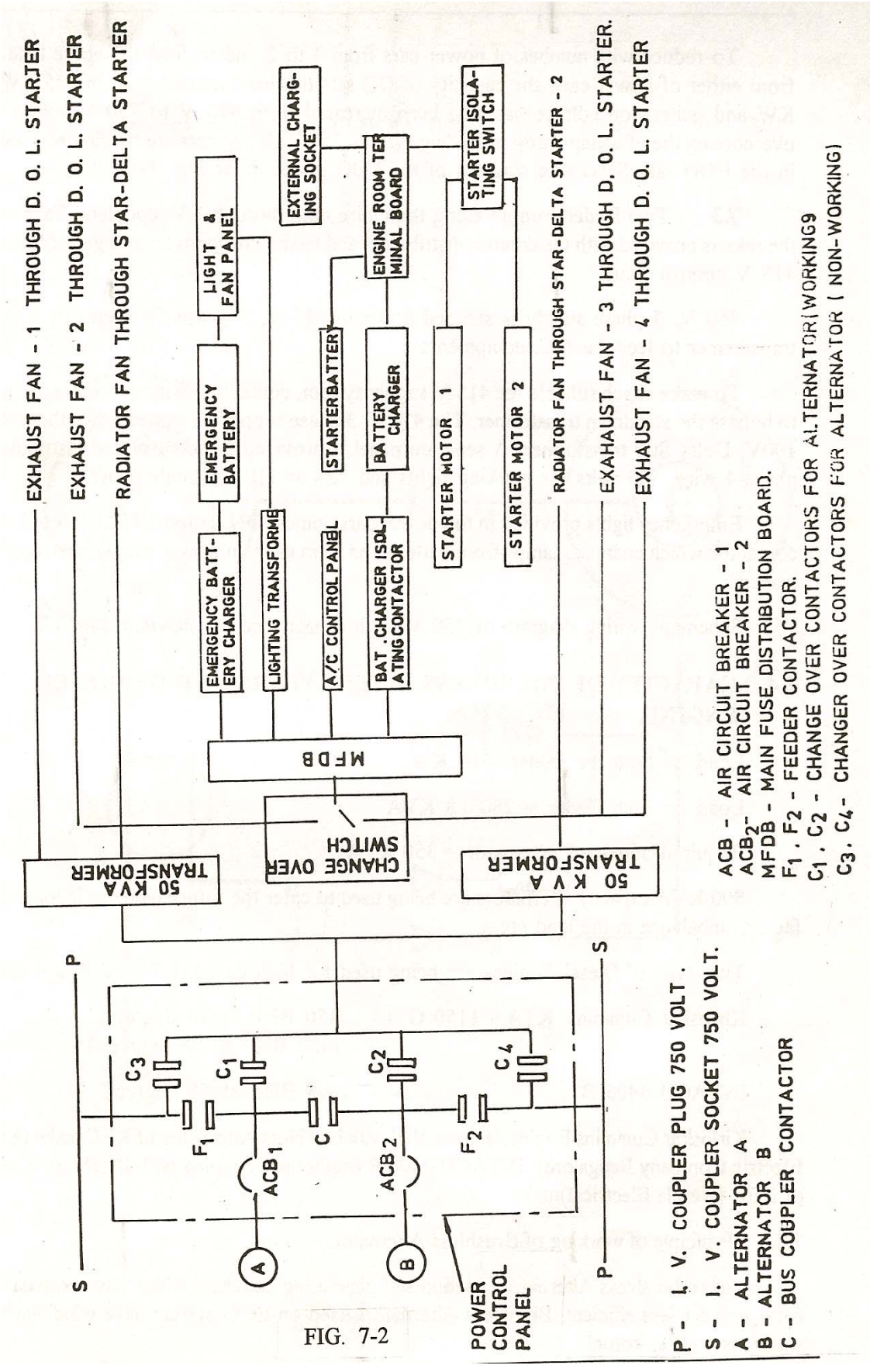

EXHAUST FAN - 1 THROUGH D. O. L. STARTER
EXHAUST FAN - 2 THROUGH D. O. L. STARTER
RADIATOR FAN THROUGH STAR-DELTA STARTER
EMERGENCY BATT-ERY CHARGER
EMERGENCY BATTERY
LIGHT & FAN PANEL
EXTERNAL CHARG-ING SOCKET
LIGHTING TRANSFORME
A/C CONTROL PANEL
STARTERBATTERY
ENGINE ROOM TER MINAL BOARD
BAT. CHARGER ISOL-ATING CONTACTOR
BATTERY CHARGER
STARTER ISOLA-TING SWITCH
STARTER MOTOR 1
STARTER MOTOR 2
MFDB
50 K V A TRANSFORMER
CHANGE OVER SWITCH
50 K V A TRANSFORMER
RADIATOR FAN THROUGH STAR-DELTA STARTER - 2
EXAHAUST FAN - 3 THROUGH D. O. L. STARTER.
EXHAUST FAN - 4 THROUGH D. O. L. STARTER
P
S
C3
C1
C2
C4
F1
F2
C
ACB 1
ACB 2
A
B
POWER CONTROL PANEL
P - I. V. COUPLER PLUG 750 VOLT .
S - I. V. COUPLER SOCKET 750 VOLT.
A - ALTERNATOR A
B - ALTERNATOR B
C - BUS COUPLER CONTACTOR
ACB - AIR CIRCUIT BREAKER - 1
ACB2- AIR CIRCUIT BREAKER - 2
MFDB - MAIN FUSE DISTRIBUTION BOARD.
F1 , F2 - FEEDER CONTACTOR.
C1 , C2 - CHANGE OVER CONTACTORS FOR ALTERNATOR(WORKING)
C3 , C4 - CHANGER OVER CONTACTORS FOR ALTERNATOR (NON-WORKING)

FIG. 7-2

To reduce with number of power cars from 3 to 2 and to feed the entire load of train from either of power cars, the capacity of DG sets has been increased from 125 KW to 250 KW and generation voltage has also been increased from 415 V to 750 V with a view to overcoming the of voltage drop in feeding system. 750 V power cars are the first and last vehicle in the EOG rake. Schematic diagram of the EOG system is at Fig. 8-1.

8.3 Two feeders run all along the entire rake through I.V. couplers. Each coach on the rake is provided with the control, distribution and feeder changeover arrangements in the 750/ 415 V control panel.

750 V, 3 phase supply is stepped down to 415 V, 3 phase 50 cycles by a step down transformer to feed the A.C. equipments.

To make coach suitable for 415V supply system, contactors with interlocks are provided to bypass the stepdown transformer. The 415 V, 3 phase supply is stepped down through 415V/ 190V, Delta Star transformer. A separate panel is provided for control and distribution of 3 phase 4 wire, 190 volts for working lights and fans at 110 V, single phase.

Emergency lights provided in the power cars comes 'ON' automatically through No-Volt contactor which energises lamps from batteries as soon as main power supply interrupts for any reason.

Schematic wiring diagram of 750V High capacity power car is in Fig. 8-2.

8.4 CAPACITY OF BRUSHLESS ALTERNATORS AND OF DIESEL ENGINE.

Load on both the feeders 560 KW

Load on each feeder - 280/0.8 KVA

Required output of Alternator ~ 350 KVA

500 KVA capacity alternators are being used to cater the future increase in load, de-rating factor, unbalance in the load etc.

