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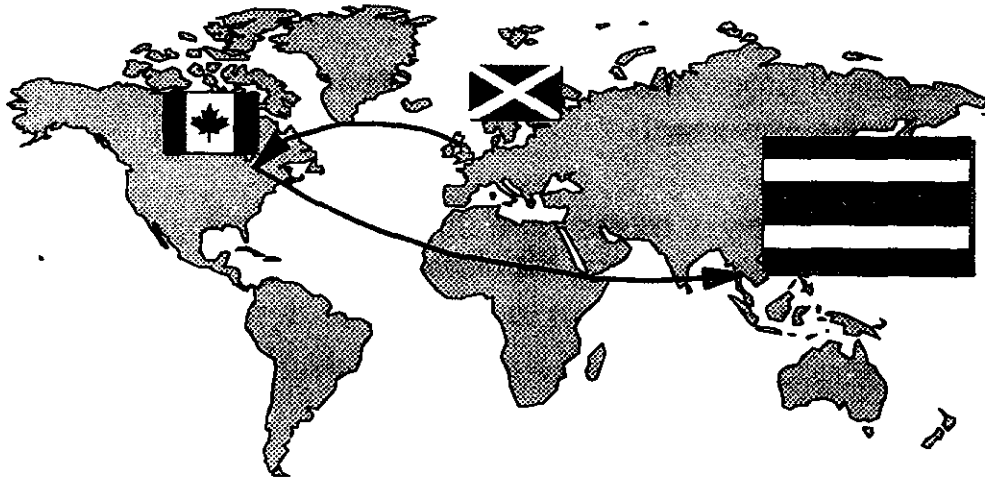
Welding Technology

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Subject Matter

Holding the world together...



Welding - A Joining Process

- **Welding is:**
 - a collection of processes for joining materials
 - economically important
 - versatile
 - ✓ ...joins hundreds of metals and alloys, e.g. steels, aluminium, nickel, copper, titanium, zirconium
 - ✓ ...in thickness from .01 mm to 600 mm and more

- [illegible]

Competing Joining Processes

- Welding pressure vessels, ships
- Brazing gas turbine vanes
- Soldering electronic component assembly
- Bolting structural steel, machine parts
- Riveting truck bodies, aircraft skins
- Adhesives aircraft
- Integral construction
 - casting, forging, powder metallurgy, machining

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[illegible]

Course Topics

- Welding Processes
- Welding Metallurgy
- Weld Quality
- Weldment Design

WA - defect

WD -

- [illegible]

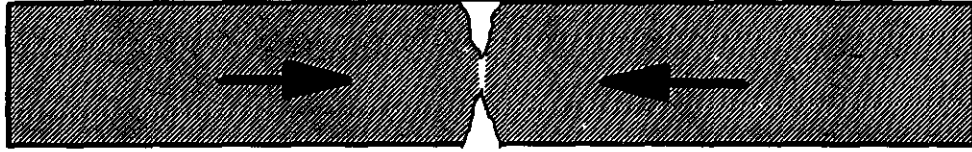
- **1 to 1-1/2 hour presentation by lecturer**
 - Students ask questions to confirm or clarify points and respond to questions posed by lecturer.
- **Tutorial**
 - Class discussion of tutorial questions and topics of interest
- **Self Study**
 - Students study reference material.

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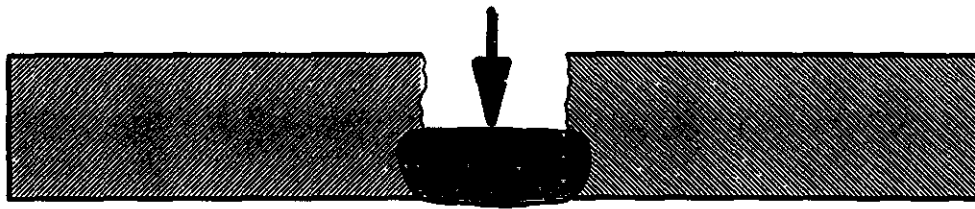
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American Welding Society

[illegible]



Solid Phase Joining



Joining by Molten Metal Bridging

[illegible]

- Energy source
- Means for removal and exclusion of contaminants
- Control of weld metallurgy

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Pre-Industrial Joining Methods

- **Soldering and brazing**
 - Early civilizations joined metals for weapons, tools and jewellery
- **Forge welding**
 - During the Iron Age it was discovered that pieces of iron could be joined by heating and hammering
- **Riveting and bolting**

Early Developments

- Forge welding is unsuitable for joining large plates and shapes
- Fusion welding
 - Promised to solve the problem of joining large metal pieces
- "Fusion" = melting
 - Fusion welding requires a sufficiently intense heat source to be passed along the joint to melt the edges

Invention of Fusion Welding

- **Electric arc**
 - Experiments showed that electric arcs could melt metals
 - In 1885, Bernados was awarded the first patent on electric fusion welding
- **Flames**
 - The French chemist LeChatelier realized that oxygen-acetylene flames were also capable of melting metal
- **Resistance Welding**
 - Joule discovered that electrical resistance heating could be used to join metals

• $Q = I^2 R t$ - current I in A , R in Ω , t in s

Acceptance & Development

- Welding used for production of military and civilian items in the western world during the 1940s
- New welding processes and techniques were subsequently developed
- Continued improvements in quality, performance, and cost

Welding Process Classification

Heat Source	Shielding Method					
	Vacuum	Inert Gas	Gas	Flux	No shielding	Mechanical exclusion
No heat	Cold pressure					
Mechanical	Explosive				Explosive	Friction, ultrasonic
Chemical		Plasma	Atomic hydrogen	Gas	Forge	Thermit
Electric resistance					HF induction, Flash butt	Spot, seam, butt welding
Electric arc		GTAW, GMAW, PAW	CO ₂ GMAW	GMAW, SAW, ESW, FCAW	Capacitor discharge	
Radiant Energy	Laser, Electron Beam	Laser	Laser	Laser	Laser	

Source: PT Houldcroft *Welding Process Technology*, Cambridge University Press