GMAW

Gas **M**etal **A**rc **W**elding

FCAW

Flux **C**ore **A**rc **W**elding

Photo taken by William M. Plate Jr. Source: English Wikipedia

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Presented at the HOME METAL SHOP CLUB

July, 2013 General Meeting

Houston, TX

Brazing and Soldering

- A metal-joining processes using a dissimilar filler metal.
- Filler metal is melted while work pieces remain solid.
- Work pieces are close-fitting and may be different metals.

Welding

- Similar metals joined by fusion or coalescence.
- Similar filler metal and work pieces melted together in a common pool.
- Close fit-up of work pieces is not required.

Welding is a Manual Art

- Welding, like floating sheet rock and laying bricks, is a manual art.
- It requires practice, confidence and good hand–eye coordination.
- Some people pick it up quickly, some never do.

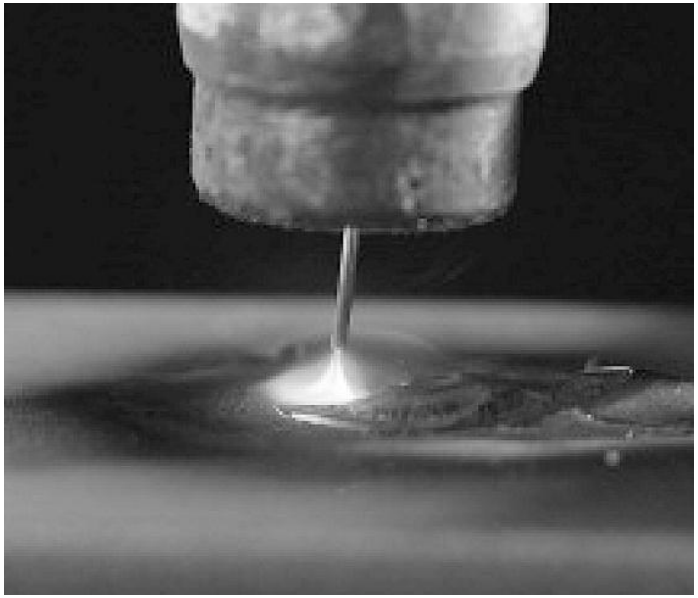
Welding in the Home Shop

- Oxyacetylene — Oxygen – Acetylene Welding (Gas)
- SMAW — Shielded Metal Arc Welding (Stick)
- GMAW / FCAW — Gas Metal – Flux Core Arc Welding (MIG - Wire Feed)
- GTAW — Gas Tungsten Arc Welding (TIG)

Various Types of GMAW / FCAW

- Short-Circuit Transfer
- Globular Transfer
- Axial Spray Transfer
- Pulsed Spray Transfer

Increasing Energy Input



Note: Short-Circuiting GMAW and gasless FCAW are the subject of this presentation

GMAW
Semi-Automated
Manual Welding

1. Continuous feed of wire filler electrode
2. Shielding gas covers arc and molten puddle
3. Gas contains and conveys heat to base metal
4. Electric Current melts wire into metal droplets

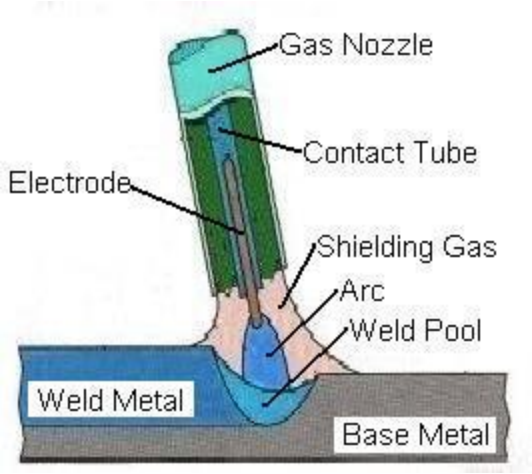
2-Lb Spool - 4” OD - 5/8” ID > $10

1. Continuous feed of wire filler electrode

10-Lb Spool - 8” OD - 2” ID > $40

Wire Diameter (carbon steel)	Welded Base Metal Thickness
0.024 inch – M0.6 ł	24 ga (0.024”) – 12 ga (0.105”)
0.030 inch – M0.8 ł *	22 ga (0.030”) – 10 ga (0.135”)
0.035 inch – M0.9 ł *	18 ga (0.048”) – 3/16”
0.045 inch – M1.2 *	16 ga (0.060”) – 5/16”

