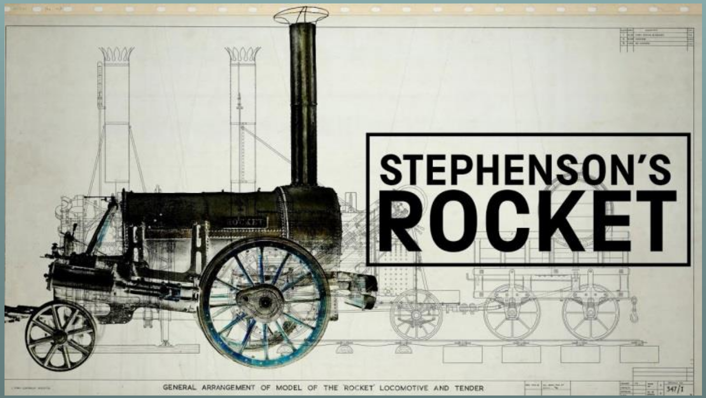
Basic Knowledge on Rolling Stocks and Operation

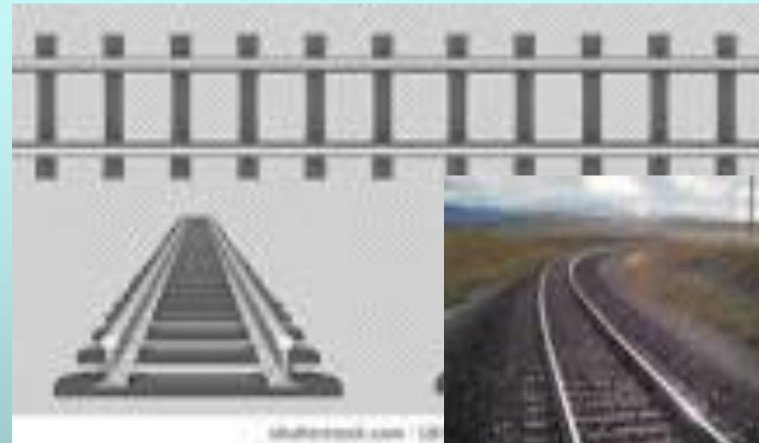
An Introduction By
U Win Oo   P.E. (Reg.No. 0091)
GM (Retd.) M.R.
Co-Project Manager (YCR-CMC)
Oriental Consultant Japan Co. Ltd.

Railway


FREIGHT
F86
COLLIERY


STEPHENSON'S
ROCKET
GENERAL ARRANGEMENT OF MODEL OF THE 'ROCKET' LOCOMOTIVE AND TENDER

Rail/ Track/ Railway



Rail → Steel bars for the wheel to run on.
Track→ Track panel + Track bed
Railway → The entire path on which the train runs.

Rolling Stock

All and everything which can be rolled and moved on the railway.

Trains

1. Passenger Train
2. Goods Train
3. (a) Diesel Multiple Unit (DMU Train)
   (b) Diesel Electric Multiple Unit (DEMU Train)

Locomotives

Steam Loco

Diesel Hydraulic Loco

Diesel Electric Loco

Diesel Hydraulic Shunting Loco

Locomotive in Service

1. Able to start and haul the train over specified routes, during running time, under schedule timing.
2. Capable of staying in service for long period of time with min. maintenance and fueling time.
3. To be economical in fuel; cheap, readily available at all time.
4. Safe for crews, passengers and environment.

Locomotive & Depots

Passenger Coaches & Depots

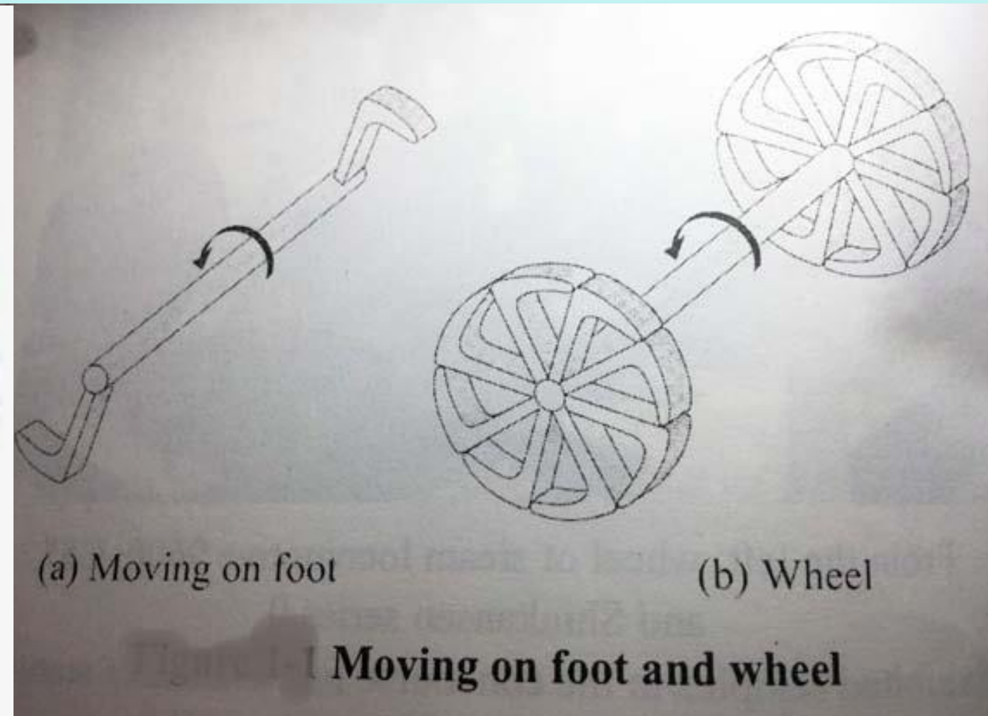
Freight Wagons & Depots

Basic Concept of Traction

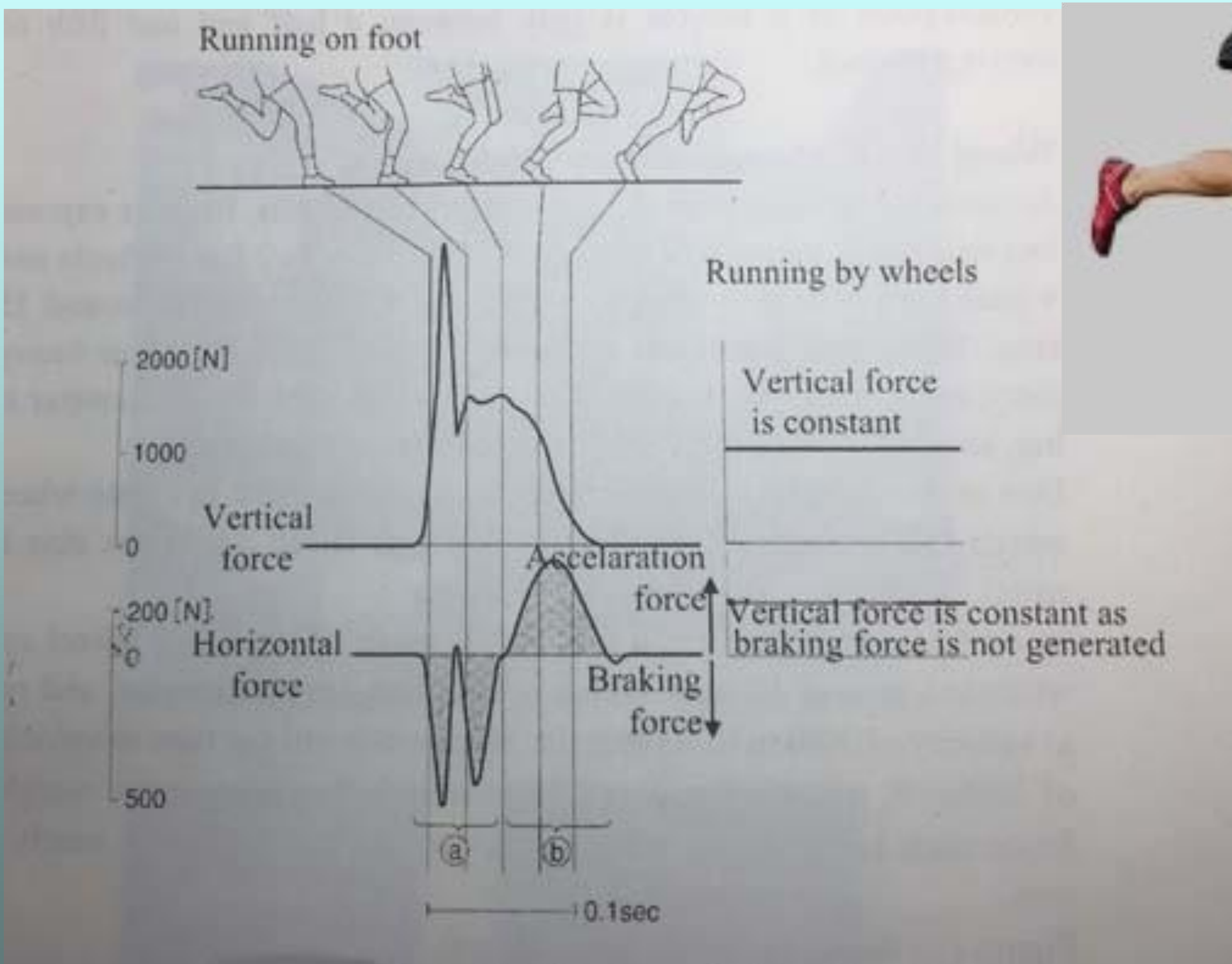
To know about train

- Train resistance Concept
- Power Requirement Concept
- Engine Characteristic Concept
- Electrical Power Concept
- Dynamic of Rolling Stock

Foot vs. Wheel

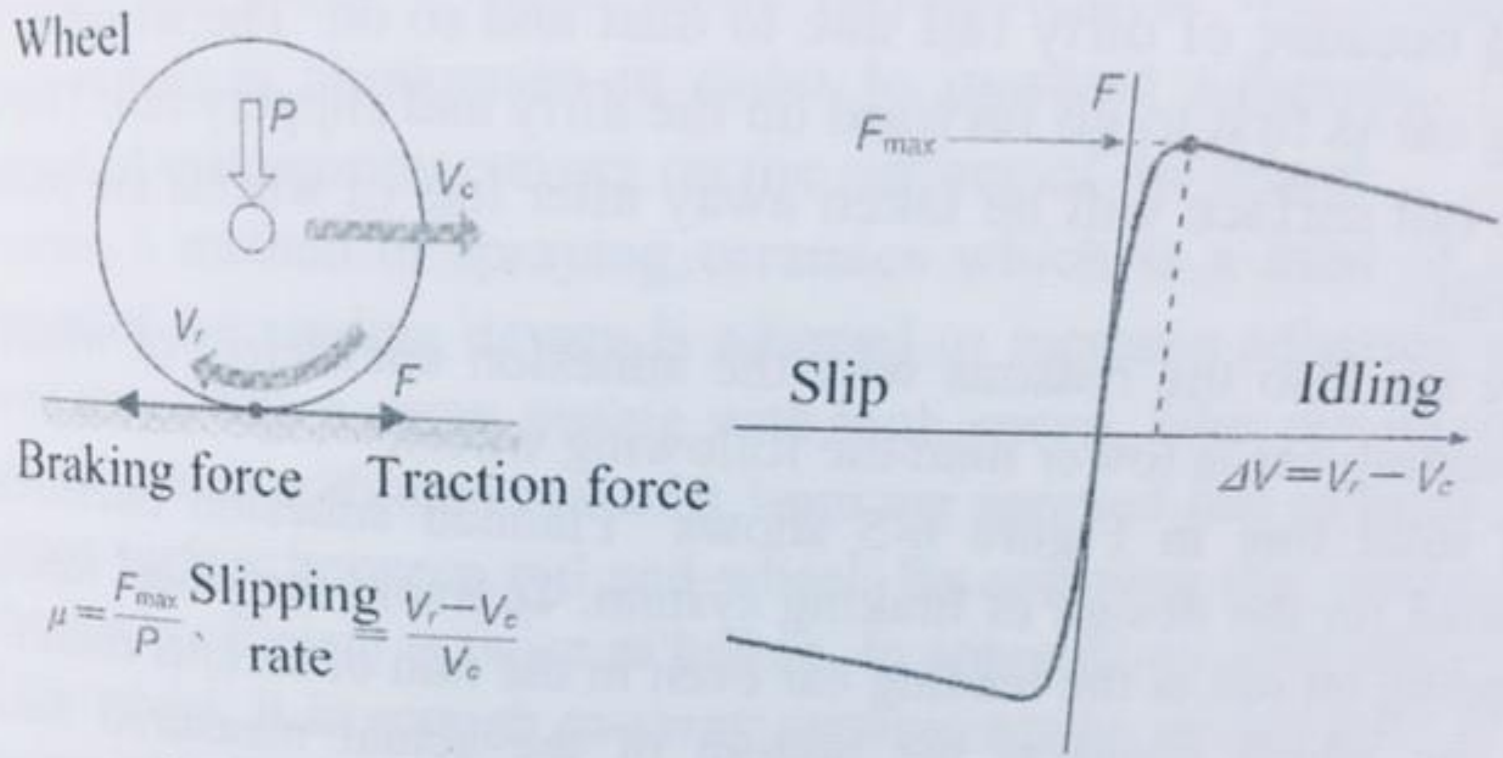


Running Foot



2 Running force variation diagram

Traction (Driving)



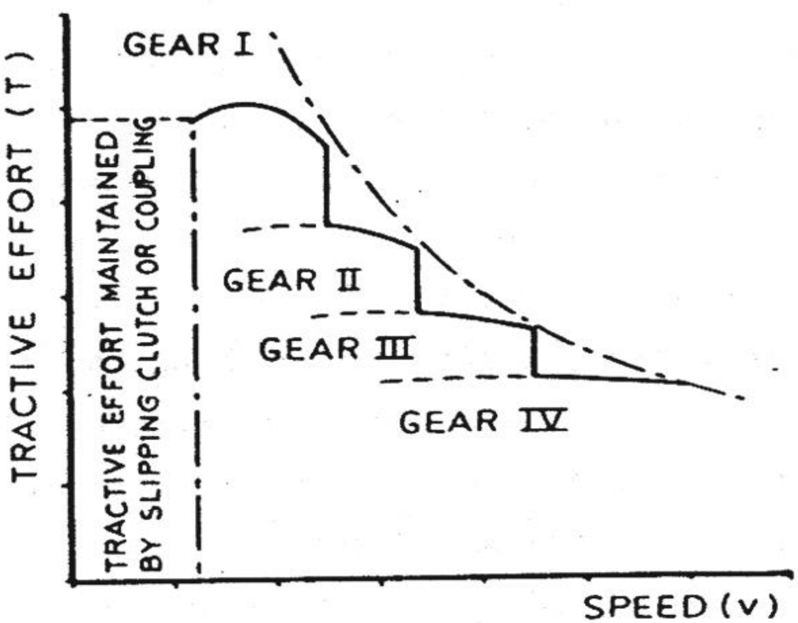
$\mu = \frac{F_{max}}{P}$, Slipping rate $= \frac{V_r - V_c}{V_c}$

