

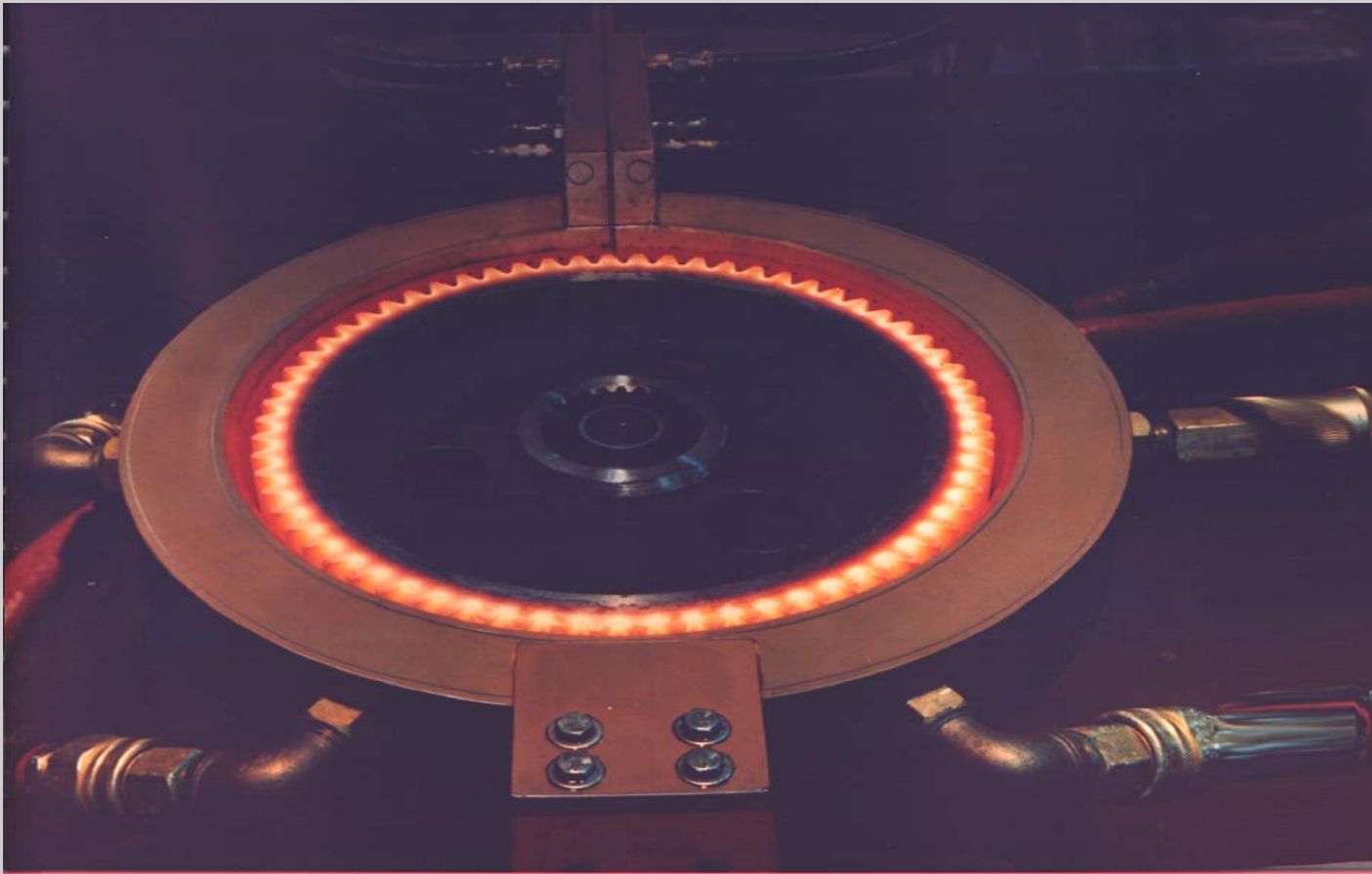


BASICS OF **INDUCTION HEATING**

Heat Treating

What is Induction Heating ?

Eddy currents internally produced on the work piece by an alternating magnetic field, causes the heating effect.



Behind the Mystery !