ł GMAW solid wire is copper coated to prevent rusting
•FCAW hollow metal tube contains flux and has no coating
Note: Wire speed feed is 50 - 400 inches/minute

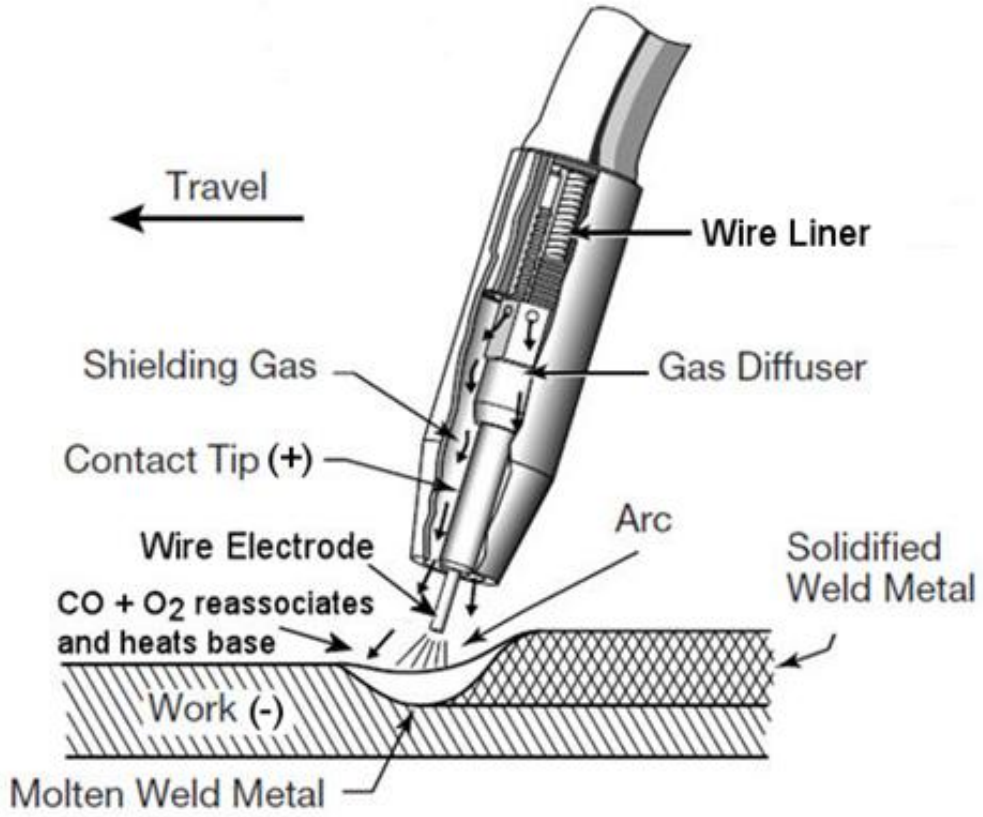


2. Shielding gas covers arc and molten puddle

Shielding Gas	Base Metal Composition
CO_2	Thick Carbon Steel
Argon + $C0_2$	Thin Carbon Steel
Argon + Helium	Aluminum
Helium + Argon + CO_2	Stainless Steel

Note: CO_2 is a reactive gas. Argon and Helium are chemically inert.

3. Gas contains and conveys heat to base metal



Note: Upward cathode jet forces create instability, hence, splatter

Argon + CO_2 floods molten pool and arc.

CO_2 disassociates at positive electrode into $CO + O_2$ and adsorbs energy from arc.

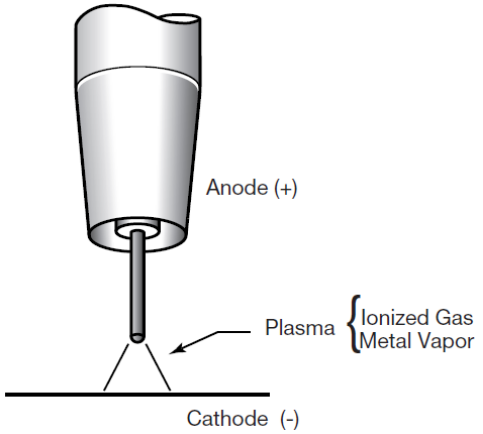
Free oxygen combines with wire's silicon and floats on pool surface as isolated glass beads.

