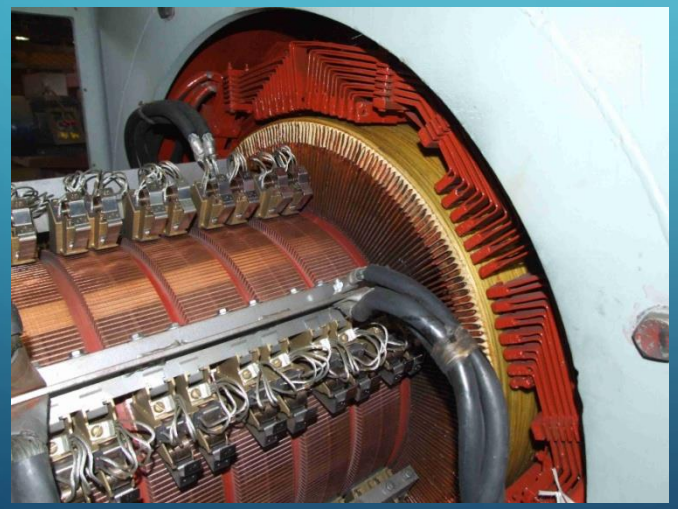
# DC MOTORS.

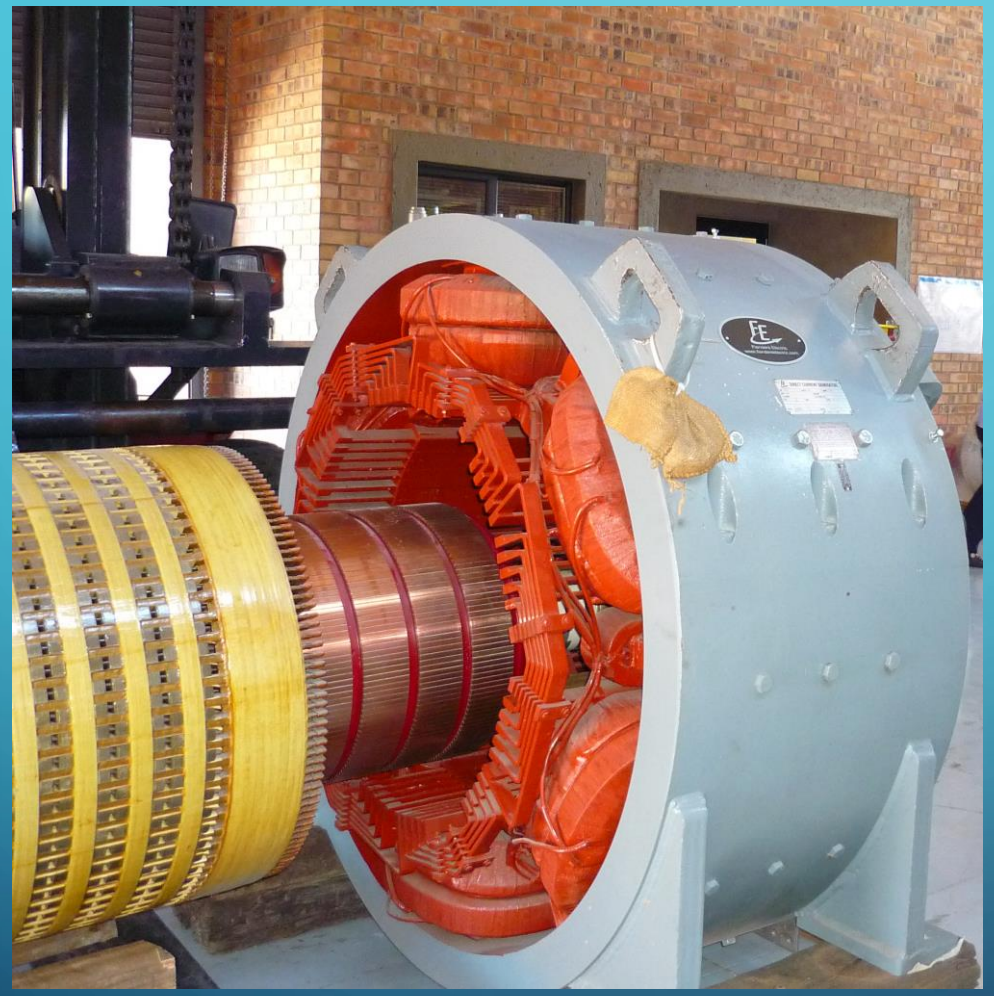
INTRODUCTION.

MAINTENANCE.

TESTING.



*Henry du Preez.*



# DC Motor,

**Armature and commutator. Field frame, with field coils, inter-poles and pole face (compensating) winding.**

*Henry du Preez.*

# Types of Armature Windings.

Lap Winding.

Wave Winding.

Frog-leg Winding.

Simplex,
Duplex, Triplex etc.

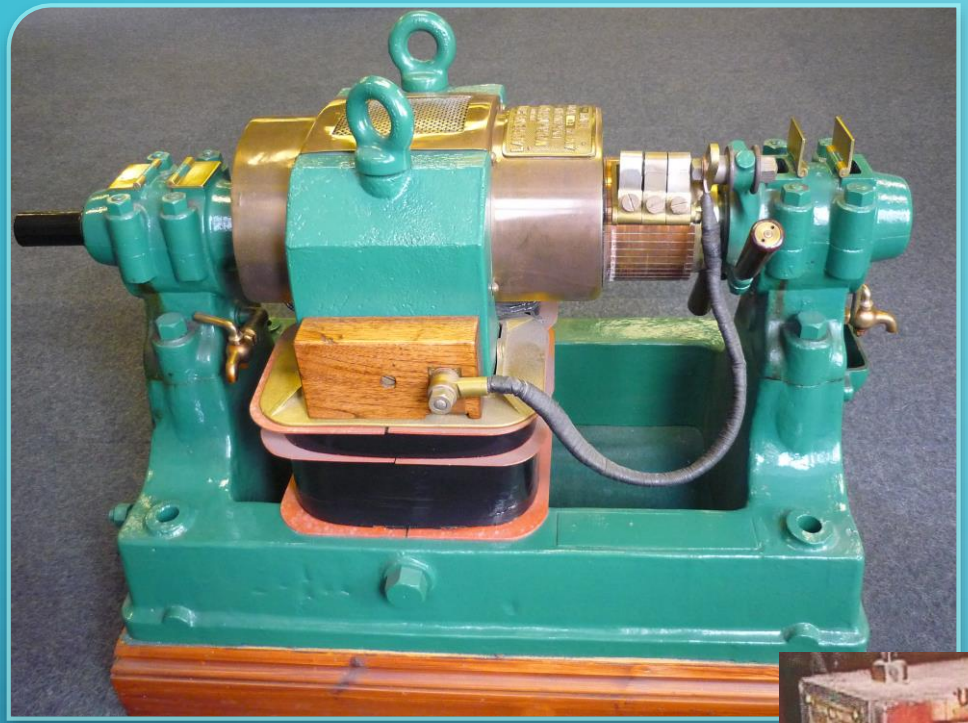
Henry du Preez.

