



# Soldagem

Método de união localizada de materiais através de aquecimento a temperaturas adequadas com ou sem aplicação de pressão, podendo-se usar material de adição.

Definição da AWS

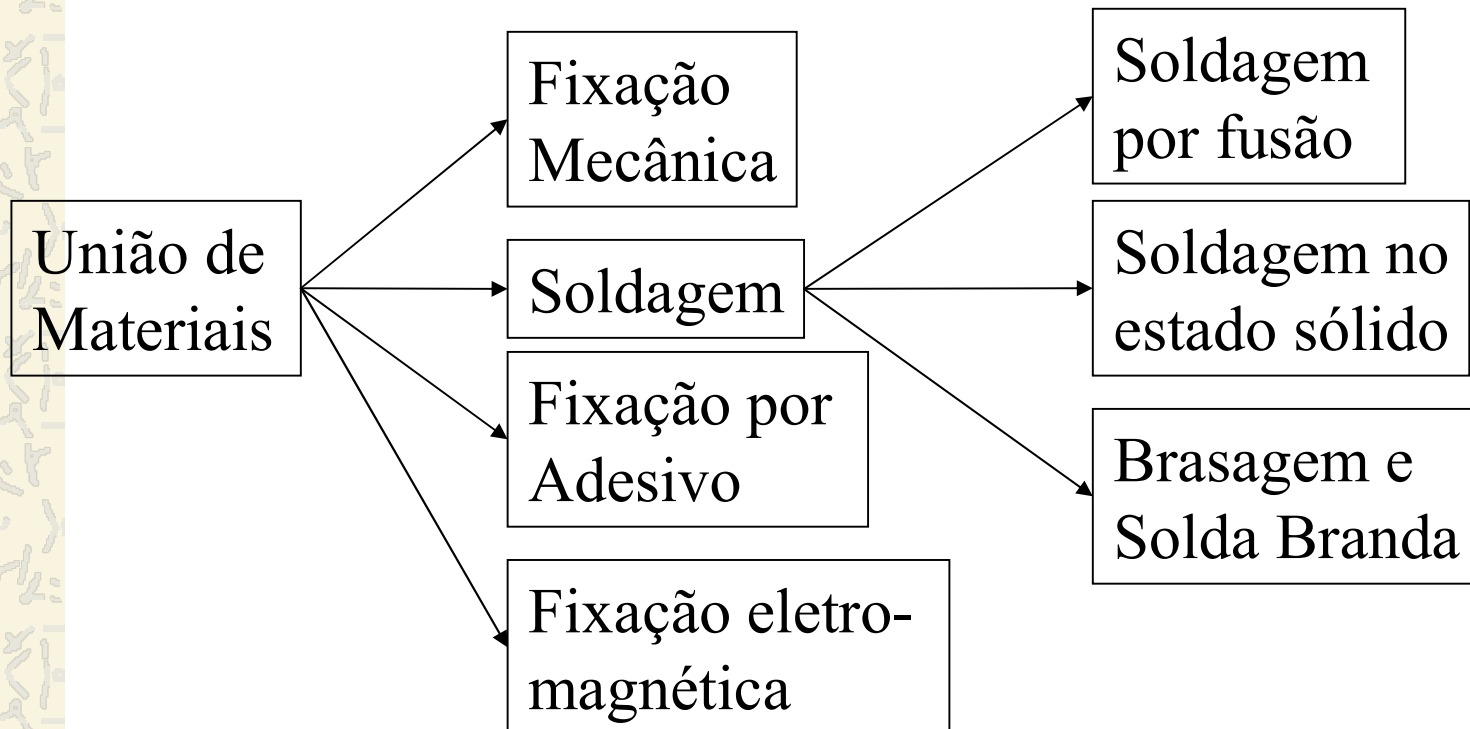
# Classificação

## Rotas para união de materiais metálicos

Operação

Método

Processo





# Processos de Soldagem

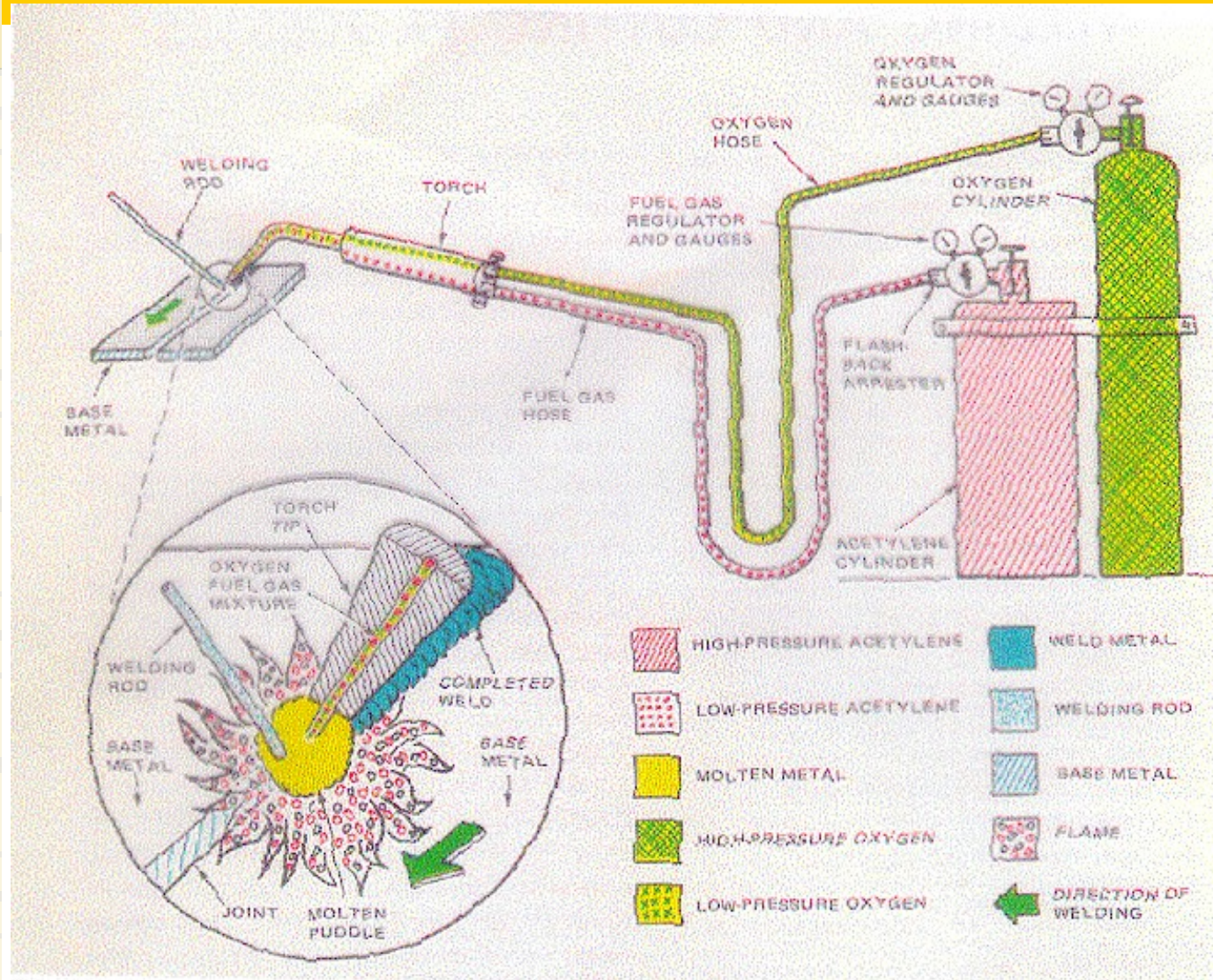
- ✘ Soldagem por fusão: utilizam fusão dos materiais a serem unidos.
- ✘ Soldagem no estado sólido: não ocorre fusão dos materiais a serem unidos ou de qualquer outro
- ✘ Brasagem: fusão somente do material de adição ( $T > 450\text{C}$ )
- ✘ Solda Branda: fusão somente do material de adição ( $T < 450\text{C}$ )



# Aplicações

- ✚ Fabricação: produção de manufaturados
- ✚ Manutenção e Reparos: Prolongamento da vida útil de peças e componentes
- ✚ Vantagens:
  - Meio barato de união de metais
  - Aplicáveis para a união de todos os metais comerciais
  - Propicia flexibilidade de projeto
  - Reduz o tempo e o custo de fabricação
  - Fácil de ser utilizado na recuperação e manutenção de produtos

# Soldagem por Oxi-gás

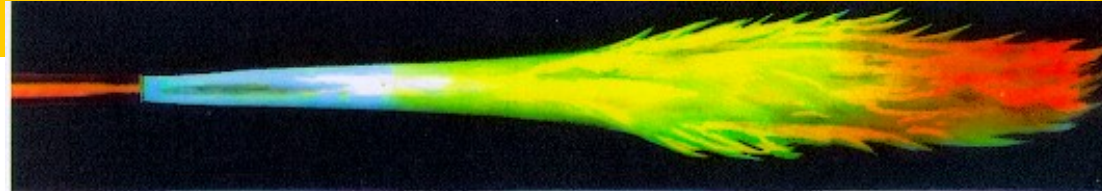


# Soldagem por Oxi-gás

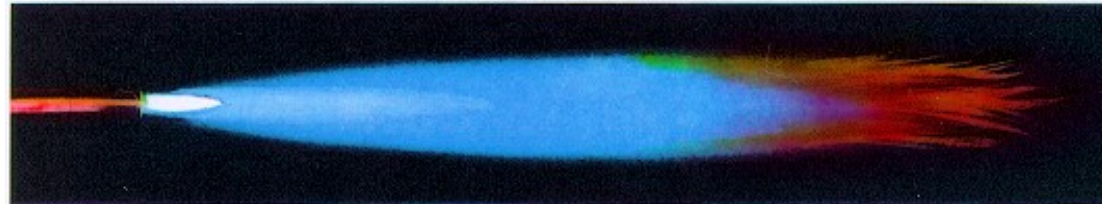


Aço ao  
Carbono

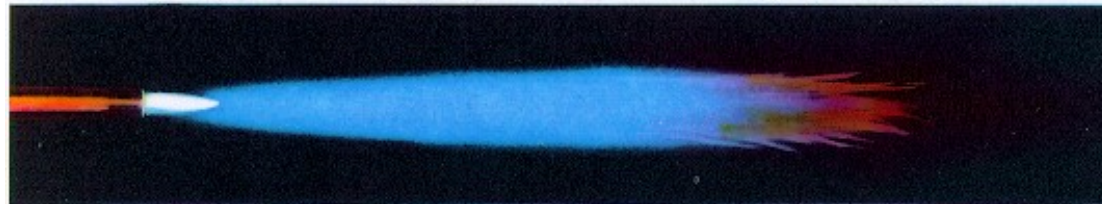
# Tipos de Chama



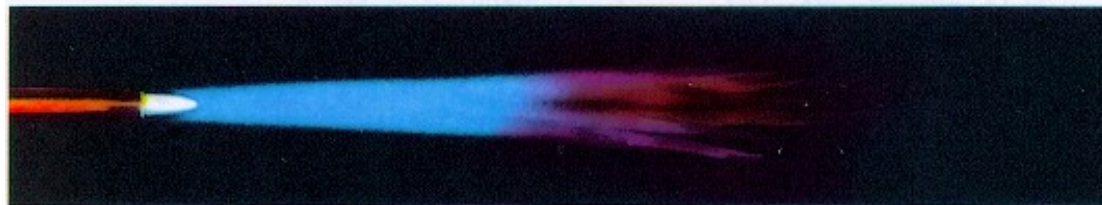
**Acetylene Burning in Atmosphere**  
Open fuel gas valve until smoke clears from flame.



**Carburizing Flame**  
(Excess acetylene with oxygen.) Used for hard-facing and welding white metal

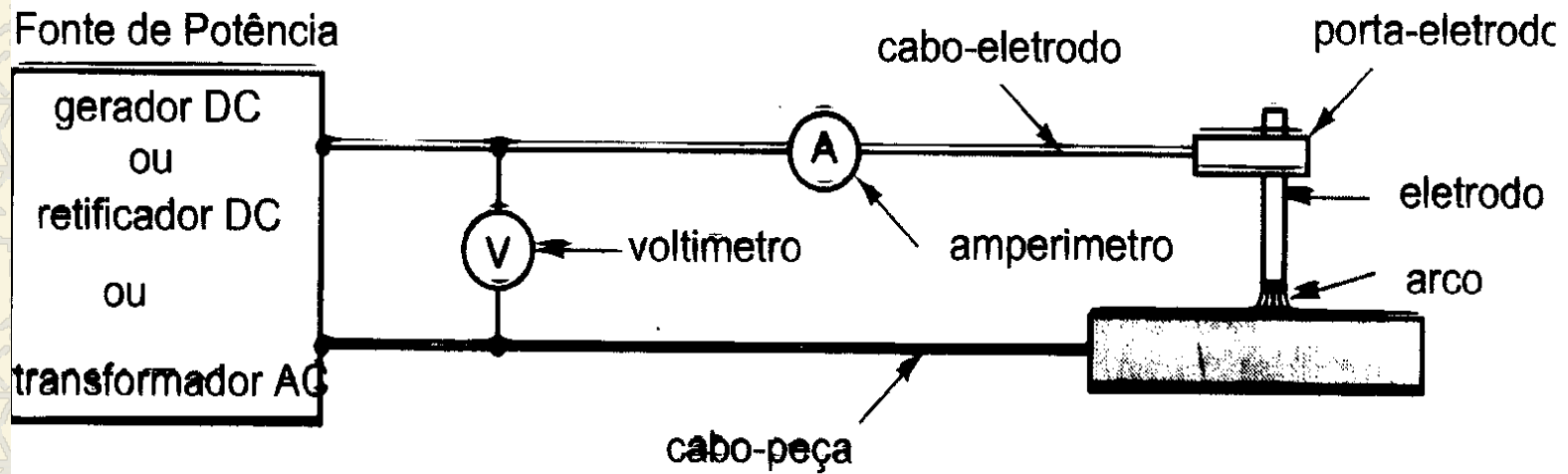


**Neutral Flame**  
(Acetylene and oxygen.) Temp. 3100 °C 5600 F. For fusion welding of steel and cast iron.



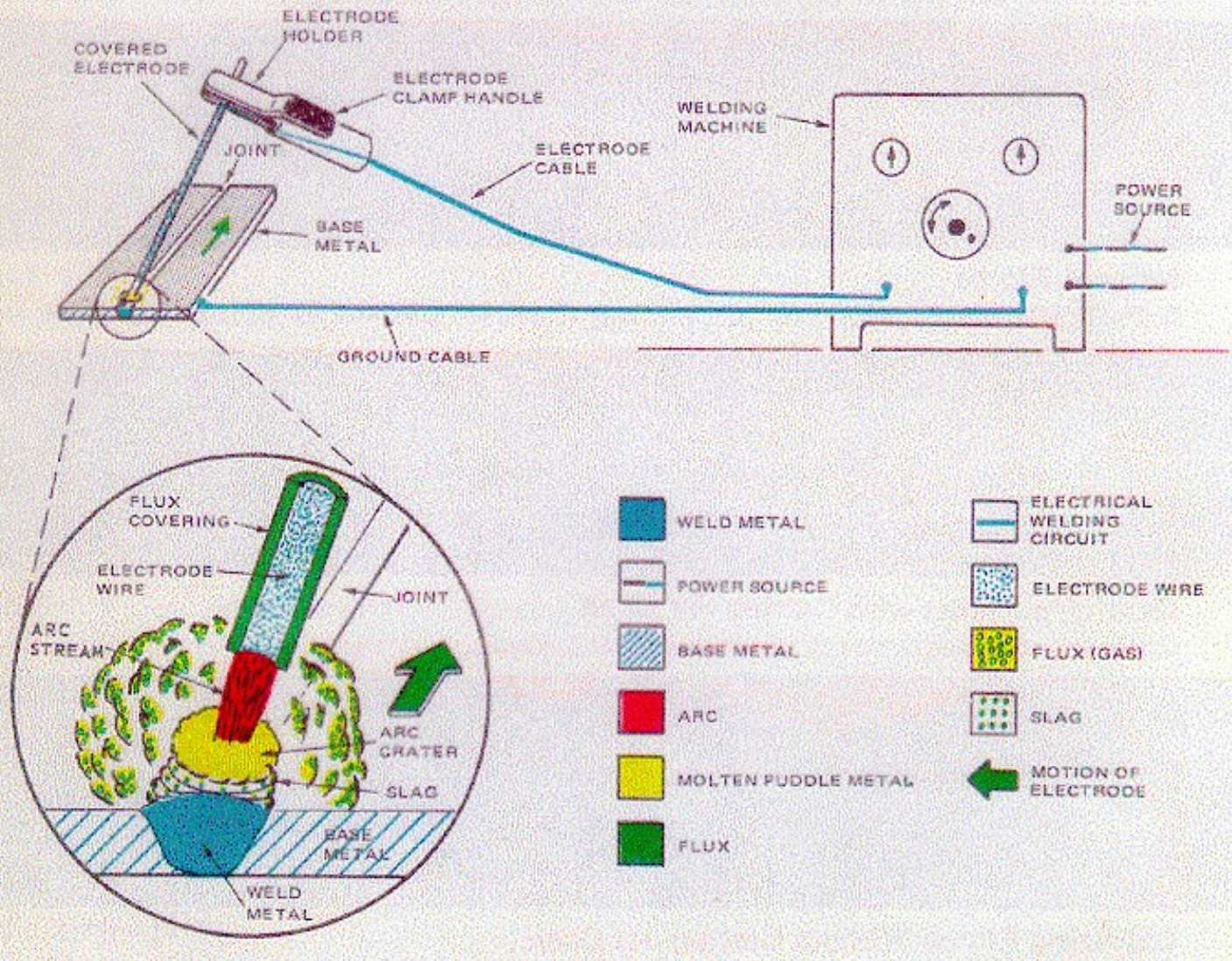
**Oxidizing Flame**  
(Acetylene and excess oxygen.) For braze welding with bronze rod.

# Soldagem a Arco Elétrico com Eletrodo Revestido (SAER)





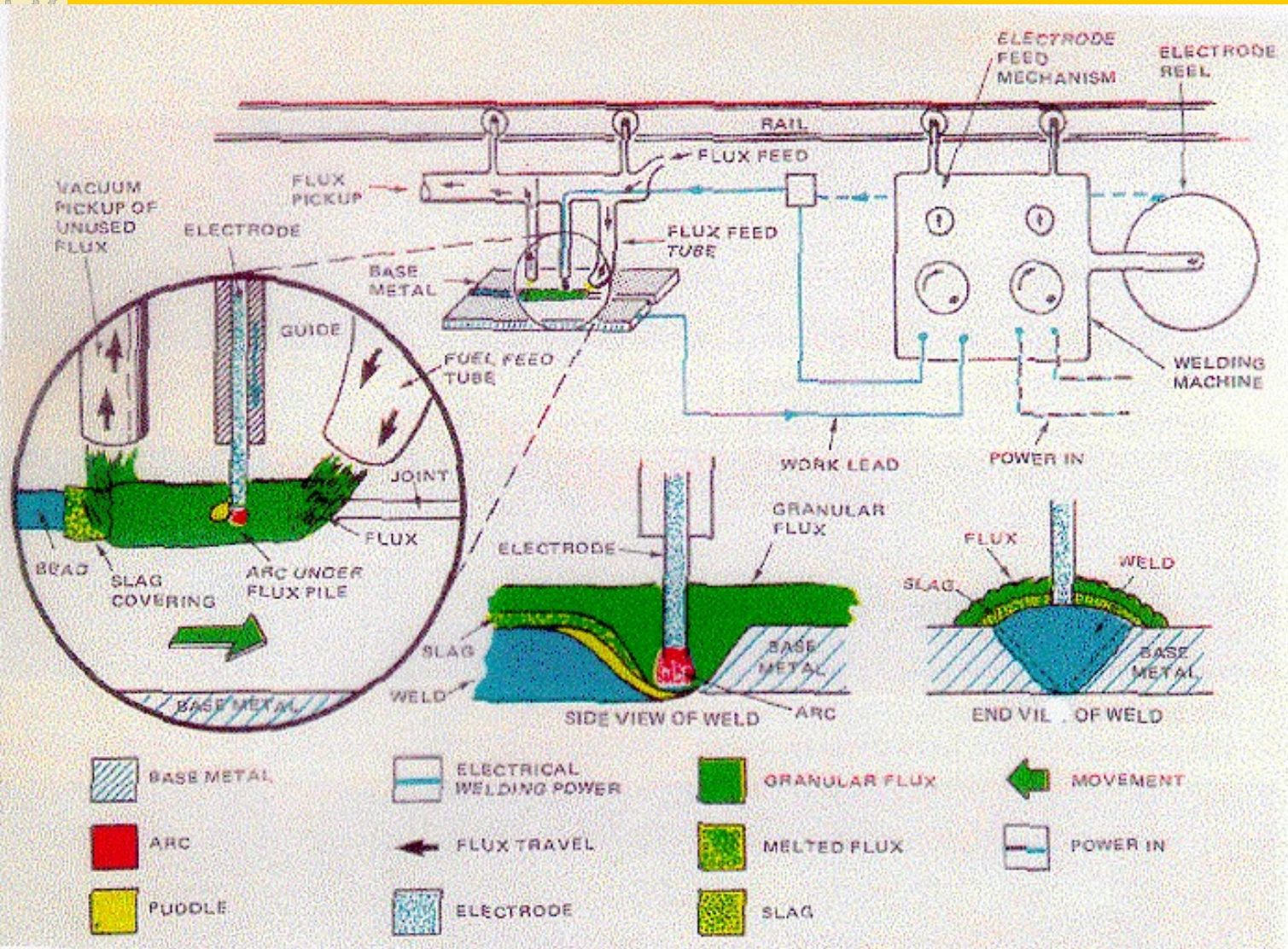
# Soldagem a Arco Elétrico com Eletrodo Revestido (SAER)



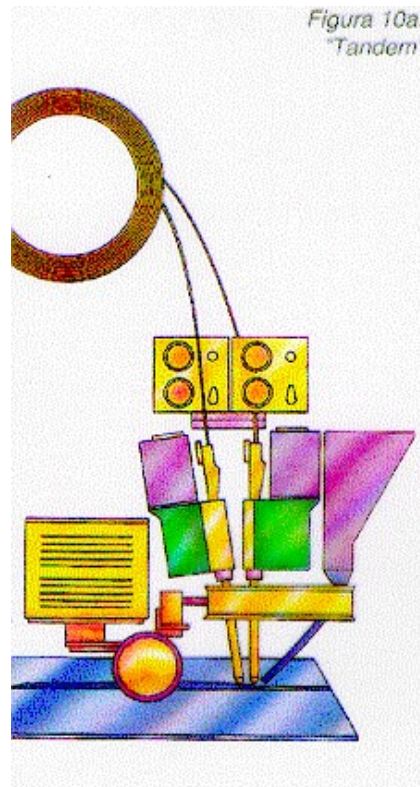
# ● Soldagem a Arco Elétrico com Eletrodo Revestido (SAER)



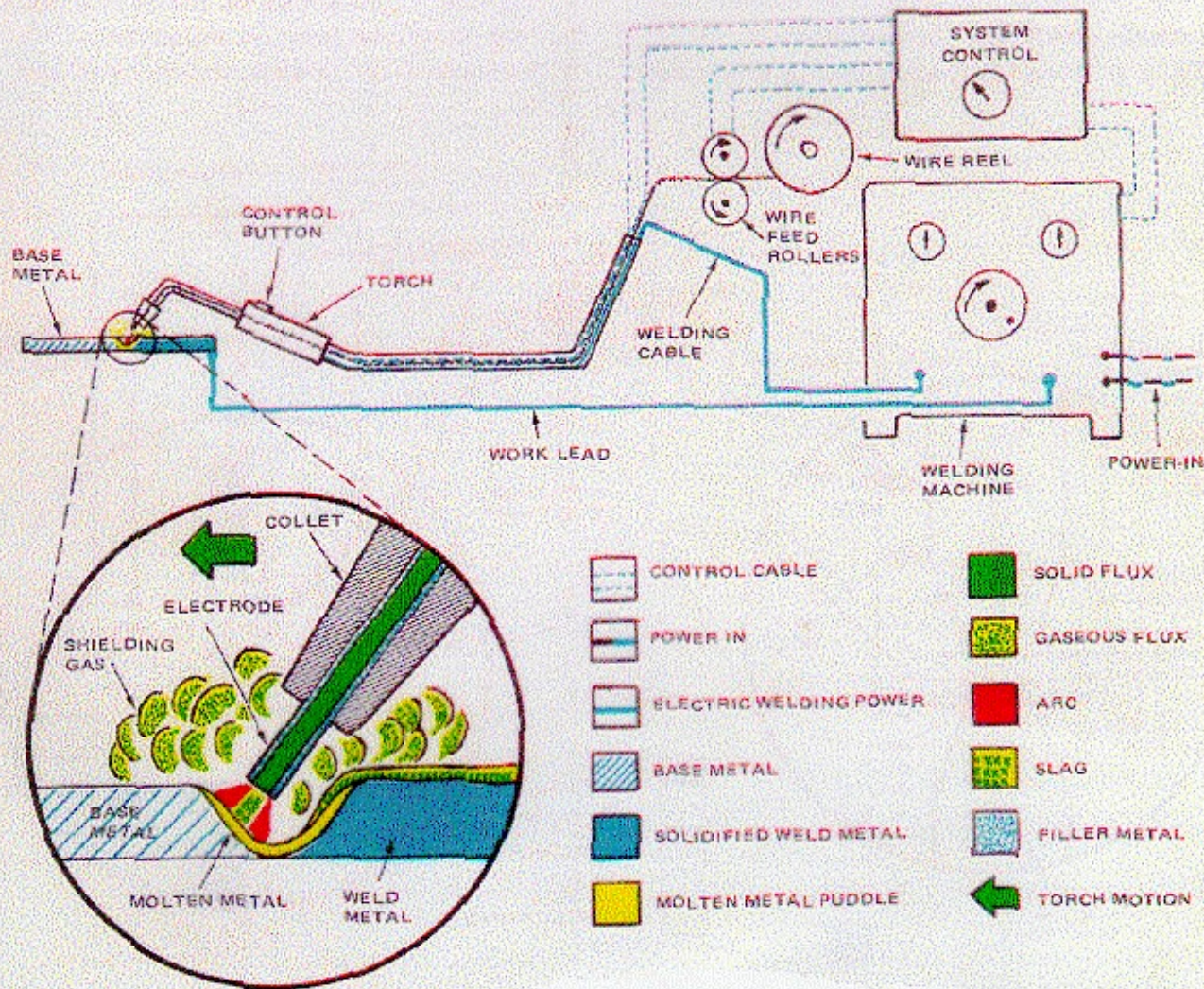
# Soldagem a Arco Submerso (SAS)



