

# DYNAMIC BRAKING

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# OBJECTIVES

**After completion of this unit, you should be able to:**

- Understand the principle of operation of Resistive Brake
- Learn a motor can run as a generator
- Appreciate the braking control
- Understand the effectiveness of Dynamic Brake
- Appreciate the characteristic of Dynamic Brake
- Appreciate the requirement of auxiliary systems

# STRUCTURE

1. Introduction: Principle of operation
2. Motors as generators
3. Braking control
4. Re-calibration of system
5. Dynamic braking effectiveness
6. Protection against wheel sliding
7. Braking effort and its characteristics
8. Auxiliary systems: Resistor cooling and motor cooling
9. Train brake application with dynamic brake

# 1. INTRODUCTION

## PRINCIPLE OF OPERATION-RESISTIVE BRAKING

- The installation of dynamic braking on diesel electric locomotives has become quite common.

- By taking advantage of the traction motors ability to act as a generator, the diesel electric locomotive offers a form of braking power which, without the use of air, can be used as a speed controlling brake on grades or a slowing brake on level track.

- Use of dynamic brake lessens brake shoe and wheel wear on both locomotive and train.
- On long down grades dynamic brake operation enables a train to be handled with fewer air applications.

- This results in safer train operation, due to the locomotive and car wheels running cooler.
- In Fig.1 the action of wheels with dynamic braking is shown.

- The momentum of the train turns the wheels. This drives traction motor as generator and forces current through the braking resistors as shown by the arrows and the resistors heat up.



- The traction motor, working as a generator, resists the turning of the wheels and tends to stop it, so the motor is used to do the same thing as the brake shoes.

- In this case the braking resistor and motor instead of the brake shoes and wheel get hot. Hence, the blowers must cool them.
- The wheels and brake shoes do not wear because there is no rubbing.
- To have dynamic braking the wheels must be turning.

- This is because generator generates only when it is turning.
- So the dynamic braking cannot be used to hold or stop train. For this purpose air brakes are to be used.
- In Fig.2, how dynamic braking works on a four motor locomotive is shown.

- The momentum of the train pushes the locomotive and turns the wheels, which drives the motors.
- The output of the motors is fed into the braking resistors.

- The driver controls the braking by moving the selector handle.
- A load-meter shows him how much braking current he is getting.

## 2. MOTORS AS GENERATORS

- We know that DC machine can be used as either a motor or a generator.
- Fig.3 (a) shows the motoring connections.

- Current is being pumped through the motor armature and field by the generator.
- This causes the motors to turn and move the locomotive.
- In Fig.3 (b) switches have been shown to change the motor connections.

- Now the generator pumps current through the motor fields only.
- Two things have happened to the armature-
  1. It was cut off from the generator,
  2. It was connected across the braking resistor.



- Now we have separated the motor field from its armature and are pumping current through the field only.
- If the locomotive is moving, the wheels are turning and driving the armature.


- It is connected across a resistor so that it has load.
- In electrical language we have a separately excited generator with a load resistance.

- In Fig.3 (b) we see that the field current is flowing in the same direction as in 3(a).
- But the armature current is reversed in (b).

- If we reverse the field current , the armature current will flow in the same direction as in motoring (a) i.e. if we change from motoring to braking if the field current stays the same, the braking current will reverse.

- If the field current is reversed, the braking current will stay the same.
- There are some points about the Fig.3 circuit to be known for understanding dynamic braking: -


1. The more current we put through the motor field, (within certain limits) the more braking current we will get.
2. The lower the braking resistance, the higher the braking current (this resistance is fixed when the locomotive is built).


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3. The faster the armature turns, the higher is the braking current.
  4. The higher the braking current, the more braking we get.


## 3. BRAKING CONTROL


- The key to controlling the output of almost any generator is its field.
- In this case, it is the traction motor field. Ref. Fig.3, the main generator supplies the current to the traction motor field.

