

Vibration Sources in Electric Motors

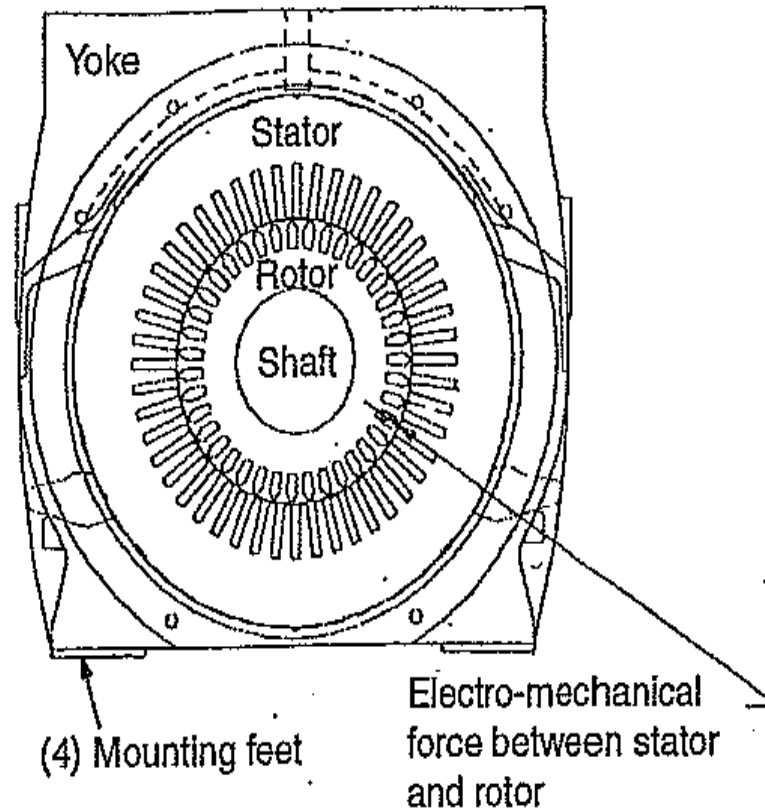
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Wayne Hall, P.E.
Jenkins Electric Company

Electrical Sources of Pulsating Force

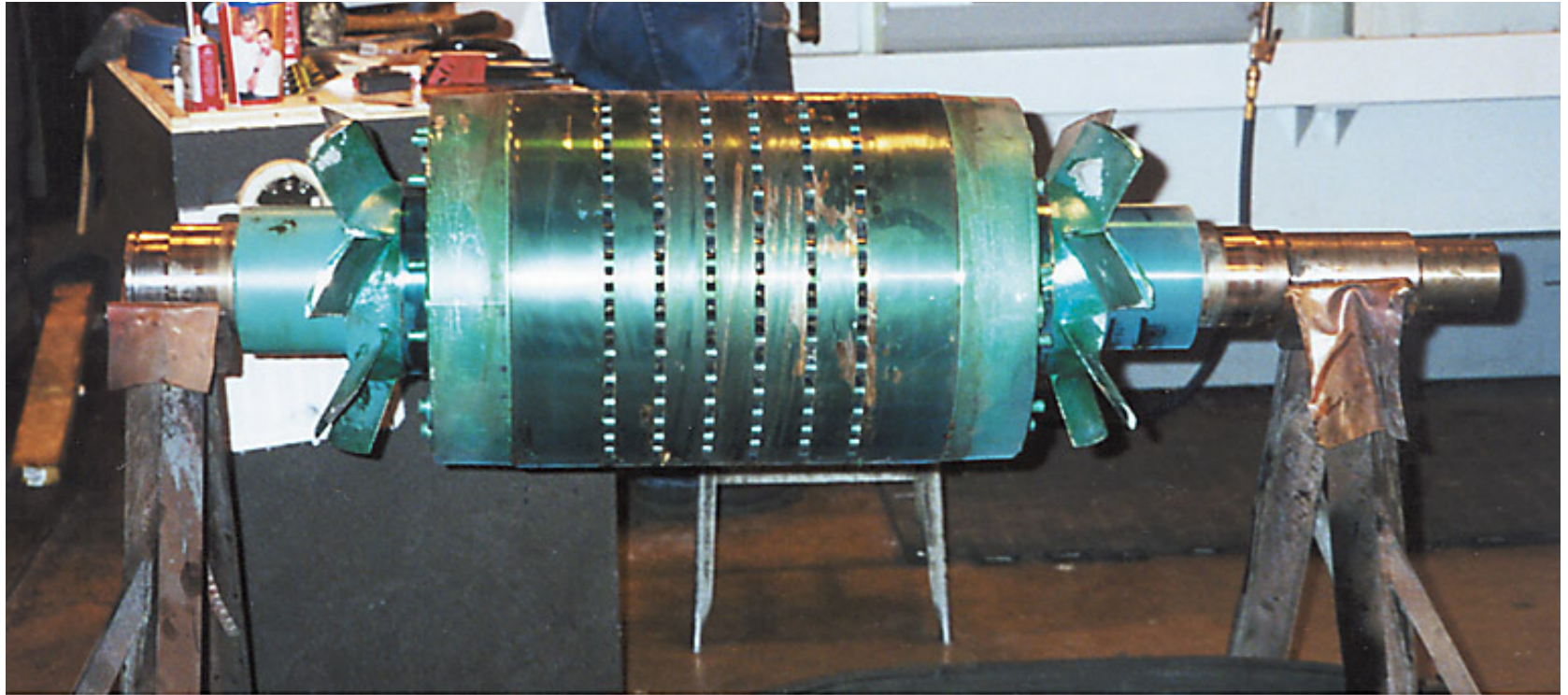
- Rotational Sources
- Radial Forces
- Axial Forces
- Winding Failures
- Power Supply/ Drives

Rotational - Tangential Force

FIGURE 1: STATOR AND ROTOR (1)



Rotor



**800 HP AC Motor
ID# 80-00019H**

Brake



Radial Forces

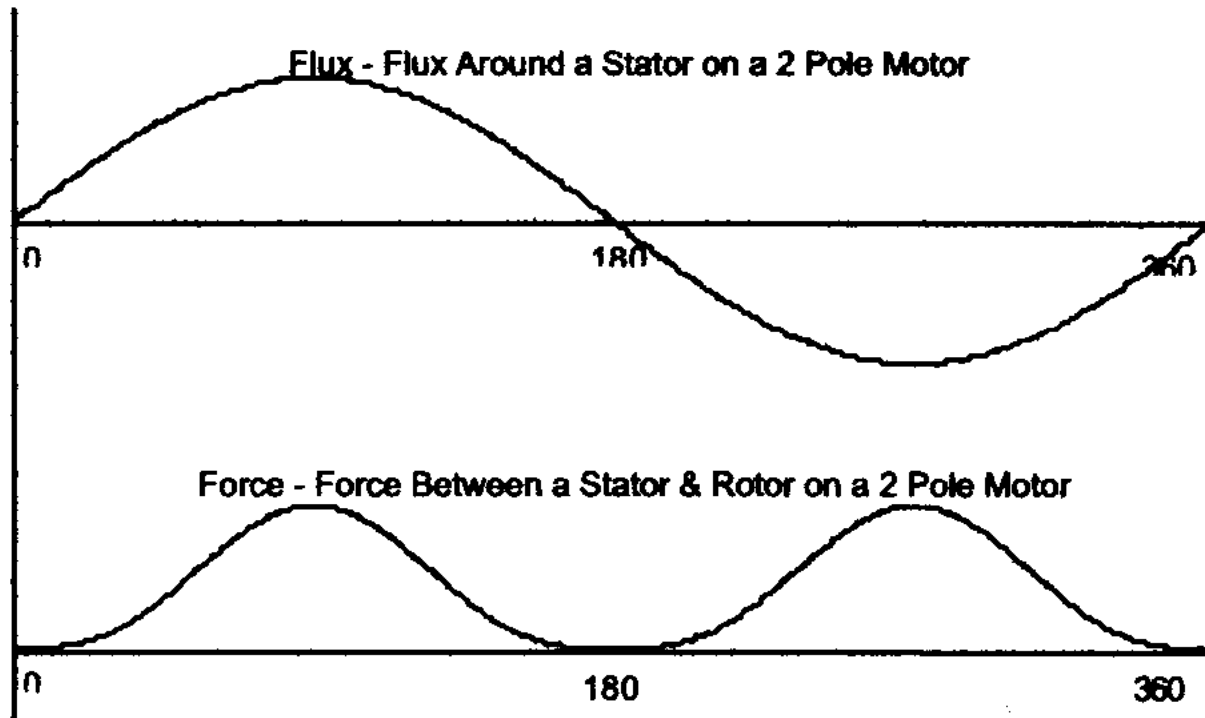
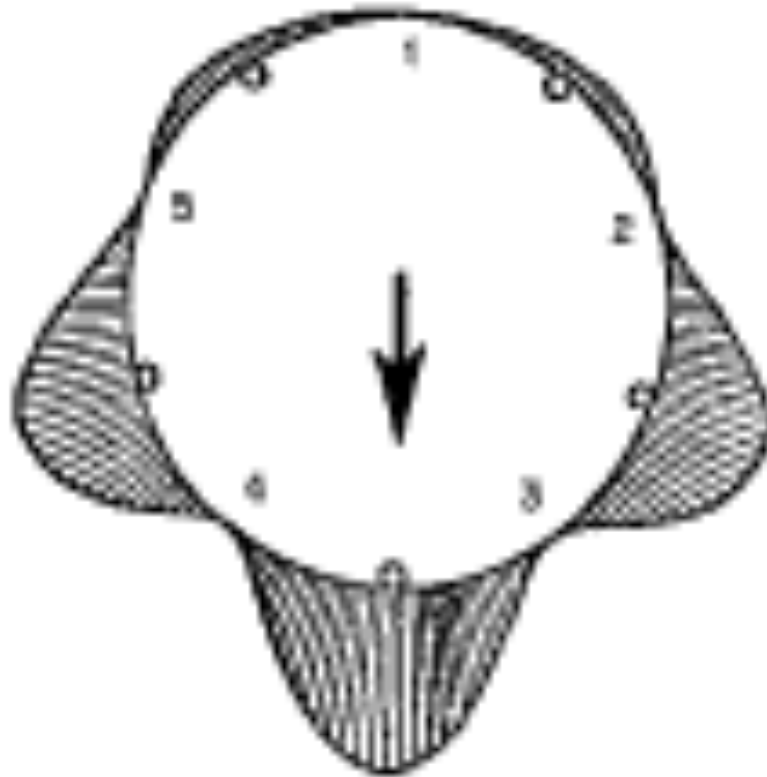
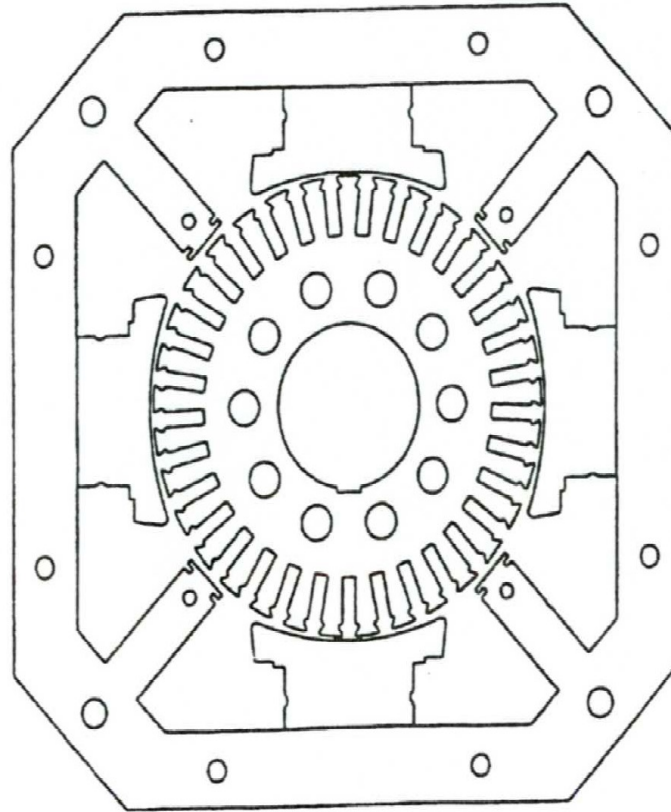