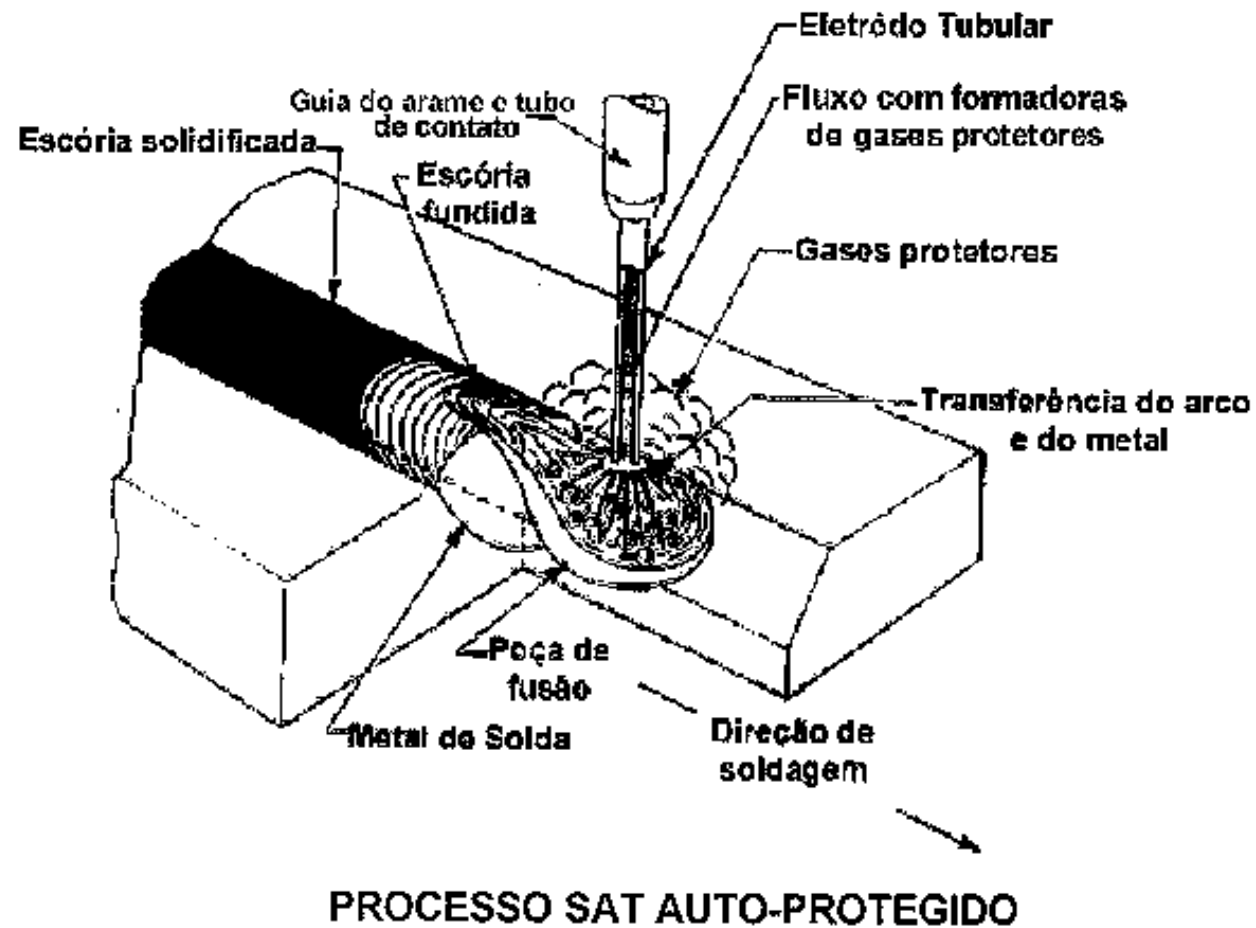
# Soldagem a Arco Submerso (SAS)



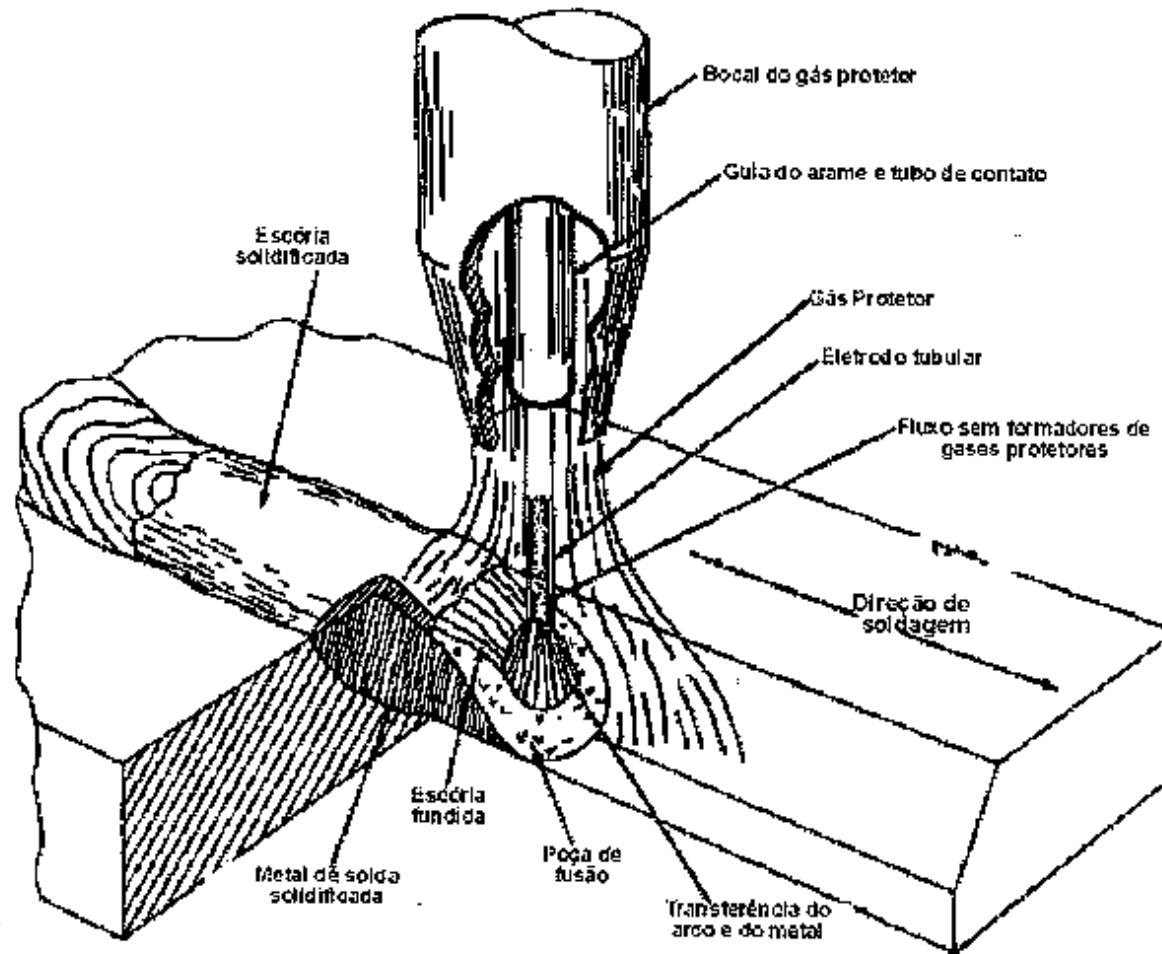
# Soldagem a Arco com Arame Tubular (SAT)



# Soldagem a Arco com Arame Tubular (SAT)

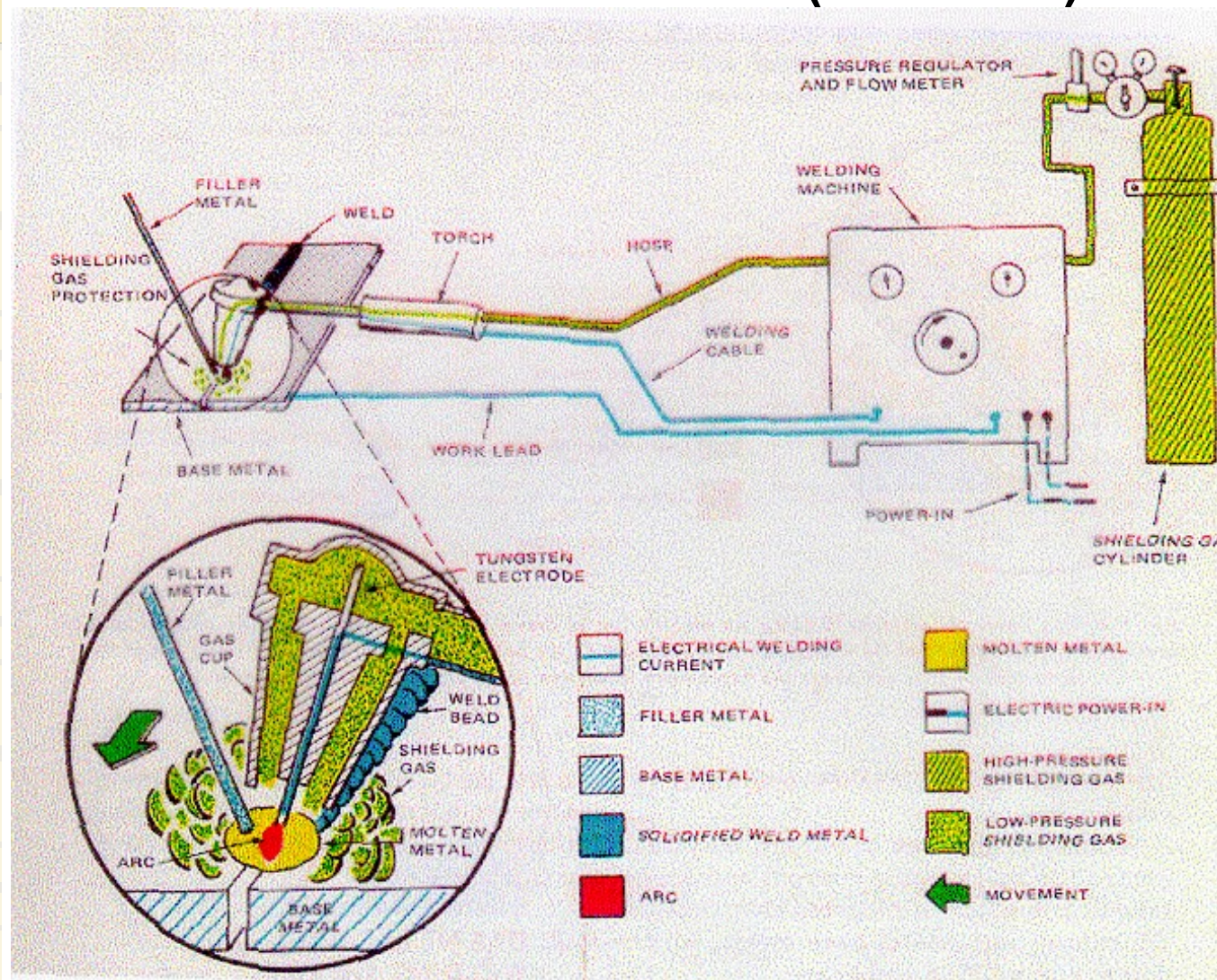


# Soldagem a Arco com Arame Tubular (SAT)



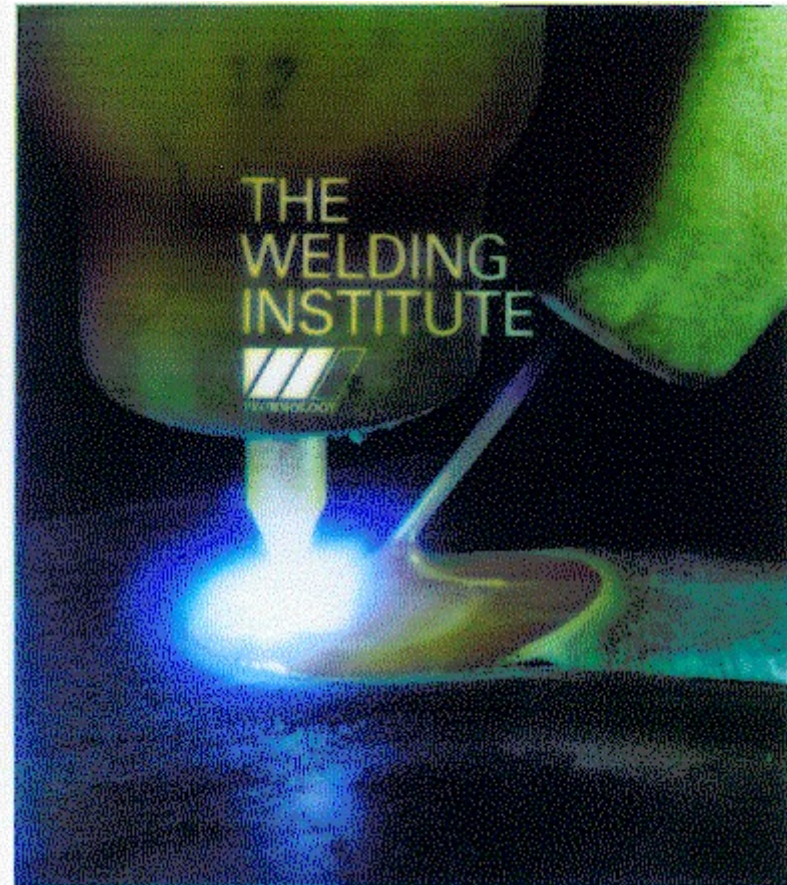
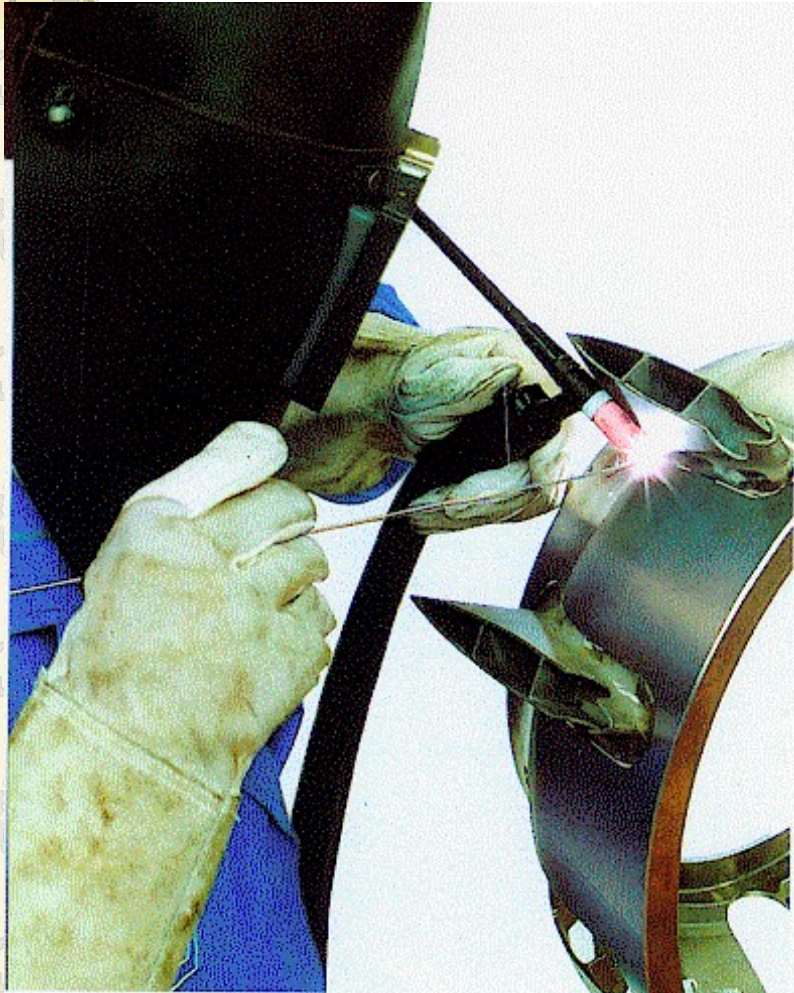
PROCESSO SAT COM PROTEÇÃO GASOSA

# Soldagem a Arco Tungstênio com Atmosfera Gasosa (SATG) ou TIG

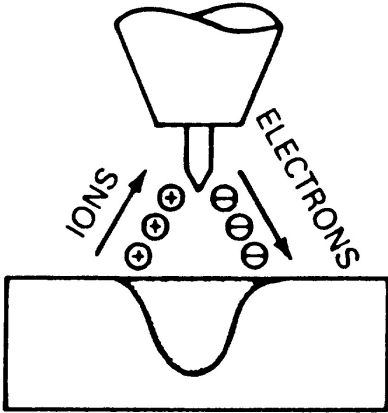
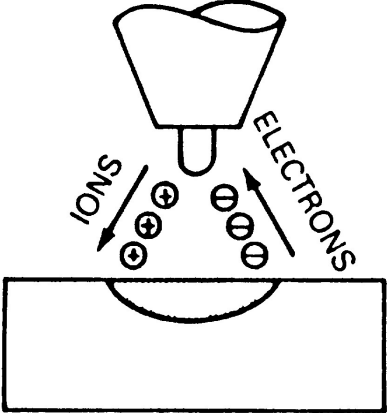
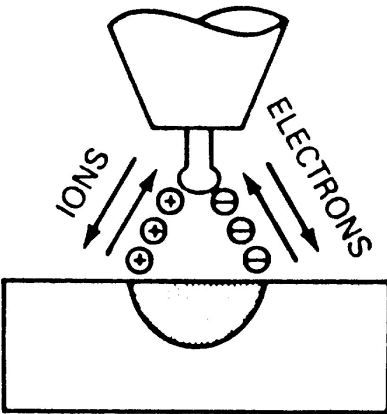




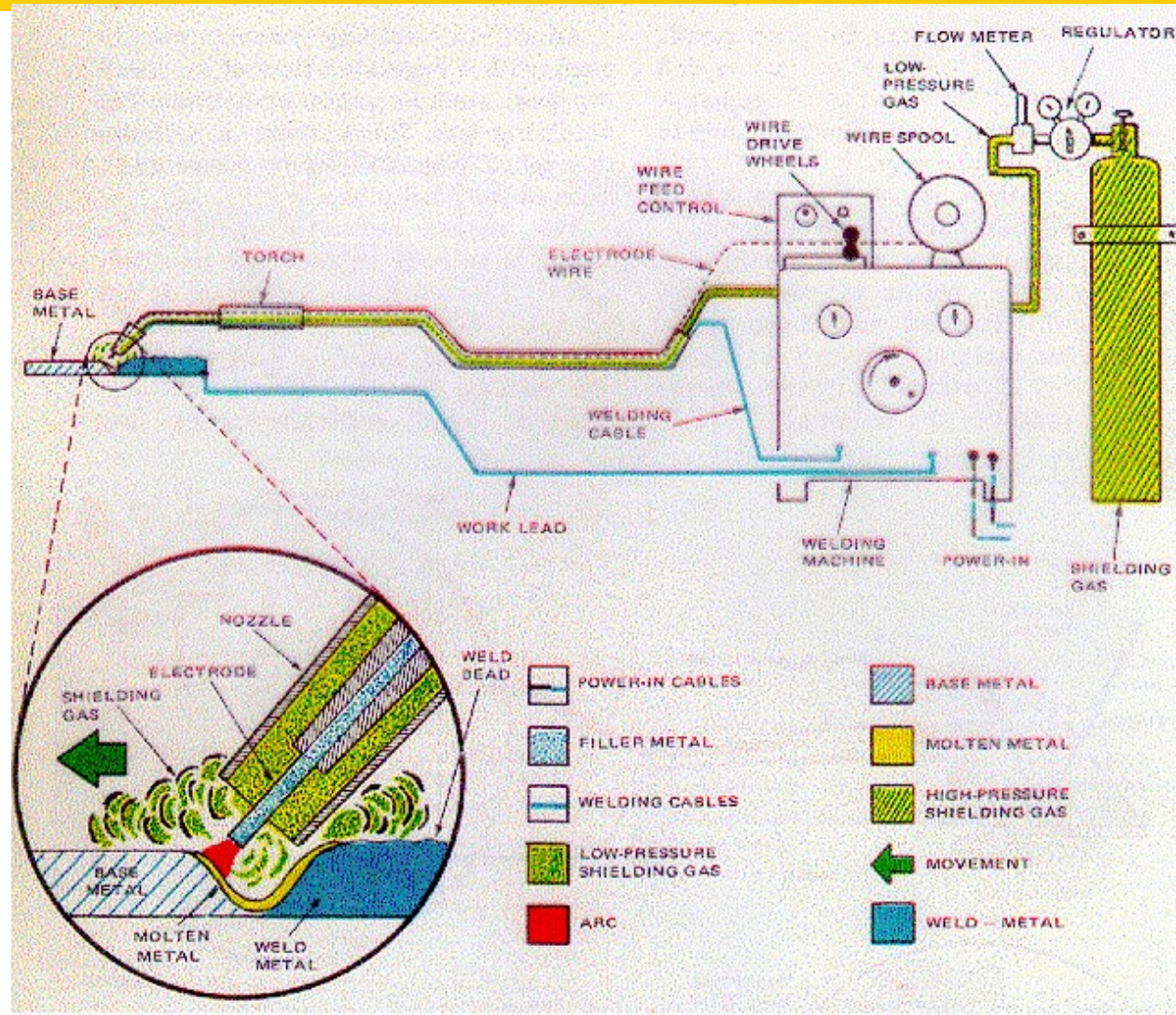
# ● Soldagem a Arco Tungstênio com Atmosfera Gasosa (SATG)



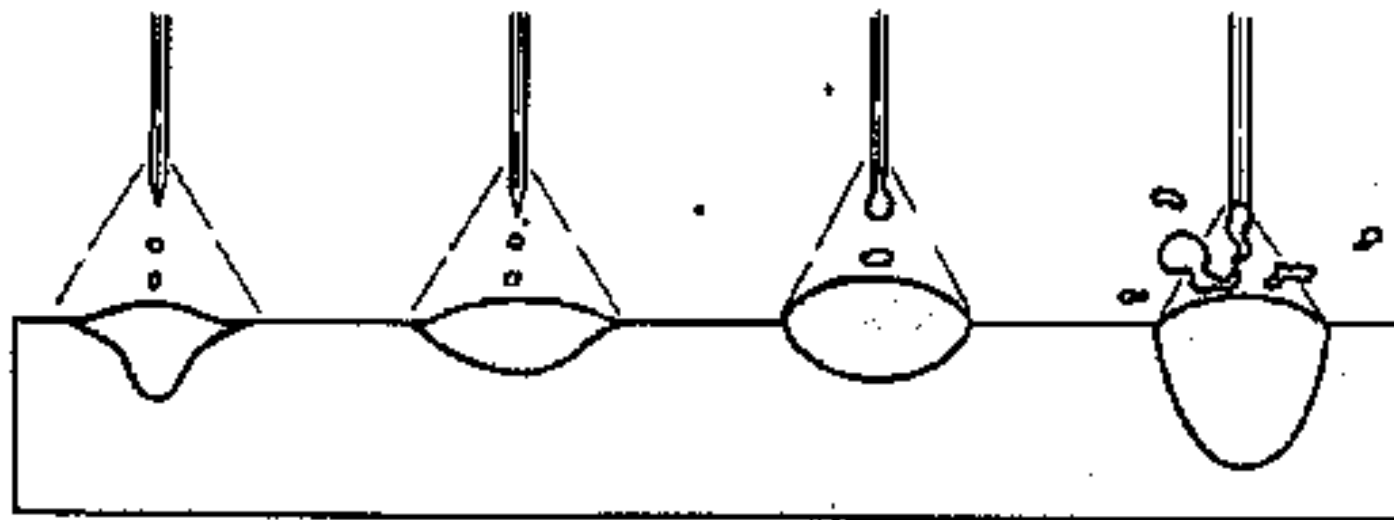
# SATG (polaridade)

tipo de corrente	cc	cc	AC
polaridade do eletrodo	negativo	positivo	
fluxo dos eletrons e ions			
características da penetração			
balanço do calor	70% peça 30% eletrodo	30% peça 70% eletrodo	50% peça 50% eletrodo
penetração	profunda e estreita	raza e larga	média
polaridade dos eletrodos do arco elétrico			