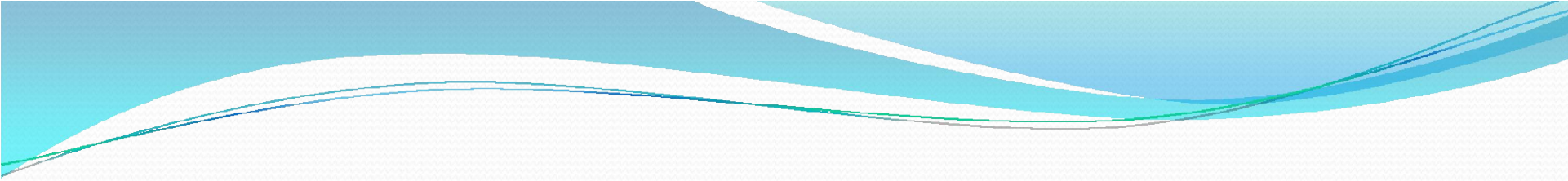


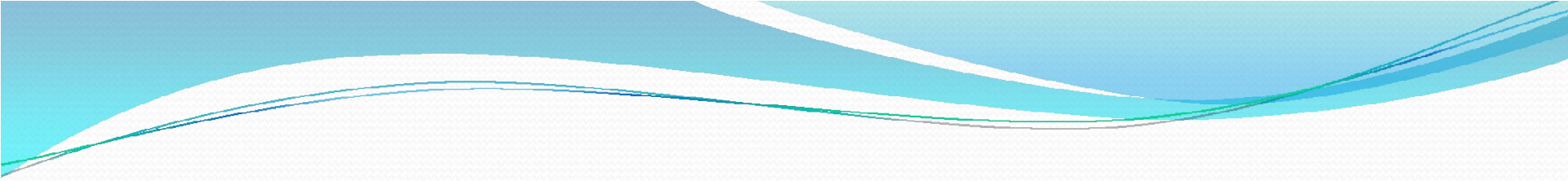
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- In excitation system chapter we have seen how the main generator output is controlled in motoring.
  - The same control is used for braking, but the generator is connected to the motor field only.

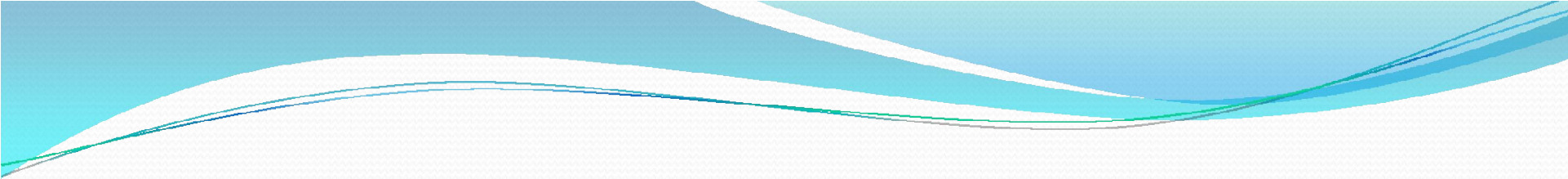
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- By controlling this we control the dynamic braking current.
  - The driver does this by moving the selector handle.

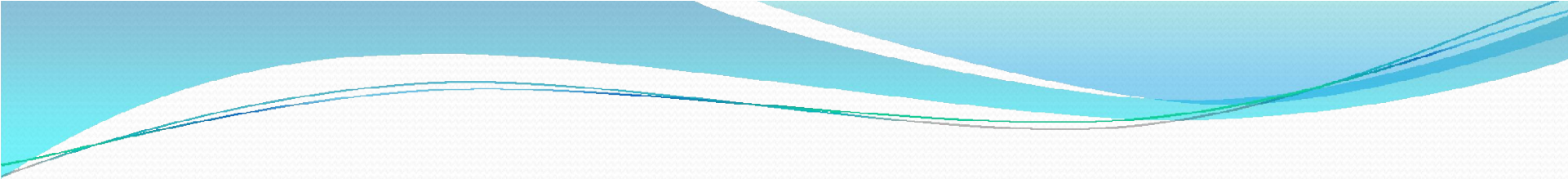
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- For example at high train speed we need a weak motor field to hold the braking current to a reasonable value.
  - This calls for a small main generator output.

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- The driver achieves this by moving the selector handle.
  - At low speed we need a strong motor field to get full braking current.
  - He gets this by moving the selector handle further into the braking sector.

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- The driver can get the amount of braking he wants for any speed by moving the selector handle.
  - The capacity of braking resistors is limited by the amount of heat it can withstand.

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- To prevent them from getting damaged blower fans are used.
  - The power for driving these fans is used from the power generated during the application of dynamic brake.


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- When there is no braking current, the fans do not run, but as the braking increases, with that the braking current and heat increases and also the fan speed increases hence giving more cooling.

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- Braking resistors usually require little attention.
  - Dirt and water are the biggest source of trouble.



## 4. RECALIBRATION OF SYSTEMS

- Assume that a train is drifting downgrade, and that the engine-man is preparing to apply the dynamic brake moves the throttle to “IDLE” position.

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- With the throttle in 'idle' all power contactors drop out and the motor-generator circuits become completely de-energized.
  - Now the engine-man moves the selector handle from whatever motoring position it was in, to the 'off' and then to the 'Big D' position.

