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ELECTRODE MATERIALS

Special electrodes, holders, and dies for resistance welding applications.

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STANDARD STOCK
GROUP A - COPPER BASE ALLOYS

Class II Alloy
(Chrome Copper) = Alloy C18200

Class II alloy is a superior resistance welding electrode material specifically recommended for high level production spot welding and seam welding of clean mild steel, and low alloy steels, low conductivity brasses and bronzes.

Suitable for projection welding dies, seam welder shafts and bearings, flash and butt welding dies and current carrying structural members.

Available as high strength and high electrical conductivity castings for such use as gun welder arms, welder platens and secondary structural members.

Class III Alloy
(Beryllium Copper with additions of Cobalt, Nickel or Silver) = Alloy C17510

Class III alloy is specifically recommended for projection welding dies, flash and butt welding dies, current carrying shafts and bushings. As castings, Class III alloy (having higher strength than Class II), is recommended for highly stressed welder structural current carrying members and heavy-duty offset electrode holders.

Class III alloy is generally recommended for spot welding and seam welding steels having high electrical resistance, such as stainless steels.

Copper No. 110 (C110)

Copper No. 110 is specified because of its high thermal and electrical conductivity. Copper 110 is used for welding fixtures, anodes, buss bar in electrical power installations, ground straps, commutators, etc. Its inherent fabrication qualities readily permit it to be bent, soldered, drilled, peened, riveted and formed to fit almost any design specification.

Copper No. 101 (O.F.H.C.)

Oxygen Free High Conductivity copper is produced by the direct conversion of selected refined cathodes and castings under carefully controlled conditions to prevent any contamination of the pure oxygen-free metal during processing.

The method of producing O.F.H.C. Copper insures an extra high grade of metal with a copper content of 99.99%. With such small content of extraneous elements, the inherent properties of elemental copper are brought forth to a high degree.

Among such characteristics are high ductility, high electrical and thermal conductivity, high impact strength, good creep resistance, ease of weldability, and low volatility under high vacuum.

AVAILABLE (Not Stocked)
GROUP A - COPPER BASE ALLOYS

Class I Alloy
(Zirconium Copper) = Alloy C15000

Class I alloy is superior to pure copper as an electrode material and is recommended as a general purpose material for resistance welding applications. It may be used as spot welding electrodes, seam welding wheels and welder fixtures.

Specifically recommended, because of its high electrical and thermal conductivity, for spot welding aluminum alloys, magnesium alloys, coated materials (tern plate, tin plate, galvanized iron, cadmium plate), brass and bronze. Class I alloy is not practical in cast form. It is not heat treatable.

Class IV Alloy (Beryllium Copper)

Class IV alloy has extremely high hardness and ultimate tensile strength although the electrical conductivity is lower than the Class III alloy. It is generally recommended as electrode material for special flash, flash butt and projection welding applications where pressures are extremely high and wear is severe but where heating is not excessive. It is available as wrought material for highest quality dies and electrodes and may also be obtained as high strength castings. It is used frequently in the forms of inserts and die facings, and may also be used for seam welder bushings.

Class IV alloy is available in the annealed condition, in this state it can be more readily machined and may be subsequently heat treated to maximum hardness.

STANDARD STOCK
GROUP B - REFRACTORY METAL COMPOSITIONS

Class 10 (Copper Tungsten)

Class 10 material is recommended as facing or inserts for projection welding electrodes and flash and butt welding dies where high electrical conductivity is desirable and a degree of malleability is necessary.

Class 11 (Copper Tungsten)

Class 11 (a harder material than Class 10) is recommended as facing and inserts for flash and butt welding dies and general purpose projection welding electrodes. It may also be used as seam welder bearing inserts and facings for electro-forming or electro-forging, such as stainless steel.

Class 12 (Copper Tungsten)

Class 12 material is specifically recommended for heavy duty projection welding electrodes and for die facings in electro-forming and electro-forging applications. It is suitable as die material for electrical upsetting of rivets and studs.

Class 13 (Tungsten)

Class 14 (Molybdenum)

Class 13 and Class 14 materials are recommended principally for welding or electro-brazing nonferrous metals having relatively high electrical conductivity.

Cross wire welding of copper and brass wires and welding of copper wire braid to brass and bronze terminals are typical applications. Generally, special set-ups and procedures are required for this type of work.

MINIMUM PHYSICAL PROPERTIES FOR RWMA ALLOYS																
GROUP A* COPPER BASE ALLOYS		HARDNESS ROCKWELL			CONDUCTIVITY % I.A.C.S.			YIELD STRENGTH ksi (typical) (5% Ext Under Load)			ULTIMATE TENSILE STRENGTH ksi			ELONGATION % IN 2" OR 4" DIAMETERS		
SIZE RANGE		CLASS			CLASS			CLASS			CLASS			CLASS		
IN	MM	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
DIAMETER - ROUND ROD STOCK (COLD WORKED)																
UP TO 1"	UP TO 25	65 HRB	75 HRB	90 HRB	80%	75%	45%	45	55	90	60	65	95	13%	13%	9%
OVER 1 TO 2	OVER 25 TO 51	60 HRB	70 HRB	90 HRB	80%	75%	45%	45	55	90	55	59	92	14%	13%	9%
OVER 2 TO 3	OVER 51 TO 76	55 HRB	65 HRB	90 HRB	80%	75%	45%	45	55	90	50	55	88	15%	13%	9%
THICKNESS - SQUARE, RECTANGULAR AND HEXAGONAL BAR STOCK (COLD WORKED)																
UP TO 1"	UP TO 25	55 HRB	70 HRB	90 HRB	80%	75%	45%	45	45	90	60	65	95	13%	13%	9%
OVER 1"	OVER 25	50 HRB	65 HRB	90 HRB	80%	75%	45%	45	40	90	50	55	90	14%	13%	9%
THICKNESS - FORGINGS																
UP TO 1"	UP TO 25	55 HRB	65 HRB	90 HRB	80%	75%	45%	45	45	50	60	55	94	12%	13%	9%
OVER 1 TO 2	OVER 25 TO 51	50 HRB	65 HRB	90 HRB	80%	75%	45%	45	45	50	50	55	90	13%	13%	9%
OVER 2	OVER 51	50 HRB	65 HRB	90 HRB	80%	75%	45%	45	40	50	50	55	88	13%	13%	9%
CASTINGS																
ALL	ALL	NA	55 HRB	90 HRB	NA	70%	45%	NA	20	45	NA	45	75	NA	12%	5%

All materials are in fully heat treated condition unless otherwise specified. Round rod up to 1" (25 mm) diameter is fully heat treated and cold worked.

CHEMICAL COMPOSITION OF RWMA MATERIALS														
GROUP A - COPPER BASE ALLOYS														
RWMA CLASS	RWMA NUMBER	DESCRIPTION	Cu (incl. Ag)	Fe	W	Cd	Ni	Co	Cr	Si	Be	Pb	Zr	Al
1	15000	Zirconium Copper	99.80 min.										.10 - .20	
2	18150	Chromium-Zirconium Copper	REM.						.5- 1.5				.05 - .25	
2	18200	Chromium Copper	REM.	.10 max.					.6 - 1.2	.10 max.		.05 max.		
3	17500	Cobalt-Beryllium Copper	REM.	.10 max.				2.4 - 2.7		.20 max.	.4 - .7 max.			.20 Max.
3	17510	Nickel-Beryllium Copper	REM.	.10 max.			1.4 - 2.2	.30 max.		.20 max.	.2 - .6			.20 max.
3	18000	Nickel-Silicon Chromium Copper	REM.	.15 max.			1.8 - 3.0		.1 - .8	.4 - .8				
4	17200	Beryllium Copper	REM.				Ni + Co, .20% min., Ni + Fe + Co .6% max.			.20 max.	1.8 - 2.0	.02 max.		.20 max.
GROUP B - REFRACTORY METAL AND REFRACTORY METAL COMPOSITES														
10	74450	Copper Tungsten	43-47		REM.									
11	74400	Copper Tungsten (ASTM B702 C1 D)	23-27		REM.									
12	74350	Copper Tungsten (ASTM B702 C1E)	18-22		REM.									
13	74300	Copper Tungsten			99.9 min.									
14	42300	Molybdenum (ASTM B387 Alloy 360 or 361)			(Mo) 99.9 Min.									

RWMA numbers correspond to five digits following a "C" in the Copper Development Association and Unified Numbering Systems.

PHYSICAL PROPERTIES					
COPPER BASE ALLOYS	HARDNESS ROCKWELL F SCALE	CONDUCTIVITY % I.A.C.S. @ 68 F	YIELD STRENGTH psi	ULTIMATE TENSILE STRENGTH psi	ELONGATION %
UNS - C11000	90	101	44,000	48,000	10
UNS - C10100	87	101	44,000	48,000	15

CHEMICAL COMPOSITION														
COPPER BASE ALLOYS														
UNS NUMBER	DESCRIPTION	Cu	Fe	P	Cd	Ni	Co	Cr	Si	Be	Pb	Zr	Al	Other Elements
C11000	ELECTROLYTIC TOUGH PITCH	99.90												Oxygen .04
C10100	Oxygen Free High Conductivity (O.F.H.C.)	99.99		.0003										Oxygen .0010

Specification Equivalents

Alloy No.	Specification
Class II Chromium Copper (C18200)	R.W.M.A., Group A SAE J463, J461, MIL-C-19311

Chemical Composition % by Weight

UNS No.	Chromium	Lead	Iron	Silicon	Zinc	Copper
C18200	0.6-1.2	0.05 Max	0.10 Max	0.10 Max	-	Balance

Corrosion Resistance

In general, this alloy has the same corrosion resistance as pure copper. As a result, mercury and ammonia compounds, as well as nitric acid, should be avoided.

Chromium Copper
Physical Properties (C18200)

Density	0.321 lb/in^3	8.89 8/cm^3
Coefficient of thermal expansion (68 to 212 F, 20 to 100 C)	9.8 x $10^{-6}F^{-1}$	17.6 x $10^{-6}C^{-1}$
Thermal Conductivity (68 F, 20 C)	187 BTU/ft•hr•F	325 W/m•C
Electrical Conductivity	80% IACS (67 F, 20 C)	.46 Megmho/cm
Melting Temperature	1960 F	1070C

Machining

Chrome copper is easily machined with either high speed steel or carbide tools. Standard, off-the-shelf tools are recommended for all general machining operations.

Turning tools should be ground with generous positive rake angles to minimize cutting resistance. Mineral oil and water-soluble cutting fluids are recommended to improve tool life and surface finish.

Minimum Mechanical Properties

Diameter or Distance Across Flats	Ultimate Tensile Strength (ksi)	Elongation (% in 2")	Rockwell Hardness B Scale
Rod (Round & Hex)			
Up to 1 inch	65	9	75
Over 1 inch to 2 inches	60	10	70
Over 2 inches to 3"	55	12	65
Over 3 inches	50	12	60
Bar			
Thickness up to 1 inch Width up to 1 inch	60	8	70
Thickness over 1" to 2" Width over 2 inches	55	12	65
Thickness over 2 inches Width over 3 inches	50	19	60

Note: Available in AT or HT temper depending upon size.

Workability

Chromium Copper Alloy C18200 is usually supplied in the cold drawn and heat treated condition. In this condition, this alloy is suited for moderate cold working, such as bending.

Forms and Tempers Most Commonly Used

		Annealed Tempers: Nominal Grain Size mm .100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Rolled or Drawn Tempers: Solution Heat Treated	Solution Heat Treated and Cold Worked	Solution Heat Treated, Cold Worked and Aged	Solution Heat Treated, Cold Worked, Aged, and Cold Worked	Solution Heat Treated and Aged	Mill Annealed	Mill Annealed and Cold Worked	Hot Finished Tempers: As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled									●	●	●			●				
	Strip, Drawn																		
	Flat Wire, Rolled																		
	Flat Wire, Drawn																		
	Bar, Rolled																		
	Bar, Drawn																●		
	Sheet											●			●				
	Plate									●	●	●							
	ROD									●	●	●	●		●	●	●		
	WIRE									●	●	●	●		●	●			
	TUBE											●	●		●				
	PIPE																		
	SHAPES																●		

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength (.5 Ext. under Load) ksi	Yield Strength (.2% Offset) ksi	Elongation in 2 in. %	Rockwell Hardness F	Rockwell Hardness B	Rockwell Hardness 30T	Shear Strength ksi	Fatigue Strength ksi	Fatigue Strength Million Cycles
FLAT PRODUCTS	.040 in.	Solution Heat Treated	34.0	19.0	....	40	—	16	—	...	....	....
		Solution Heat Treated and Aged (500C-3 hrs)	51.0	36.0	...	22	—	59	—	...	....	....
		Solution Heat Treated and Cold Worked (50%)	53.0	51.0	....	6	—	66	—	...	....	....
		Solution Heat Treated, Cold Worked (50%), and Aged (450C-3 hrs)	67.0	59.0	....	14	—	79	—	...	....	....
PLATE	2.0 in.	Solution Heat Treated and Aged	58.0	42.0	....	25	—	70	—	...	....	....
	3.0 in.	Solution Heat Treated and Aged	56.0	40.0	....	30	—	68	—	...	....	....
ROD	.156 in.	Solution Heat Treated and Cold Worked (91%)	74.0	73.0	....	5	—	—	—	...	....	....
		Solution Heat Treated, Cold Worked (90%), and Aged	86.0	77.0	....	14	—	—	—	...	....	....
	.500 in.	Solution Heat Treated	45.0	14.0	....	40	—	—	—	...	....	....
		Solution Heat Treated and Aged (500C-3 hrs)	70.0	55.0	....	21	—	70	—	...	....	....
		Solution Heat Treated and Cold Worked (60.5%)	57.0	56.0	....	11	—	65	—	...	....	....
		Solution Heat Treated and Cold Worked (60.5%) and Aged (450C-3 hrs)	77.0	65.0	....	16	—	82	—	...	....	....
		Solution Heat Treated, Cold Worked (50%), Aged and Cold Worked (6%)	77.0	67.0	....	19	—	83	—	...	....	....
	1.0 in.	Solution Heat Treated and Aged	72.0	65.0	....	18	—	80	—	...	....	....
	2.0 in.	Solution Heat Treated and Aged	70.0	65.0	....	18	—	75	—	...	....	....
	3.0 in.	Solution Heat Treated and Aged	65.0	55.0	....	18	—	70	—	...	....	....
	4.0 in.	Solution Heat Treated and Aged	55.0	43.0	....	25	—	68	—	...	....	....
TUBE	3/8 in.OD X .094 in.	Mill Annealed	40.0	15.0	....	50	59	—	—	...	....	....
	1.250in.OD X .212 in.	Solution Heat Treated and Cold Worked (76%)	59.0	57.0	....	21	—	67	—	...	....	....
		Solution Heat Treated, Cold Worked (76%), Aged and Cold Worked (28%)	69.0	63.0	....	26	—	84	—	...	....	....

