Welding Techniques & Concerns

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Welding Suggestions

- CLEAN!!!!
  - You can only weld bare metal
  - Remove oxides, paints, oils, rust, etc
- Prepare joints/interfaces
  - Make every part fit the best you can BEFORE welds
  - For wheelchair tubing, may need to assemble jigs
  - Clamp carefully
- Be patient and calm

Welding Geometries

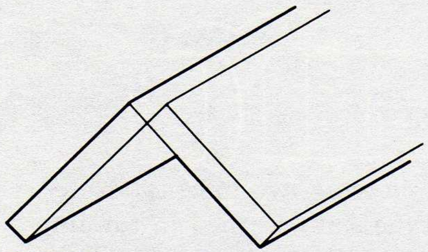


FIGURE 5-16 Open corner joint. Most frequently used. Excellent penetration producing a full-strength weld.

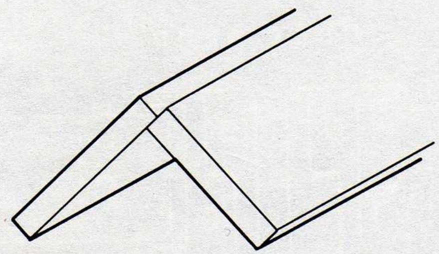


FIGURE 5-17 Half open corner joint. Penetration quite difficult. May require welding in the inside for full strength.

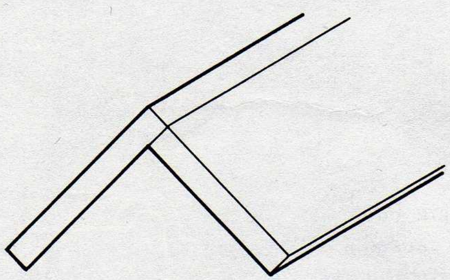


FIGURE 5-18 Closed corner joint. Penetration impossible. Will require weld in the inside for full strength.

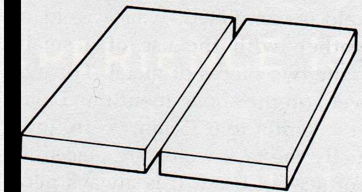


FIGURE 6-1A The butt joint is a joint between members lying in the same plane.

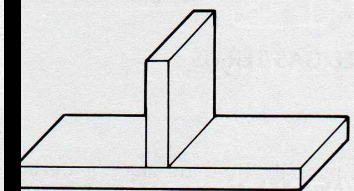


FIGURE 6-1B The tee joint is a joint between members located at right angles to each other.

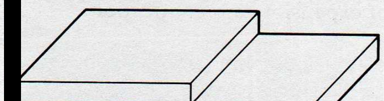
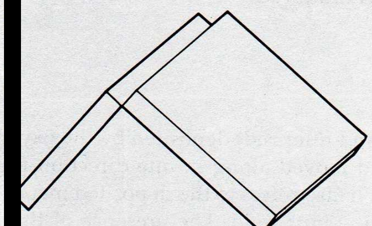
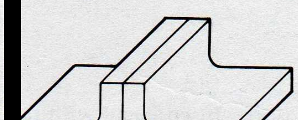


FIGURE 6-1C The lap joint is a joint between overlapping members.



IGURE 6-1D The corner joint is a joint between members located at right angles to each other.



IGURE 6-1E The edge joint is a joint between the edges of parallel members.

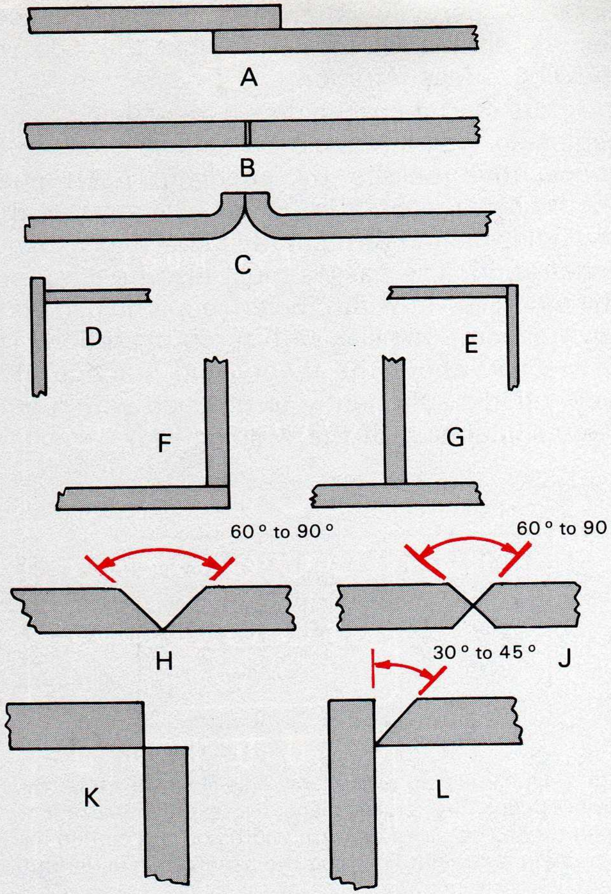


Fig. 4-17. Some typical welding joint designs: A—Sheet steel lap joint in the flat position. B—Sheet steel butt joint in the flat position. C—Flange joint in the flat position. D and E—Outside corner joints. F and G—Inside corner joints (G is sometimes called a T-joint.) H, J, K, and L—Joint designs for metal plate. Note that when welding joints A, B, and E through L, welding rod is used as the filler metal. When welding the joints at C and D on sheet metal, no welding rod is required as a filler metal because the metal pieces themselves are melted to form the bead and to join the pieces together.

Oxygen-Acetylene Welding

- Set gas pressures according to tip being used
  - Never exceed 15 psi in acetylene

TABLE 5-1 Welding Tip Size and Application Data

Tip Size	Drill Size	Length of Average Inner Flame Cone (in.)	Oxygen Pressure psi		Acetylene Pressure psi		Acetylene Consumption C.F.H.[a]		Metal Thickness (in.)	Metal Thickness (mm)
			Min.	Max.	Min.	Max.	Min.	Max.		
000	75	7/32	1/2	2	1/2	2	1/2	3	(Up to 1/32)	0.794
00	70	7/32	1	2	1	2	1	4	(1/64–3/64)	0.397–1.19
0	65	3/8	1	3	1	3	2	6	(1/32–5/64)	0.794–1.98
1	60	3/8	1	4	1	4	4	8	(3/64–3/32)	1.19–2.38
2	56	3/8	2	5	2	5	7	13	(1/16–1/8)	1.58–3.175
3	53	3/8	3	7	3	7	8	36	(1/8–3/16)	3.175–4.76
4	49	5/8	4	10	4	10	10	41	(3/16–1/4)	4.76–6.35
5	43	1	5	12	5	15	15	59	(1/4–1/2)	6.35–12.7
6	36	1 1/16	6	14	6	15	55	127	(1/2–3/4)	12.7–19.05
7	30	1 1/4	7	16	7	15	78	152	(3/4–1 1/4)	19.05–31.75
8	29	1 1/4	9	19	8	15	81	160	(1 1/4–2)	31.75–50.8
9	28	1 7/16	10	20	9	15	90	166	(2–2 1/2)	50.8–63.5
10	27	1 7/16	11	22	10	15	100	169	(2 1/2–3)	63.5–76.2
11	26	1 7/16	13	24	11	15	106	175	(3–3 1/2)	76.2–88.9
12	25	1 1/2	14	28	12	15	111	211	(3 1/2–4)	88.9–101.6

[a] *Oxygen consumption is 1.1 times the acetylene under neutral flame conditions.*

Oxygen-Acetylene Welding

- Adjusting Flame
  - Almost all operations will use a neutral flame

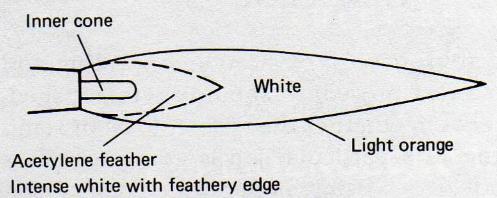


FIGURE 5-7 **Carburizing flame.**

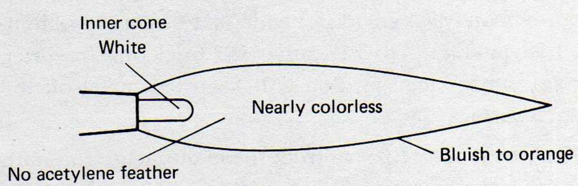


FIGURE 5-9 **Neutral flame.**

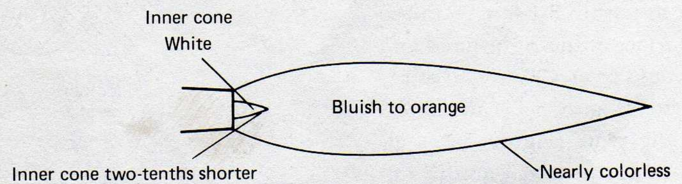


FIGURE 5-10 **Oxidizing flame.**

Oxygen-Acetylene Welding

- Forehand welding
  - Leave weld behind you, right to left (for right handed)

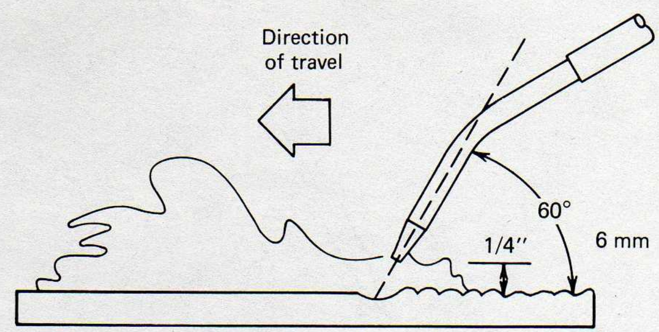


FIGURE 5-11 Side view of torch position.