μ : Adhesion coefficient
V_r : Circumferential speed
V_c : Running spped
ΔV : Slipping speed

F: Adhesion
Fmax: Maximum adhesion
P: Upward and downward load

Figure 6-4 Relationship between adhesion and slipping speed

Vehicle Performance characteristic on Road/Rail-road



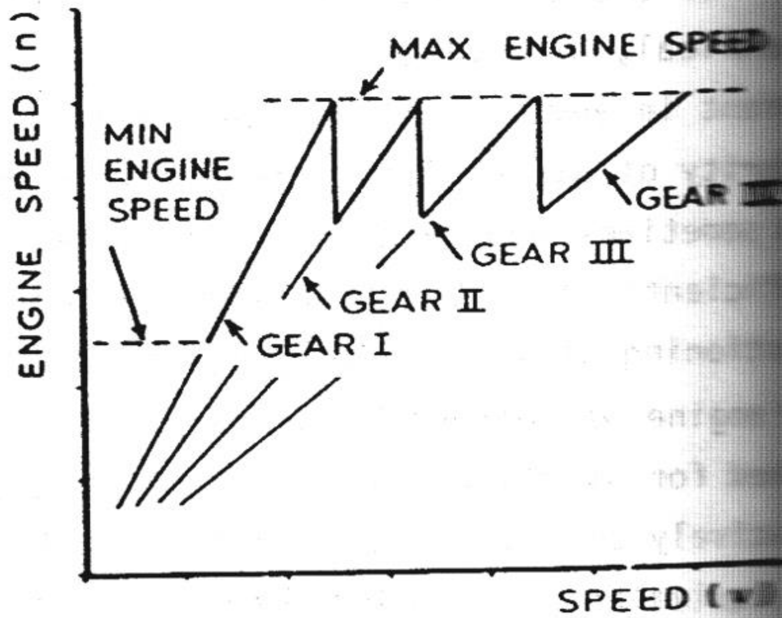


Fig. 213. Performance characteristics of a motor-coach or small industrial locomotive with changes of mechanical gear ratio.

Fig. 214. Engine speeds corresponding to the performance characteristics of Fig. 213.

Train Resistance

What difference between
Roadway and Railways ?

Train

13 N/ton

at slow speed

(1N=0.22lb,0.1 kgf)

Road Vehicle

Cart on Virgin Soil	1300-1750 N/ton
Car on bad road	450-650 N/ton
Car on good road	90 N/ton
Ind.Vehicle on road	175 N/ton

Train resistance

The tractive resistance of a Vehicle is usually defined as being equal and opposite to the force needed to maintain the vehicle at any particular value of constant speed over a length of straight and level track.

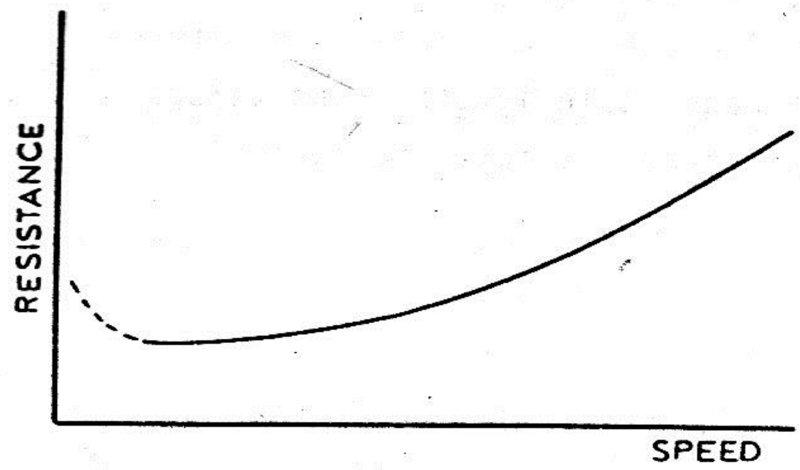


Fig. 2. Typical relationship of resistance with speed.

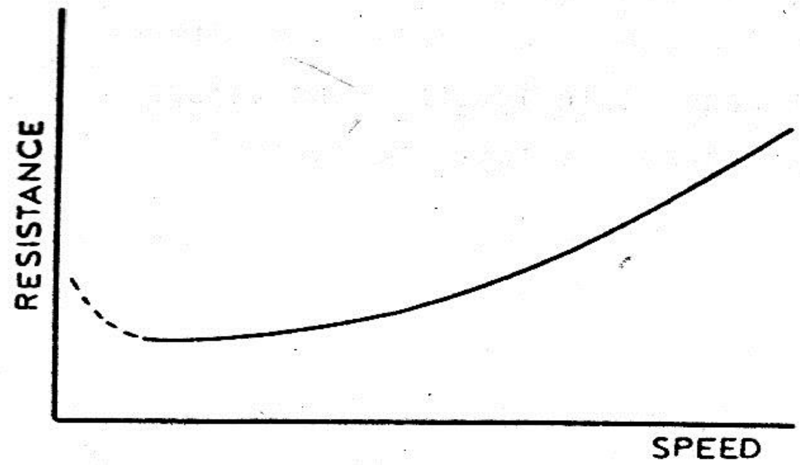


Fig. 2. Typical relationship of resistance with speed.

Total Running Resistance of vehicle

$R = A + B v + C v^2$

Where A, B, C are constants.

A= mechanical, Journal friction, track adhesion

B= flange, track, internal friction of train

C= air

V= train speed

Principle components of train resistance

(a) Bearing Resistance
(b) Rolling Resistance
(c) Air Resistance

Mechanical Resistance

(a) Bearing Resistance- depends on speed, bearing pressure, method of lubrication
(b) Rolling Resistance- depends on tyre and flange’s contact with the rail
(c) Air Resistance (> 100 km/h effected) depends on size & shape of train

Air Resistance

-No matter at low speed,

But

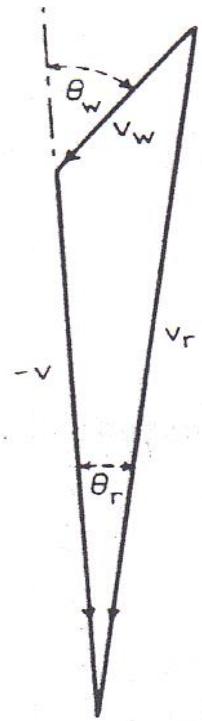
100 -200 km/h

Important.

More precisely,

Over 160 km/h

Major important



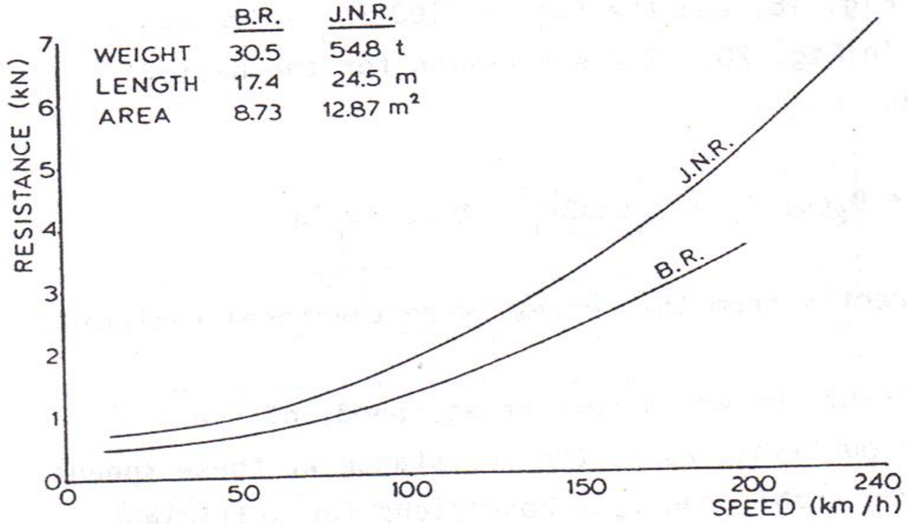
Velocity at the front of train

Fig. 5. Air velocity relative to train as affected by wind.

$$R_a=Vr^2\,(D_0+D_1\,\mathrm{Cos}\theta_r + D_2\,\mathrm{Cos}\,2\theta_r + D_3\,\mathrm{Cos}\,3\theta_r.....$$

Total Resistance of any vehicle of a train can therefore usually be expressed with sufficient accuracy in the form of-

$$R_a = A + B\,v + C\,v^2 + Vr^2\,(D_0 + D_1 \cos\theta_r + D_2 \cos 2\theta_r + D_3 \cos 3\theta_r + D_4 \cos 4\theta_r)$$



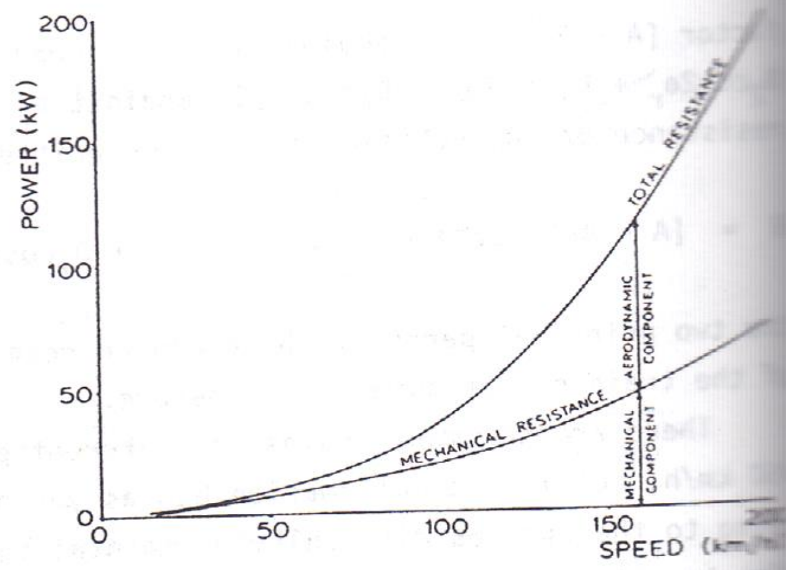


Fig. 29. Typical values of resistance in average conditions for one coach of high speed trains on British Railways and on the Japanese National Railways, Tokaido Line.

Fig. 30. Power required for overcoming the mechanical and aerodynamic components of the resistance of a typical British Railways coach.

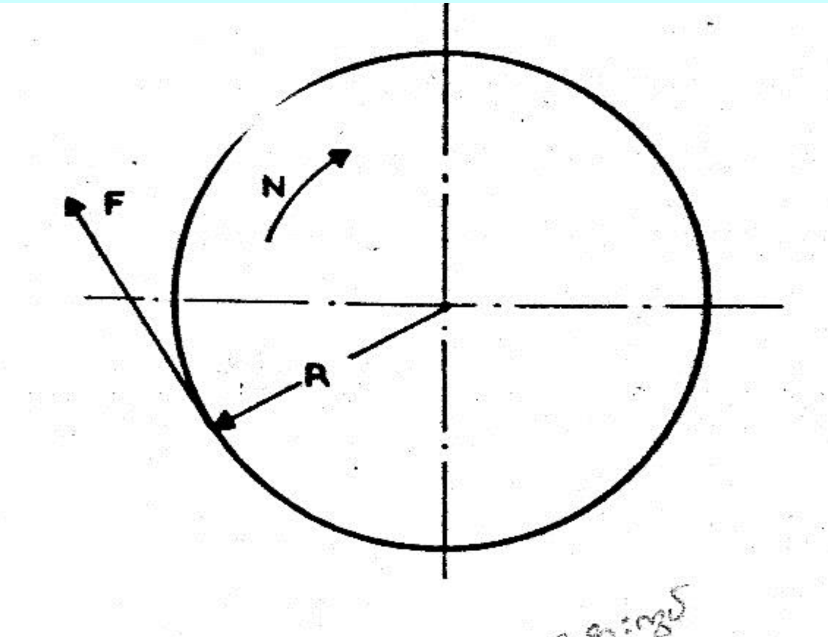


FIG. 1. *Work done at rim of wheel.*

Workdone in one rotation of wheel

= force at wheel rim (lb) x length of circumference

= force x 2 π R

One HP is workdone at the rate of 33000 ft lb per min (550 ft-lb/sec).

Example;

A locomotive draws a train, whose total weight is 250 tons, along a level track at 40 mph. If the force to draw the train is 12 lb per ton, what HP must the engine provide?

$$40 \text{ mph} = \frac{40 \times 5280}{60} = 3520 \text{ ft/min (speed)}$$

Total pull = 12 lb/ton x 250 ton = 3000 lb

Workdone per min = F x V = 3000 lb x 3520 ft/min

$$HP = \frac{3000 \times 3520}{33000} = 320 \quad \text{(This HP is at the drawbar.)}$$

Dawbar HP= Power developed at the drawbar of the locomotive.

Rail HP = Power developed at the wheel tread of locomotive.