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- Moving the SH to 'Big D'

accomplishes the following:

- i. Causes braking switch (BKT) to throw reconnecting the power circuits:
  - Connects all motor fields in series,
  - Connects series motor fields across main generator,
  - Connects motor armatures across braking grids.



ii. Energizes braking relay (BKR) which:

a) Raises engine speed to 4th notch,

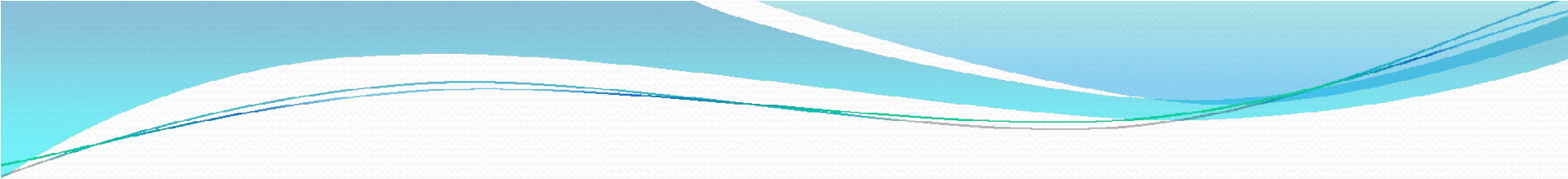
b) Replaces engine speed signal with braking control signal at reference-mixer circuit.


c) Re-calibrates control circuits as required,

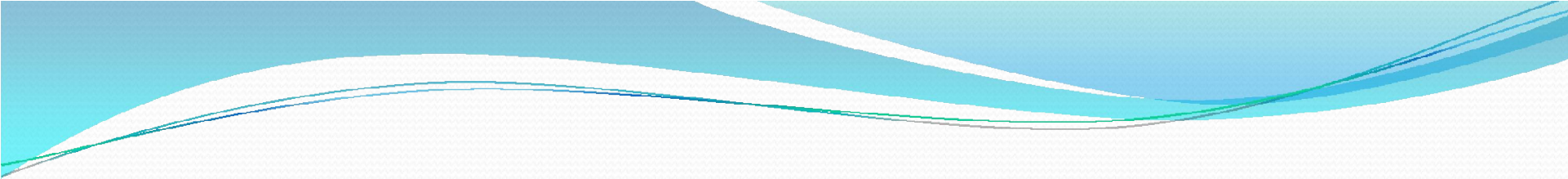


iii. Sets up braking potentiometer (BKCP).

- Figure.5 shows a typical motor-generator circuit for a 4 motor locomotive.

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- All power contactors are in their braking positions and the directions of current flow are shown.
  - Note that the starting field is in the circuit with the generator armature and motor fields during braking.

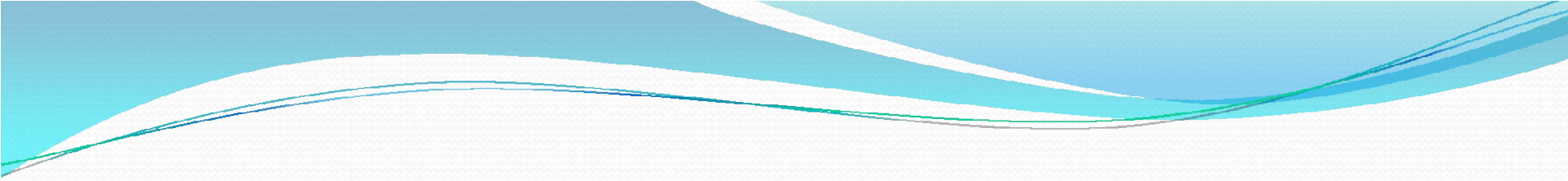
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- This is done to make the generator more stable at the very low range of voltages used in braking.
  - Current in the starting field creates an opposite effect to that in the shunt field; consequently much more exciting terminal voltages than would otherwise be needed.

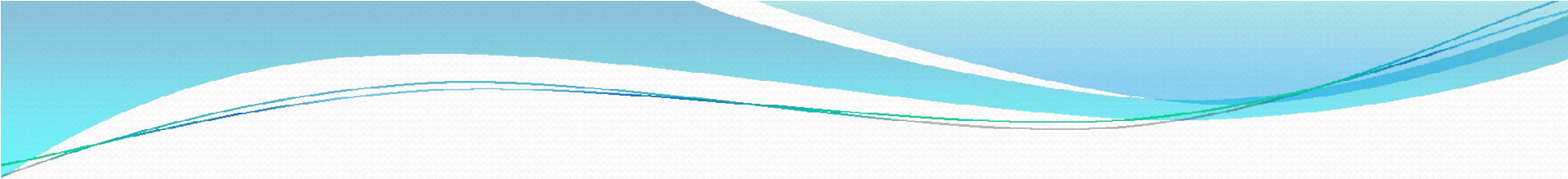
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- This makes it possible to operate the exciter at output levels more nearly comparable to those in motoring.