# Soldagem a Arco Metálico com Atmosfera Gasosa (SAMG) ou MIG/MAG



# Influência dos gases



ARGON

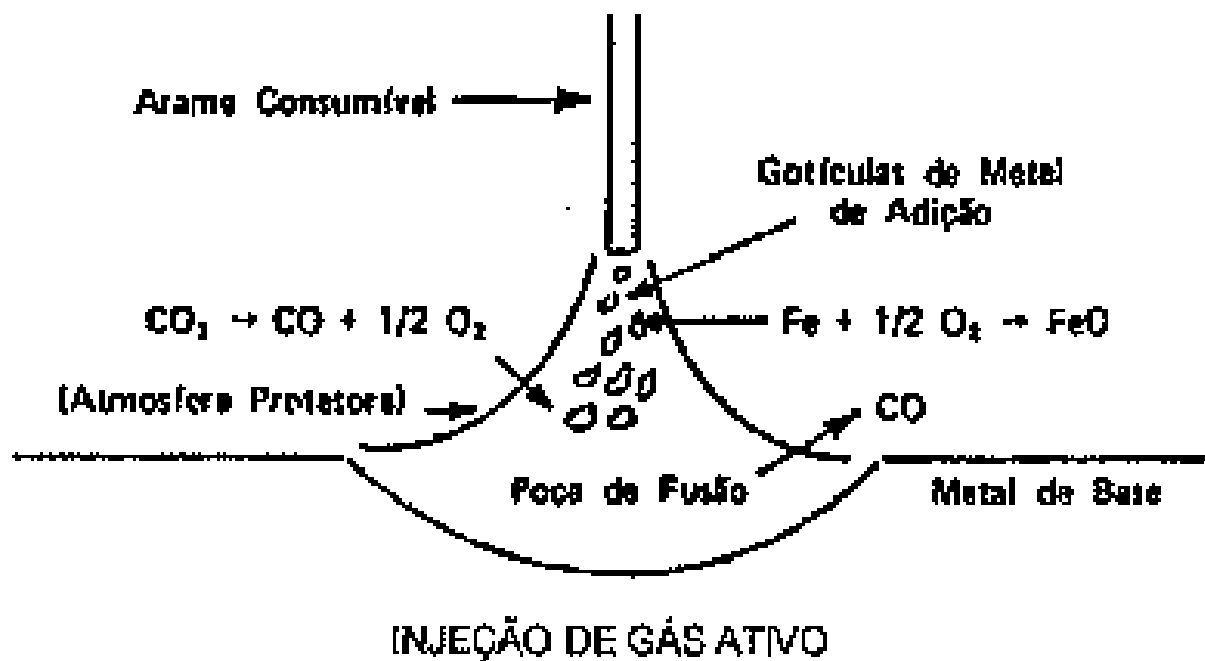
ARGON-HELIUM

HELIUM

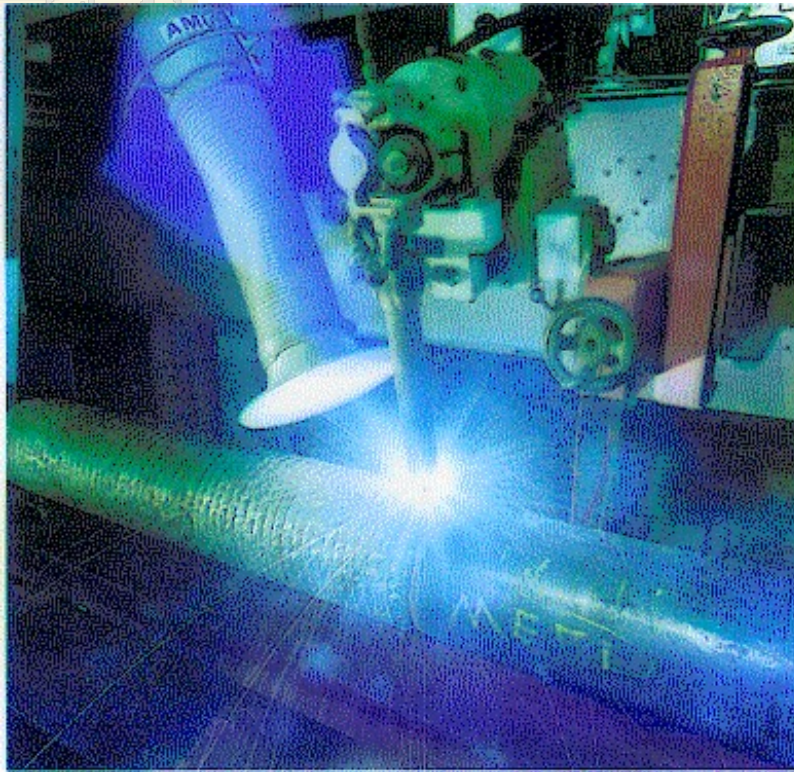
CO<sub>2</sub>

PROFUNDIDADE DE PENETRAÇÃO E FORMATO DO CORDÃO PARA DIFERENTES GASES

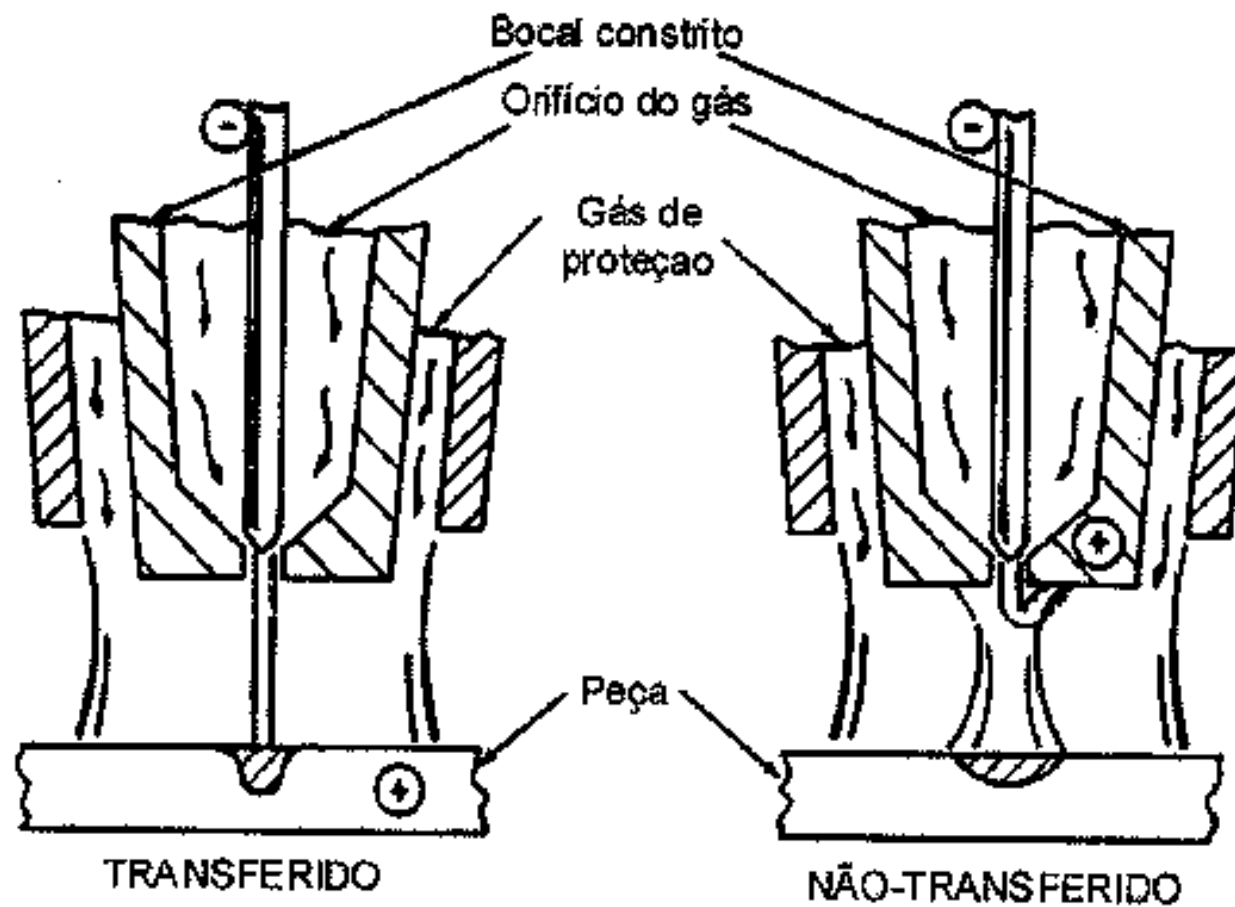
# Gás Ativo



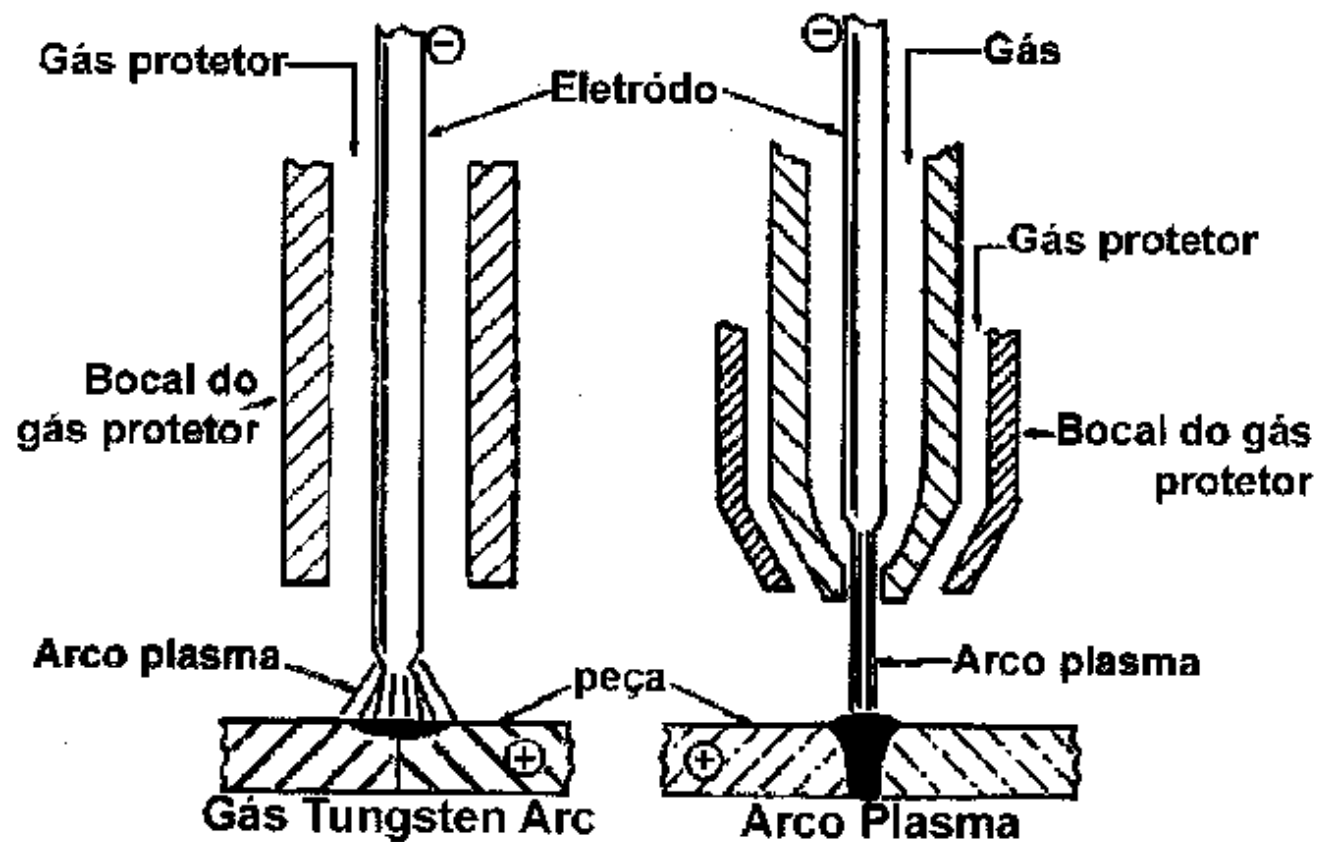
# ● Soldagem a Arco Metálico com Atmosfera Gasosa (SAMG)



# Soldagem a Arco Plasma (SAP)



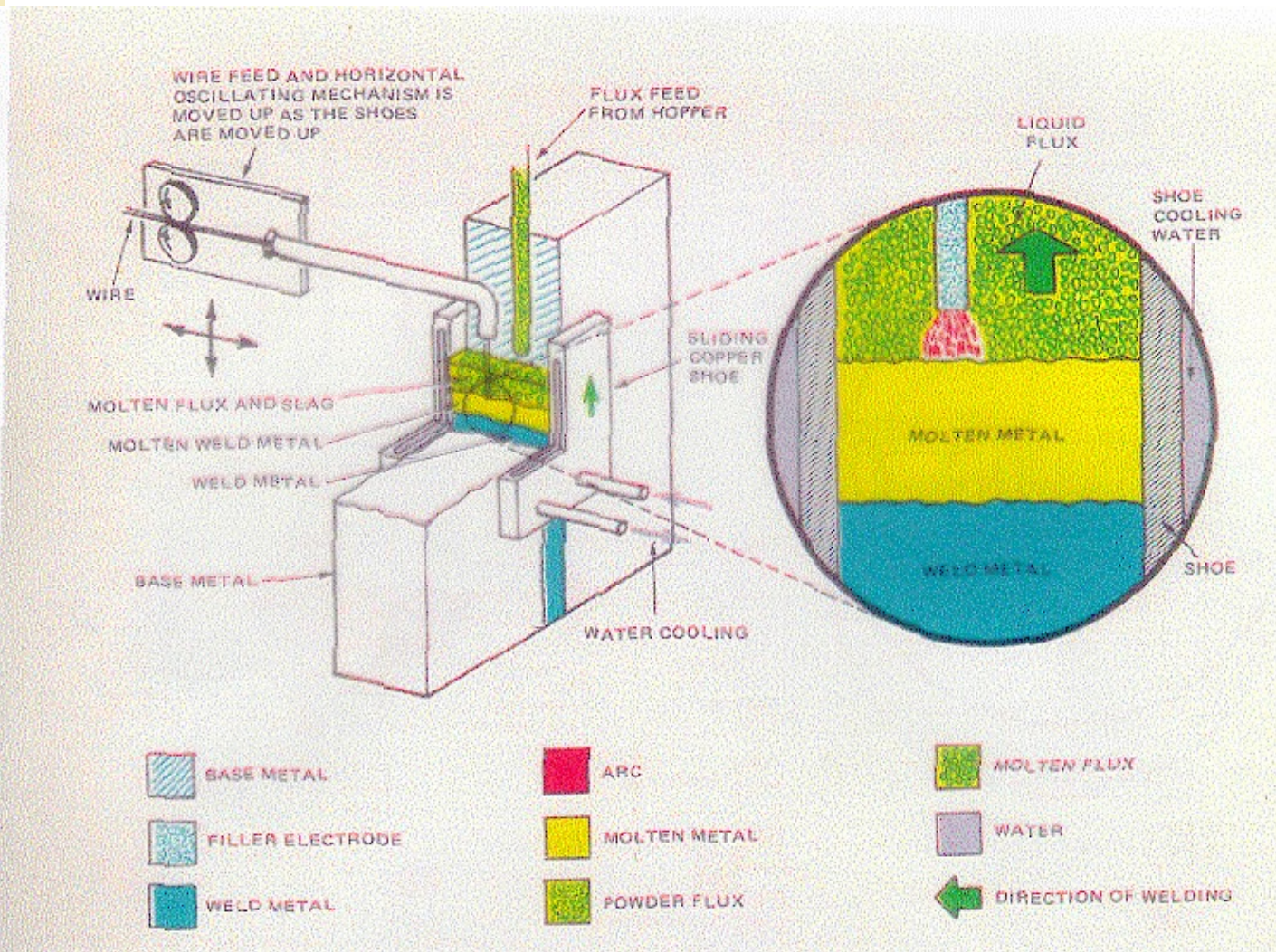
# Comparação SATG e SAP



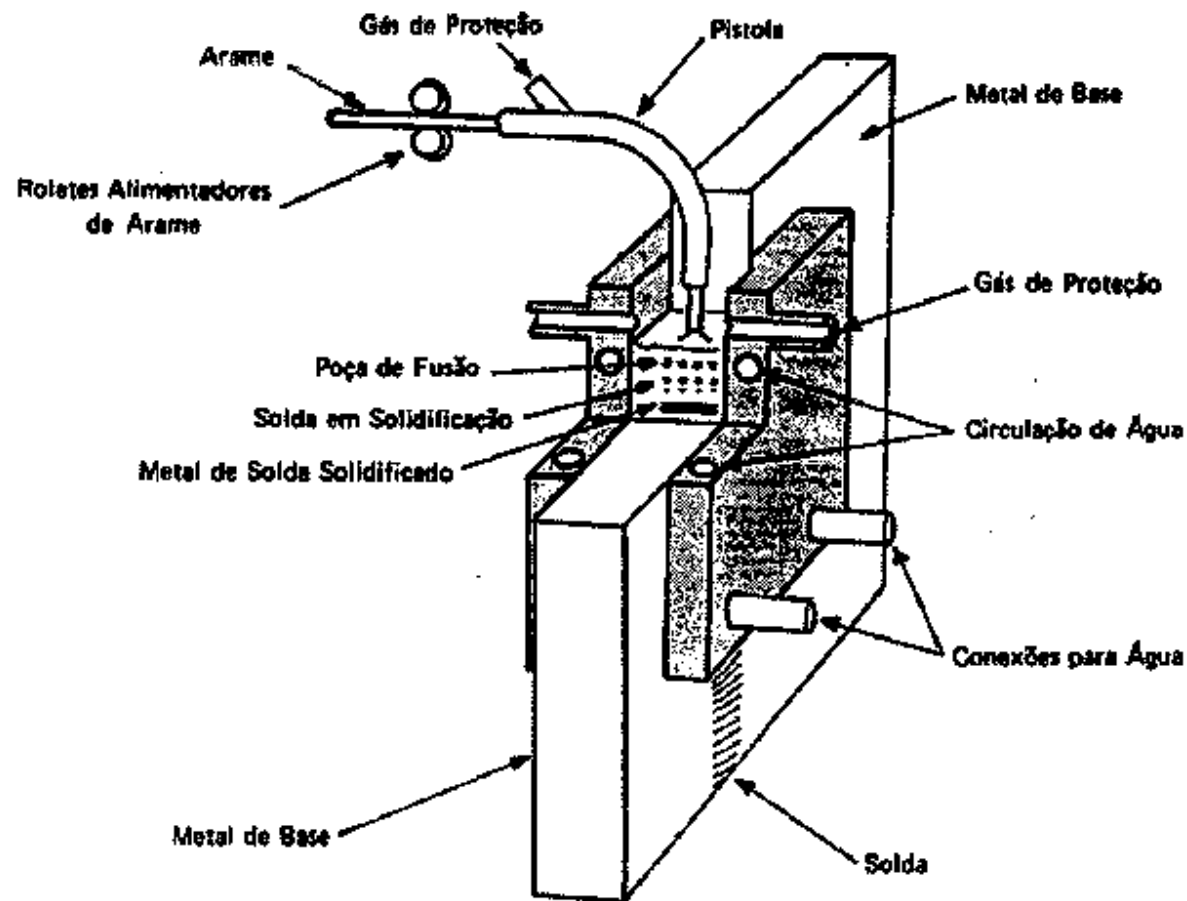
COMPARAÇÃO ENTRE OS PROCESSOS SATG E SAP

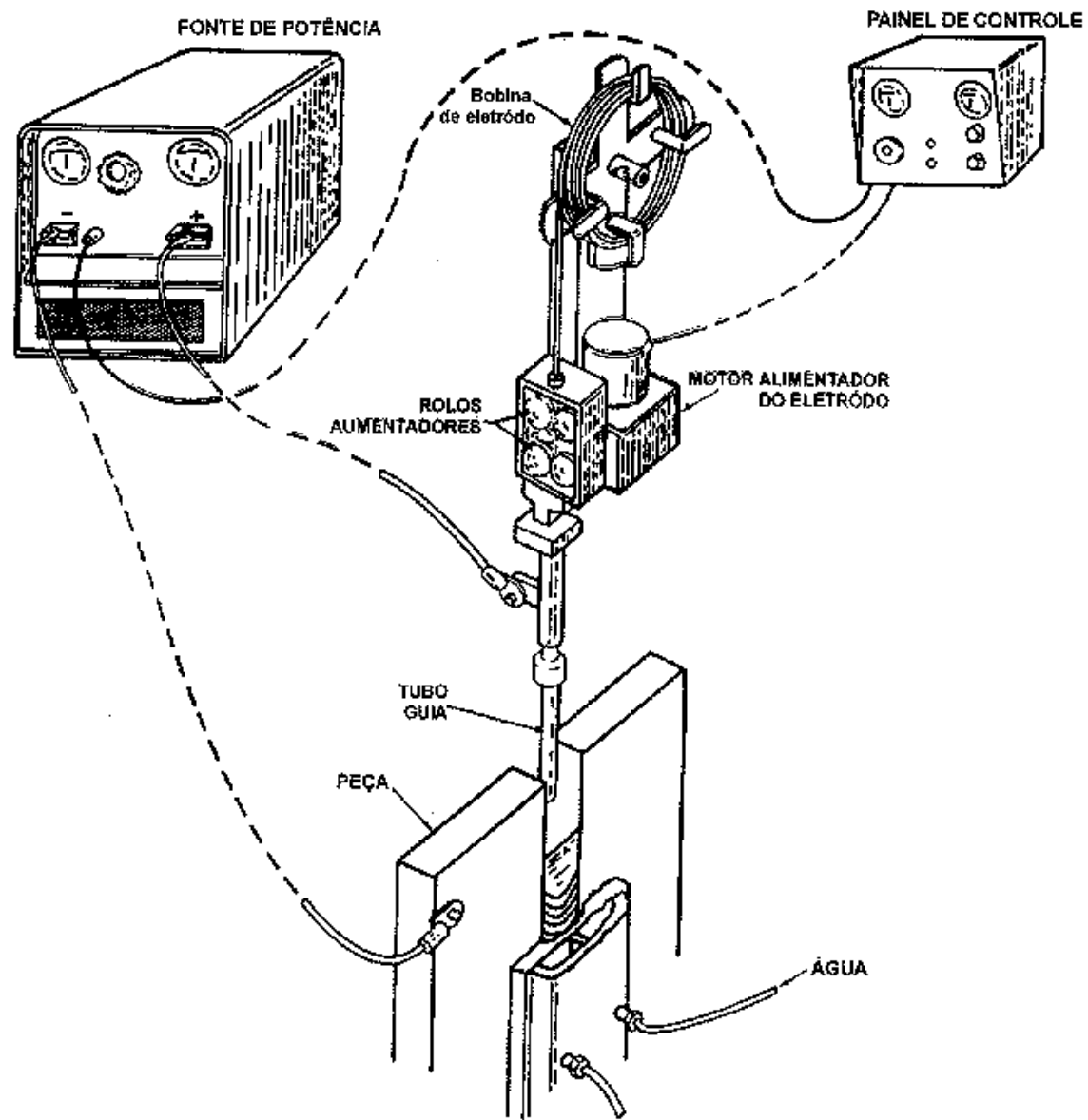


# Soldagem a Eletroescória e Eletrogás



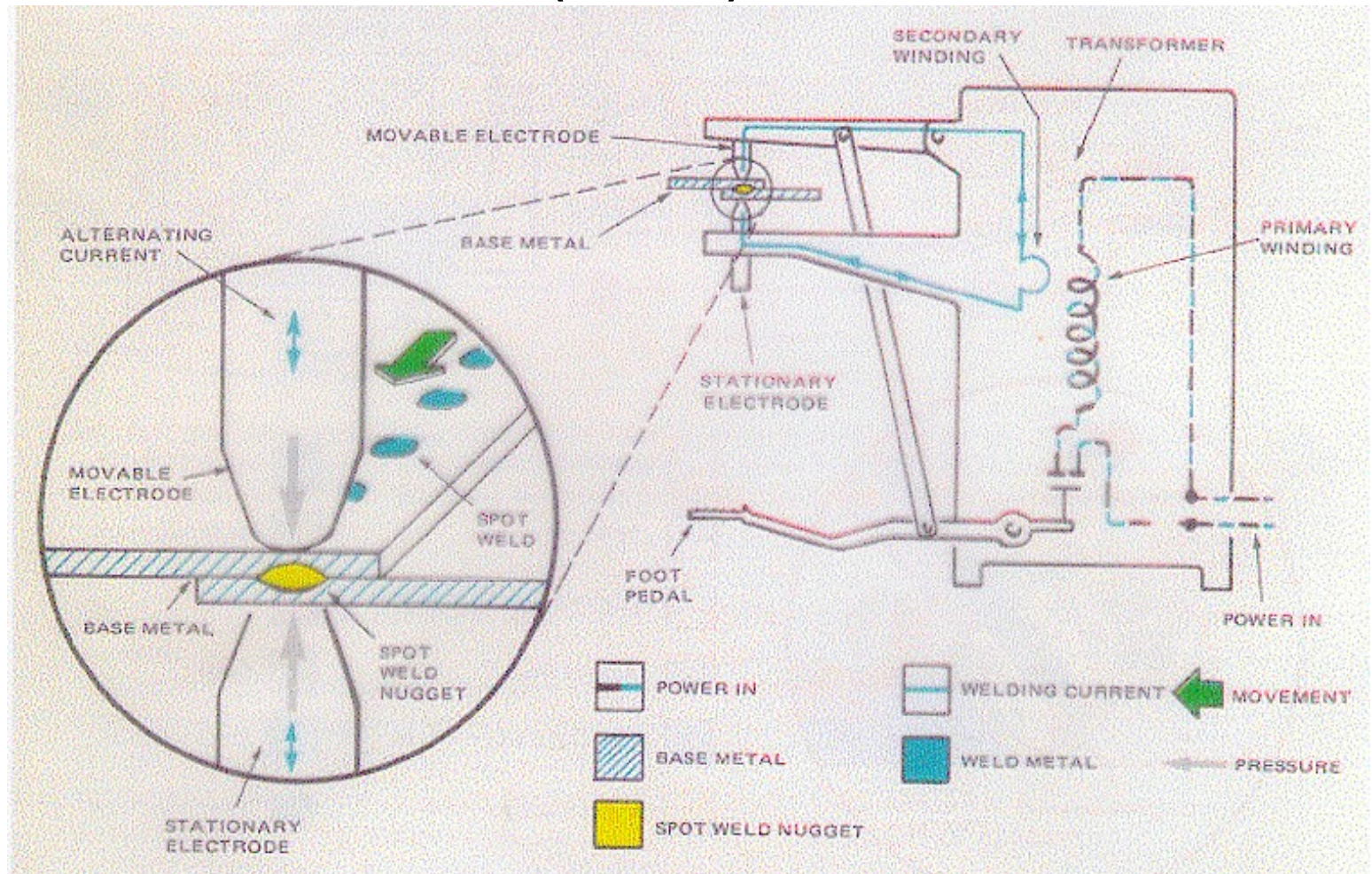
# Soldagem por Eletroescória ou por Eletrogás (SEE ou SEG)