DHP = RHP - power required to move the locomotive itself (inertia, bearings, pin/bush friction)

Drawbar HP (data based on Indian Locomotives)

Steam Loco 7- 8 hp/ton of loco

Diesel Loco 13- 16 hp/ton of loco

Electric Loco 31- 38 hp/ton of loco

Thermal Efficiency of Locomotives

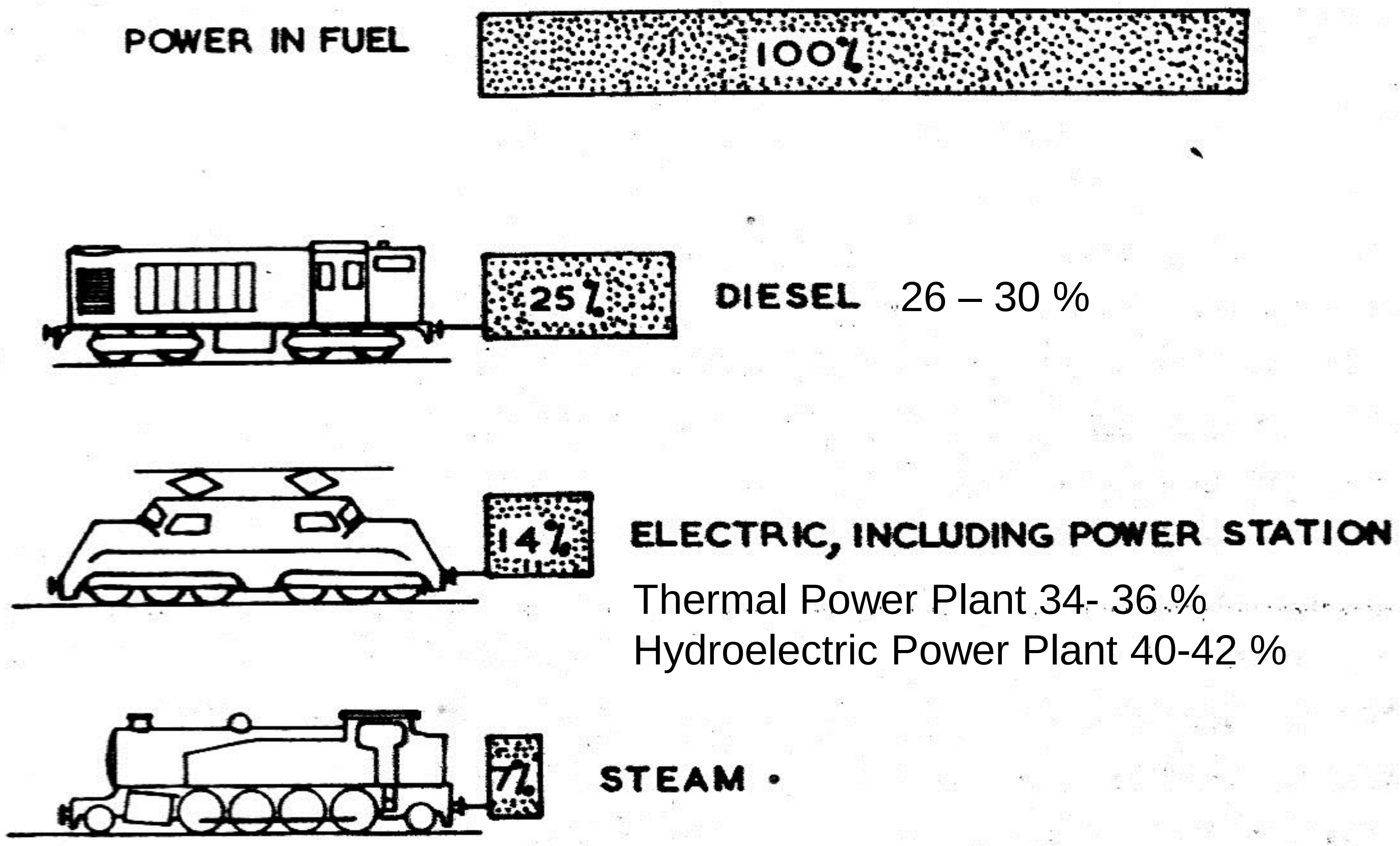


FIG. 4. *Diagram showing the proportion of power released by the burning fuel which is available at the drawbar of various locomotives.*

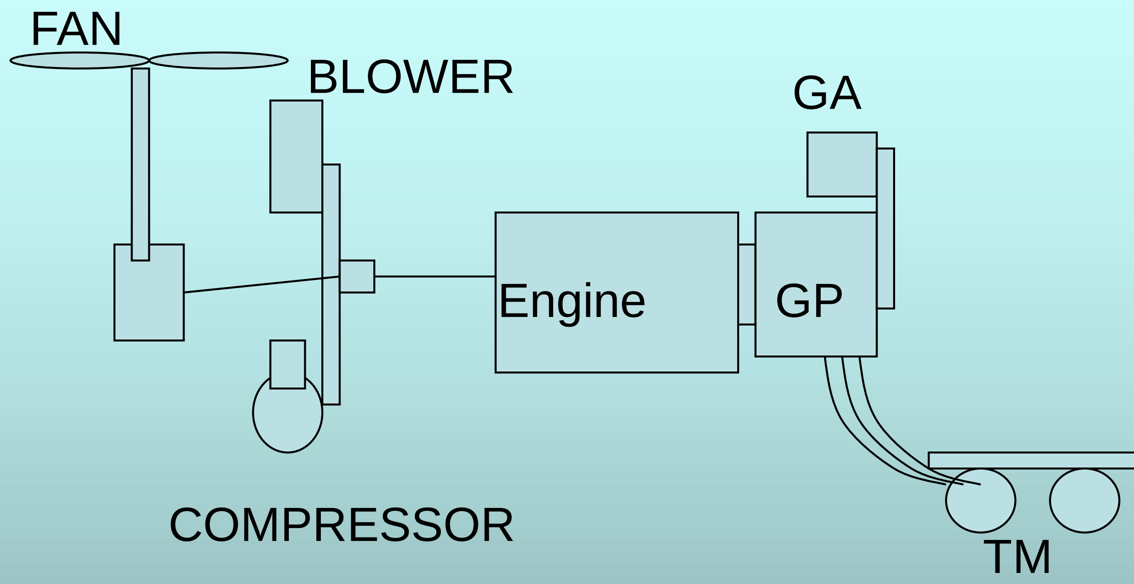
BHP = IHP – Mechanical Losses (15%-20%)

RHP= BHP – power used in Auxiliary machines (5-10 %) such as cooling fan, blower fans, compressor, exhauster, dynamo, etc.) – Transmission Loss (15% of remain)

Transmission loss due to;

Hydraulic- gear, torque converter, coupling, cardenshafts, etc.

Electric – GP,GA, TM, Gears, Inverters, etc.



Example Engine Power

2000HP-Aux.100HP (5%) =1900 HP

1900HP – Tran; 285HP (15%)=1615 RHP

Tractive Effort

TE is the force in lb at the rail wheel rim.

Maximum Tractive Effort which occurred when wheels are just on the point of slipping. It is also called Starting TE.

Steam Loco Adhesion 0.25 (TE / W)

Diesel Loco Adhesion 0.30 (TE / W)

Maximum TE based on total wt on the driving wheels.

Continuous Tractive Effort which is based on Engine power and Maximum durable current output of Generator/ Alternator.

$TE/W = 0.3 \rightarrow W/TE = 3.3$ $\quad W = 75$ Ton

Max. $TE = W/3.3$

$$\text{Max. } TE = \frac{75 \times 2240}{3.3} = 50909 \text{ lb}$$

$$RHP = \frac{T \times V}{33000} = \frac{T \times M}{375}$$

Where T = Tractive Effort lb

V = Speed ft /min

M = Speed mph

M= 5mph, T= RHPx 375/M = 1615 x 375 / 5

MPH	Tractive Effort lb
5	121125
10	60562
12	50468
15	40375
20	30281
25	24225
30	20187
35	17303
40	15140
45	13458
50	12112

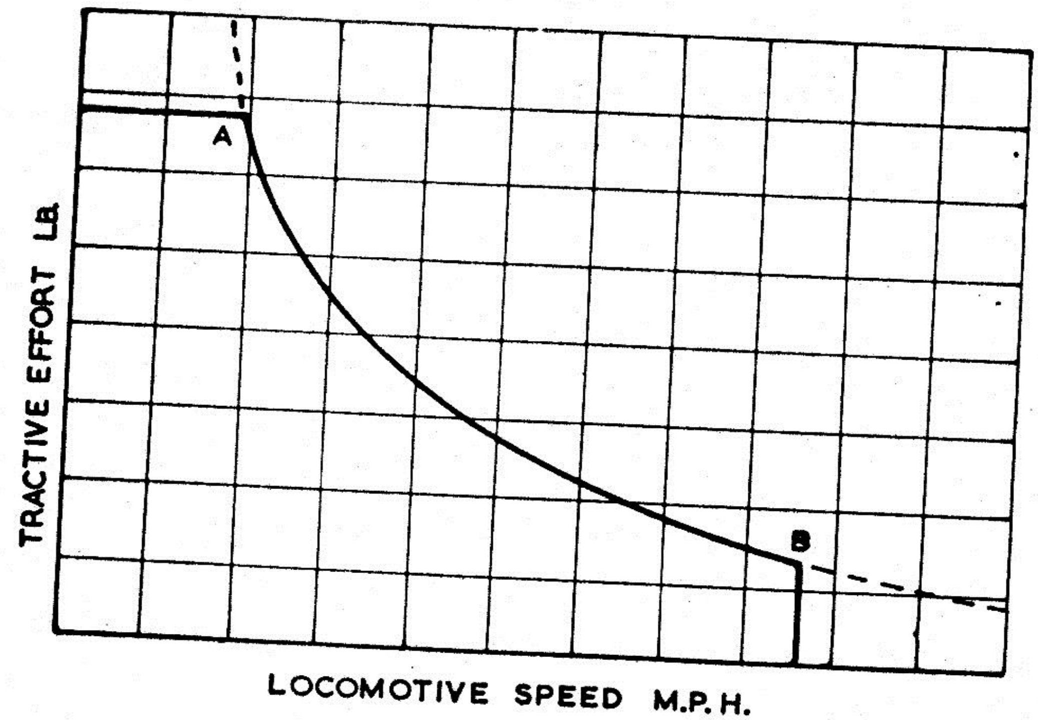


FIG. 3. *Theoretical relationship between locomotive speed and tractive effort at constant horse-power.*

Constant HP curve

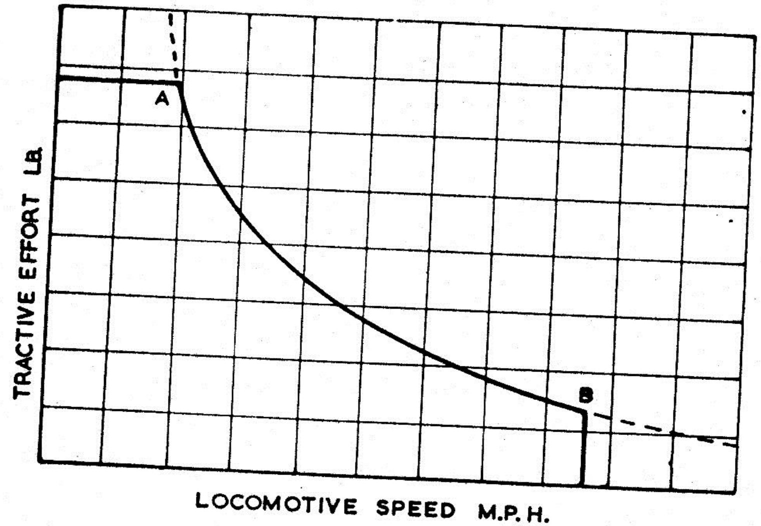


FIG. 3. *Theoretical relationship between locomotive speed and tractive effort at constant horse-power.*

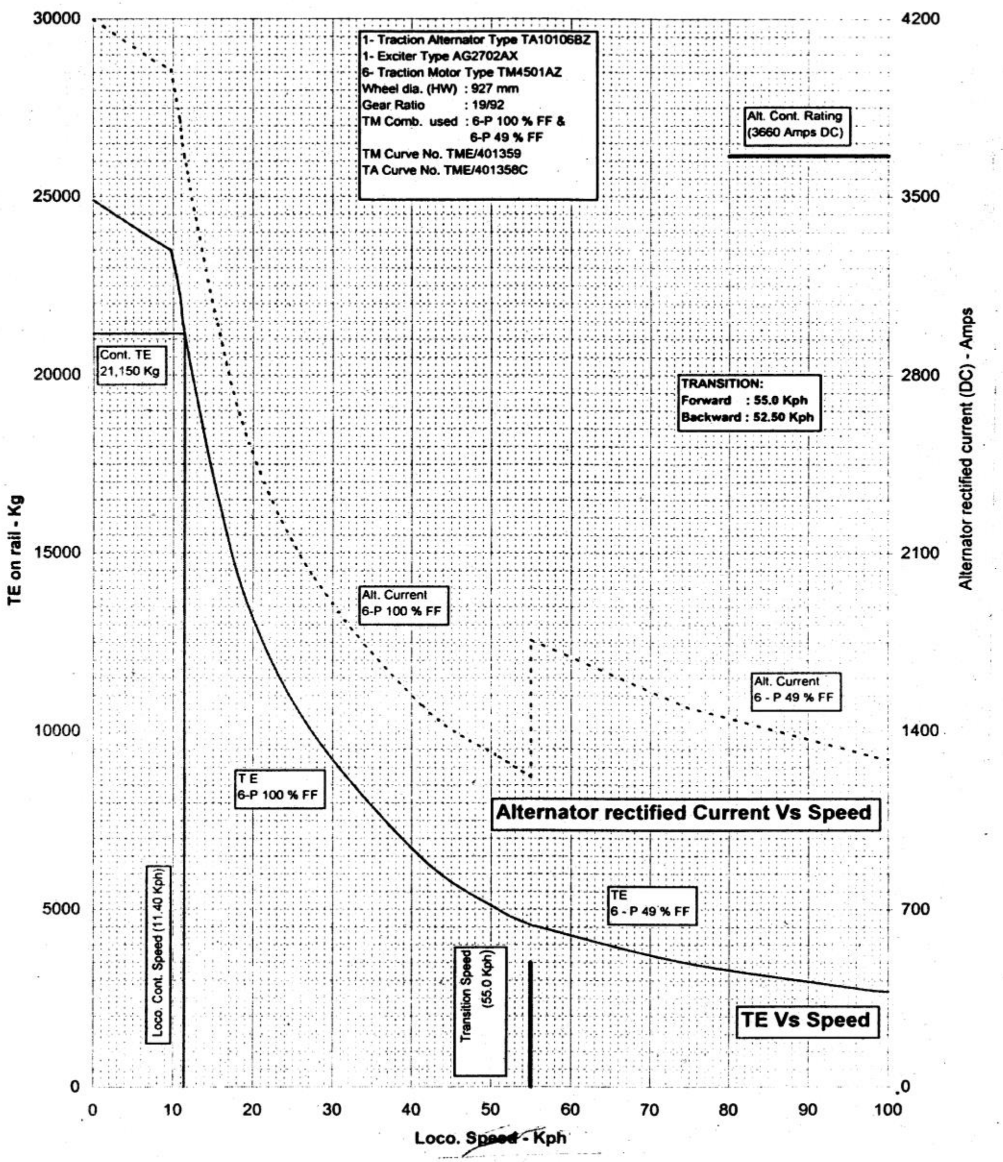
Any point on the curve gives the same HP output and the performance of the locomotive, in term of speed and tractive effort, is therefore fixed.