## **5. DYNAMIC BRAKING EFFECTIVENES**

- Maximum braking excitation (selector handle all the way forward) will give maximum braking effort for any locomotive speed.


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- If, for example, the engine-man imposes maximum excitation at a speed of say a few miles per hour; the braking effort will be relatively low because the armatures are turning slowly.

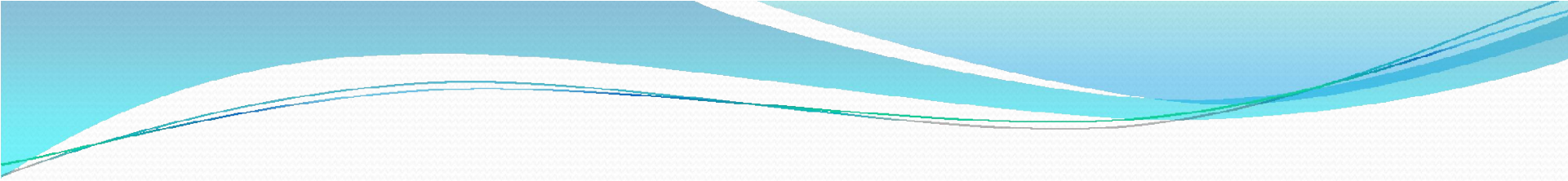
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- If, on the contrary, the train is moving faster, the higher rotational speed of the armatures will tend to cause a higher current to flow through them, therefore, a greater braking effort will follow.

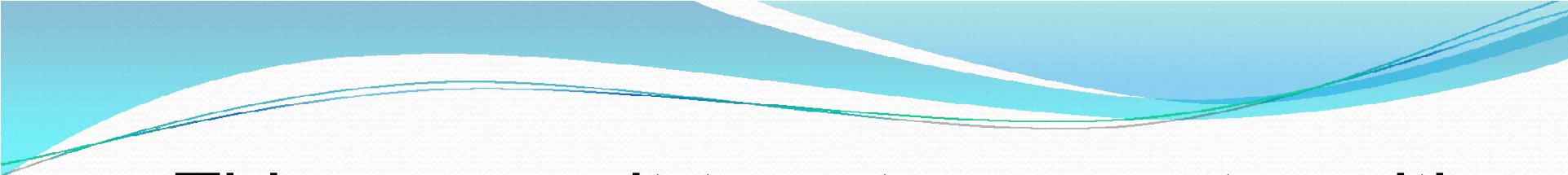
- In cases in which the tonnage is such that the train speed on a grade cannot be controlled fully with dynamic braking, and would tend to accelerate despite the use of dynamic braking, the engine-man can use the air brakes on the train to complement the action of dynamic braking.

## **6. PROTECTION AGAINST WHEEL SLIDING**


- It is desirable to provide protection against the possibility of wheel sliding.

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- When two separately excited generators are connected in series with each other across a load and the speed of one is permitted to slow below the speed of the other, the faster generator feeds current through the armature of the slower generator.

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- The latter generator thus has current flowing through its armature from a separate source (the faster generator) and excitation current in its field.

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- This causes it to act as a motor with a torque applied to it and it slows further.
  - Eventually, it might possibly stop and skid the wheels or even reverse them.



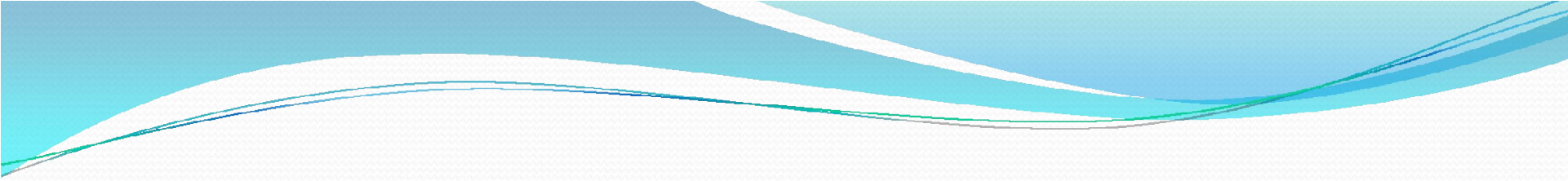
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- Even if wheel skidding does not occur, the fact that one motor and its connected wheels are rotating slower than the other wheels of the locomotive, will cause the slower wheels to be dragged along, thus causing what is best described a “rolling slide”.

# 7. BRAKING EFFORT AND ITS CHARACTERISTICS

- In dynamic braking, the system produces the traction motor characteristic .
- Variable limits are placed on both the traction motor field and armature current to provide smooth control and prevent damage to the motor or braking grids.