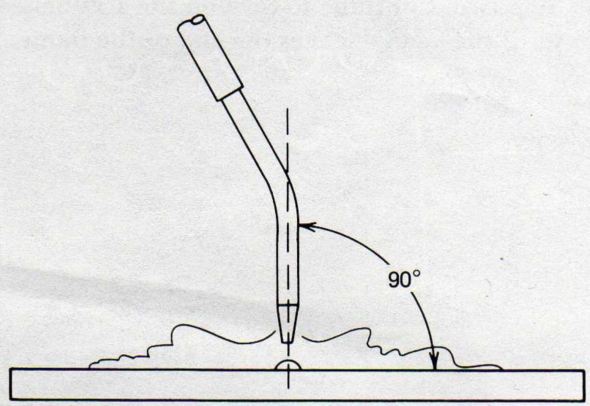


FIGURE 5-12 End view of torch position.

Oxygen-Acetylene Welding

- Troubleshooting

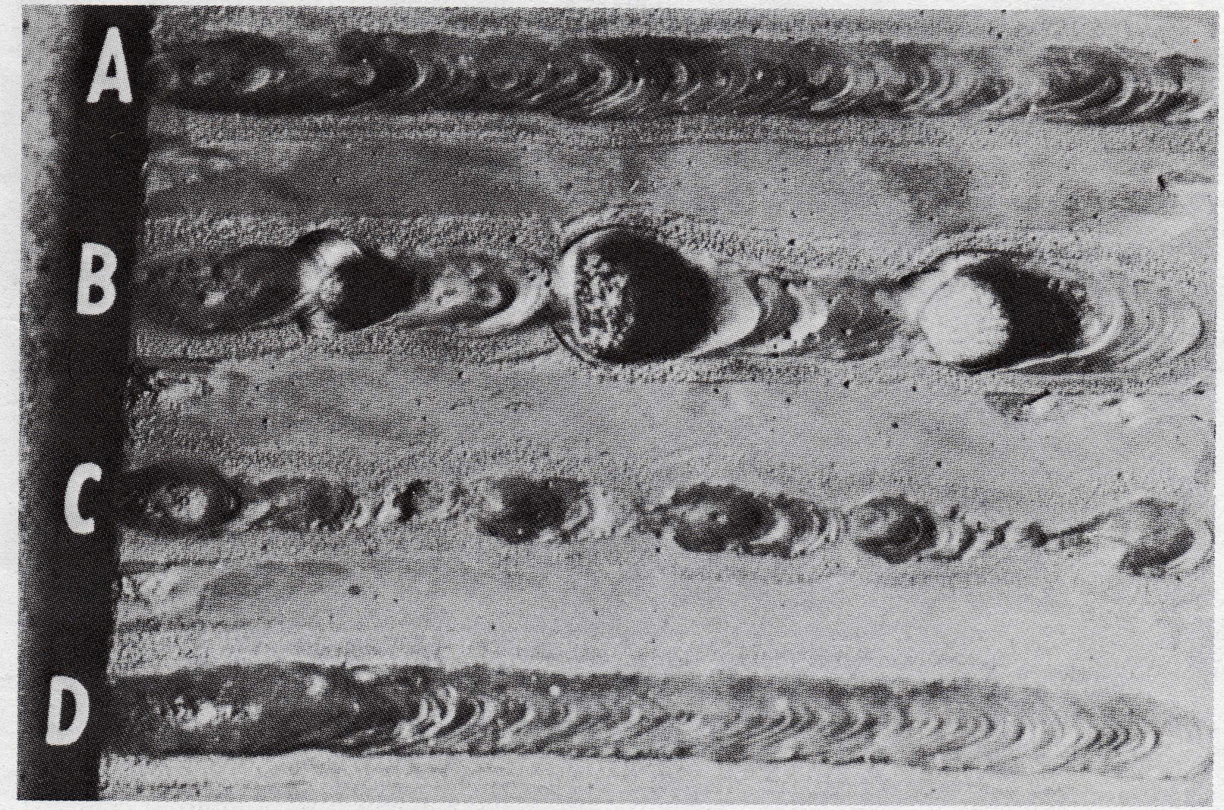


FIGURE 5-15 Samples of weld bead defects. (A) This is a fairly satisfactory weld bead. The ripple of the bead could be more uniform. (B) This poor bead may be caused by too slow a speed of travel or by a torch tip too large for the particular thickness of material being used. (C) This defect is generally caused by moving too rapidly and not allowing a proper weld bead to form. (D) This is a satisfactory weld except for the burned section at the end. This defect is caused by not moving the weld bead fast enough as the weld is being completed.

Arc Welding

- "Stick" or Shielded Metal Arc Welding (SMAW)
  - Electrode coated with protective flux
  - Constant voltage, varied flux

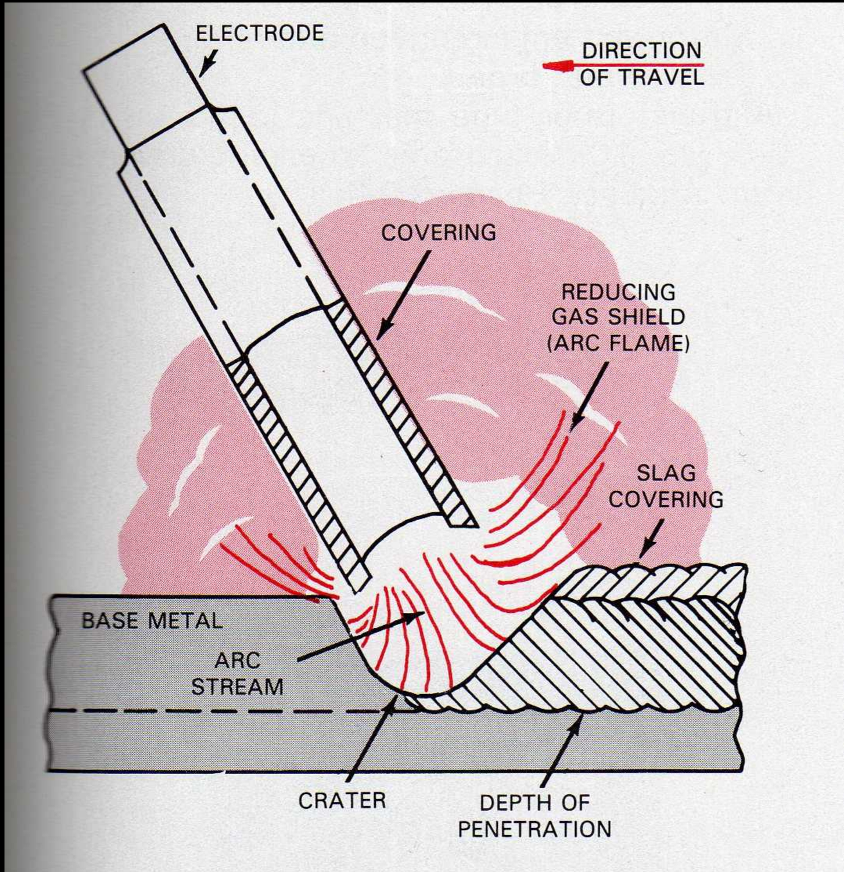


Fig. 10-3. A covered electrode arc weld in progress.