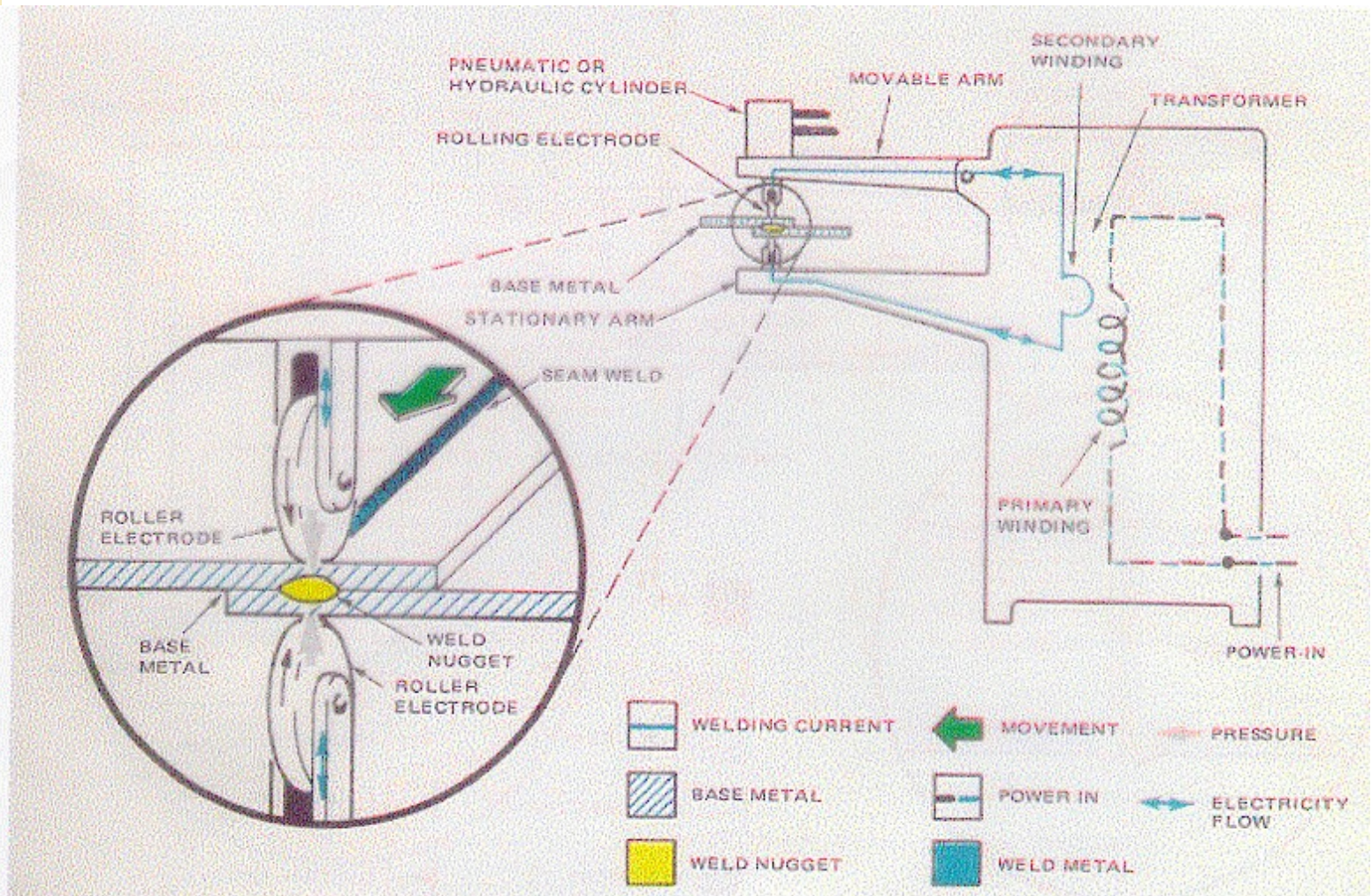


EQUIPAMENTO PARA SOLDAGEM SEG

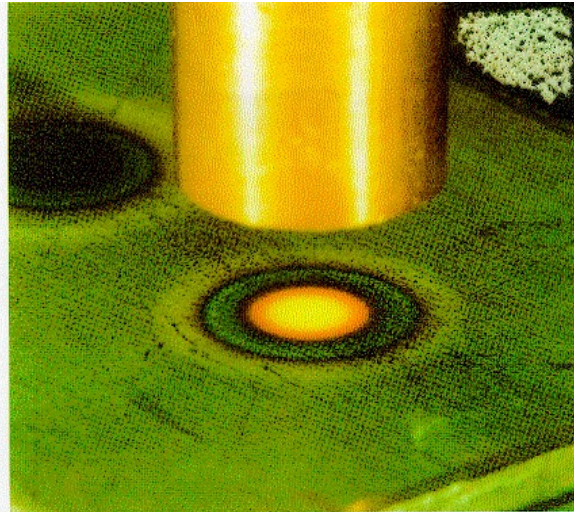
# Soldagem por Resistência por Ponto (SRP)



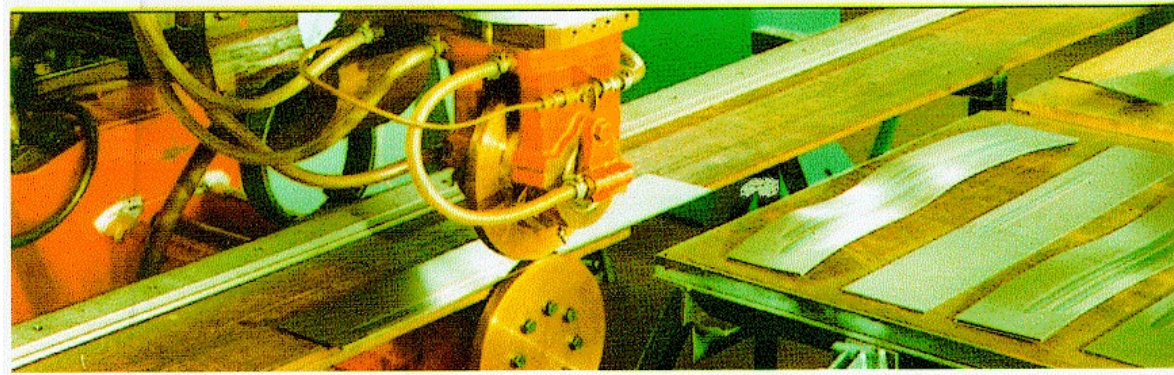
# Soldagem por Resistência por Costura (SRC)



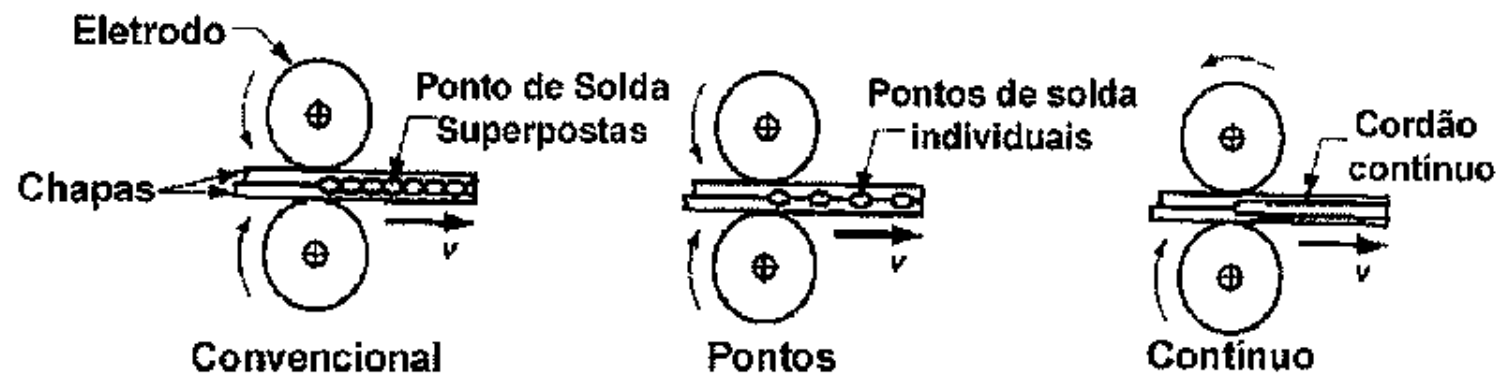
# SRP e SRC



Soldagem por ponto logo após o levantamento do eletrôdo

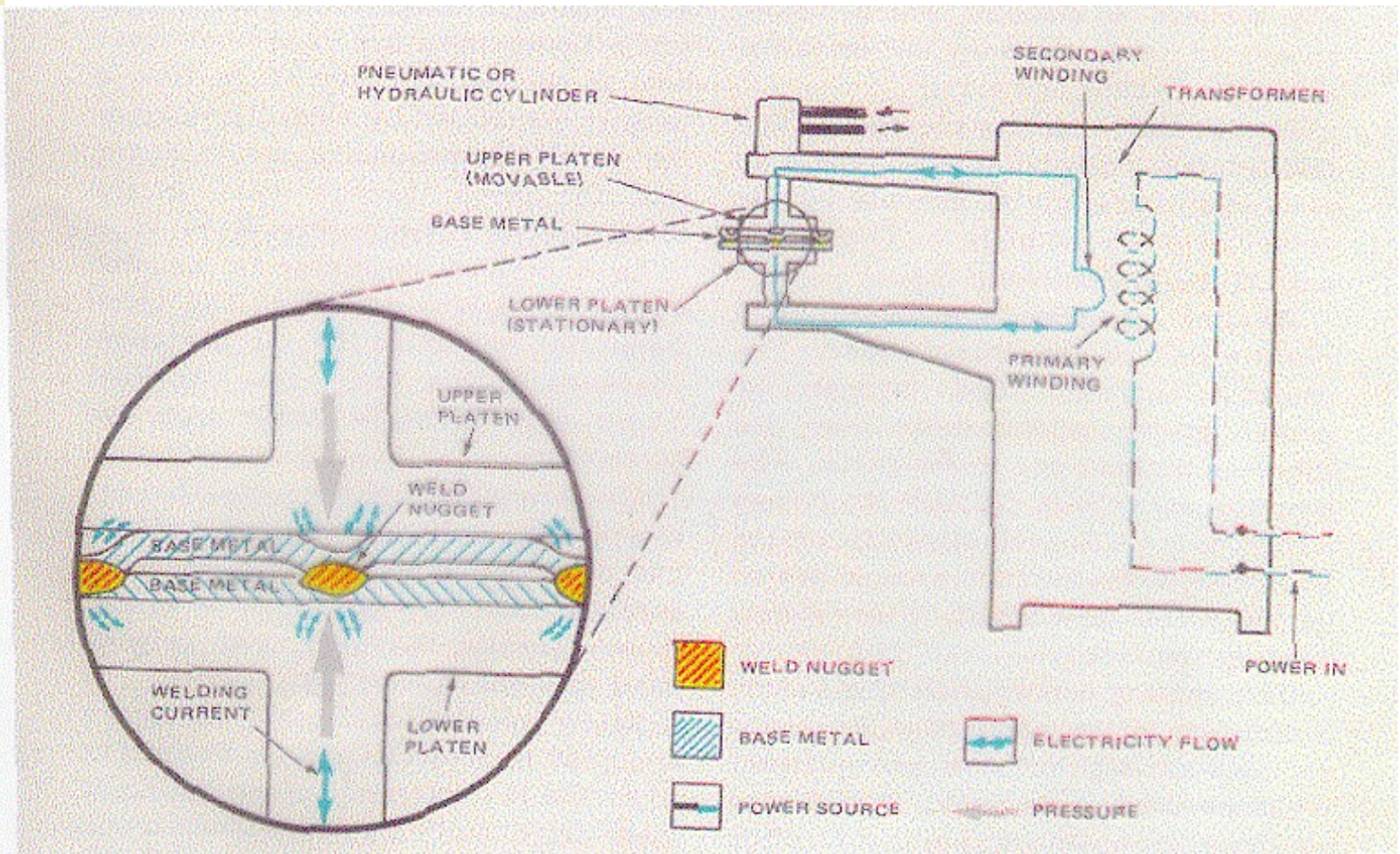


# Tipos de cordão

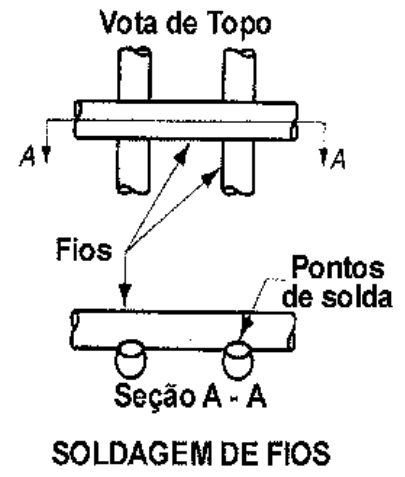
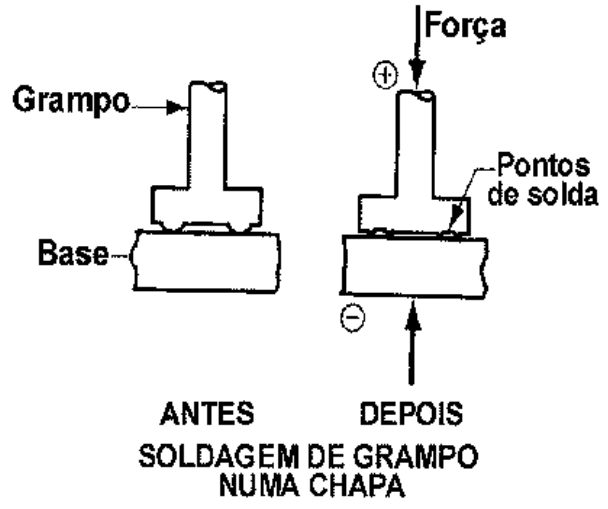
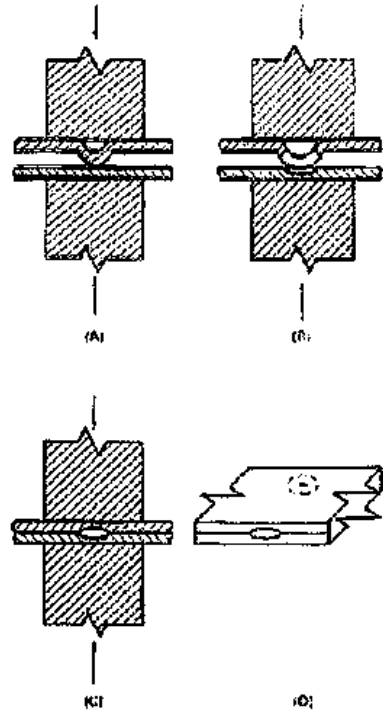


TIPOS DE CORDÕES DE SOLDA

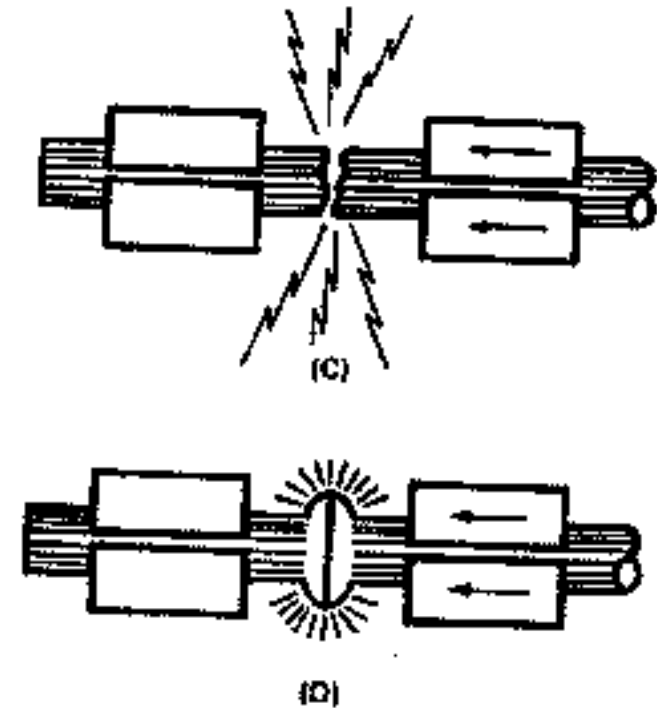
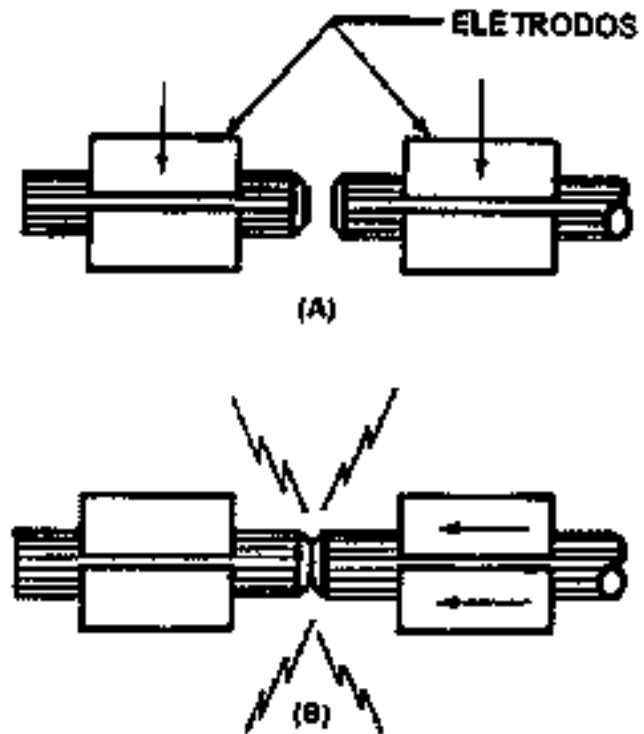
# Soldagem por Resistência por Projeção (SRPR)



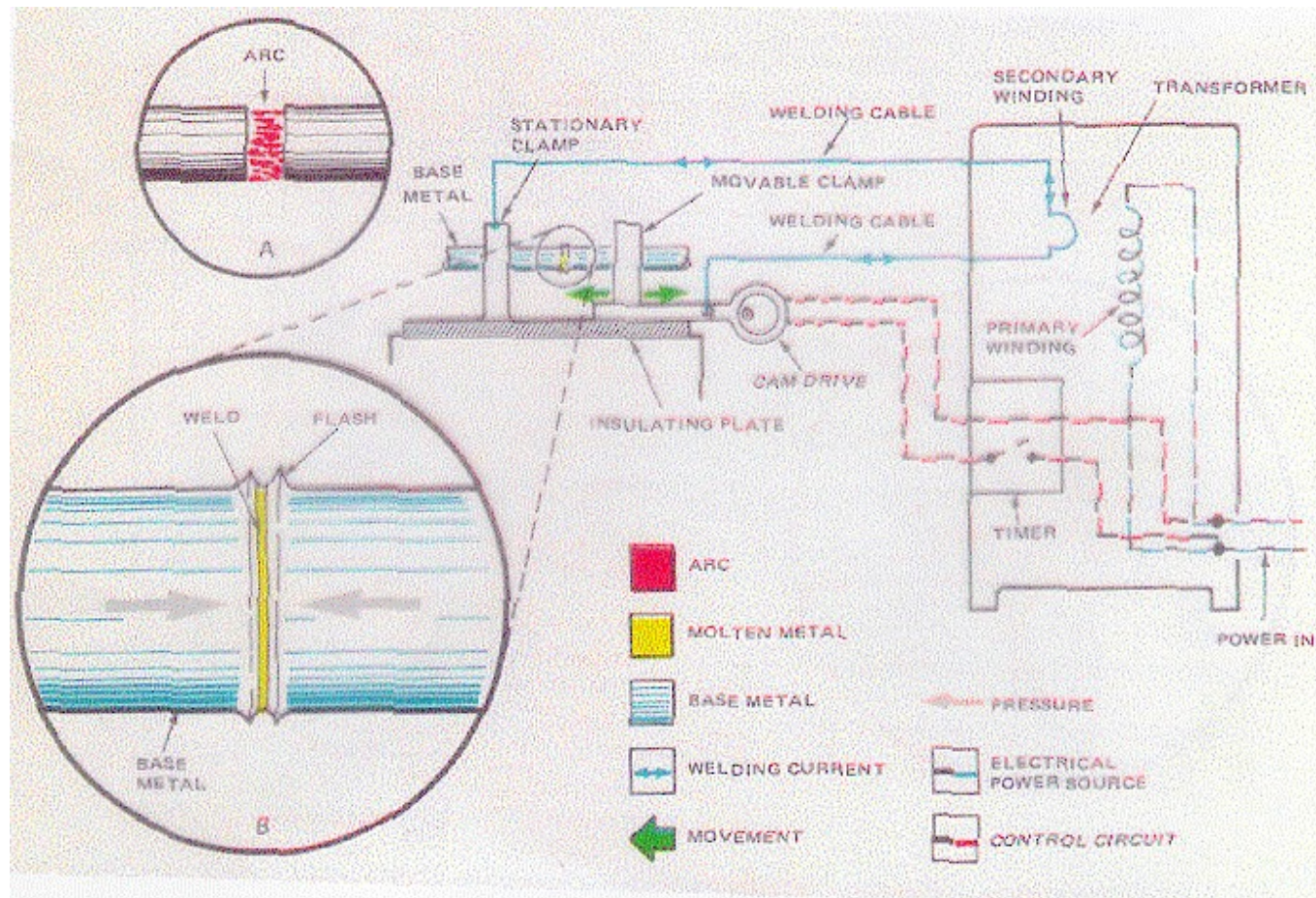




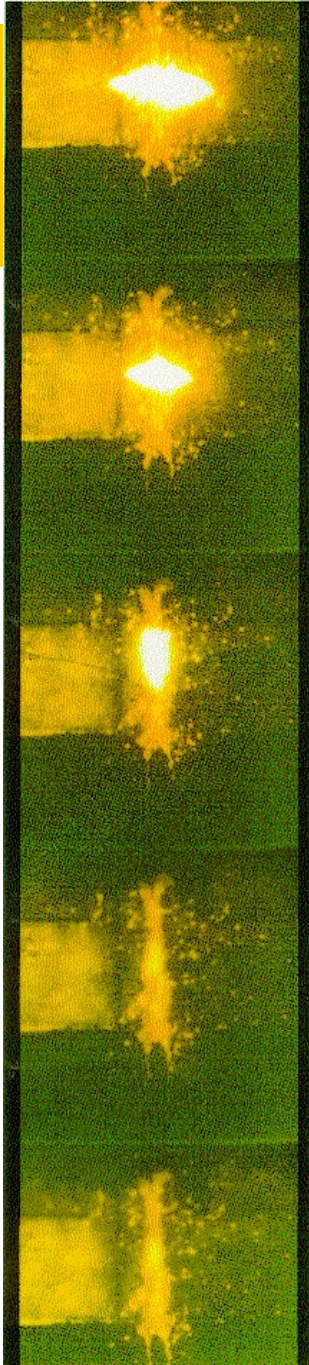
# Soldagem ao Arco por Centelhamento (SAC)