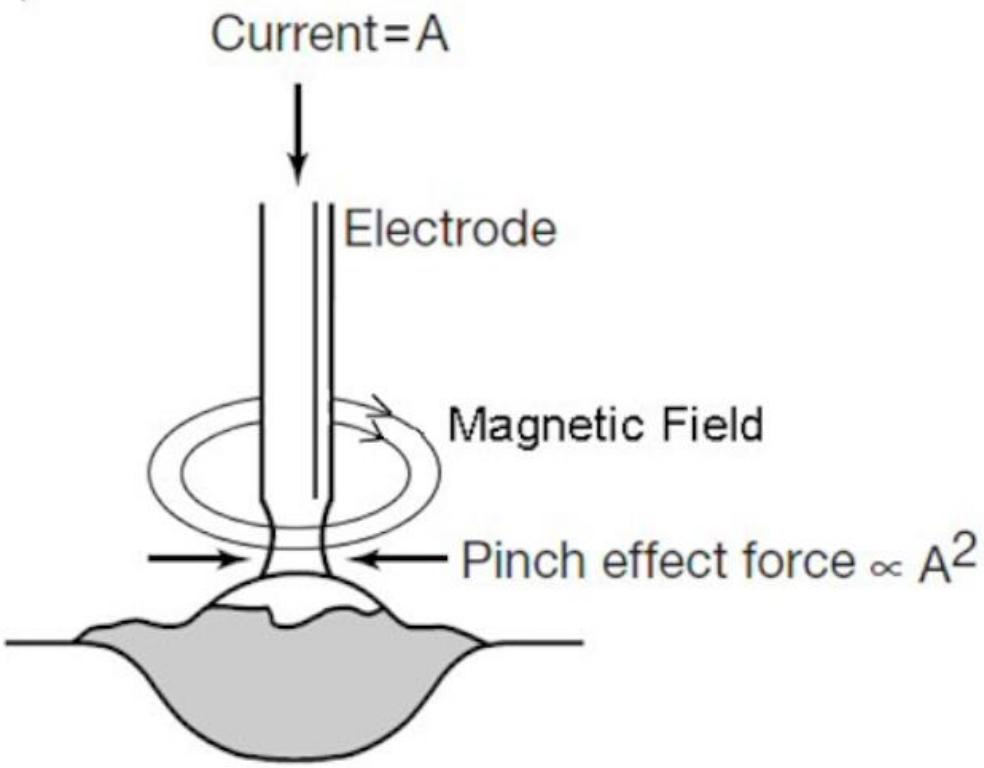
$CO + O_2$ recombines to CO_2 at negative work and releases heat.

Argon has low ionization potential (14.7 eV) for ease of arc start and stabilization (compare to helium 24.5 eV.

Argon has low thermal conductivity (10% of helium)