This constant HP curve could in theory, be extended indefinately at both ends but is limited at the high speed end ‘B’ by the maximum speed required in service and at the low speed end ‘A’ by the adhesion between wheels and rail.

Bharat Heavy Electricals Ltd., Bhopal
(Transportation Systems Group)

Performance of 1350 HP (UIC Cond.) MG DE Locomotive Type YDM4 for Myanmar Rlys

Input to traction : 1180 HP (Site Cond.) 8th notch - 1100 RPM
(700 V AC/DC System with type 'E' excitation control)



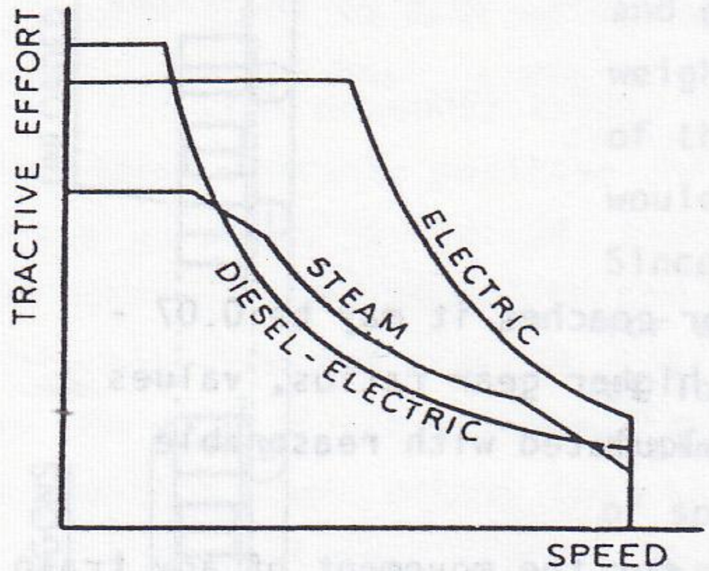


Fig. 35. Typical tractive effort-speed characteristics of different forms of locomotive.

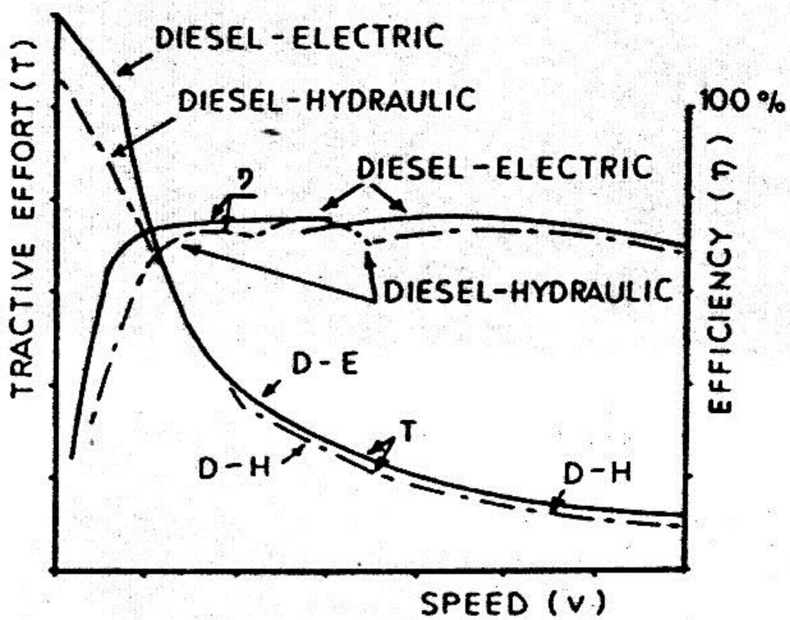
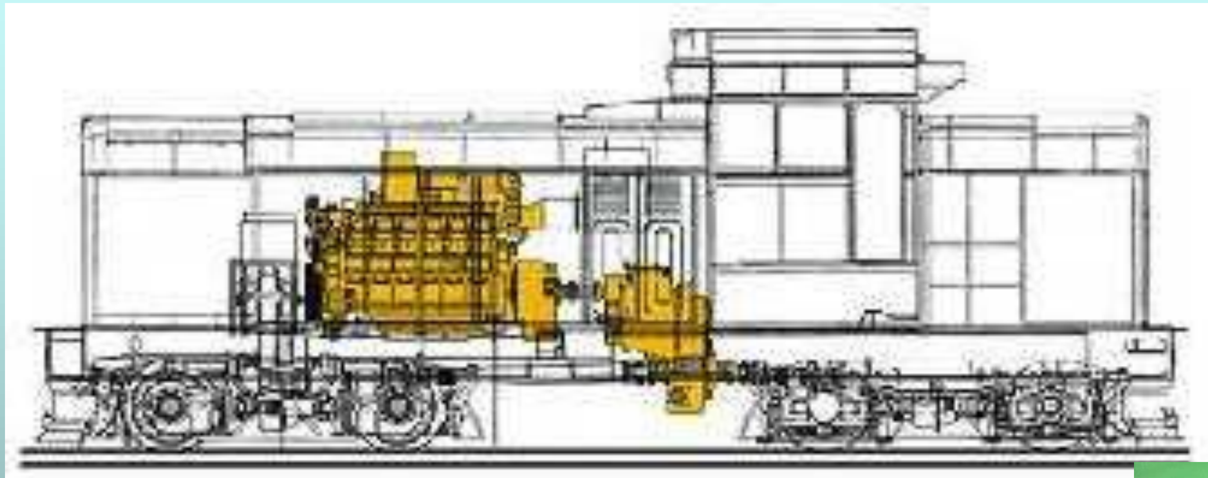
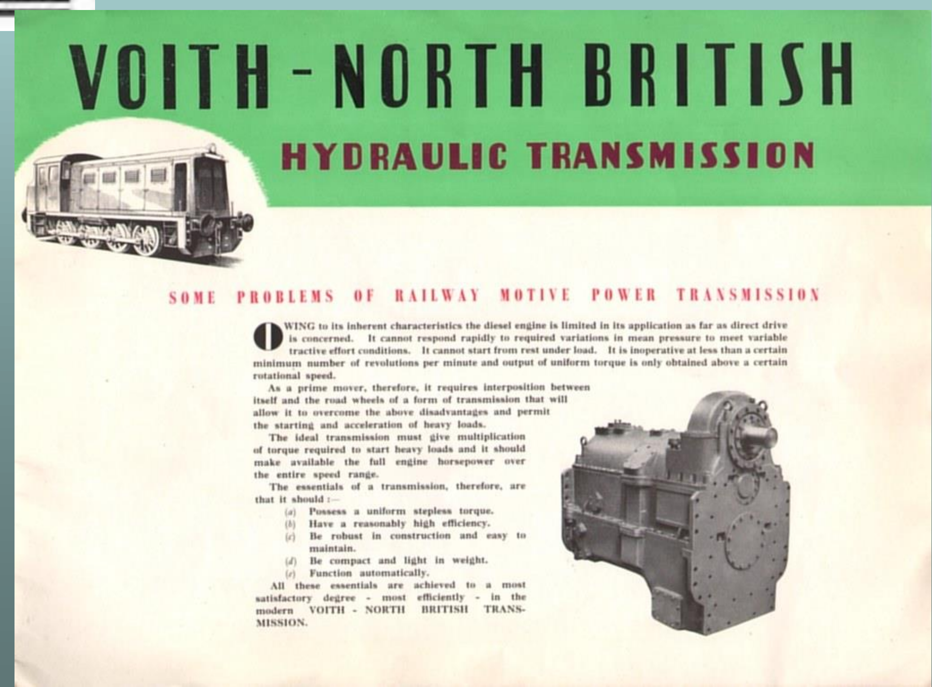


Fig. 228. Comparison of performance and overall transmission efficiency of two locomotives having similar engines but employing electric and hydraulic transmissions [8].

Hydraulic Transmission





VOITH - NORTH BRITISH

HYDRAULIC TRANSMISSION

SOME PROBLEMS OF RAILWAY MOTIVE POWER TRANSMISSION

OWING to its inherent characteristics the diesel engine is limited in its application as far as direct drive is concerned. It cannot respond rapidly to required variations in mean pressure to meet variable tractive effort conditions. It cannot start from rest under load. It is inoperative at less than a certain minimum number of revolutions per minute and output of uniform torque is only obtained above a certain rotational speed.

As a prime mover, therefore, it requires interposition between itself and the road wheels of a form of transmission that will allow it to overcome the above disadvantages and permit the starting and acceleration of heavy loads.

The ideal transmission must give multiplication of torque required to start heavy loads and it should make available the full engine horsepower over the entire speed range.

The essentials of a transmission, therefore, are that it should :—

(*a*) Possess a uniform stepless torque.
(*b*) Have a reasonably high efficiency.
(*c*) Be robust in construction and easy to maintain.
(*d*) Be compact and light in weight.
(*e*) Function automatically.

All these essentials are achieved to a most satisfactory degree - most efficiently - in the modern VOITH - NORTH BRITISH TRANSMISSION.

Electric Transmission

Basic Electrical Power

Watt = Rate of working when a steady current of one ampere flows enter a pressure of one volt.

Watt = Ampere x Volt

There are 746 Watts in one HP.

$$HP = \frac{\text{Amp. x Volt}}{746} = \frac{I \times V}{746}$$

1 kW = 1000 W

$$= \frac{1000}{746} = 1.34 \text{ HP}$$

Advantages

1. Smooth starting without shocks
2. Full driving torque available from standstill
3. Engine can be run at its most suitable speed range which gives higher efficiency.
4. Speed of traction unit auto adjust according to load and gradient so as to maintain constant output (not overload).
5. Not only work as torque converter but also work as reversing gear.

Types

1. DC- DC -> Engine drives DC generator supplying series traction motors
2. AC-DC -> Engine drives 3 Ph alternator supplying series traction motors through silicon diode rectifiers.
3. AC-AC -> Diesel Engine drives alternator in conjunction with rectifiers supplying three phase induction motors through frequency converters.

Basic Electrical Machines

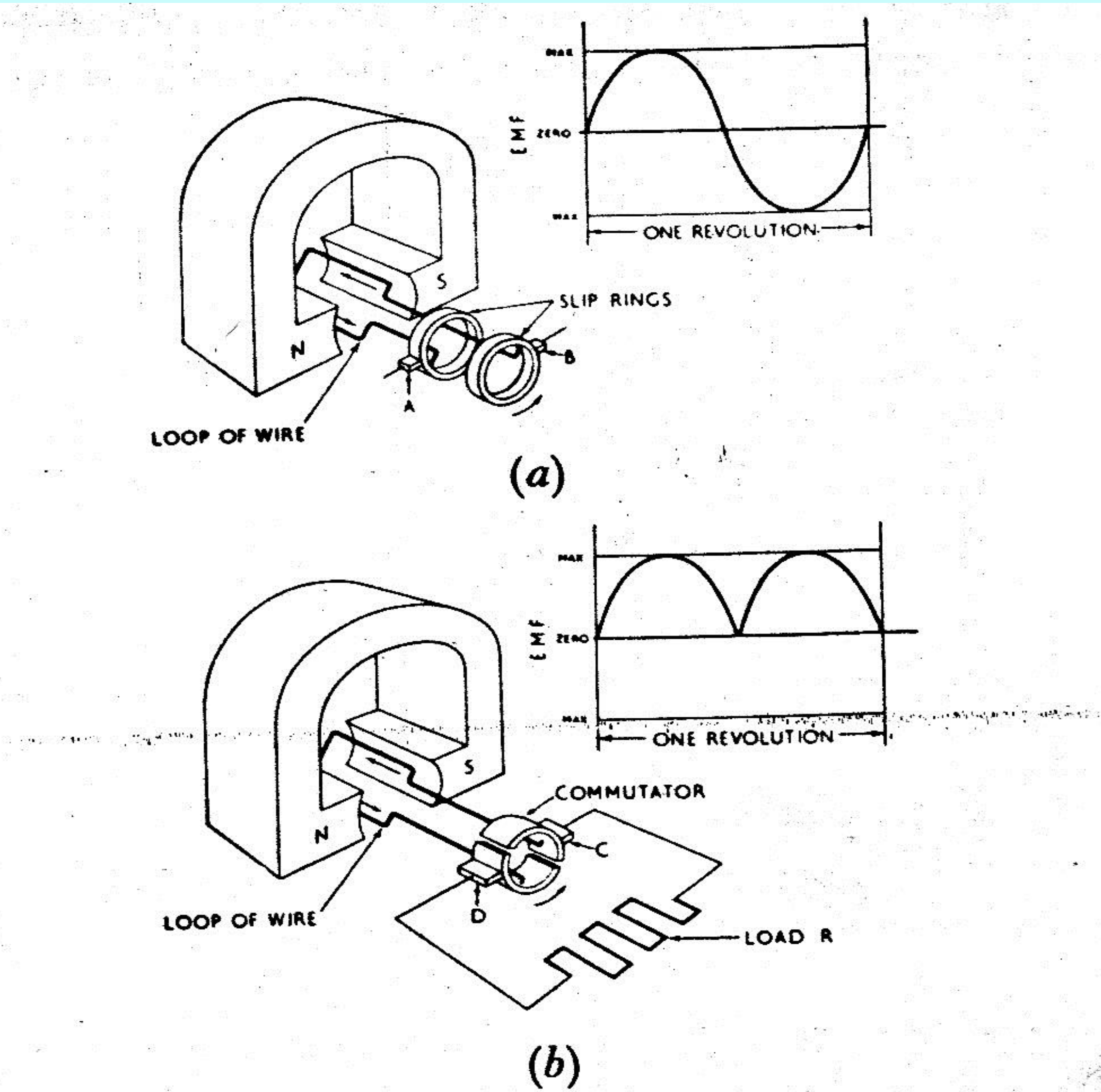


FIG. 49. (*a*) Principle of an alternating current generator.
(*b*) Principle of a direct current generator.