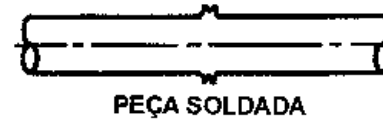
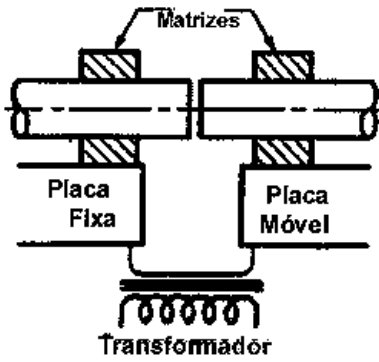


# Soldagem ao Arco por Centelhamento

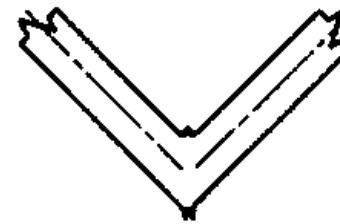
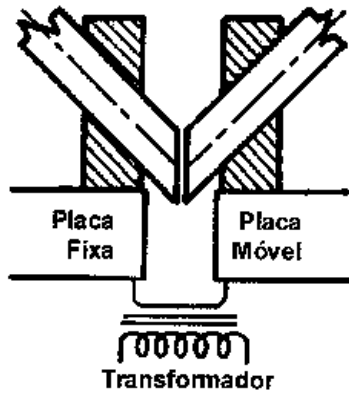


Processo de Soldagem a Arco por Centelhamento (SAC)

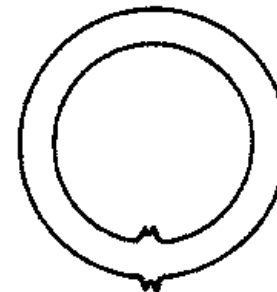
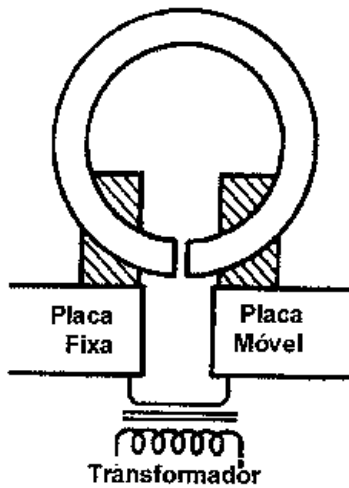




(A) SOLDAGEM ALINHADA



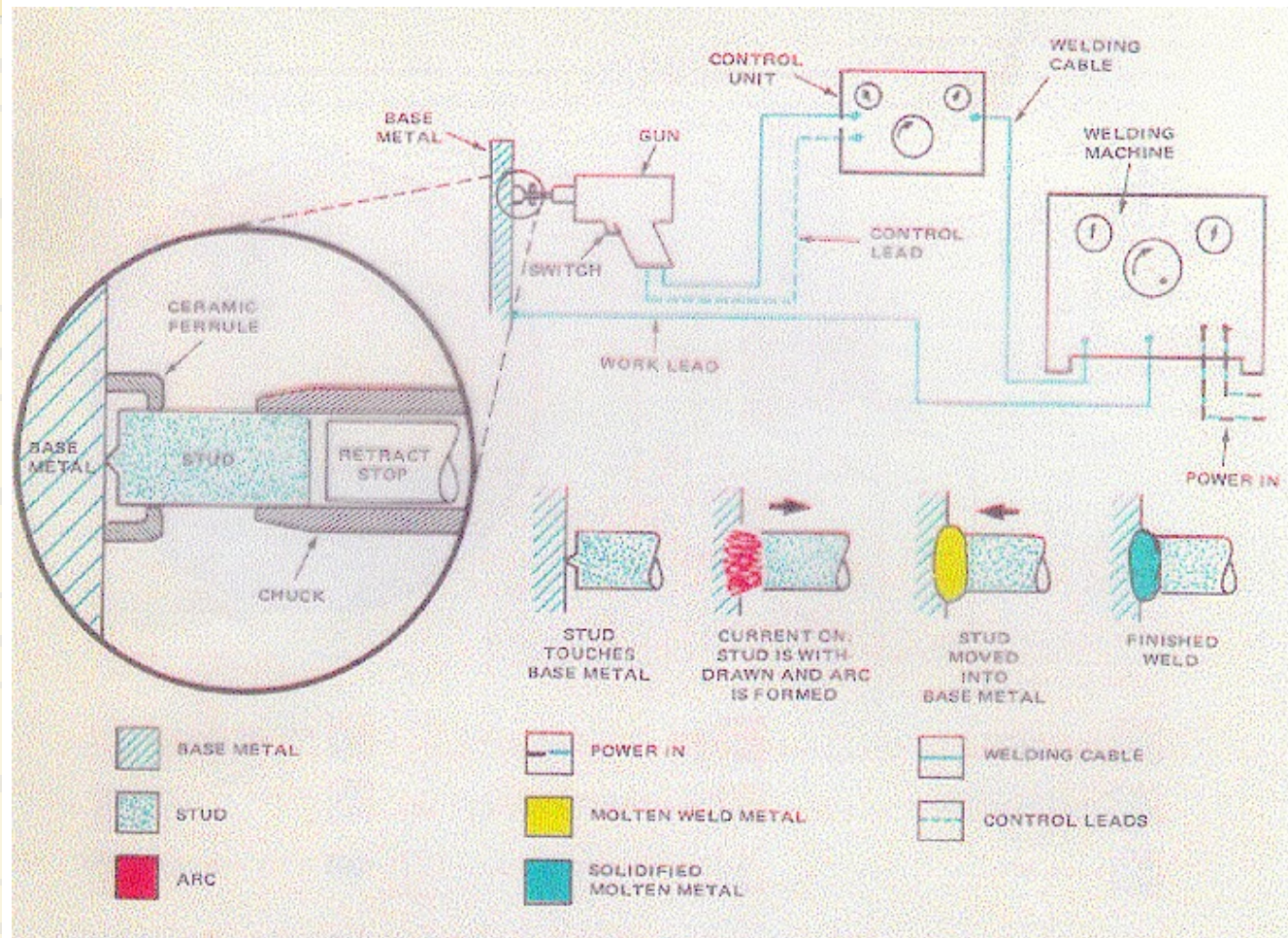
(B) SOLDAGEM DE ESQUADRIA



(C) SOLDAGEM DE ANEL

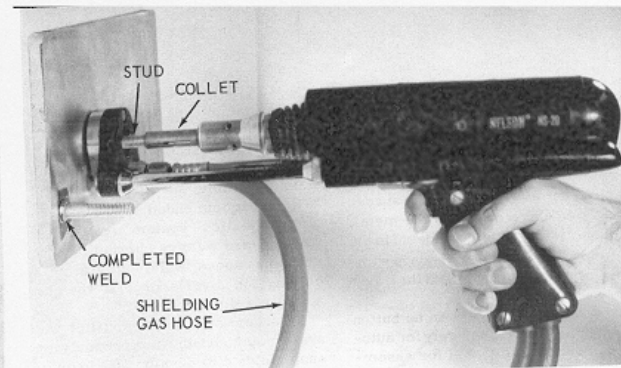
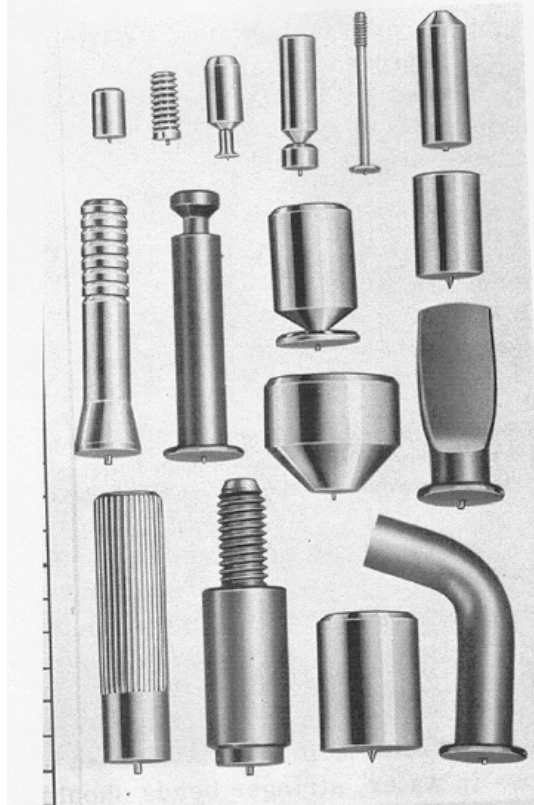
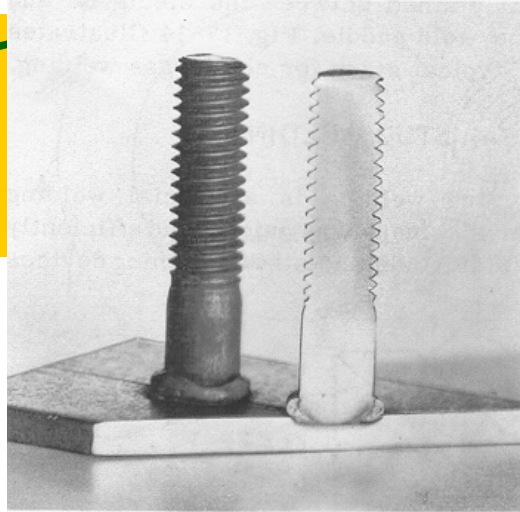


# Soldagem de Pinos (SP)

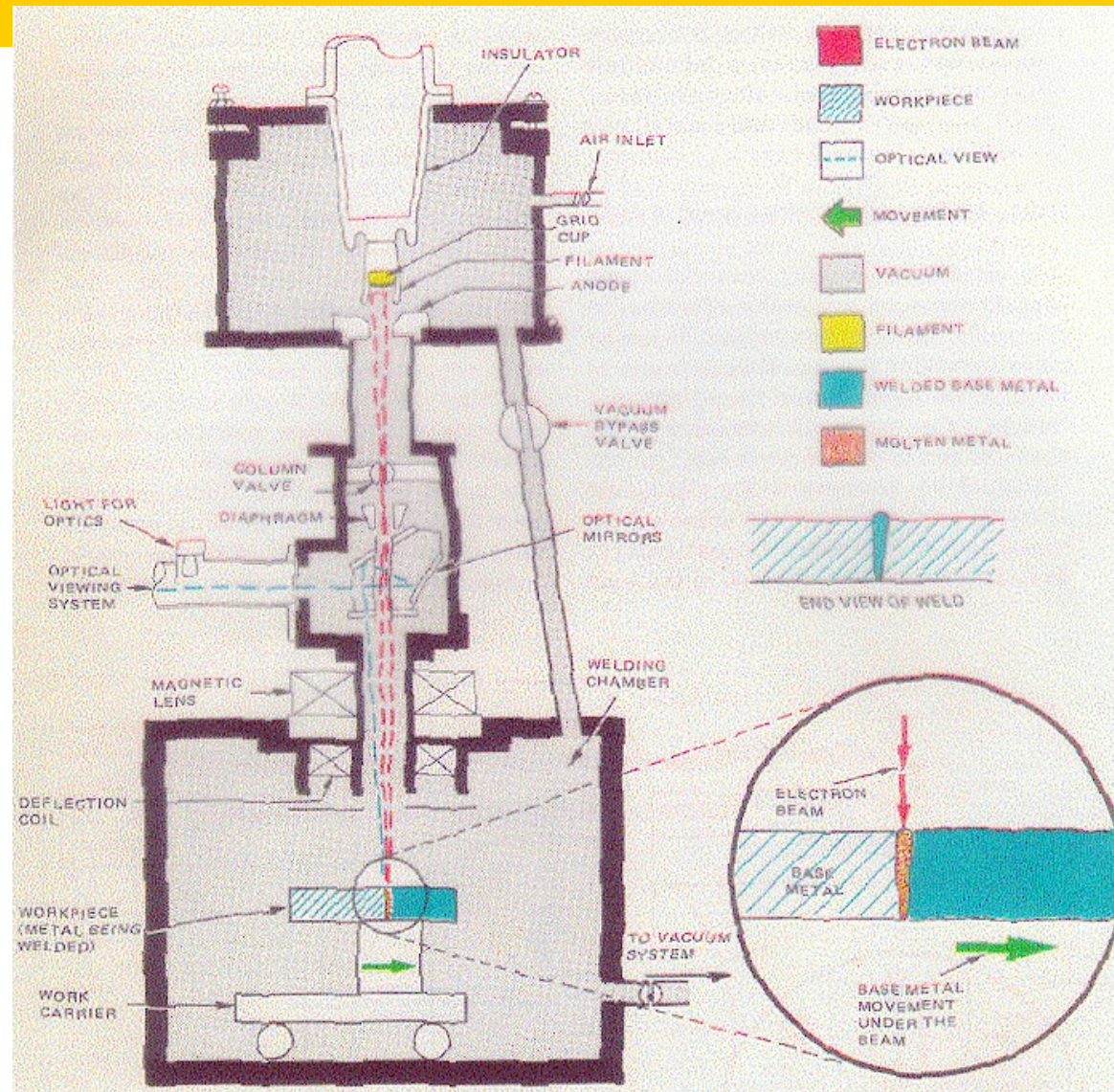


Processo de Soldagem de Pinos (SP)

# SOLDAGEM DE PINOS

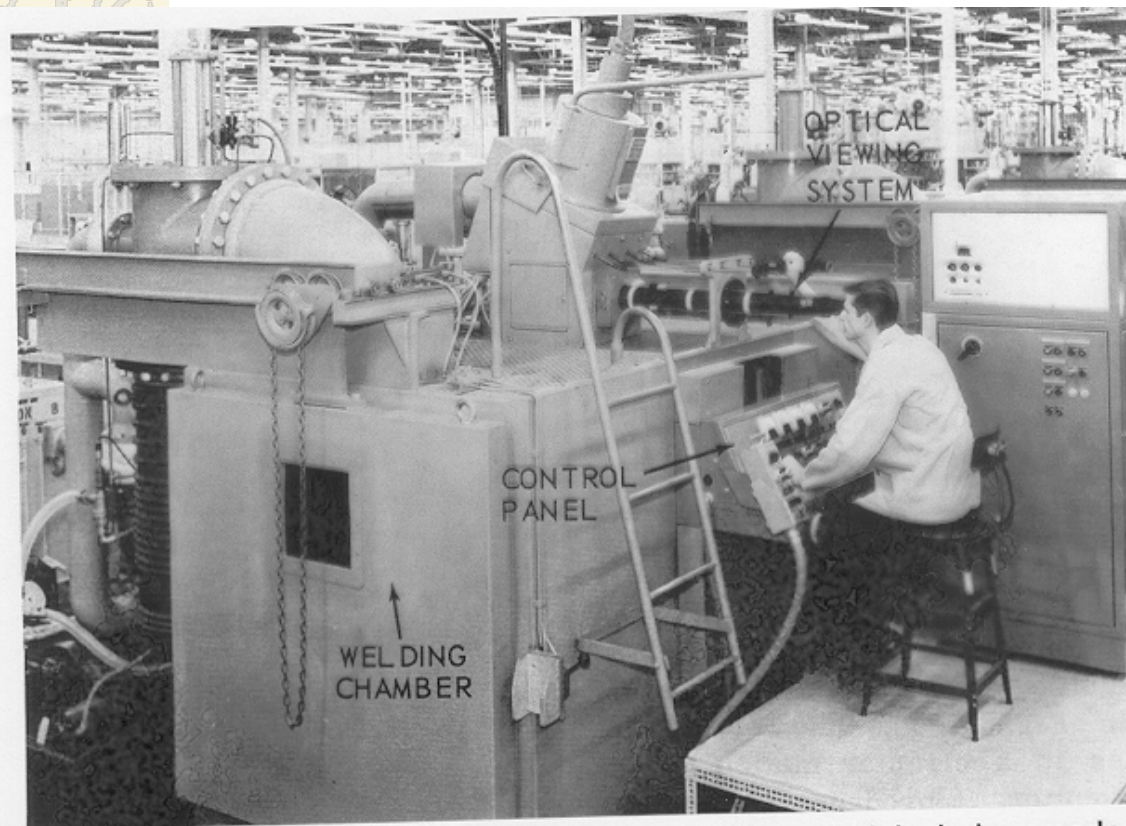


# Soldagem por Feixe de Elétron (SFE)





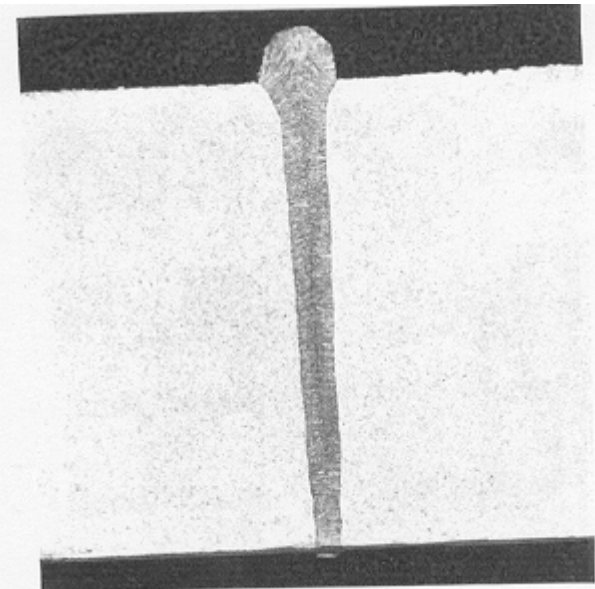
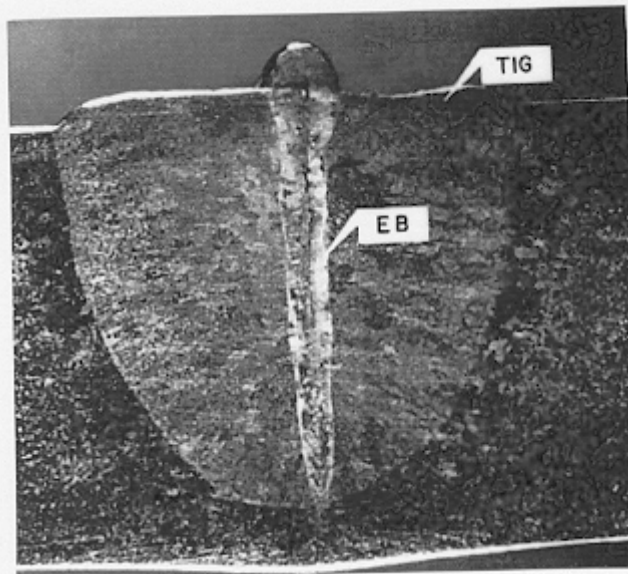
# Soldagem por Feixe de Elétrons



Complete electron beam welding machine. The weld is being made within an enclosed chamber. The operator views the weld through a special optical system. (Hamilton Standard Div., United Aircraft Corp.)

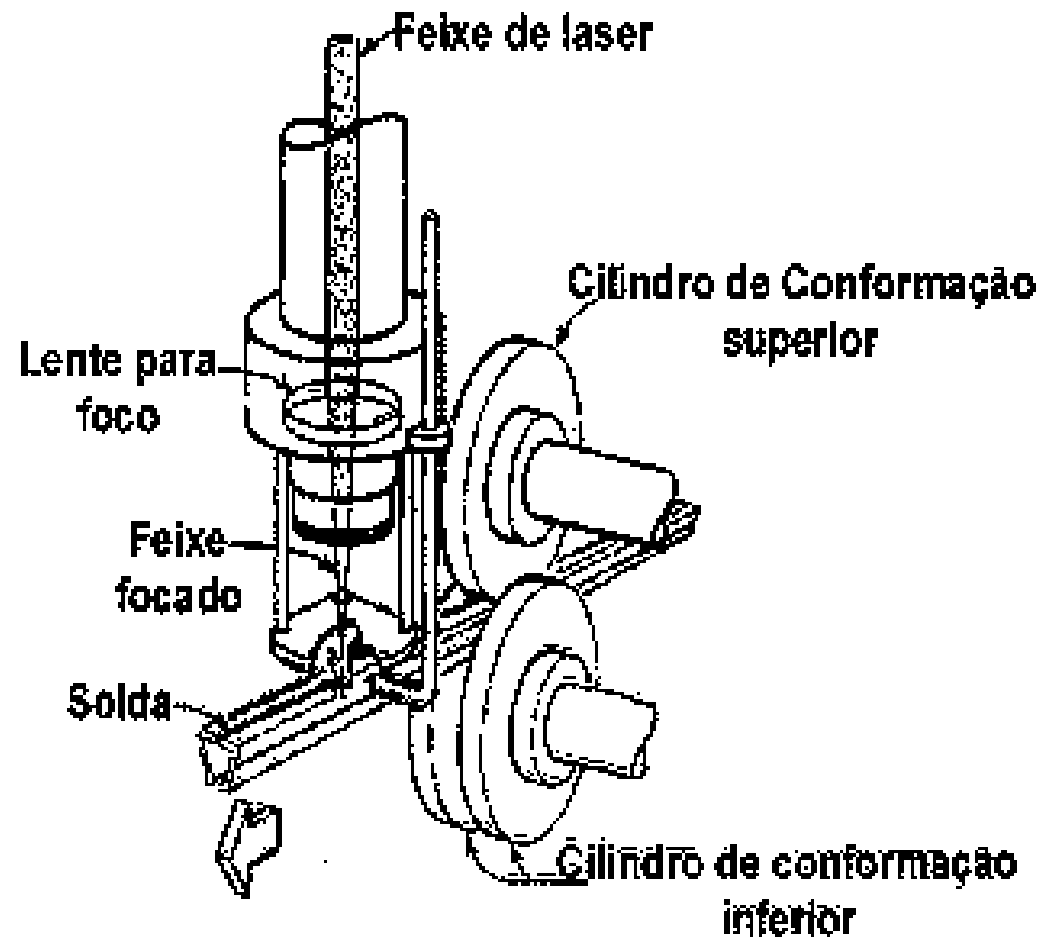
Filme

# Soldagem por Feixe de Elétron

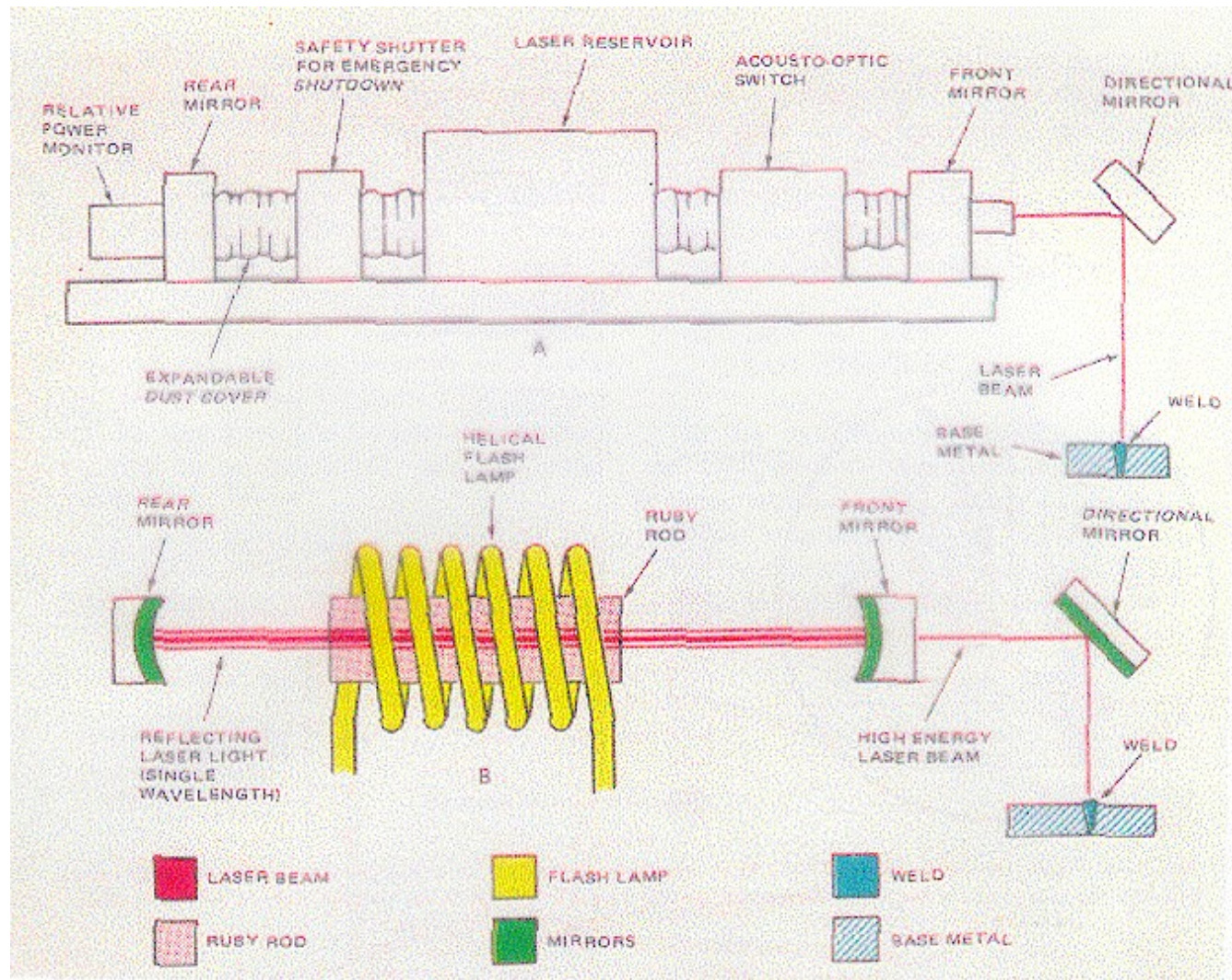


Material: aço

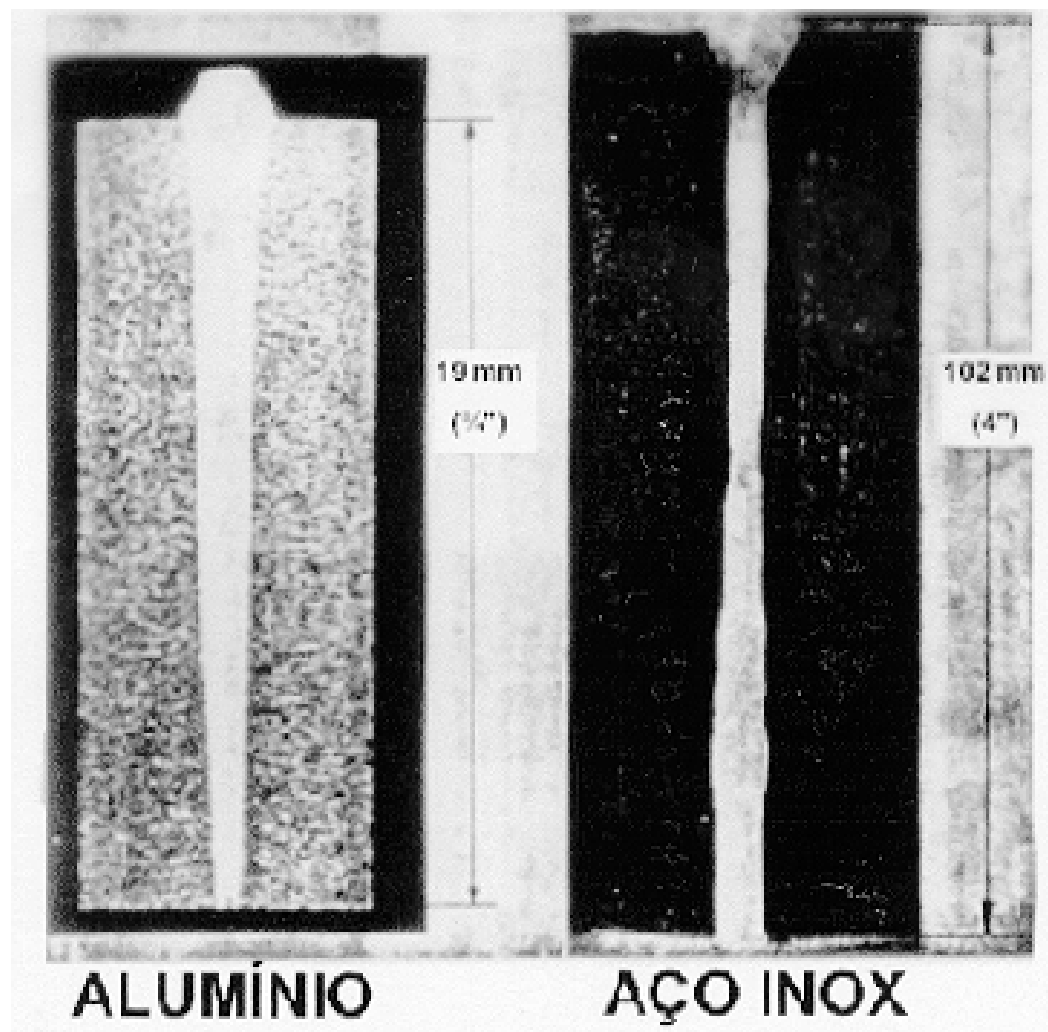
# Soldagem por LASER (SL)