# Comments:

**Because there is a commutator (a sliding switch) there is settings and maintenance required.**

**These settings are critical to the operation and life of the DC Motor.**

*Henry du Preez.*

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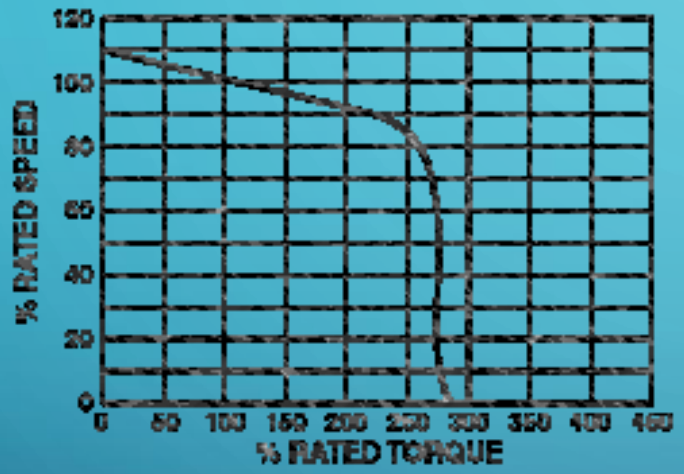
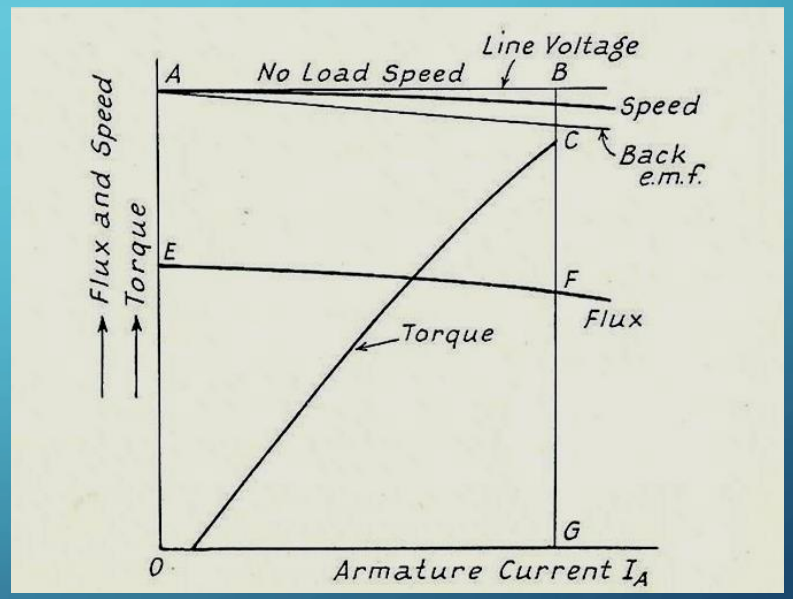
# The characteristics of DC Motors.

## Shunt Wound Motor.





**Shunt Wound - DC Operation**
**Typical Speed - Torque Curve**




**Load Characteristics of a Shunt Motor.**

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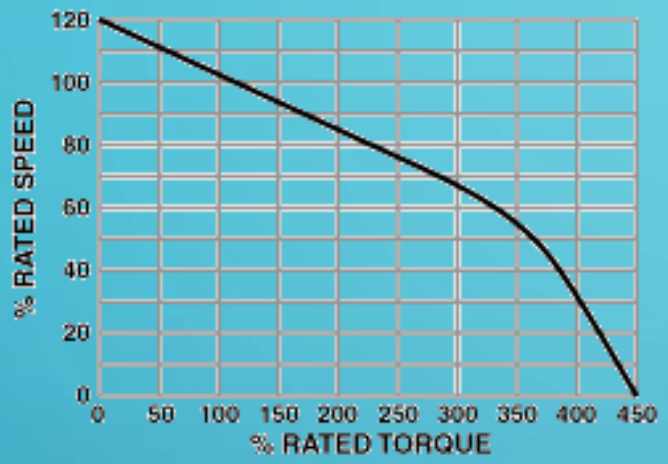
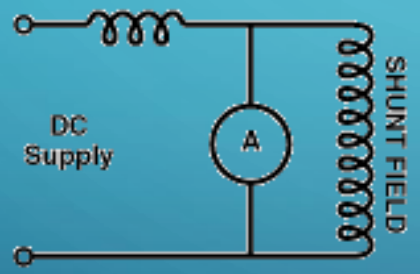
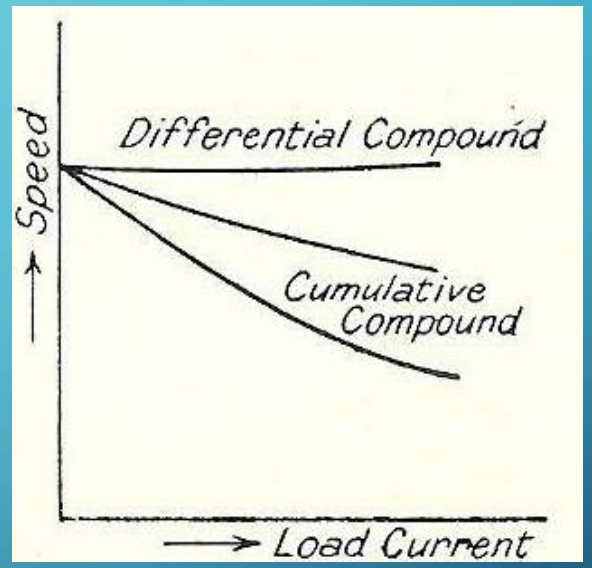
# Compound Wound Motor.




**Compound Wound - DC Operation**
**Typical Speed - Torque Curve**




**Load Characteristic**
**of**
**Compound Motors.**

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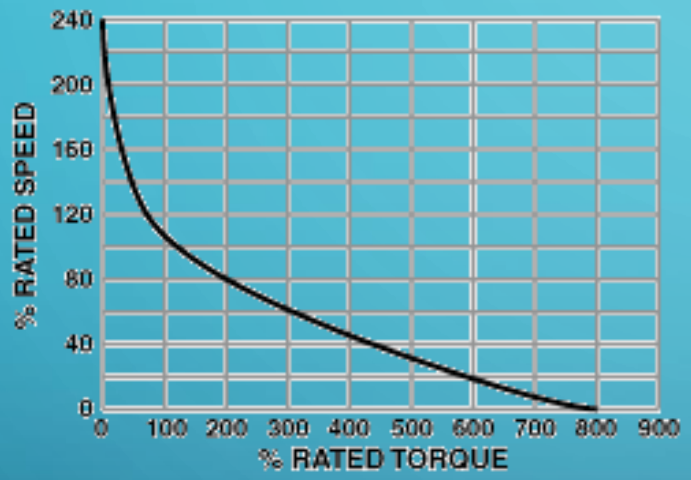
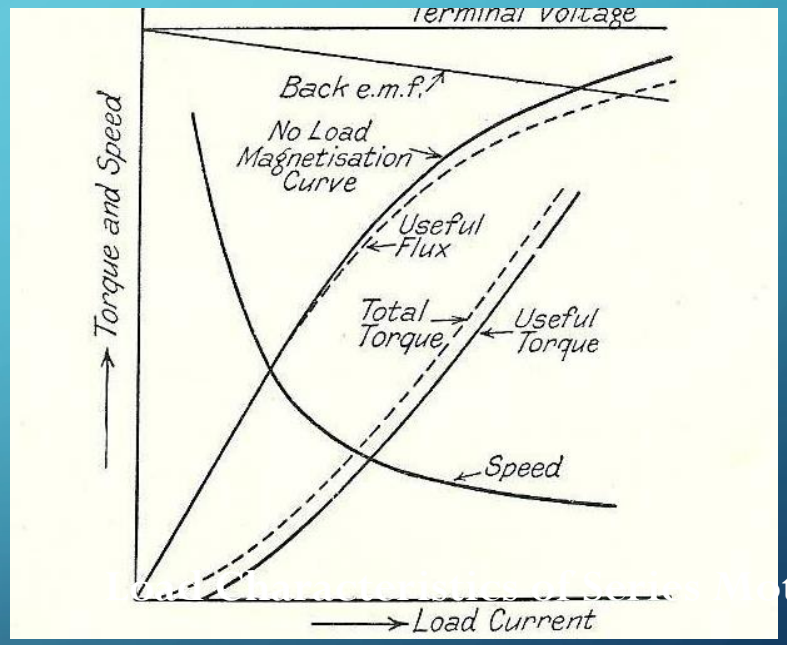
# Series Wound Motors.

**Series Wound - DC Operation**
**Typical Speed - Torque Curve**








tor.