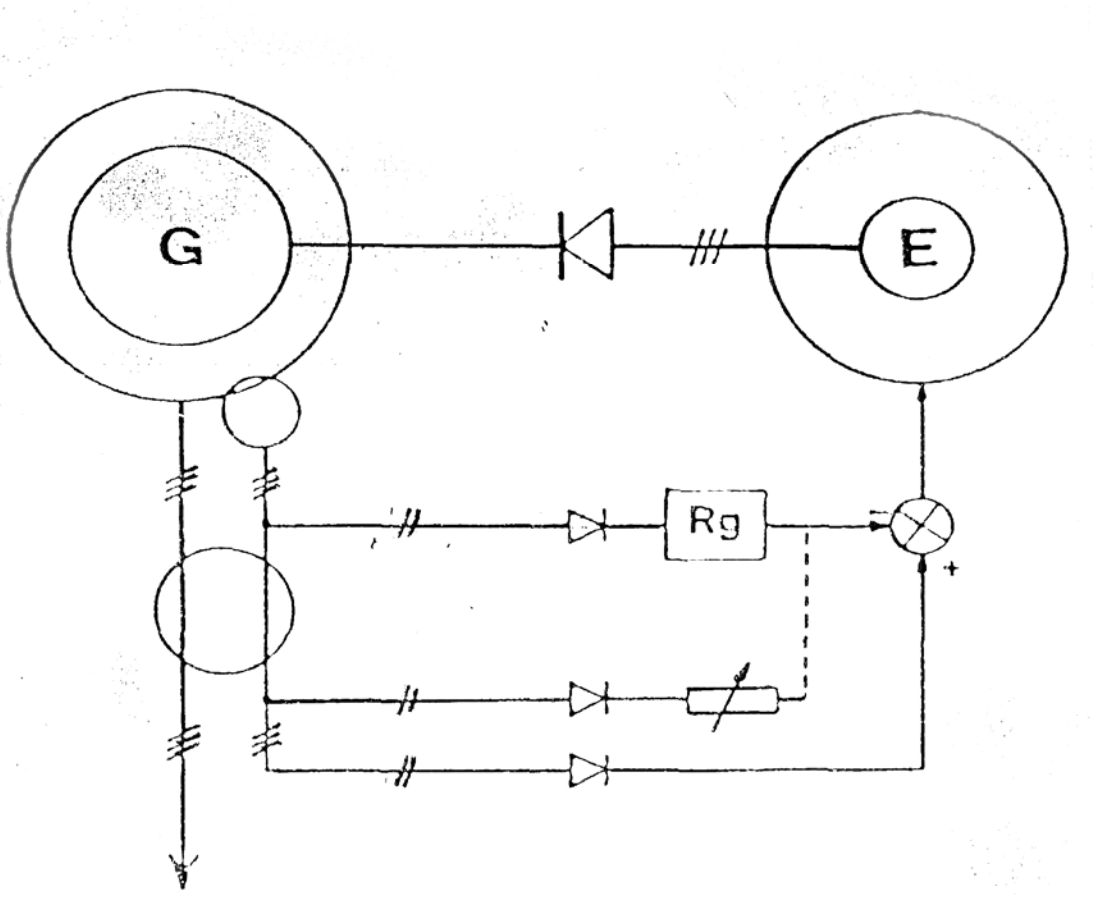
Two type of Diesel Engines are being used for high capacity 750 V Power cars.

Kirloskar Cummins. KTA - 1150 G	–	450 BHP at 38 degree C
	–	(427 BHP at 55 degree C)
INTACH 3406 B	–	398 BHP at 55 degree C

Kirloskar Cummins Engines are coupled with brushless Alternator of KEC make (Kirloskar Electric Company Bangalore). INTACH 3406 B engines are coupled with Brushless Alternators of KEL (Kerala Electrical) make.

8.4.1 Principle of working of Brushless Alternator.

Unlike brushless Alternators used in self generating coaches, which have no windings on rotor and are less efficient, Brushless Alternators used on BOG system have windings both on stator as well as rotor.



Brushgear is eliminated with provision of rotating diodes in the excitation system. A sketch showing the principle of working is at Fig, 8-3

Three phase output is collected from stator of main Alternator (G) & field is wired on rotor.

Three phase output from stator is also rectified and through a regulator (Rg) fed to the stator of Exciter (E) which is mounted on main shaft. Three phase Output from rotor to Exciter (E), is rectified through rotating diodes and fed to the rotor of main Alternator (G). The need for brushes, is therefore eliminated.

A cut section of the KEC alternator is at Fig. 8-4.

8.5 PROTECTIVE DEVICES

8.5.1 Diesel Engine Protection

Following protective devices are provided for Diesel Engine :

i) High water temperature

ii) Low water level in radiator

iii) Low lubricating oil

iv) Over speed

The high water temperature protective device cuts off the load automatically and the engine returns to idling speed and the other devices cut-off the load as well as shut-down the engine. All the protective devices are designed to give audio-visual indication when they operate.

7.5.2 ALTERNATOR PROTECTION

Alternators are provided with following protective devices :

a) Alternator overload.

b) Under voltage.

c) Earth leakage.

d) Short circuit

7.5.3 FEEDER PROTECTION

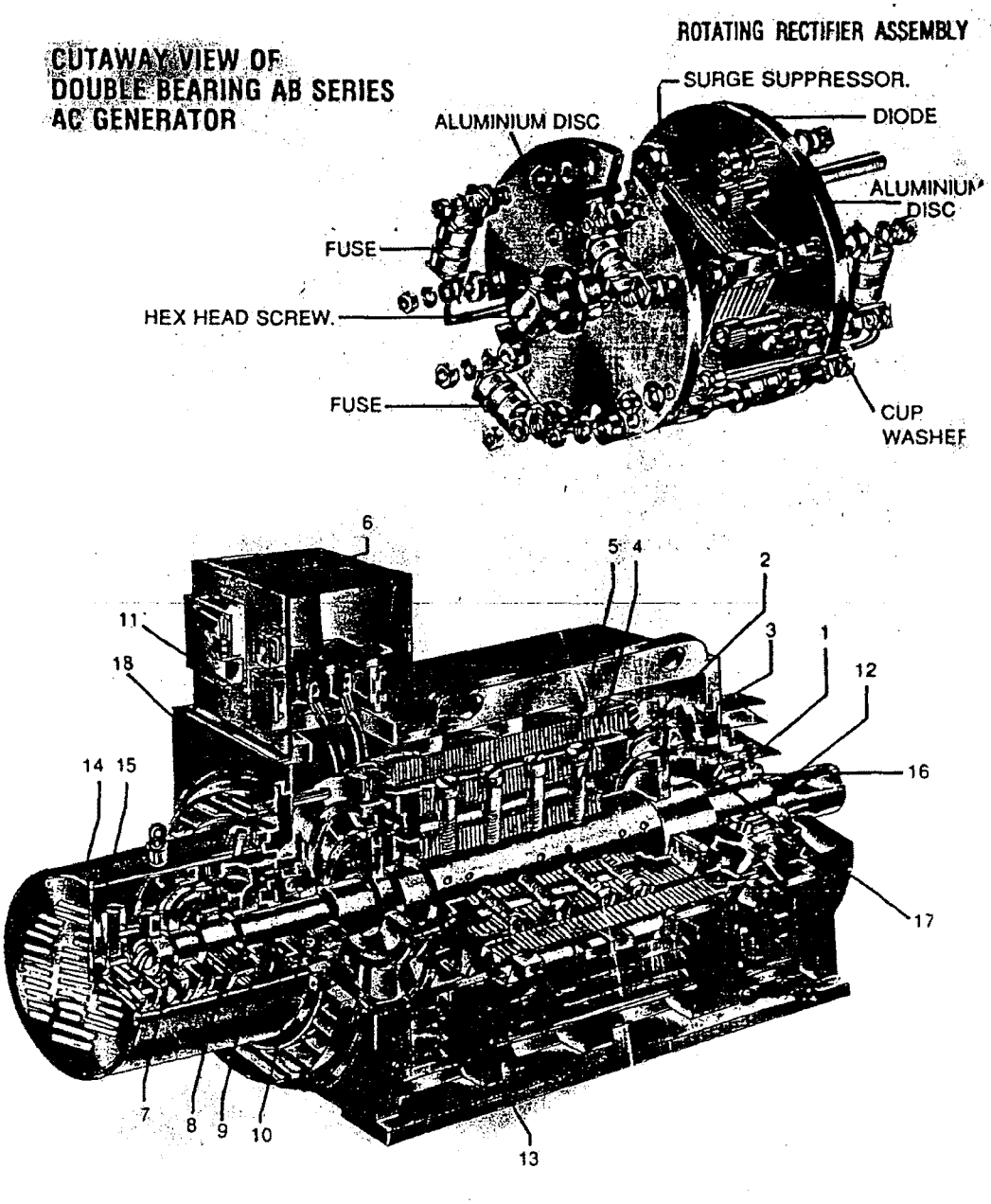
Following devices are provided for feeder protection