FIG. 2. One Period Flux Wave & Magnetic Force Wave

Unbalanced Magnetic Fields



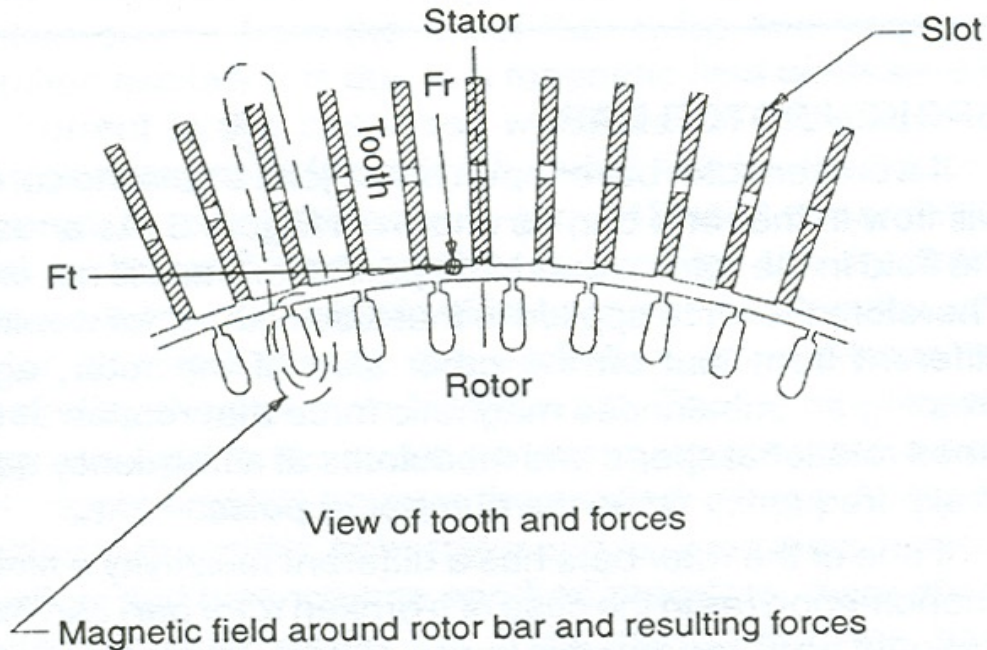
Radial Forces – Frequency of Supply- Poles