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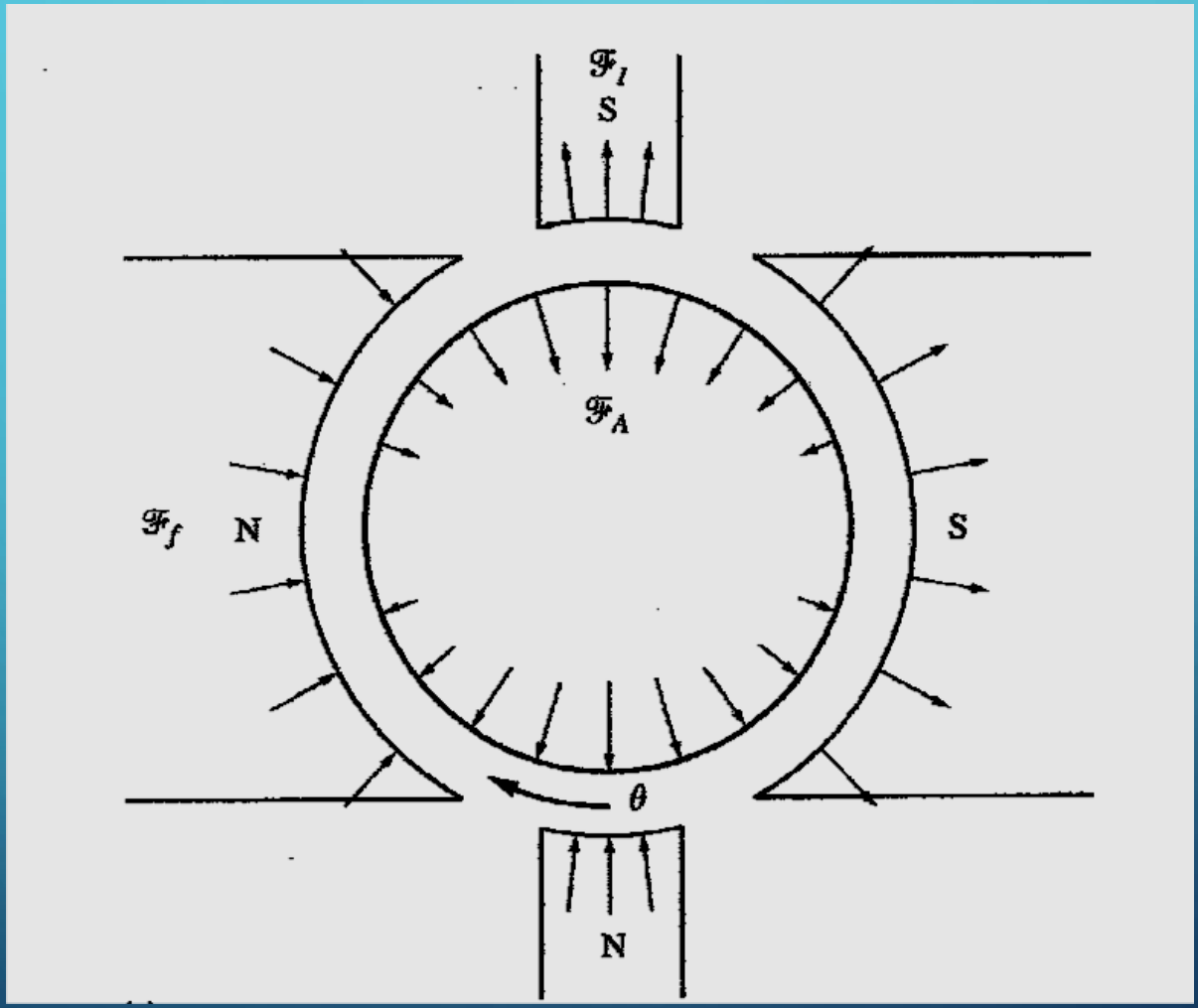
# Diagram showing the Flux Pattern in the Motor Armature, Inter-poles and Fields.

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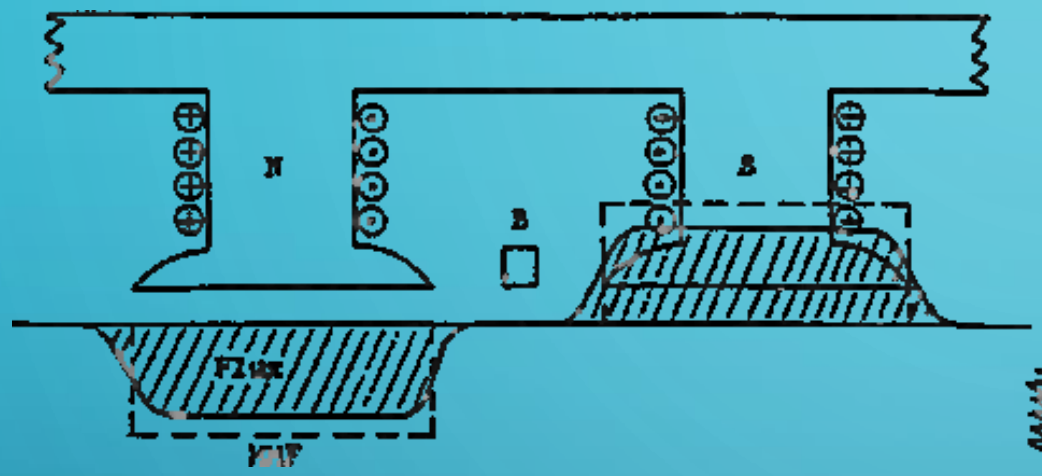
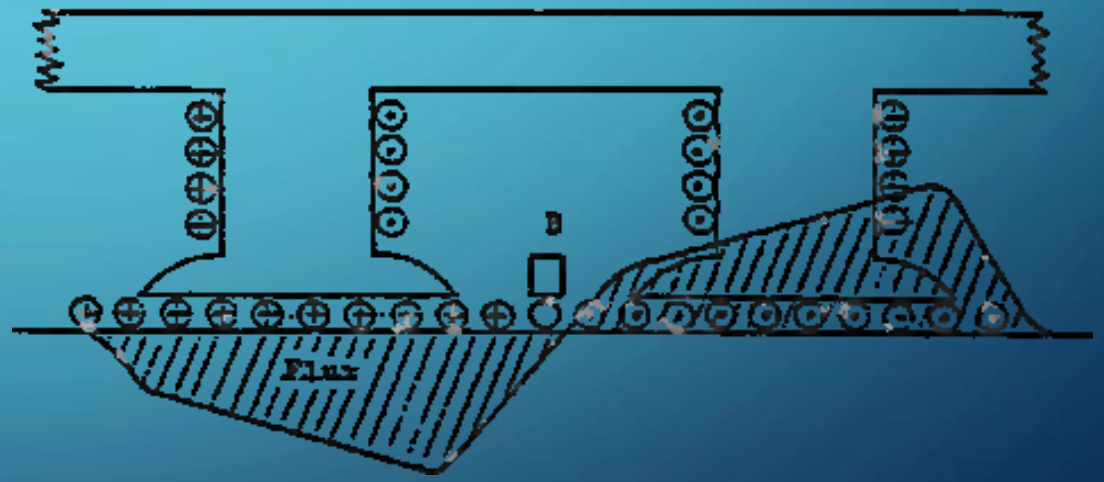
Flux pattern under no load conditions




Flux pattern under load conditions distortion due to armature reaction.

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# Field flux,Armature Reaction, Compensating Winding, and Interpoles.