## **7.1 ARMATURE CURRENT LIMIT**


- In dynamic braking it is desirable to automatically limit the current which can be supplied by the motors, so as to protect the motors and the braking grids.


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- This is done by measuring armature current in terms of traction motor voltage, using a voltage divider across a traction motor in braking.

# 8. AUXILIARY SYSTEMS

## 8.1 RESISTOR COOLING SYSTEM

- The current which the traction motor armatures pumps through the braking resistors represents the power required to decelerate the train, which must be dissipated in the form of heat.

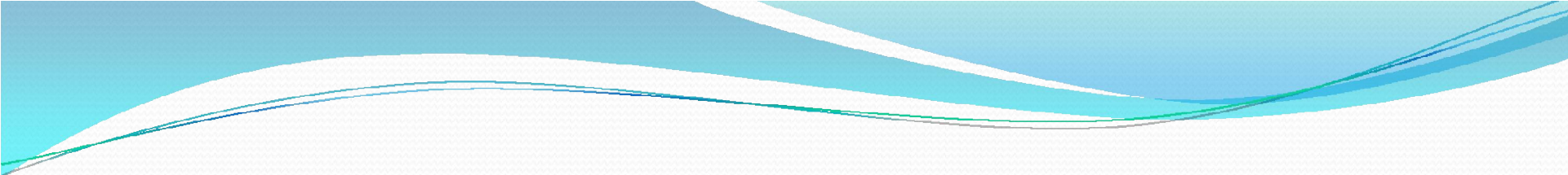
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- To remove the heat from the resistance grids, motor driven fans blow air through them.
  - The electrical energy to run the braking blower is taken from the energy supplied by the traction motors in braking.

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- The cooling system is self-controlled to provide the proper amount of cooling air for various degrees of braking power.
  - As braking power and heat increase, the motor driven fans run faster to supply more cooling air.

## **8.2 TRACTION MOTOR COOLING SYSTEM**


- During normal motoring operation the traction motors are forced ventilated by mechanical blowers driven by the diesel engine.

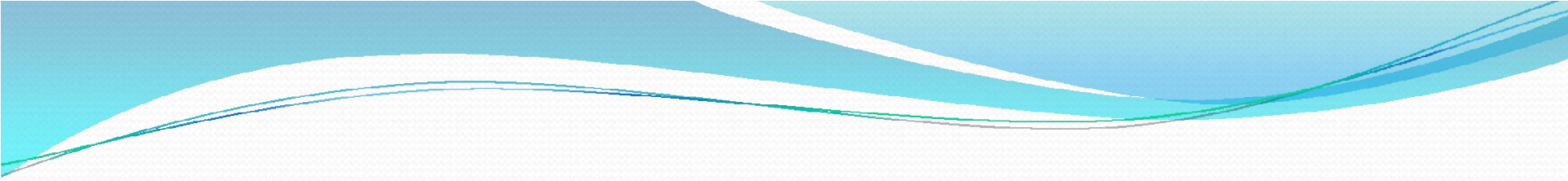


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- In dynamic braking, circuits are added to the engine speed control system to increase engine speed to approximately 4<sup>th</sup> Notch in order to supply sufficient air for motor cooling during dynamic braking operation.

## **9. TRAIN BRAKING WITH DYNAMIC BRAKING**


- The brakes may be applied on the train while the dynamic brake is being used.
- The dynamic braking circuits include the dynamic brake interlock magnet valve coil.


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- The magnet valve (BKIV) is a part of the locomotive's air brake system.
  - Its function is to prevent the locomotive's air brakes from system.

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- Its function is to prevent the locomotive's air brakes from being automatically applied when dynamic braking is being used and a train line reduction is made.

## 10. SUMMARY

- A diesel locomotive equipped with dynamic brake is very useful in controlling rate of acceleration in grades and speed in level track without using conventional air brake, which leads to excessive unwanted wear of brake blocks and wheels.

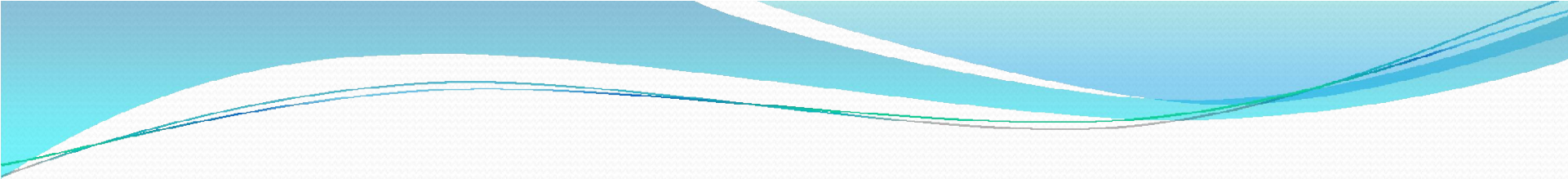
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- Resistive brake with automatic limit is very common for diesel locomotives, which provides a facility of braking effort control through drivers' selector handle.
  - The braking effort achieved with resistive brake has a typical characteristic of depending on train speed.