4a. Electric Current melts wire into metal droplets

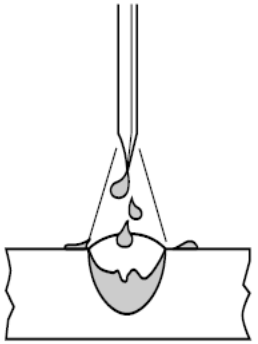


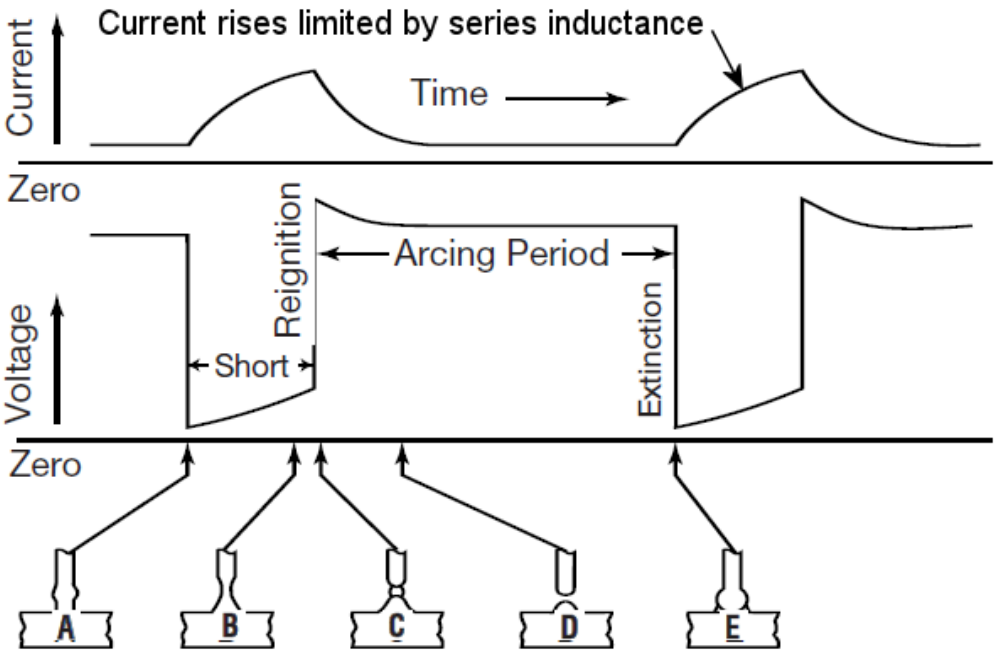


Short Circuit Metal Transfer

- Wire dips into molten pool
- Current heats and melts wire
- Magnetic force pinches drop
- Surface tension contains drop
- Arc produces jet force on drop
- Globular drop hits molten pool
- Electrode (+) is hottest part of arc

4b. Electric Current melts wire into metal droplets





Short-Circuit Transfer

A. Wire contacts molten puddle

B. Magnetic force pinches off drop

C. Arc develops and current drops

D. Surface tension contains drop

E. Wire dips into puddle again

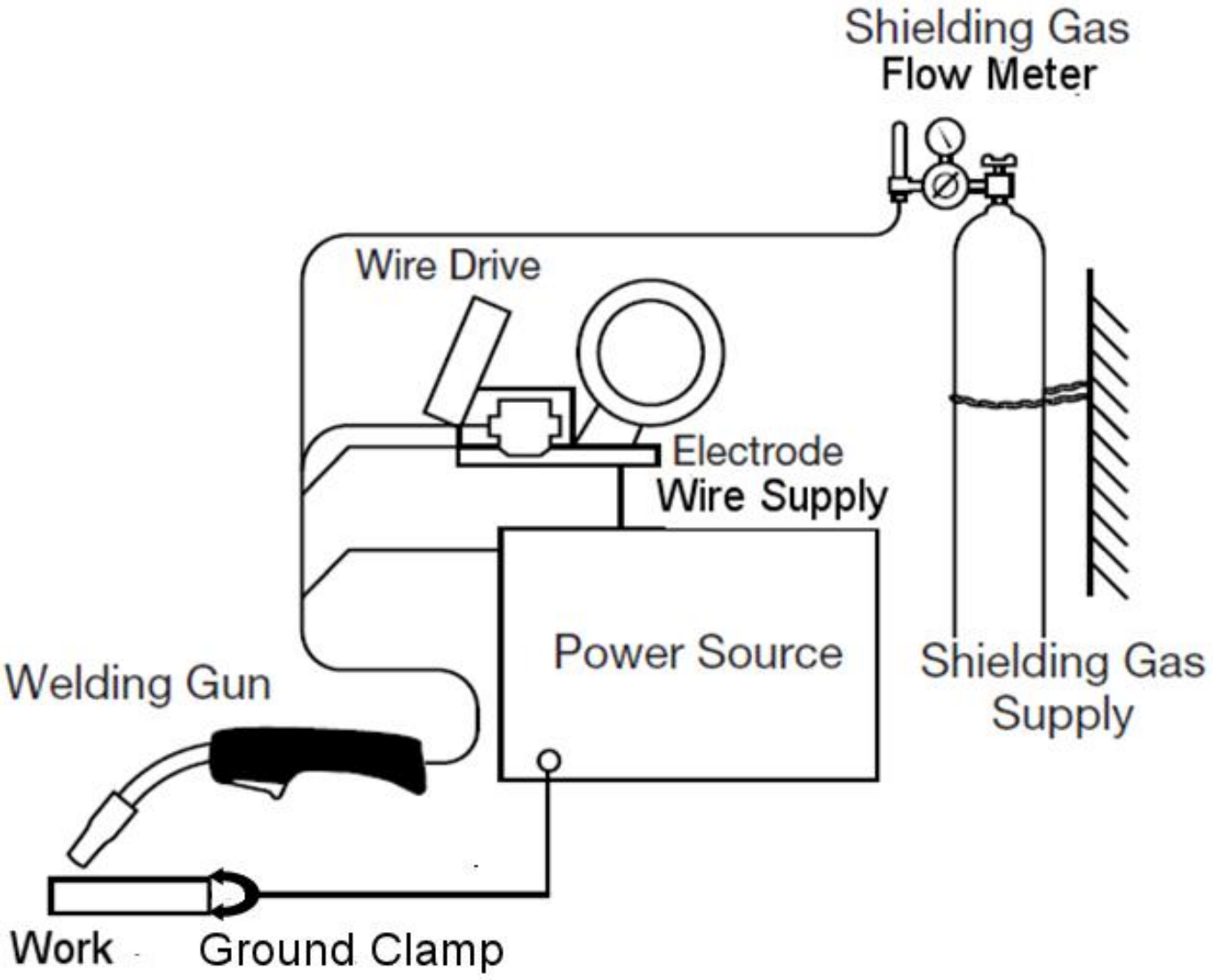
Note: Process repeats 100 – 200 times per second and produces the “Frying Bacon” sound.