i) Feeder Earth leakage.

ii) Feeder overload.

7.6 FIRE-EXTINGUISHERS

Each power car is provided with 2 nos. of 5 Kg. capacity dry powder type fire extinguishers conforming to Spec. IS-2171. The chemical powder used is to specification IS:4308 specification for dry powder for the fighting. One of the fire extinguishers is located in the alternator room and the other in the engine room.



1. BEARING (D.E.)
2. FAN
3. END SHIELD (D.E)
4. ROTOR
5. STATOR
6. TERMINAL BOX
7. ADAPTOR
8. EXCITER ROTOR
9. EXCITER STATOR
10. BEARING (N.D.E)
11. GENERATOR CONTROL UNIT
12. SHAFT
13. BODY
14. END COVER
15. RECTIFIER ASSEMBLY
16. EXTERNAL BEARING CAP (D.E.)
17. INSIDE BEARING CAP (D.E.)
18. END SHIELD (N.D.E.)

FIG 8-3

9. MID - ON - GENERATION

9.0 INTRODUCTION

Effectiveness of generation system in coaches of a rake is assessed with reference to an index known as Generation/non-generation ratio, which is a ratio of period of generation to the period of non generation of train .Slow branch line trains having long halts, could have G/ NG ratio less than 2 and super fast trains could have G/NG ratio as high as 6.

Slow trains with G/NG ratio less than 2 are likely to have problems in meeting the load, as the batteries will remain undercharged and could become prematurely ineffective.

Mid-On-Generation system, which is based on meeting load through DG sets in a power car is recommended for such services to meet TL load satisfactorily.

General layout of power car is shown at figure (1-2) It will be seen that only a part of coach is used for DG sets.

9.1 BRIEF DESCRIPTION OF "MOG" POWER CAR:

a) MOG Power car is equipped with 2 DG sets each capable of taking full load. This power car is marshalled at the middle of rake so that it has to feed 6 coaches on either side.

b) Generation is at 415 V, 50 Hz having step down Transformer (Delta/star) 415 V/ 110 Volts for distribution.

c} Load distribution among 3 phases so that phase to earth voltage remains minimum.

d) Power car is capable of feeding both sides of the rake.

e) D.G. Set is mounted on common frame made out of I- section of steel.

f) Anti vibration mountings are provided to the set so that vibrations can be minimized.

g) Tier coupling in between alternator and diesel engine to transfer mechanical power and absorb the jerks due to misalignment.

h} Exhaust pipe lagged with asbestos rope so that the engine room do not get heated up.,

i} Engine room is ventilated so that sufficient air for radiator and engine suction is available. If possible, filters are required to be provided to reduce dust.

j) Capacity of diesel tank is sufficient to work the power car continuously for 30 hrs.

k} Provision of baffles so that at the time of braking diesel may not get accumulated on one side i.e. towards direction of train and engine getting air locked.

1} Provision of battery charger for starting of diesel engine. Battery box is mounted under frame while charger is inside the power car with fine and coarse charging.

m} Sufficient light in power car to have quick location of defects in case of failure.

n) 24 V plugs in engine/alternator room and also near electric panel for hand lamp.

o} Sitting and resting seats for crew of power car.

p) Inter vehicle coupler junction boxes transformer contactor switch etc., of requisite capacity as per code of practice.

q} Panel indicating meters of direct acting, indicating type conforming to IS 1248-1968 with selector switches, wherever essential.

r) Transformer is solidly earthed.

s) Safety devices for engine and alternator are incorporated.

9.2 WIRING DIAGRAM OF MOG POWER CAR :- IS AT FIG. (9-1)

A change over switch has been provided so that either of two sets could be connected, keep other as standby. The sizes of cables are given at table -1, below :-

TABLE - I

SIZES OF CABLES USED IN "MOG" SYSTEM

S.No.	AREA Sq.mm	No. OF Strands /Normal Dia	Permisible Current (A)
1.	4	7/0.85	10 (BW)
2.	10	80/0.4	15 (JB)
3.	16	7/1.70	30 (DF)
4.	35	7/2.52	50
5.	50	19/1.78	70
6.	70	19/2.14	80
7.	120	37/2.03	100
8.	70	990/0.3	80 (IVC)

9.3 LOAD CALCULATION FOR MOG RAKE :

DETAILS OF ELECTRICAL LOAD OF VARIOUS COACHES
BROAD GAUGE COACHES

Type of Coaches	Layout Deference	Light Load in Watts	Fan Load in Watts	Total Load in Watts
GS	CSC-1593	28 x 25 = 700	18 x 60 = 1080	1780
SCNY	CSC-1585	28 x 25 = 700	29 x 60 = 1740	2440
AC Chair Car	CSC-1607	CL 26 x 40 = 1040 + {14 x 25 = 350} + RL (50%) 13 x 25} = 1715	29 x 60 = 1740	3275
SLR Power Car	CSC-1627	25 x 25 = 625 9 x 60 = 540 + 14 x 40 = 560} = 910	9 x 60 = 540 9 x 60 = 540 Battery = 540 Charging = 1080	1165
GS	CSC-1600	28 x 25 = 700	16 x 60 = 960	1660
SCNY	CSC-1626	26 x 25 = 650	16 x 60 = 96	
PC	CSC-1480	CL 20 x 40 = 800} + 13 x 25 = 325} + RL 10x25=250} = 1375 (50%)	20 x 60 = 1200	2575
SLR	CSC1533	21 x 25 = 525 14 x 40 = 560} + 14 x 25 = 350} = 910	9 x 60 = 540 8 x 60 = 480} + Battery Charging = 500) = 980	1085

ELECTRIC LOAD OF MOG TYPE RAKE COMPOSITION

Rake 12 + 1	Composition Power Car	Broad Gauge (KW)	Meter Gauge (KW)
1	PC	1 x 1.99 = 1.99	1 x 1.89 = 1.89
2	SLR	2 x 1.165 = 2.33	2 x 1.035 = 2.15
1	AC Chair Car	1 x 3.275 = 3.27	I x 2.57 = 2.57
2	SCNY	2 x 2.44 = 4.88	2 x 1.61 = 5.22
7	GS	7 x 1.78 = 12.46	7 x 1.66 = 11.62
		TOTAL = 24.93	= 21.43