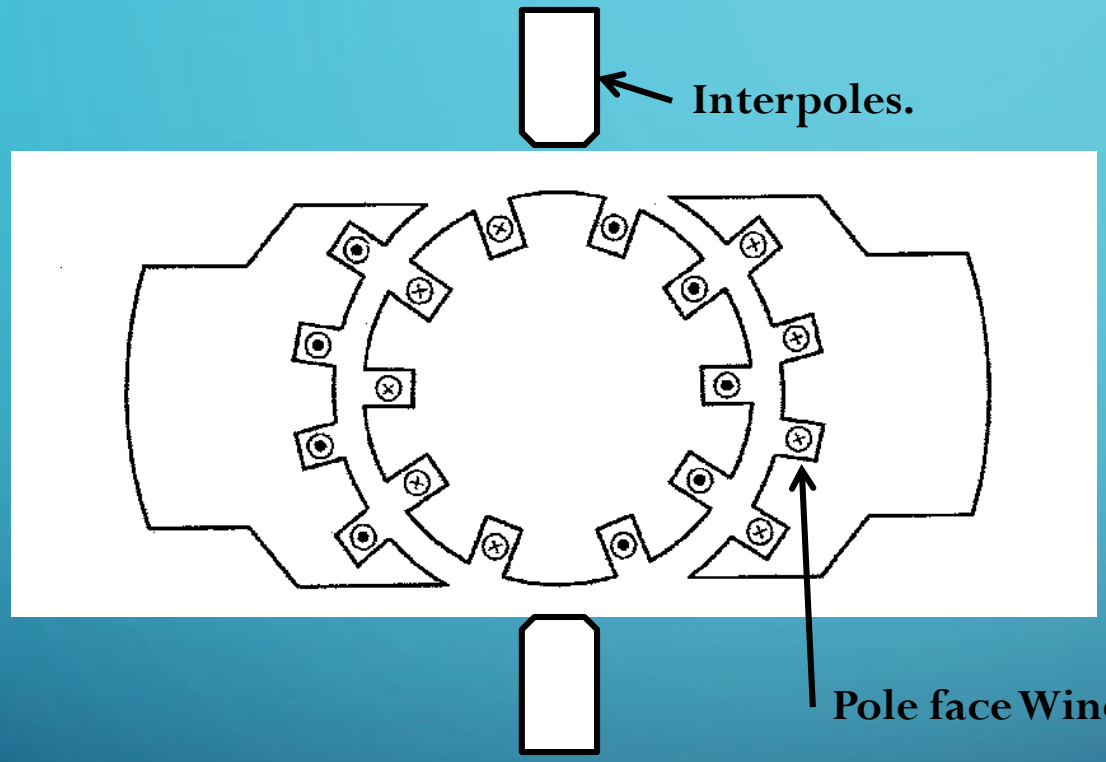


Diagram showing how Compensating Winding (Pole Face Winding) counteracts Armature Winding (Reaction Flux).

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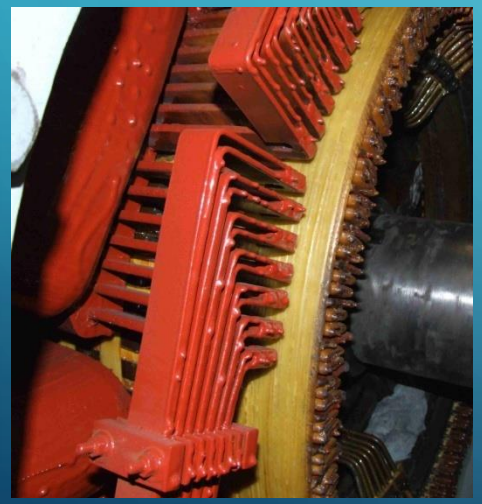
# Compensating Winding



Two variations of compensating windings. The winding, at left, is more common in large machines, where the high armature current requires a large conductor.

*Henry du Preez.*

# Critical Elements of DC Motor Maintenance

**I will overlook the obvious mechanical factors as these apply to all machines. (Vibration, Bearings, Alignment, etc).**

**Commutator.**

**Brushes.**

**Neutral settings.**

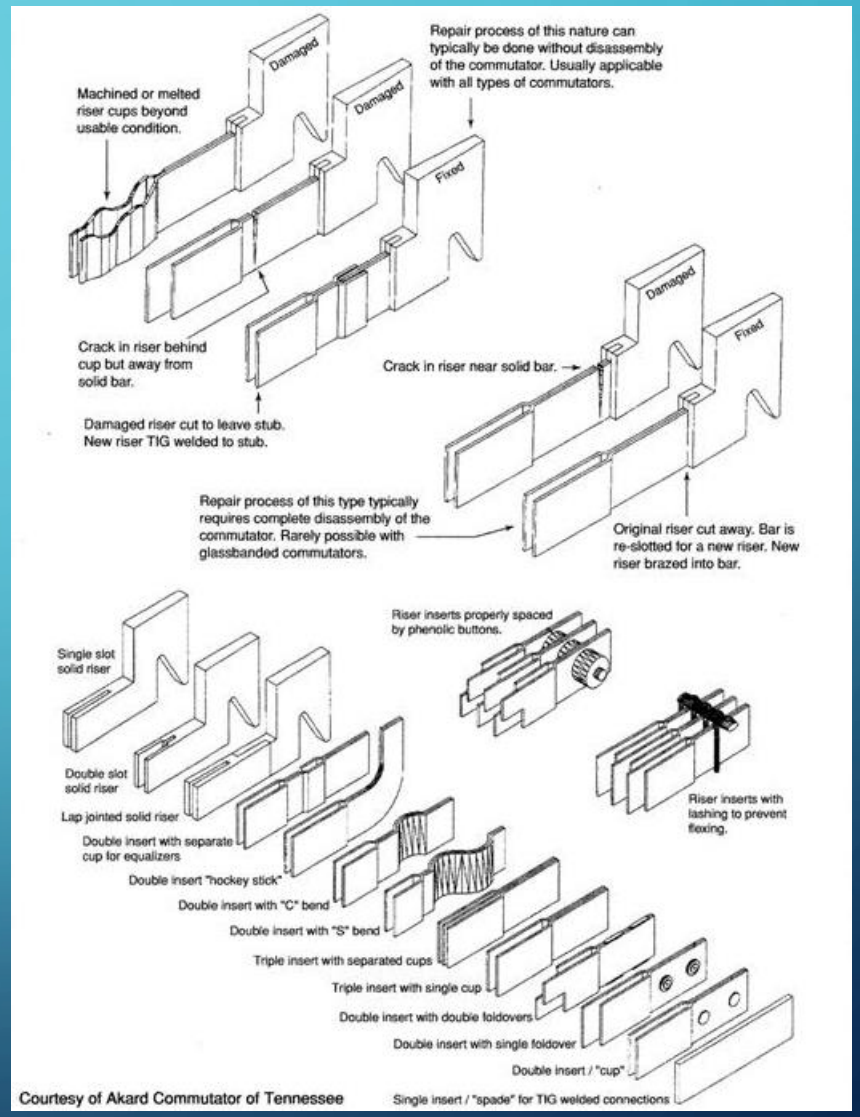
*Henry du Preez.*

**By monitoring the condition of DC motors, you can spot and correct developing problems during regular maintenance, saving time and money. Changing weak brush springs or correcting a problematic air supply is much easier than replacing a motor.**

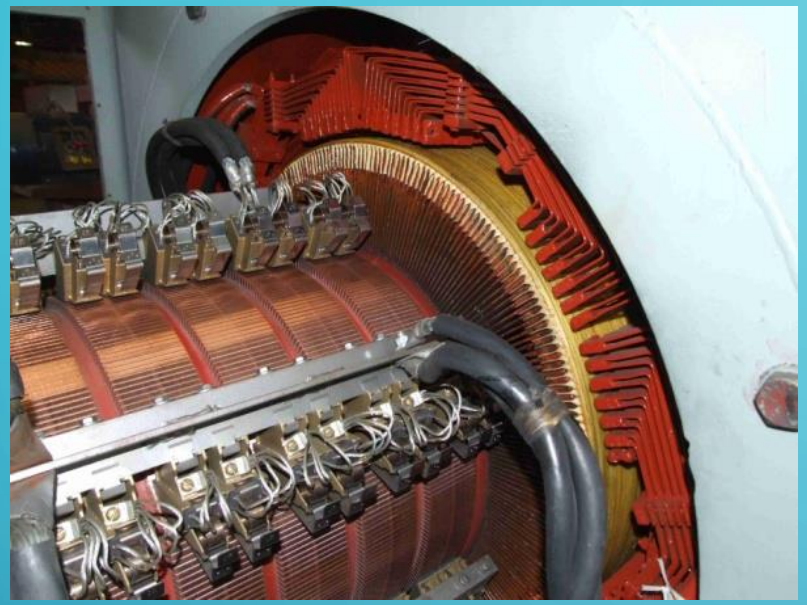
**It's much more effective to treat the root of a problem than the symptom. When it takes five people one shift to change a motor, every DC motor replacement avoided is like a week in the bank. And that's a week better spent on other maintenance issues.**