◆ **Proximity Effect**

◆ **Power Density**

◆ **Skin Depth**

◆ **Curie**

◆ **Martensite**

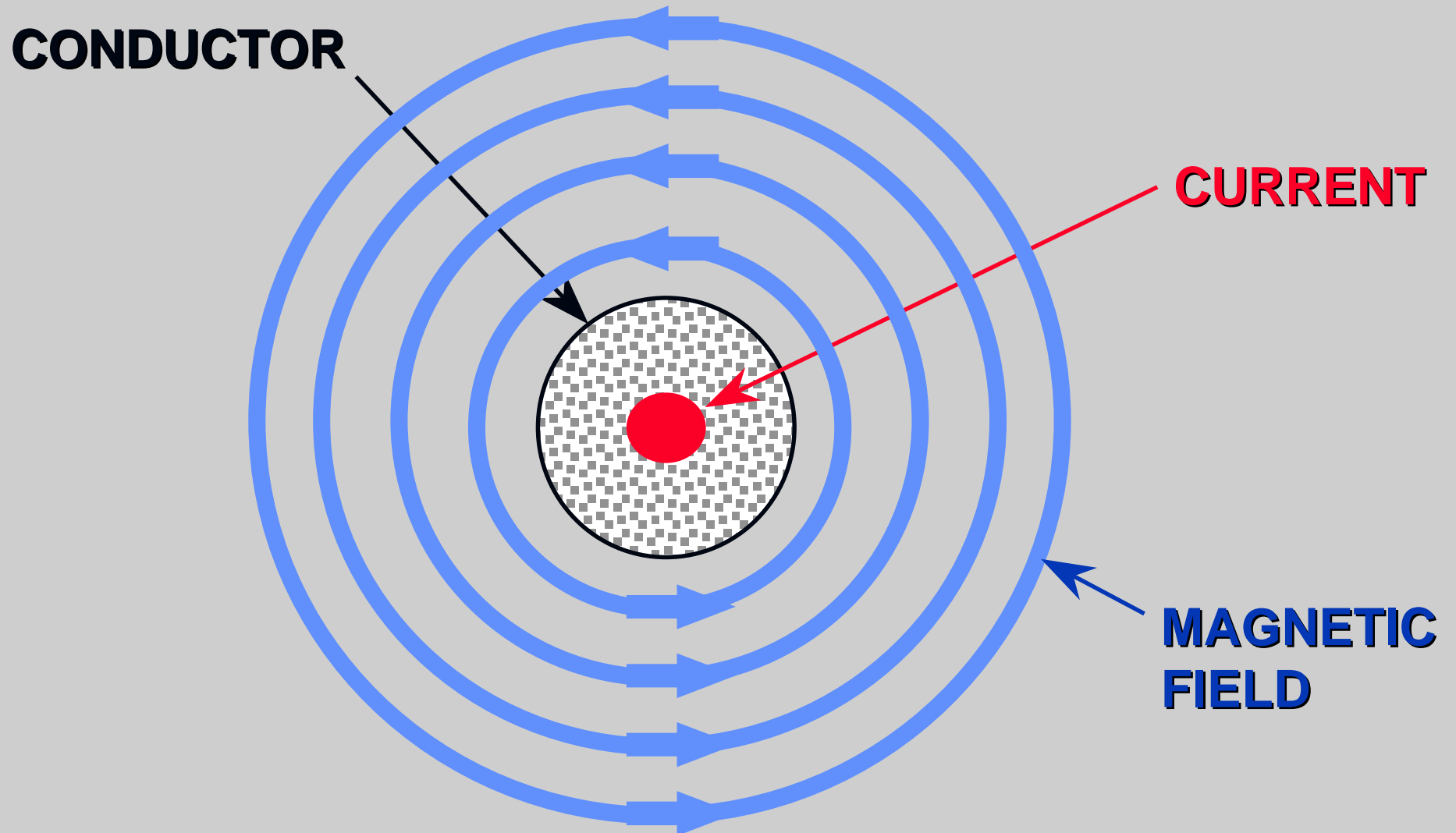


◆ **Transformation**

◆ **Energy Density**

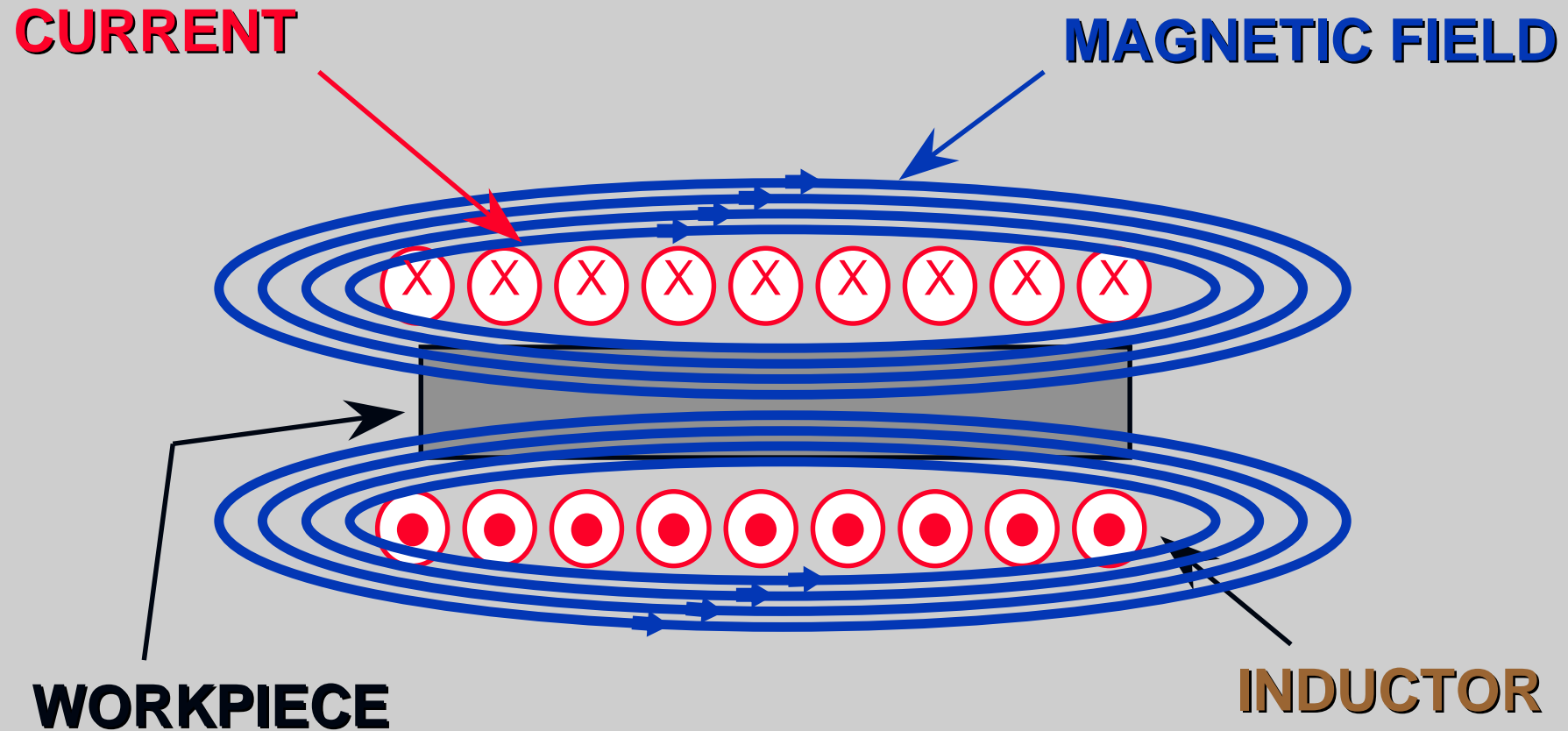
◆
$$e = -N \frac{d\Phi}{dt}$$

Magnetic Field Theory



Electromagnetic Induction Theory

Eddy currents internally produced on the workpiece by an alternating magnetic field, causes the heating effect.