Wiring Diagram of MOG Power Car

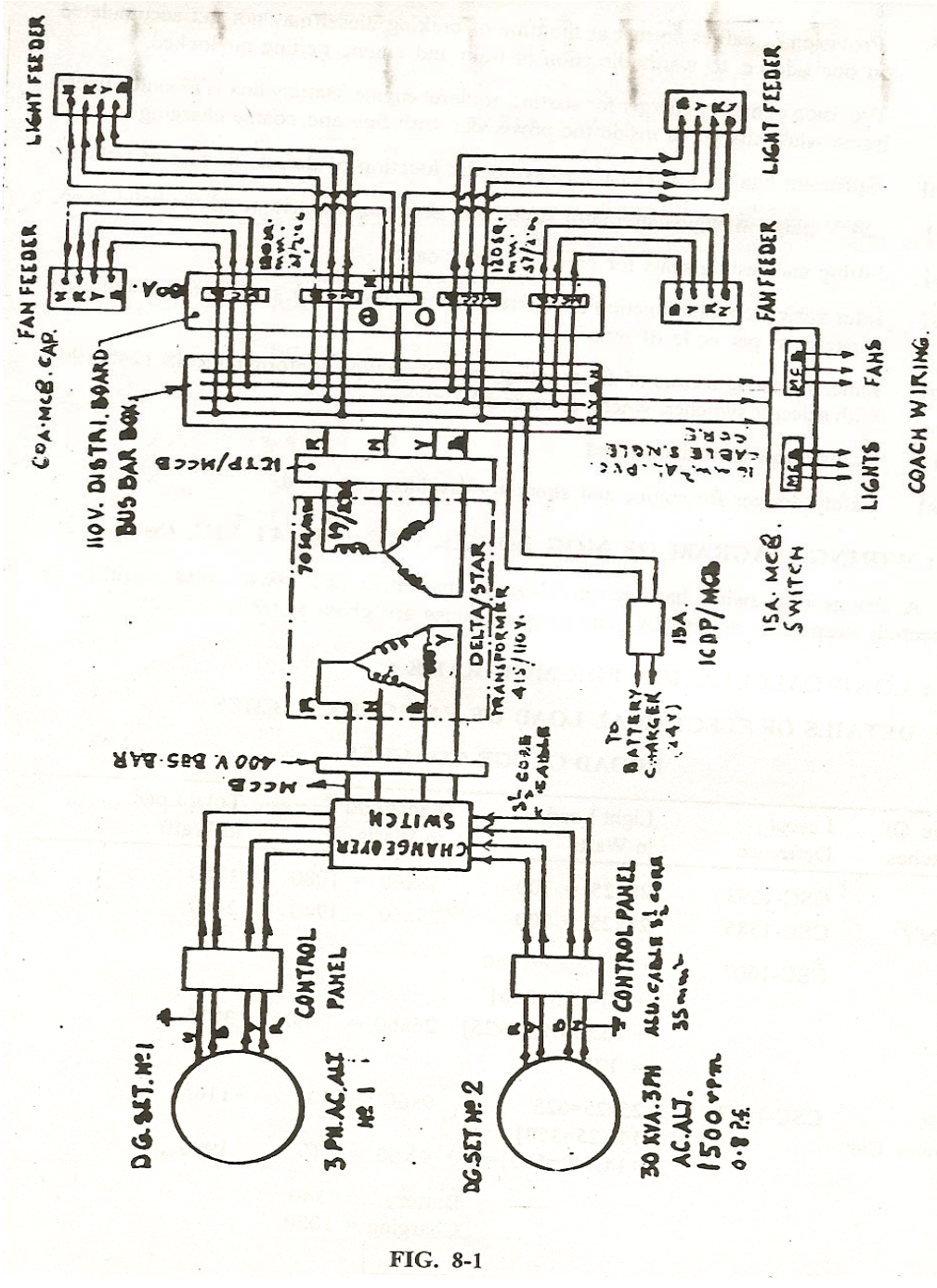


FIG. 8-1

9.4 DISTRIBUTION OF LOAD AND CALCULATION FOR VOLTAGE DROP:

A) Assuming BG rake composition as given at para 8.3, and also balanced load in 3 phases the distribution of load being transmitted on main feeder/coupler on end of power car is as given below.

FORMATION	KW	AMPS		
SLR	1.6	7.6	7.6	7.6(SLR)
SCNY	2.44	160	45.0	16,0 (SCNY)
GS	1.78	11.6	56.6	11.6 (GS)
GS	1.78	11.6	68.2	11.6 (GS)
GS	1.78	11.6	79.8	11.6 (GS)
Power Car	1.99	13.0	92.8	13.0 (PC)
GS	1.78	11.6	70.0	11.6
GS	1.78	11.6	58.4	11.6
GS	1.78	11.6	46.8	11.6
GS	1.78	11.6	35.2	11.6
SCNY	2.44	16.0	23.6	16.0
SLR	1.16	7.6	7.6	7.6

B) CALCULATION FOR VOLTAGE DROP :-

i) Feeder Cable Resistance of Aluminum cable size 37/2.06 at 20°C = 0.2423×10^3 ohm/meter

ii) Feeder cable resistance of Aluminum cable size 37/2.06 at 50° = 0.27×10^3 ohm/meter

iii) Coupler cable resistance of Aluminum cable size 990/0.3 at 20°C = 0.415×10^3 ohm/meter

iv) Aluminum coupler cable resistance of Aluminum cable size 990/0.3 at 50° C = $0.498 \times 10\ 3^3$ ohm/meter

v) FEEDER CABLE RESISTANCE / PHASE / COACH = $25 \times 0.27 \times 10^3$ ohms

for 25 meter length = 6.75×10^3 ohms

vi) Coupler cable resistance /phase / coach = $1.5 \times 0.498 \times 10^3$

for 1.5 meter length = 0.75×10^3 ohms

vii) Assume 2x10 constant resistance/ phase/coach

vii) Total resistance/phase/coach = 9.5 x 10 (v + vi + vii) ohms

viii) Voltage drop = voltage drop/phase

= voltage drop in 1/2 length of power car + voltage drop in other coaches.

= 92.8x1/2 x 9.5 x 10 + 9.5 x 10 x (79.8 + 68.2 + 56.6 + 45 + 29 + 7.6)

= 0.44 + 9.5x10 x 286.2 - 3.16 Volts.

Voltage drop phase to phase T x 3.16 = 5.47
i.e. say 5% of system voltage of 110 V.

9.5 CAPACITY CALCULATION OF DG SET FOR MOG :-

Load on alternator = 25 KW

Considering efficiency of alternator = 25/0.84 = 29.76 KW

The diesel engine has to be uprated as per site conditions.

Altitude = 600 Mtrs.

Atmosphere temperature = 40 °C

Relative humidity = 100 %

Required power to alternator = 29.76 / 0.86 KW

= 35.6 KW

= 35.6 / 0.747 = 47.72 HP

= 48 (say) HP

As such required capacity of alternator is

Load/PF = 25 / 0.85 = 29.4 = 30 KVA (Say)

There is one power car attached at the middle of rake, which supplies both sides 3 phase 110 V AC supply from 2 DG sets capacity,30 KVA each. One set shall be capable of feeding the whole rake, while other set is stand by.

9.6 ADVANTAGES AND DRAWBACKS OF MID-ON GENERATION :-

Advantages :-
- i) System is reliable as compared to self generation system.
- ii) Maintenance of batteries and other under frame equipments. is eliminated.
- iii) Fluorescent lighting can be used for better amenities, simplicity in maintenance of AC fans.

Draw backs :-
- i) Staff to operate DG. set is required.
- ii) Dependence on HSD oil ;
- iii) Noise and smoke pollution.