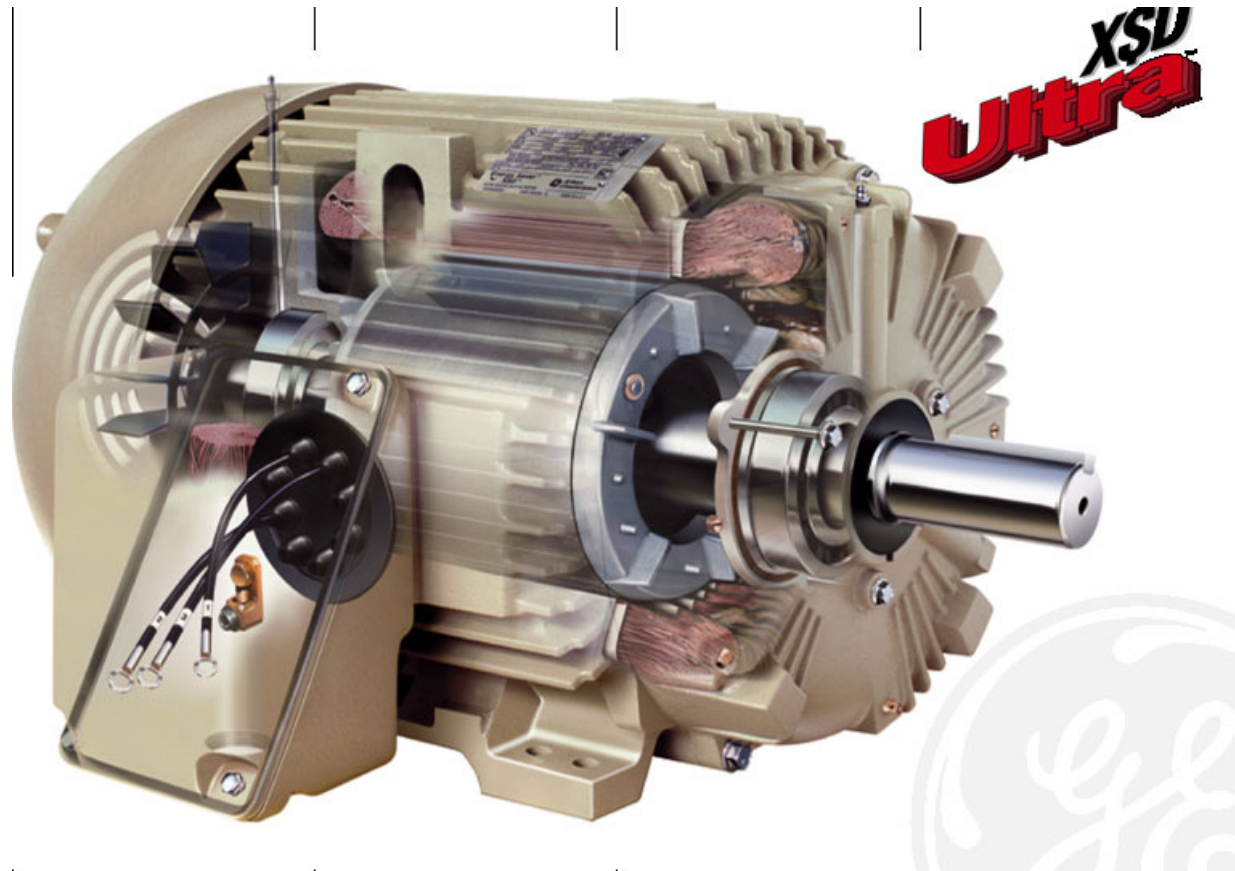
DC Motor Typical Four Pole Lamination

Radial Forces - Slot Passing

FIGURE 7: MAGNETIC FIELD AROUND ROTOR BAR AND RESULTING FORCE ON STATOR TEETH



Axial Forces - Magnetic Center

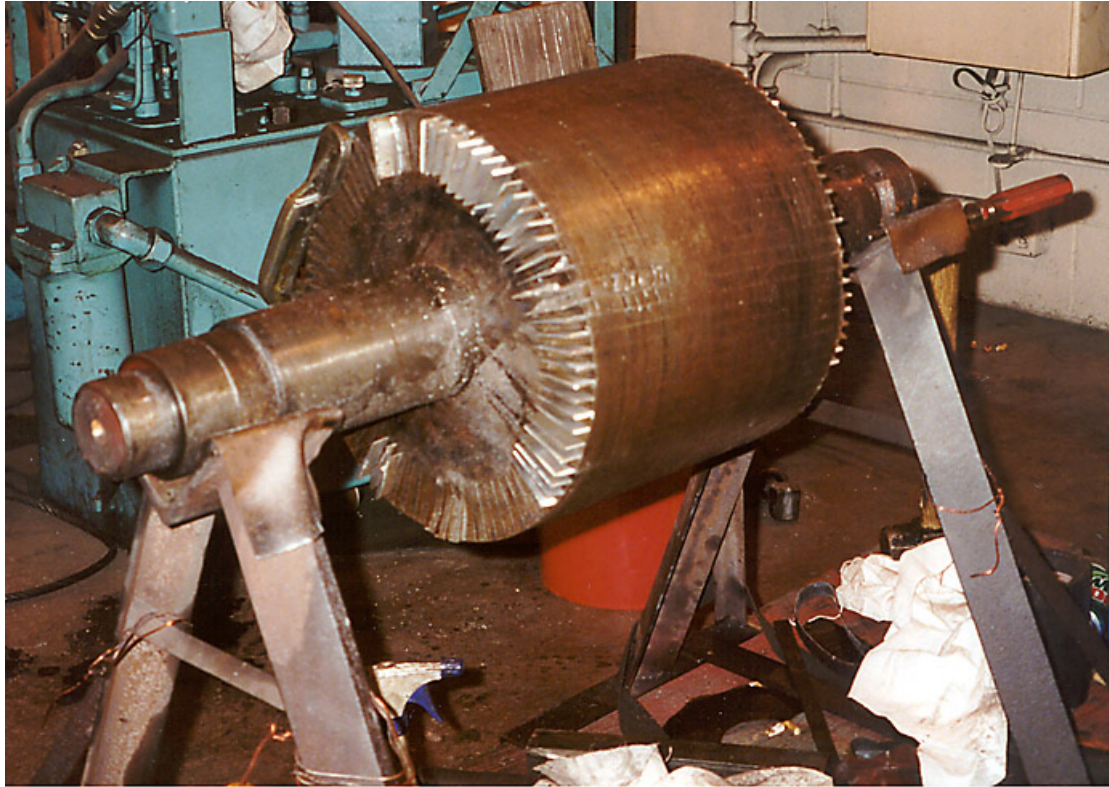


Axial Forces - Air Passages



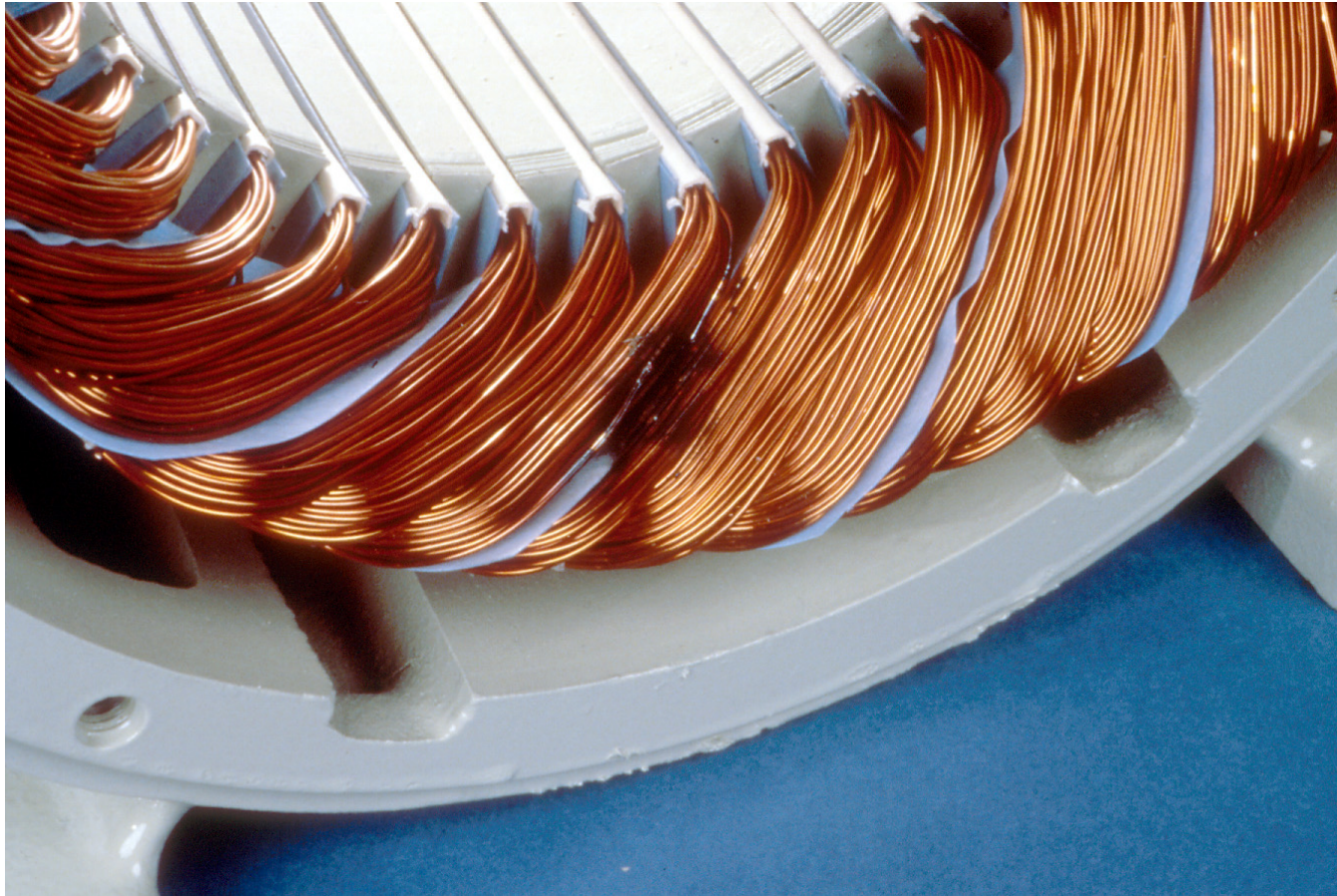
300 HP Synchronous Motor
ID#80-00008AJ

Axial Forces – Rotor Cage

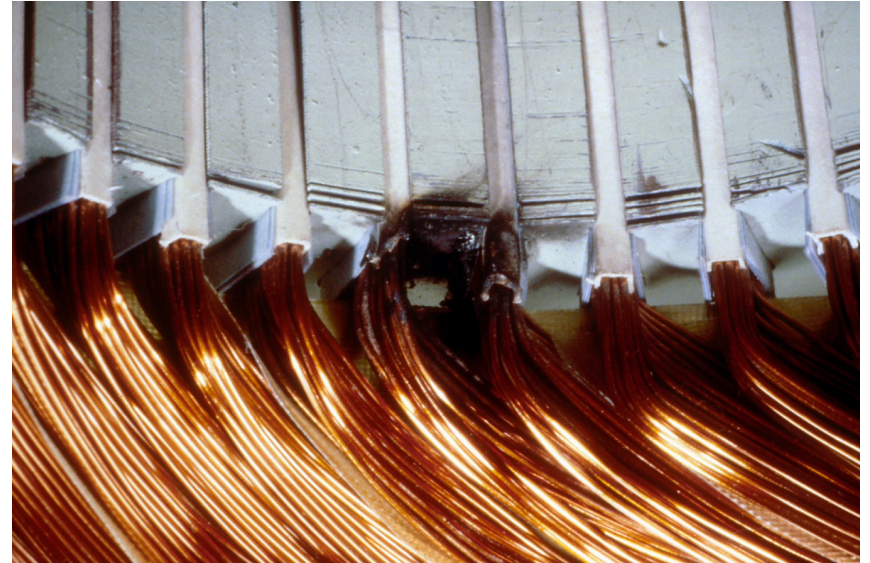
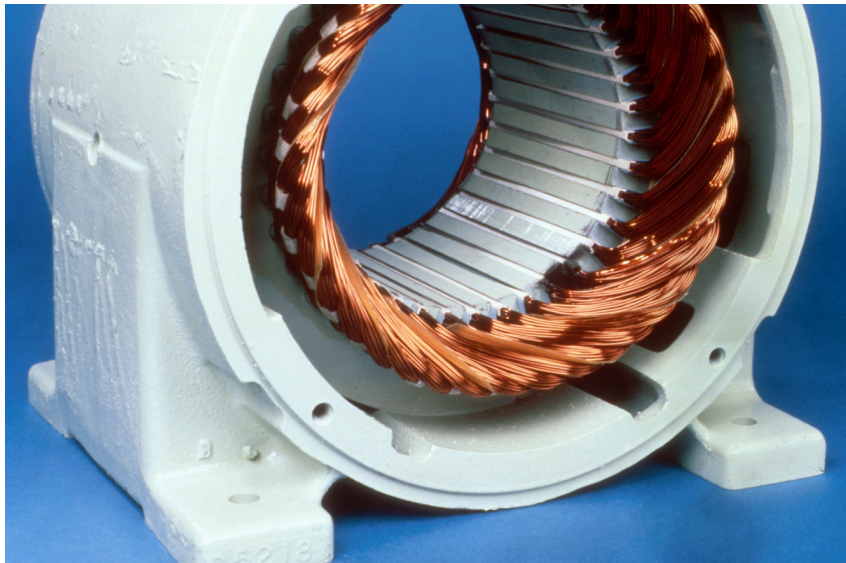