The values listed above represent approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

Composition—percent

	Nominal	Minimum	Maximum
Copper	99.1	....	....
Iron	....	....	.10
Chromium	9	.6	1.2
Silicon	....	....	.10
Lead	....	....	.05
Arsenic	....	....	....
Calcium	....	....	....
Lithium	....	....	....
Phosphorus	....	....	....
Zinc	....	....	....
Silver	....	....	....
Copper (Incl. Ag) +Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	
Pipe	
Rod	
Shapes	
Tube	
Wire	F9

Physical Properties

	English Units		C.G.S. Units	
Melting Point (Liquidus)	1967	F	1075	C
Melting Point (Solidus)	1958	F	1070	C
Density	.321	lb/cu in @ 68 F	8.89	gm/cu cm @ 20 C
Specific Gravity	8.89		8.89	
Coefficient of Thermal Expansion	.0000098	per ° F from 68 F to 212 F	.0000176	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion		per ° F from 68 F to 392 F		per ° C from 20 C to 200 C
Coefficient of Thermal Expansion		per ° F from 68 F to 572 F		per ° C from 20 C to 300 C
Thermal Conductivity**	187	Btu/sq ft/ft/hr/°F @ 68 F	.77	cal/sq cm/cm/sec/° C @ 20 C
Electrical Resistivity (Annealed)**	13.0	Ohms (circ mil/ft) @ 68 F	2.16	Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)**	80	% IACS @ 68 F	.463	Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092	Btu/lb °F @ 68 F	.092	cal/gm/° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000	psi	12,000	Kg/sq mm
Modulus of Rigidity	7,200,000	psi	5,100	Kg/sq mm

*Volume Basis
**Solution Heat Treated, Cold Worked (50% minimum) and Aged (Volume Basis)

Typical Uses

Resistance welding machine electrodes, seam welding wheels, electrical switch gear, electrode holder jaws, cable connectors, current carrying arms and shafts, circuit breaker parts, arcing and bridging parts, grid siderods in electron tubes, molds, spot welding tips, flash welding electrodes, electrical and thermal conductors requiring greater strength than copper, switch contacts

Common Fabrication Processes

Hot: Extrusion, rolling, forging
Cold: Drawing, rolling, impacting, heading, bending, swaging

Fabrication Properties

Capacity for Being Cold Worked ..... Excellent
Capacity for Being Hot Formed ..... Good
Hot Forgeability Rating (Forging Brass = 100) 80
Hot Working Temperature ..... 1500-1700 F or 800-925 C
***Annealing Temperature ..... F or C
Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:
Soldering ..... Good
Brazing ..... Good
Oxyacetylene Welding ..... Not Recommended
Gas Shielded Arc Welding ..... Good
Coated Metal Arc Welding ..... Not Recommended
Resistance Welding: Spot ..... Not Recommended; Seam ..... Not Recommended; Butt ..... Fair

***Recommended Solution Heat Treating and Aging Cycles

Condition	Solution Treating		Time	Aging		Time
Solution Heat Treated and Aged or Solution Heat Treated, Cold Worked and Aged	1800-1850F	980-1000C	10-30 min.	800-930F	425-500C	2-4 hrs.

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

Specifications Equivalents

Alloy No.	DIN Material No.
C17510 Class III Beryllium Copper	2.0850

Chemical Composition % by Weight

Be	Ni	Cu
0.2 - 0.6	1.4 - 2.2	Balance

Material Properties

High thermal conductivity combined with good hardness and high temperature strength. Good resistance to tampering. Not suitable for case hardening or nitrating.

Applications

Low pressure blow molds. Limited applications for injection molds. Inserts in steel and aluminum molds. Provides higher cooling rates at critical mold areas. Sealing tools. Cooling inserts in molds and casting molds. Plungers for die casting of light metal castings. Nozzles and needles for hot runner systems.

Mechanical Properties

Hardness	Brinell	*163-213	RB92-102
Tensile Strength**	KSI	115	
Yield Strength**	KSI	100	
Elongation**	%	10	
Elastic Modules	KSI	19,200	

*Hardness Conversions are approximate.
**Tensile Test values are nominal approximations and depend on specimen size and orientation.

Physical Properties

Thermal Conductivity	BTU/(ft hr F)	145
Specific Heat	BTU/lb/F	0.1
Thermal Expansion	in/in/F	10.0×10^{-6}
Density	lb/cu/F	0.317
Hot Forming***	1500-1750°F	Air or Water Cooled
Heat Treatment***	Anneal 1650-1750°F to approx. HB 100	1/2 hr. & Water Quench
	Harden 900°F to approx. HB 200	3 hr. Air Cool

***Class III Beryllium Copper is pre-tempered to the correct strength. Hot forming and further heat treatment are not needed or recommended. Direct machining to desired configuration is preferred.

Machining Data

Machining	Tungsten Carbide	High Speed Steel
Turning		
cutting speed (SFM)	1500 - 1800	200 - 300
rake angle (Deg)	5	10
feed (IPR)	.010	.025
Milling		
cutting speed (SFM)	800 - 1600	400 - 800
rake angle (Deg)	10	10
feed (inch/tooth)	.005 - .008	.005 - .008
depth of cut	.050 - .125	.050 - .125
Drilling		
cutting speed (SFM)		200 - 600
feed (IPR)		.002 - .009

Composition—percent

	Nominal	Minimum	Maximum
Copper	96.9	....	....
Iron	....	....	.10
Nickel	1.7	1.4	2.2
Beryllium	.4	.2	.6
Copper (incl. Ag) +Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B441, B534
Pipe	
Rod	B441
Shapes	
Tube	
Wire	

Physical Properties

	English Units		C.G.S. Units	
Melting Point (Liquidus)	1955	F	1068	C
Melting Point (Solidus)	1885	F	1029	C
Density	.316	lb/cu in @ 68 F	8.75	gm/cu cm @ 20 C
Specific Gravity	8.75		8.75	
Coefficient of Thermal Expansion		per ° F from 68 F to 212 F		per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000098	per ° F from 68 F to 392 F	.0000176	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion		per ° F from 68 F to 572 F		per ° C from 20 C to 300 C
Thermal Conductivity	120 - 150	Btu/sq ft/ft/hr/°F @ 68 F	.49 - .62	cal/sq cm/cm/sec/° C @ 20 C
Electrical Resistivity (Annealed)	22.8	Ohms (circ mil/ft) @ 68 F	3.79	Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)**	45	% IACS @ 68 F	.261	Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.10	Btu/lb °F @ 68 F	.10	cal/gm/° C @ 20 C
Modulus of Elasticity (Tension)	19,000,000	psi	13,500	Kg/sq mm
Modulus of Rigidity	7,500,000	psi	5,250	Kg/sq mm

*In the precipitation hardened condition
**Volume Basis

Typical Uses

HARDWARE: fuse clips, fasteners, springs, switch parts, relay parts, electrical conductors
INDUSTRIAL: welding equipment

Common Fabrication Processes

Blanking, forming and bending, turning, drilling, tapping

Fabrication Properties

Capacity for Being Cold Worked ..... Excellent
Capacity for Being Hot Formed ..... Good
Hot Forgeability Rating (Forging Brass = 100) .....
Hot Working Temperature ..... 1200-1625 F or 650-765 C
Machinability Rating (Free Cutting Brass = 100) .....
Solution Heat Treating Temperature ..... 1675-1725 F or 900-950 C

Suitability for being joined by:
Soldering ..... Good
Brazing ..... Good
Oxyacetylene Welding ..... Not Recommended
Gas Shielded Arc Welding ..... Fair
Coated Metal Arc Welding ..... Fair
Resistance Welding: Spot ..... Good; Seam ..... Fair; Butt ..... Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

Forms and Tempers Most Commonly Used

		Annealed Tempers: Nominal Grain Size mm								Rolled or Drawn Tempers									Hot Finished Tempers		
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Solution Heat Treated	Solution Heat Treated and Cold Worked	Solution Heat Treated, Cold Worked and Aged	Solution Heat Treated, Cold Worked, Aged, and Cold Worked	Solution Heat Treated and Aged	Mill Annealed	Mill Annealed and Cold Worked	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled									●	●	●			●				
	Strip, Drawn																		
	Flat Wire, Rolled																		
	Flat Wire, Drawn																		
	Bar, Rolled																		
	Bar, Drawn																●		
	Sheet											●			●				
	Plate									●	●	●							
	ROD									●	●	●	●		●	●	●		
	WIRE									●	●	●	●		●	●			
	TUBE											●	●		●				
	PIPE																		
	SHAPES																●		

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength (.5 Ext. under Load) ksi	Yield Strength (.2% Offset) ksi	Elongation in 2 in. %	Rockwell Hardness F	Rockwell Hardness B	Rockwell Hardness 30T	Shear Strength ksi	Fatigue Strength ksi	Fatigue Strength Million Cycles
FLAT PRODUCTS	.040 in.	Solution Heat Treated	34.0	19.0	....	40	—	16	—	...	....	....
		Solution Heat Treated and Aged (500C-3 hrs)	51.0	36.0	...	22	—	59	—	...	....	....
		Solution Heat Treated and Cold Worked (50%)	53.0	51.0	....	6	—	66	—	...	....	....
		Solution Heat Treated, Cold Worked (50%), and Aged (450C-3 hrs)	67.0	59.0	....	14	—	79	—	...	....	....
PLATE	2.0 in.	Solution Heat Treated and Aged	58.0	42.0	....	25	—	70	—	...	....	....
	3.0 in.	Solution Heat Treated and Aged	56.0	40.0	....	30	—	68	—	...	....	....
ROD	.156 in.	Solution Heat Treated and Cold Worked (91%)	74.0	73.0	....	5	—	—	—	...	....	....
		Solution Heat Treated, Cold Worked (90%), and Aged	86.0	77.0	....	14	—	—	—	...	....	....
	.500 in.	Solution Heat Treated	45.0	14.0	....	40	—	—	—	...	....	....
		Solution Heat Treated and Aged (500C-3 hrs)	70.0	55.0	....	21	—	70	—	...	....	....
		Solution Heat Treated and Cold Worked (60.5%)	57.0	56.0	....	11	—	65	—	...	....	....
		Solution Heat Treated and Cold Worked (60.5%) and Aged (450C-3 hrs)	77.0	65.0	....	16	—	82	—	...	....	....
		Solution Heat Treated, Cold Worked (50%), Aged and Cold Worked (6%)	77.0	67.0	....	19	—	83	—	...	....	....
	1.0 in.	Solution Heat Treated and Aged	72.0	65.0	....	18	—	80	—	...	....	....
	2.0 in.	Solution Heat Treated and Aged	70.0	65.0	....	18	—	75	—	...	....	....
	3.0 in.	Solution Heat Treated and Aged	65.0	55.0	....	18	—	70	—	...	....	....
	4.0 in.	Solution Heat Treated and Aged	55.0	43.0	....	25	—	68	—	...	....	....
TUBE	3/8 in.OD X .094 in.	Mill Annealed	40.0	15.0	....	50	59	—	—	...	....	....
	1.250in.OD X .212 in.	Solution Heat Treated and Cold Worked (76%)	59.0	57.0	....	21	—	67	—	...	....	....
		Solution Heat Treated, Cold Worked (76%), Aged and Cold Worked (28%)	69.0	63.0	....	26	—	84	—	...	....	....

The values listed above represent approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

Specifications Equivalents

Alloy Number	DIN Material No.
C17200 Class IV Beryllium Copper	2.1247

Chemical Composition % by Weight

Be	Ni+Co	Ni+Co+Fe	Cu
1.80 - 2.00	.02 min.	.06 max.	Balance

Material Properties

Precipitation hardened alloy with good thermal conductivity and high hardness. Not suitable for case hardening or nitrating.

Applications

Injection molds and high pressure blow molds. Inserts in steel molds for higher cooling rates at critical mold areas. Inserts in aluminum molds for higher strength and wear resistance. Cooling inserts in molds and casting molds. Nozzles and needles for hot runner systems.

Mechanical Properties

Hardness	Brinell	255-297	RC25-32
Tensile Strength**	KSI	130	
Yield Strength**	KSI	110	
Elongation**	%	7	
Elastic Modules	KSI	18,500	

*Hardness Conversions are approximate.

**Tensile Test values are nominal approximations and depend on specimen size and orientation.

Physical Properties

Thermal Conductivity	BTU/(ft hr F)	60
Specific Heat	BTU/lb/F	0.1
Thermal Expansion	in/in/F	9.7×10^{-6}
Density	lb/cu in	0.298
Hot Forming***	1350-1500°F	Air or Water Cooled
Heat Treatment***	Anneal 1425-1475°F in approx. HB 150 Hardened 600°F to approx. HB 370	1/2 hr. & Water Quench 3 hr. Air Cool

***Class IV Beryllium Copper is pre-tempered to the correct strength. Hot forming and further heat treatment are not needed or recommended. Direct machining to desired configuration is preferred.

Figures

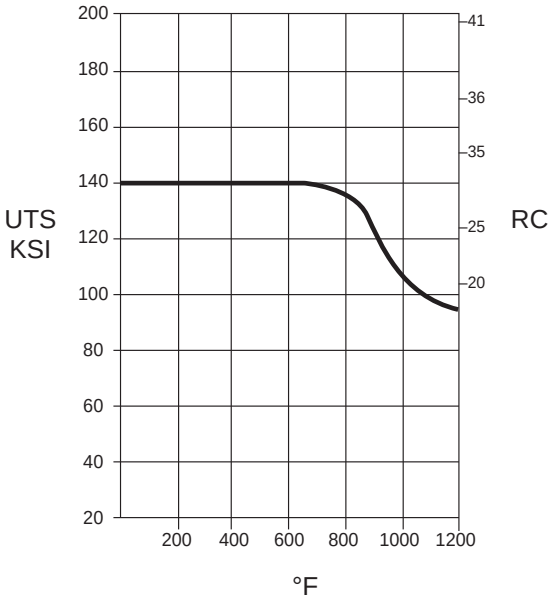


Figure 1: Resistance to softening with use at high temperatures.