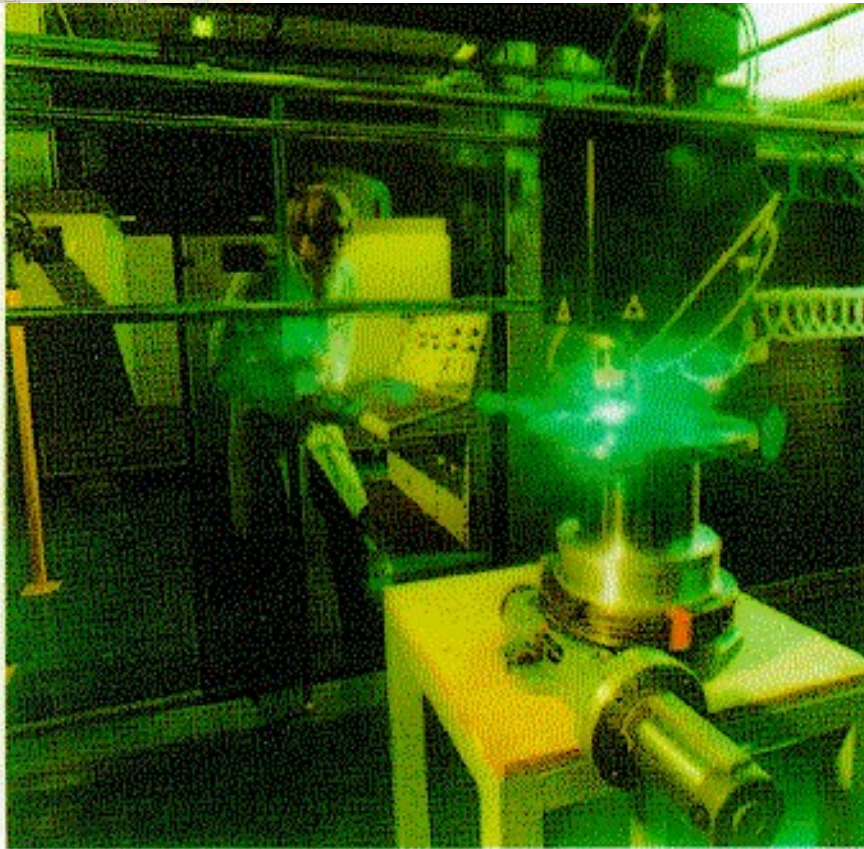
# Fontes de LASER



# Penetração



# Soldagem por LASER





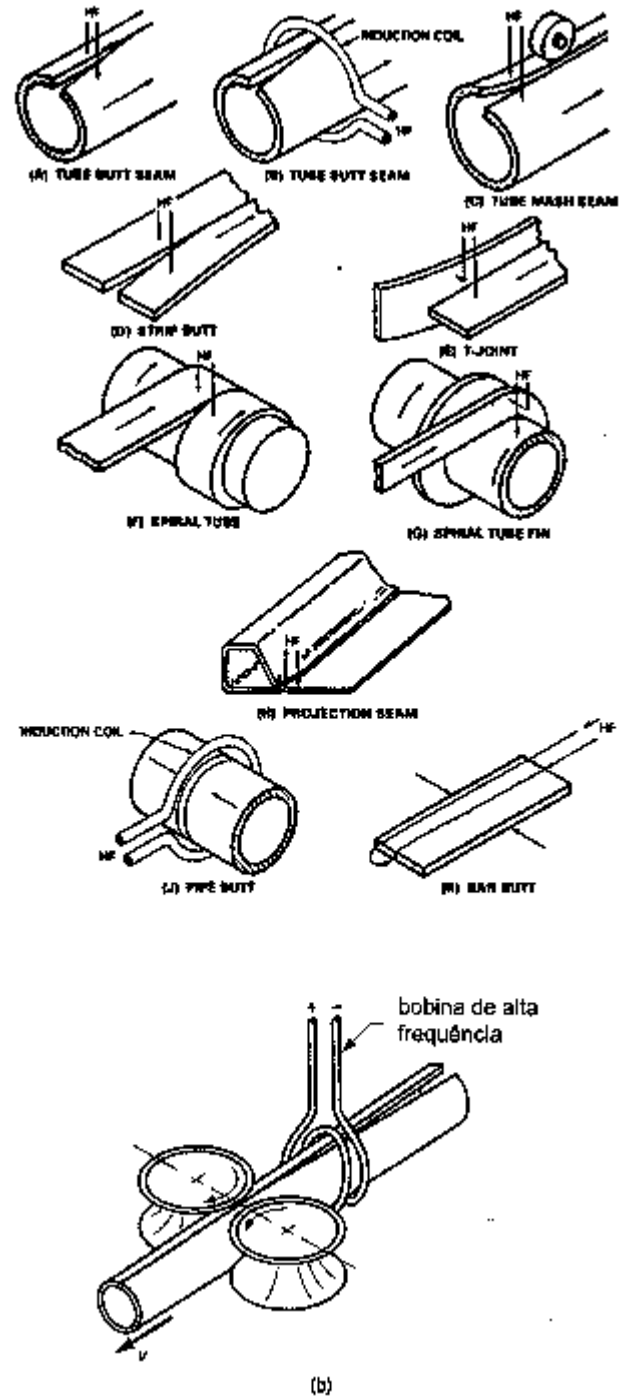
# Soldagem por LASER

 Filme laser pulsado

 Filme laser contínuo

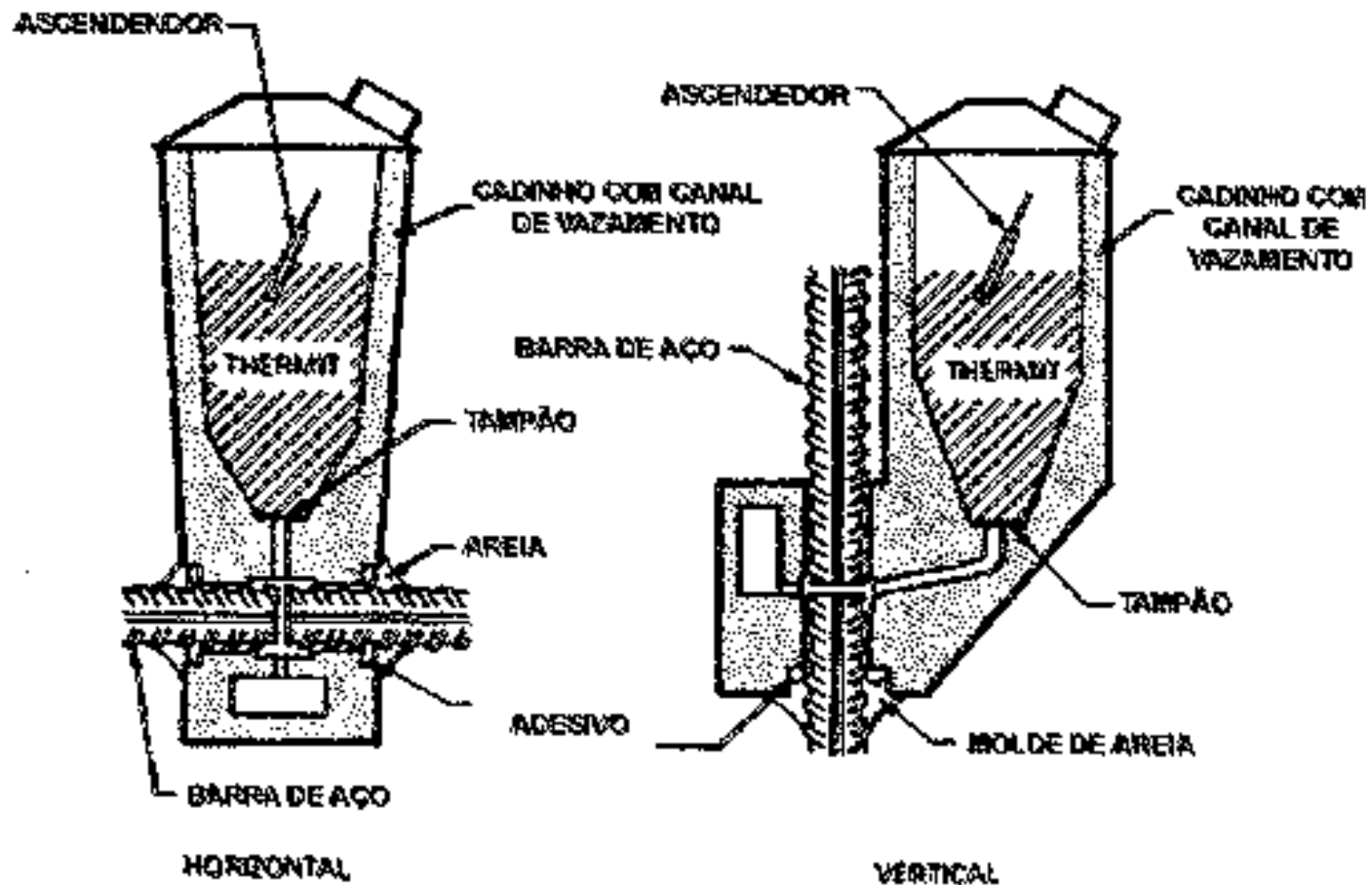
# Soldagem por Indução (SIN)

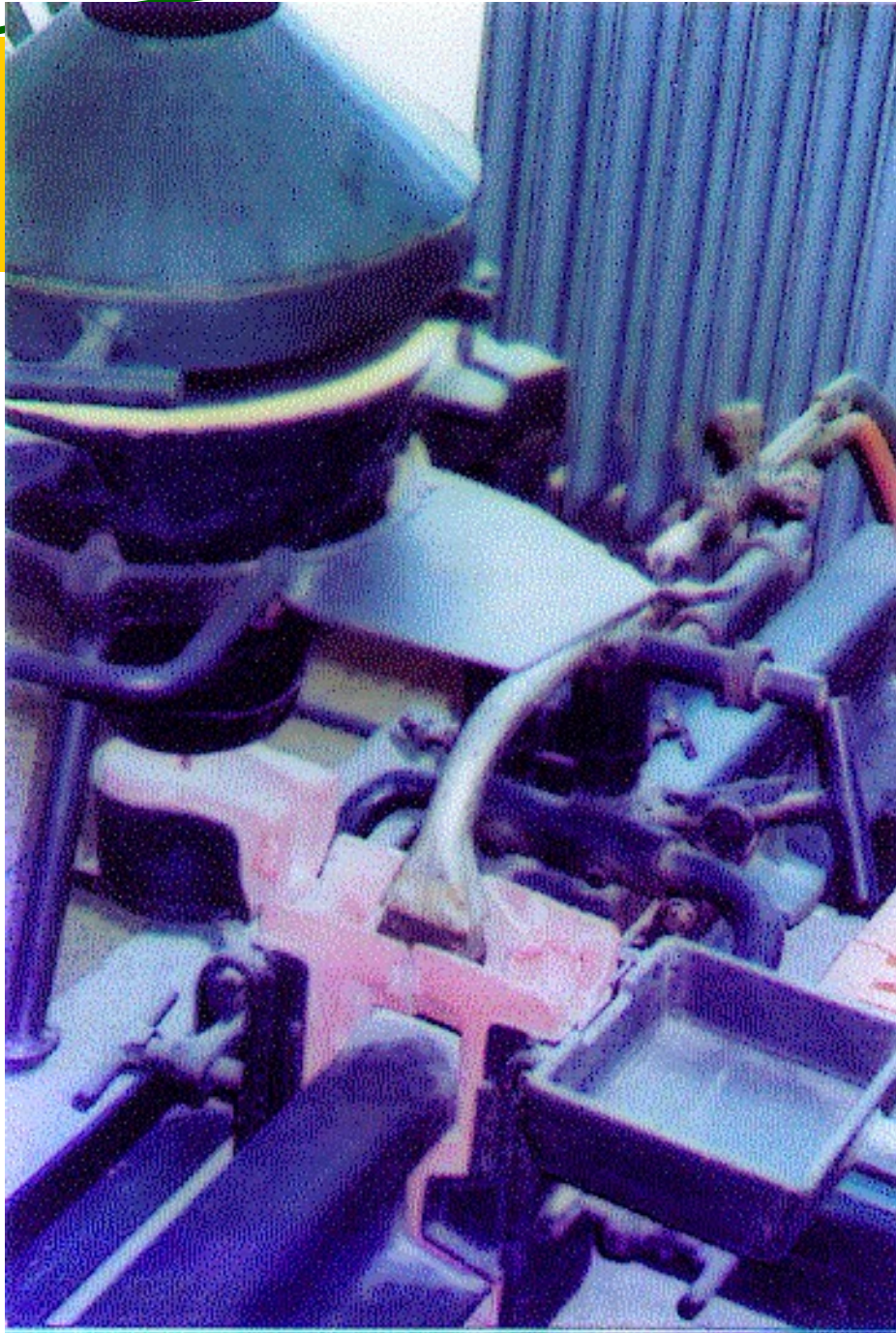
Filme





# Soldagem por Aluminotermia (SAL)

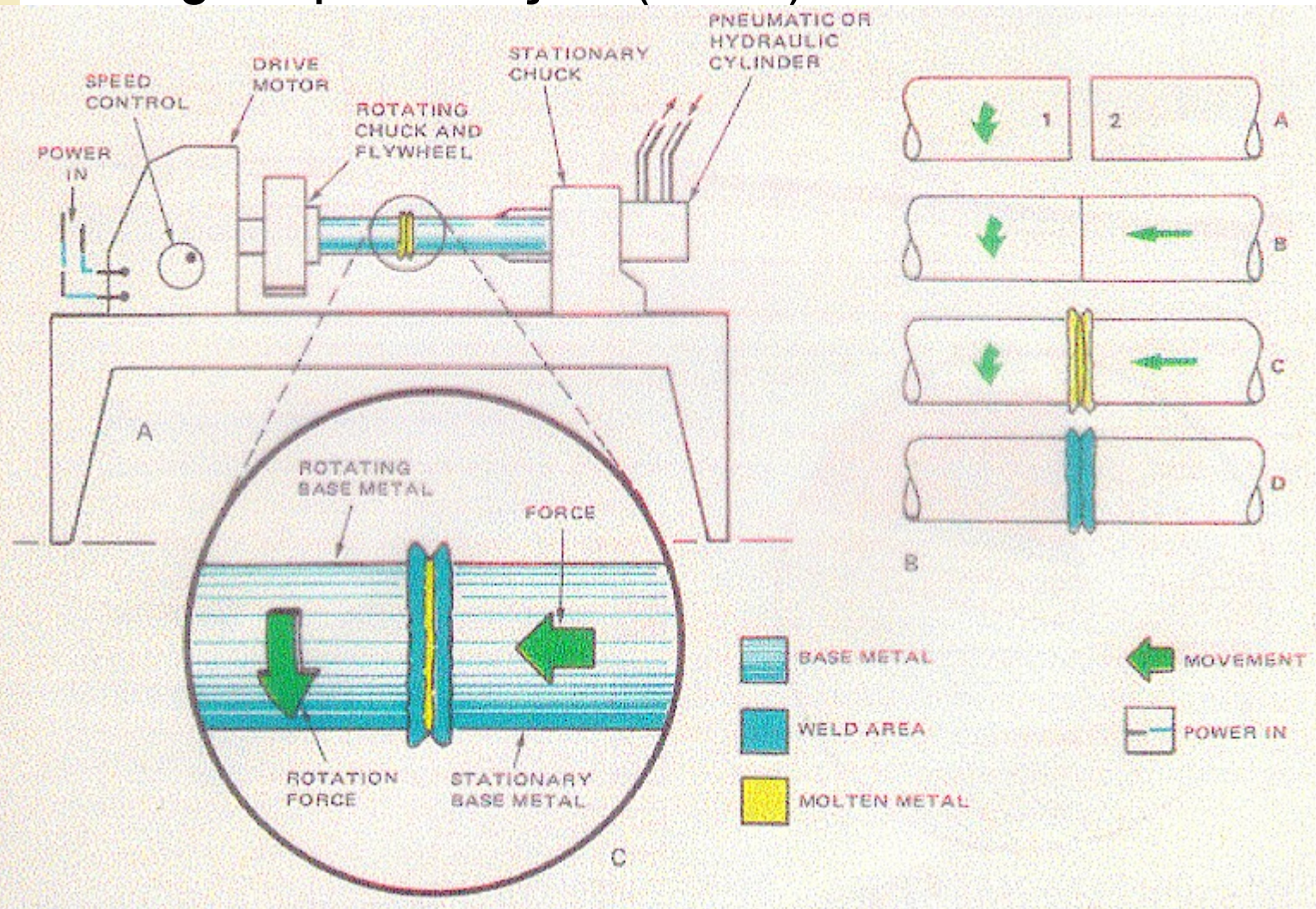


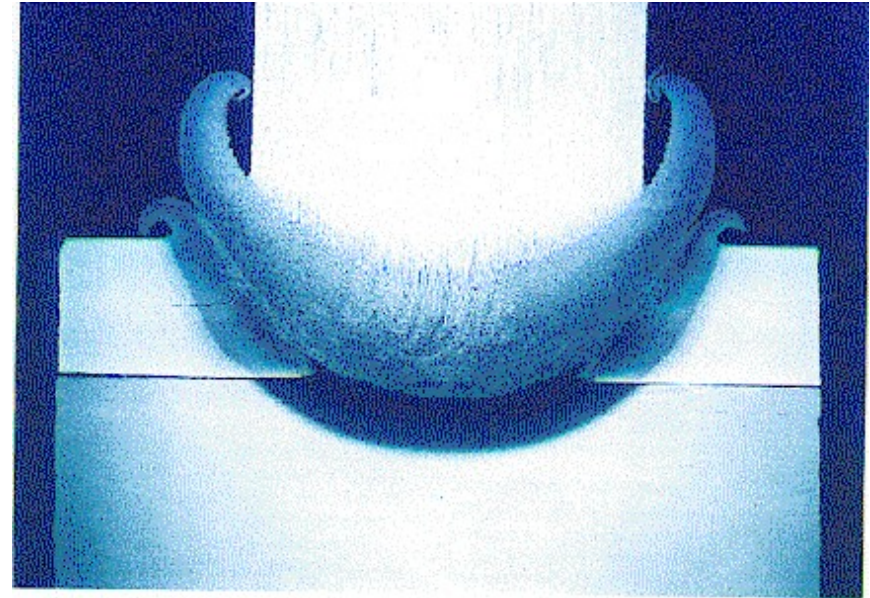
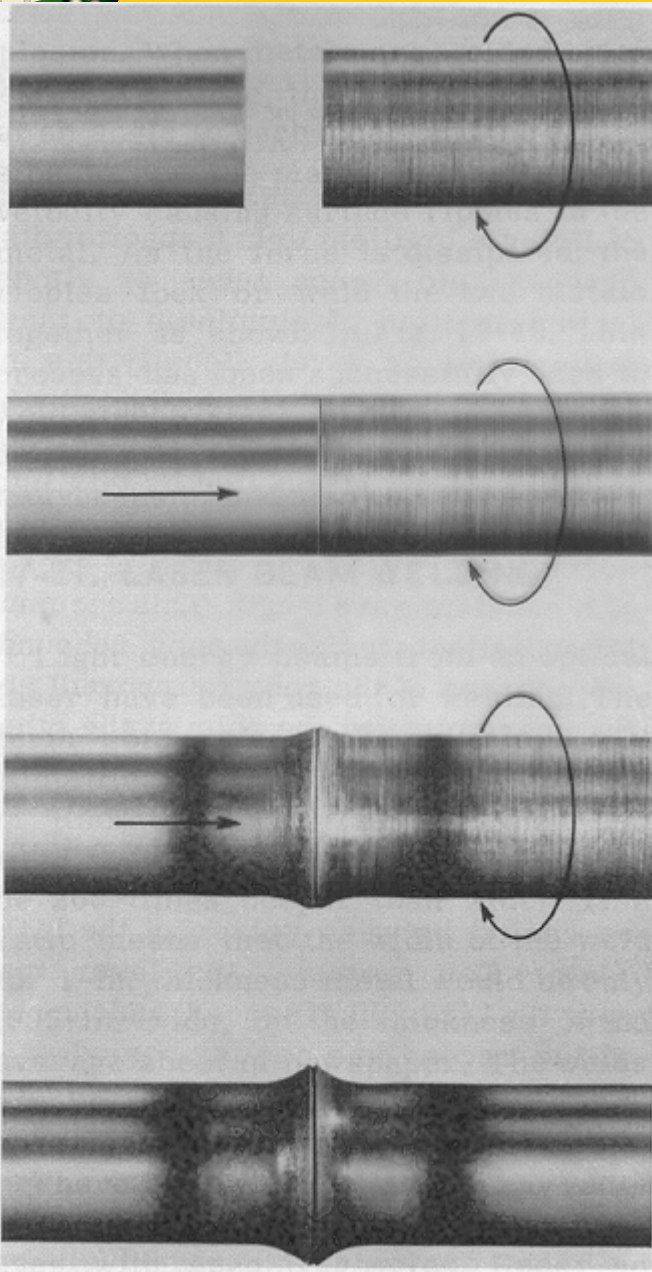
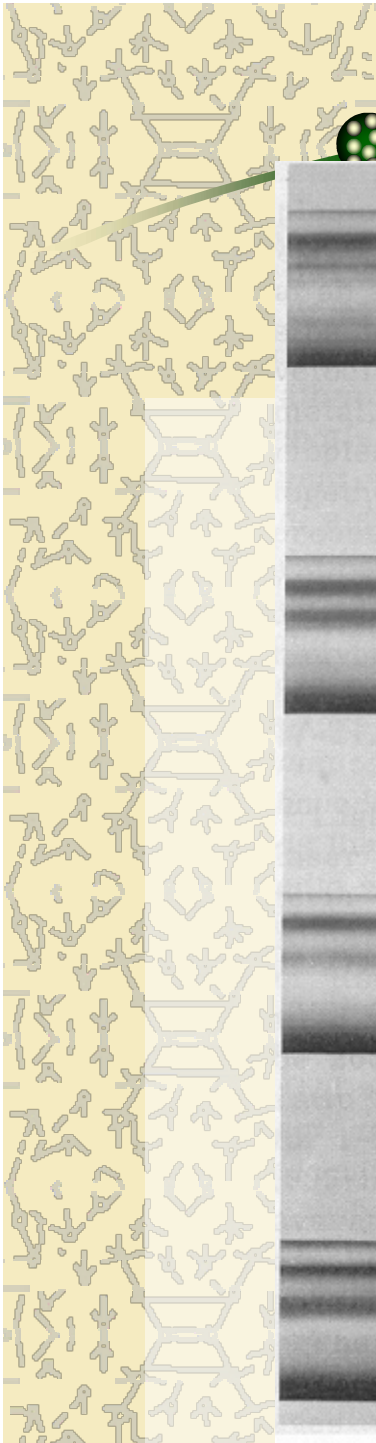