**Rotor w/Shaft
ID# 90-00015B**

Winding Failures - Inter-phase Fault



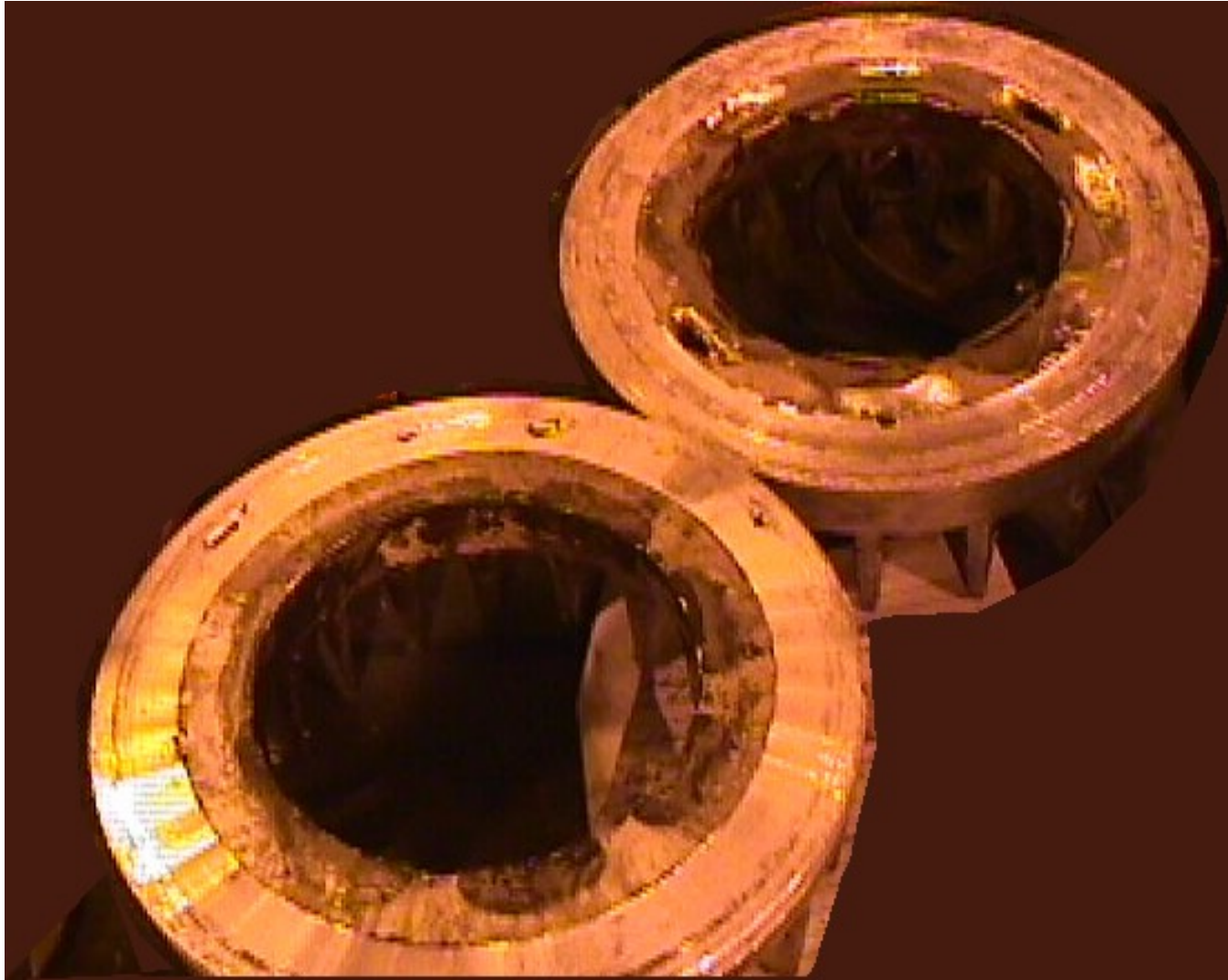
Ground Fault



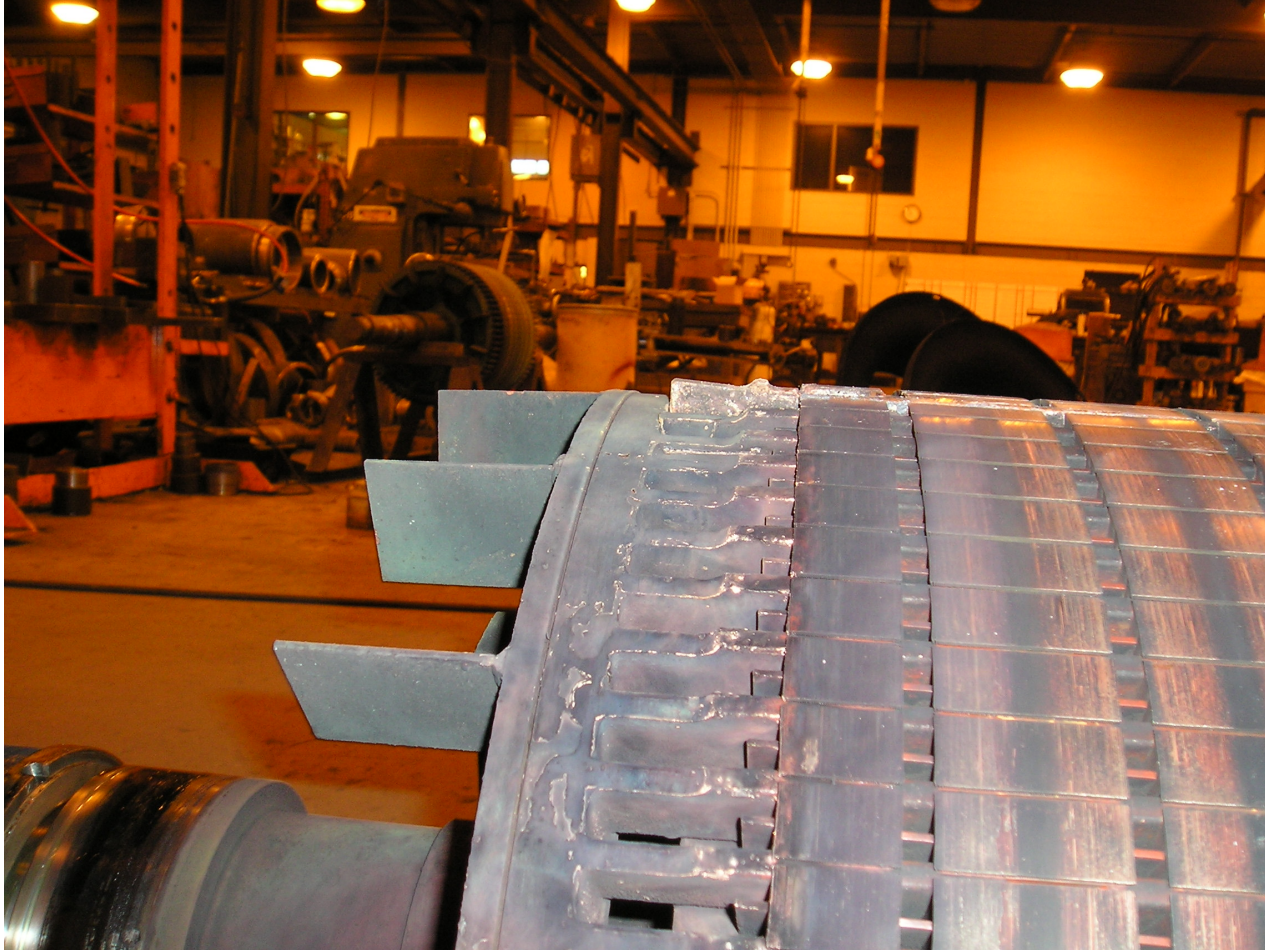
Open Sections



Open Sections



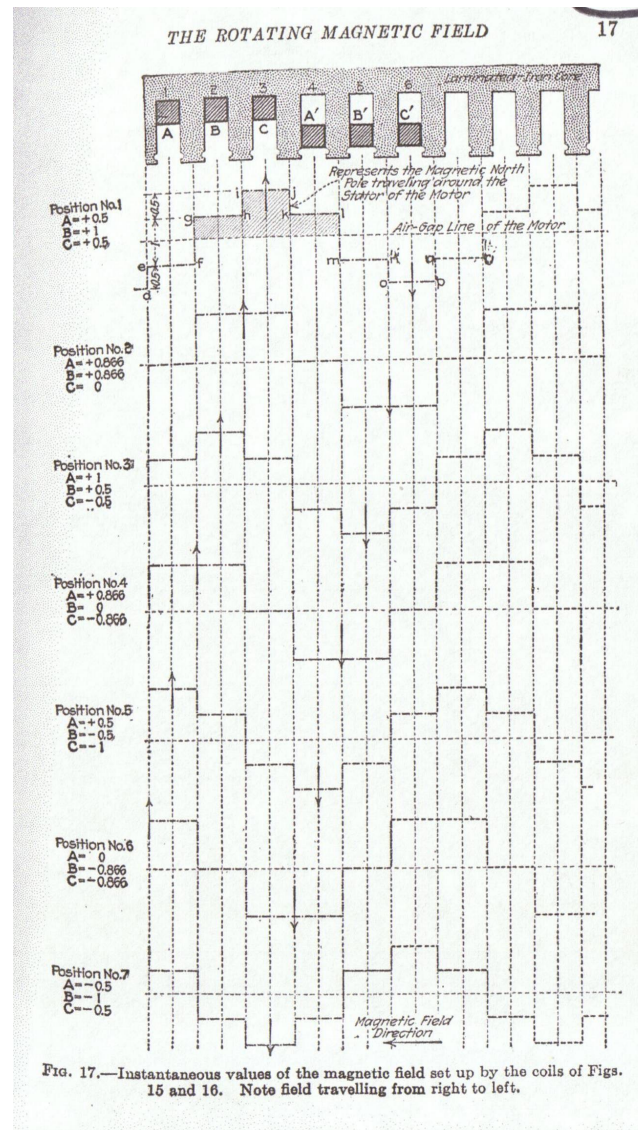
Broken Rotor Bars



Power Supply and Drives

- Unbalanced Voltage Supply
- Intermittent Connections
- Pulsing from the Drive
- Harmonics from the Drive
- Encoder/Feedback Devices

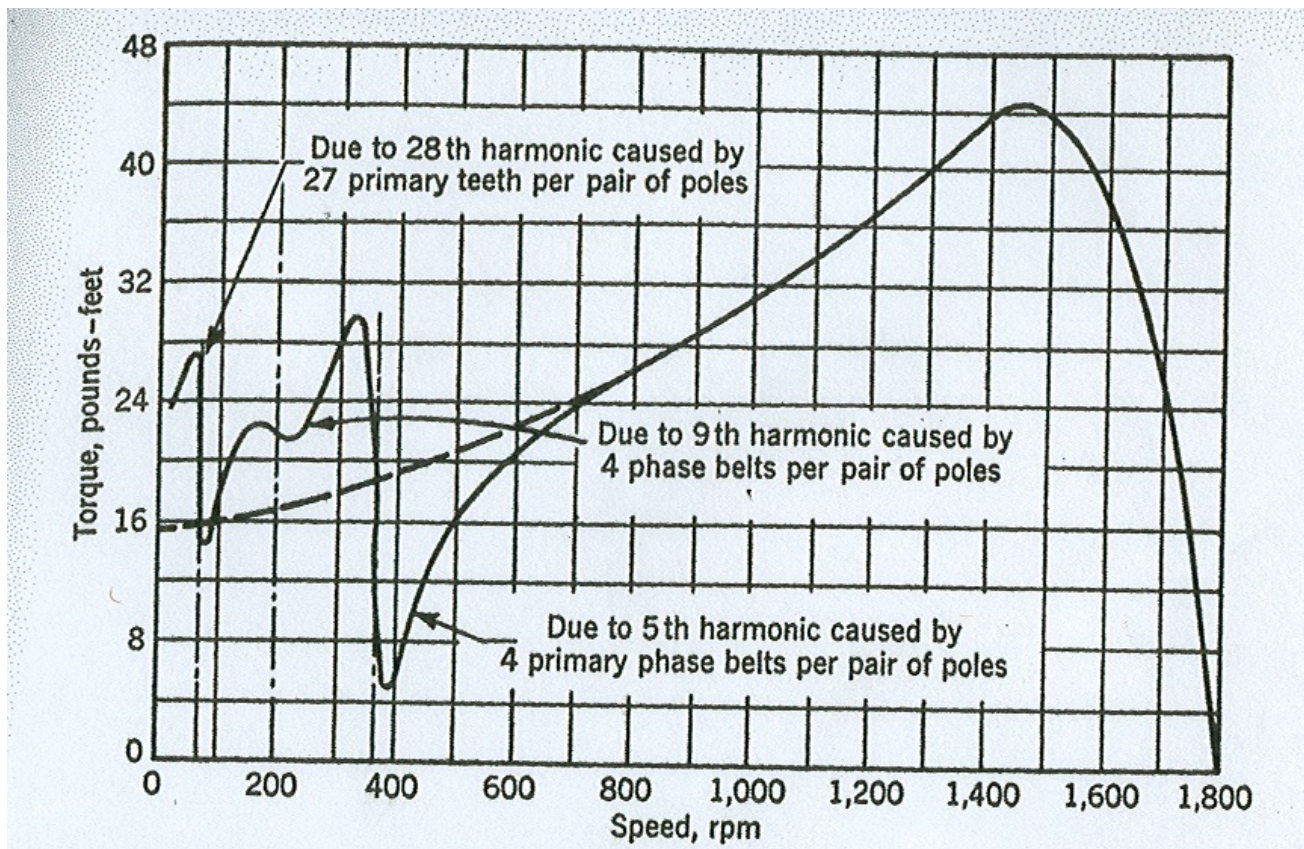
Unbalanced Supply Voltage



Intermittent Connections



Harmonics from Drive



Power Supply/Drives

- Encoder/ Feedback faults



Mechanical Sources

- Rotating Mass
- Eccentricity
- Roughness
- Load
- Rubbing
- Misalignment
- Distortion/Strain
- Oil Whirl