10. FIRE HAZARDS

10.1: Excessive current in the cables is the only probable cause of electrical fires on coaches. The excessive current in the cables can result either due to inadequate size of cables used in the circuit or any short circuit in electrical circuit.

10.1.1 Sizes of the cables on different circuits on the coaches have already been standardized and included in specification EL/TL/48 and if proper care is taken during wiring of coaches, this cause can be eliminated and hence need not be discussed further.

10.1.2 This leaves short circuit on coach wiring as the only cause of excessive current and therefore, complete care is to be taken to ensure that -

i) Cause of electrical short circuits on the coaches are avoided;

ii) In case electrical short circuits take place, the protective device in the circuit should isolate the fault instantaneously without causing damage to the cables;

iii) In case the electrical fire does break out, it should be ensured that the fire does not spread, for which equipment and material used in wiring should be of good quality particularly where fire retardant properties of the item have been specified. This includes items like cables and PVC conduits, boards, paints on wooden members in the vicinity of the wiring etc.

10.2 CABLE SIZES:

10.2.1 Aluminium conductor PVC insulated un-sheathed cables to IS:694 are specified for use in coach wiring. Sizes of cables for various circuits on coach wiring shall be as per annexure-I (as specified in RDSO's drawing no.SKEL-3928 alt.l)

10.2.2 Flammability test has now been included as an acceptable test under clause 15.2 of IS:694-1990 (Third Revision).

10.3 EARTH CHECKING:

10.3.1 The train lighting wiring is on two-wire unearthed system and therefore at least two earths one on positive polarity and the other on negative polarity are necessary to cause short circuit through the coach body, (counting the possibility of direct short between the cables of opposite polarities because of segregation of positive and negative wiring on superstructure). Thus earthing of wiring on the coach is first stage cause short circuit and should therefore be checked promptly. The earth will be checked both on positive and negative wire separately and the procedure for earth testing and the trouble shooting along with sample equipment (Earth indicating lamp) recommended for earth checking is given in the Annexure-III (sheet 1 to IV).

10.3.2 Light point, fan point and the switches are particularly prone to earthing in metal bodied coaches and therefore to minimize its possibility, proper attention is required to be paid at the time of fitment of the lamp holder, brush holder of the fan and toggle switches and while carrying out their maintenance in service.

10.3.3 The insulating bush in the mounting lug of the fan SHALL NOT BE PROVIDED. The dia of the mounting hole provided in the mounting lug shall be of 9 mm. It shall be ensured that fan base of all the fans have a live contact with the coach body.

10.3.4 All electrical fittings both on super structure and on under frame shall be mounted directly on the coach body and not electrically insulated.

10.4 AIR CLEARANCES:

10.4.1 Air clearance of 10 mm has been specified between any live part and the coach body and 4 mm between parts of opposite polarities. (EL/TL/48 clause 3.9.4) This is primarily to ensure adequate separation to facilitate ease of fitment and maintenance in service. In case of clearance being inadequate, there can be a possibility of short circuit caused by the working tools or other inadvertent causes on the coach. It is therefore important that adequate clearance as specified is maintained in all fittings etc., between live parts and earth or between parts of opposite polarity.

10.5 DAMAGED INSULATION :

10.5.1 Cable insulation on coaches get damaged in various ways resulting in earth on wiring which in turn may cause short circuit. Therefore, insulation damage should be prevented and attended promptly.

10.5.2 It is noted that for testing the maintenance staff many times adopt dangerous practice of chipping the cable insulation. This leaves a permanent scar on the cable insulation and even its subsequent taping with tape will not be quite satisfactory. Staff should be educated and asked not to chip cable insulation in middle and to test feed etc. in course of maintenance at terminals only.

10.5.3 The cables passing through the holes in the metallic members on the coach are liable to get their insulation punctured because of pressing and chafing against the sharp edges. This may result in earthing on the coach. This should be protected against by providing proper PVC grommets to BS:1767 or grade 6 of IS:5831 with non inflammable properties.

10.5.4 At cable terminals, cable lugs should always be taped to insulate the bare portion of the conductor, if any, and also portions where the clearances are critical.

10.5.5 Crimped connections are to be made properly as specified Annexure II. The poor joint will cause heating, damaging the insulation of the cables at the end. A poor joint can always be detected easily by feeling the temperature of the socket with full load current passing through it. A hot terminal indicates either and improper connection or a bad crimped joint.

10.5.6 While cause of damage to cable insulations as detailed in paras above should be checked, a record of insulation of the coach wiring should also be maintained to monitor the health of insulation of wiring.

10.5.7 Coach insulation test: Insulation resistance of coach should be measured with 500 v megger. Procedure to be adopted for insulation measurement shall be as under:-

(i) Superstructure wiring and under frame wiring will be tested separately for which the main negative fuse in the junction box will be opened and controlling switch L1, L2, F+, SPM1,SPM2 will be kept off.

Insulation resistance will be measured with all fittings and equipment connected both on under frame & superstructure. The under frame wiring will be tested with battery fuse open.

(ii) Insulation resistance under fair weather conditions will be minimum 2 Meg Ohm. However, under adverse (highly humid/wet) weather conditions, the minimum insulation up to 1 Meg Ohm, will be acceptable.

(iii) In case insulation resistance is found less than mentioned in. para above, individual sub Circuits at junction box, i.e. L1, L2,F+SPM1 and SPM2 for super structure wiring will be meggered separately and the coach will be treated to have passed the test if insulation resistance value of these feeders individually is within the limits prescribed in para above.

10.6 REWIRING:

10.6.1 Rewiring of the coach shall be planned on the basis of cab life on the 20 years. However, after 15 years of service, the coach wires shall be subjected to simple tests, during POH and if the insulation is found not passing tests, the coach shall be taken up for rewiring along with its POH. The test procedure and the requirements of tests are given in Annexure-IV.

Coach shall be taken up for rewiring after 20 years of service. However, if for certain specific reasons, coach is not taken up for rewiring, the rewiring will be deferred only if cable passes the test of Annexure IV.

10.6.2 Notwithstanding the above, coach shall be taken for rewiring or for replacement of certain portion of wiring as and when they are found mechanically damaged and tampered with. The coaches with tampered, damaged and loose wiring are dangerous because of their proneness to earthing and short circuit and as such should not be permitted in service.

10.7 BATTERY BOX:

10.7.1 The monoblock of battery shall be arranged in single row perpendicular to track, inside a sturdy steel box and secured to under frame by bolts and nuts, lock nuts or split pins as per ICF drawing no.ICF/SK-7-1-306 for BG and MG coaches. FRP trays shall be provided at the bottom of the battery box to avoid corrosion *of* battery box from spillage of acid. The battery box shall be suitable for accommodating 18 monoblocks of battery conforming to RDSO's spec. no.EL/TL-38 (Rev.B) with amendment no. 1. The box shall be provided with ventilating grills to permit flow of outside air over the cells. A drain pipe shall be provided at the bottom of the box to allow split acid or water to drain out. The location and a design of the ventilation and drain arrangements shall be such as to avoid ingress of dust into the battery box. Provision shall be made on the front cover for part opening for inspection and maintenance of the cells. The cells shall be tightly packed by wooden packings inside the battery box in all skies except at top. The battery box and wooden packings shall be protected against corrosion by battery acid by two coats of acid resistance paint as per RDSO specn.no.EL/TL/19-1973,Appendix E. In addition, wooden packings shall also be protected against attack by vermin. The battery box shall have minimum 150 mm clearance at the top of battery for maintenance of cells,

10.7.2 The battery fuses shall be located in a battery charging socket and fuse box to RDSO's Drg.no.SKEL-3930. This box shall be provided adjacent to the positive end of the battery box and shall be accessible without the necessity of entering between the track rails. Rewirable 32A for single battery and 24A for double battery tinned copper fuses conforming to specn.no.IS:9925-1961 shall be provided according to coach loads.