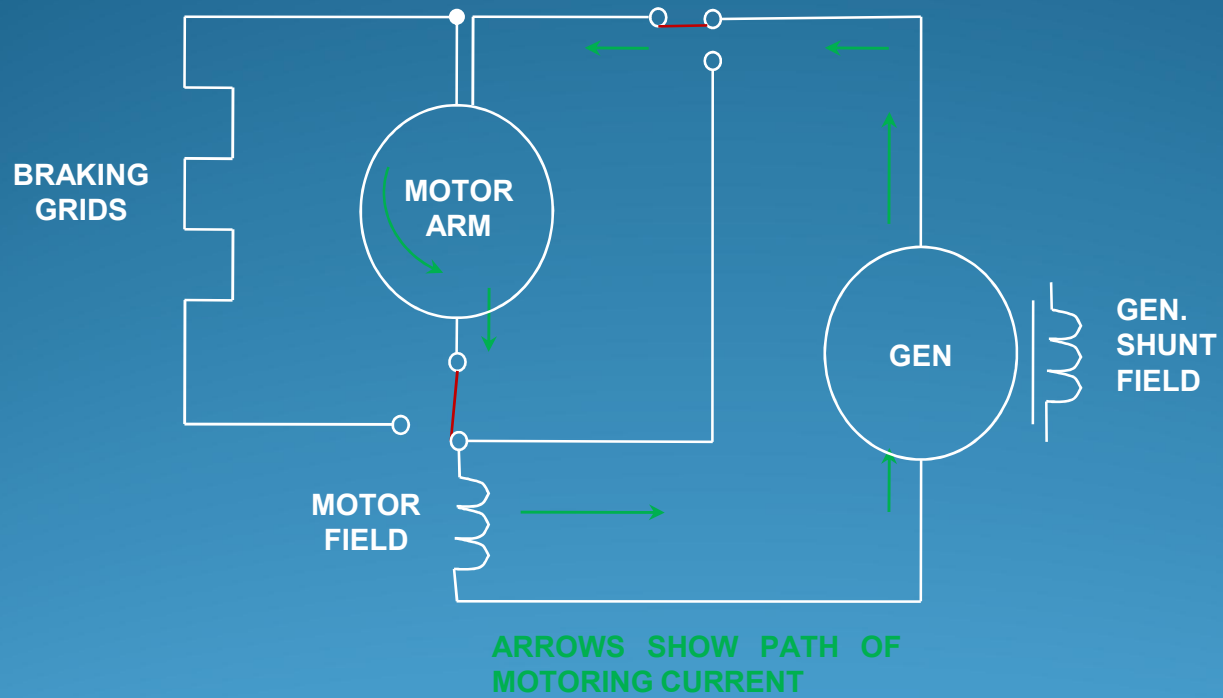
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- The braking grids (resistors) have self-cooling arrangement, which does not involve separate energy source.
  - To cool the traction motors during their operation as generators, the engine driven traction motor blowers are run as higher speed by increasing the engine RPM.

# 11. SELF-ASSESSMENT EXERCISES

1. Explain the principle of resistive braking.
2. What do you mean by braking control and how it is achieved in diesel electric locomotives?
3. Explain the effectiveness of resistive braking.