Rotating Mass



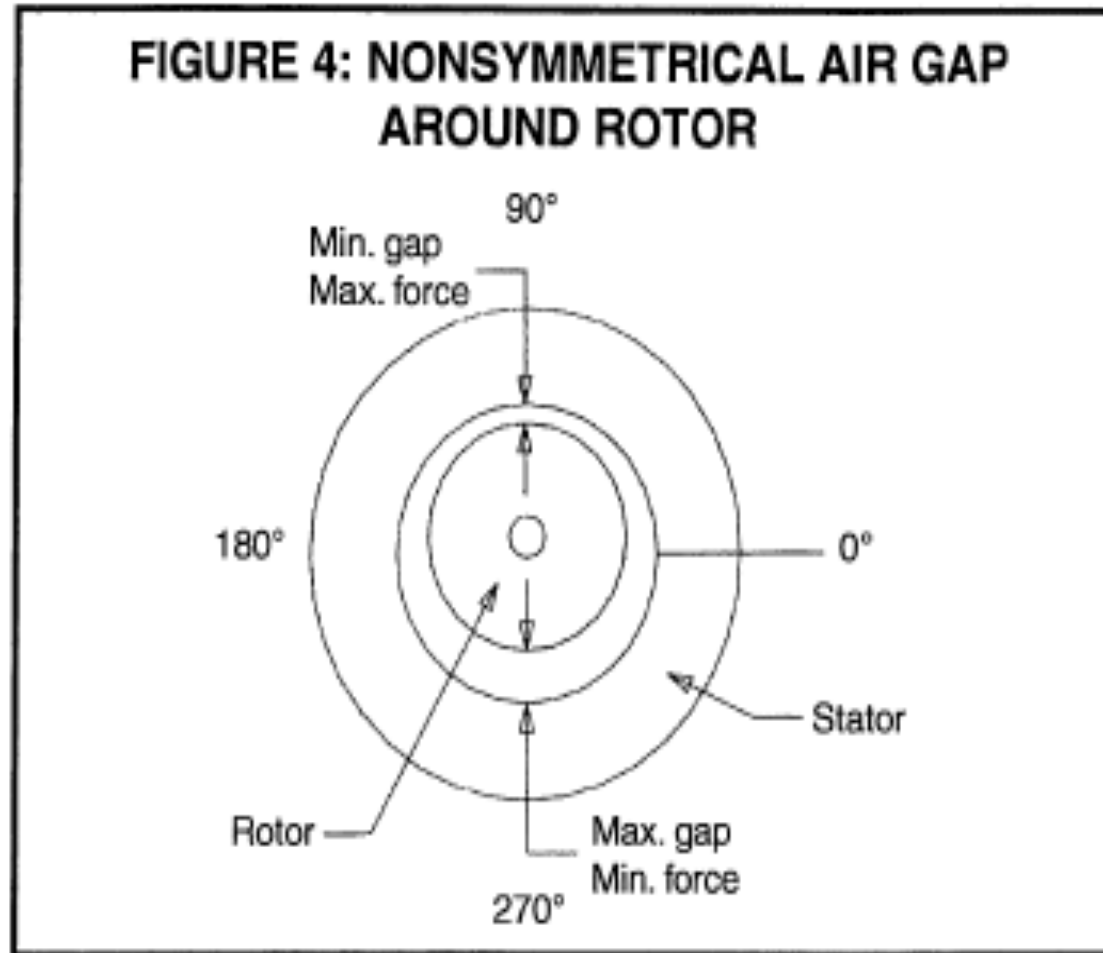
Coupling and Key



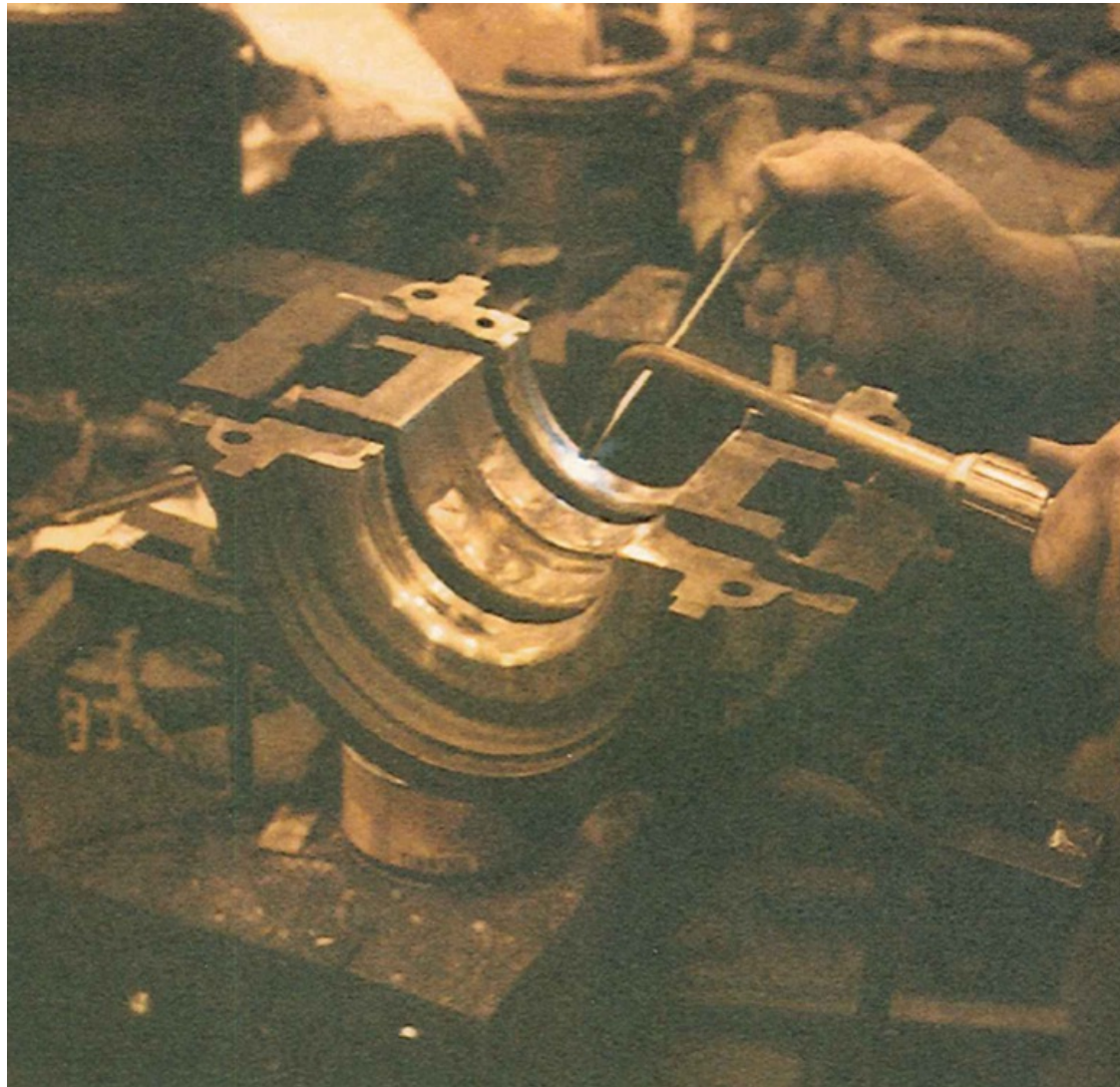
Rotating Mass – Fan Blade



Eccentricity – Rotor Air Gap



Eccentricity – Bearing

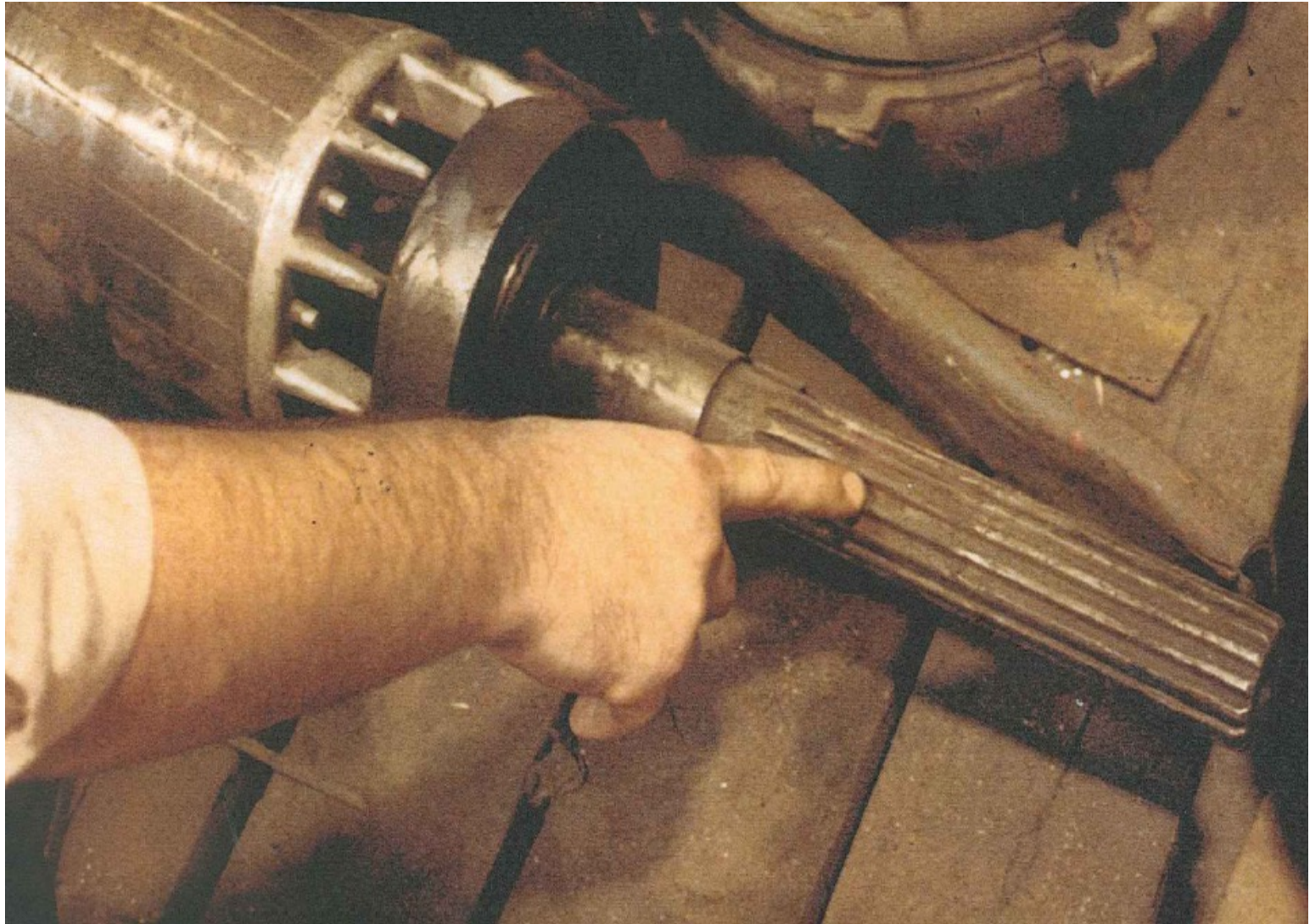


Roughness in Bearing

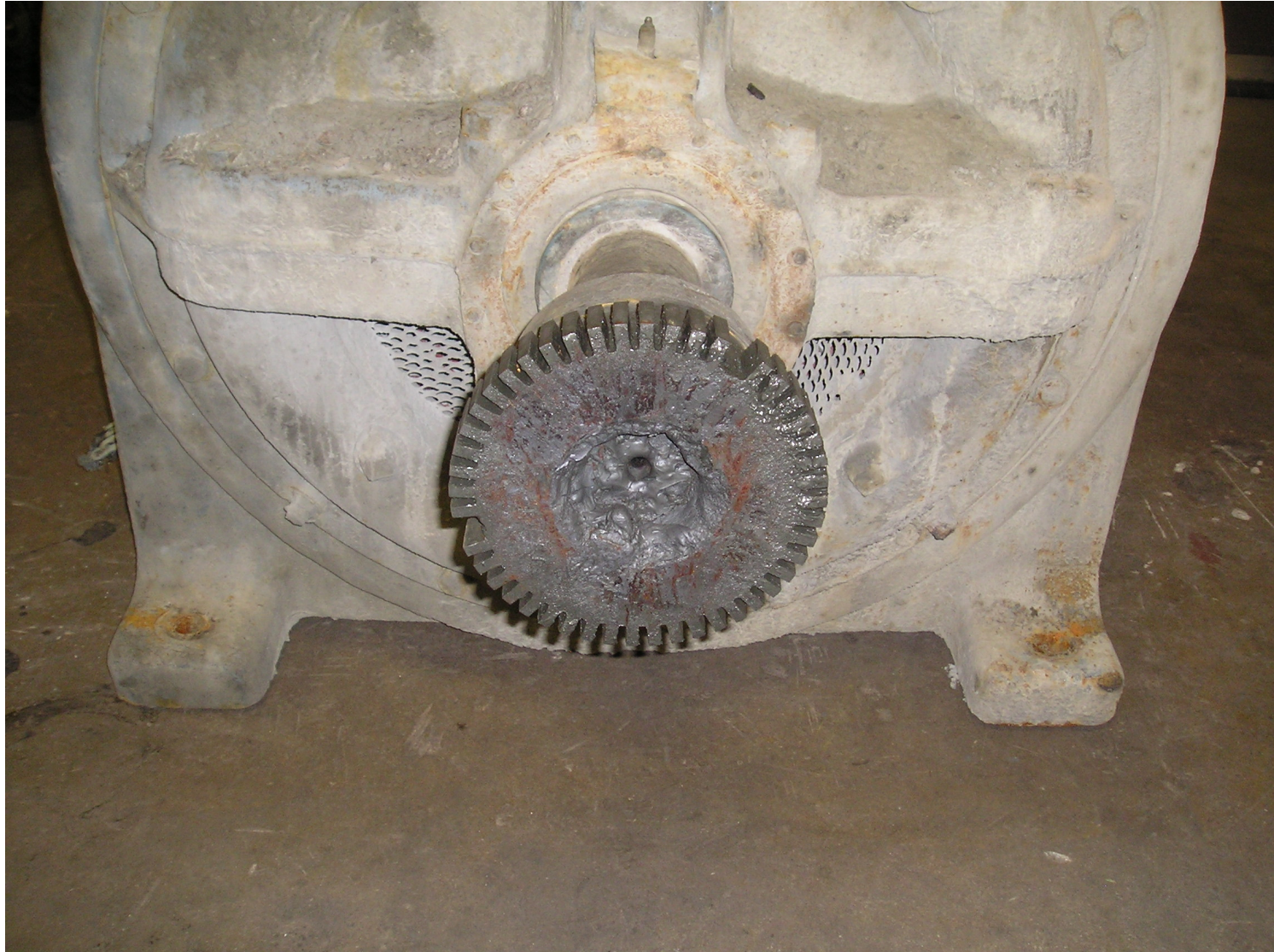
Careful handling and installation practices can minimize or eliminate true brinelling problems.