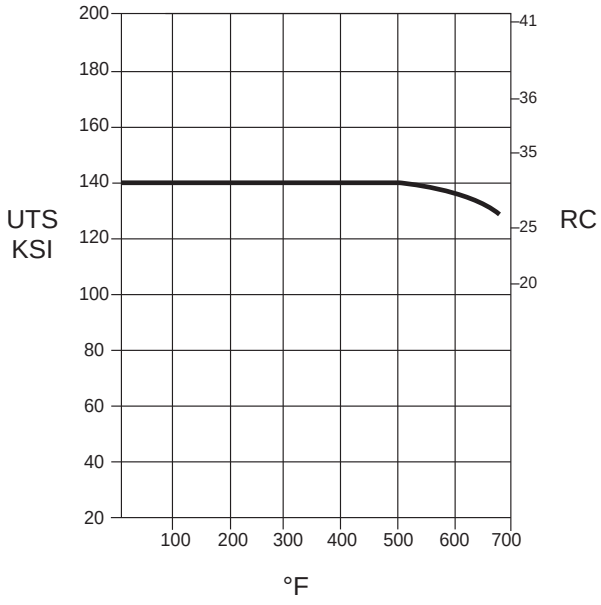


Figure 2: Strength at high operating temperatures.

Machining Data

Machining	Tungsten Carbide	High Speed Steel
Turning		
cutting speed (SFM)	900 - 1200	200 - 300
rake angle (Deg)	10	10
feed (IPR)	.010	.025
Milling		
cutting speed (SFM)	300 - 600	150 - 200
rake angle (deg)	10	10
feed (inch/tooth)	.001 - .003	.001 - .003
depth of cut	.060 - .125	.060 - .125
Drilling		
cutting speed (SFM)		100 - 300
feed (IPR)		.002 - .009

Specification Equivalents

Alloy Number	DIN Material No.
C17200 Class IV Beryllium Copper	2.1247

Chemical Composition % by Weight

Be	Ni + Co	Ni + Co+Fe	Cu
1.80 - 2.00	.02 min.	.06 max.	Balance

Material Properties

Precipitation hardened alloy with good thermal conductivity and high hardness. Not suitable for case hardening or nitrating.

Applications

Injection molds and high pressure blow molds. Inserts in steel molds for higher cooling rates at critical mold areas. Inserts in aluminum molds for higher strength and wear resistance. Cooling inserts in molds and casting molds. Nozzles and needles for hot runner systems.

Mechanical Properties

Hardness	Brinell	*332-393	RC36-43
Tensile Strength**	KSI	180	
Yield Strength**	KSI	155	
Elongation**	%	3	
Elastic Modules	KSI	18,500	

*Hardness Conversions are approximate.

**Tensile Test values are nominal approximations and depend on specimen size and orientation.

Physical Properties

Thermal Conductivity	BTU/(ft hr F)	60
Specific Heat	BTU/lb/F	0.1
Thermal Expansion	in/in/F	9.7×10^{-6}
Density	lb/cu in	0.298
Hot Forming***	1350-1500°F	Air or Water Cooled
Teat Treatment***	Anneal 1425-1474°F in approx. HB150 Harden 600°F to approx. HB 370	1/2 hr. & Water Quench 3 hr. Air Cool

***Class IV Beryllium Copper is pre-tempered to the correct strength. Hot forming and further heat treatment are not needed or recommended. Direct machining to desired configuration is preferred.

Figures

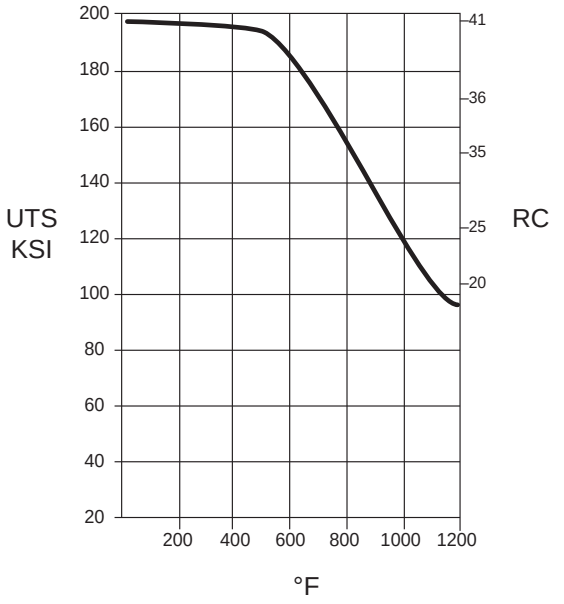


Figure 1: Resistance to softening with use at high temperatures.

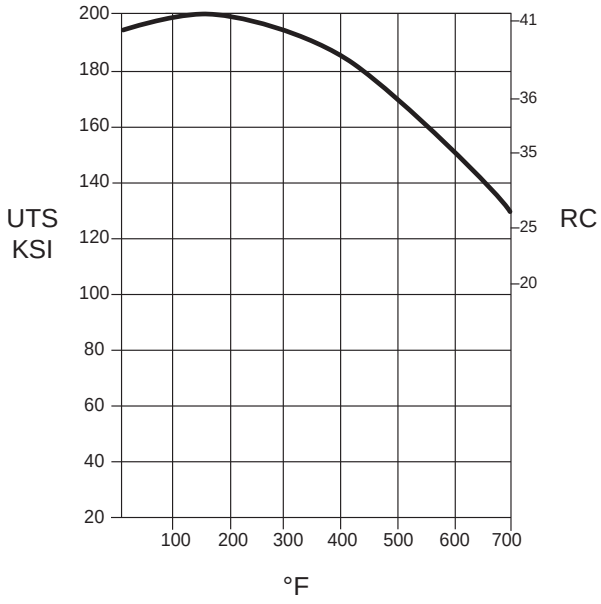


Figure 2: Strength at high operating temperatures.

Machining Data

Machining	Tungsten Carbide	High Speed Steel
Turning		
cutting speed (SFM)	900 - 1200	200 - 300
rake angle (Deg)	10	10
feed (IPR)	.010	.025
Milling		
cutting speed (SFM)	300 - 600	150 - 200
rake angle (deg)	10	10
feed (inch/tooth)	.001 - .003	.001 - .003
depth of cut	.060 - .125	.060 - .125
Drilling		
cutting speed (SFM)		100 - 300
feed (IPR)		.002 - .009

Specifications Equivalents

Alloy Number	Specifications
UNS-C11000	SAE-CA110, ASTM-B133, B187

Chemical Composition % by Weight

Copper	Oxygen
99.90	.04

Material Properties

Hard drawn bus bar with high thermal and electrical conductivity. Good resistance and tampering. Not suitable for case hardening.

Applications

Copper No. 11000 is used for welding fixtures, anodes, bus bar in electrical power installations, ground straps, commutators, etc. Its inherent fabrication qualities readily permit it to be bent, soldered, drilled, peened, riveted and formed to fit almost any design specification.

Mechanical Properties

Hardness*	Rockwell F Scale	94
Tensile Strength**	PSI	48,000
Yield Strength**	PSI	44,000
Elongation**	%	10
Shear Strength	PSI	29,000

*Hardness Conversions are approximate.

**Tensile Test values are nominal approximations and depend on specimen size and orientation.

Physical Properties

Thermal Conductivity	BTU/(sq ft-ft-hr-F)	226
Specific Heat	BTU/lb/F @ 68F	.092
Thermal Expansion	per °F from 68 F to 212 F	.0000094
Density	lb/cu in @ 68 F	.321 - .323
Electrical Conductivity*	% IACS @ 68 F	101
Modules of Elasticity	PSI	17,000,000

*Based on specimen size and orientation.

Fabrication Properties

Capacity for Being Cold Worked	Excellent
Capacity for Being Hot Formed	Excellent
Hot Forgeability Rating (Forging Brass = 100)	65
Hot Working Temperature	1400-1600 F or 750-875 C
Annealing Temperature	700-1200 F or 375-650 C
Machinability Rating (Free Cutting Brass = 100)	20
Suitability for being joined by:	Soldering/Excellent Brazing/Good Oxyacetylene Welding/Not Recommended Gas Shielded Arc Welding/Fair Coated Metal Arc Welding/Not Recommended Spot/Not Recommeded
Resistance Welding	Seam/Not Recommended Butt/Good

Composition—percent

	Nominal	Minimum	Maximum
Copper (incl. Silver)	....	99.90	....
Oxygen	.04	....	....

Nearest Applicable A S T M Specifications

Flat Products	B11, B48, B101, B124, B133, B152, B187, B272, B370
Pipe	B188
Rod	B12, B49, B124, B133, B187
Shapes	B124, B133, B187, B283
Tube	B111, B188, B447
Wire	B1, B2, B3, B8, B33, B47, B49, B116, B189, B246, B286, B298, B355

Physical Properties

	English Units		C.G.S. Units	
Melting Point (Liquidus)	1981	F	1083	C
Melting Point (Solidus)	1949	F	1065	C
Density	.321 - .323	lb/cu in @ 68 F	8.89 - 8.94	gm/cu cm @ 20 C
Specific Gravity	8.89 - 8.94		8.89 - 8.94	
Coefficient of Thermal Expansion	.0000094	per ° F from 68 F to 212 F	.0000170	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000096	per ° F from 68 F to 392 F	.0000173	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098	per ° F from 68 F to 572 F	.0000177	per ° C from 20 C to 300 C
Thermal Conductivity	226	Btu/sq ft/ft/hr/°F @ 68 F	.934	cal/sq cm/cm/sec/° C @ 20 C
Electrical Resistivity (Annealed)	10.3	Ohms (circ mil/ft) @ 68 F	1.71	Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	101	% IACS @ 68 F	.586	Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092	Btu/lb °F @ 68 F	.092	cal/gm/° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000	psi	12,000	Kg/sq mm
Modulus of Rigidity	6,400,000	psi	4,500	Kg/sq mm

*Volume and Weight Basis

Typical Uses

ARCHITECTURAL: building fronts, downspouts, flashing, gutters, roofing, screening, spouting
AUTOMOTIVE: gaskets, radiators
ELECTRICAL: bus bars, conductivity wire, contacts, radio parts, switches, terminals
HARDWARE: ball floats, butts, cotter pins, nails, rivets, soldering copper, tacks
MISCELLANEOUS: anodes, chemical process equipment, kettles, pans, printing rolls, rotating bands, road bed expansion plates, vats

Common Fabrication Processes

Blanking, coining, coppersmithing, drawing, etching, forming and bending, heading and upsetting, hot forging and pressing, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked ..... Excellent
Capacity for Being Hot Formed ..... Excellent
Hot Forgeability Rating (Forging Brass = 100) 65
Hot Working Temperature ..... 1400-1600 F or 750-875 C
Annealing Temperature ..... 700-1200 F or 375-650 C
Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:
Soldering ..... Excellent
Brazing ..... Good
Oxyacetylene Welding ..... Not Recommended
Gas Shielded Arc Welding ..... Fair
Coated Metal Arc Welding ..... Not Recommended
Resistance Welding
Spot ..... Not Recommended
Seam ..... Not Recommended
Butt ..... Good

Forms and Tempers Most Commonly Used

		Annealed Tempers								Rolled or Drawn Tempers											Hot Finished Tempers		
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn—General Purpose (1)	Hard Drawn (2)	Light Drawn—Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled					●		●		●	●	●		●		●	●				●		
	Strip, Drawn							●						●									
	Flat Wire, Rolled							●						●									
	Flat Wire, Drawn							●						●	●								
	Bar, Rolled							●			●			●	●						●		
	Bar, Drawn							●			●			●	●								
	Sheet							●		●		●									●		
	Plate							●		●											●		
	ROD							●						●							●		
	WIRE							●		●	●			●		●							
	TUBE					●		●										●	●	●			
	PIPE																						
	SHAPES							●						●							●	●	

1. DRAWN—GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN—BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section	Temper	Tensile Strength	Yield Strength (.5 Ext. under Load)	Yield Strength (.2% Offset)	Elongation in 2 in.	Rockwell Hardness F	Rockwell Hardness B	Rockwell Hardness 30T	Shear Strength	Fatigue Strength	Fatigue Strength
	in.		ksi	ksi	ksi	%				ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm	32.0	10.0	....	45	40	—	—	22.0	....	....
		.025 mm	34.0	11.0	....	45	45	—	—	23.0	11.0	100
		Eighth Hard	36.0	28.0	....	30	60	10	25	25.0	....	....
		Quarter Hard	38.0	30.0	....	25	70	25	36	25.0	....	....
		Half Hard	42.0	36.0	....	14	84	40	50	26.0	13.0	100
		Hard	50.0	45.0	....	6	90	50	57	28.0	13.0	100
		Spring	55.0	50.0	....	4	94	60	63	29.0	14.0	100
		Extra Spring	57.0	53.0	....	4	95	62	64	29.0	....	....
		As Hot Rolled	34.0	10.0	....	45	45	—	—	23.0	....	....
	.025 in.	.050 mm	32.0	10.0	....	50	40	—	—	22.0	....	....
		Eighth Hard	36.0	28.0	....	40	60	10	—	25.0	....	....
		Quarter Hard	38.0	30.0	....	35	70	25	—	25.0	....	....
		Hard	50.0	45.0	....	12	90	50	—	28.0	....	....
		As Hot Rolled	32.0	10.0	....	50	40	—	—	22.0	....	....
	1.0 in.	Hard	45.0	40.0	....	20	85	45	—	26.0	....	....
ROD	1.0 in.	.050 mm	32.0	10.0	....	55	40	—	—	22.0	....	....
	.250 in.	Hard (40%)	55.0	50.0	....	10	94	60	—	29.0	....	....
	1.0 in	Hard (35%)	48.0	44.0	....	16	87	47	—	27.0	17.0	100
	2.0 in.	Hard (16%)	45.0	40.0	....	20	85	45	—	26.0	....	....
	1.0 in.	As Hot Rolled	32.0	10.0	....	55	40	—	—	22.0	....	....
WIRE	.080 in.	.050 mm	35.0	. . .	....	35*	—	—	—	24.0	....	....
		Hard	55.0	. . .	....	1.5**	—	—	—	29.0	....	....
		Spring	66.0	. . .	....	1.5**	—	—	—	33.0	....	....
TUBE	1.0 in. OD X.065 in.	.050 mm	32.0	10.0	....	45	40	—	—	22.0	....	....
		.025 mm	34.0	11.0	....	45	45	—	—	23.0	....	....
		Light Drawn (15%)	40.0	32.0	....	25	77	35	45	26.0	....	....
		Hard Drawn (40%)	55.0	50.0	....	8	95	60	63	29.0	....	....
SHAPES	.500 in.	.050 mm	32.0	10.0	....	50	40	—	—	22.0	....	....
		Hard (15%)	40.0	32.0	....	30	—	35	—	26.0	....	....
		As Hot Rolled	32.0	10.0	....	50	40	—	—	22.0	....	....
		As Extruded	32.0	10.0	....	50	40	—	—	22.0	....	....

*Elongation in 10 inches. **Elongation in 60 inches.