Diagram of essential feature of Diesel Electric Transmission

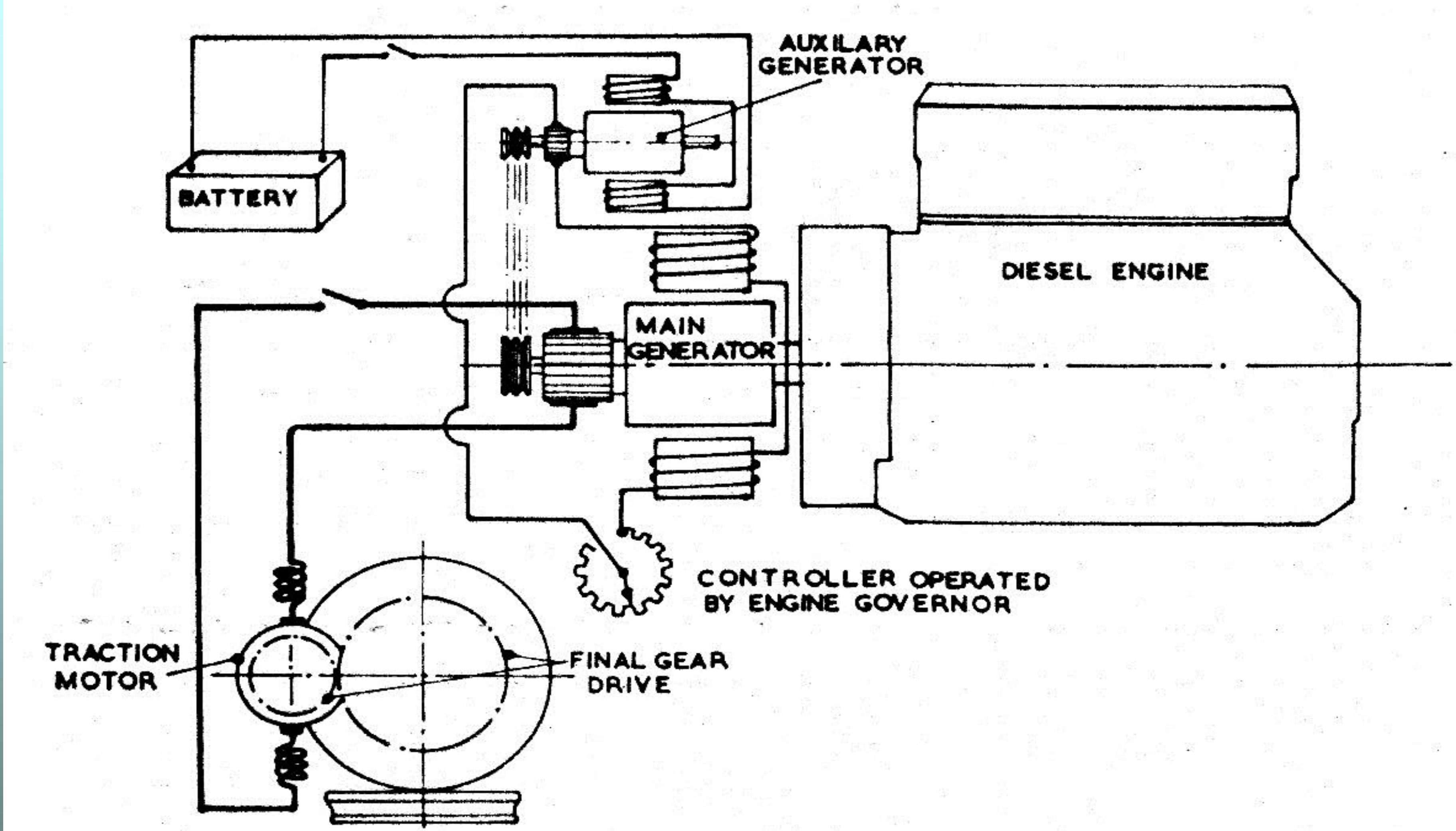


FIG. 50. *Diagram of essential features of diesel-electric transmission.*

Engine Loading

The ideal system of transmission for a diesel locomotive is one in which the full power of the engine can be utilized by conversion to tractive effort over the whole speed range of the locomotive.

(a) Over loading → drop in engine speed and output.

(b) Full output of engine will never be utilized.

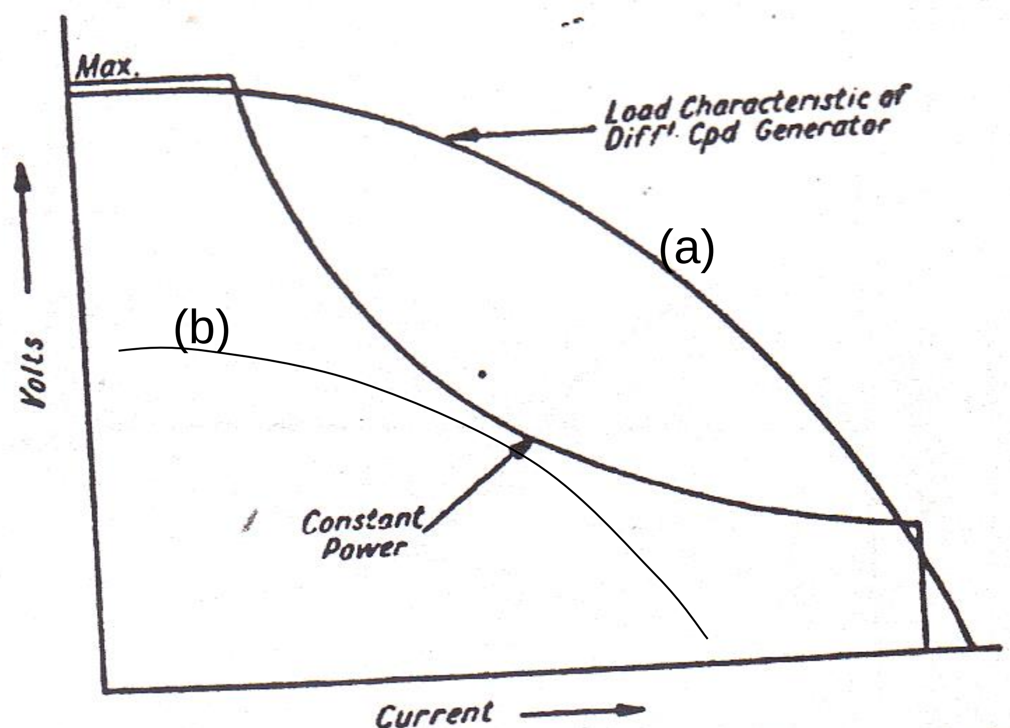


FIG. 120. Constant power characteristic (ideal), and load characteristic of differentially-compounded generator.

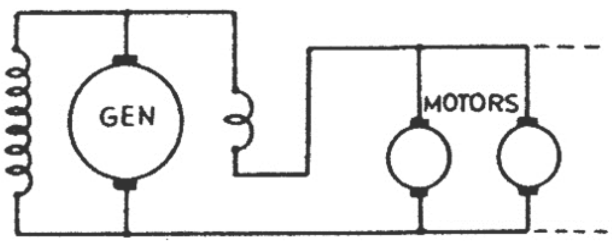
Loading Control

The generator output be regulated by varying the engine speed.

Speed and power output of diesel electric locomotive can be controlled by varying either the engine speed or generator excitation.

Engine speed by Master controller→ Governor

Excitation by Variable resistor



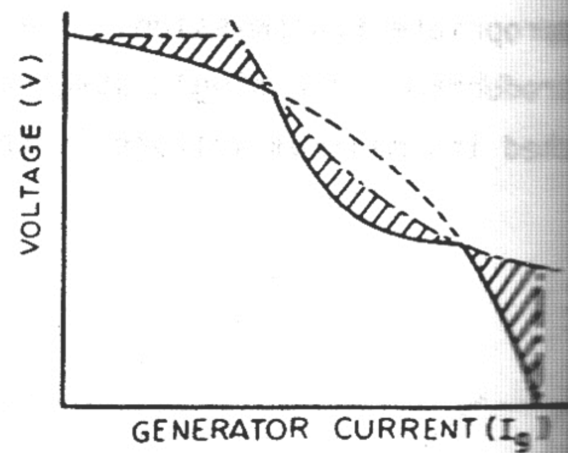


Fig. 206. Simple generator arrangement as used in small industrial locomotives or railcars.

Fig. 207. Generator performance obtained with the arrangement shown in Fig. 206. The sha
area represents loss of performance due to the generator characteristic.

Governor– (1) to reduce the fuel supply if speed tends to increase.

(2) to reduce the load if speed tends to fall

Dalian 2000 hp Diesel Locomotive

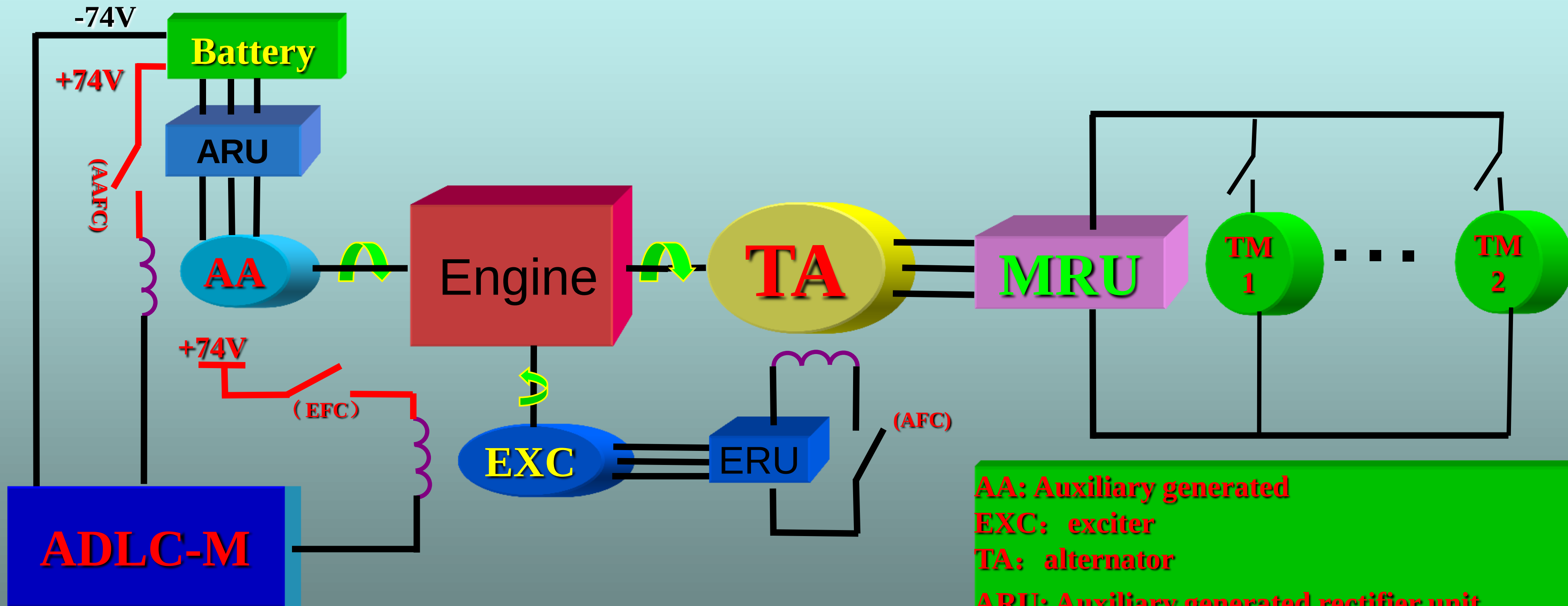
Electric system structure principle

$F = C_m \phi I$

$E = C_e \phi n$

$P = V I$

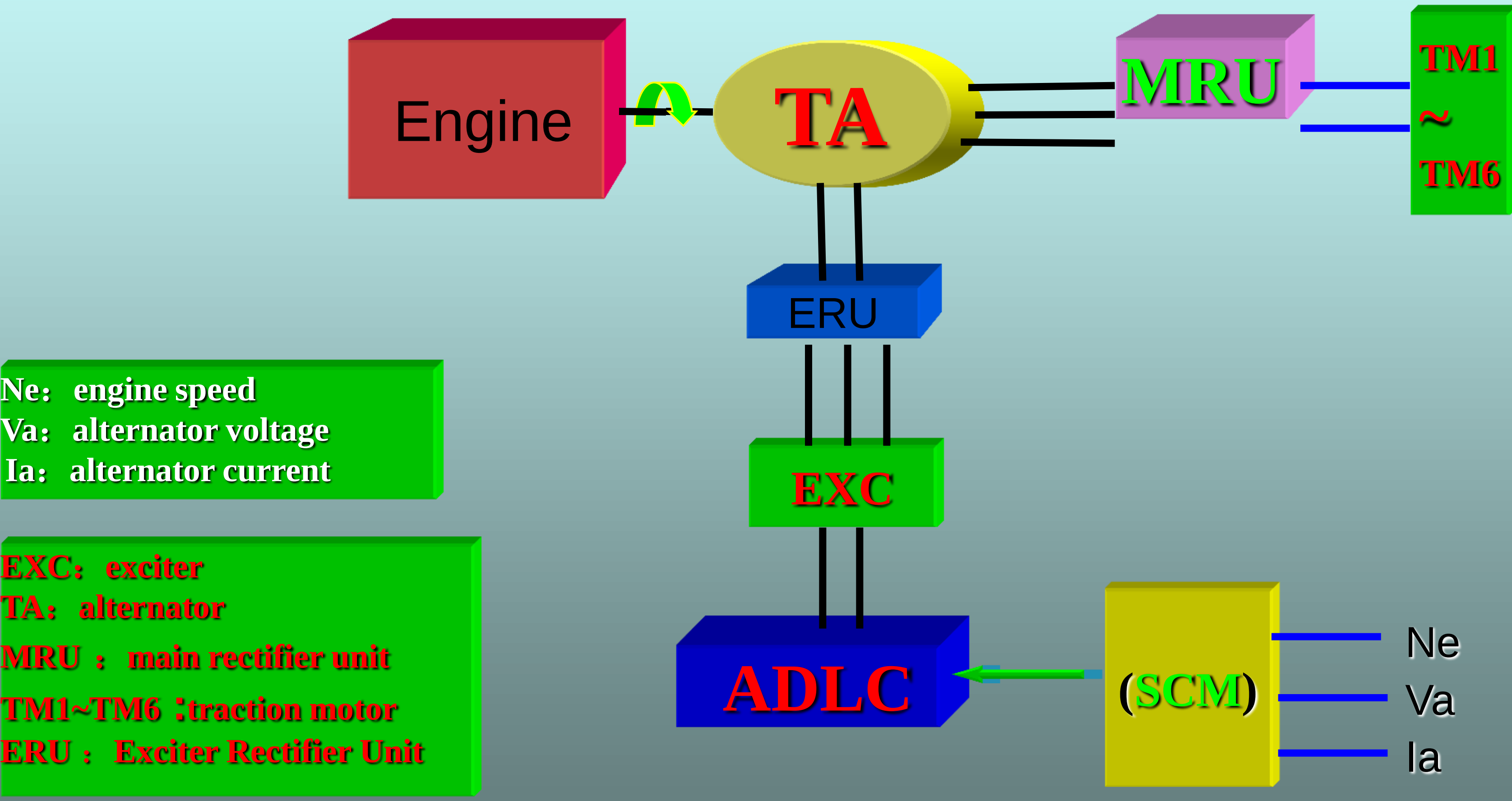
$V = I R$



- AA: Auxiliary generated
- EXC: exciter
- TA: alternator
- ARU: Auxiliary generated rectifier unit
- ERU: exiter rectifier unit
- MRU : main rectifier unit
- TM1~TM6 : traction motor

Main Transmission Constant Power Of Control System

It implements constant power output of the diesel engine (at certain speed) or voltage or current limit of the alternator by direct control of the excitation of the exciter



Alternator application in DEL

The Generator of a high-powered diesel electric loco to be a large and expensive to cover a wide range of V & I.