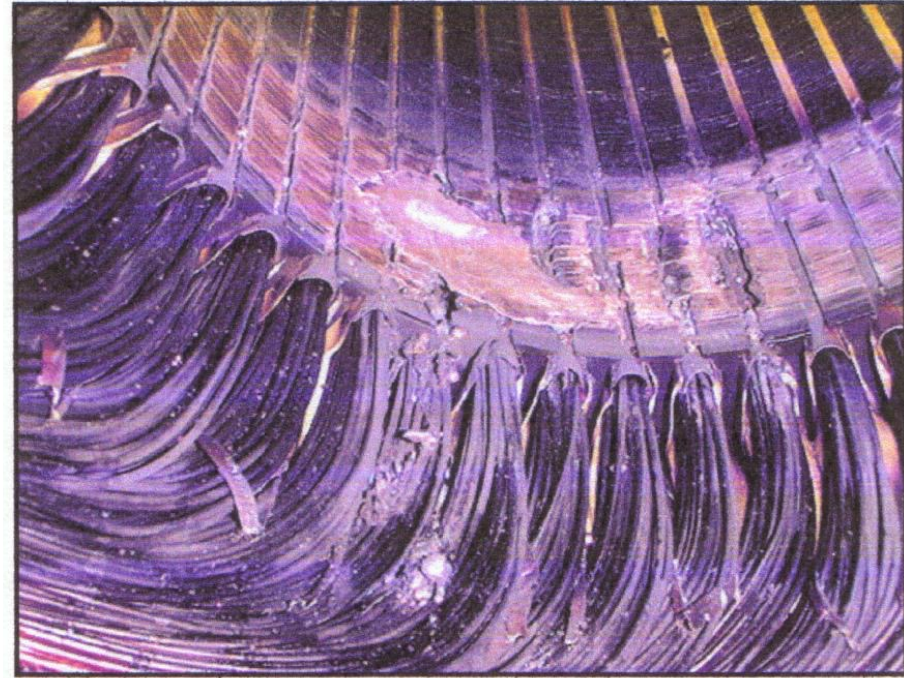
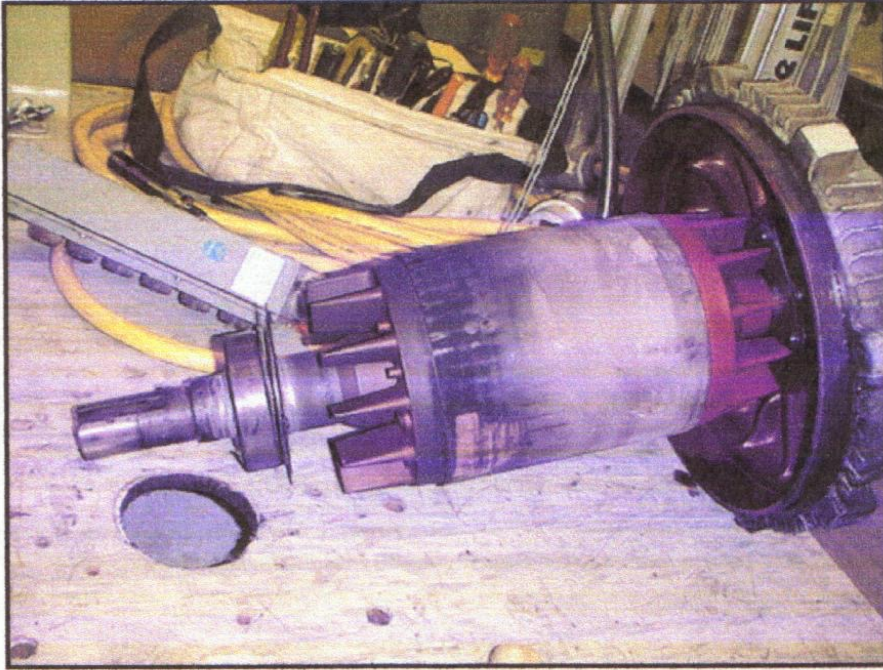
Roughness in Gears