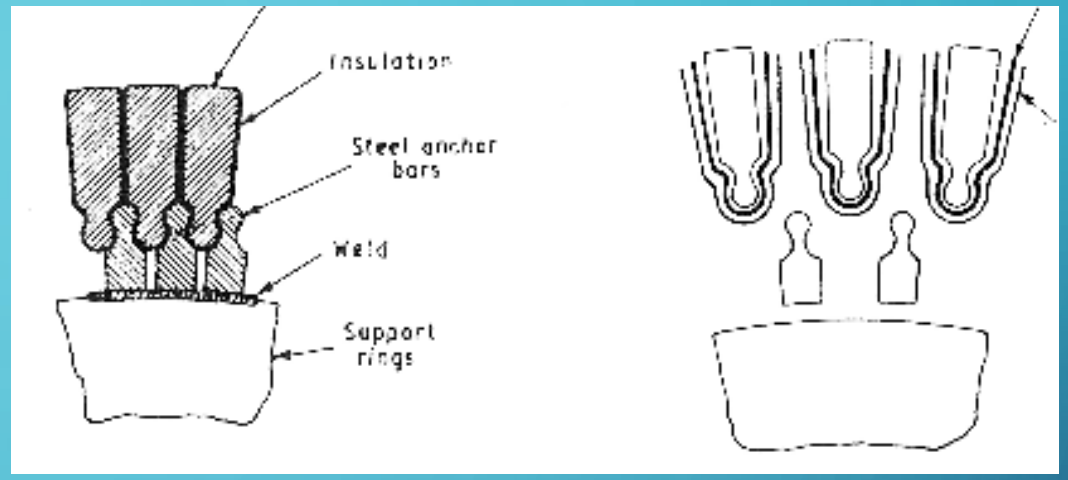
*Henry du Preez.*

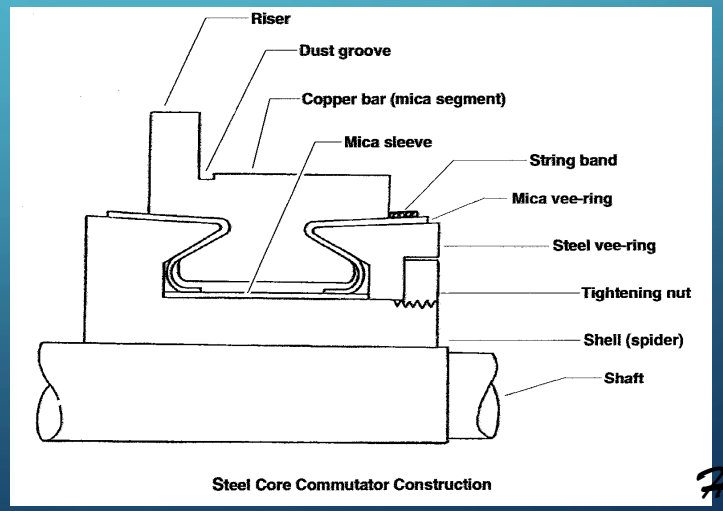
# Commutators.

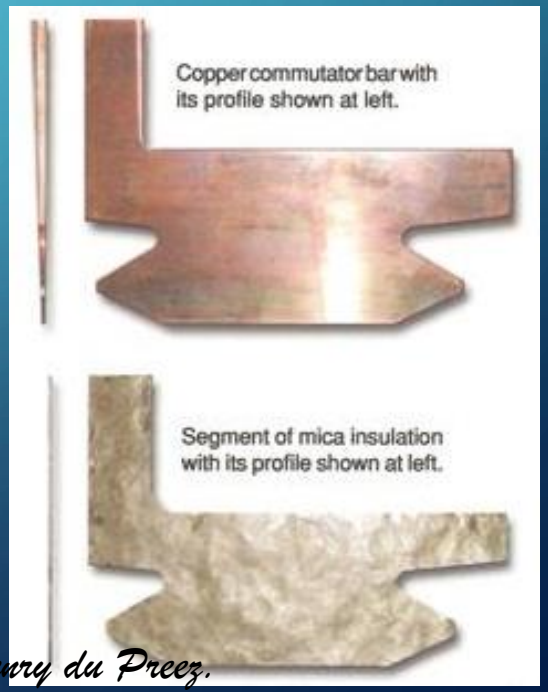




*Henry du Preez.*





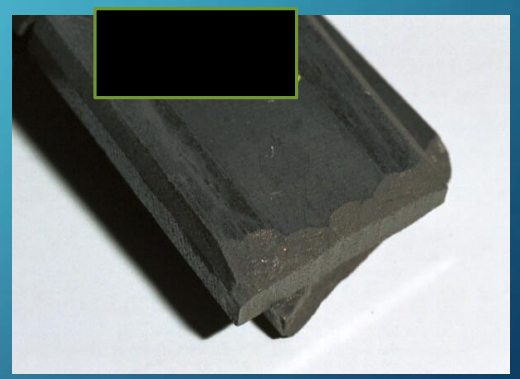




*Henry du Preez.*

# Commutator Functions.

- Provides a sliding Electrical Contact.
- Acts as a Reversing Switch.



- **Commutators and Brushes require regular maintenance.**

*Henry du Preez.*

# Commutator Maintenance.

1) The commutator surface must be smooth without any grooving, pitting, burn marks and generally have a good patina.
2) Brushes must be free in the holders, with correct spring tension and longer than the minimum.
3) Brushes must be properly bedded.
4) Commutator tolerances must be within the limits.
5) Undercutting and segments (bars) must be as described below.