Faraday's Law

Induction refers to the electromagnetic phenomenon discovered by Michael Faraday.

$$e = -N \frac{d\Phi}{dt}$$

e = Voltage

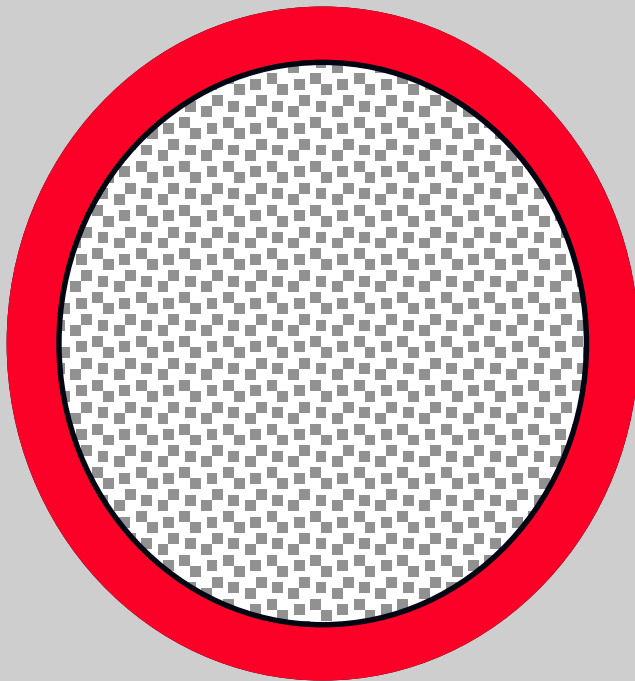
N = Number of Turns

Φ = Magnetic Field [webers]

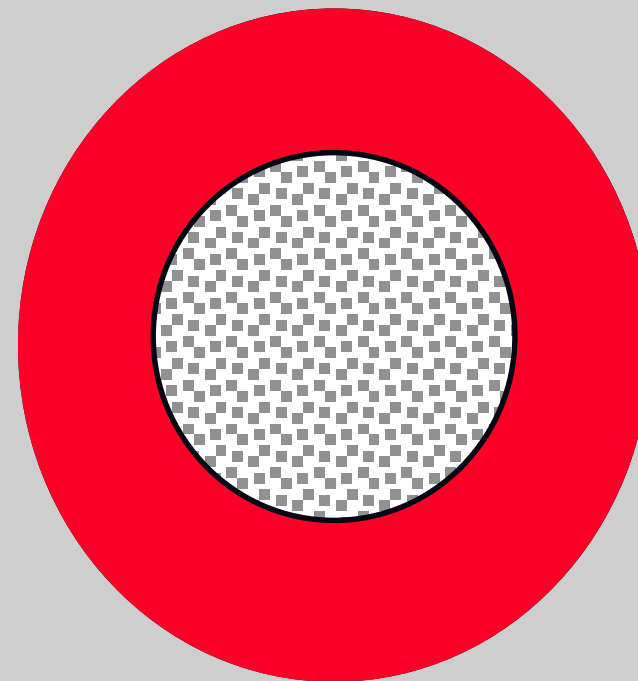
$\frac{d\Phi}{dt}$ = Rate of change of
Magnetic Field

Skin Depth

Effect of frequency on current penetration.