The values listed above represent approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

Specification Equivalents

Copper Alloy Number	Specifications
C10100	SAE-CA102/ASTM-F68-68

Chemical Composition % by Weight

Copper	Residual Deoxidants	Phosphorus	Tellurium
99.99	-	.0003	.0010

Material Properties

High thermal and electrical conductivity and high ductility combined with low volatility makes this material indispensable in the electronic industry.

Applications

Some typical uses for Copper Alloy 10100 in the electrical and electronic are bus bars, bus conductors, wave guides, hollow conductors, lead-in wires and anodes for vaccum tubes, glass to metal seals and others.

Mechanical Properties

Hardness*	Rockwell F Scale	87
Tensile Strength**	PSI	48,000
Yield Strength**	PSI	44,000
Elongation**	%	15
Shear strength	PSI	-

*Hardness Conversions are approximate.

**Tensile Test values are nominal approximations and depend on specimen size and orientation.

Physical Properties

Thermal Conductivity	BTU/(sq ft-ft-hr-F)	226
Specific Heat	BTU/lb/°F @ 68F	.092
Thermal Expansion	per °F from 68 F to 212 F	.0000094
Density	lb/cu in @ 68 F	.323
Electrical Conductivity*	% IACS @ 68 F	101
Modulus of Elasticity	PSI	17,000,000

*Based on specimen size and orientation.

Fabrication Properties

Capacity for Being Cold Worked	Excellent
Capacity for Being Hot Formed	Excellent
Hot Forgeability Rating (Forging Brass = 100)	65
Hot Working Temperature	1400-1600 F or 750-875 C
Annealing Temperature	700-1200 F or 375-650 C
Machinability Rating (Free Cutting Brass = 100)	20
Suitability for being joined by:	Soldering/Excellent Brazing/Good Oxyacetylene Welding/Not Recommended Gas Shielded Arc Welding/Fair Coated Metal Arc Welding/Not Recommended Spot/Not Recommended
Resistance Welding	Seam/Not Recommended Butt/Good

Composition—percent

	Nominal	Minimum	Maximum
Copper	....	99.99	....
Residual Deoxidants	...	None	
Phosphorus	...	....	.0003
Tellurium	...	....	.0010
Other Named Elements*,**	...	....	....

Nearest Applicable A S T M Specifications

Flat Products	B48, B133, B152, B187
	B272, B432, F68
Pipe	B42, B188, F68
Rod	B12, B49, B133, B187, F68
Shapes	B133, B187, F68
Tube	B68, B75, B188, B280, B372, F68
Wire	B1, B2, B3, F68

*Hg, max., 1 ppm, (.0001%); Zn, max., 1 ppm, (.0001%); Cd, max., 1 ppm, (.0001%); S, max., 18 ppm, (.0018%); Pb, max., 10 ppm, (.0010%); Se, max., 10 ppm (.0010%); Bi, max., 10 ppm (.0010%); Oxygen max., 10 ppm, (.0010%).

**The total of the seven following elements, Se, Te, Bi, As, Sb, Sn and Mn not to exceed 40 ppm, (.0040%).

Physical Properties

	English Units		C.G.S. Units	
Melting Point (Liquidus)	1981	F	1083	C
Melting Point (Solidus)	1981	F	1083	C
Density	.323	lb/cu in @ 68 F	8.94	gm/cu cm @ 20 C
Specific Gravity	8.94		8.94	
Coefficient of Thermal Expansion	.0000094	per ° F from 68 F to 212 F	.0000170	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000096	per ° F from 68 F to 392 F	.0000173	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098	per ° F from 68 F to 572 F	.0000177	per ° C from 20 C to 300 C
Thermal Conductivity	226	Btu/sq ft/ft/hr/°F @ 68 F	.934	cal/sq cm/cm/sec/° C @ 20 C
Electrical Resistivity (Annealed)	10.3	Ohms (circ mil/ft) @ 68 F	1.71	Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	101	% IACS @ 68 F	.586	Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092	Btu/lb °F @ 68 F	.092	cal/gm/° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000	psi	12,000	Kg/sq mm
Modulus of Rigidity	6,400,000	psi	4,500	Kg/sq mm

*Volume and Weight Basis, minimum value

Typical Uses

ELECTRICAL AND ELECTRONIC: bus bars, bus conductors and other conductors, wave guides, hollow conductors, lead-in wires and anodes for vacuum tubes, vacuum seals, transistor components, glass to metal seals, coaxial cables and coaxial tubes, klystrons, micro-wave tubes, automotive rectifiers.

Common Fabrication Processes

Blanking, coining, coppersmithing, drawing, etching, forming and bending, heading and upsetting, hot forging and pressing, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping.

Fabrication Properties

Capacity for Being Cold Worked ..... Excellent
Capacity for Being Hot Formed ..... Excellent
Hot Forgeability Rating (Forging Brass = 100) 65
Hot Working Temperature ..... 1400-1600 F or 750-875 C
Annealing Temperature ..... 700-1200 F or 375-650 C
Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:
Soldering ..... Excellent
Brazing ..... Excellent
Oxyacetylene Welding ..... Fair
Gas Shielded Arc Welding ..... Good
Coated Metal Arc Welding ..... Not Recommended
Resistance Welding: Spot ..... Not Recommended
Resistance Welding: Seam ..... Not Recommended
Resistance Welding: Butt ..... Good

Forms and Tempers Most Commonly Used

		Annealed Tempers							Rolled or Drawn Tempers											Hot Finished Tempers		
		Nominal Grain Size mm																				
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn—General Purpose (1)	Hard Drawn (2)	Light Drawn—Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled					●		●		●	●	●		●		●	●				●		
	Strip, Drawn							●						●									
	Flat Wire, Rolled							●						●									
	Flat Wire, Drawn							●						●	●								
	Bar, Rolled							●			●			●	●						●		
	Bar, Drawn							●			●			●	●								
	Sheet							●		●		●									●		
	Plate									●											●		
	ROD													●							●	●	
	WIRE							●		●	●			●		●							
	TUBE					●		●										●	●	●			
	PIPE																	●					
	SHAPES							●						●							●	●	

1. DRAWN—GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN—BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section	Temper	Tensile Strength	Yield Strength (.5 Ext. under Load)	Yield Strength (.2% Offset)	Elongation in 2 in.	Rockwell Hardness F	Rockwell Hardness B	Rockwell Hardness 30T	Shear Strength	Fatigue Strength	Fatigue Strength Million Cycles
	in.		ksi	ksi	ksi	%				ksi	ksi	
FLAT PRODUCTS	.040 in.	.050 mm	32.0	10.0	....	45	40	—	—	22.0	....	....
		.025 mm	34.0	11.0	....	45	45	—	—	23.0	11.0	100
		Eighth Hard	36.0	28.0	....	30	60	10	25	25.0	....	....
		Quarter Hard	38.0	30.0	....	25	70	25	36	25.0	....	....
		Half Hard	42.0	36.0	....	14	84	40	50	26.0	13.0	100
		Hard	50.0	45.0	....	6	90	50	57	28.0	13.0	100
		Spring	55.0	50.0	....	4	94	60	63	29.0	14.0	100
		Extra Spring	57.0	53.0	....	4	95	62	64	29.0	....	....
		As Hot Rolled	34.0	10.0	....	45	45	—	—	23.0	....	....
	.025 in.	.050 mm	32.0	10.0	....	50	40	—	—	22.0	....	....
		Eighth Hard	36.0	28.0	....	40	60	10	—	25.0	....	....
		Quarter Hard	38.0	30.0	....	35	70	25	—	25.0	....	....
		Hard	50.0	45.0	....	12	90	50	—	28.0	....	....
		As Hot Rolled	32.0	10.0	....	50	40	—	—	22.0	....	....
	1.0 in.	Hard	45.0	40.0	....	20	85	45	—	26.0	....	....
ROD	1.0 in.	.050 mm	32.0	10.0	....	55	40	—	—	22.0	....	....
	.250 in.	Hard (40%)	55.0	50.0	....	10	94	60	—	29.0	....	....
	1.0 in	Hard (35%)	48.0	44.0	....	16	87	47	—	27.0	17.0	100
	2.0 in.	Hard (16%)	45.0	40.0	....	20	85	45	—	26.0	....	....
	1.0 in.	As Hot Rolled	32.0	10.0	....	55	40	—	—	22.0	....	....
WIRE	.080 in.	.050 mm	35.0	. . .	....	35*	—	—	—	24.0	....	....
		Hard	55.0	. . .	....	1.5**	—	—	—	29.0	....	....
		Spring	66.0	. . .	....	1.5**	—	—	—	33.0	....	....
TUBE	1.0 in. OD	.050 mm	32.0	10.0	....	45	40	—	—	22.0	....	....
	X.065 in.	.025 mm	34.0	11.0	....	45	45	—	—	23.0	....	....
		Light Drawn (15%)	40.0	32.0	....	25	77	35	45	26.0	....	....
		Hard Drawn (40%)	55.0	50.0	....	8	95	60	63	29.0	....	....
SHAPES	.500 in.	.050 mm	32.0	10.0	....	50	40	—	—	22.0	....	....
		Hard (15%)	40.0	32.0	....	30	—	35	—	26.0	....	....
		As Hot Rolled	32.0	10.0	....	50	40	—	—	22.0	....	....
		As Extruded	32.0	10.0	....	50	40	—	—	22.0	....	....

*Elongation in 10 inches. **Elongation in 60 inches.

The values listed above represent approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

STANDARD BAR STOCK SIZES

SQUARES Class II & Class III	WT. /FT.
1/8 X 1/8	.05
3/8 X 3/8	.54
1/2 X 1/2	.96
5/8 X 5/8	1.50
3/4 X 3/4	2.16
1 X 1	3.84
1-1/4 X 1-1/4	6.00
1-1/2 X 1-1/2	8.64
2 X 2	15.36
HEXAGONS Class II & Class III	**WT. /FT.**
1/2	.839
3/4	1.89
7/8	2.50
1	3.36
1-1/4	5.25
1-1/2	7.55

PLATE SIZES

1/8
3/16
1/4
3/8
1/2
5/8
3/4
1
1-1/4
1-1/2
1-3/4
2
2-1/2
3
4
5
6

Thickness X Width X Length X .322 = Approx. Total Weight

ROUNDS Class II & Class III	WT. /FT.
1/8	.048
3/16	.106
1/4	.189
5/16	.296
3/8	.426
7/16	.577
.482	.701
1/2	.758
9/16	.961
5/8	1.18
3/4	1.70
7/8	2.32
1	3.03
1-1/8	3.84
1-1/4	4.74
1-3/8	5.76
1-1/2	6.82
1-5/8	8.01
1-3/4	9.36
2	12.12
2-1/4	15.48
2-1/2	18.96
2-3/4	23.00
3	27.14
3-1/8	29.64
3-1/4	32.20
3-1/2	37.30
3-5/8	39.11
4-1/8	51.80
5-1/8	78.19
6-1/8	111.68
7-1/8	151.13
8-1/8	202.34
10-1/8	314.35

RECTANGLES Class II & Class III	WT. /FT.
1/4 X 1/2	.48
1/4 X 3/4	.72
1/4 X 1	.96
1/4 X 1-1/2	1.44
1/4 X 2	1.92
1/4 X 3	2.90
3/8 X 1/2	.73
3/8 X 3/4	1.08
3/8 X 1	1.45
3/8 X 1-1/2	2.17
3/8 X 2	2.91
1/2 X 5/8	1.21
1/2 X 3/4	1.44
1/2 X 1	1.92
1/2 X 1-1/2	2.88
1/2 X 2	3.84
1/2 X 2-1/2	4.80
1/2 X 3	5.76
1/2 X 4	7.73
5/8 X 3/4	1.80
5/8 X 1	2.40
5/8 X 1-1/2	3.60
5/8 X 2	4.80
3/4 X 1	2.88
3/4 X 1-1/4	3.63
3/4 X 1-1/2	4.32
3/4 X 1-3/4	5.07
3/4 X 2	5.76
3/4 X 2-1/2	7.20
3/4 X 3	8.64
1 X 1-1/4	4.85
1 X 1-1/2	5.76
1 X 2	7.68
1 X 2-1/2	9.60
1 X 3	11.52
1 X 4	15.46
1-1/4 X 1-1/2	7.25
1-1/4 X 2	9.66
1-1/2 X 2	11.52
1-1/2 X 3	17.28

O.F.H.C. 101 AND ALLOY C-110

ROUNDS AND PLATES AVAILABLE

Cut To Your Specifications

ROUNDS

1/4 dia. × 12' ml
5/16 dia. × 12' ml
3/8 dia. × 12' ml
7/16 dia. × 12' ml
1/2 dia. × 12' ml
5/8 dia. × 12' ml
3/4 dia. × 12' ml
7/8 dia. × 12' ml
1 dia. × 12' ml
1 1/8 dia. × 12' ml
1 1/4 dia. × 12' ml
1 1/2 dia. × 12' ml
2 dia. × 12' ml
2 1/4 dia. × 12' ml
2 1/2 dia. × 12' ml
3 dia. × 12' ml
4 dia. × ml
5 dia. × ml
6 dia. × ml

PLATES

1/8 × 36 × 96
1/4 × 36 × 96
3/8 × 36 × 96
1/2 × 36 × 96
5/8 × 36 × 96
3/4 × 36 × 96
1 × 36 × 96
1 1/4 × 36 × 96
1 1/2 × 36 × 96
2 × 36 × 96
2 1/2 × 24 × 72
3 × 24 × 72
3 1/2 × 24 × 72
4 × 24 × 72

Manufacturer Cross Reference

RWMA	GROUP A COPPER BASE ALLOYS						GROUP B REFRACTORY METAL COMPOSITIONS				
MANUFACTURER	CLASS 1	CLASS 1A	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 10	CLASS 11	CLASS 12	CLASS 13	CLASS 14
Ampco		Ampcoloy 98	Ampcoloy 97	Ampcoloy 940	Ampcoloy 84	Ampcoloy 92	Ampcoloy 40	Ampcoloy 42	Ampcoloy 43	Ampcoloy 80	
CMW	Elkaloy® A	CMW 2	CMW 3	CMW 100	CMW 73	Elkaloy® D	Elkonite® 1W3	Elkonite® 10W3	Elkonite® 30W3	Elkonite® 100W	Elkonite® 100M
Cadi	C-1	C-1A	C-2	C-3	C-4	C-5	C-1W	C-10	C-20	C-T	C-M
Centerline	Centerline CL-1	Centerline CL-1A	Centerline CL-2	Centerline CL-3	Centerline CL-4	Centerline CL-5	Centerline 1W3	Centerline 10W3	Centerline 20W3	Centerline 100W	Centerline 100M
Electroloy	Electroloy A	Electroloy 100-A	Electroloy XX	Electroloy TX	Electroloy B	Electroloy Molin-2	Electroloy 1	Electroloy 10	Electroloy 20	Electroloy 100	Electroloy 500
Hercules	H-1	H-1A	H-2	H-3	H-4	H-5	H-1W	H-10W	H-20W	H-100W	H-14M
Tipaloy	#100	100-A	#130	200/240	T-5	T-5	T-1W	T-10W	T-20W	T-100W	T-100M
Tuffaloy Products	Tuffaloy 88	Tuffaloy 88-A	Tuffaloy 77	Tuffaloy 55	Tuffaloy 44	Tuffaloy 66	Tuffaloy 1W	Tuffaloy 10W	Tuffaloy 20W	Tuffaloy 100W	Tuffaloy 100M
Weldaloy	Weldaloy 10	Weldaloy 20HC	Weldaloy 20	Weldaloy 60	Weldaloy 40	Weldaloy 50	Weldtung 10CT8	Weldtung 20CT	Weldtung 30CT	Weldtung W	Weldtung M
Welform	CL-1	CL-1A	CL-2	CL-3	CL-4	CL-5	W-1-W	W-10W	W-20W	W-100W	W-100M
Availability	Bars Forgings	Bars Forgings Castings	Bars Forgings Castings	Bars Forgings Castings	Bars Forgings Castings	Castings	Bars Inserts	Bars Inserts	Bars Inserts	Bars Inserts	Bars Inserts

Refactory materials are a combination of tungsten or tungsten carbide with copper and/or silver. The result is a very hard material with superior arc and wear resistance, and strength at elevated temperatures, yet retaining good thermal and electrical conductivity.