For mechanical reason, commutator circumferential velocity is limited.

Min. value for the commutator bar width of 3.2 mm with an insulated gap of 0.8 mm, giving pitch of 4.0 mm are generally accepted.

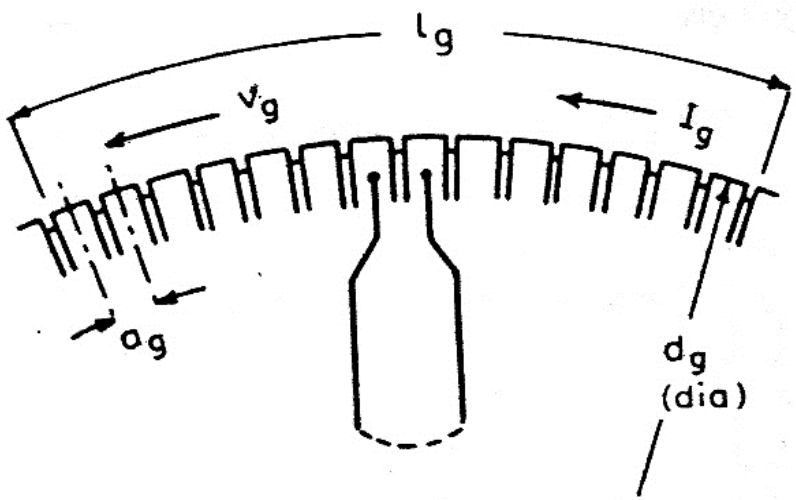


Fig. 211. Arc of a typical generator commutator.

Max. power which can be produced by such a generator is directly proportional to its commutator, but if this is increased, the speed of rotation must be reduced proportionately.

To avoid the limitation, alternator replaces the DC generator for high power locomotives. Alternator is brushless.

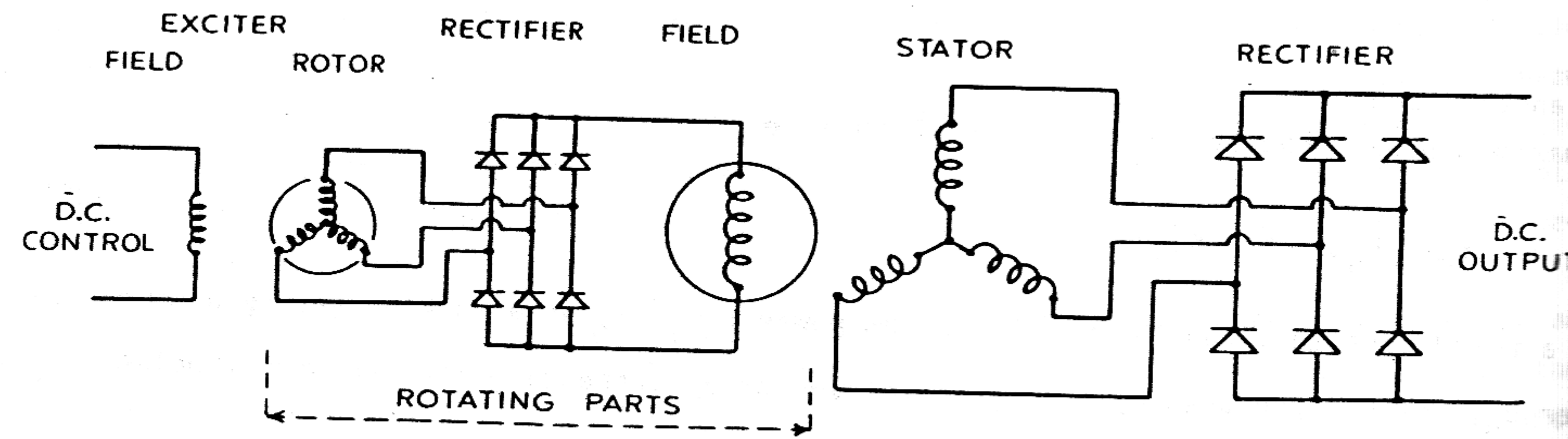


Fig. 212. Circuit of "brushless" A.C. generator.

Braking

Braking is application of negative tractive effort to the train. Characteristic of equipment needed for normal deceleration may be considered on the same line (for acceleration). But for safety reason, braking is normally applied to all the wheels of the train.

Theoretically the limiting value of retardation obtainable be (u g) where u is limiting value of friction at the wheel rail contact and g is gravitational constant.

Max. value 2.5 m/s^2 (deceleration)

But British railway recommended 1.2 m/s^2 (deceleration)

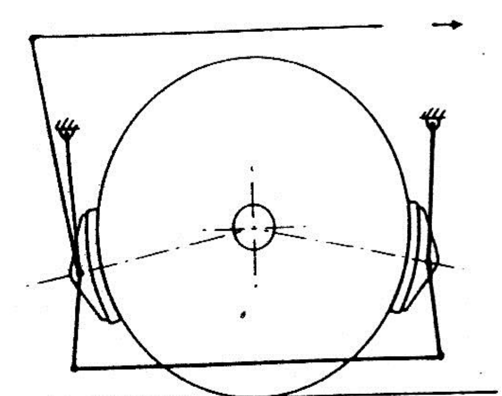


Fig. 258. Typical arrangement of "double acting" braking.

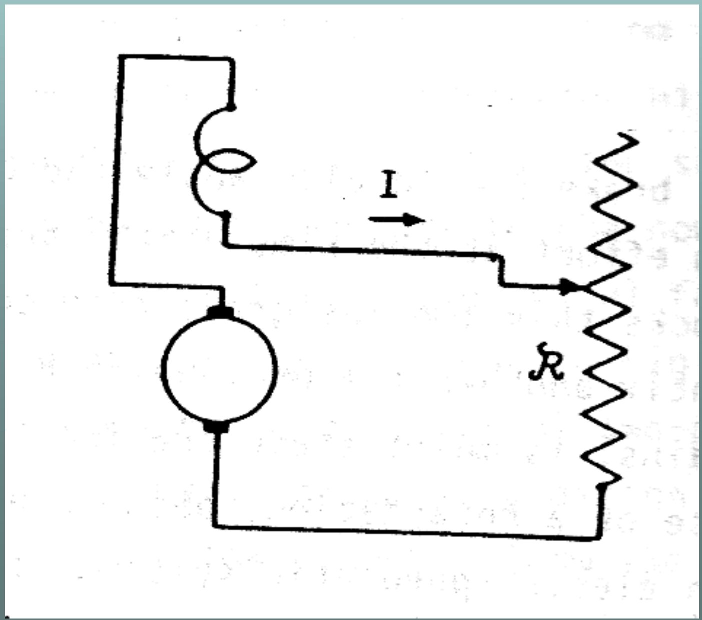
A DANGEROUS JOB
Before brakes were controlled solely from the engine, many railroad cars had brake vans, with hand-operated screw brakes manned by brakemen. The train engineer coordinated the braking with signals from the engine whistle.

Rheostatic Braking

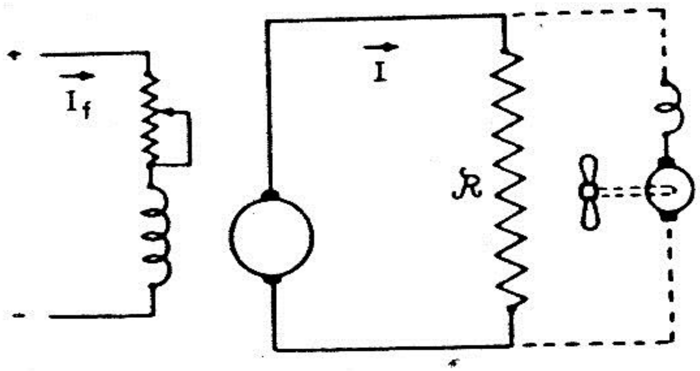
Rheostatic braking of locomotive by DC motor-

- Easily controllable
- Independent
- Reliable

If DC series motor is disconnected when running at speed v and reconnected with its field connections reversed, across a variable resistor of resistance R as shown in fig., it will, provided that the value of 'R' is not too great, built up as a generator forcing a current 'I' through the armature in the reverse direction, the resultant power being absorbed in the resistor.



The series field winding of motor can be used for separate excitation.



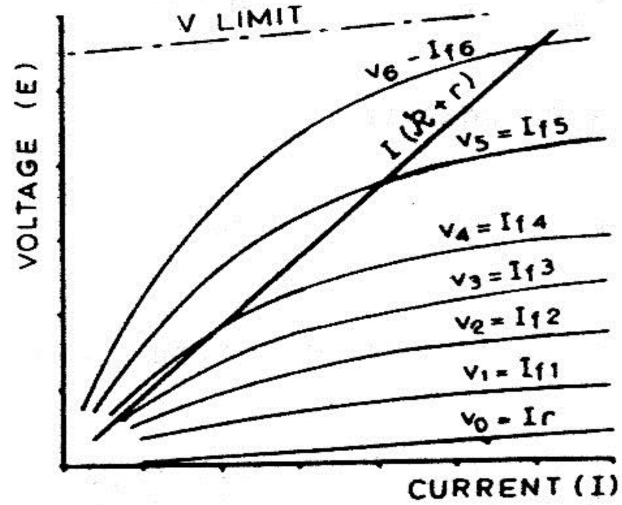


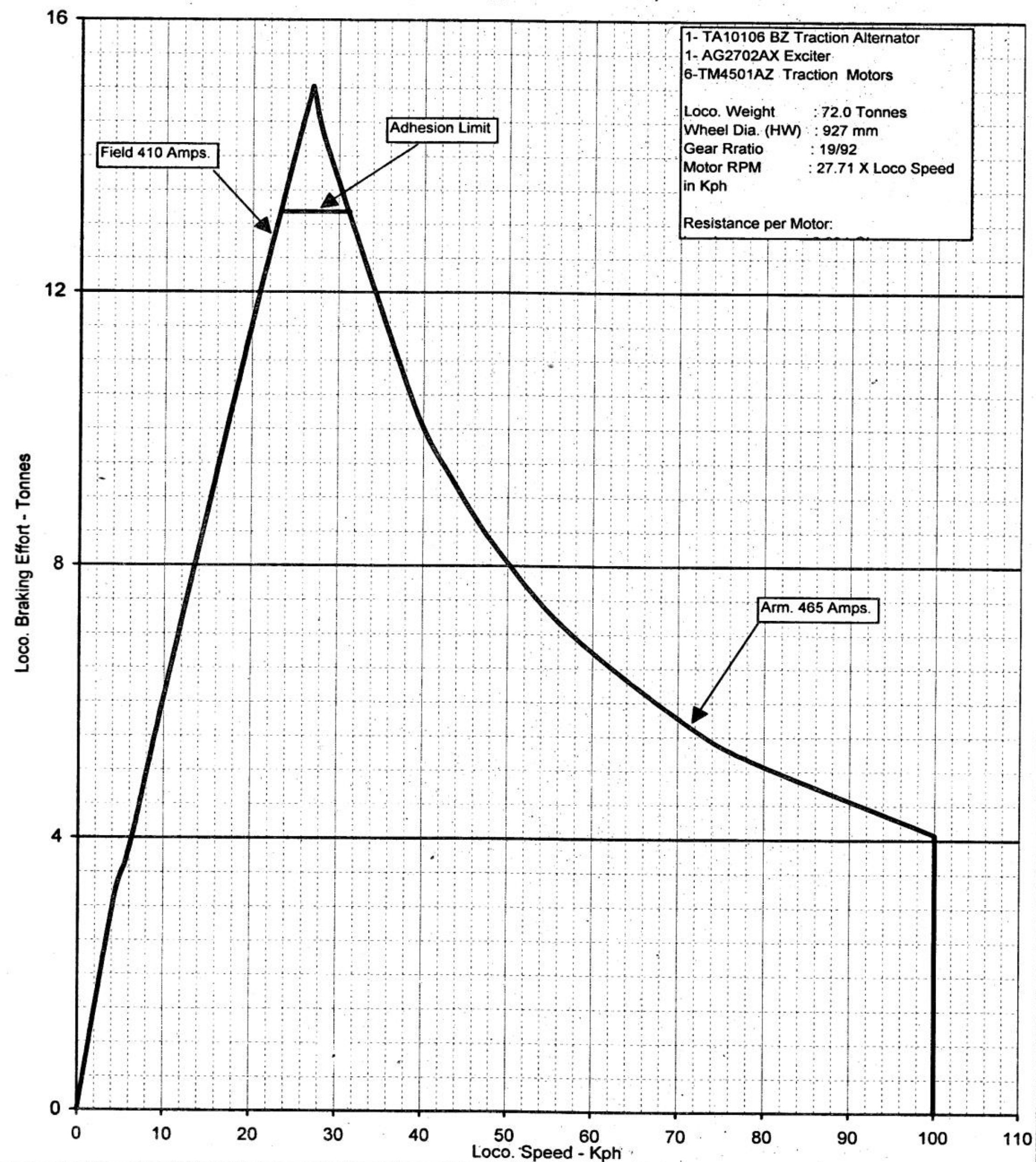
Fig. 279. Use of D.C. motor with separate excitation and fixed resistor for rheostatic braking.