HIGH FREQUENCY



LOW FREQUENCY

Reference Depth

$$d = 3160 \sqrt{\frac{\rho}{\mu f}} \quad (\text{English units [in]})$$

$$d = 5030 \sqrt{\frac{\rho}{\mu f}} \quad (\text{Metric units [cm]})$$

$\mu = 1$ Above Curie for non-magnetic materials

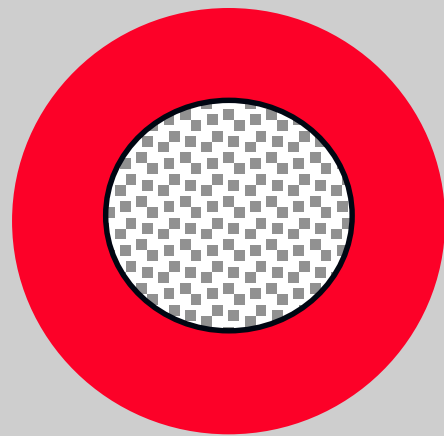
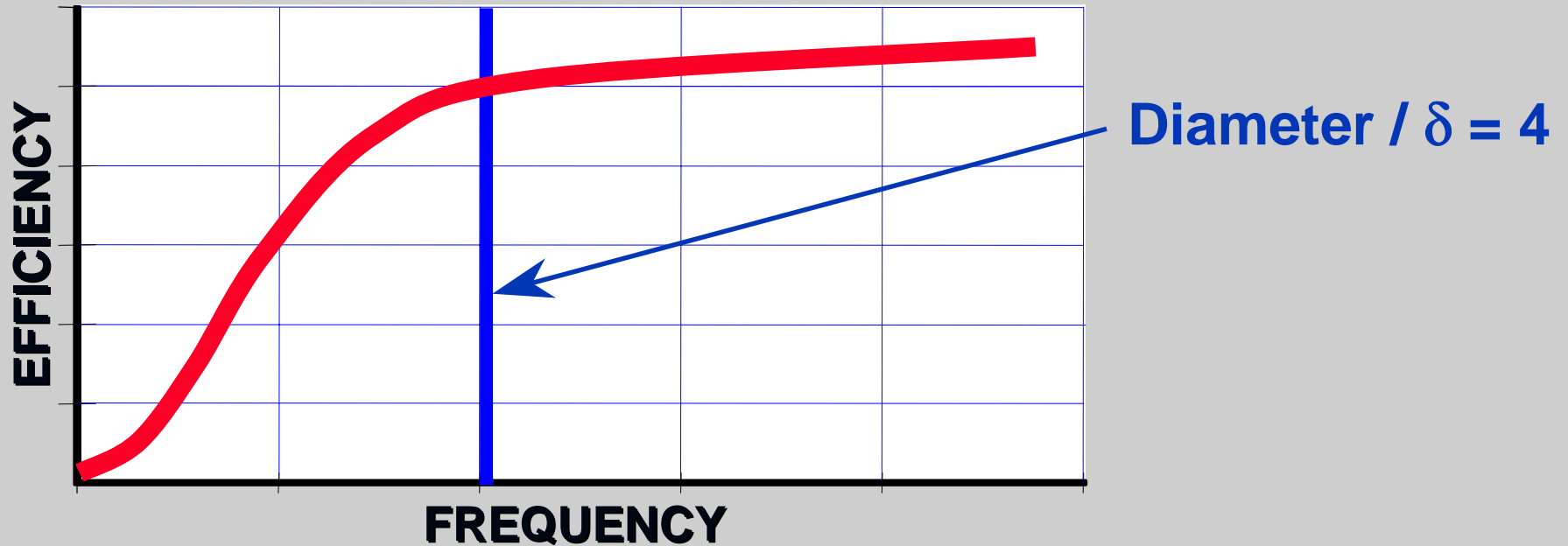
$\rho =$ Electrical Resistivity

$f =$ Frequency (Hz)

Efficiency versus Frequency

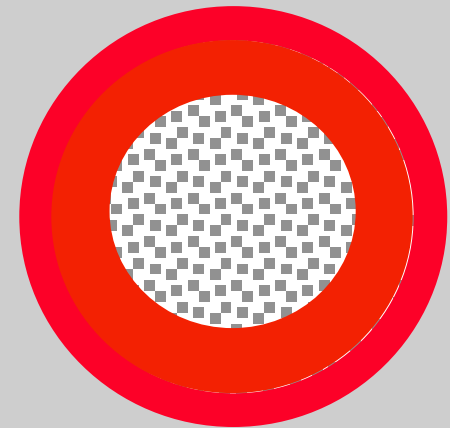
Diameter Fixed

δ = Reference Depth



LOW FREQUENCY

High frequency is more efficient, but requires longer heat time for conduction to center