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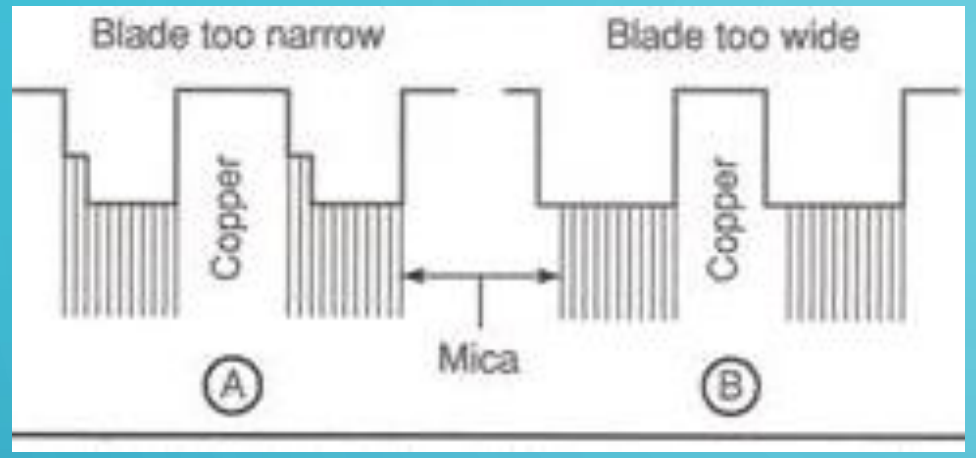
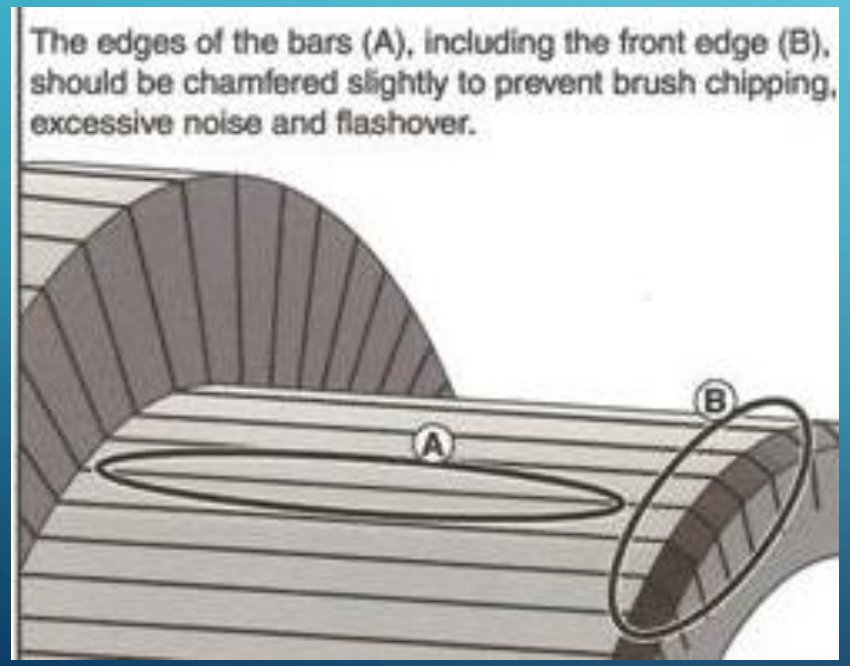
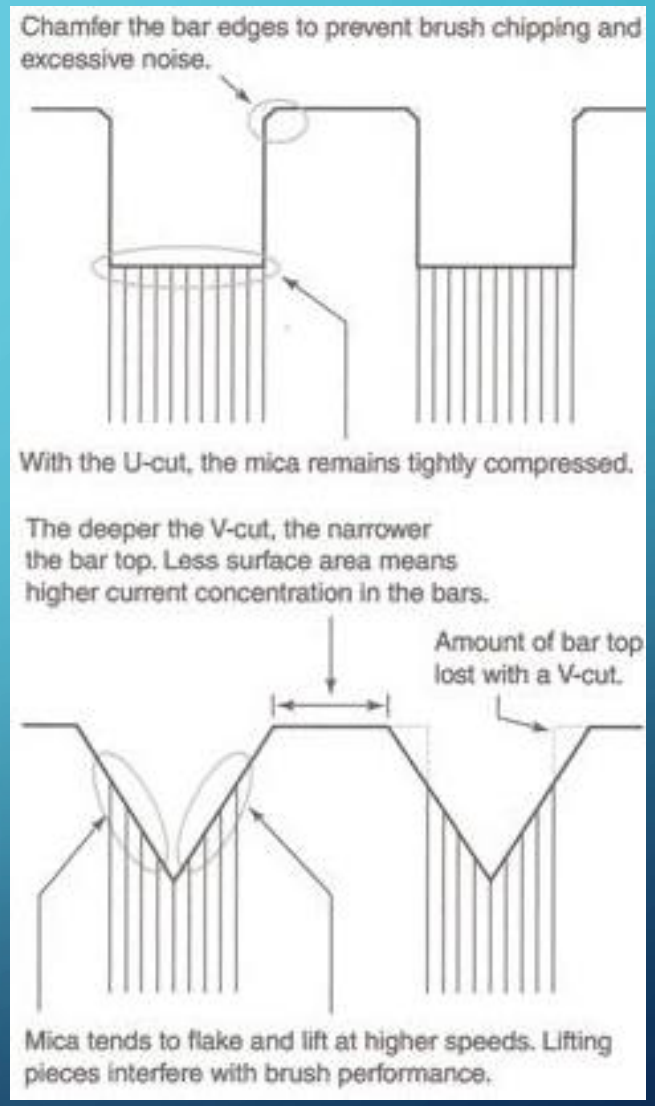



*Henry du Preez.*

# Commutator Run-out & Finish.

| | Peripheral Speed. | |
|---|---|---|
| | <= 1524m/min. | > 1524m/min |
| Max. Total Indicated run-out. | 0.076mm | 0.038mm |
| Max. Total indicated run-out In any quadrant. | 0.038mm | 0.025mm |
| Max. Between adjacent bars. | 0.005mm | 0.005mm |
| Max.Taper. | 0.1667mm/m | |
| Surface finish. | 40 to 70 microns | |

*Henry du Preez.*

# Neutral on DC Motors vs. DC Generators

- DC Motors:
  - Typically set on Precise Electrical Neutral, as in many cases, they are in reversing applications.
  - It is possible to aid commutation in single rotation direction motor applications by “slightly” moving yoke off neutral;

However, recommended in extreme cases only.

- DC Generators:
  - Typically, intentionally set ½to ¾commutator bar against rotation to boost commutating field strength and aid in commutation

*Henry du Preez.*

# Various Methods of Setting Electrical Neutral

- PVN (Pencil Volt Neutral)
- DC “Kick” or “Flash” Method
- Bi-Directional Speed Matching
- Generators, Voltage Drop at Stall
- AC Null Method
- Brush Potential Method
- Tram Markings / Mechanical Method
- AC Curve Method

*Henry du Preez.*

# AC Plot Method (more accurate variation).

Very easy and accurate to do on site.

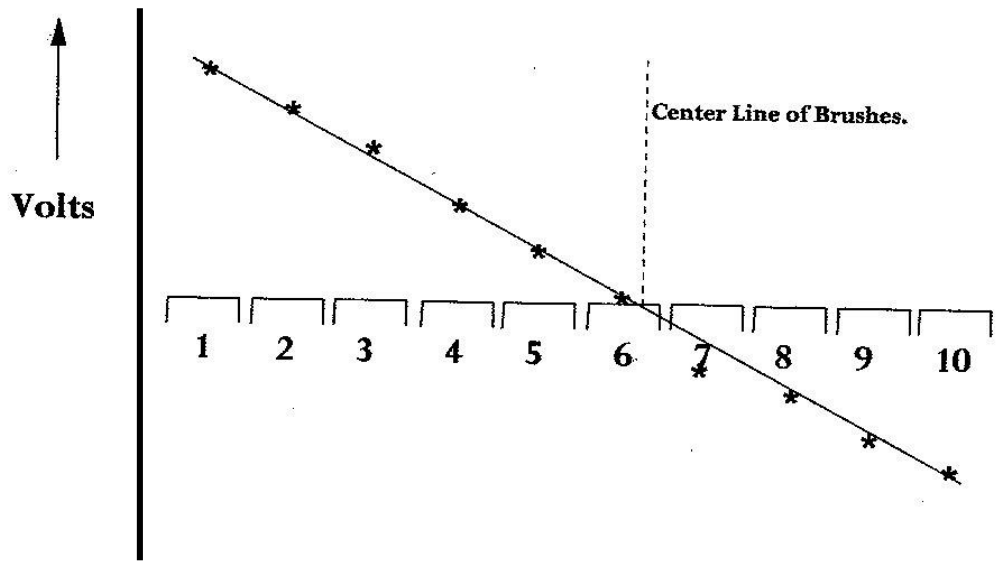
1) Remove all the brushes or slide strips of insulation between the brushes and the commutator.
2) Count the number of segments and divide by the number of brush arms. (= n)
3) Number ten segments 1 to 10 from one side of the brush past the brush to the other side of the brush.
4) Repeat the numbering n + 1 segments from the original no 1 segment.

5) Apply an AC voltage to the field as above.
6) Measure the voltage between segments 1 and 1, 2 and 2, 3 and 3 through to segment 10.

7) Plot the voltage on a graph depicting the segments.
8) Drawing a straight line thru the points, where the graph cuts the zero is the neutral point.
9) Set the center of the brush on this segment

*Henry du Preez.*

# AC Plot Method




In this case the center line of the brushes would be 0.75 along the 6th segment.

*Henry du Preez.*

# Check List. ( Brush arrangement).

1) Brush arm spacing.
2) Stagger (If any both - axial and radial).
3) Connections.
4) Brush box gap to commutator.
5) Brush tension springs. (All correct tension and same).
6) All same brush grade. (Do not mix brush grade or suppliers).
7) Brush wear.

*Henry du Preez.*

# Testing of DC Machines.

Besides the routine test on a DC Motor/Generator major repair it is always good to do a load test at least as the inter-poles and compensating (pole-face) windings are not in reality operational and therefore you cannot say that underload commutation could completely unacceptable.

Generally if two machines are available back to back testing is used.