The mechanical and physical properties vary with the composition. The thermal and electrical conductivity increases with the amount of copper or silver, while the hardness, strength and resistance to mechanical wear increase with the amount of tungsten or tungsten carbide. The application will determine the material choice.

RESISTANCE WELDING

Copper Tungsten Materials

Typical Physical and Mechanical Properties

RWMA Group B	Nominal Composition % Weight	Electrical Conductivity % IACS	Rockwell Hardness	Ultimate Strength PSI	Cross Breaking Strength PSI	Density GMS/CC	Accepted Material Designation	Typical Resistance Welding Applications
—	45% Copper 55% Tungsten	53	79B	63,000	110,000	12.6	Elkonite® 1W3	Flash and butt welding die inserts requiring high electrical and thermal conductivity. Electrode facings for the welding of stainless steel.
—	32% Copper 68% Tungsten	50	88B	75,000	130,000	13.93	Elkonite® 3W3	
Class 10	30% Copper 70% Tungsten	48	90B	85,000	140,000	14.18	Elkonite® 5W3	Light duty projection welding dies where weld pressures are medium to light.
Class 11	25% Copper 75% Tungsten	46	98B	90,000	150,000	14.70	Elkonite® 10W3	Used for facings and inserts for flash and butt welding dies, projection welding electrodes, seam welding bearing inserts, facings for electro-forming and electro-forging dies. Often used for EDM electrodes for greater wear ratios.
Class 11 & 12	22% Copper 78% Tungsten	44	99B	94,000	160,000	14.80	Elkonite® 20W3	CL 12 used where a slightly harder material is required for the same applications as CL 11.
Class 12	20% Copper 80% Tungsten	42	103B	98,000	170,000	15.4	Elkonite® 30W3	Heavy duty projection welding electrodes, die facings for electro-forming and electro-forging, also facings for upsetting of rivets and studs.
—	25% Copper Alloy 75% Tungsten	28	109B	160,000	200,000	14.7	Elkonite® 10W53	Supplied in fully heat treated condition and must be heat treated after brazing. Used where temperatures and pressures are relatively high for electro-forging and electrical upsetting.
—	50% Copper 50% Tungsten Carbide	47	94B	70,000	140,000	11.27	Elkonite® TC-5	Light duty projection welding dies where pressures are not extreme but where abrasion may be encountered.
—	44% Copper 56% Tungsten Carbide	42	99B	75,000	160,000	11.67	Elkonite® TC-10	Where abrasion is encountered for heavy duty projection welding electrode and die facings for electro-forming and electro-forging.
—	30% Copper 70% Tungsten Carbide	30	37C	85,000	180,000	12.6	Elkonite® TC-20	An extremely hard material, highly resistant to wear for electro-forging and upsetting, impractical to machine and should be ground.
—	30% Copper Alloy 70% Tungsten Carbide	18	47C	150,000	220,000	12.6	Elkonite® TC-53	Extremely hard material requiring grinding. Supplied in fully heat treated condition and must be heat treated after brazing. Use in very abrasive applications for electical upsetting and electro-forging.

RECTANGULAR BARS 8" LONG

STANDARD TOLERANCE + .015-.000

THICKNESS x WIDTH
1/8 x 1/8 1/8 x 3/16 1/8 x 1/4 1/8 x 3/8 1/8 x 1/2
1/8 x 5/8 1/8 x 3/4 1/8 x 7/8 1/8 x 1 1/8 x 1-1/8
1/8 x 1-1/4 1/8 x 1-3/8 1/8 x 1-1/2 1/8 x 1-5/8 1/8 x 1-3/4
1/8 x 2 1/8 x 3 1/8 x 4
3/16 x 3/16 3/16 x 1/4 3/16 x 3/8 3/16 x 1/2 3/16 x 5/8
3/16 x 3/4 3/16 x 7/8 3/16 x 1 3/16 x 1-1/8 3/16 x 1-1/4
3/16 x 3/8 3/16 x 1-1/2 3/16 x 1-5/8 3/16 x 1-3/4 3/16 x 2
3/16 x 3 3/16 x 4
1/4 x 1/4 1/4 x 3/8 1/4 x 1/2 1/4 x 5/8 1/4 x 3/4
1/4 x 7/8 1/4 x 1 1/4 x 1-1/8 1/4 x 1-1/4 1/4 x 1-3/8
1/4 x 1-1/2 1/4 x 1-5/8 1/4 x 1-3/4 1/4 x 2 1/4 x 3 1/4 x 4
3/8 x 3/8 3/8 x 1/2 3/8 x 5/8 3/8 x 3/4 3/8 x 7/8
3/8 x 1 3/8 x 1-1/8 3/8 x 1-1/4 3/8 x 1-3/8 3/8 x 1-1/2
3/8 x 1-5/8 3/8 x 1-3/4 3/8 x 2 3/8 x 3 3/8 x 4
1/2 x 1/2 1/2 x 5/8 1/2 x 3/4

THICKNESS x WIDTH
1/2 x 7/8 1/2 x 1 1/2 x 1-1/8 1/2 x 1-1/4 1/2 x 1-3/8
1/2 x 1-1/2 1/2 x 1-5/8 1/2 x 1-3/4 1/2 x 2 1/2 x 3 1/2 x 4
5/8 x 5/8 5/8 x 3/4 5/8 x 7/8 5/8 x 1 5/8 x 1-1/8
5/8 x 1-1/4 5/8 x 1-3/8 5/8 x 1-1/2 5/8 x 1-5/8 5/8 x 1-3/4
5/8 x 2 5/8 x 3 5/8 x 4
3/4 x 3/4 3/4 x 7/8 3/4 x 1 3/4 x 1-1/8 3/4 x 1-1/4
3/4 x 1-3/8 3/4 x 1-1/2 3/4 x 1-5/8 3/4 x 1-3/4 3/4 x 2
3/4 x 3 3/4 x 4
7/8 x 7/8 7/8 x 1 7/8 x 1-1/8 7/8 x 1-1/4 7/8 x 1-3/8
7/8 x 1-1/2 7/8 x 1-5/8 7/8 x 1-3/4 7/8 x 2 7/8 x 3 7/8 x 4
1 x 1 1 x 1-1/8 1 x 1-1/4 1 x 1-3/8 1 x 1-1/2
1 x 1-5/8 1 x 1-3/4 1 x 2 1 x 3 1 x 4
1-1/8 x 1-1/8
1-1/4 x 1-1/4 1-1/4 x 1-1/2 1-1/4 x 1-3/4 1-1/4 x 2
1-1/2 x 1-1/2 1-1/2 x 2
1-5/8 x 2
1-3/4 x 1-3/4 1-3/4 x 2
2 x 2

ROUND BARS

8" LONG

STANDARD TOLERANCE + .010-.000

FINISHED DIAMETER
1/8 3/16 1/4 5/16 3/8
7/16 1/2 9/16 5/8 3/4
7/8 1 1-1/8 1-1/4 1-3/8
1-1/2 1-5/8 1-3/4 2 2-1/4 2-1/2

12" LONG

STANDARD TOLERANCE + .050-.000

FINISHED DIAMETER
1/8 3/16 1/4 5/16 3/8
7/16 1/2 9/16 5/8 3/4
7/8 1

DISC

STANDARD TOLERANCE + .050-.000

DIAMETER x THICKNESS
3/8 x 3/16 3/8 x 1/4 1/2 x 3/16 1/2 x 1/4 5/8 x 1/4
3/4 x 1/4 7/8 x 1/4 1 x 1/4 1-1/4 x 1/4 1-3/8 x 1/4
1-1/2 x 1/4 1-3/4 x 1/4 2 x 1/4

Special Sizes Available Upon Request

Class 13 = (Tungsten)
Class 14 = (Molybdenum)

Class 13 and 14 materials are recommended principally for welding or electro-brazing non-ferrous metals having relatively high electrical conductivity.

Cross wire welding of copper and brass wires and welding of copper wire braid to brass and bronze terminals are typical applications. Generally, special set-ups and procedures are required for this type of work.

Also available
Silver Tungsten **S35WS**
S20WS
S50WS

BRASS AND BRONZE

Alloy 360 Brass
(C36000 Free-Cutting Brass)

Alloy 360 Brass resists corrosion and is easily soldered or brazed. Gears and pinions are among many applications that 360 Brass is used. This alloy is also used in high speed screw machine parts and has a machinability rating of 100%.

Alloy 464 Naval Brass
(C46400)

Alloy 464 Naval Brass is recommended for marine hardware and pump shafts as well as nuts, bolts, rivets, and valve stems. It is highly known for resisting corrosion in seawater even at higher than normal temperatures. This alloy is excellent for hot working. Naval Brass is 40% zinc brass and 1% tin and is easily soldered, brazed and welded.

Alloy 932 Bearing Bronze
(C93200 Bearing Bronze 660)

Alloy 932 Bearing Bronze is recommended for bearings, bushings and wear plates. This alloy also resists corrosion in seawater but not as well as the Alloy 464 Naval Brass. Bearing Bronze is used for pump and valve components as well as automotive equipment and hoists. Alloy 932 has good machining capabilities and excellent antifriction qualities.

Alloy 954 Aluminum Bronze
(C95400 Aluminum Bronze)

There are many recommended uses for 954 Aluminum Bronze some of which include weld guns, nuts, bearings, pump parts, bushings and gears. This all-purpose alloy resists wear and deformation under extreme loads and stress. Alloy 954 has a machinability rating of 60% along with high ductility and weldability.

The alloys above are available in diameters, rectangles, squares, hex, and tubing. Other Brass and Bronze alloys are also available upon request.

SEAM WELDING WHEELS

Seam Welding Wheels are definitely not as widely used as they were ten years ago. The availability of some alloys or R.W.M.A classes of copper are becoming harder and harder to acquire.

FACT OR FICTION:

All weld wheels are made the same.

FICTION

All seam welding wheels are not manufactured the same. There are distributors and manufacturers that supply weld wheels that are **cast** billet, cut to thickness, and then heat treated to meet R.W.M.A. standards for hardness and conductivity. This method of producing weld wheels will work in some instances. When researching wheels, initially, this method is cheaper. Over a year's period, production versus total costs, (including cost of the wheels, dressing and change over), Southern Copper can offer an alternative to cast billet weld wheels that will last longer and be more cost effective. We can offer forged weld wheels in sizes and alloys that will best meet your application needs. Southern Copper's pricing, availability and the quality of product will definitely be an advantage to your company.

RWMA CLASS 2
HARDNESS: 65 ROCKWELL "B" MINIMUM
CONDUCTIVITY: 75% I.A.C.S. MINIMUM

RWMA CLASS 2 PREMIUM
HARDNESS: 75 ROCKWELL "B" MINIMUM
CONDUCTIVITY: 75% I.A.C.S. MINIMUM

FACT

The most commonly used alloy for weld wheels is R.W.M.A. Class 2 Copper. This alloy is recommended for seam welding hot-rolled and cold rolled steels. It is sometimes used for welding coated metals as well.

When one is welding thicker gages, or where higher pressures maybe needed to secure the proper weld bead, Southern Copper recommends R.W.M.A. alloy Class 2 Premium weld wheel. The hardness of these wheels (approximately 75 Rockwell "B" for Class 2 Premium compared to 65 Rockwell "B" minimum for standard Class 2 weld wheel). The conductivity for both wheels is 75% I.A.C.S.. This classification can also fall into two different alloys, C18200 and C18150. Southern Copper stocks the C18200 weld wheel.

FICTION

Some distributors claim that they can supply Class 2 Premium weld wheels in a much harder condition (hardness of 80 or higher). Our answer to this statement is they are trying to sell you a "bill of goods". Although Class 2 Premium weld wheels do typically range from a Rockwell "B" hardness of 75-82, no manufacturer or distributor can guarantee a minimum hardness of 80. Also, material with higher hardness can lead to stress fractures in the wheel when welding.

SEAM WELDING WHEELS

FACT

This R.W.M.A. Classification is covered by two different alloys, Alloy C18000 and Alloy C17510.

R.W.M.A. Class 3 (C17510) is primarily used for seam welding stainless steel, as well as where high temperatures may be needed to insure proper welds. Most machinists find it easier to machine. However, the cost of this alloy is usually much higher than the R.W.M.A. Class 3 (C18000).

R.W.M.A. Class 3 (C18000). is primarily used for seam welding where high temperatures are needed, as well as hot and cold rolled steel, as well as some coated metals. It also can be used to weld stainless steel, given strict use of certain parameters.

FICTION

All distributors or manufacturers disclose the alloy or R.W.M.A. classification they are using to manufacture your weld wheel. Resistance Welding Manufacturers Association standards do not require the distributor or manufacturer to disclose the classification or alloy of the material they are using to produce your weld wheel. Therefore, if you are having a problem with your welding processes, it may not be the R.W.M.A. Class of material you are using, but the alloy.