HIGH FREQUENCY

Permeability

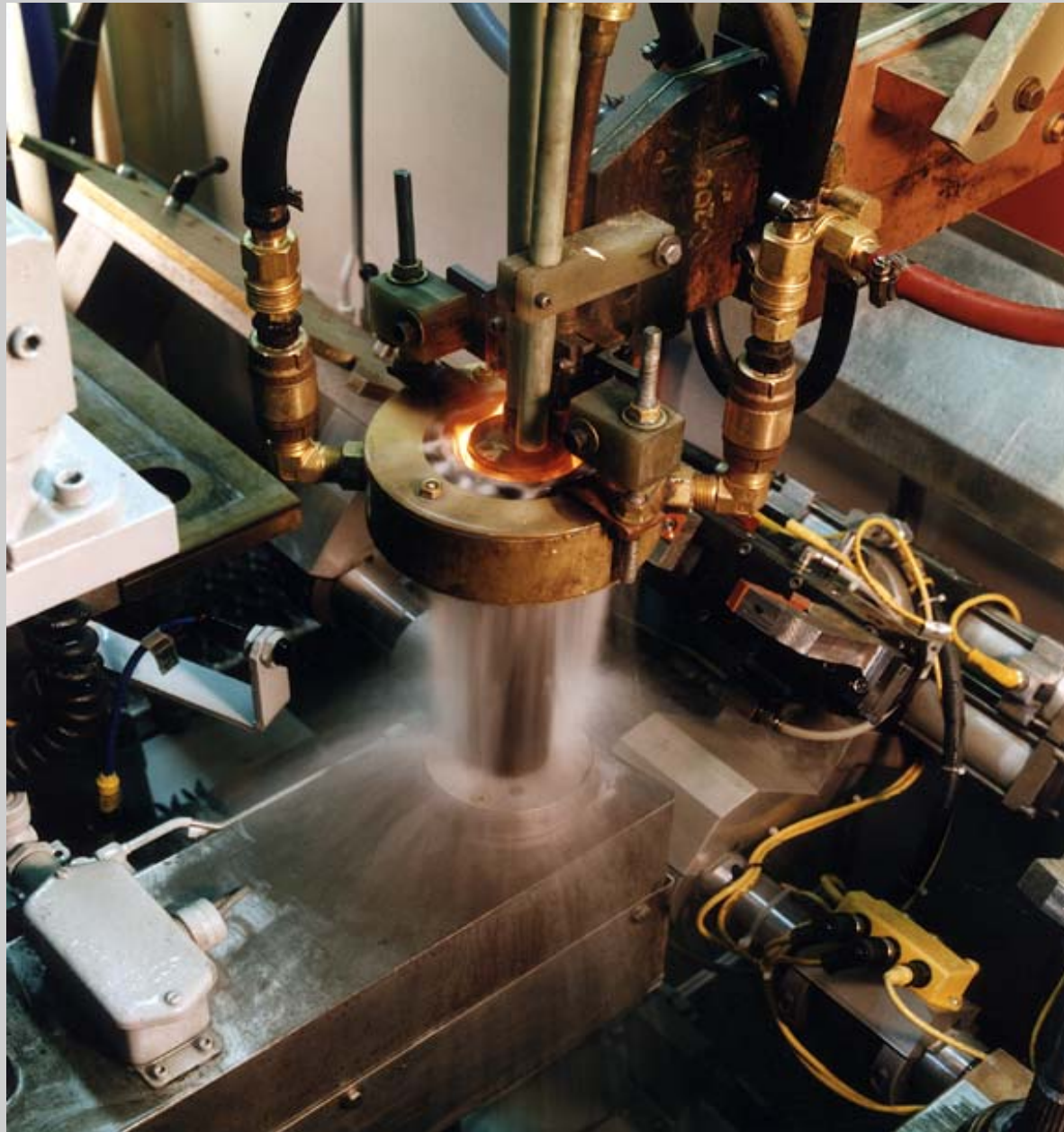
A measure of how magnetic a material is.

It is the unit less measure of flux density in the material divided by what the density would have been in air.

μ [Unit less]

Induction Hardening

H
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Advantages of Induction Heating

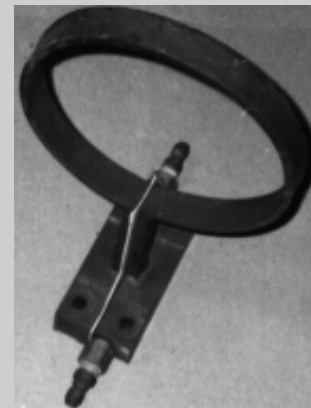
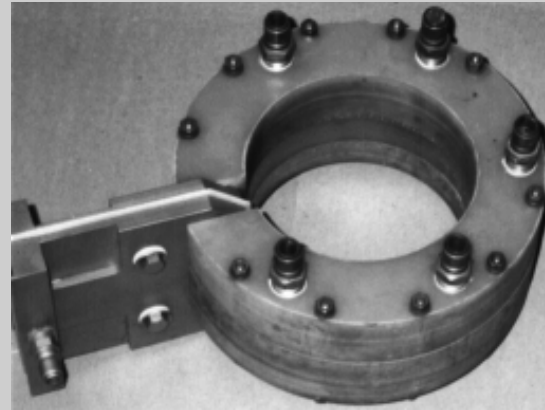
- ◆ **Rapid Heating**
- ◆ **High Power Densities**
- ◆ **Accurate Location of the Heated Area**
- ◆ **Accurate Time and Temperature Control**
- ◆ **Clean Operating Conditions**
- ◆ **Minimal Stand-by Power**
- ◆ **Easily Adapts to Automation**

Considerations for New Equipment

- ◆ **Material**
- ◆ **Hardness Desired**
- ◆ **Pattern Desired**
- ◆ **Production Rate**
- ◆ **Means of Locating**
- ◆ **Quench Media**
- ◆ **Frequency**
- ◆ **Inductor Configuration**
- ◆ **Power Required**
- ◆ **Output Voltage**
- ◆ **Part Rotation**
- ◆ **Efficiency**
- ◆ **Quality Control**
- ◆ **Power Factor**
- ◆ **Utility Requirements**

The Overall Process

- ◆ Inductor
- ◆ Quench Barrel
- ◆ Part
- ◆ Locator



What is an Inductor ?