10.7.3 Mild steel rods threaded at both end shall be fixed to the battery boxes after loading the cells as an anti-theft arrangement in accordance with para 6.12 of IRS Specn.no.E-45/1977. -

10.8 PROTECTIVE DEVICES:

10.8.1 Notwithstanding the above precautions, the possibility of short circuit on coach cannot be discounted altogether and, therefore, protective devices are necessary to afford protection in the event of any short circuit or excessive current on the coaches. As mentioned earlier, short circuits are the only probable cause of electrical fires and, therefore, if provision of proper protective devices is ensured, it will go a long way in avoiding incidence of fires of electrical origin on coaches.

10.8.2 On coaches rewirable fuses and HRC fuses have been standardized . The sizes and the rated current of these protective devices for different circuits are given below and it should be ensured that only correct size of these devices are put on the coach.

10.8.3 The quality of protective devices is also important and should conform to their relevant specification indicated below, while rewirable fuses and HRC fuses as at Table 1 shall be procured by Railways from renowned sources approved by RDSO/Railways.

10.8.4 SEGREGATION OF POSITIVE & NEGATIVE CABLES:

10.8.4.1 The wiring on the underframe and endwalls of the coach shall be run in Rigid steel conduits and on the superstructure in Rigid PVC conducts and the positive and negative cables shall be segregated by running them in two separate conduits.

Note: The phase & field cables from the alternator to terminal box shall run in one flexible PVC conduit arid-from terminal box to Rectifier-cum-Regulator and from Rectifier-cum-Regulator to underframe terminal board (VTB) in one rigid steel conduit.

Sr. No.	Circuit	fuse location	Fuse rating	Non fusing non-tripping Current	Minimum size of cable protected for Short Circuit		
					60 Sec. Fusing /Tripping Current	Size	Short Time (60 Sec) Rating of Cable
1	Positive/ Negative branch fuse	DFB	6A (0.20 8A-mm)(35SWG)	8A	13A(4mm^2)	7/0.85	37A
2	LI,LII &F+	Jun Box	16A HRC	-	-	7/1.7 (16 mm^2)	148 A
3	SPM-I & SPM-II	-do-	-do-	-	-	7/1.7 (16 mm^2)	148 A
4	Main –ve	-do-	35A HRC	-	-	7/2.52 (35 mm^2)	325 A
5	Battery Fuse						
	a. Single Battery	Battery Box	32A(20SWG)	45.0A	70A	7/2.52 (35 mm^2)	325 A
	b. Double Battery	-do-	24A(22SWG)	34A	53A	(35 mm^2)	325 A
6	Alternator						
	i) Phase	Rectifier Cum Regulator	32 A HRC	-	-	-	-
	ii) Field		6/10 A* HRC	-	-	-	-

* (In case of M/s stone India Ltd. Only)

Protective devices	Description	Specification Ref.
Rewirable fuses		IS: 9926-1981*
HRC Fuses	tinned copper rewirable fuse wires	IS:9224-979 (Part. II)

. HRC fuses * Type I- HRC fi

* In addition, fuse wire sizes have also been adopted from 15:9567-1980 for tin or tin - lead coated copper wire used in electronics industry.

10.9 COACH WIRING - ACCESSORIES:

10.9.1 Connectors

Wiring for fan point, berth light, step light, tail light and side light fittings on the coach shall be terminated in a connector. This will ensure that when these fittings are removed from the coach, the coach wiring is not disturbed and remains in position with its opposite polarities terminals adequately apart.

The connectors are covered under IS:6896 and shall be of tough non-ignitable moulding material or rigid PVC.

10.9.2 Cleats:

` The cleats used in coach wiring shall be of rigid PVC with non-inflammable properties. However, wooden cleats pressure impregnated with ASCU fire retardant can be used but they shall be further provided with two coats of fire retarding paint of approved make.

10.9.3 Grommets and bushes:

Grommets used in coach wiring on coaches to protect cable insulation shall be of hard PVC as per BS:1767-1951 or to grade 6 of IS:5831. The bushes used on coaches at various locations shall be of the same class of PVC with non-inflammable properties.

10.9.4 Conduits:

Flexible PVC conduits shall be used for toilet wiring under the water tank. The flexible PVC conduits shall conform to IS:6946.

Rigid PVC conduits used in wiring at other locations on the coach shall be as per IS;9537.

The PVC conduits both flexible and rigid shall be for fire retardant class and shall pass flame retarding test as specified in specification IS:9537.

10.9.5 Insulation tapes:

PVC adhesive tapes to IS:7809 Part III, Section 1 shall be used in the coach wiring. The thickness of the tapes shall be of 0.20mm, 0.22mm, or 0,25mm. Tapes with backing material as cloth or equivalent and meeting the test requirements (specially fire retardant properties) to TS:7809 Part-2 can also be used.

10.9.6 Distribution fuse board and terminal boards:

Various terminal board and panel boards used in each wiring shall be of FRP with fire retardant properties to ICF specification no.ICF/ELEC./866.

10.10 WOOD AND FIRE RETARDANT PAINT:

10.10.1 Insulating blocks are provided for the lamp holders and switches to insulate the

fitting from the coach body. Blocks shall be of seasoned hard teak wood.

10.10.2 All the wooden boards, blocks and cleats used in the wiring or in the vicinity of the wiring shall be painted with two coats of fire retardant paint as approved by RDSO. The

following fire retardant paints are approved by RDSO and they only shall be used for painting cleats and wooden blocks and other wooden boards in vicinity of wiring in coach.

(i) Acrylic superlac plastic emulsion paint of M/s Shalimar.

(ii) Fire resistant paint, light grey of M/s Jenson & Nicholson.

(iii) Mica base fire retardant paint of M/s Central Glass and Ceramic Research Institute

10.11 MAINTENANCE SCHEDULES:

10.11.1 Round trip maintenance schedule:

1. The loose and exposed/hanging wiring shall be secured and properly covered. In case of wiring needs replacement, the coach shall be taken for repairs.

2. Look for any overheating of terminal and cable insulation etc..

   This is to be checked by switching 'ON' the coach load and then feeling the temperature of various terminals by hand. An overheated terminal can be either due to looseness or because of defective jointing (crimping). The terminal should therefore, be tightened and if joint is heated the crimping be redone.

3. Check for proper sizes of fuses: An overheated fuse can blow prematurely and therefore should be replaced. Check for proper securing and tightness of connections.

   HRC fuses should be checked for correct size, connections and if it is healthy. Replace if blown and tighten connections, if found loose.

4. Provide tape at terminals and overheated portion of cable insulation at terminals.

5. Check earth on coach wiring and attend if an earth is noted as per procedure given in Annexure -III. However, in emergencies, a coach with negative earth fault which could not be attended can be given in service but then the coach will be taken up for repairs during next trip. Before allowing such coach in service, a particular check will be made that all protection devices are properly provided. The coach shall also be marked with defect and noted for attention during next trip.

10.11.2 Workshop and sick line schedule:

1. In addition to items mentioned above, insulation resistance of coach wiring shall be measured on all coaches before being turned out of shops/sidelines after repairs in accordance with procedure given under para 9.5.7 above.