RWMA CLASS 3 (C17510)
HARDNESS: 90 ROCKWELL “B” MINIMUM
CONDUCTIVITY: 45% I.A.C.S. MINIMUM

RWMA CLASS 3 (C18000)
HARDNESS: 90 ROCKWELL “B” HARDNESS
CONDUCTIVITY: 45% I.A.C.S. MINIMUM
OTHER R.W.M.A CLASSIFICATIONS:

FACT

This R.W.M.A. Class can be found in smaller diameters, and very few rectangles/ or squares, but is very unlikely to be found in forged discs as forgings, which are used for seam welding. These coppers are used for welding aluminum, some coated metals, and hot and cold rolled steels.

R.W.M.A. Class 1 - C16200 OR C15000
HARDNESS: 55 ROCKWELL “B” MINIMUM
CONDUCTIVITY: 75% I.A.C.S. MINIMUM

Due to the current move to convert or switch from inches to the metric system as a universal measuring system we are including the three tables below to allow conversion from inches into millimeters.

Examples:

Convert 0.588 inches into millimeters

From Table I 0.580 inches = 14.73 millimeters
From Table I 0.008 inches = 0.203 millimeters
Total 0.588 inches = 14.933 millimeters

Convert 3.065 inches into millimeters

From Table II 3 inches = 76.2002 millimeters
From Table I 0.060 inches = 1.524 millimeters
From Table I 0.005 inches = 0.127 millimeters
Total 3.065 inches = 77.8512 millimeters

Convert 2-51/64 inches into millimeters

From Table II 2-25/32 inches = 70.6439 millimeters
From Table II 1/64 inches = 0.3969 millimeters
Total 2-51/64 inches = 71.0408 millimeters

TABLE I
Decimals of an inch into millimeters

Inches	Milli-meters	Inches	Milli-meters
0.001	0.025	0.460	11.68
0.002	0.051	0.470	11.94
0.003	0.076	0.480	11.94
0.004	0.102	0.490	12.45
0.005	0.127	0.500	12.70
0.006	0.152	0.510	12.95
0.007	0.178	0.520	13.21
0.008	0.203	0.530	13.26
0.009	0.229	0.540	13.72
0.010	0.254	0.550	13.97
0.020	0.508	0.560	14.22
		0.570	14.48
0.030	0.762	0.580	14.73
0.040	1.016	0.590	14.99
0.050	1.270	0.600	15.24
0.060	1.524	0.610	15.49
0.070	1.778	0.620	15.75
0.080	2.032	0.630	16.00
0.090	2.286	0.640	16.26
0.100	2.540	0.650	16.51
0.110	2.794	0.660	16.76
0.120	3.048	0.670	17.02
0.130	3.302	0.680	17.27
0.140	3.56	0.690	17.53
0.150	3.81	0.700	17.78
0.160	4.06	0.710	18.03
0.170	4.32	0.720	18.29
0.180	4.57	0.730	18.54
0.190	4.83	0.740	18.80
0.200	5.08	0.750	19.05
0.210	5.33	0.760	19.30
0.220	5.59	0.770	19.56
0.230	5.84	0.780	19.81
0.240	6.10	0.790	20.07
0.250	6.35	0.800	20.32
0.260	6.60	0.810	20.57
0.270	6.86	0.820	20.83
0.280	7.11	0.830	21.08
0.290	7.37	0.840	21.34
0.300	7.62	0.850	21.59
0.310	7.87	0.860	21.84
0.320	8.13	0.870	22.10
0.330	8.38	0.880	22.35
0.340	8.64	0.890	22.61
0.350	8.89	0.900	22.86
0.360	9.14	0.910	23.11
0.370	9.40	0.920	23.37
0.380	9.65	0.930	23.62
0.390	9.91	0.940	23.88
0.400	10.16	0.950	24.13
0.410	10.41	0.960	24.38
0.420	10.67	0.970	24.64
0.430	10.92	0.980	24.89
0.440	11.18	0.990	25.15
0.450	11.43	1.000	25.40

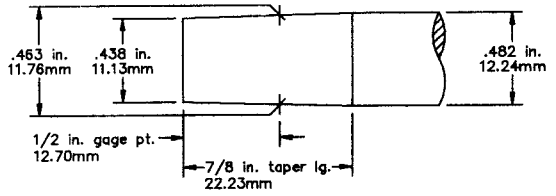
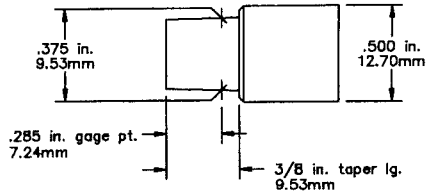
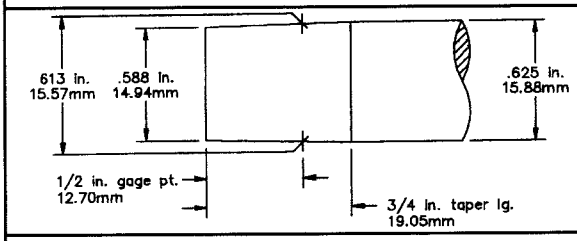
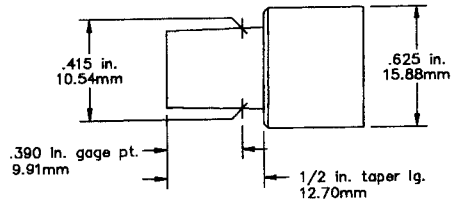
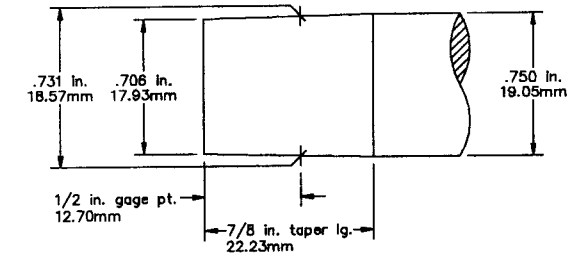
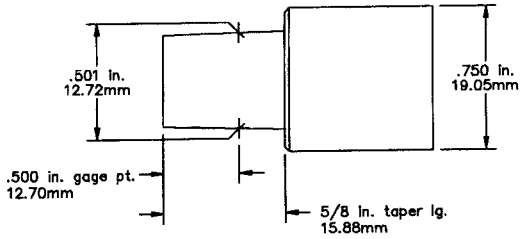
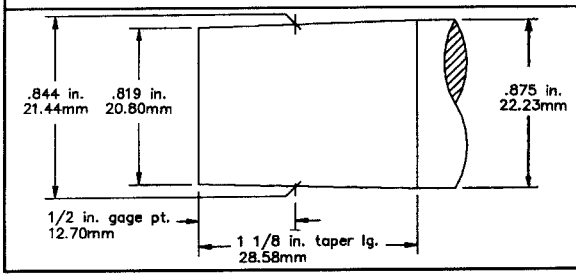
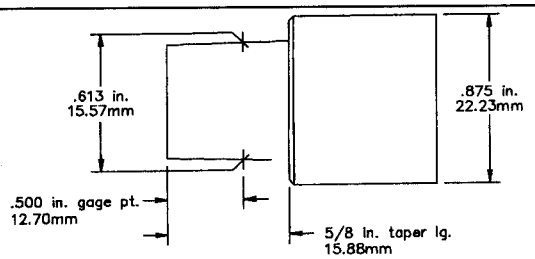
For Taper Dimensions in inches and millimeters

TABLE II
Fractions of an inch into millimeters

Inches	Milli-meters	Inches	Milli-meters
1/64	0.3969	33/64	13.0969
1/32	0.7937	17/32	13.4937
3/64	1.1906	35/64	13.8906
1/16	1.5875	9/16	14.2875
5/64	1.9844	37/64	14.6844
3/32	2.3812	19/32	15.0812
7/64	2.7781	39/64	15.4781
1/8	3.1750	5/8	15.8750
9/64	3.5719	41/64	16.2719
5/32	3.9687	21/32	16.6687
11/64	4.3656	43/64	17.0656
3/16	4.7625	11/16	17.4625
13/64	5.1594	45/64	17.8594
7/32	5.5562	23/32	18.2562
15/64	5.9531	47/64	18.6531
1/4	6.3500	3/4	19.0500
17/64	6.7469	49/64	19.4469
9/32	7.1437	25/32	19.8437
19/64	7.5406	51/64	20.2406
5/16	7.9375	13/16	20.6375
21/64	8.3344	53/64	21.0344
11/32	8.7312	27/32	21.4312
23/64	9.1281	55/64	21.8281
3/8	9.5250	7/8	22.2250
25/64	9.9219	57/64	22.6219
13/32	10.3187	29/32	23.0187
27/64	10.7156	59/64	23.4156
7/16	11.1125	15/16	23.8125
29/64	11.5094	61/64	24.2094
15/32	11.9062	31/32	24.6062
31/64	12.3031	63/64	25.0031
1/2	12.7000	1	25.4001

TABLE III
Gage-Decimal-Millimeter Conversion Chart

Gage	Decimal	Millimeter
3	.239	6.350
4	.234	5.953
5	.209	5.556
6	.194	5.159
7	.179	4.762
8	.164	4.365
9	.150	3.968
10	.135	3.571
11	.120	3.175
12	.105	2.778
13	.090	2.381
14	.075	1.984
15	.067	1.778
16	.060	1.587
17	.054	1.422
18	.048	1.270
19	.042	1.118
20	.036	.965
21	.033	.865
22	.030	.793
23	.027	.711
24	.024	.635
25	.021	.559
26	.018	.483
27	.016	.432
28	.015	.396
29	.014	.356
30	.012	.330
31	.011	.279
32	.010	.254
33	.009	.229
34	.0082	.216
35	.008	.203
36	.007	.178
37	.0064	.168
38	.006	.152

Standard Tapered Electrode Theoretical Dimensions	Taper Size	Standard Male Taper Cap taper Dimensions
	4RW 1MT	
	5RW 2MT	
	6RW	
	7RW 3MT	

Drawings Full Size

CODING FOR STRAIGHT TAPERED ELECTRODES

X X X X X

Material	Nose	Attachment	Length
1 = CMW® 28 3 = CMW® 3 5 = CMW® 100 6 = ELKONITE® 10W3 7 = ELKONITE® TC5 8 = ELKON® 100M 9 = ELKON® 100W	1 = Dome 2 = Pointed 3 = Flat 4 = Offset 5 = 2" Sph. R 6 = 10" Sph. R. 7 = Truncated 8 = 3" Sph. R 9 = 4" Sph. R 0 = Shank for Male Cap	1 = No. 4RW No. 1MT 2 = No. 5RW No. 2MT 3 = No. 7RW No. 3MT 4 = No. 6RW	1 = 1" 2 = 1 1/4" 3 = 1 1/2" 4 = 1 3/4" 5 = 2" 6 = 2 1/4" 7 = 2 1/2" 8 = 2 3/4" 9 = 3" 12 = 3 1/4" 14 = 3 1/2" 16 = 3 3/4" 18 = 4" 20 = 4 1/4" 22 = 4 1/2"
Note: Prefix MP = Shank for Female Cap			

RWMA CODING FOR STRAIGHT TAPERED ELECTRODES

X X X X X

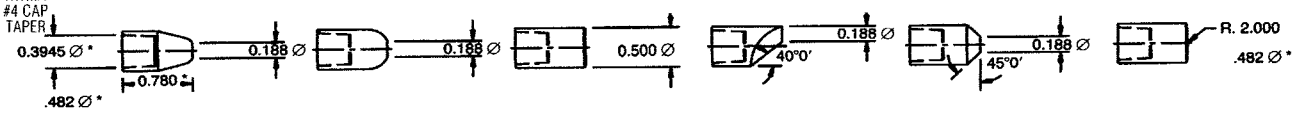
Nose	Material	Attachment	Length in no. of 1/4"
A = Pointed B = Dome C = Flat D = Offset E = Truncated	1 = RWMA CL 1 CMW® 28 2 = RWMA CL 2 CMW® 3 3 = RWMA CL 3 CMW® 100	4 = No. 4RW No. 1MT 5 = No. 5RW No. 2MT 6 = No. 6RW 7 = No. 7RW No. 3MT	04 = 1" 05 = 1 1/4" 06 = 1 1/2" 07 = 1 3/4" 08 = 2" 09 = 2 1/4" 10 = 2 1/2" 11 = 2 3/4" 12 = 3" 13 = 3 1/4" 14 = 3 1/2" 15 = 3 3/4" 16 = 4" 17 = 4 1/4" 18 = 4 1/2"

CMW FEMALE CAP ELECTRODES

ALL DIM. MARKED WITH AN (*) ARE COMMON TO EACH CAP IN A HORIZONTAL LINE.

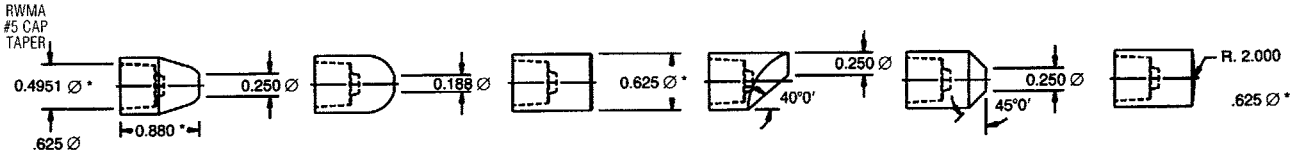
POINTED	DOME	FLAT	OFFSET	TRUNCATED	RADIUS
MPA14Z CMW® 28 MPA24 CMW® 3 MPA24Z CMW® 328	MPB14Z CMW® 28 MPB24 CMW® 3 MPB24Z CMW ®328	MPC14Z CMW® 28 MPC24 CMW® 3 MPC24Z CMW® 328	MPD14Z CMW® 28 MPD24 CMW® 3 MPD24Z CMW® 328	MPE14Z CMW® 28 MPE24 CMW® 3 MPE24Z CMW® 328	MPF14Z CMW® 28 MPF24 CMW® 3 MPF24Z CMW® 328

RWMA #4 CAP TAPER



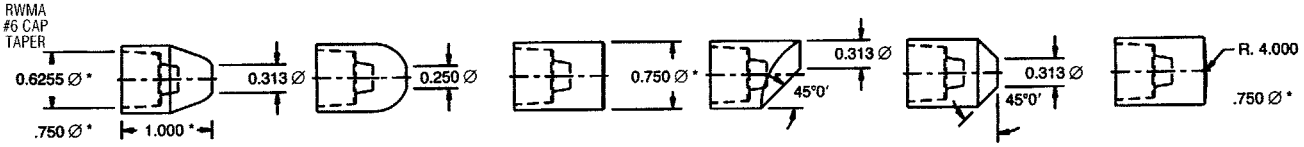
MPA15Z CMW® 28 MPA25 CMW® 3 MPA25Z CMW® 328	MPB15Z CMW® 28 MPB25 CMW® 3 MPB25Z CMW® 328	MPC15Z CMW® 28 MPC25 CMW® 3 MPC25Z CMW® 328	MPD15Z CMW® 28 MPD25 CMW®3 MPD25Z CMW® 328	MPE15Z CMW® 28 MPE25 CMW® 3 MPE25Z CMW® 328	MPF15Z CMW® 28 MPF25 CMW® 3 MPF25Z CMW® 328

RWMA #5 CAP TAPER



MPA16Z CMW® 28 MPA26 CMW® 3 MPA26Z CMW® 328	MPB16Z CMW® 28 MPB26 CMW® 3 MPB26Z CMW® 328	MPC16Z CMW® 28 MPC26 CMW® 3 MPC26Z CMW® 328	MPD16Z CMW® 28 MPB26 CMW® 3 MPD26Z CMW® 328	MPE16Z CMW® 28 MPE26 CMW® 3 MPE26Z CMW® 328	MPF16Z CMW® 28 MPF26 CMW® 3 MPF26Z CMW® 328

RWMA #6 CAP TAPER

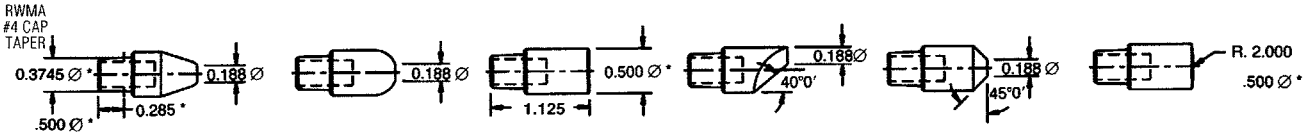


CMW MALE CAP ELECTRODES

ALL DIM. MARKED WITH AN (*) ARE COMMON TO EACH CAP IN A HORIZONTAL LINE.