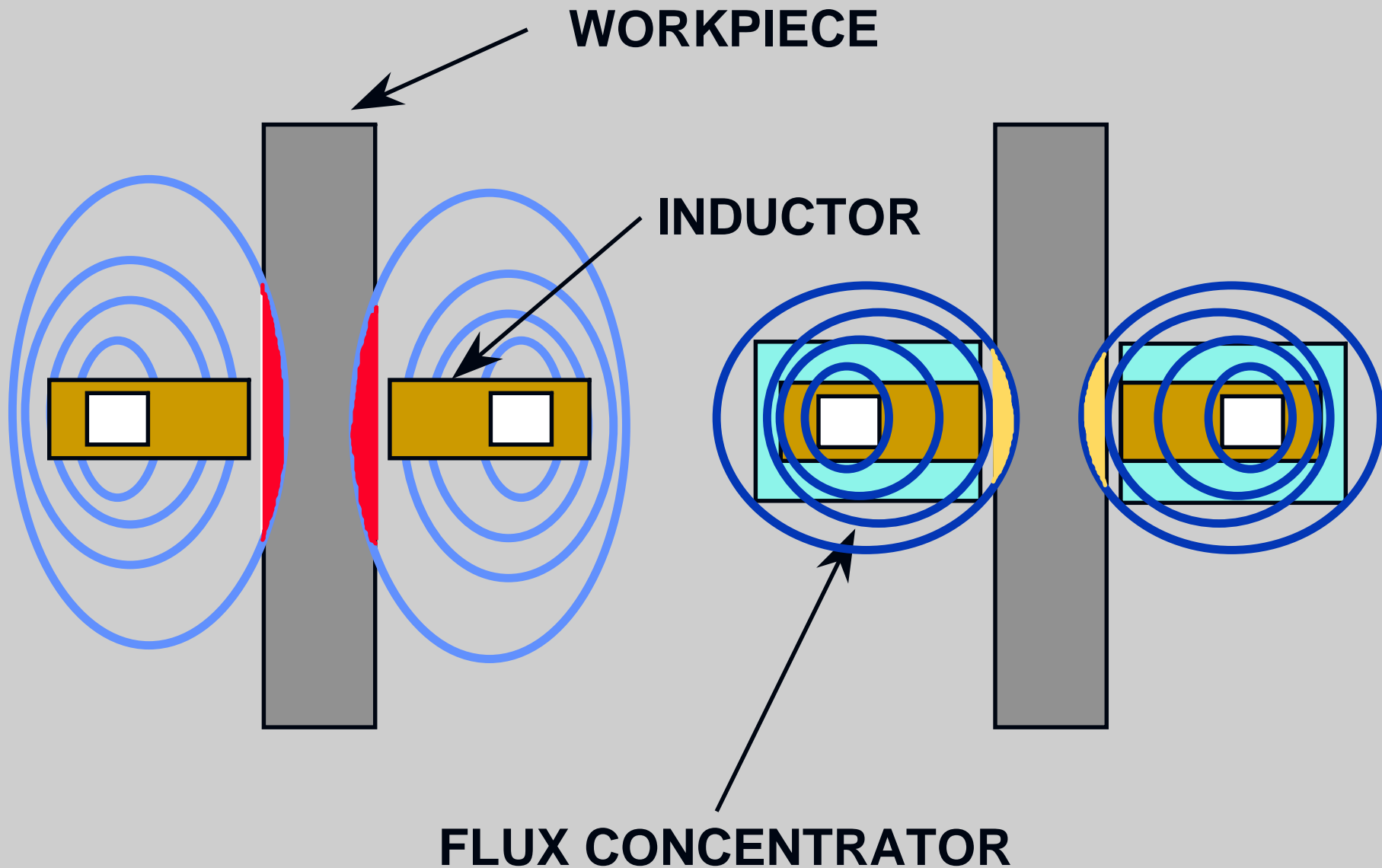
◆ INDUCTOR EXAMPLE



Example of a Two Turn Inductor