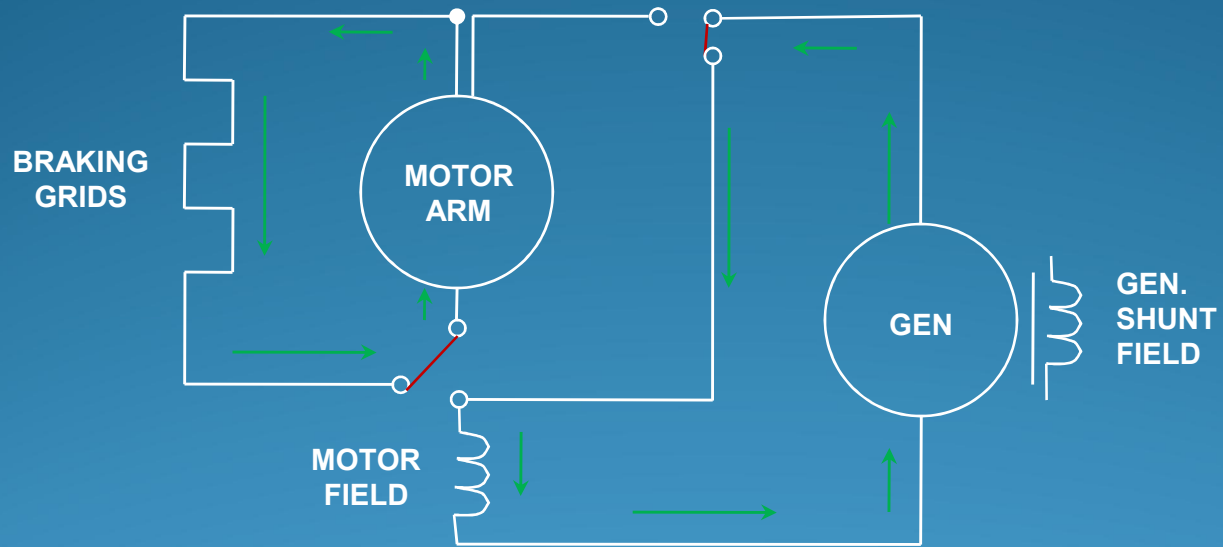


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4. Explain the characteristic of resistive braking with necessary diagram.
  5. What are the auxiliary systems involved in dynamic brake system?



MOTORING CIRCUIT

Fig 1



ARROWS SHOW PATH OF  
MOTORING CURRENT

**DYNAMIC BRAKING CIRCUIT**

Fig 3(b)