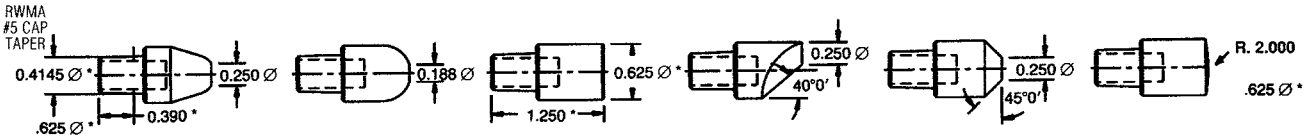
POINTED	DOME	FLAT	OFFSET	TRUNCATED	RADIUS
MA14Z CMW® 28 MA24 CMW® 3 MA24Z CMW® 328	MB14Z CMW® 28 MB24 CMW® 3 MB24Z CMW® 328	MC14Z CMW® 28 MC24 CMW® 3 MC24Z CMW® 328	MD14Z CMW® 28 MD24 CMW® 3 MD24Z CMW® 328	ME14Z CMW® 28 ME24 CMW® 3 ME24Z CMW® 328	MF14Z CMW® 28 MF24 CMW® 3 MF24Z CMW® 328

RWMA #4 CAP TAPER



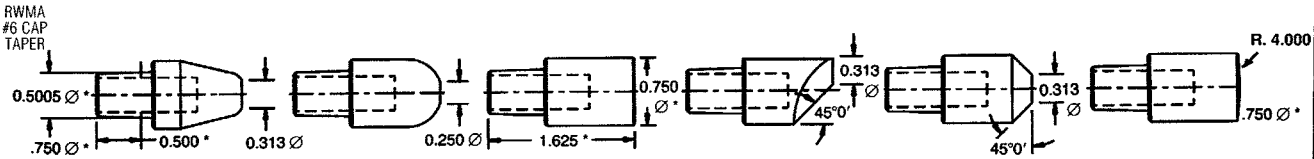
MA15Z CMW® 28 MA25 CMW® 3 MA25Z CMW® 328	MB15Z CMW® 28 MB25 CMW® 3 MB25Z CMW® 328	MC15Z CMW® 28 MC25 CMW® 3 MC25Z CMW® 328	MD15Z CMW® 28 MD25 CMW® 3 MD25Z CMW® 328	ME15Z CMW® 28 ME25 CMW® 3 ME25Z CMW® 328	MF15Z CMW® 28 MF25 CMW® 3 MF25Z CMW® 328

RWMA #5 CAP TAPER



MA16Z CMW® 28 MA26 CMW® 3 MA26Z CMW® 328	MB16Z CMW® 28 MB26 CMW® 3 MB26Z CMW® 328	MC16Z CMW® 28 MC26 CMW® 3 MC26Z CMW® 328	MD16Z CMW® 28 MD26 CMW® 3 MD26Z CMW® 328	ME16Z CMW® 28 ME26 CMW® 3 ME26Z CMW® 328	MF16Z CMW® 28 MF26 CMW® 3 MF26Z CMW® 328

RWMA #6 CAP TAPER



DIMENSIONS ARE IN INCHES.

SEE PAGES 39 AND 40 FOR SHANKS.

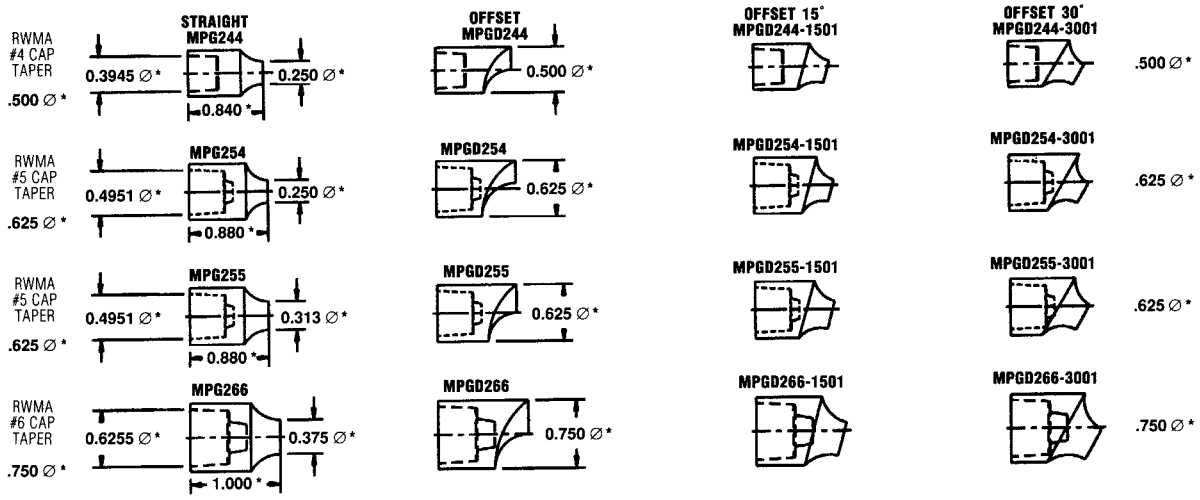
The CMW GCAP®* electrode is the answer to welding galvanized steels. The GCAP's® revolutionary design, and precision manufacturing from CMW Engineering provides for no sticking from the very first weld. GCAP® electrode nuggets meet or exceed industry standards for high quality welds from the first weld through the life of the cap. This cap design made from R.W.M.A. Class II material eliminates brass build-up by literally rolling the brass away. You will use electric power (up to 25% less) and still achieve superior welds due to GCAP® design. Productivity will increase with up to 10 times more welds without dressing.

For best use of CMW GCAPS®, a stepper program is recommended. Consult CMW application engineering.

*U.S. Patent 4,954,687; 5,015,816; 5,126,528.
Other patents pending.

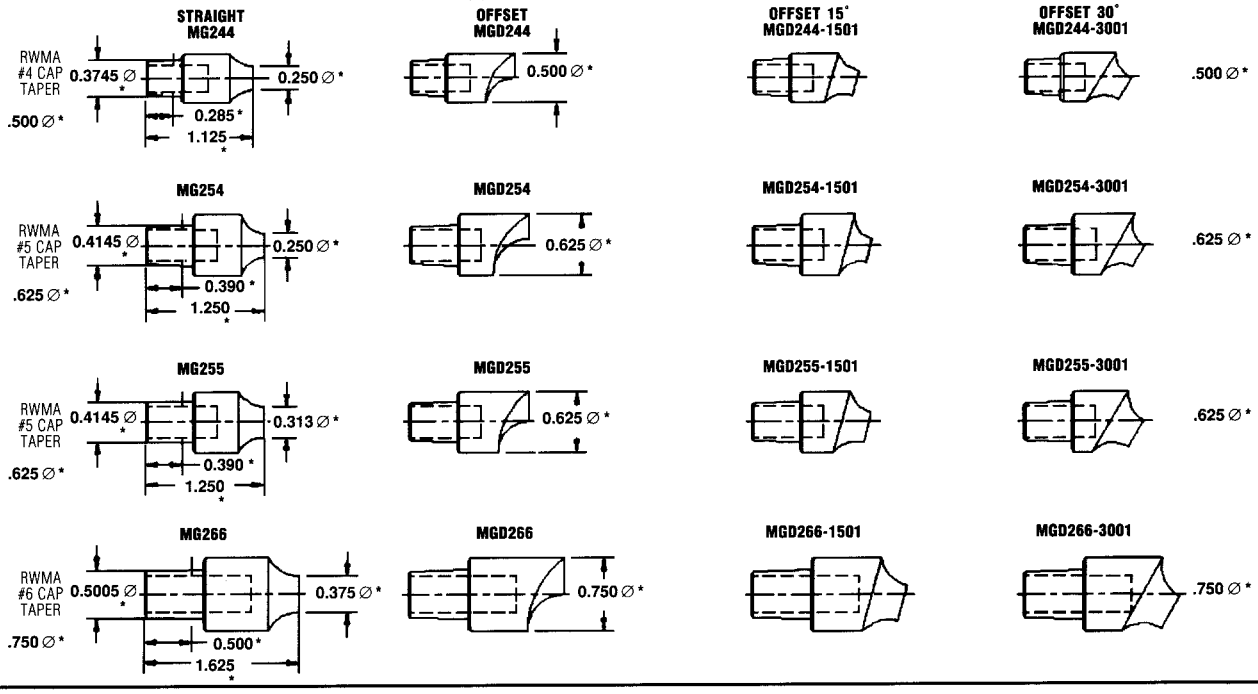
CMW GCAP® FEMALE CAP ELECTRODES

ALL DIM. MARKED WITH AN (*) ARE COMMON TO EACH CAP IN A HORIZONTAL LINE.



CMW GCAP® MALE CAP ELECTRODES

ALL DIM. MARKED WITH AN (*) ARE COMMON TO EACH CAP IN A HORIZONTAL LINE.



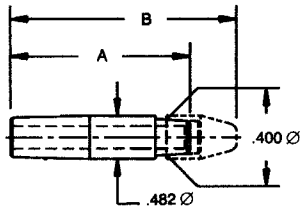
DIMENSIONS ARE IN INCHES. SEE PAGES 39 AND 40 FOR SHANKS.

*GCap® is a registered trademark owned by CMW.

These shanks are shown with a blind water hole for cap replacement without shutting off water. Shanks with through water holes are available, by adding "TH" to the basic part number. Example; MP30212TH.

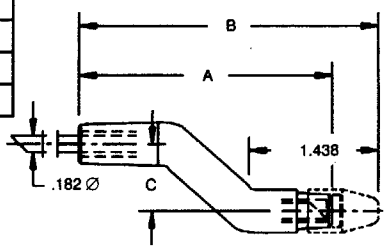
Shanks for female caps with #4 RWMA tapers

PART NO. *	A DIM.	B DIM.
MP3012	1.25	1.75
MP3013	1.50	2.00
MP3014	1.75	2.25
MP3015	2.00	2.50
MP3016	2.25	2.75
MP3017	2.50	3.00
MP3018	2.75	3.25
MP3019	3.00	3.50
MP30112	3.25	3.75
MP30114	3.50	4.00
MP30116	3.75	4.25
MP30118	4.00	4.50



Bent offset shanks for female caps with #4 RWMA tapers

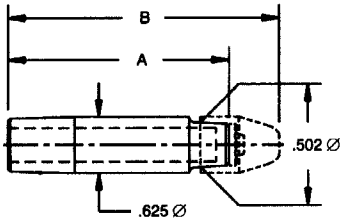
PART NO. *	A DIM.	B DIM.	C DIM.
MP3019-08	2.62	3.28	.50
MP3019-12	2.56	3.22	.75
MP30112-12	2.81	3.47	.75
MP30112-16	2.37	3.03	1.00
MP30116-16	2.87	3.53	1.00
MP30116-20	2.60	3.28	1.25



Bent Dimensions for Reference Only

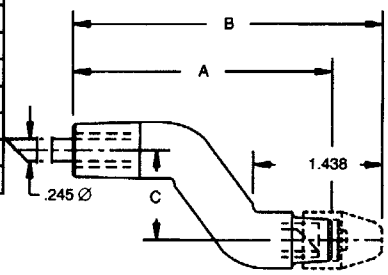
Shanks for female caps with #5 RWMA tapers

PART NO. *	A DIM.	B DIM.
MP3023	1.46	2.00
MP3024	1.71	2.25
MP3025	1.96	2.50
MP3026	2.21	2.75
MP3027	2.46	3.00
MP3028	2.71	3.25
MP3029	2.96	3.50
MP30212	3.21	3.75
MP30214	3.46	4.00
MP30216	3.71	4.25
MP30218	3.96	4.50
MP30220	4.21	4.75
MP30222	4.46	5.00



Bent offset shanks for female caps with #5 RWMA tapers

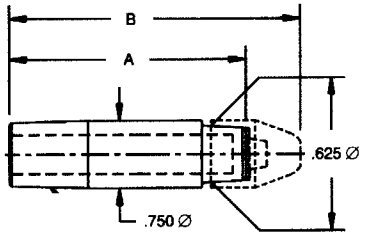
PART NO. *	A DIM.	B DIM.	C DIM.
MP3029-08	2.58	3.20	.50
MP3029-12	2.60	3.12	.75
MP30212-12	2.77	3.44	.75
MP30212-16	2.33	3.00	1.00
MP30214-12	3.00	3.66	.75
MP30214-16	2.81	3.48	1.00
MP30216-16	2.83	3.49	1.00
MP30216-20	2.77	3.43	1.25



Bent Dimensions for Reference Only

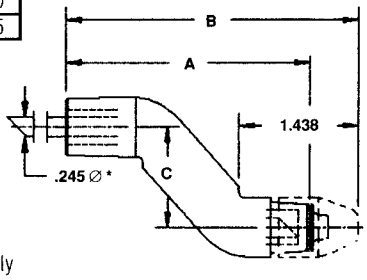
Shanks for female caps with #6 RWMA tapers

PART NO. *	A DIM.	B DIM.
MP3044	1.64	2.25
MP3045	1.89	2.50
MP3046	2.14	2.75
MP3047	2.39	3.00
MP3048	2.64	3.25
MP3049	2.89	3.50
MP30412	3.14	3.75
MP30414	3.39	4.00
MP30416	3.64	4.25
MP30418	3.89	4.50
MP30420	4.14	4.75
MP30422	4.39	5.00



Bent offset shanks for female caps with #6 RWMA tapers

PART NO. *	A DIM.	B DIM.	C DIM.
MP3049-08	2.69	3.30	.50
MP30412-12	2.81	3.42	.75
MP30414-12	2.94	3.55	.75
MP30416-16	3.06	3.67	1.00
MP30420-20	3.25	3.86	1.25



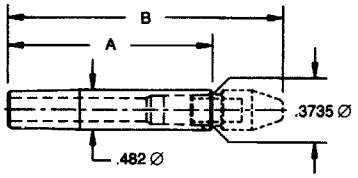
Bent Dimensions for Reference Only

DIMENSIONS ARE IN INCHES.