 Filme

# Soldagem no Estado Sólido

## Soldagem por Fricção (SFRI)





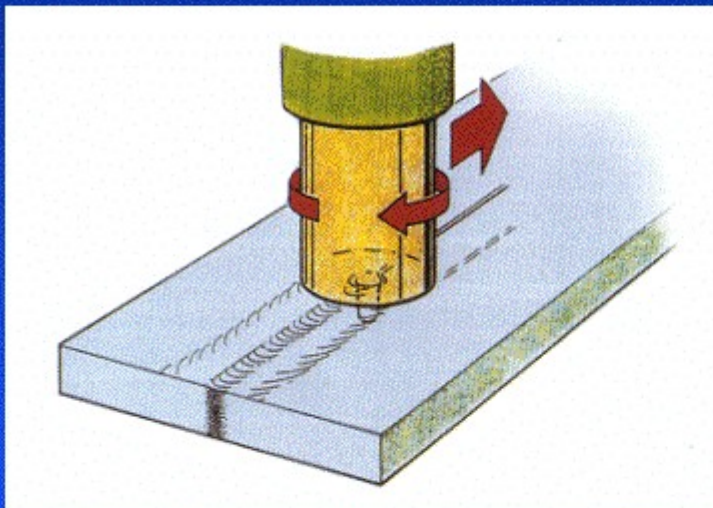
🐝 Filme Tarugo

🐝 Filme Tubo

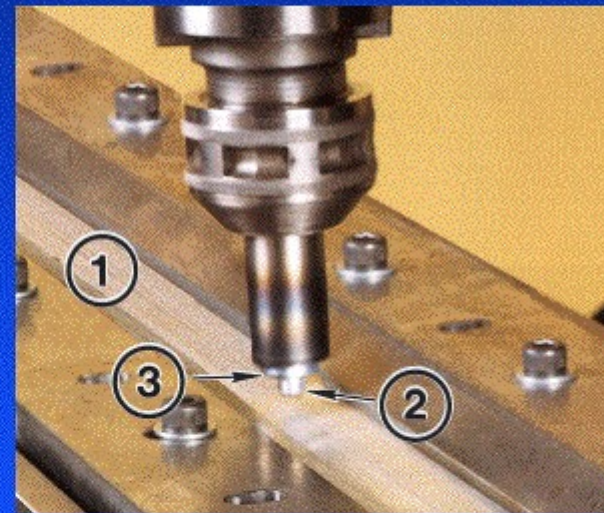
# Soldagem por Fricção-Mistura

## Friction Stir Welding

### ■ Principle



### ■ Example





# Soldagem por Fricção-Mistura

 Filme FSW liga Mg

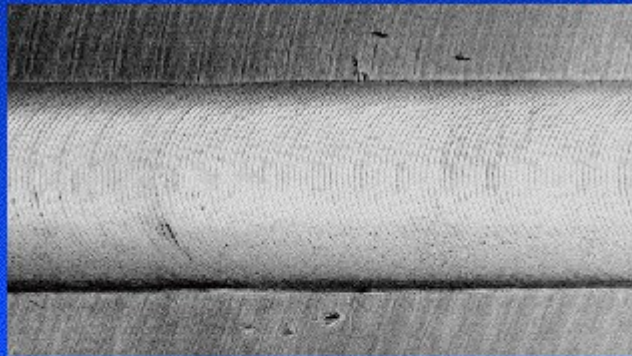
 Filme FSW liga Al

 Filme FSW aço

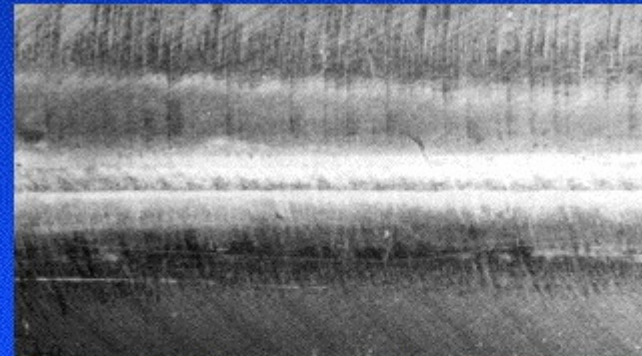
# Soldagem por Fricção-Mistura

## Typical weld appearance

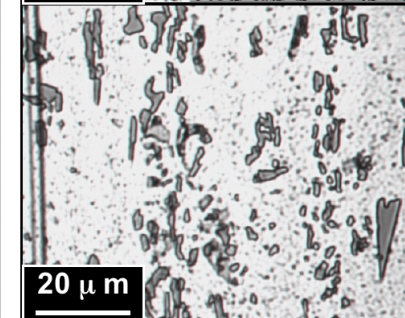
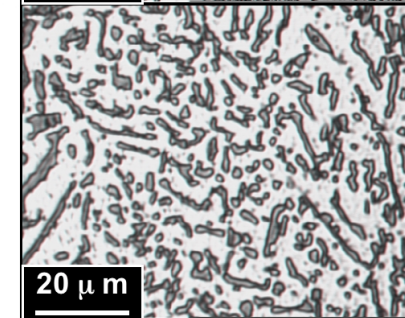
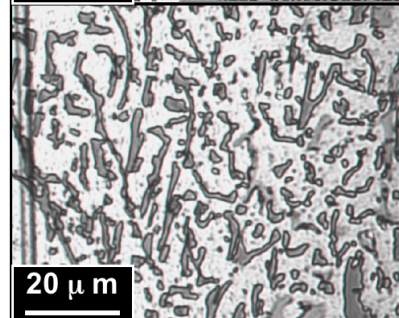
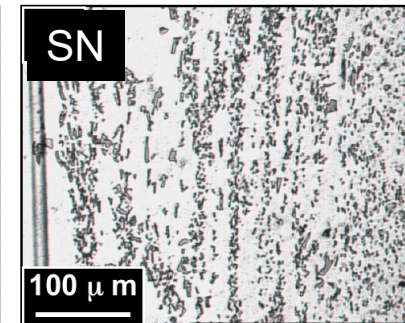
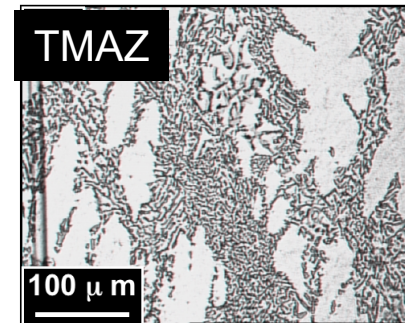
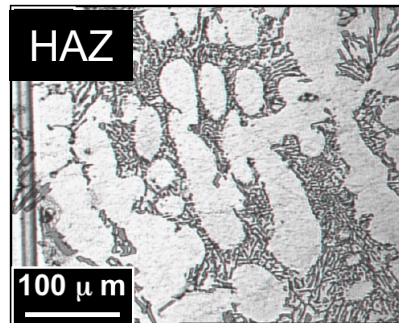
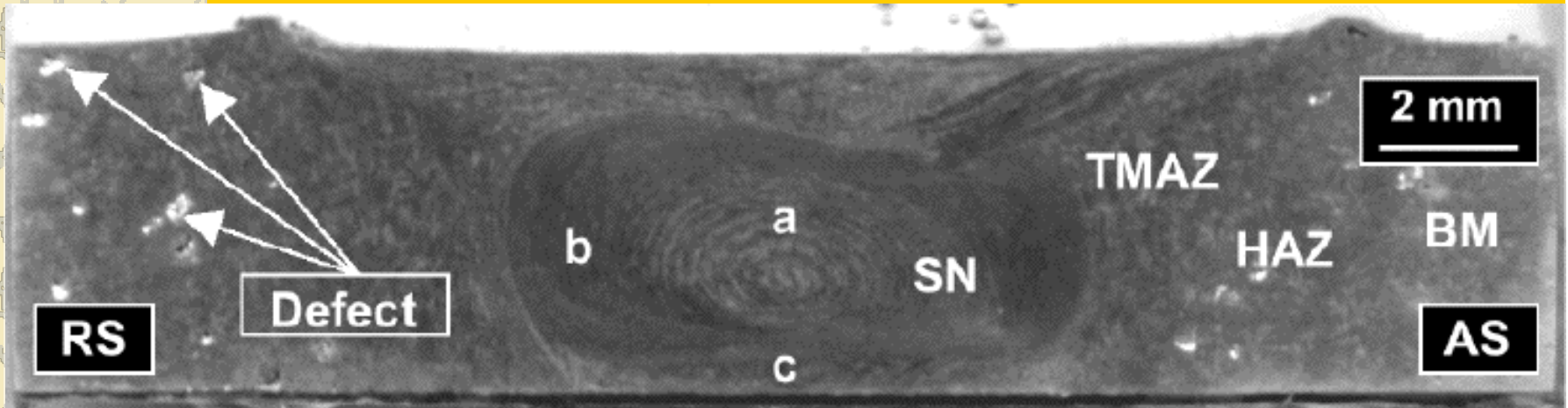
■ Top surface



■ Root surface



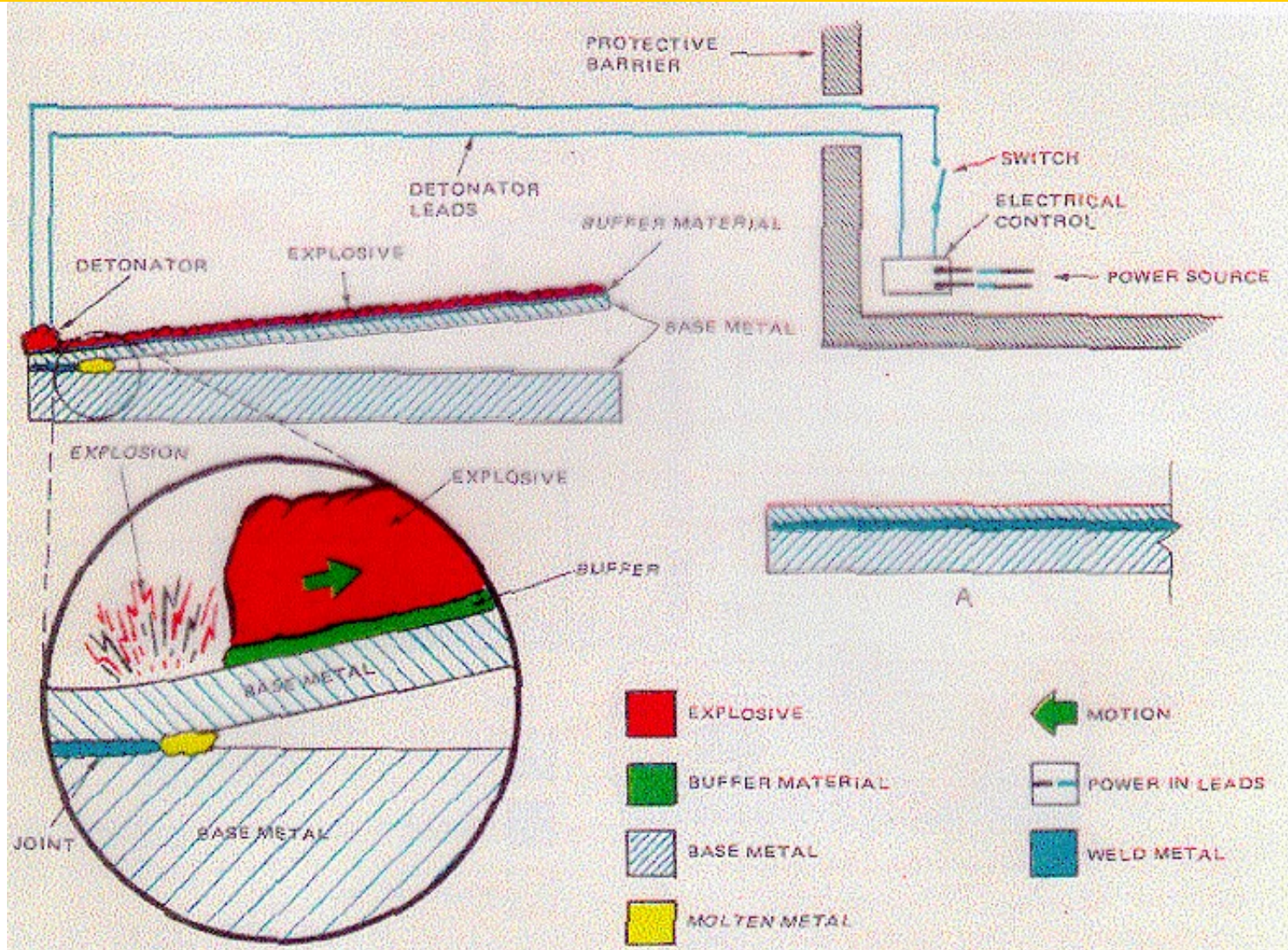
# Microestrutura Típica



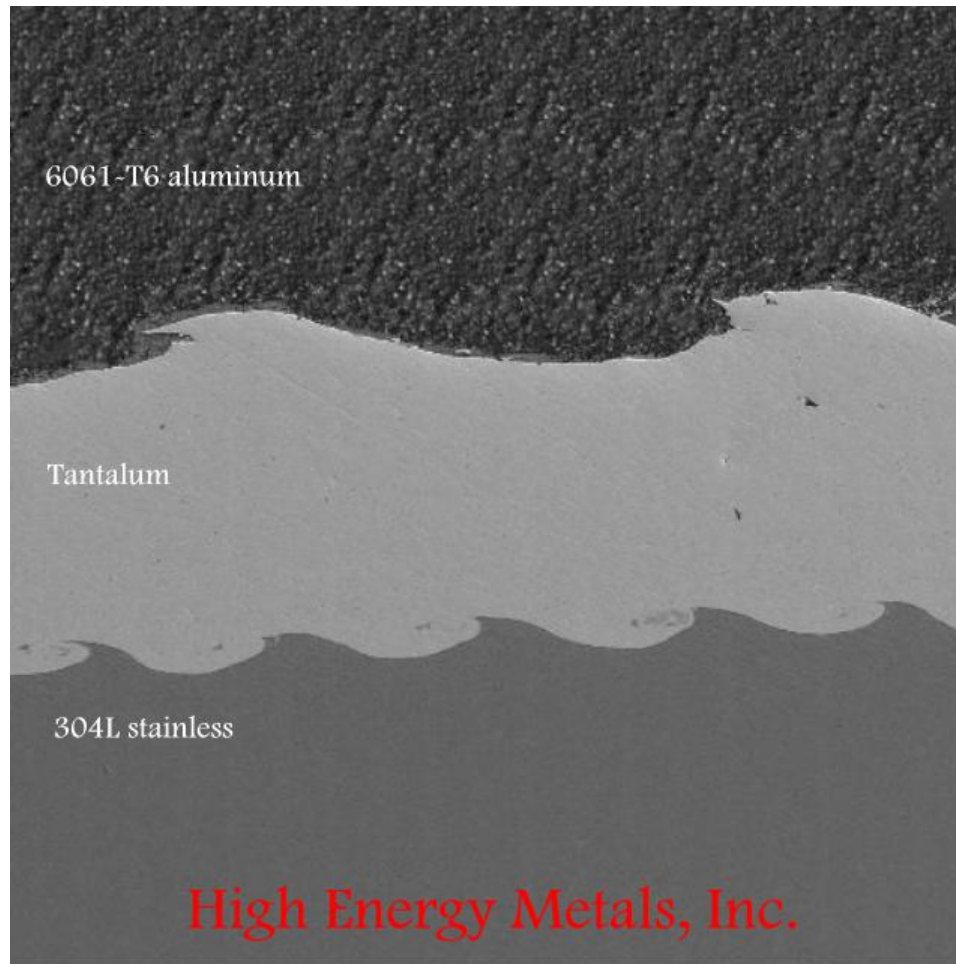
Liga Al-Si



# Soldagem por Explosão (SEXP)



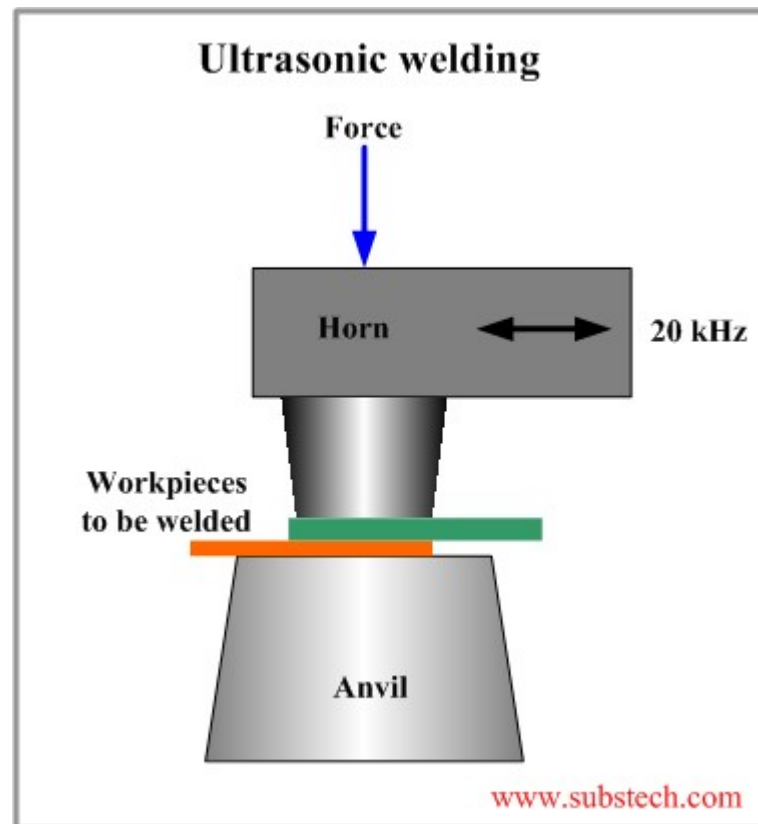
# Soldagem por explosão



Animação

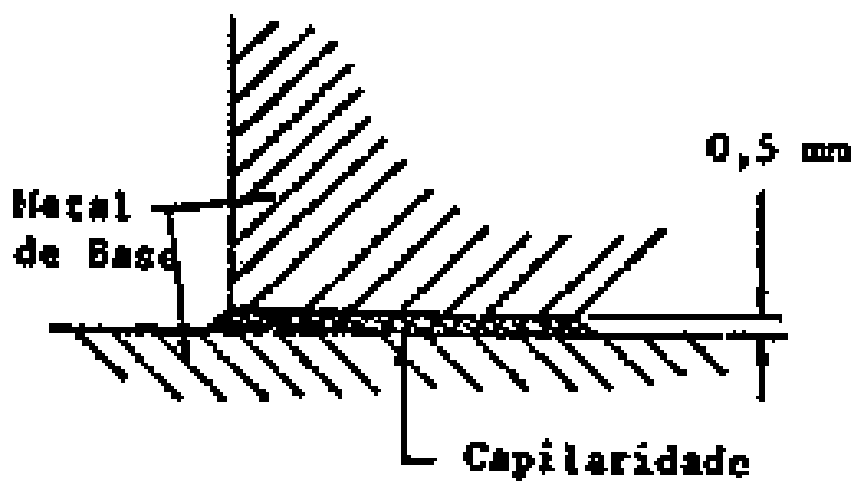
Filme

# Soldagem por Ultrassom

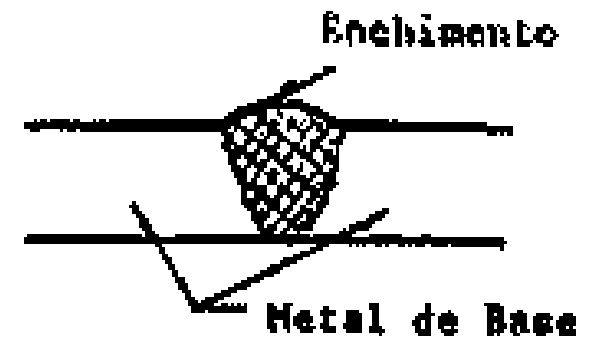


Filme

# Brasagem ( $T > 450^{\circ}\text{C}$ )



(a) Brasagem

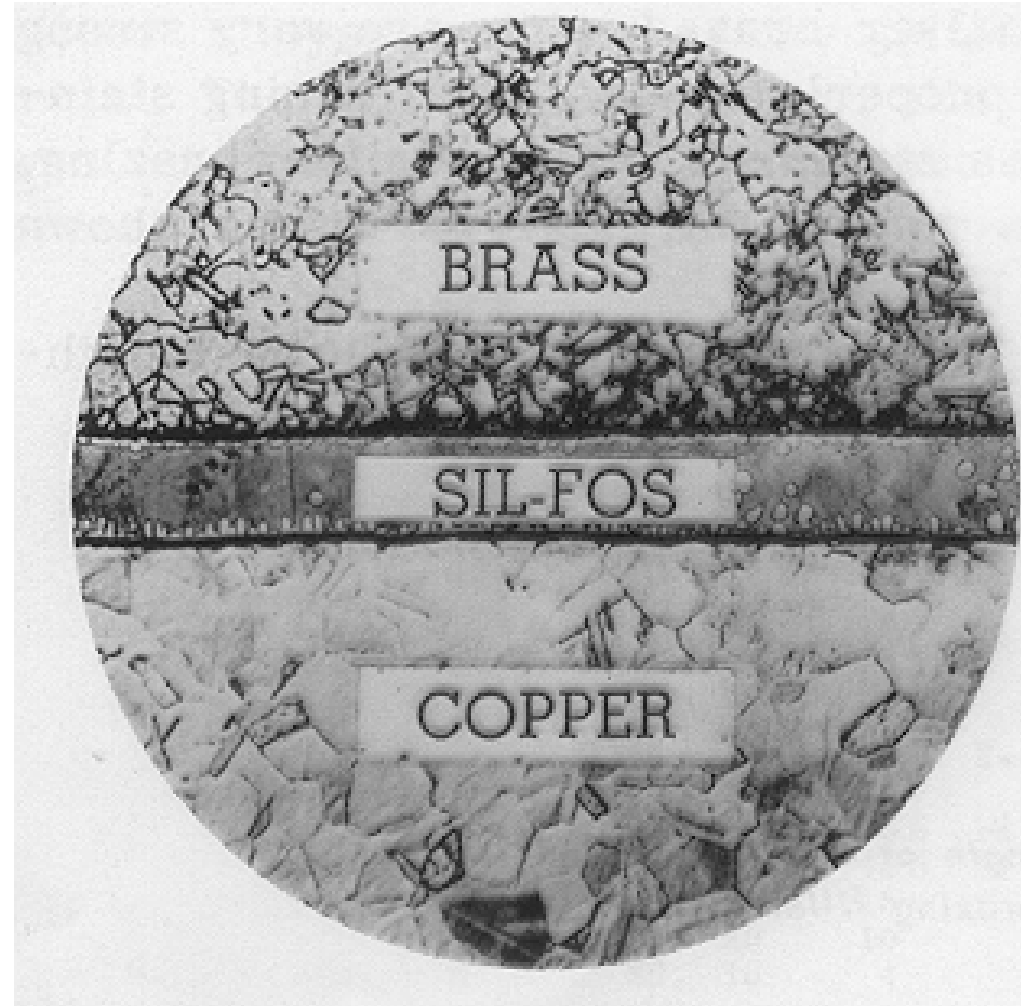


(b) Solda-brasagem

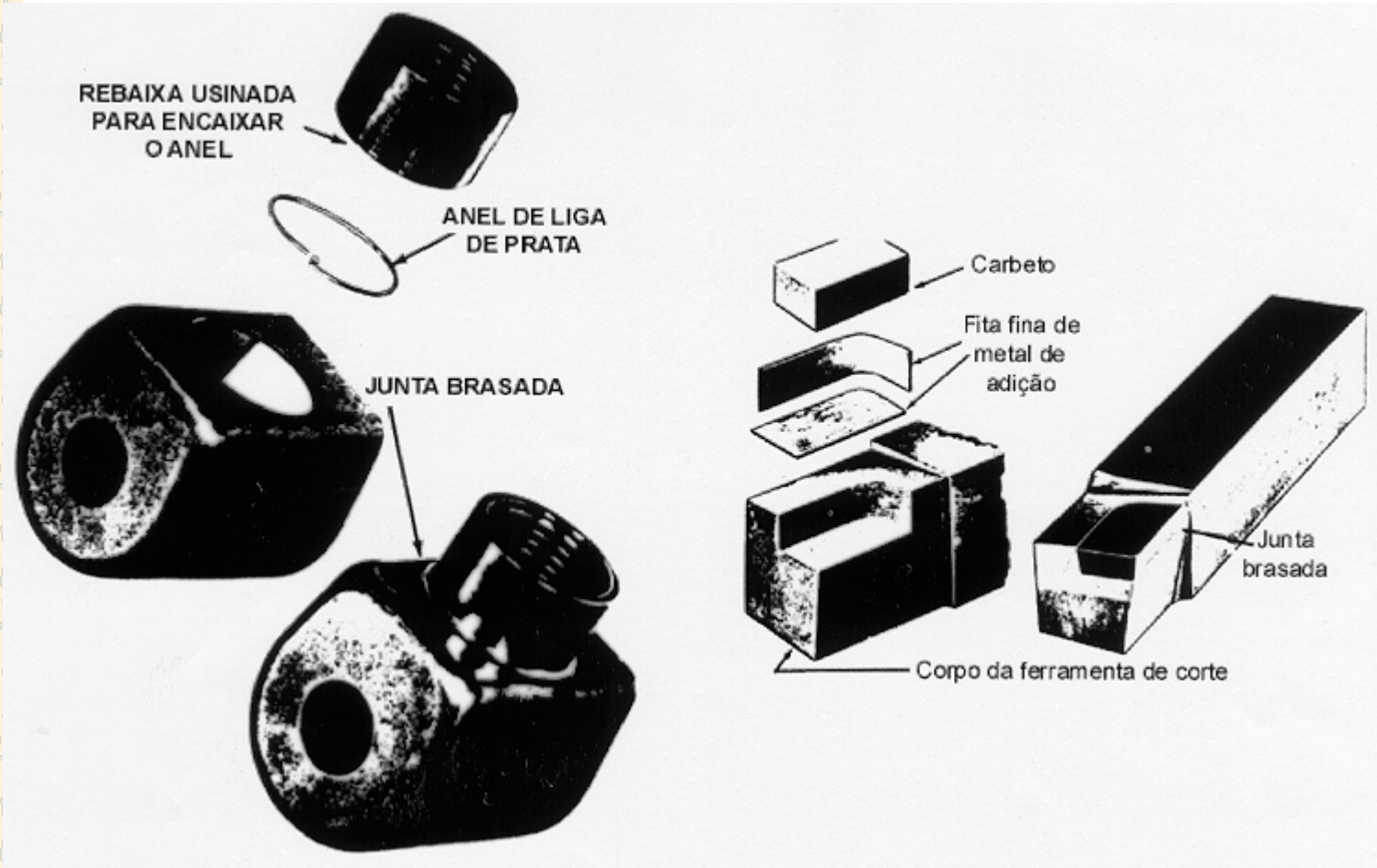
## BRASAGEM E SOLDA-BRASAGEM

Simulação Ni-Cu (capilar de 10 nm)