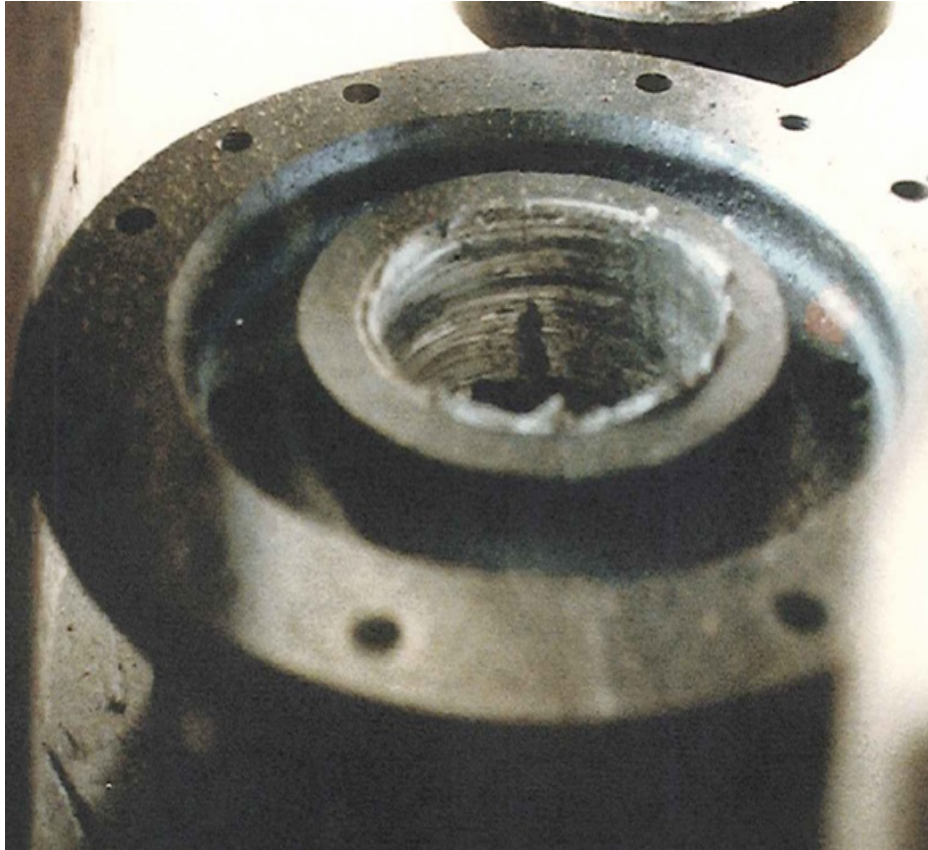
Load



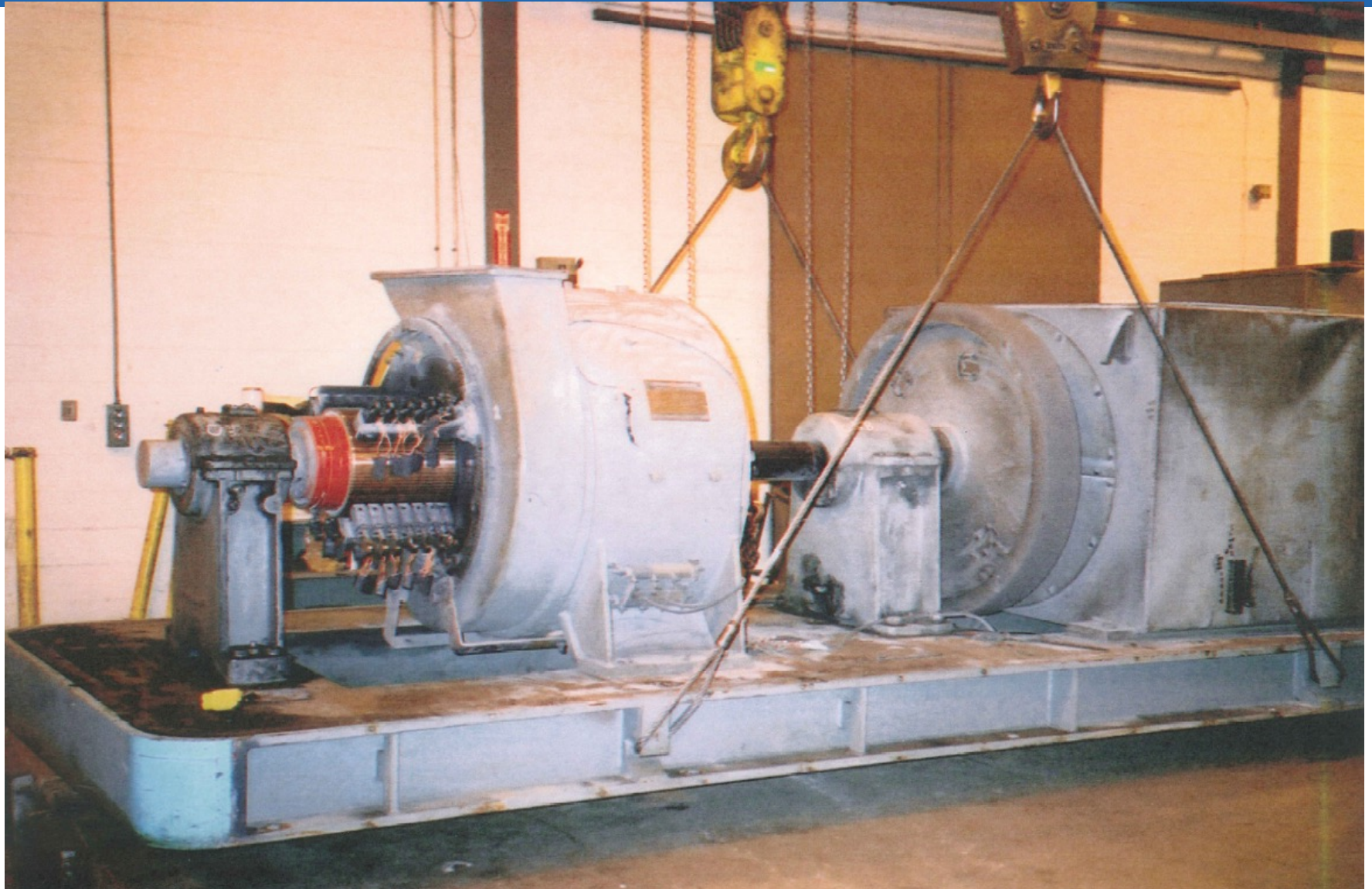
Rubbing



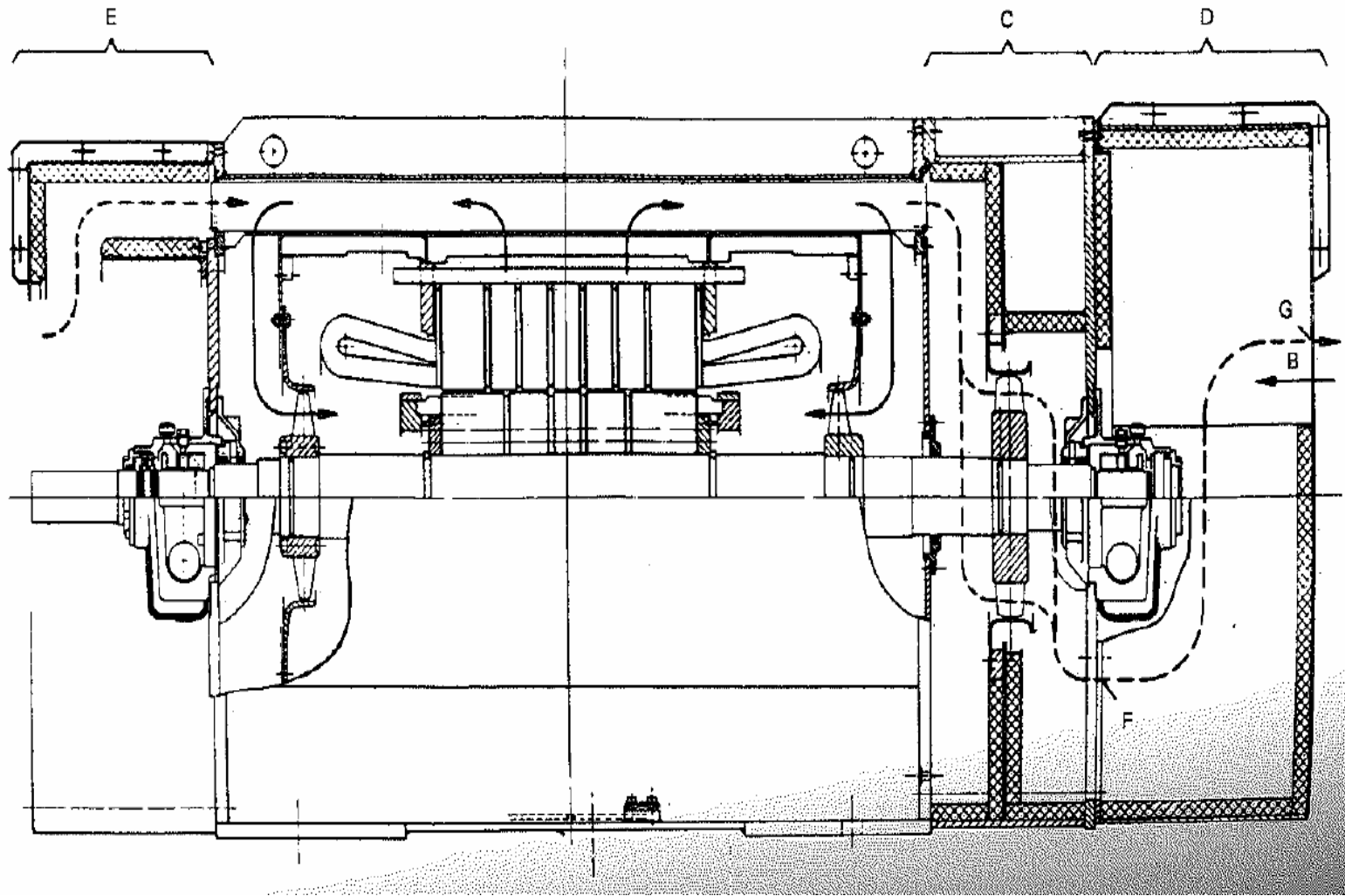
Rubbing - Bearing



Misalignment



Air Passages in Stator and Rotor



Warped Frame

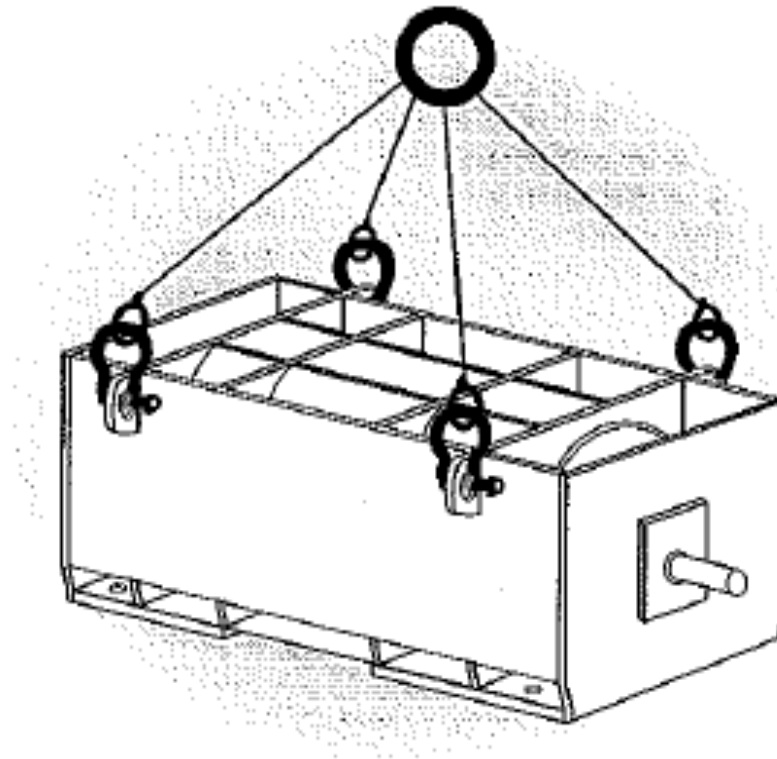


Figure 1. Always use the manufacturer provided lifting points.

Water or Electric Supply Piping

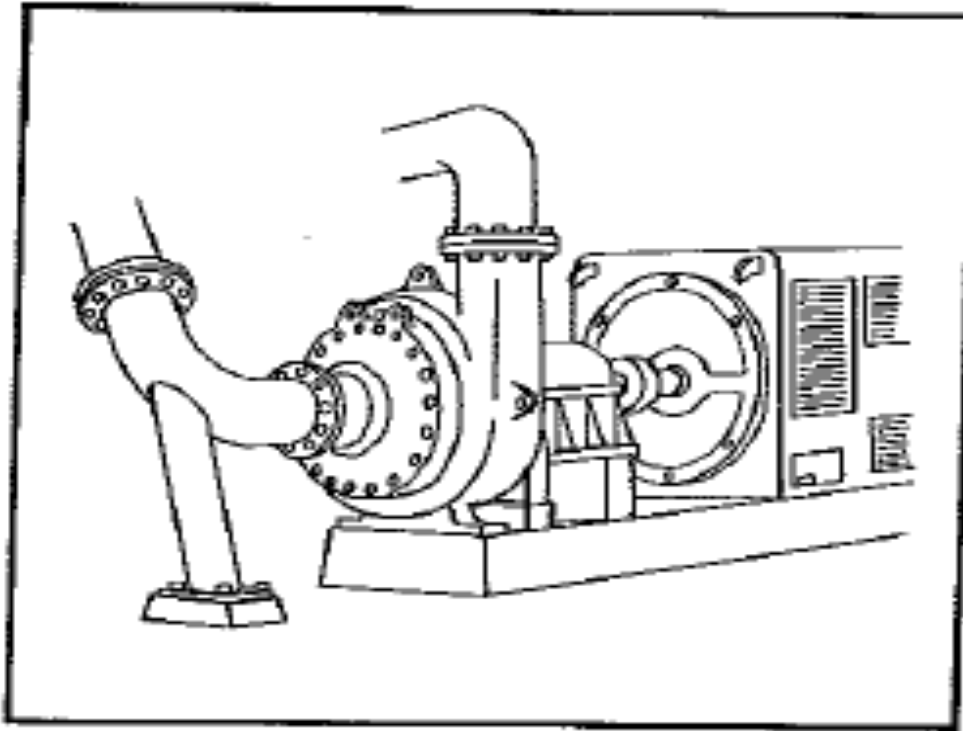


Figure 9-17. One type of support used to minimize drive vibration transmitted to a pump from the external piping.

Amplifier Effects

- Resonance
- Soft Foot - Rocking
- Looseness

Amplifier Effects - Resonance



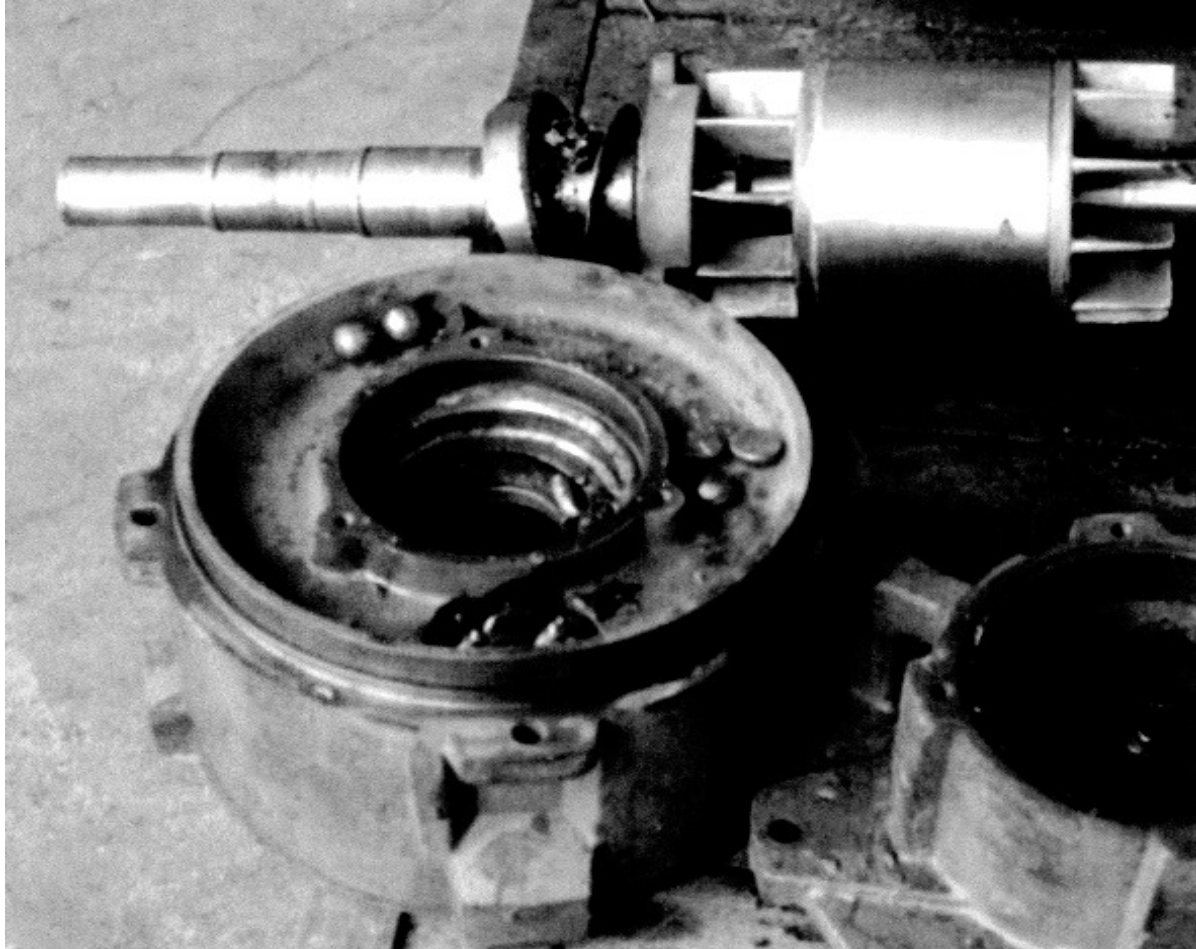
Amplifier Effects – Soft Foot



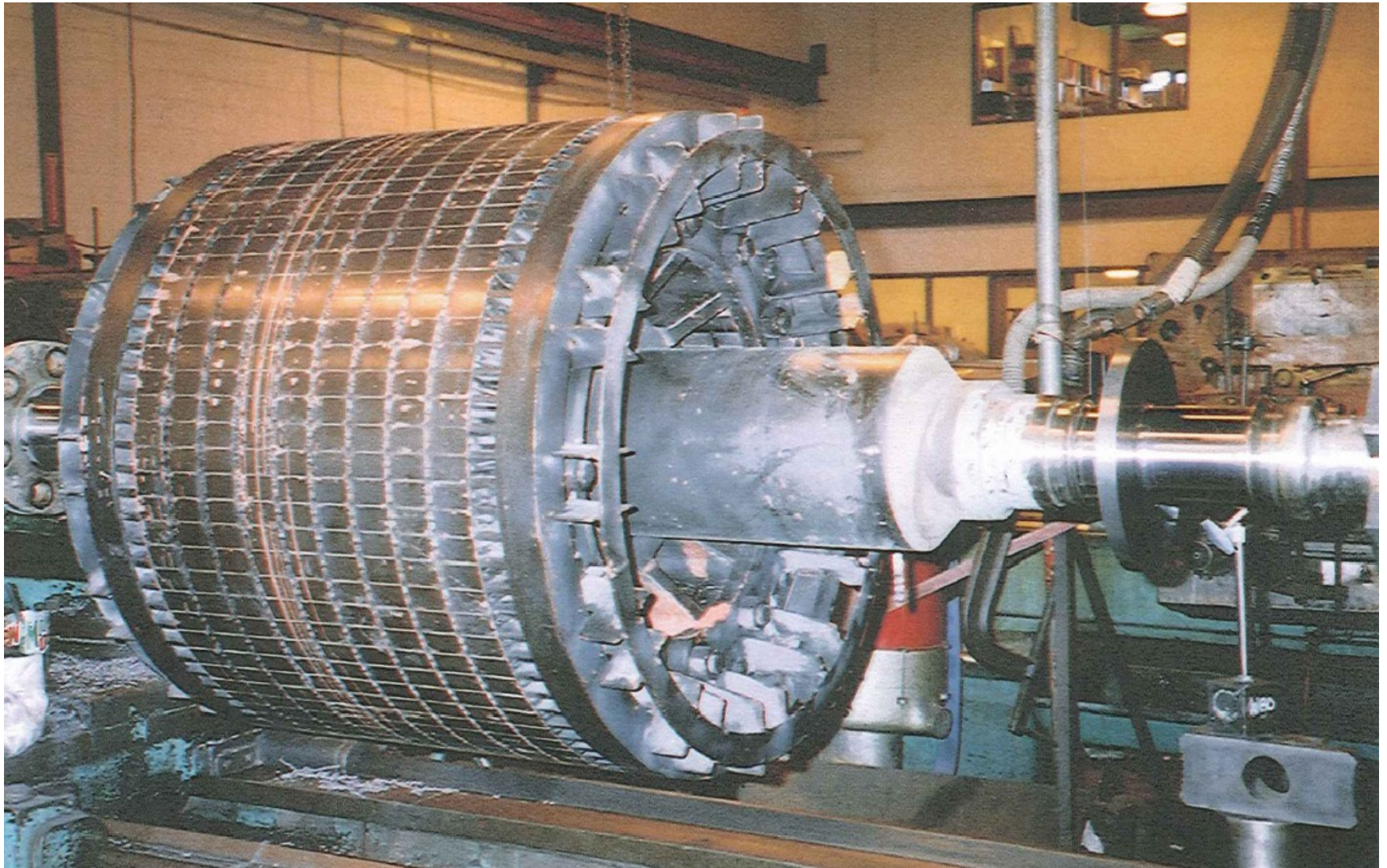
Amplifier Effects – Looseness Bearing Journal