Arc Welding

TABLE 14-4 AWS Electrode Classification

Number	Significance	Example
First two or three numbers	Minimum tensile strength in psi and kPa	E60XX = 413,685 kPa (60,000 psi) E70XX = 482,633 kPa (70,000 psi) E100XX = 689,475 kPa (100,000 psi)
Second last	Welding position (or position electrode must be used in)	EXX1X = all positions except vertical down EXX2X = flat, horizontal fillet, and flat butt EXX3X = flat EXX4X = vertical down
Last	Usability Type of current Type of arc Type of penetration Presence of iron powder	EXXX0 = deep penetration, DCRP EXXX1 = deep penetration AC, DCRP EXXX2 = medium penetration AC-DCSP EXXX3 = medium to shallow penetration AC/DCRP

Arc Welding

Suggested Metal Thickness		Electrode size		E6010 and E6011	E6012	E6013	E6020	E6022	E6027
in.	mm	in.	mm						
1/16 & less	1.6 & less	1/16	1.6		20-40	20-40			
1/16-5/64	1.6-2.0	5/64	2.0		25-60	25-60			
5/64-1/8	2.0-3.2	3/32	2.4	40-80	35-85	45-90			
1/8-1/4	3.2-6.4	1/8	3.2	75-125	80-140	80-130	100-150	110-160	125-185
1/4-3/8	6.4-9.5	5/32	4.0	110-170	110-190	105-180	130-190	140-190	169-240
3/8-1/2	9.5-12.7	3/16	4.8	140-215	140-240	150-230	175-250	170-400	210-300
1/2-3/4	12.7-19.1	7/32	5.6	170-250	200-320	210-300	225-310	370-520	250-350
3/4-1	19.1-25.4	1/4	6.4	210-320	250-400	250-350	275-375		300-420
1 - up	25.4 - up	5/16	8.0	275-425	300-500	320-430	340-450		375-475

Fig. 10-19. A table of E60XX series electrodes with suggested metal thickness applications, and amperage ranges. These values are suggested and may be varied as required.

Suggested Metal Thickness		Electrode size		E7014	E7015 and E7016	E7018	E7024 and E7028	E7027	E7048
in.	mm	in.	mm						
5/64-1/8	2.0-3.2	3/32*	2.4*	80-125	65-110	70-100	100-145		
1/8-1/4	3.2-6.4	1/8	3.2	110-160	100-150	115-165	140-190	125-185	80-140
1/4-3/8	6.4-9.5	5/32	4.0	150-210	140-200	150-220	180-250	160-240	150-220
3/8-1/2	9.5-12.7	3/16	4.8	200-275	180-255	200-275	230-305	210-300	210-270
1/2-3/4	12.7-19.1	7/32	5.6	260-340	240-320	260-340	275-365	250-350	
3/4-1	19.1-25.4	1/4	6.4	330-415	300-390	315-400	335-430	300-420	
1 - up	25.4 - up	5/16*	8.0*	390-500	375-475	375-470	400-525	375-475	

Note: When welding vertically up, currents near the lower limit of the range are generally used.
*: These diameters are not manufactured in the E7028 classification.

Fig. 10-20. A table of E70XX series electrodes with suggested metal thickness applications, and amperage ranges. These values are suggested and may be varied as required.

Arc Welding

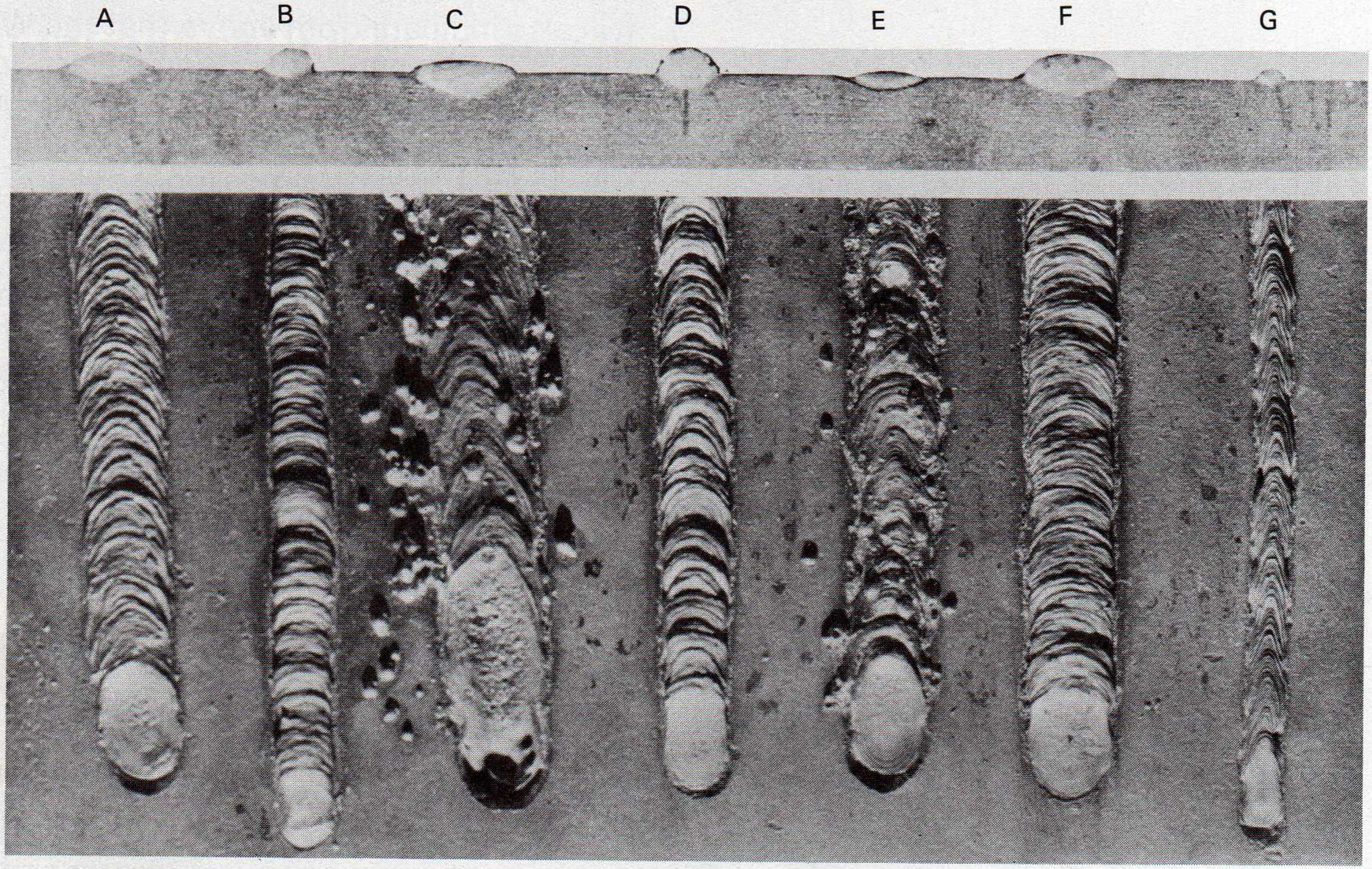


Fig. 10-24. The effects of current, arc length, and travel speed on covered electrode beads. A—Correct current, arc length, and travel speed; B—Amperage too low; C—Amperage too high; D—Too short an arc length; E—Arc length too long; F—Travel speed too slow; G—Travel speed too fast. (American Welding Society)

MIG Welding

- Metal Inert Gas or Gas Metal Arc Welding (GMAW)
  - Variable voltage
  - Gas shielding (typically Argon)
  - Automatic Wire Feed
    - Electrode and filler the same

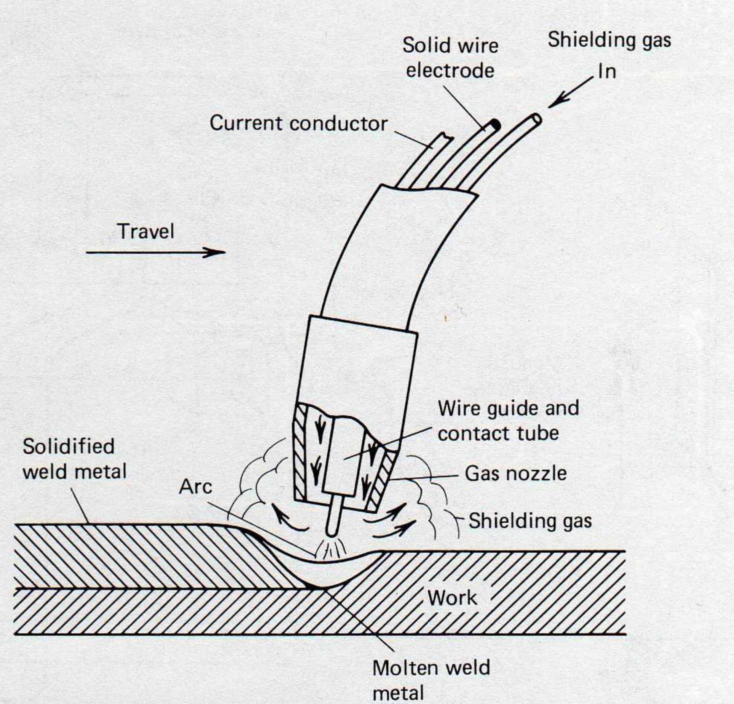


FIGURE 19-1 Gas metal arc welding. (Courtesy of Lincoln.)