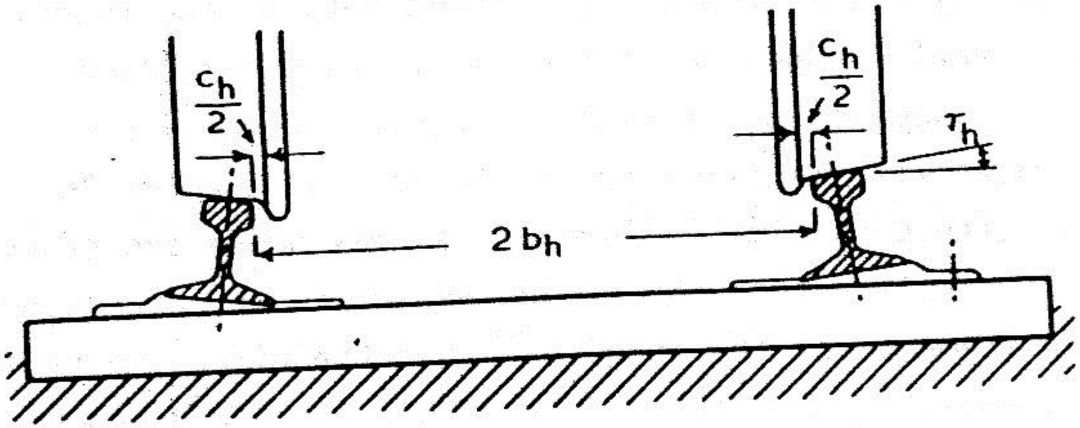
Fig. 280. Characteristics of D.C. separately excited motor with fixed resistor used for rheostatic braking.

BHARAT HEAVY ELECTRICALS LIMITED

TRANSPORTATION SYSTEMS GROUP

Dynamic Braking Characteristic of 1350/1180 HP
MG DE Locomotive Type YDM4 for Myanmar Railways
(700 Volts AC-DC system with type 'E' excitation control)





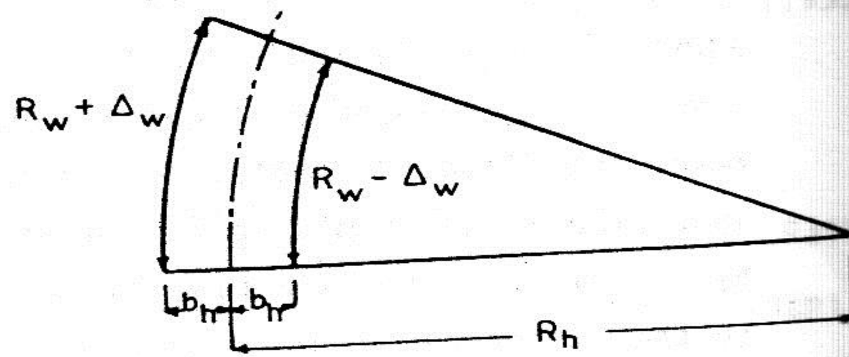


Fig. 417. Arrangement of conventional track.

Fig. 418. True rolling of wheelset of one radian around a curve.

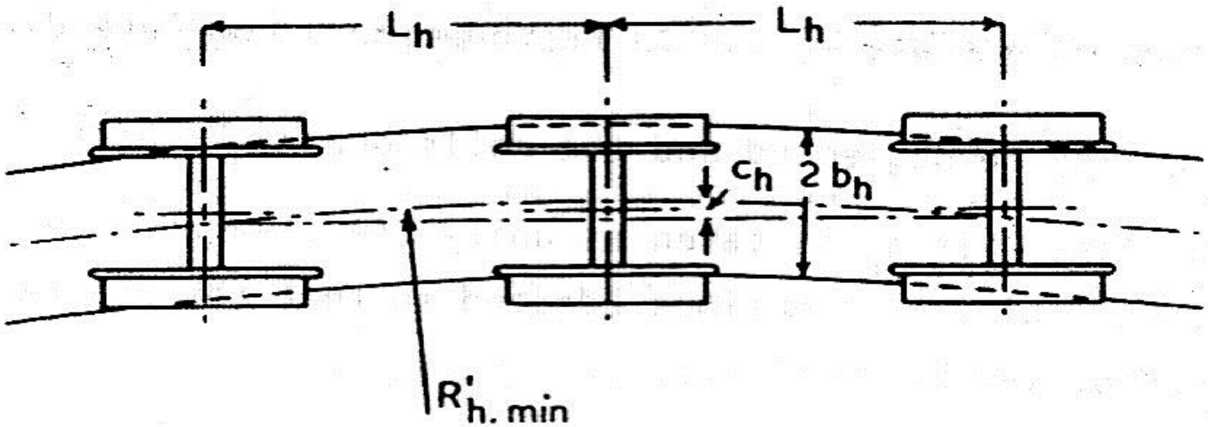


Fig. 419. Passage of a six-wheeled vehicle around a sharp curve.

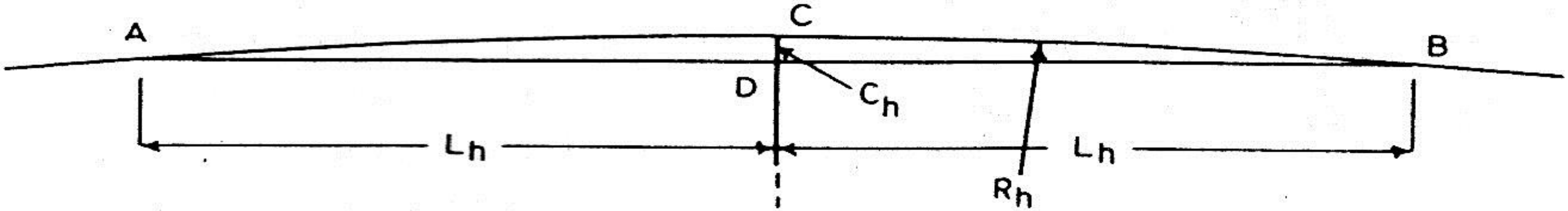
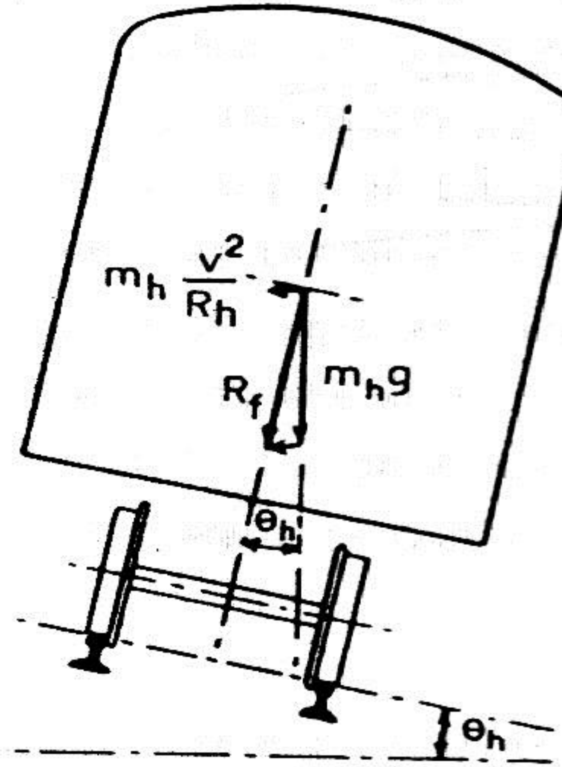


Fig. 420. Curve and adjacent point drawn to consistent scale.



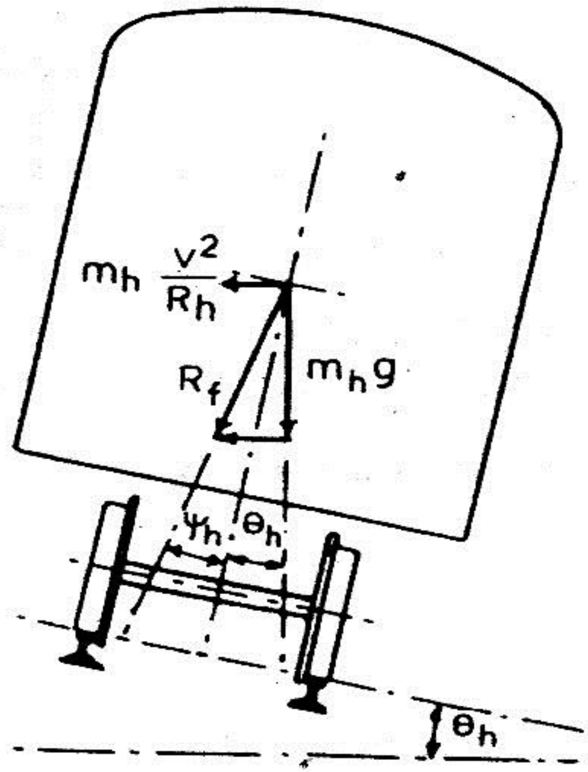


Fig. 423. Vehicle passing round a curve with superelevated track.

Fig. 424. Vehicle passing round a superelevated curve with cant deficiency.

Track Irregularity

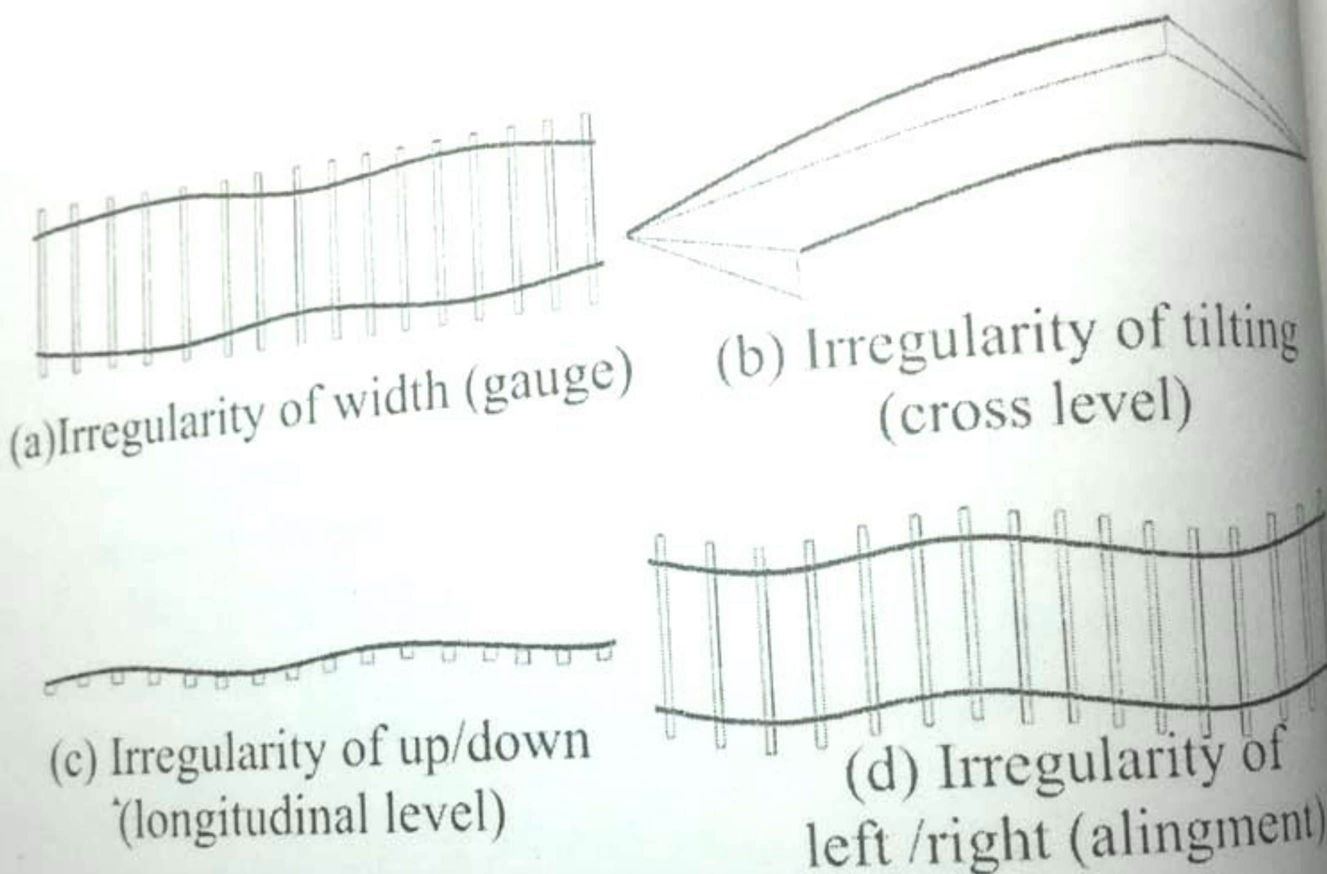
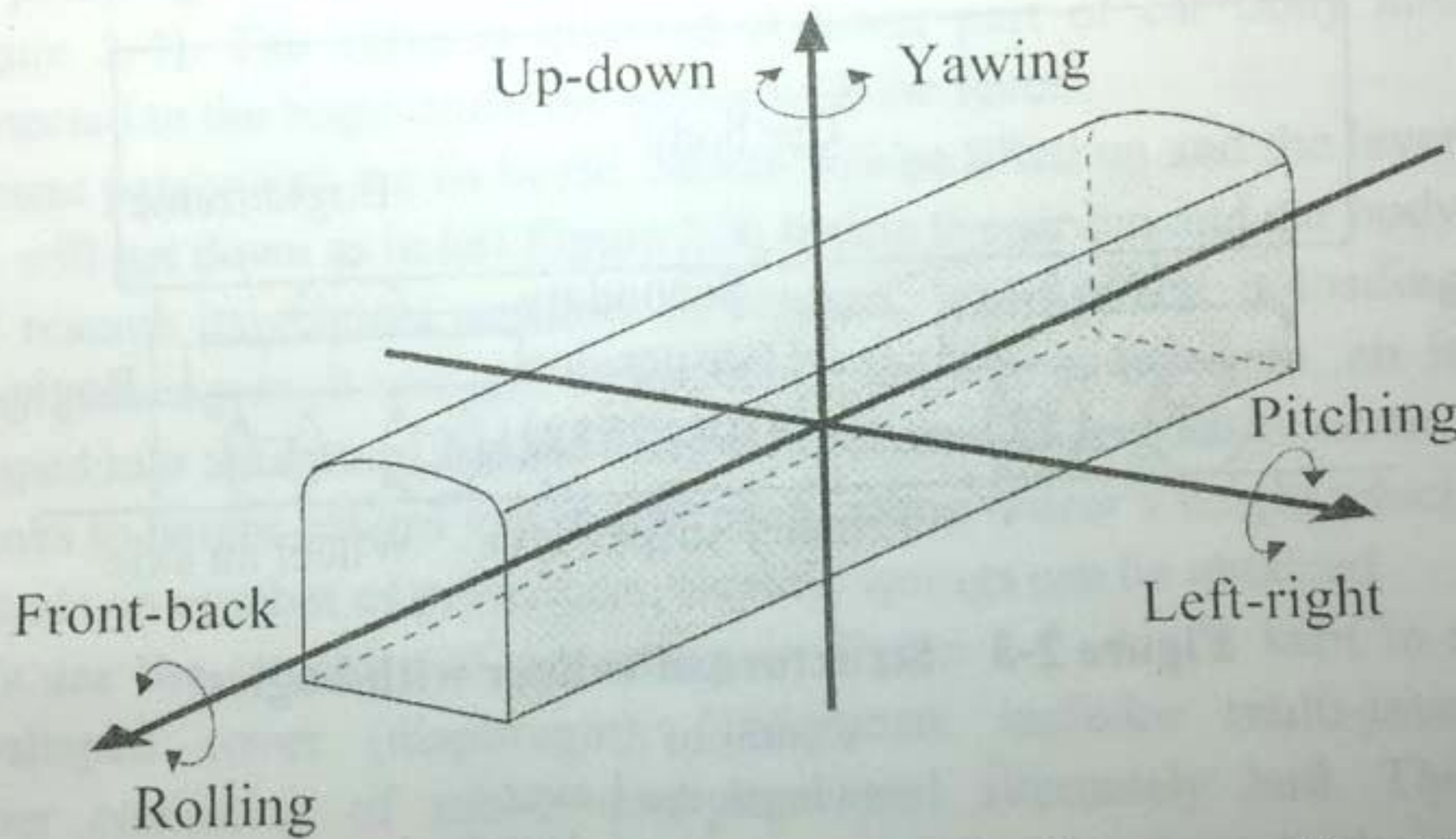