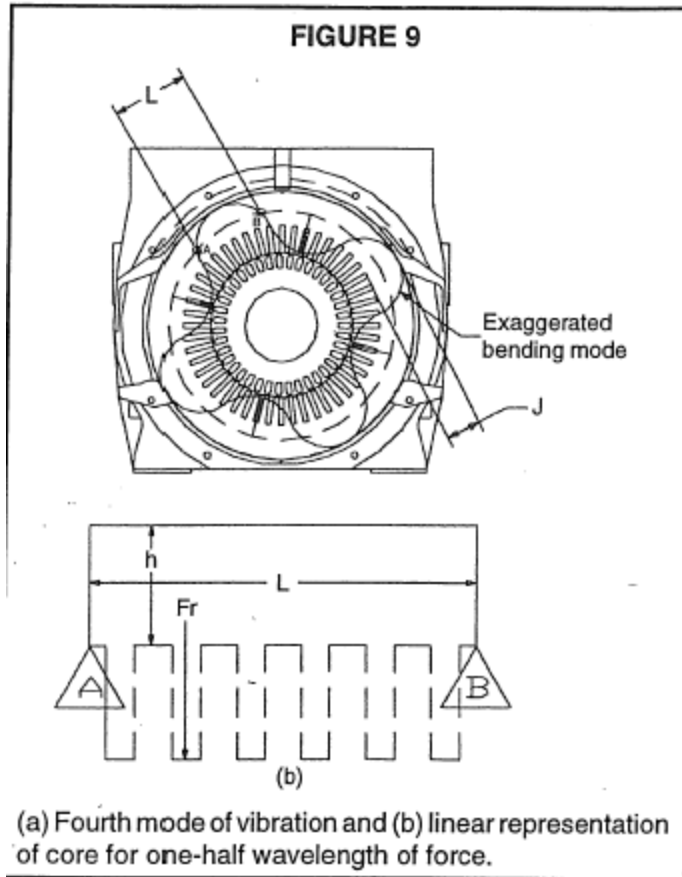
Amplifier Effects – Looseness Bearing Housing



Rotor and Sleeve Journal

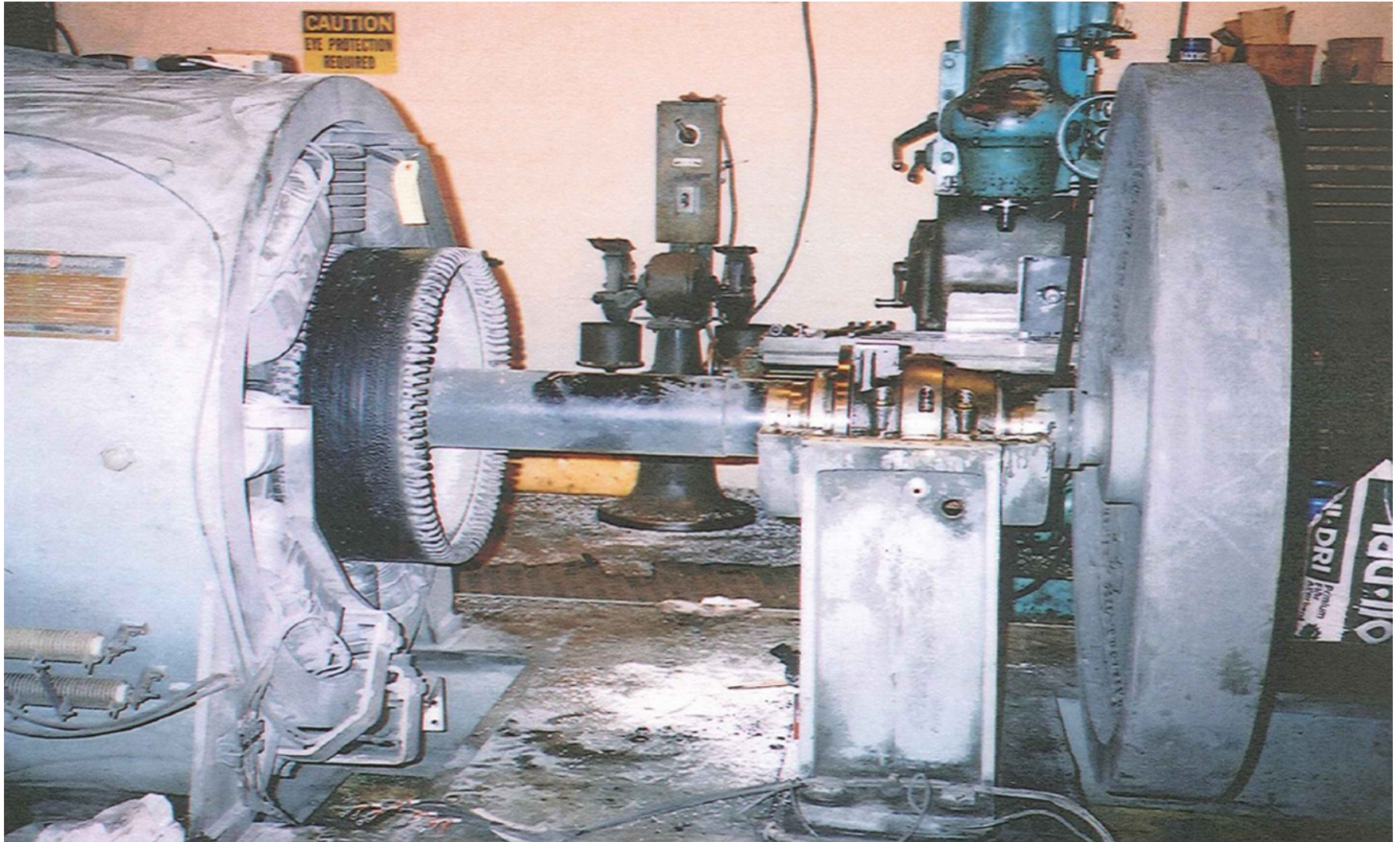


Amplifier Effects - Looseness – Stator Core

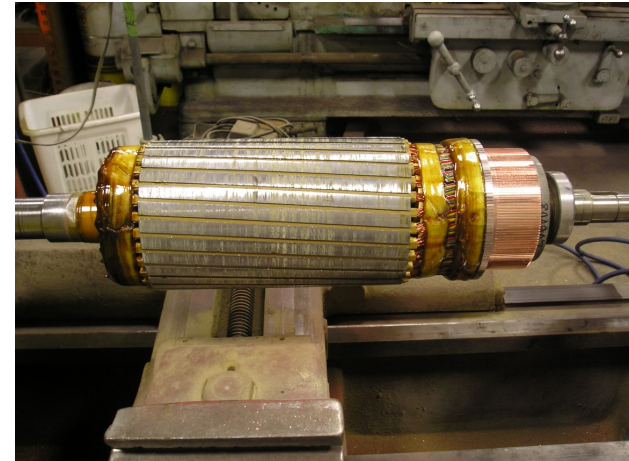
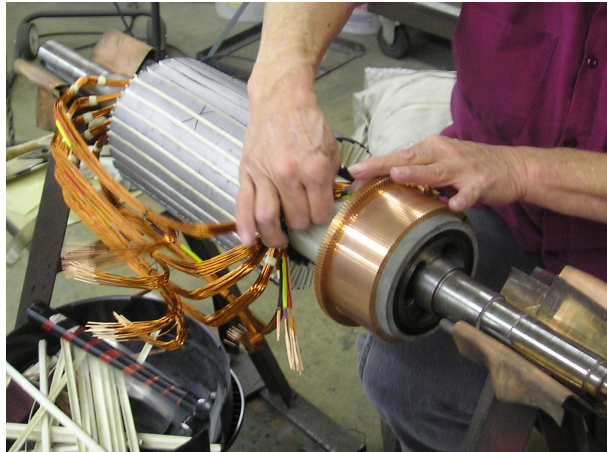
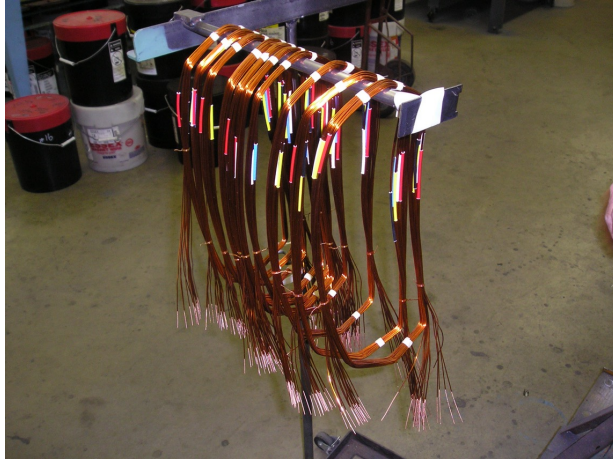


$$L = \frac{\pi D_s}{2M}$$

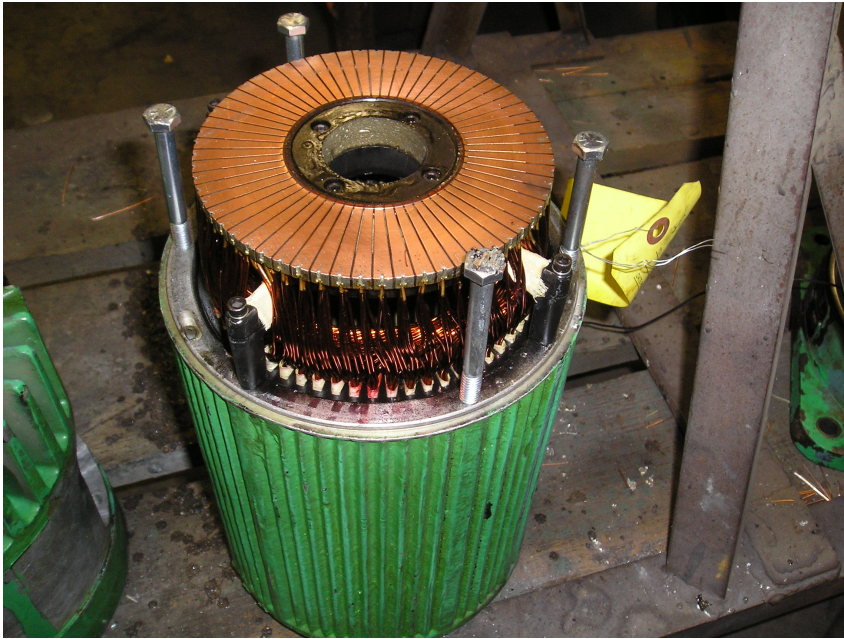
Amplifier Effects - Looseness – Pedestal



Armature Winding



Inside Out Motor



References

1. William R. Finley, Mark M. Hodowanec, and Warren G. Holter, “An analytical approach to solving motor vibration problems,” EASA Tech Note 40, Electrical Apparatus Service Association, Inc., St Louis, March 2002, 16 pages.
2. Tom Bishop, “Motor and drive system resonance problems and solutions,” *EASA Currents*, pages 4 to 8, March 2007.
3. Richard L. Nailen, Managing Motors, Barks Publications, Inc. Chicago, 1991.
4. S.A. Naser, Handbook of Electric Machines, McGraw-Hill, NY, 1987.