MIG Welding

- Short Circuit GMAW – low voltage machines

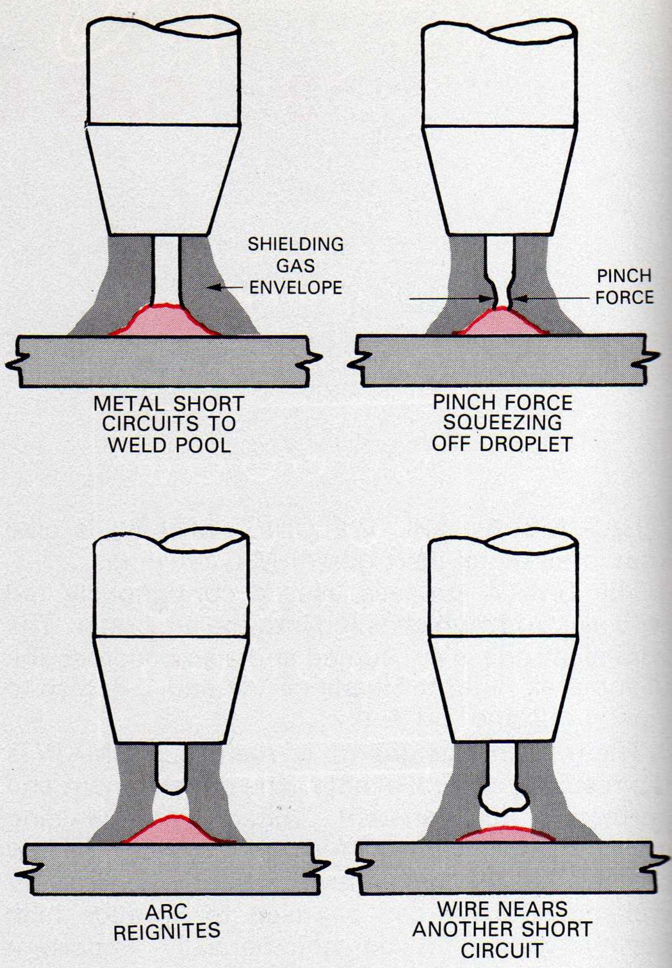


Fig. 13-2. The sequence of metal transfer during the short circuiting, GMAW method.

MIG Welding

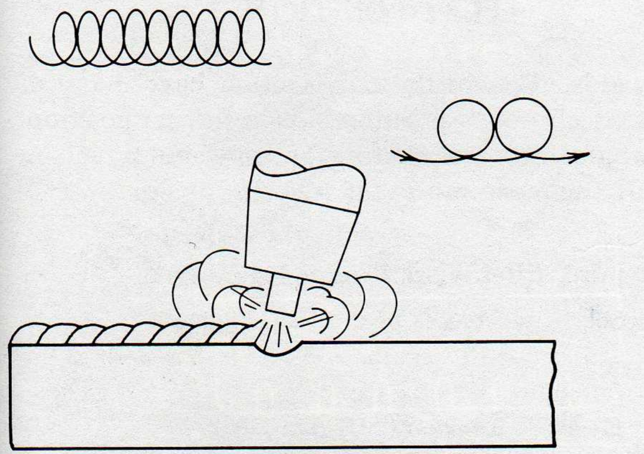


FIGURE 19-17 Using a clockwise circular motion.

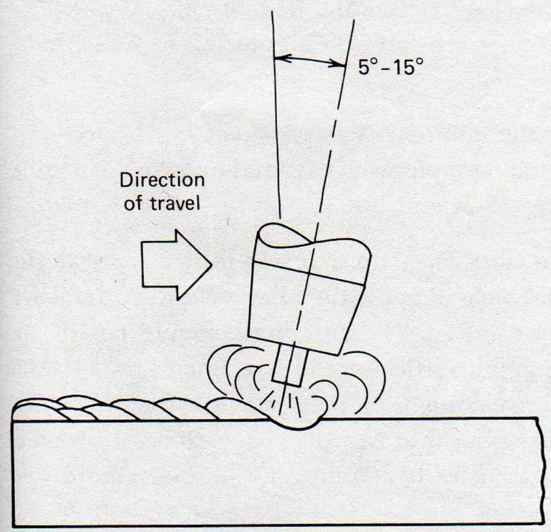


FIGURE 19-18 Side view.

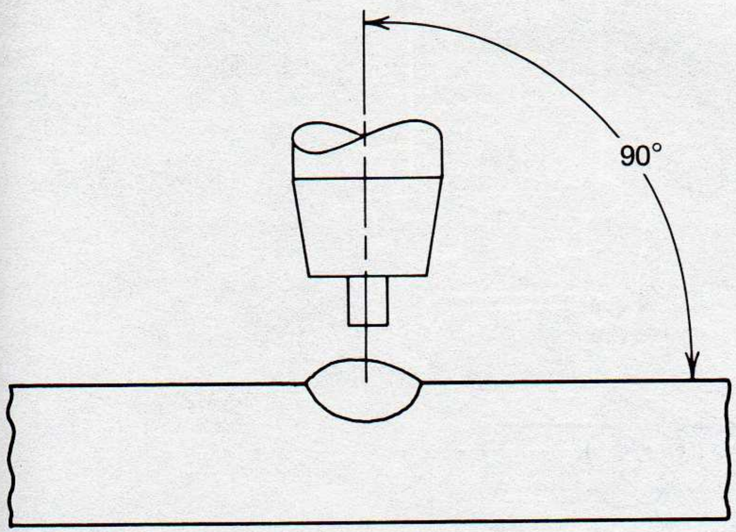


FIGURE 19-16 End view.

Welding Problems

Heat Affected Zone (HAZ)

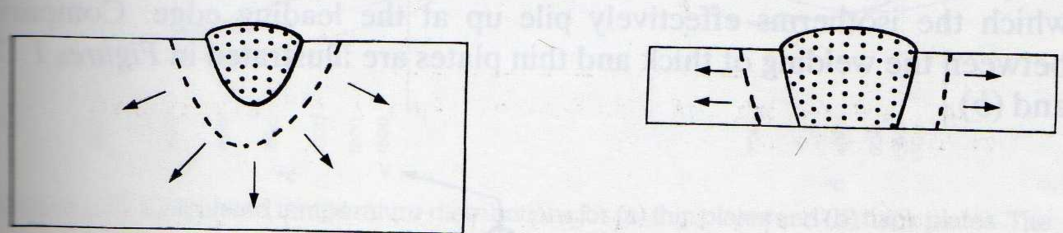


Figure 1.15 Three- and two-dimensional heat flow in welding

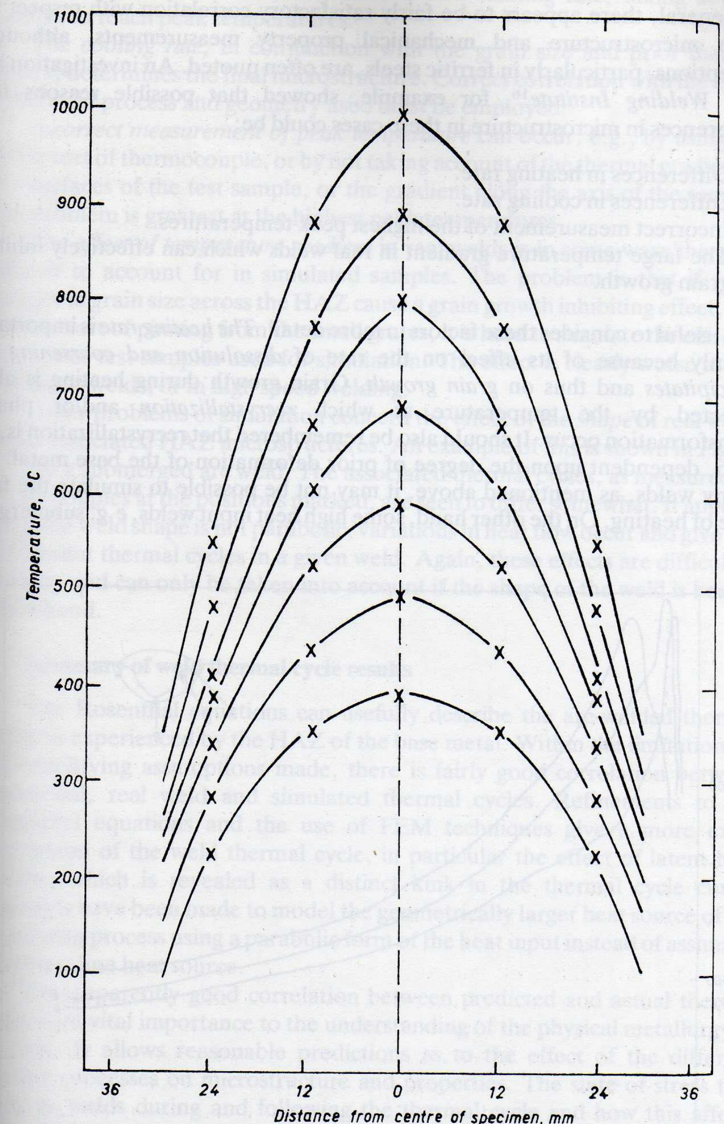


Figure 1.26 Measured longitudinal temperature distribution in 6.37 mm diameter specimens in a weld simulator for temperatures in the range 400–1000 °C. The heated span is 76.2 mm. After Keane, D.M., Bower, E.N. and Hammond, J., Tests during simulation, *Weld Thermal Simulators for Research and Problem Solving*, ed. Dolby, R.E., The Welding Institute, Cambridge, 1972

Heat Affected Zone (HAZ)