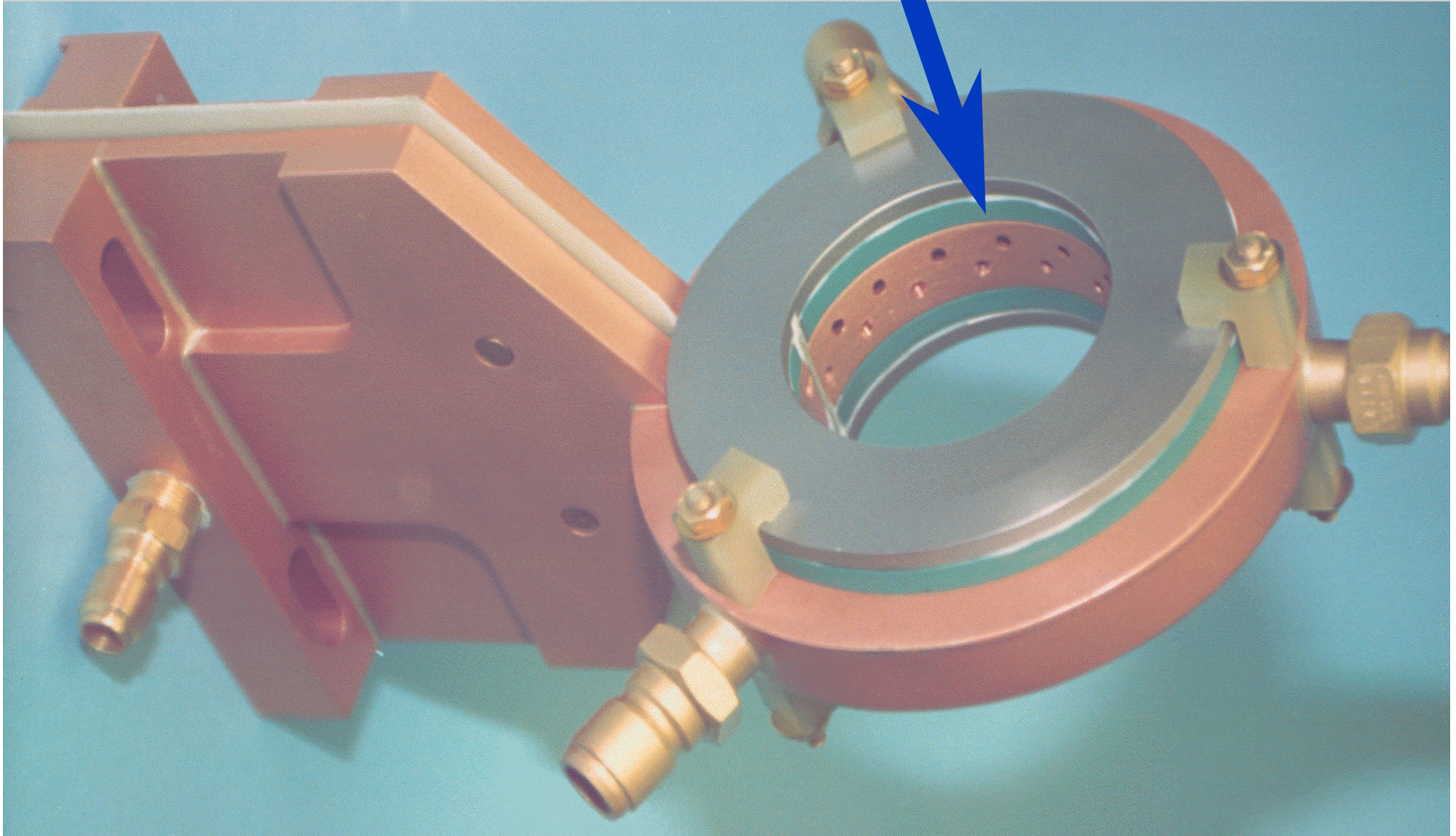
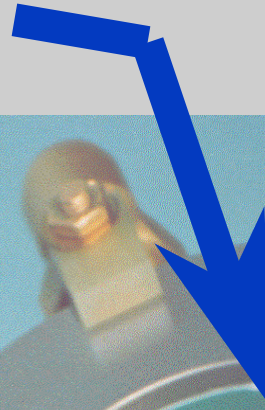