Portable Wire Feed Welding Machine Properties

- Constant Voltage - inductor current limit control
- Low heat input
- Employ shot circuit transfer of filler metal wire
- Small diameter wires (0.022 – 0.045 inch, M0.6 – M1.2)
- 93% electrode efficiency due to low splatter
- 120 – 240 Volt 20 amp electrical supply
- Weld thin sheet metal 0.024 – 0.200 inches
- All position welding
- Two knob control
- 20 – 40% weld time duty cycle
- $400 - $900 price range

Note: If it has a handle on its top, it's a portable welding machine.

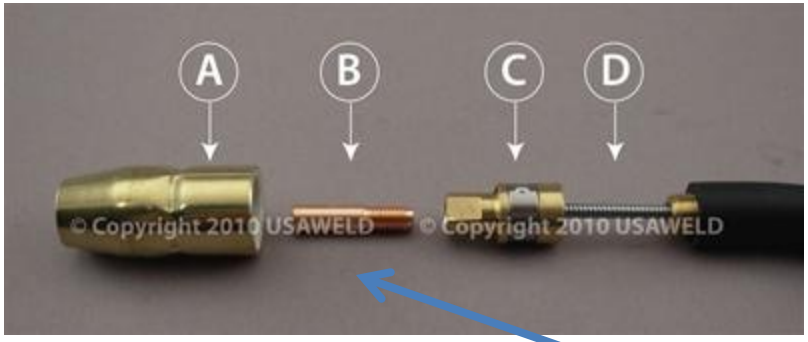
Basic GMAW - Wire Feed System



Drive Rollers

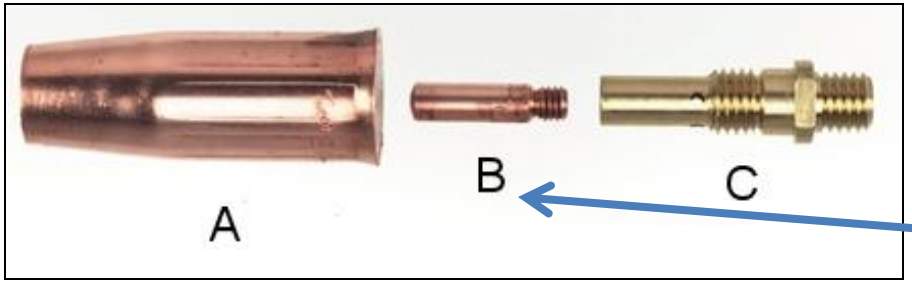
Wire Type	Steel	Aluminum	Flux Core
Idler Roller			
Drive Roller	V-Groove	U-Groove	Knurled