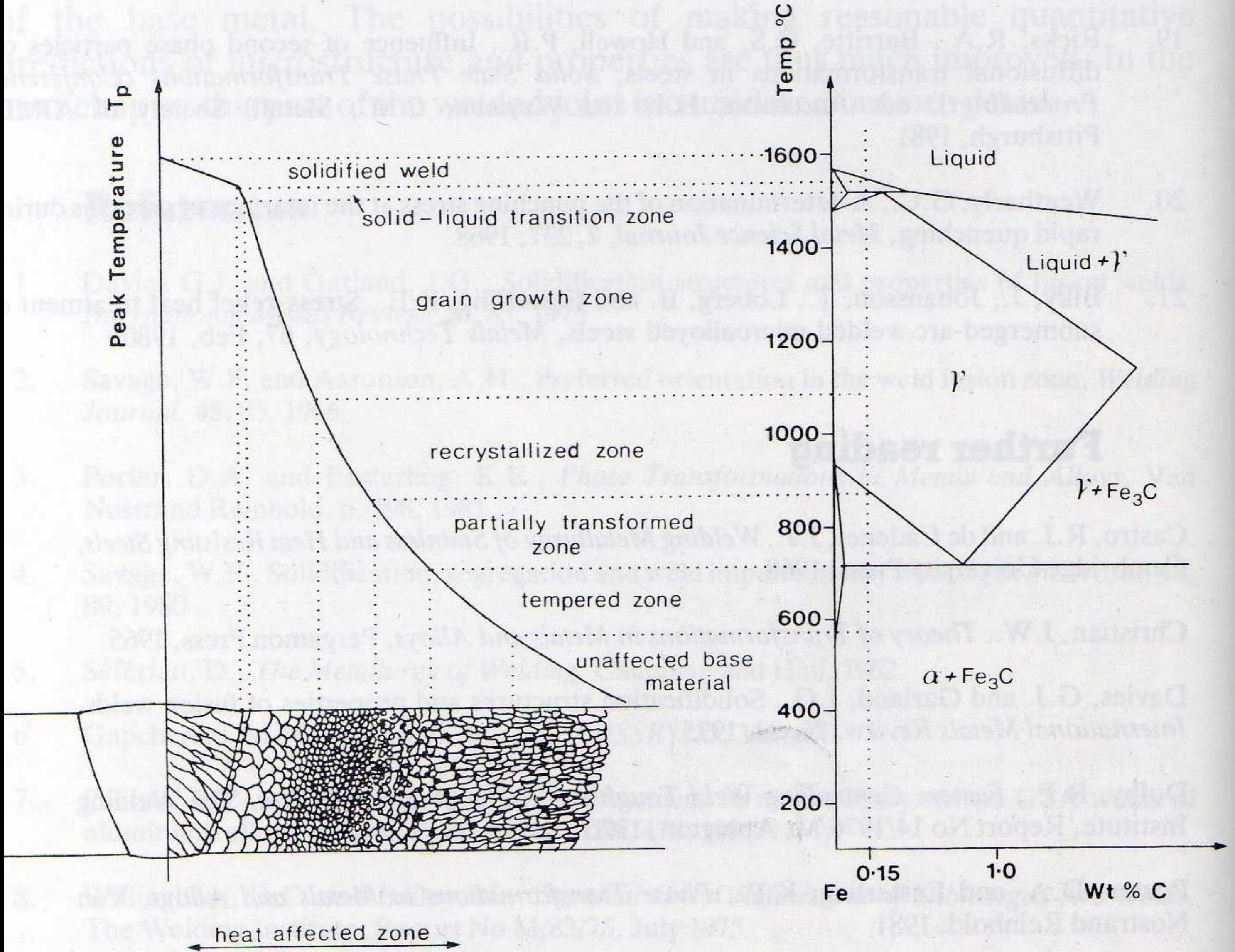


Figure 3.1 A schematic diagram of the various sub-zones of the heat-affected zone approximately corresponding to the alloy C_0 (0.15 wt % C) indicated on the Fe–Fe_3C equilibrium diagram. Compare with *Figure 3.28*

Heat Affected Zone (HAZ)

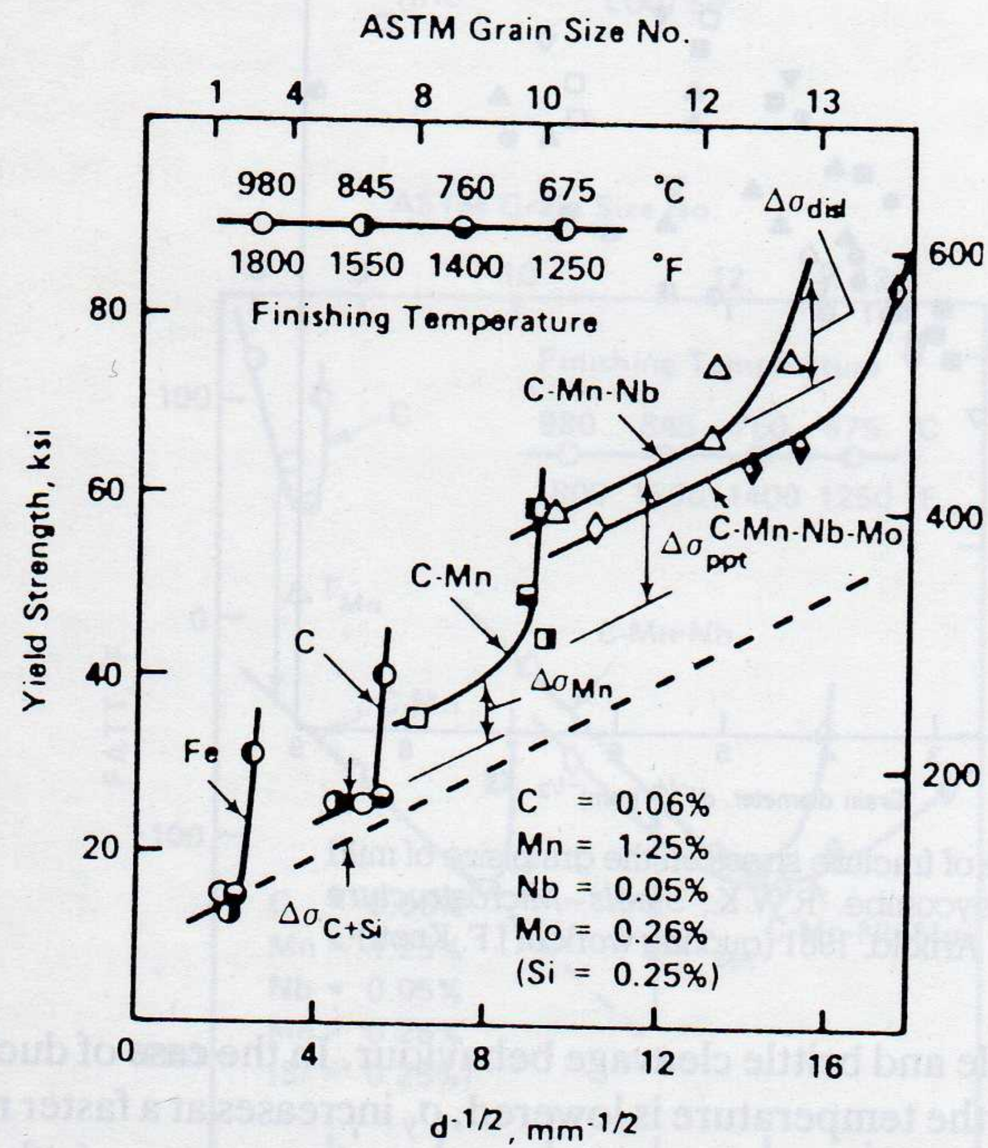


Figure 3.3 Relationship between yield strength and grain size for a number of steels. After Porter, L.F. and Repas., P.E., The evolution of HSLA steels, *Journal of Metals,* 14, April 1982

Heat Affected Zone (HAZ)