Use of Flux Concentrators

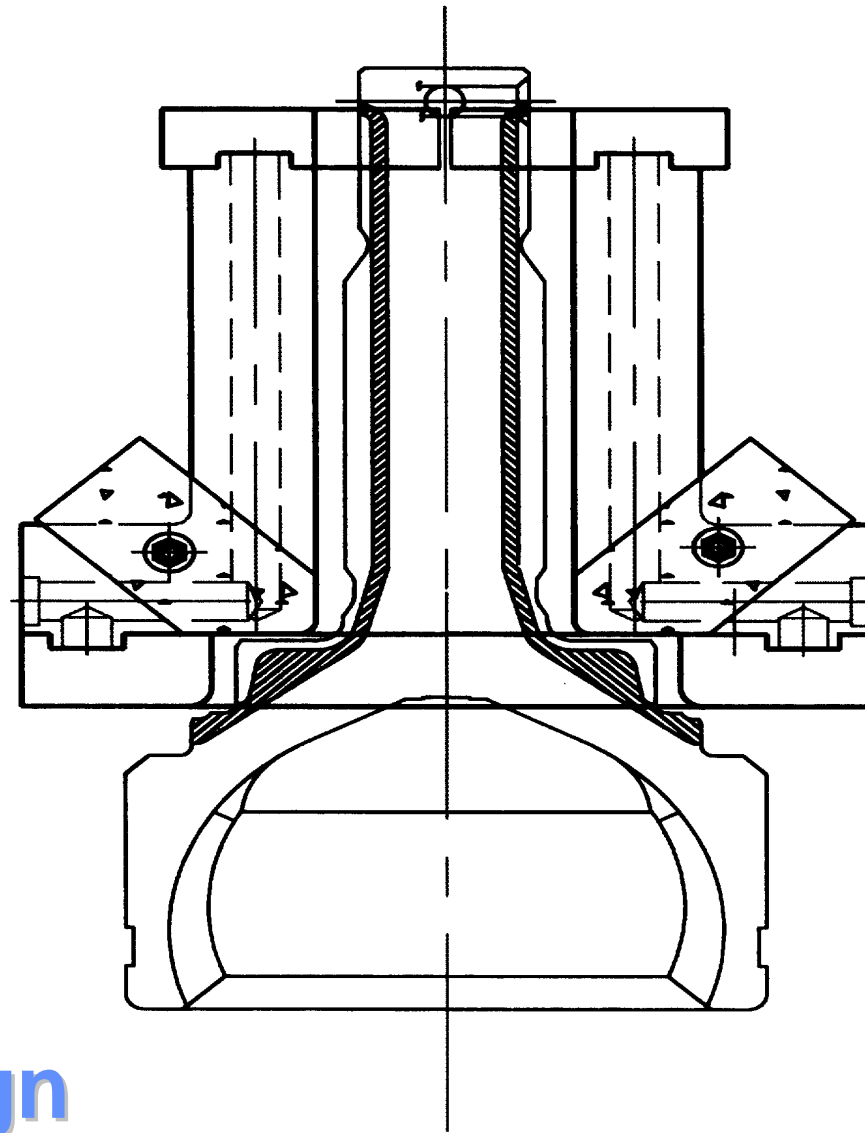


Example of Flux Concentrator

FLUX CONCENTRATOR

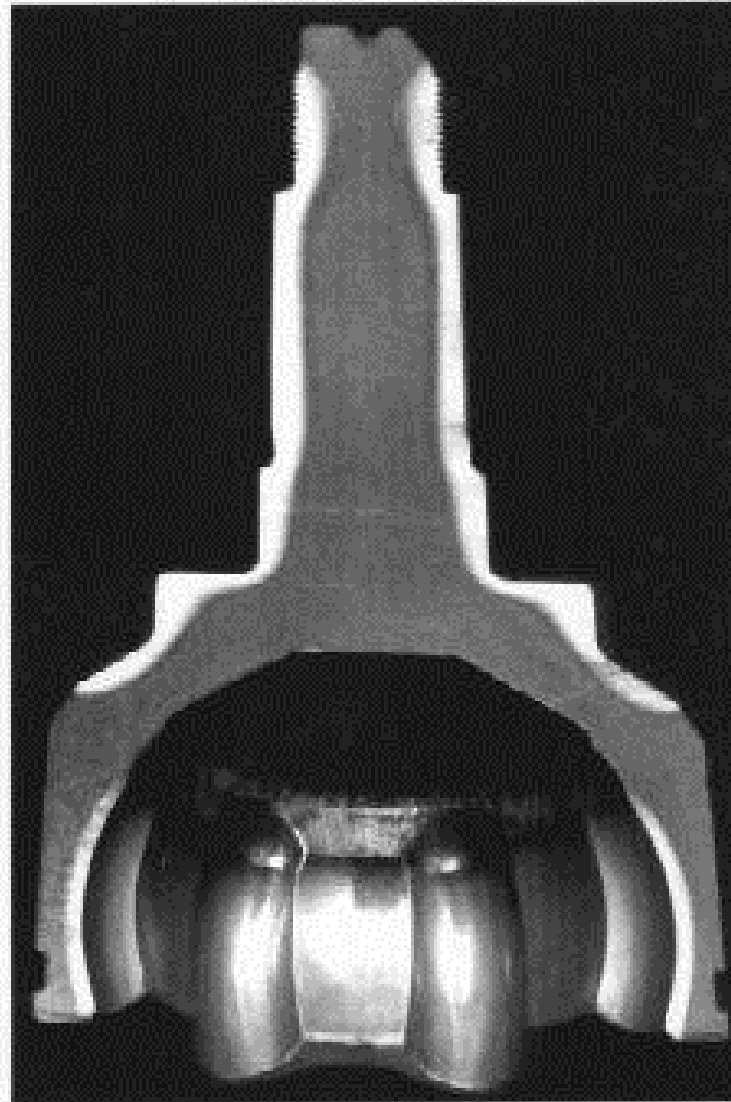


Difficult Heat Treating Pattern



Inductor Design

Difficult Heat Treating Pattern



Actual Pattern

Typical Applications For Induction Heating

- Billet heating
 - Extruding
 - Soldering, Brazing
- Heat treatment, including case hardening, tempering and annealing
 - Shrink fitting
 - Strip heating
 - Tube and Wire heating
 - Continuous annealing
- Epitaxial growth (crystal growing)
 - Forging
 - Stress relieving
- Plasma applications
 - Cap sealing

So What Next?

Now you are hopefully more aware of induction heating, the only thing left for you to do is to contact one of our sales team.

Pick up the phone and call Inductoheat Banyard on 01202 627800 or email induction@inductoheat.co.uk

Alternatively, fill out the project specification enquiry form or request a brochure from our website.

You can be sure of a fast response with one of our sales team happy to help you in answering any further questions, or offering any advice regarding induction heating.