Welding Gun Consumables



A. Gas Nozzle
B. Contact Tip
C. Gas Diffuser
D. Wire Liner

Hobart, Miller, Chicago Electric ¼”-28

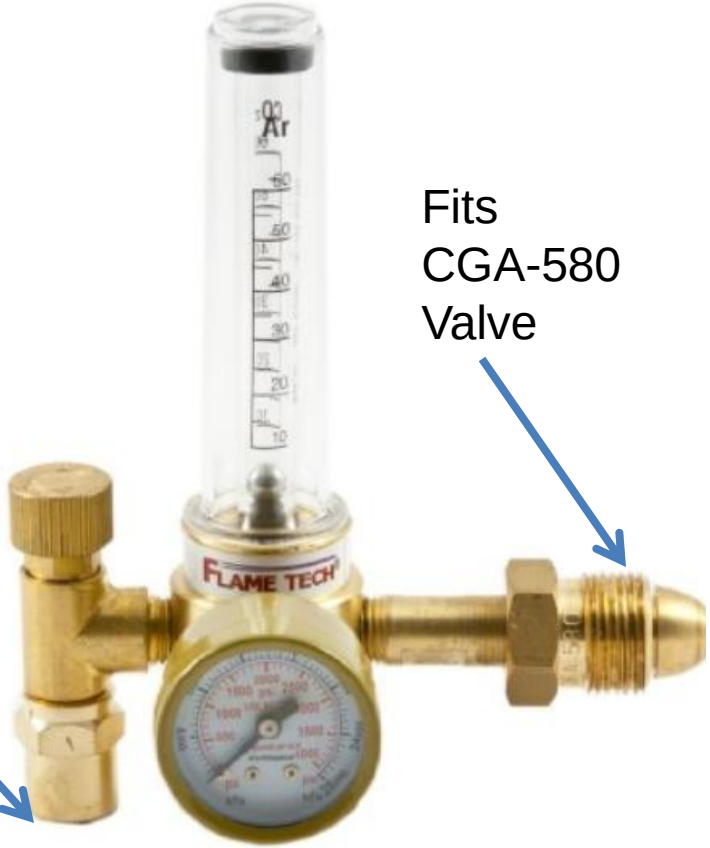


Lincoln, Tweco M6x1

Wire Liner

- Liners guide the electrode wire from the welder to the welding gun.
- They accommodate 2 wire diameters; e.g. 0.023 and 0.030 inch.
- Liners can be plain spiral metal, teflon coated spiral, or non-metal tubular.