Back to Back testing of two DC machines.

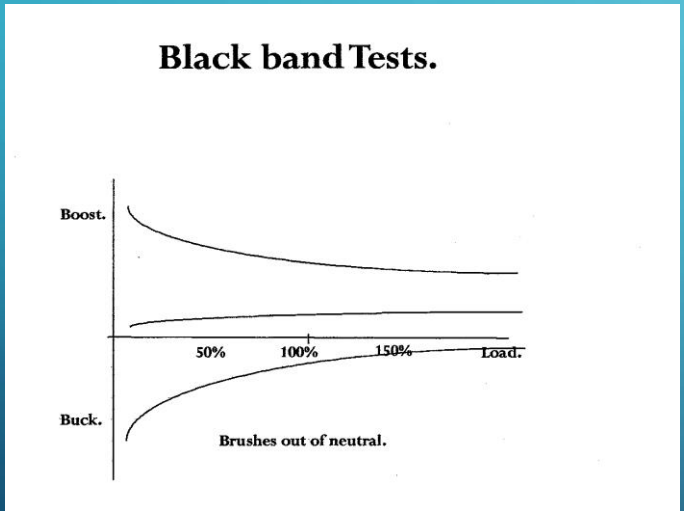
Henry du Preez.

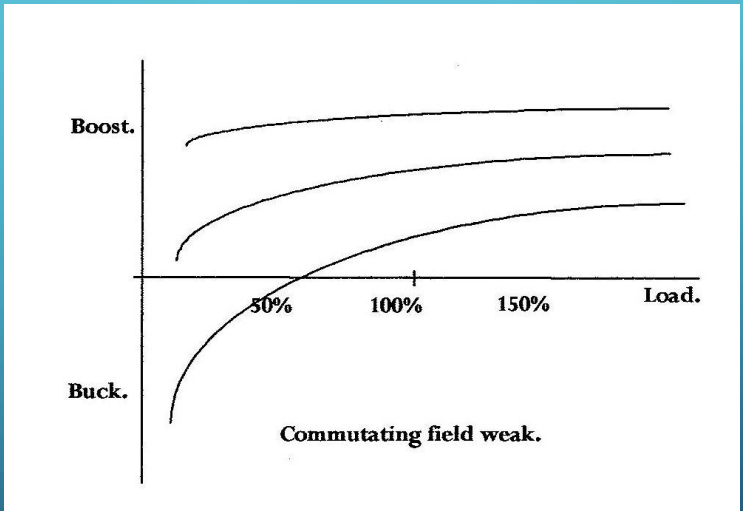
**Back to Back testing of two DC machines.**

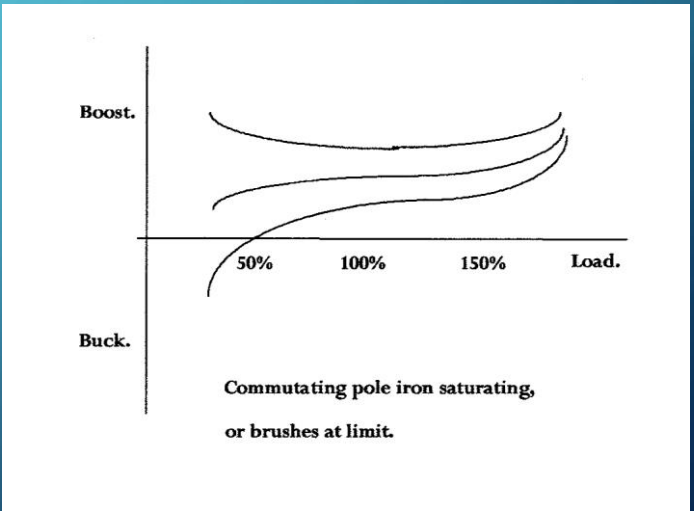
*Henry du Preez.*

# Black band Method.

Using the method of black banding as described can be used to accurately set the neutral, this is however time consuming and elaborate and is only used on difficult and problem machines.

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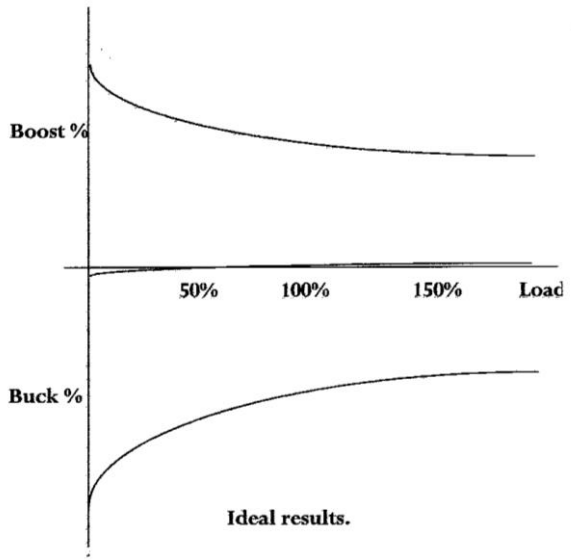
# Black band Tests.




Ideal results.

*Henry du Preez.*

# Common commutator wear patterns.

It's relatively easy to judge DC motor performance by looking at the commutator. During normal commutation, brush current vaporizes some copper molecules, depositing a uniformly tan to charcoal-brown copper-oxide film (about 8 x $10^{-6}$ thick) on the commutator. Faint charcoal streaks along the brush paths may also indicate normal commutation. Even a heavy film coating isn't necessarily cause for alarm, particularly if no areas are unusually dark or worn.The following three conditions demonstrate what can happen to a commutator that has been neglected.

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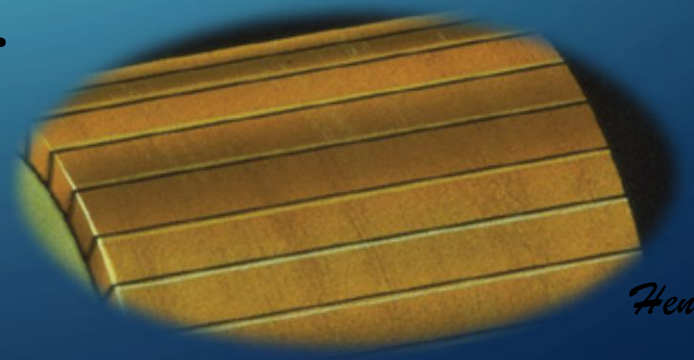

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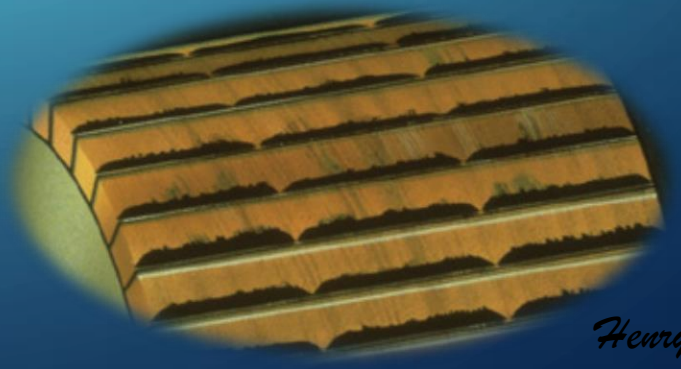
# Slot bar marking and burning.

Alternating dark and light bars on the commutator can be caused by the first (or last) conductor in the slot passing under the brush before (or after) entering the field of commutation. Certain factors can exacerbate slot bar marking and cause slot bar burning , including electrical overload, incorrect neutral setting, improper inter-pole strength, and contamination. When the trailing edges of the darker bars appear etched or burnt, you need to resurface the commutator.