2. The wiring shall also be checked for proper wiring practices in terms of specifications particularly those mentioned above,

3. Cable joints should be avoided. In case of joints in cable , if seen during POH in the workshop, replace the cable.

ANNEXURE-I (REF:CLAUSE 9.2.1)

CABLE SIZES OF COACH

S.NO. EQUIPMENT	PVC CABLE (Aluminium to 18:694-1990)			
Description	Terminal	Area sq.mm	Size	Colour
1. 2.	3.	4.	5.	6.
1. Alternator 4.5KW	A1,A2,A3	16 10	220/0.3 141/0.3	Grey(Aluminium) Grey (Copper)
	F+	4	56/0.3	Red(Aluminium)
		1.5	48/0.2	Red(Copper)
	F-	4	56/0.3	Blue(Aluminium)
		1.5	48/0.2	Blue(Copper)
2. Rectifier-cum-Regulator	A1,A2,A3	16 10	220/0.3 141.0.3	Grey(Aluminium) Grey (Copper)
	F+	4 1.5	56/0.3 48/0.2	Red(Aluminium) Red(copper)
	F-	4 1.5	56/0.3 48/0.2	Blue (Aluminium) Blue(Copper)
	B+	50	19/1.78	Red
		50	19/1.78	Blue
3. Battery 120AH	B+ B-	35 35	7/2.52 7/2.52	Red Blue
4. Battery charging terminal & fuse box	-ve	35 35	7/2.52 7/2.52	Red Blue
5. Battery charging terminal board	+ve -ve	16 16	7/1.7 7.17	Red Blue
6. Junction box	PM	35 /50	7/2.52	Red
		35/50	19/1.78	
	B-	35/50	7/2.52	Blue
			19/1.78	
	SPM I +ve	16	7/1.7	Red
	SPM 11 +ve	16	7/1.7	Red
	SI & SII	16	7/1.7	Blue
	LI +	16	7/1.7	Yellow
	LII +	16	7/1.7	Yellow
	F+	16	7/1.7	Red
	L -	35	7/2.52	Blue
	F -	35	7/2.52	Black
7. Emergency Feed Terminal Board	-ve +ve	16 16	7/1.7 7/1.7	Red Blue

8,	Fan and Regulator	+ve	4	7/0.85	Red	
		–ve	4	7/0.85	Black	
9.	Lamp Holder	+ve	4	7/0.85	Yellow	
		-ve	4	7/0.85	Blue	
10.	Switch	-	4	7/0.85		-
11.	Alarm pull chain coach indication lighting	+ve	4	7/0.85	Yellow	
		-ve	4	7/0.85	Blue	
12.	Limit switch	+ve	4	7/0.85	Yellow	

JOINTING & CRIMPING

A-0 Jointing by crimping also known as compression jointing, is quick and comparatively inexpensive and has been adopted for coach wiring.

A-l **CRIMPING**

A-l-1 Remove insulation from the conductor, 1 mm longer than the inner length of the barrel of the socket/sleeve to be crimped.

A-1-2 Apply a thin coat of inhibiting grease of approved make over the conductor,

A-1-3 Select the right size of socket/sleeve. Cross-sectional area (..mm^2) stamped on the socket should match with the cross-sectional area of the cable conductor.

A-1-4 Remove the sealing plug from the open end of the socket and ensure that a thin coat of inhibiting grease provided by the manufacturer of the socket is intact and the inner surface is free from dirt. If not, remove the old inhibiting grease, clean and apply a thin layer of fresh inhibiting grease.

A-1-5 Crimp with appropriate crimping tool and die as recommended by the manufacturer of the socket. The cross-sectional area marked on the recommended die should match the cable. Only the correct socket, die and crimping tool will ensure reliable joint.

A-1-6 After crimping, verify that the cross-sectional area impressed by the die, and the cross-sectional area stamped on the socket referred to in 1.3 do not differ.

A-1-7 Apply insulating tape on the joint where required.

A-1-8 Recommended sizes of the socket/terminal sleeves which are based on diameter over the conductor stipulated in IS:694-1990 are given in the table A-1.

******

TABLE A-1

SR.NO.	DESCRIPTION	DRG.NO.
1.	Crimping Sockets – General purpose	E 301
2.	Crimping Sockets for train lighting dynamos and switch gears.	E 302
3.	Crimping Sockets – Reducer Pin	E 303
4.	Crimping Sockets – Ring Tongue	E 304
5.	Crimping features for straight through joints	E 305
6.	Crimping Sockets – Double ended	E 308
7.	Crimping Pin	E 309
8.	Crimping end ferrule	E 310
9.	Crimping Sockets – Angular (above $50mm^2$)	E 311
10.	Crimping Sockets for TL dynamo and switch gear short barreled.	E 312
11.	Crimping Sockets – Slotted tongue	E 313
12.	Crimping Sockets angular (up to $50mm^2$)	E 314
13.	Crimping battery and connectors.	E 315
14.	Crimping terminal for tonum TL dynamos and field coil.	E 316
15.	Crimping Socket – Circular Palm	E 317
16.	Crimping Socket – Short barreled palm type	E 318
17.	Crimping Socket – Fork book torque type.	E 319

ANNEXURE III

(SHEET-1)

TROUBLE SHOOTING INSTRUCTIONS FOR EARTH ON COACH WIRING (CLAUSE 10.3.1)

Connect the earth indicating device to the EFTB as shown in sheet IV

(1)	(2)	(3).	**(4)**
Lamp do not glow at all.	Both Lamps glow Unequally.	Both Lamps glow Equally.	One Lamp burns brightly while the other is not Glowing at all.
Either one or both the lamps defective. Replace the Defective lamp/ Lamps and re-Test.	i) Battery Box leaky. ii)Partial earth on Positive or negative wiring (not serious but should be attended to as early as possible as per the sequence Shown in (4).	Coach wiring is healthy.	Earth fault is either in positive or negative wiring, the polarity given by the glass window of the device thus, "POSITIVE EARTHED" or "NEGATIVE EARTHED" by the brightly burning lamp.

Examine junction box, distribution fuse board and emergency feed terminal boards at both the ends and check for physical contact of any terminal/led wires with Earth. Insulate the terminals/leads properly and repeat the test.

Only one lamp burns	Both lamps glow
Separate the body wiring From junction box and re-test	Coach wiring healthy

Only one lamp burns	Both lamps glow
Fault in under frame Wiring (see Sheet III)	Fault in body wiring

POSIRIVE EARTH	NEGATIVE EARTH
(See Sheet No.II)	(See Sheet No.II)

ANNEXURE III

(SHEET III)

Trouble shooting for earth on

POSITIVE EARTH

Disconnect F+ cable in the junction box and re-set

One Lamp burns Isloate SI+ SII+ and re-test

One Lamp burns Roof LI+ or LII defective.

One lamp burns LI+ defective Isolate each light point of LI circuit individually at DFB. Repeat test Till defective section is detected.

Both Lamps burn LII+ defective. Isolate each light point of the LII circuit at DFB. Repeat test till defective section is detected.

Both lamps burn SI+ or SII Defective. Isolate S+& re-test.

One lamp burns SII* defective. Check the defective section (as indicated by the lamp Marking) till the defect is detected.

Both lamps burn SI+ defective. Check the defective section (as indicated by the Lamp marking) till the defect is detected.

Both lamps glow F+ defective Reconnect F+ and isolate each fan Individually at DFB. Repeat test till defective section is detected.

NEGATIVE EARTH(*)

(*) NEGATIVE EARTH

Disconnect F-cable in the junction box & re-test

One lamp burns. Isolate SI- & SII- and re-test.

One Lamp burns L- Defective. Locate defect.

Both lamps glow. SI or SII defective. Isolate each other and detect defective section.