Gas Flow Meters



Fits
CGA-580
Valve

5/8-18

Variable Area Flow Meter
Rotameter

Right
Hand
Thread

Orifice Flow Gauge Regulator

Typical Gas Flow = 25 Cubic Feet per Hour ~ 12 Liters per Minute

Ground Clamps

Best

Better

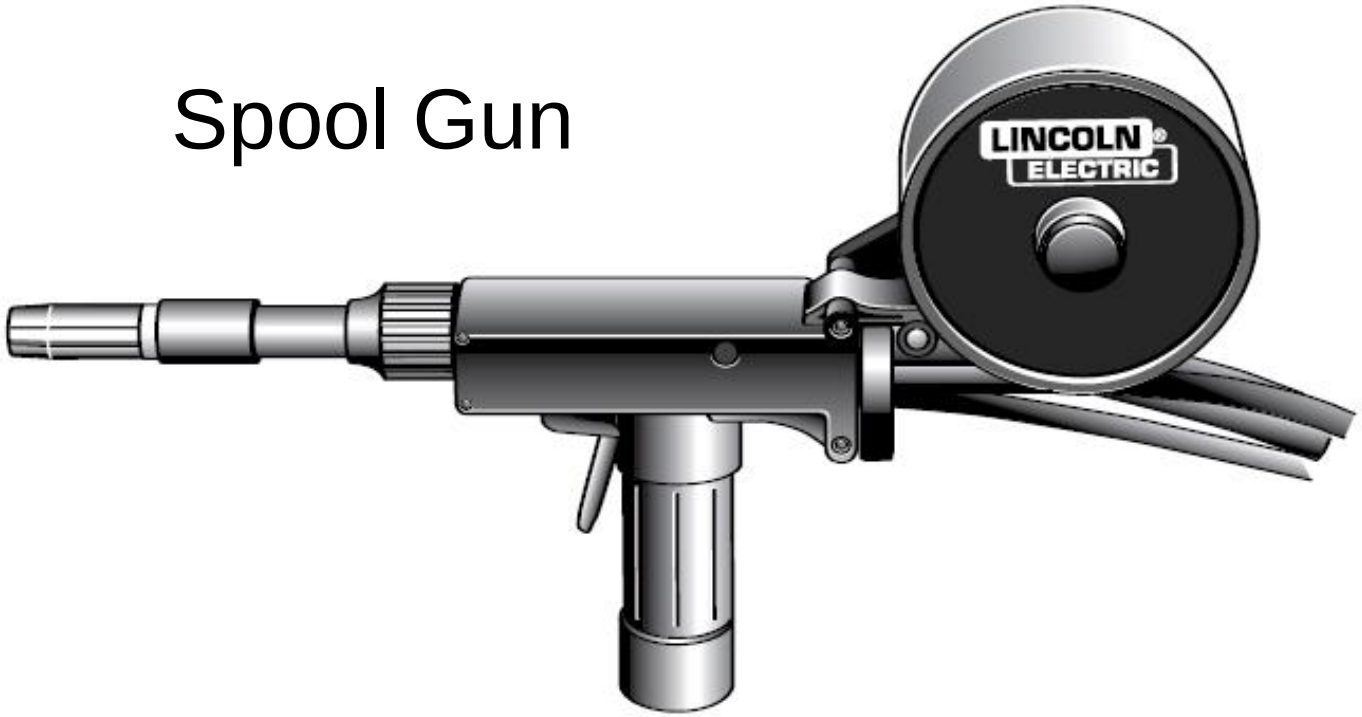
Good

Poor

$$ Portable Wire Feed Welder $$ Enhancements

- Solid state continuously variable heat setting
- Panel meters to monitor / set heat and wire speed
- Timer for arc spot welding
- Pause timer for interrupted or stitch welding
- Pre- and post-flow of shielding gas
- Shielding gas purge switch
- Both top and bottom wire rolls are gear driven
- Variable inductance control
- Burn-back control prevents wire sticking and end of weld
- Cast removal or wire straighten device
- Flexible Swan Neck welding gun

Spool Gun

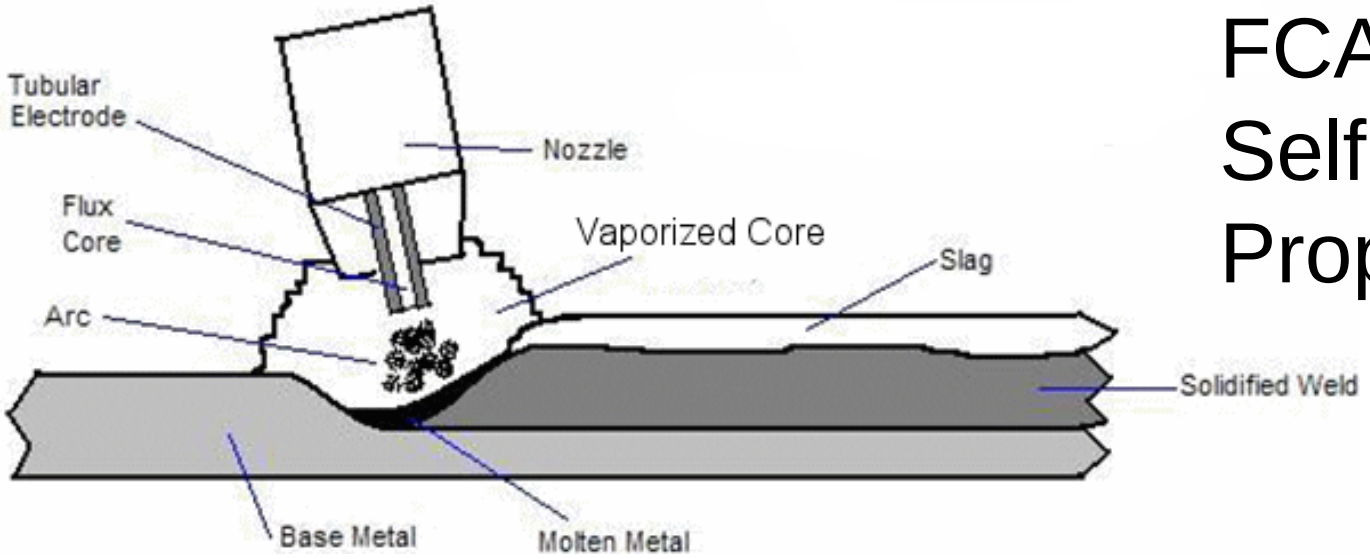


- Short liner delivers aluminum wire having low column strength
- Has own wire feed motor and speed control
- Use U–groove drive roll on aluminum to prevent crushing wire
- Special contact tip accommodates diametrical heat expansion
- Use 100% argon shielding gas

GMAW Video

[GMAW Welding Tips]

FCAW s Self-shielding Properties



- No shielding gas required
- Weld outdoors in windy environment
- Fast-freezing slag cover allows all-position operation
- Tolerant to surface contamination and poor preparation
- Flux contains scavengers and deoxidizers
- Requires cleanup of slag and spatter
- Use electrode negative (-) hottest part of arc at work
- Observe operator fume protection especially indoors

FCAW Video

FCAW Welding Tips

Welding Safety

- Secure, close valve, and cap gas cylinders not in use.
- Be aware of CO, Ozone, NO_2, and phosgene resulting from heated chlorinated solvents.
- Ventilate room of fumes especially with FCAW.
- Avoid confined spaces, tanks, and air displacement by shielding gas.
- Gloves, helmet, and jacket for spark, ultra violet, and heat protection.
- Ear Plugs and cap for vertical and overhead welding.
- Magnetic field from high current may affect wrist watch or pacemaker.
- Stand in a dry area with high-top insulating foot ware.
- Wear clothing with covered pockets and no pants cuffs.
- Synthetic fiber clothing can melt onto your skin.
- Welding sparks can start dust or steel wool fire.