Figure 2-1 Track's inconsistence

Rolling Stock Vibration



3 axis of rolling stock and vibration around 3 axes

Rolling Stock Suspension

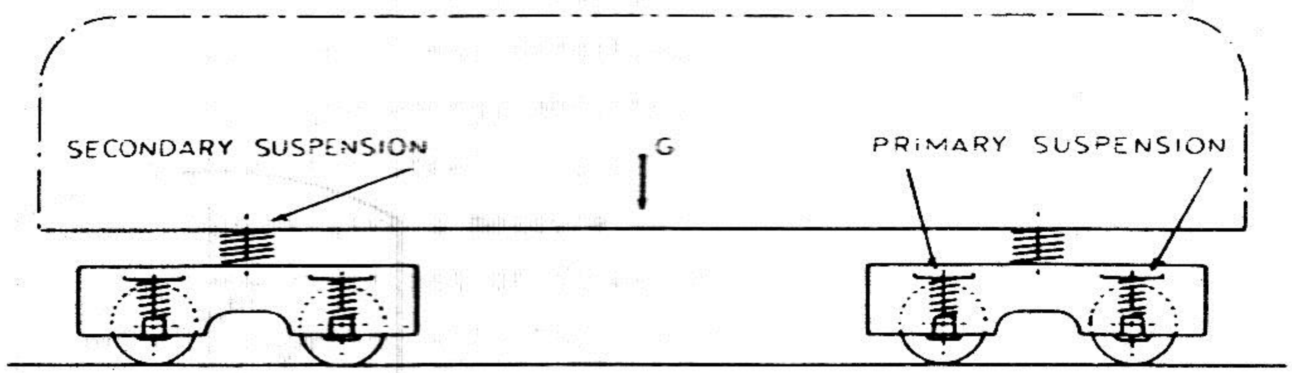
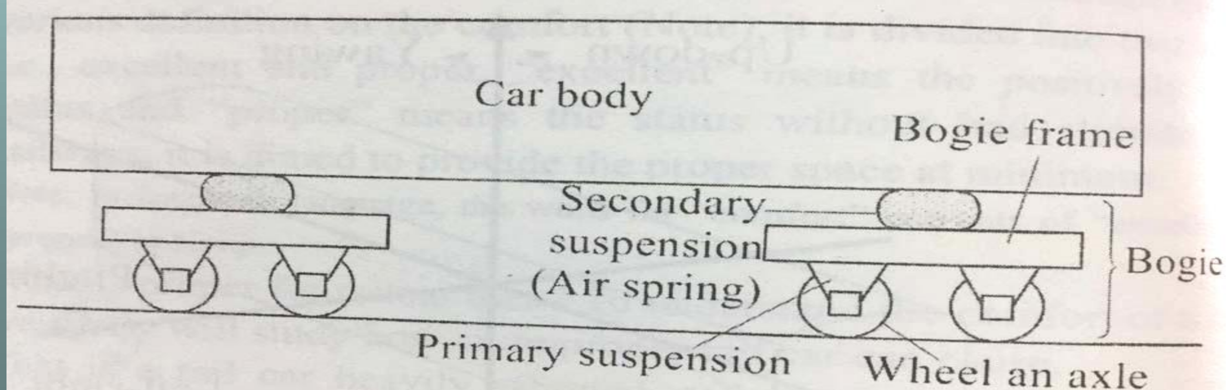
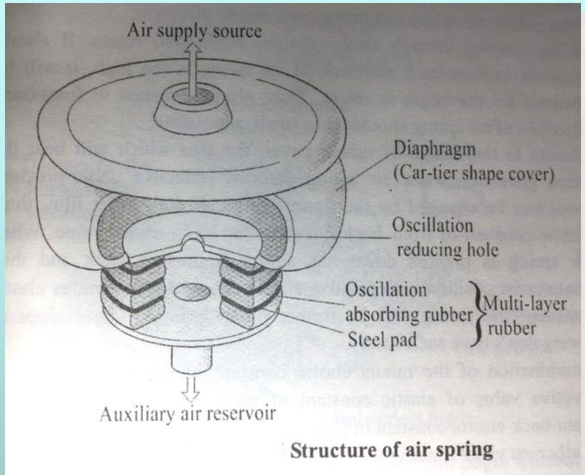


Fig. 392. Suspension of a typical railway vehicle.



Structure of railcar with bogies

Air Bag Suspension



Structure of air spring

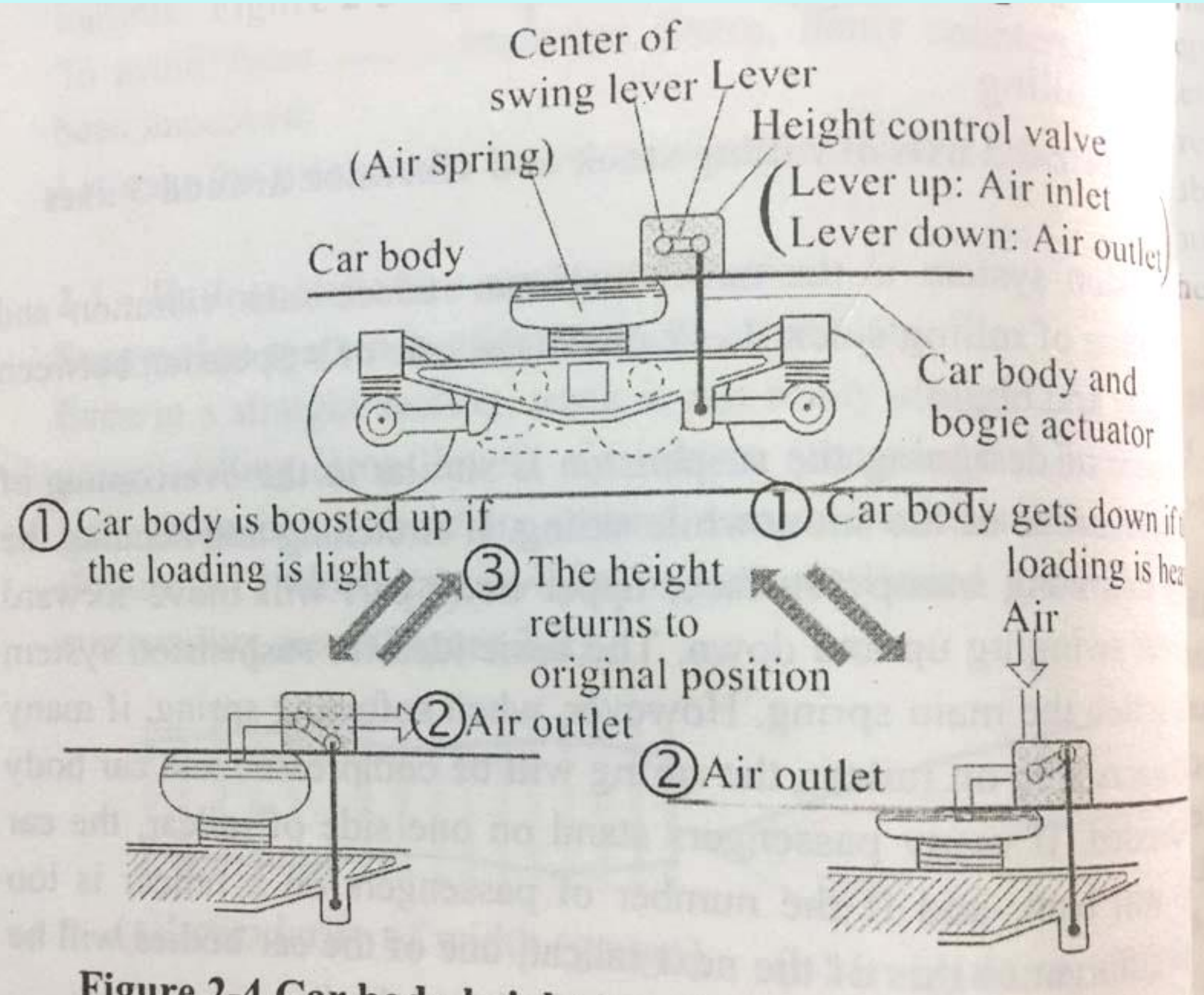
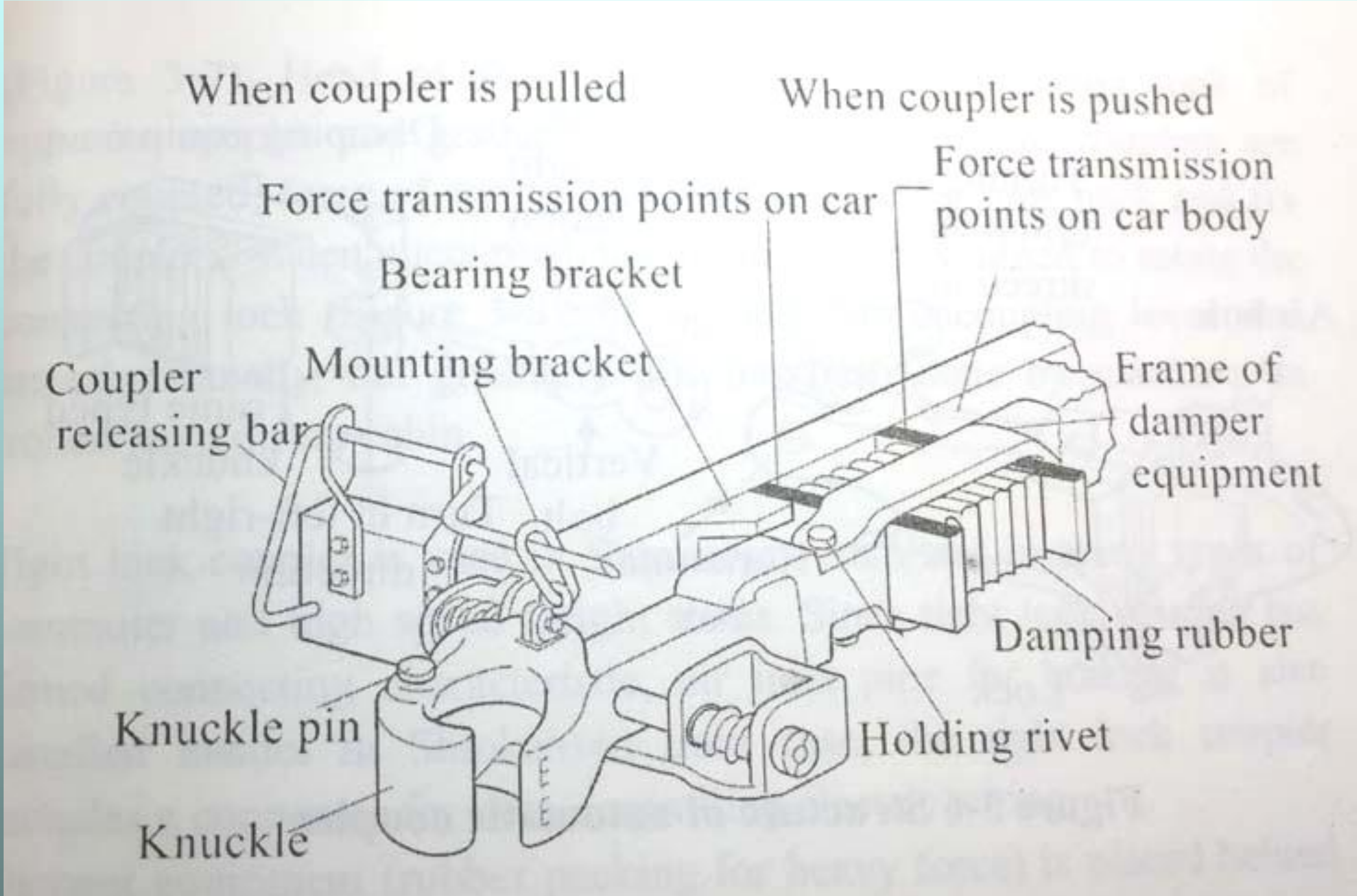


Figure 2-4 Car body height-keeping structure with air sprin

Buffer Coupler



Structure of British couplers

Thank You
Q & A

References;

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2.The Diesel Locomotive by R.L. Aston

3.Illustrated Science of Railways by Dr Masayuki Miyamoto

4.စက်ခေါင်းအင်အား အသုံးချခြင်း ဆိုင်ရာ လုပ်ထုံးလုပ်နည်း လက်စွဲ