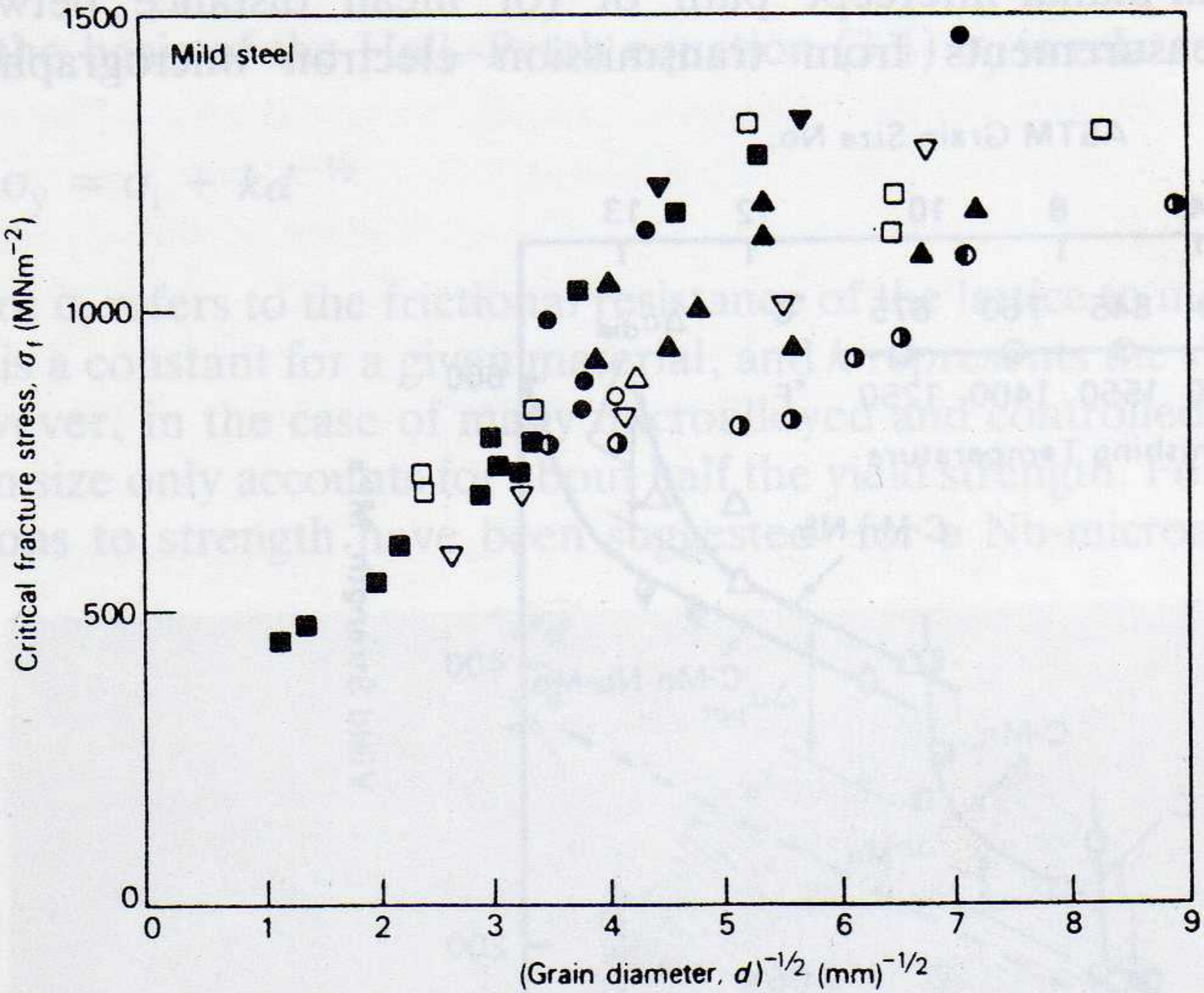
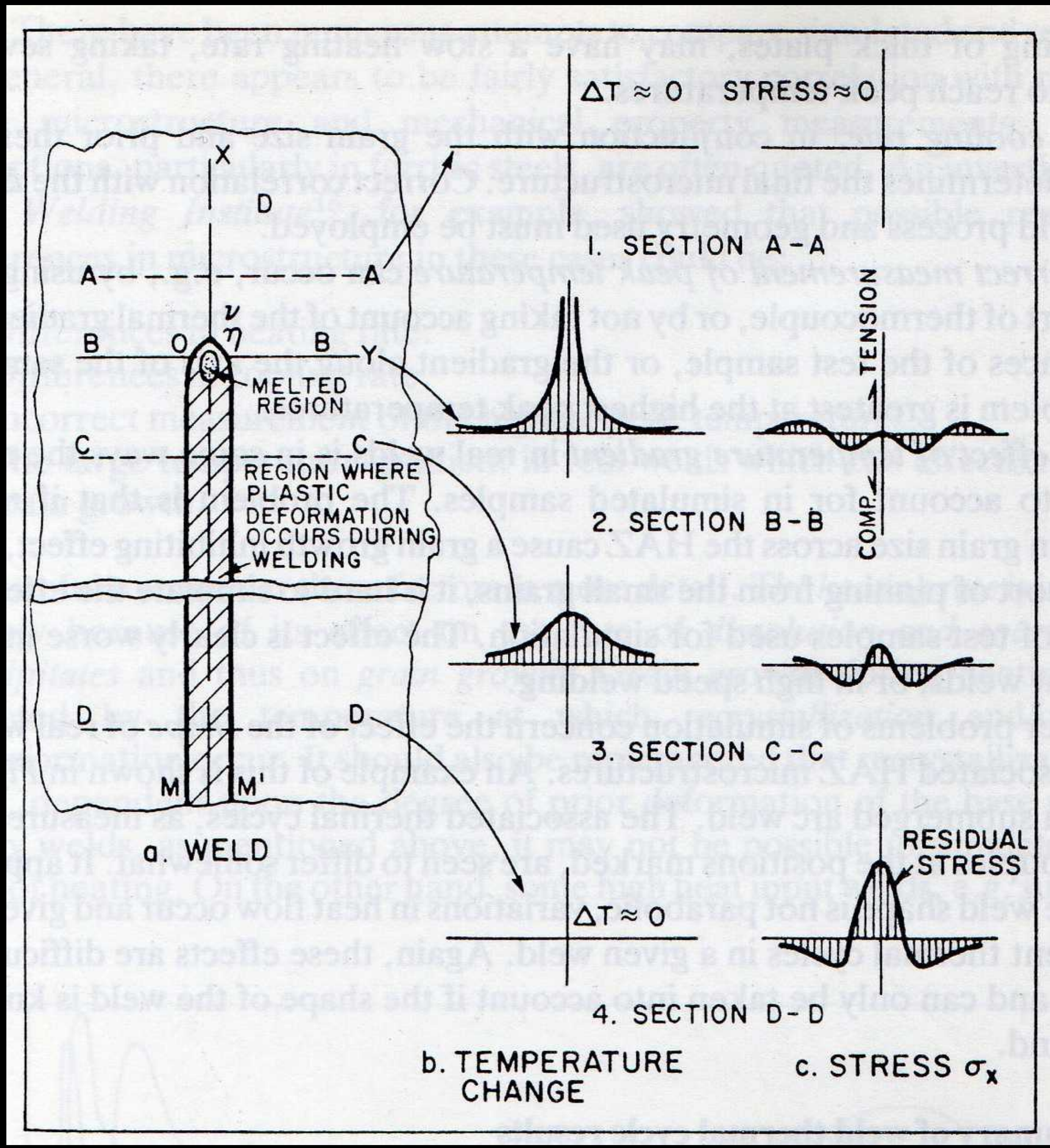


Figure 3.4 Dependence of fracture stress on the grain size of mild steel. Taken from Honeycombe, R.W.K., *Steels – Microstructure and Properties*, Edward Arnold, 1981 (quoting work of J.F. Knott)