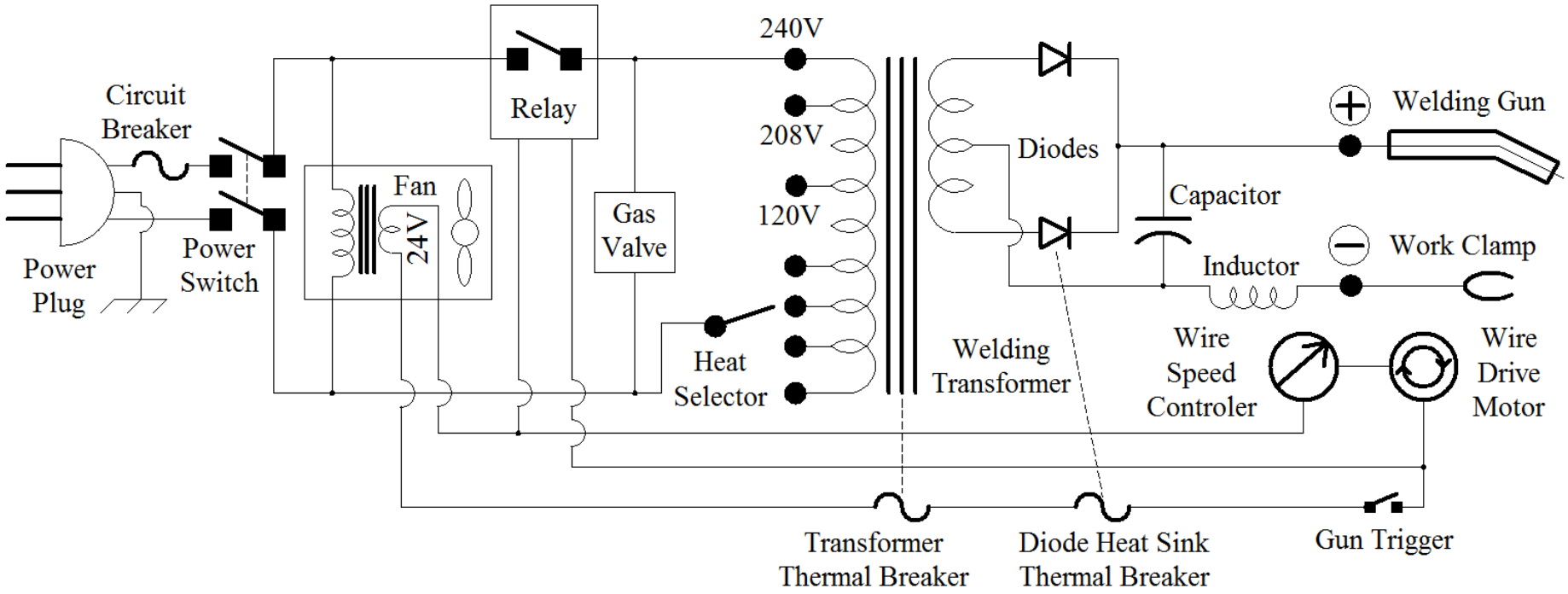
Century 125GL - 120V Welder

64000 mfd capacitor added – 0.024 (M0.6) wire – C25 Gas 20 CFM

Heat Setting	Open Circuit Voltage (DC Volts)	Welding Voltage (DC Volts)	Welding Current (DC Amps)	Welding Power (Watts)	Line Current (AC Amps)	Power Factor (%)
1	30	20	82	1640	15	91
2	34	19	108	2052	20	86
3	38	18	112	2016	25	67
4	40	16	125	2000	30	56

Note: Welding power decreases at high welding current due to resistance of aluminum transformer secondary winding and fixed aluminum wire inductor. Aluminum has 60% conductivity of copper.

Typical Electrical Diagram for a Portable Wire Feed Welder



By Dick Kostelnicek 06/2013

GMAW – FCAW

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Dick Kostelnicek ~ 07-13-2013