Both lamps glow F- defective Locate defect.

ANNEXURE III

(SHEET III)

If fault is in underframe wiring, connect the earth indicating device at the battery terminals and test.

POSITIVE EARTH

Locate defective section of the underframe positive cables by disconnecting each cable from the underframe terminal board.

NEGATIVE EARTH

Locate defective section of the underframe negative cables by disconnecting each cable from the underframe terminal board.

NOTE : (i) A coach may have multiple earth faults which is a rare occurrence. By the procedure given above, second fault, if any, can be detected only after the first one has been put right. Hence it is necessary to test the entire wiring every time has been put right.

(ii) If the fault/faults are not located, the coach should be sent to workshop.

ANNEXURE IV

TEST PROCEDURE FOR TL CABLES (REF: CLAUSE 9.6.1) :

1. Equipment required :

   i) High voltage testers (voltage0-3KV, AC 50 cycles) with tripping current setting of 5 milli amps.

   ii) Metallic water bath and

   iii) Watch (0-10 minutes)

2. Procedure :

   2.1 Open covers to expose wiring for visual examination. In case of wiring in conduits, take out length of cables on sample basis to assess cable condition.

   2.2 Look for any cuts in insulation signs of overheating, swelling of insulation and corrosion of conductor etc.

   2.3 Cables found damaged during visual examination should be changed.

   2.4 Cables found in healthy condition will be subjected to dielectric test.

   2.4.1 Take samples of cable for dielectric testing from the portion of coach wiring considered to be worst affected because of its exposure to heat and Winmoisture etc. One sample each will be taken from under frame wiring and superstructure wiring but in case of doubt about the worst affected portion of working more than one sample can be taken for testing. The cable sample should be of one meter length.

   2.4.2 Wind the cable sample around a round mandrel of 5 times the outside diameter of the cable. Give 5complete turns of cable on mandrel with adjacent turns in contact with each other. Now unwind the cable from the mandrel. Repeat cycle of winding and unwinding of the sample on the mandrel 5 times.

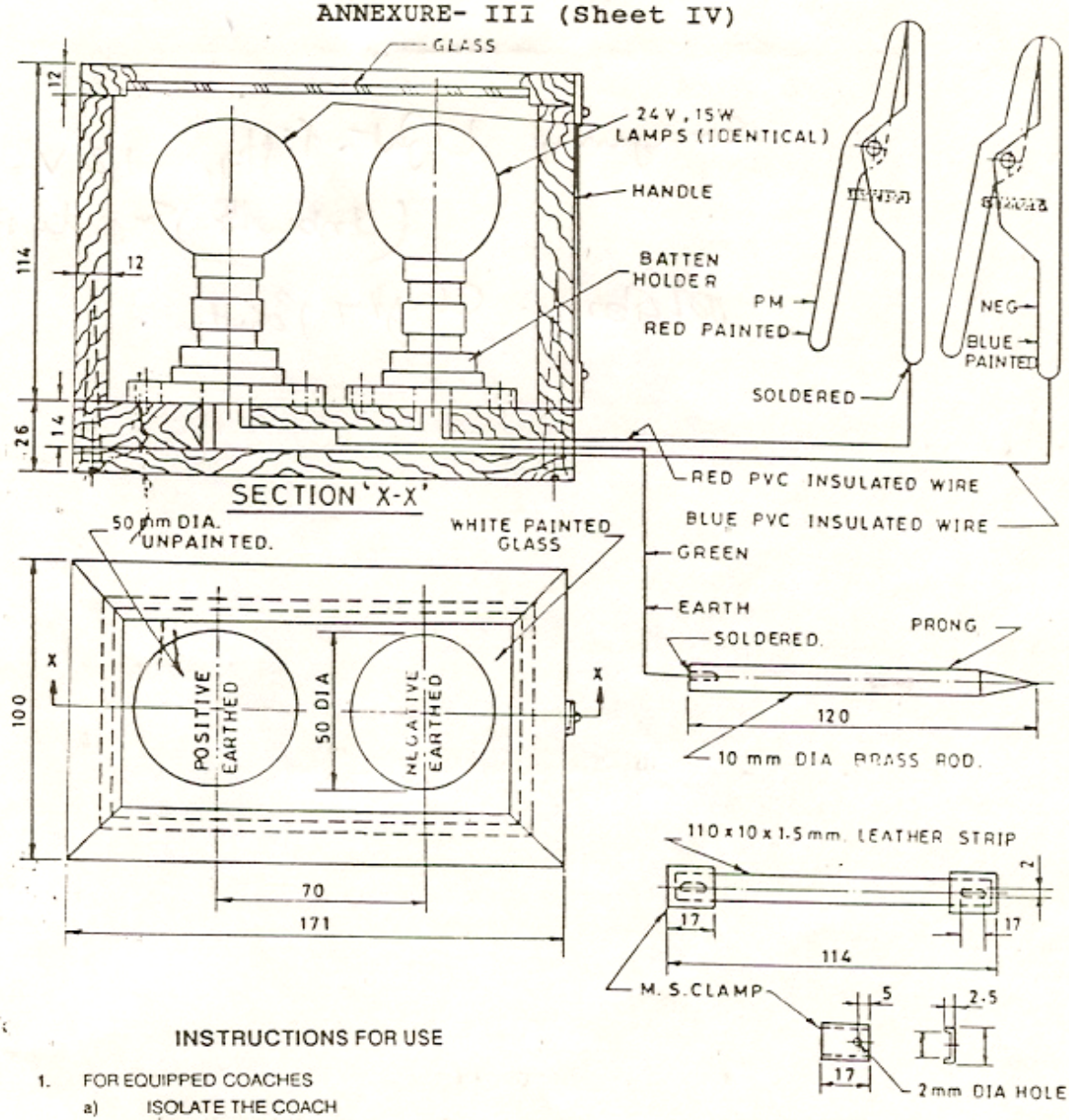
   2.4.3 Keep the cable sample in water bath for 24 hours with about 50mm length of the cable at two ends remaining out of water.

   2.4.4 Cable sample be kept in the water bath and AC voltage of 50 cycles be applied between conductor and water bath from high voltage tester. The voltage be gradually increased upto 1.5kV and be maintained at 1.5 kV for 5 minutes.

   3.0 The cable will be treated to have passed the test i.e. it is suitable for further service on coaches, if it stands to 1.5 kv for t5 minutes without any breakdown or tripping of high voltage tester with tripping current set at 5 milli amp.

   4.0 For purpose of record, the voltage be increased in steps of 1 KV upto 6 KV or upto range of HV tester whichever is less and the voltage withstood by the cable samples be noted.

ANNEXURE- III (Sheet IV)



INSTRUCTIONS FOR USE

1. FOR EQUIPPED COACHES
   - a) ISOLATE THE COACH
   - b) SWITCH ON ALL LIGHTS & FANS
   - c) CONNECT THE RED CONNECTOR TO THE P.M. & THE BLUE CONNECTOR TO THE NEGATIVE OF THE COACH E.F.T B.
   - d) PRESS HOME THE POINTED END OF THE EARTH PRONG (GREEN LEAD) ON THE COACH BODY ENSURING A PROPER ELECTRICAL CONTACT
   - e) PROCEED AS DESCRIBED IN ANNEXTURE III SHEET I, II, III, AND IV
2. FOR UNEQUIPPED COACHES
   CONNECT A HEALTHY EQUIPPED COACH TO THE UNEQUIPPED COACH UNDER CHECK THROUGH EMERGENCY FEED TERMINAL BOARD & TEST AS INDICATED ABOVE

EARTH INDICATOR LAMP
(PORTABLE)

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