Heat Effects



Heat Effects

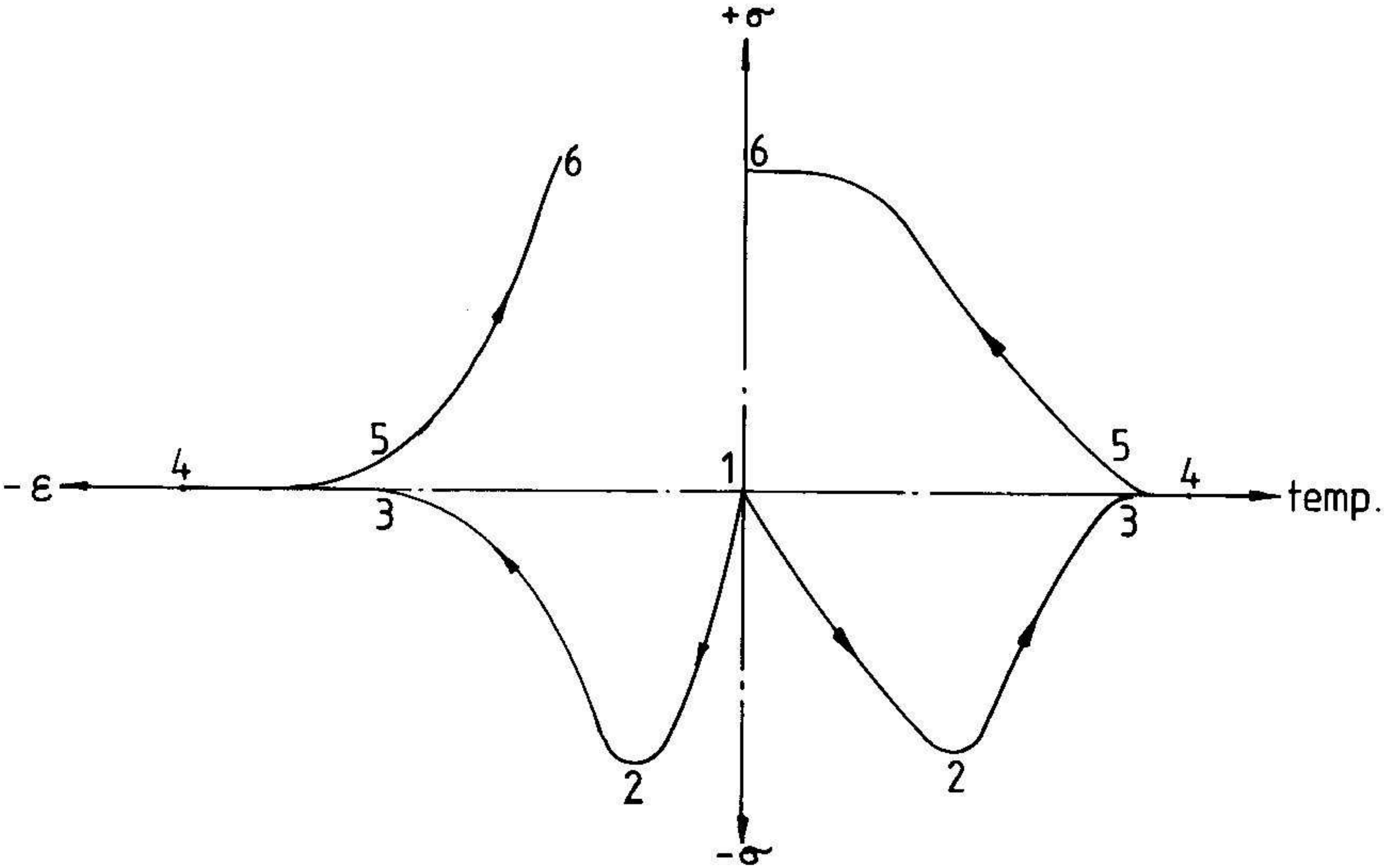


Figure 1.30 Schematic illustration of the variations in stress–temperature and stress–strain during a weld thermal cycle. Point 6 refers to the final residual stress and strain after the element has cooled to ambient temperature

Heat Effects

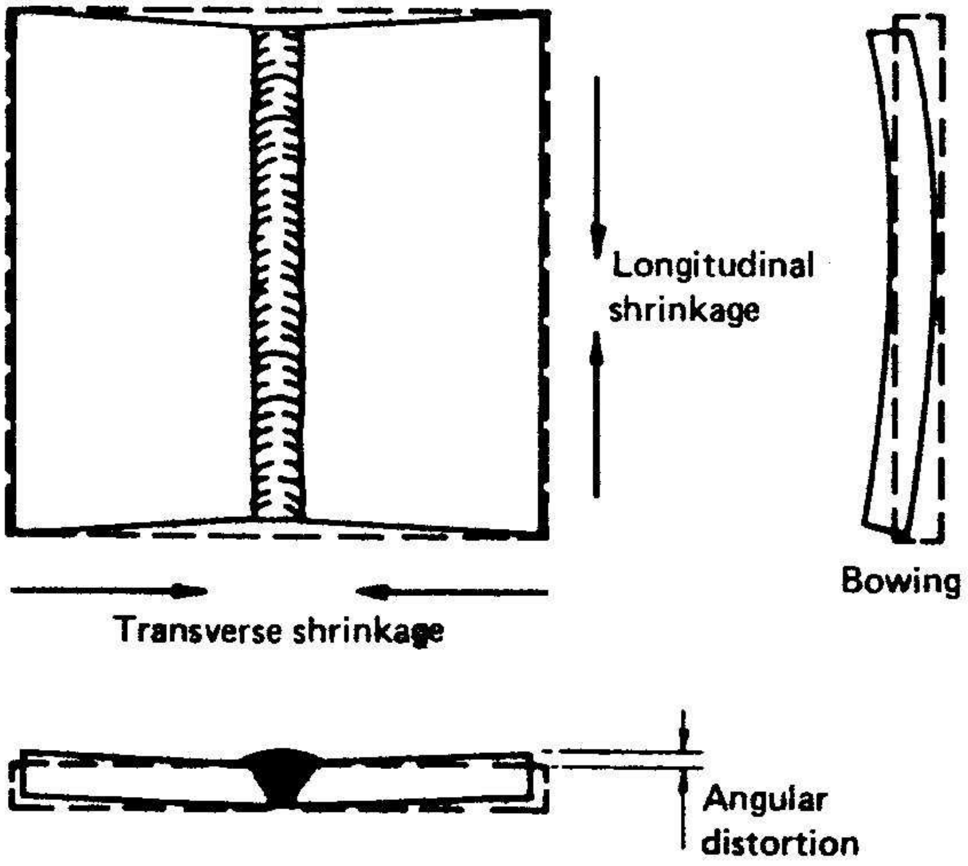


Figure 1.32 Types of distortion in butt welded plates. After Allen, J.S., The effect of residual stresses on distortion, *Residual Stresses and their Effect*, p. 5, ed. Parlane, A.J.A., The Welding Institute, 1981

Negating Heat Effects

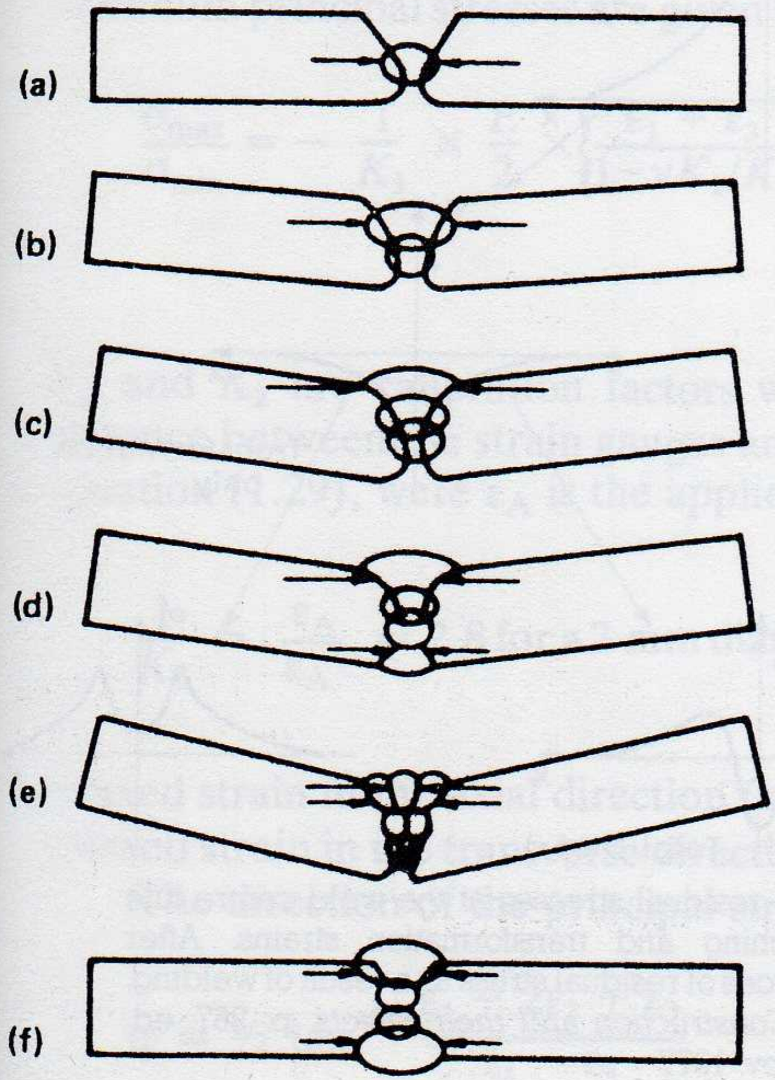


Figure 1.33 Possible welding procedures to avoid distortion of a butt welded plate. After Allen, J.S., The effect of residual stresses on distortion, *Residual Stresses and their Effect,* p. 5, ed. Parlane, A.J.A., The Welding Institute, 1981