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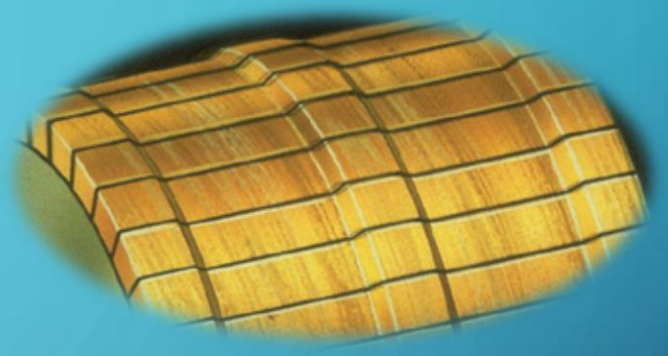
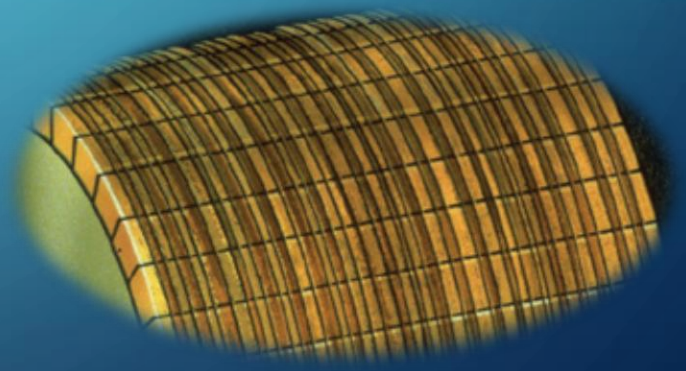
*Streaking*. Dark streaks along the brush path (often found on motors with long-life brushes) indicate metal is migrating from the commutator to the brushes. Insufficient brush spring tension, too light a load, or a brush grade that is too porous can be responsible. Contamination by chlorine, hydrochloric acid, silicon vapors, or other harsh chemicals can also cause streaking. Remedying the contributing factor(s) early on can prevent the condition from progressing to the more severe stage of threading.

*Henry du Preez.*

*Grooving* **Unlike threading, grooves tend to smoothly wear to the width of the brushes, and commutator material is worn away rather than transferred to the brushes. Although grooving is usually due to abrasive dust in the environment, it can also be caused by a brush grade that's too abrasive.**

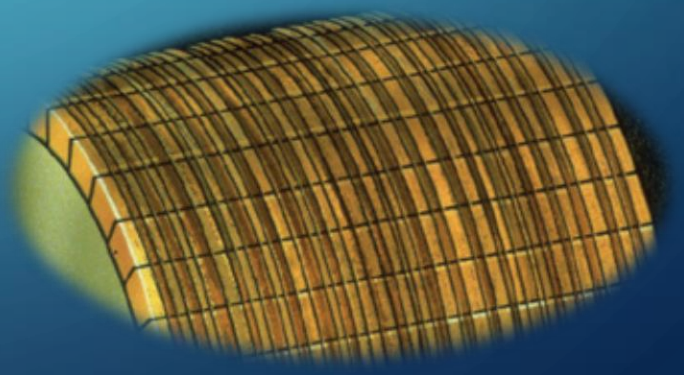


**As grooving progresses, the sloped walls pinch the brushes, diverting spring tension from the brush face. This increases electrical resistance, generating more heat at the brushes and commutator.**



*Henry du Preez.*

*Threading*. Threading involves the transfer of excessive amounts of metal to the brushes during commutation when brush path(s) start to resemble the threads on a bolt . As with streaking, threading may be due to inadequate brush spring tension or too light a load. Left unchecked, the condition will lead to rapid brush wear. If you detect threading soon enough, you can machine the commutator in place to restore the finish.



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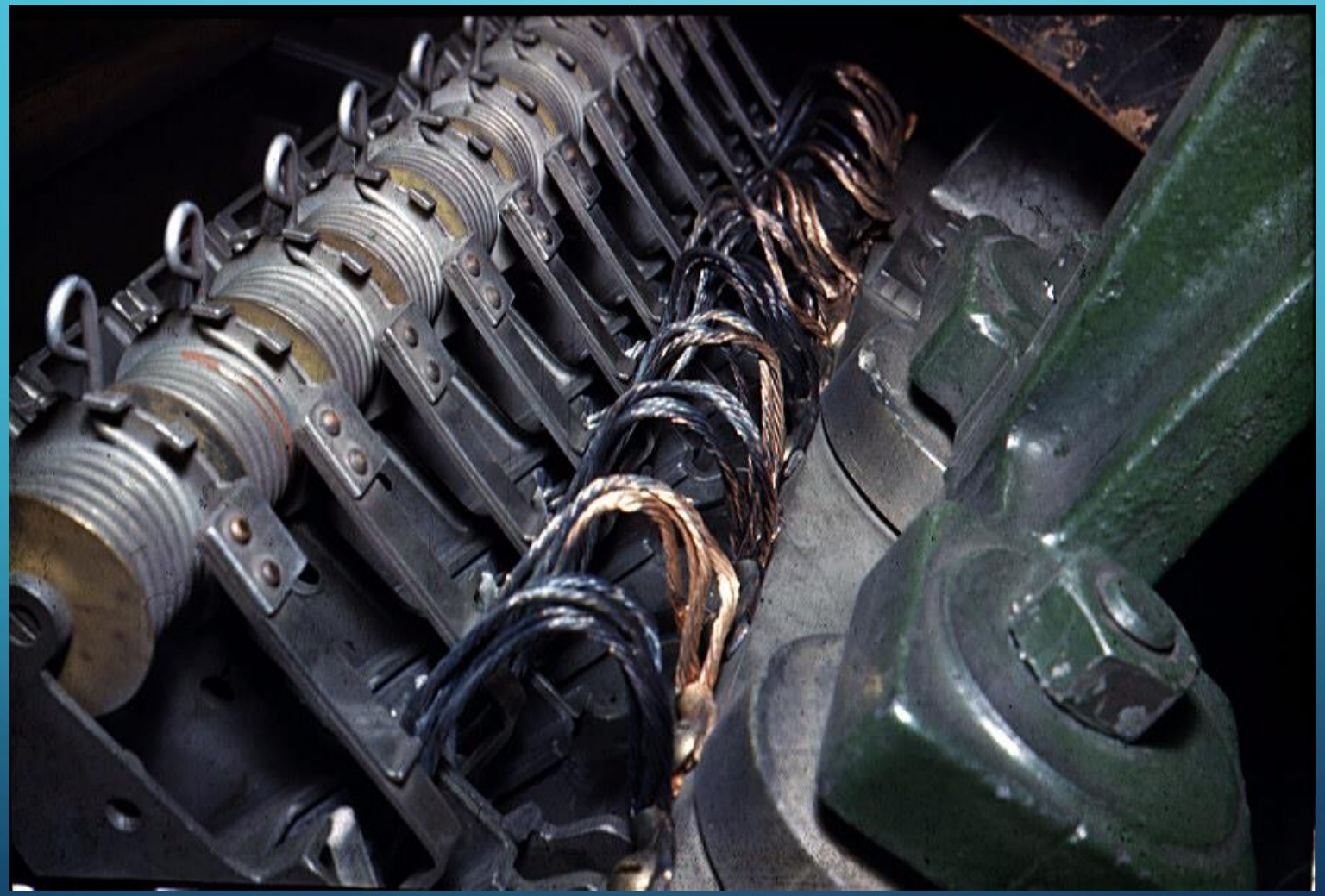

*Henry du Preez.*

## Selective Action

- Selective action results when brushes do not share current evenly.
- It can be caused by
  - non-uniform filming,
  - mixing of brush grades,
  - poor connections,
  - uneven temperatures,
  - uneven spring pressures and other factors.
- With selective action, often one path of brushes will wear, or even burn up, while other paths do not.

*Henry du Preez.*

**Brush Grade families:**

- Graphite Brushes.
- Carbon and Carbon-Graphite Brushes.
- Electro-graphitic Brushes.
- Metal-Graphite Brushes.

**Grade Characteristics.**

- Specific resistance.
- Hardness.
- Apparent Density.
- Abrasiveness.
- Contact Drop.
- Current-carrying Capacity.
- Maximum Speed.
- Friction Coefficient.
- Transverse Strength.

*Henry du Preez.*

# I would just like to thank
# The
# Rotating Machines
# Technical Form.

# Questions ?

*Henry du Preez.*