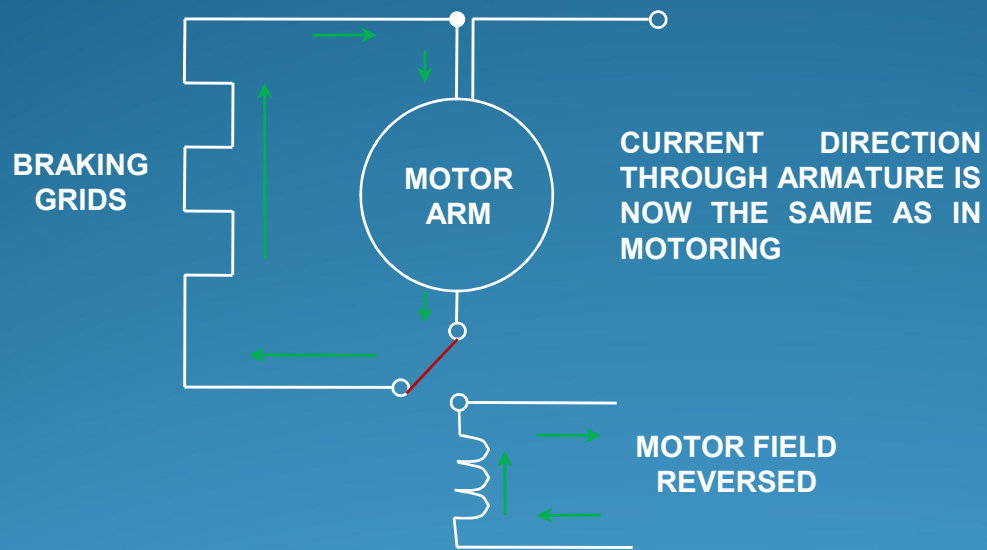
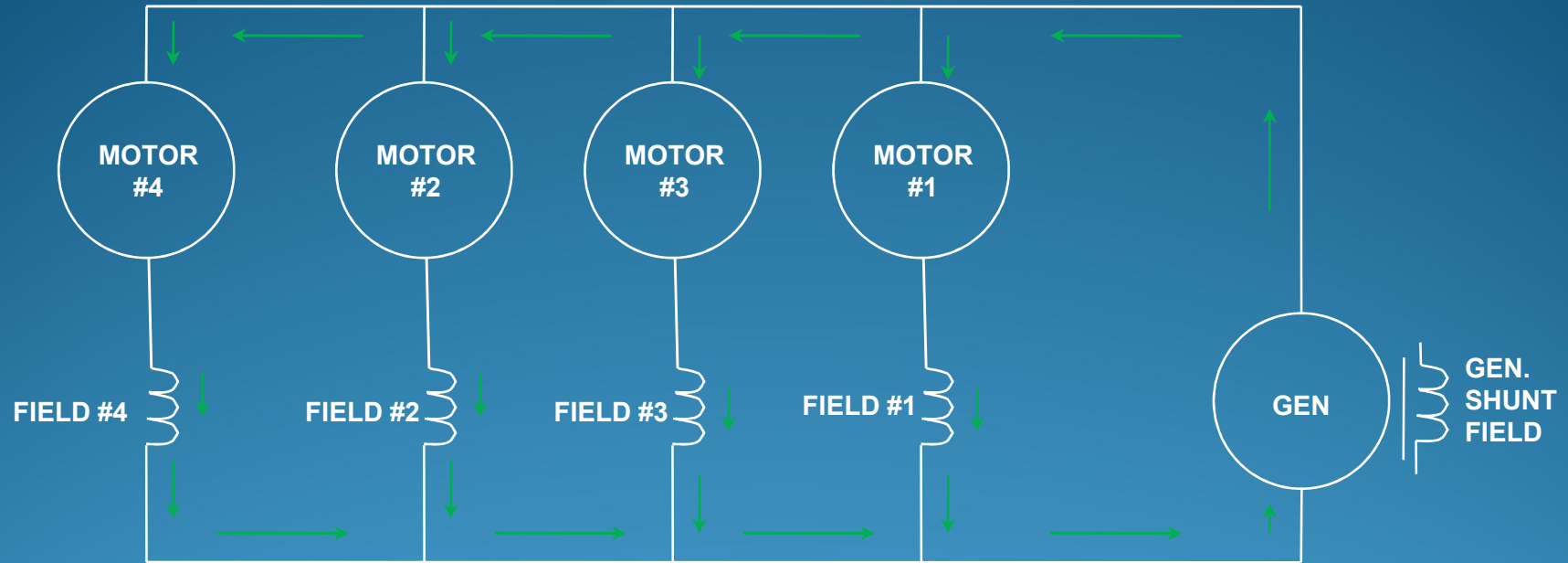
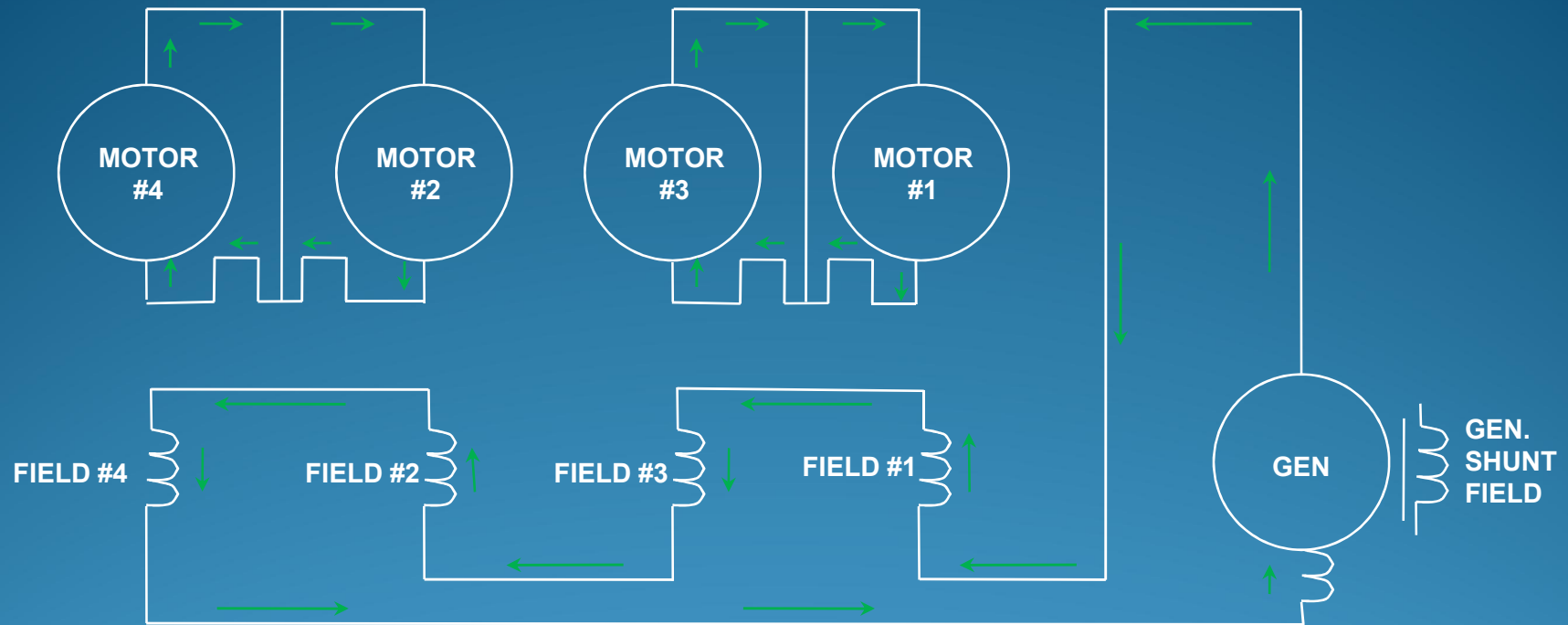


Fig 3(c)



PARALLEL MOTORING CIRCUIT

Fig 4



**DYNAMIC BRAKING CIRCUIT**

**Fig 5**