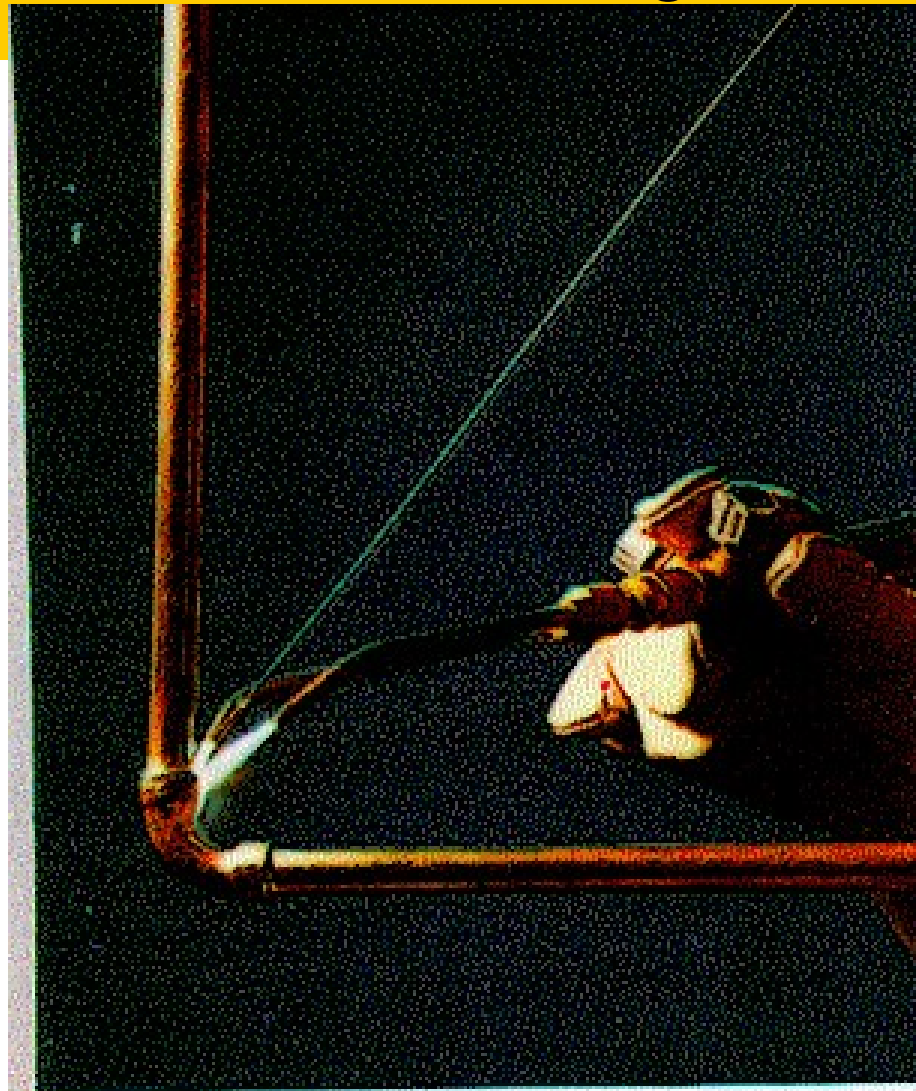
# Brasagem



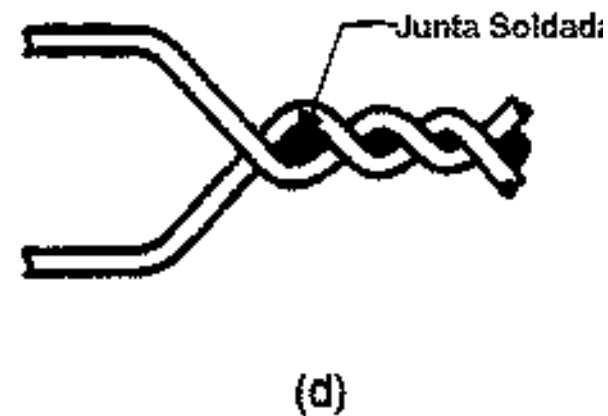
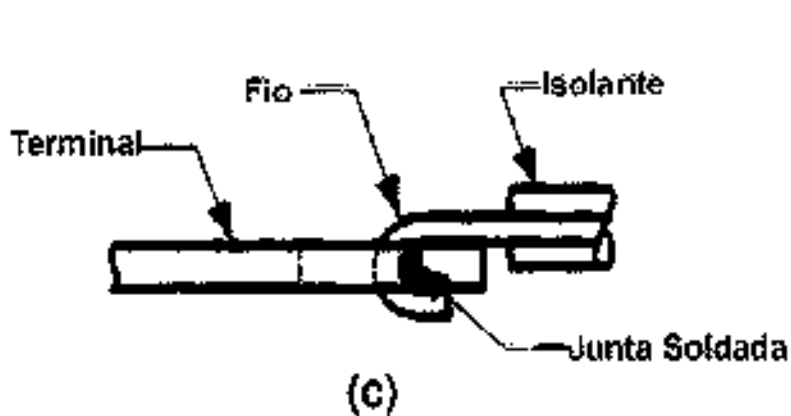
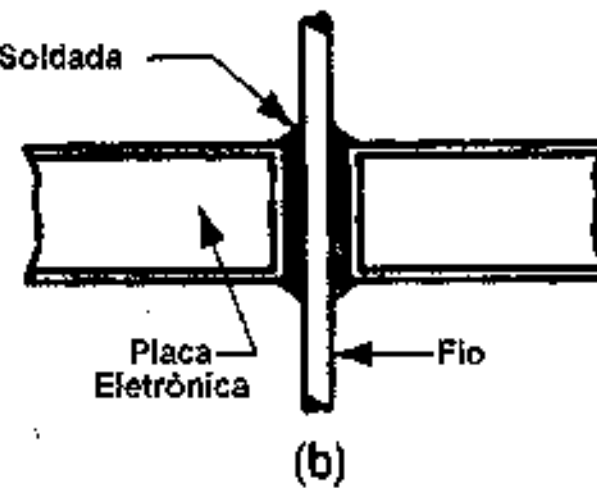
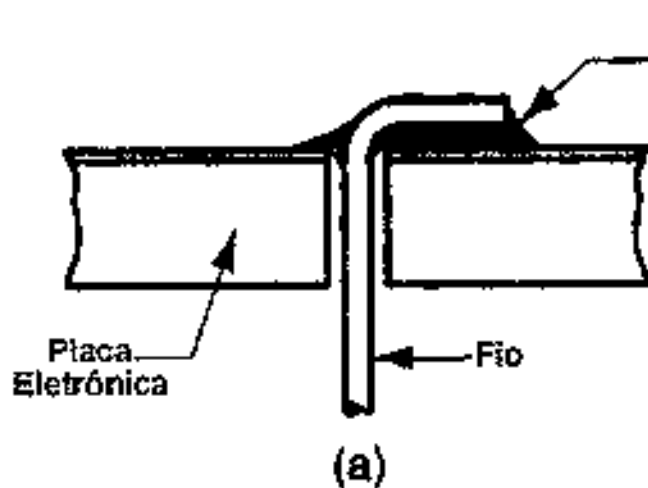
# Brasagem



# Solda Brasagem



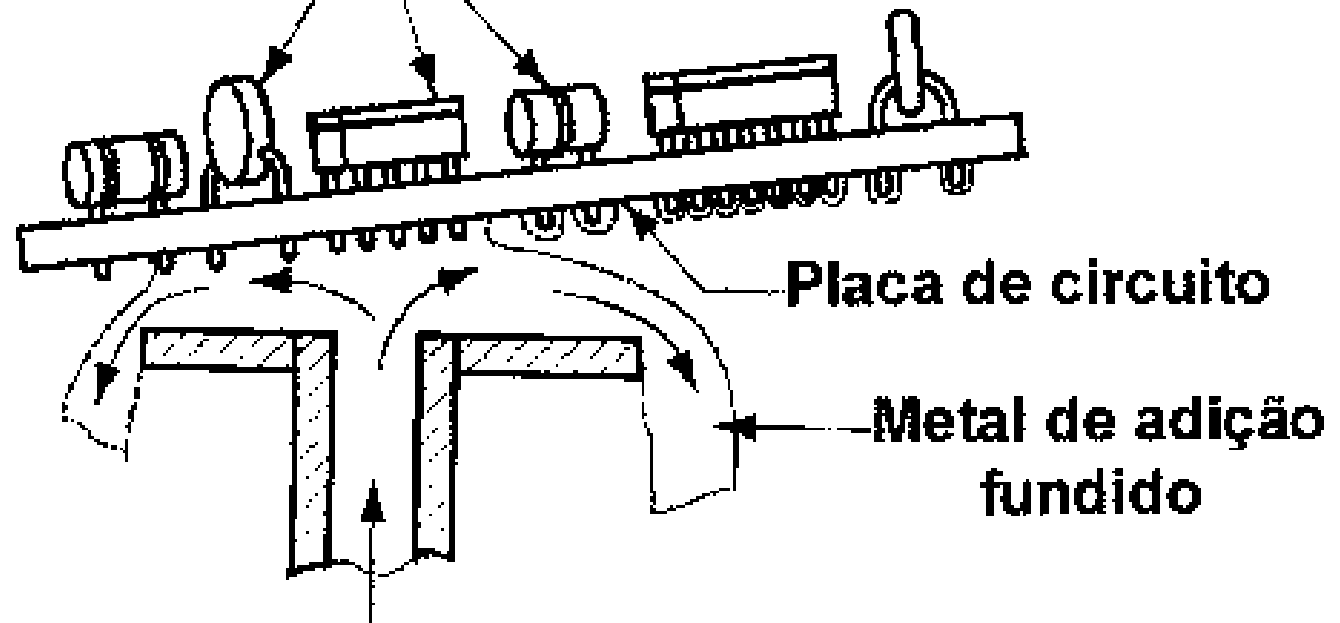
# Solda Branda ( $T < 450^{\circ}\text{C}$ )



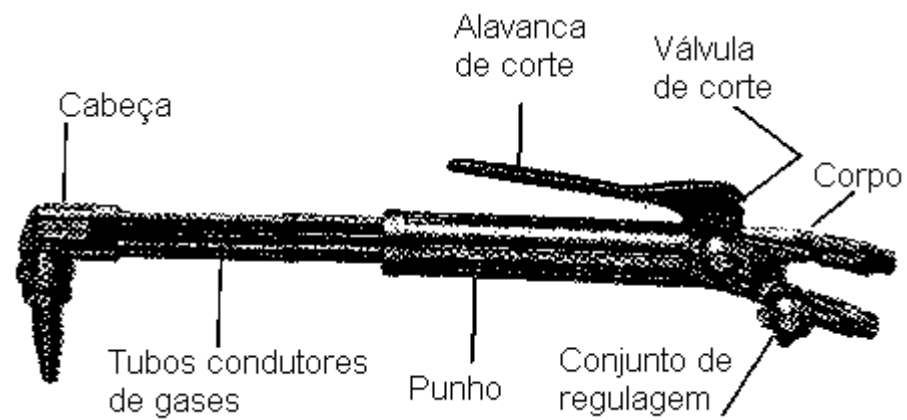
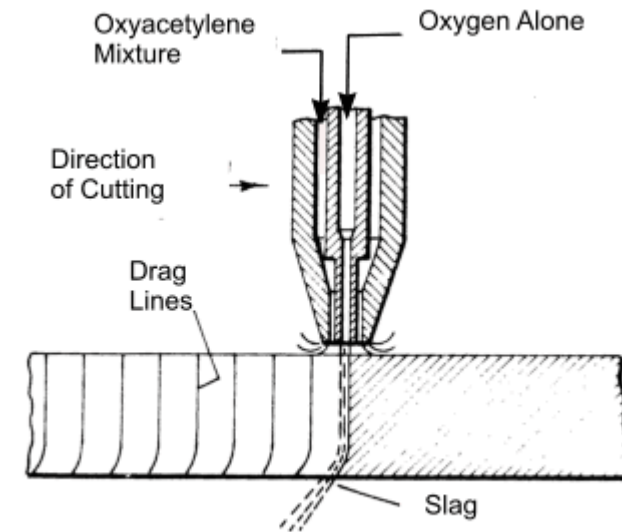


# Solda Branda

**Componentes**



# Oxicorte



Filme

# Oxicorte



correto



muito rápido

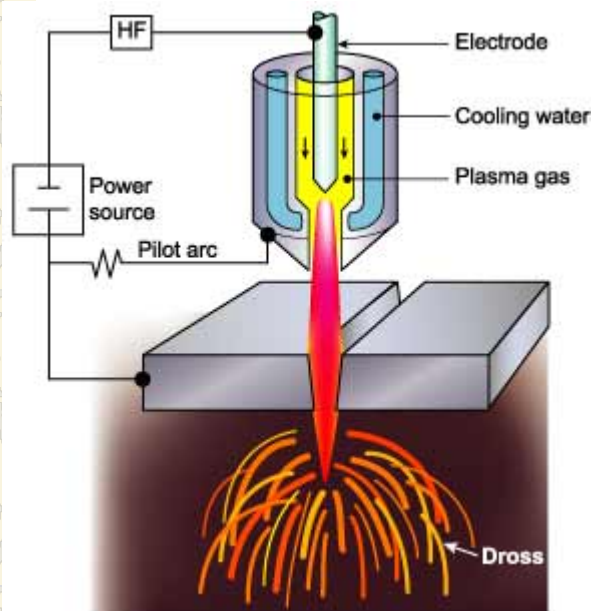


bico muito distante da chapa



fluxo de  $O_2$  muito alto

# Corte a plasma

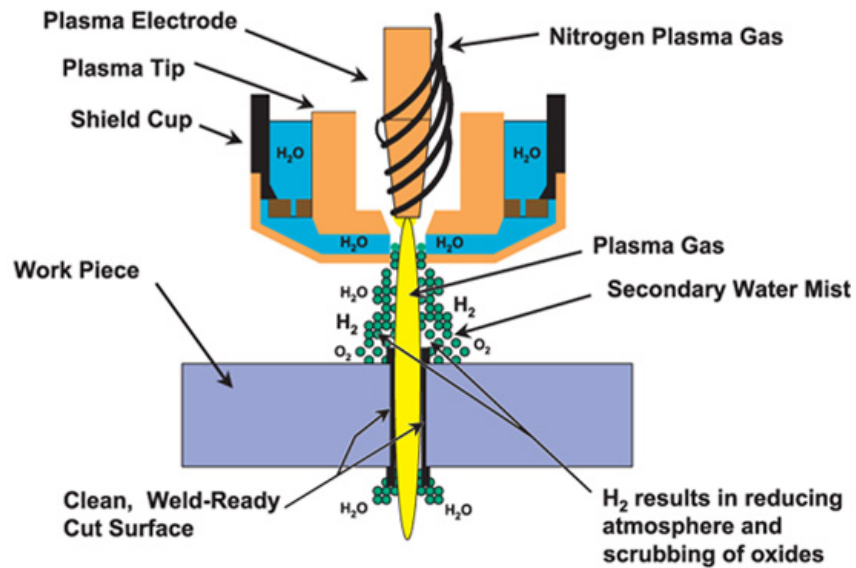


Filme



# Corte a plasma

## Effect of N<sub>2</sub>/H<sub>2</sub>O Plasma on Non-Ferrous



Não ferrosos

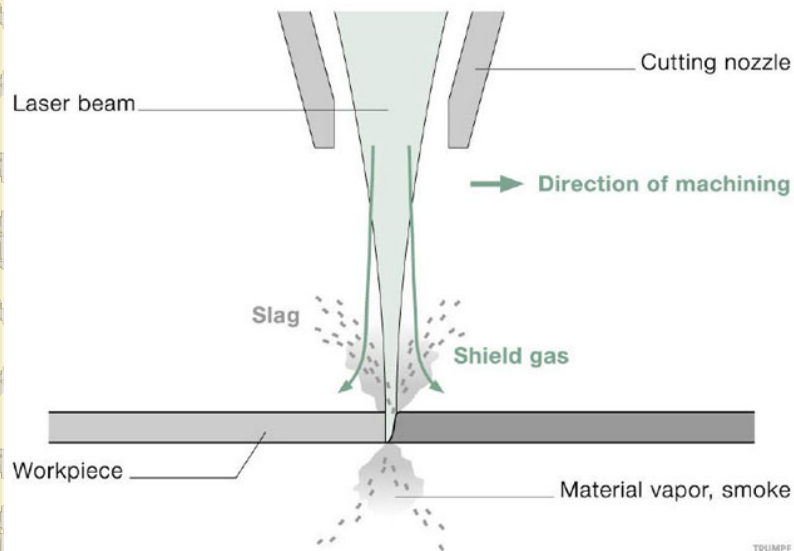


# Corte a LASER



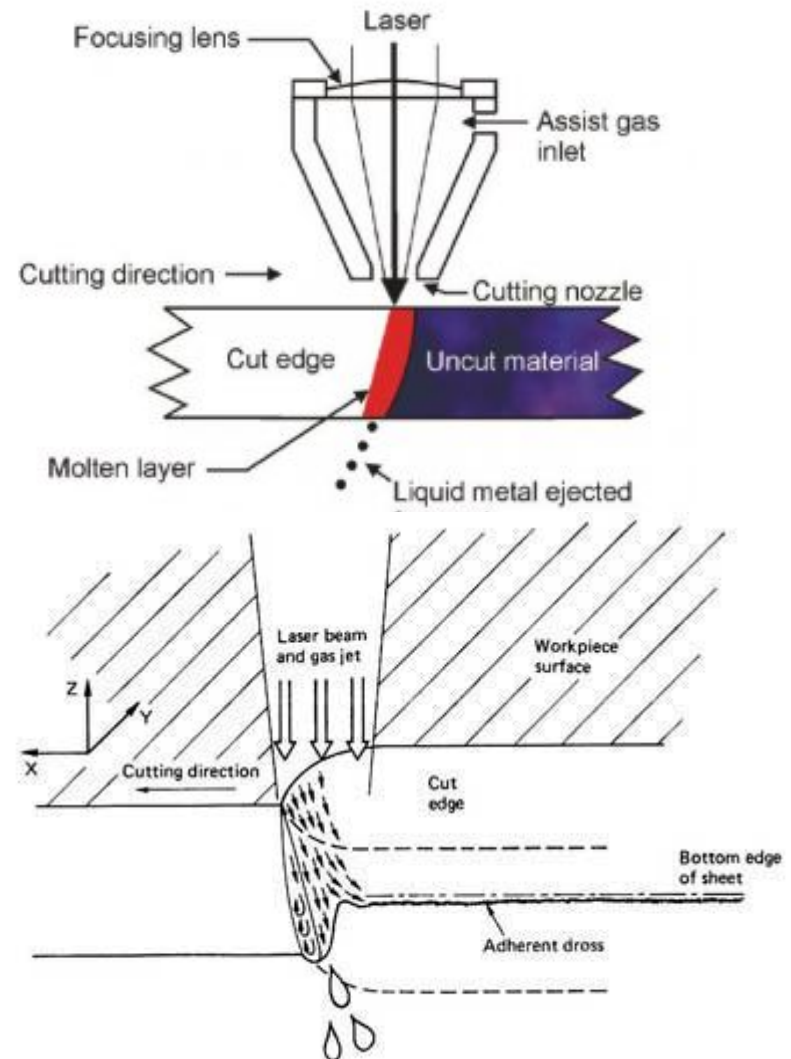
Filme

# Corte a LASER



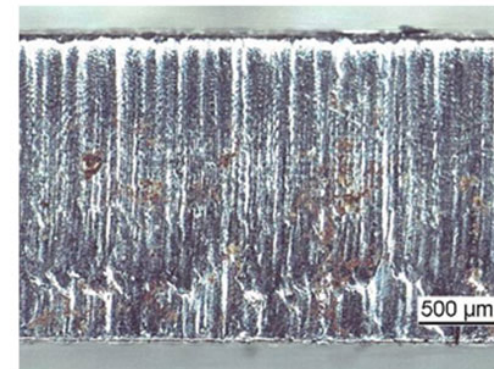
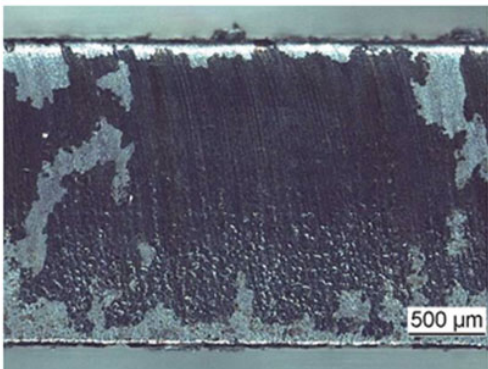
Sublimação  
(chapas muito finas)

Fusão + fluxo de gás

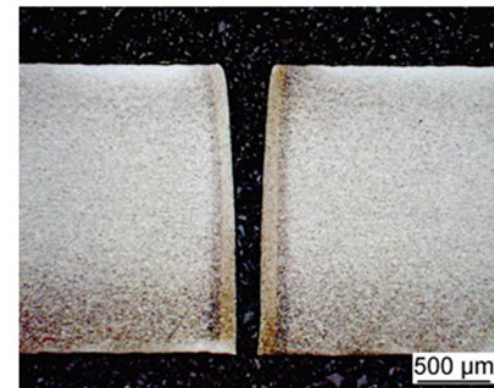
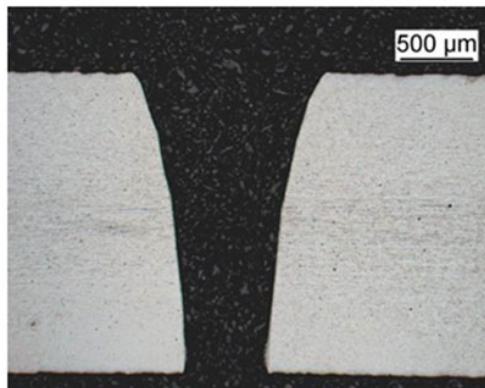
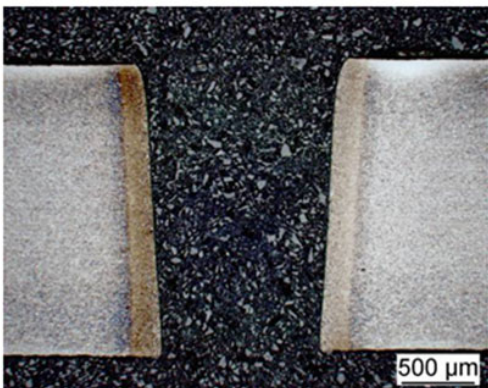


# Plasma x LASER

Cut surface



Cross-section



O<sub>2</sub>-Plasma cutting

N<sub>2</sub>-Plasma cutting

Laser cutting



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