Negating Heat Effects

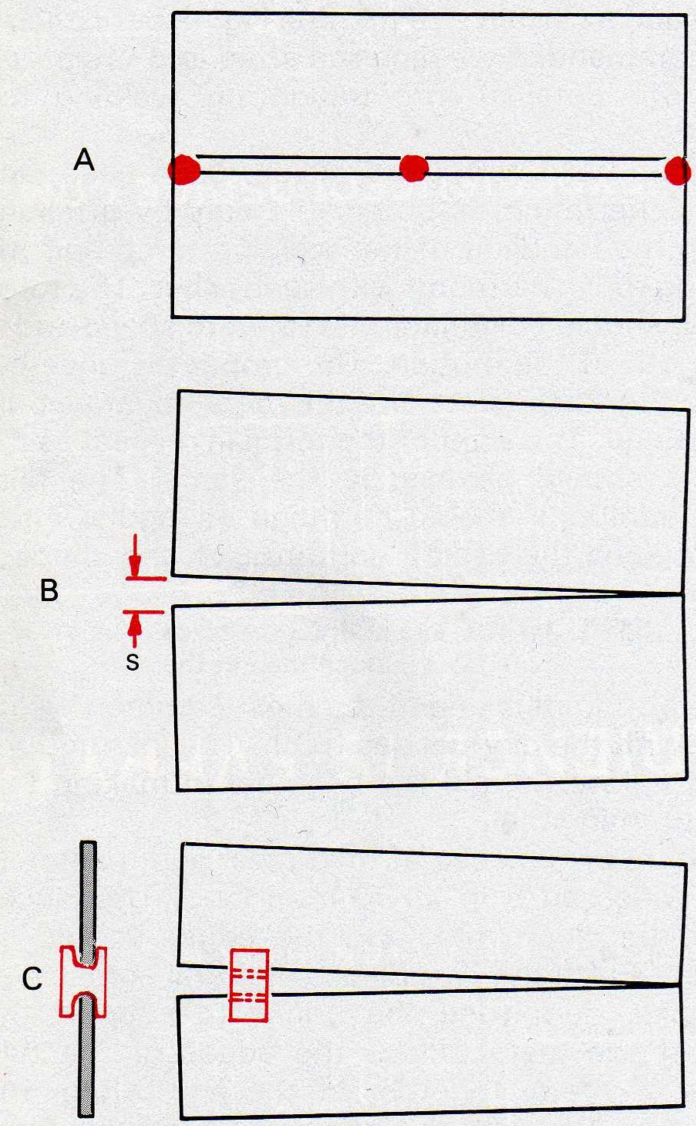


Fig. 4-19. Some methods used to maintain correct position of welded pieces, since the weld metal shrinks as it solidifies and cools: A—''Tacking'' pieces together before welding. B—Allowing for shrinkage (S). C—Use of special wedges.

Negating Heat Effects

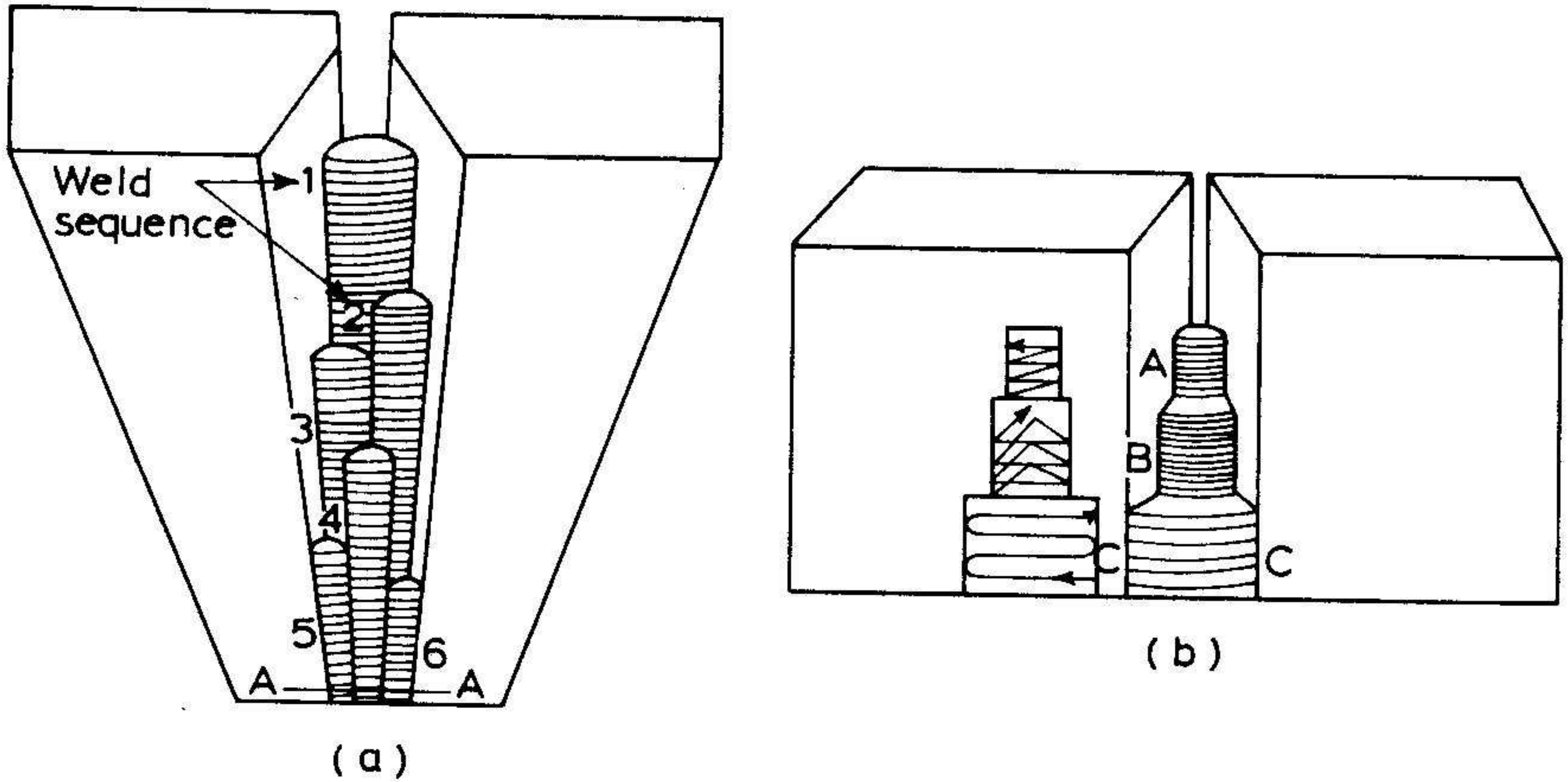


Figure 1.12 Ideal filler metal configurations of (a) a single vee-butt weld and (b) a vertical butt weld. After Woods, P.F., *Fundamentals of Welding Skills,* Macmillan, London, 1976

Negating Heat Effects

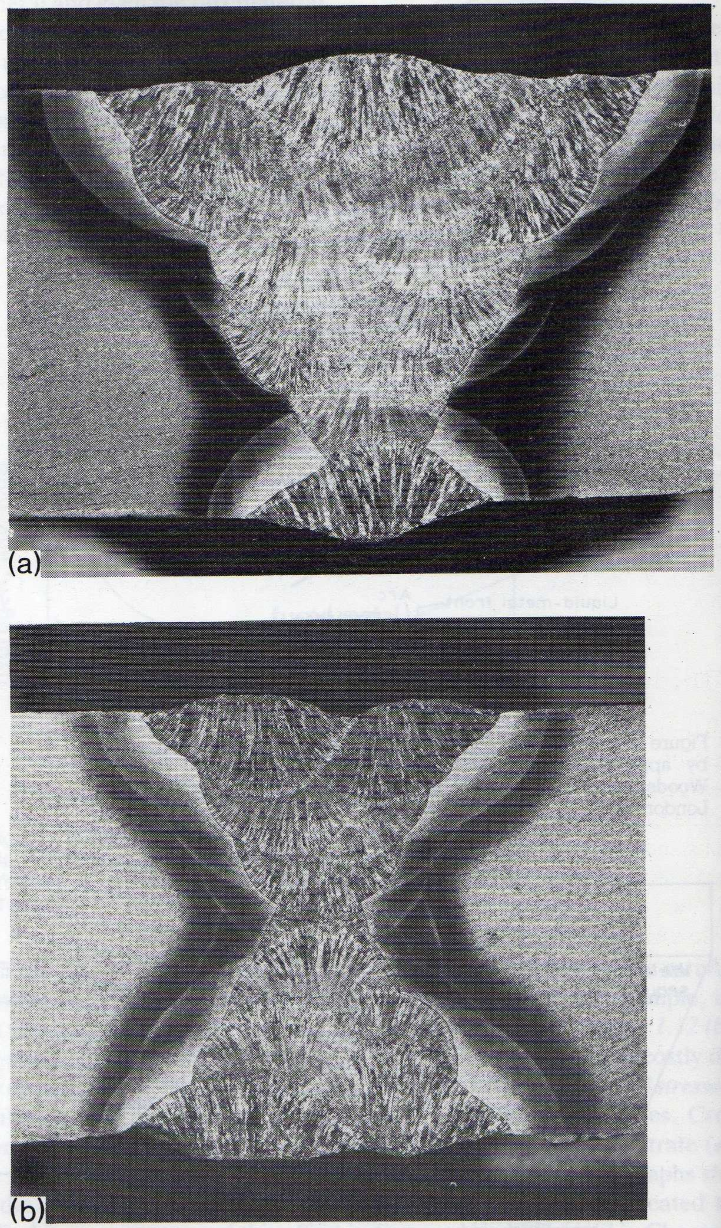


Figure 1.13 Manual metal arc welds of (a) a single vee-butt weld and (b) a double vee-butt weld. The plate thickness in both cases is 18 cm. (By courtesy of ESAB, Gothenburg)

References

Althouse, Andrew D, et al. “Modern Welding,” Goodheart-Willcox Company, Inc, South Holland, Ill., 1988.

Easterling, Kenneth. “Introduction to the Physical Metallurgy of Welding,” Butterworths Monographs in Materials, 1983.

Gaylen, Jerry, et. al. “Welding Fundamentals and Procedures,” John Wiley & Sons, 1984.

Olson, D.L. et al. (editors), “Welding Theory and Practice,” North-Holland, 1990.