SEE PAGES 37 AND 38 FOR STANDARD AND GCAP® ELECTRODE CAPS.

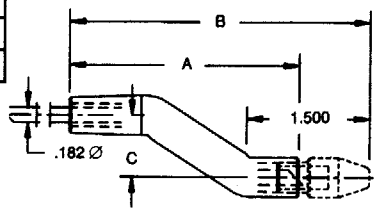
Shanks for male caps with #4 RWMA tapers

PART NO. *	A DIM.	B DIM.
3012	1.25	1.88
3013	1.50	2.12
3014	1.75	2.38
3015	2.00	2.62
3016	2.25	2.88
3017	2.50	3.12
3018	2.75	3.38
3019	3.00	3.62
30112	3.25	3.88
30114	3.50	4.12
30116	3.75	4.38
30118	4.00	4.62



Bent offset shanks for male caps with #4 RWMA tapers

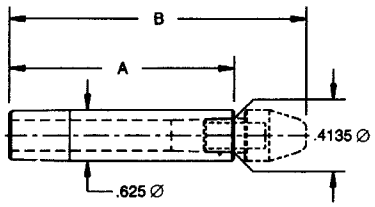
PART NO. *	A DIM.	B DIM.	C DIM.
3019-08	2.62	3.37	.50
3019-12	2.56	3.31	.75
30112-12	2.81	3.56	.75
30112-16	2.37	3.12	1.00
30116-16	2.87	3.62	1.00
30116-20	2.62	3.37	1.25



Bent Dimensions for Reference Only

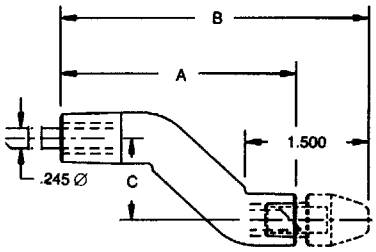
Shanks for male caps with #5 RWMA tapers

PART NO. *	A DIM.	B DIM.
3022	1.25	2.00
3023	1.50	2.25
3024	1.75	2.50
3025	2.00	2.75
3026	2.25	3.00
3027	2.50	3.25
3028	2.75	3.50
3029	3.00	3.75
30212	3.25	4.00
30214	3.50	4.25
30216	3.75	4.50
30218	4.00	4.75
30220	4.25	5.00
30222	4.50	5.25



Bent offset shanks for male caps with #5 RWMA tapers

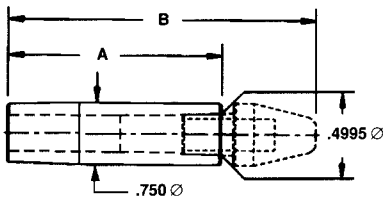
PART NO. *	A DIM.	B DIM.	C DIM.
3028-08	2.37	3.12	.50
3028-12	2.31	3.06	.75
30212-12	2.81	3.56	.75
30212-16	2.37	3.12	1.00
30214-12	3.06	3.81	.75
30214-16	2.62	3.37	1.00
30214-20	2.37	3.12	1.25
30216-16	2.87	3.62	1.00
30216-20	2.62	3.37	1.25



Bent Dimensions for Reference Only

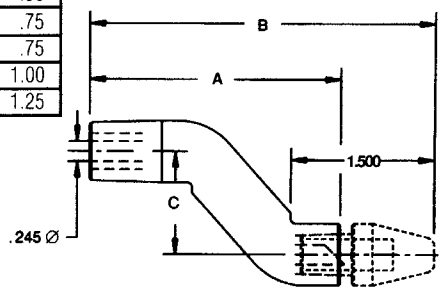
Shanks for male caps with #6 RWMA tapers

PART NO. *	A DIM.	B DIM.
3043	1.50	2.62
3044	1.75	2.88
3045	2.00	3.12
3046	2.25	3.38
3047	2.50	3.62
3048	2.75	3.88
3049	3.00	4.12
30412	3.25	4.38
30414	3.50	4.62
30416	3.75	4.88
30418	4.00	5.12
30420	4.25	5.38
30422	4.50	5.62



Bent offset shanks for male caps with #6 RWMA tapers

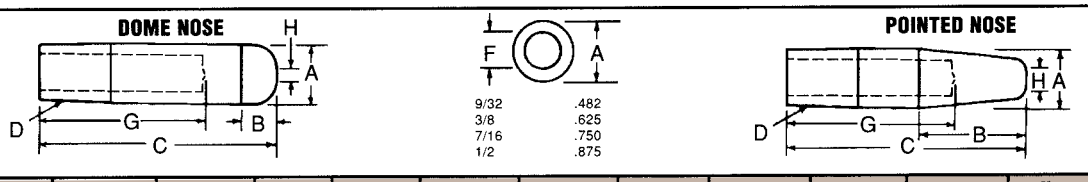
PART NO. *	A DIM.	B DIM.	C DIM.
30412-08	2.62	3.75	.50
30412-12	2.56	3.69	.75
30414-12	2.75	3.88	.75
30416-16	2.87	4.00	1.00
30420-20	3.12	4.25	1.25



Bent Dimensions for Reference Only

DIMENSIONS ARE IN INCHES.

SEE PAGES 37 AND 38 FOR STANDARD AND GCAP® ELECTRODE CAPS.



CMW® 28 Part No.	CMW® 3 Part No.	CMW® 100 Part No.	Nose Length B	Face Dia. H	Major Dia. A	Overall Length C	Taper D	Hole Depth G	CMW® 28 Part No.	CMW® 3 Part No.	CMW® 100 Part No.	Nose Length B	Face Dia. H
Class 1	Class 2	Class 3							Class 1	Class 2	Class 3		

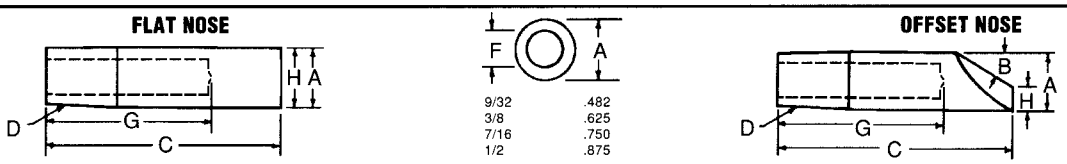
4RW (# 1MT)

1111	**3111**	**5111**	13/64			1		5/8	**1211**	**3211**	**5211**	3/8	
1112	**3112**	**5112**	1/4			1-1/4		3/4	**1212**	**3212**	**5212**	3/8	
1113	**3113**	**5113**	1/4			1-1/2		1	**1213**	**3213**	**5213**	5/8	
1114	**3114**	**5114**				1-3/4	4RW	1-1/4	**1214**	**3214**	**5214**		
1115	**3115**	**5115**	1/4			2		1-1/2	**1215**	**3215**	**5215**	3/4	
1116	**3116**	**5116**				2-1/4		1-3/4	**1216**	**3216**	**5216**		
1117	**3117**	**5117**		3/16	.482	2-1/2	OR	2	**1217**	**3217**	**5217**		3/16
1118	**3118**	**5118**	1/4			2-3/4		2-1/4	**1218**	**3218**	**5218**	3/4	
1119	**3119**	**5119**				3		2-1/2	**1219**	**3219**	**5219**		
11112	**31112**	**51112**				3-1/4	1MT	2-3/4	**12112**	**32112**	**52112**		
11114	**31114**	**51114**	1/4			3-1/2		3	**12114**	**32114**	**52114**	3/4	
11116	**31116**	**51116**				3-3/4		3-1/4	**12116**	**32116**	**52116**		
11118	**31118**	**51118**	1/4			4		3-1/2	**12118**	**32118**	**52118**	3/4	

5RW (# 2MT)

1122	**3122**	**5122**				1-1/4		3/4	**1222**	**3222**	**5222**	1/2	
1123	**3123**	**5123**	3/8			1-1/2		3/4	**1223**	**3223**	**5223**	3/4	
1124	**3124**	**5124**				1-3/4		1	**1224**	**3224**	**5224**	3/4	
1125	**3125**	**5125**				2	5RW	1-1/4	**1225**	**3225**	**5225**		
1126	**3126**	**5126**	3/8			2-1/4		1-1/2	**1226**	**3226**	**5226**	1-1/8	
1127	**3127**	**5127**				2-1/2		1-3/4	**1227**	**3227**	**5227**		
1128	**3128**	**5128**		1/4	.625	2-3/4	OR	2	**1228**	**3228**	**5228**		1/4
1129	**3129**	**5129**	3/8			3		2-1/4	**1229**	**3229**	**5229**	1-1/8	
11212	**31212**	**51212**				3-1/4		2-1/2	**12212**	**32212**	**52212**		
11214	**31214**	**51214**				3-1/2	2MT	2-3/4	**12214**	**32214**	**52214**		
11216	**31216**	**51216**	3/8			3-3/4		3	**12216**	**32216**	**52216**	1-1/8	
11218	**31218**	**51218**				4		3-1/4	**12218**	**32218**	**52218**		
11220	**31220**	**51220**				4-1/4		3-1/2	**12220**	**32220**	**52220**		
11222	**31222**	**51222**	3/8			4-1/2		3-3/4	**12222**	**32222**	**52222**	1-1/8	

Electrodes of other tapers and alloys available upon request.



CMW® 28 Part No.	CMW® 3 Part No.	CMW® 100 Part No.	Face Dia. H	Major Dia. A	Overall Length C	Taper D	Hole Depth G	CMW® 28 Part No.	CMW® 3 Part No.	CMW® 100 Part No.	Nose Angle B	Face Dia. H
Class 1	Class 2	Class 3						Class 1	Class 2	Class 3		

4RW (# 1MT)

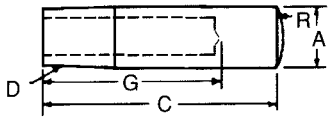
1311	**3311**	**5311**	.482	.482	1	4RW OR 1MT	5/8	**1411**	**3411**	**5411**	45°	3/16
1312	**3312**	**5312**			1-1/4		3/4	**1412**	**3412**	**5412**	40°	
1313	**3313**	**5313**			1-1/2		1	**1413**	**3413**	**5413**	30°	
1314	**3314**	**5314**			1-3/4		1-1/4	**1414**	**3414**	**5414**		
1315	**3315**	**5315**			2		1-1/2	**1415**	**3415**	**5415**	30°	
1316	**3316**	**5316**			2-1/4		1-3/4	**1416**	**3416**	**5416**		
1317	**3317**	**5317**			2-1/2		2	**1417**	**3417**	**5417**		
1318	**3318**	**5318**			2-3/4		2-1/4	**1418**	**3418**	**5418**	30°	
1319	**3319**	**5319**			3		2-1/2	**1419**	**3419**	**5419**		
13112	**33112**	**53112**			3-1/4		2-3/4	**14112**	**34112**	**54112**		
13114	**33114**	**53114**			3-1/2		3	**14114**	**34114**	**54114**	30°	
13116	**33116**	**53116**			3-3/4		3-1/4	**14116**	**34116**	**54116**		
13118	**33118**	**53118**			4		3-1/2	**14118**	**34118**	**54118**	30°	

5RW (# 2MT)

1322	**3322**	**5322**	5/8	.625	1-1/4	5RW OR 2MT	3/4	**1422**	**3422**	**5422**	40°	1/4
1323	**3323**	**5323**			1-1/2		3/4	**1423**	**3423**	**5423**	40°	
1324	**3324**	**5324**			1-3/4		1	**1424**	**3424**	**5424**	30°	
1325	**3325**	**5325**			2		1-1/4	**1425**	**3425**	**5425**		
1326	**3326**	**5326**			2-1/4		1-1/2	**1426**	**3426**	**5426**	30°	
1327	**3327**	**5327**			2-1/2		1-3/4	**1427**	**3427**	**5427**		
1328	**3328**	**5328**			2-3/4		2	**1428**	**3428**	**5428**		
1329	**3329**	**5329**			3		2-1/4	**1429**	**3429**	**5429**	30°	
13212	**33212**	**53212**			3-1/4		2-1/2	**14212**	**34212**	**54212**		
13214	**33214**	**53214**			3-1/2		2-3/4	**14214**	**34214**	**54214**		
13216	**33216**	**53216**			3-3/4		3	**14216**	**34216**	**54216**	30°	
13218	**33218**	**53218**			4		3-1/4	**14218**	**34218**	**54218**		
13220	**33220**	**53220**			4-1/4		3-1/2	**14220**	**34220**	**54220**	30°	
13222	**33222**	**53222**			4-1/2		3-3/4	**14222**	**34222**	**54222**		

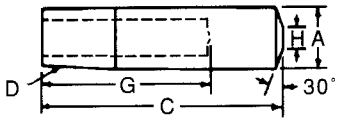
Electrodes of other tapers and alloys available upon request.

RADIUS NOSE



9/32	.482
3/8	.625
7/16	.750
1/2	.875

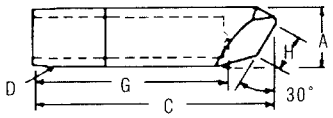
TRUNCATED NOSE



CMW® 28 Part No.	CMW® 3 Part No.	CMW® 100 Part No.	Major Dia. A	Overall Length C	Taper D	Hole Depth G	Spherical Radius R
Class 1	Class 2	Class 3					
1523	**3523**	**5523**	.625	1-1/2	5RW OR 2MT	3/4	2
1525	**3525**	**5525**		2		1-1/4	
1527	**3527**	**5527**		2-1/2		1-3/4	
1529	**3529**	**5529**		3		2-1/4	
15218	**35218**	**56218**		4		3-1/4	
1623	**3623**	**5623**		1-1/2		3/4	10
1625	**3625**	**5625**		2		1-1/4	
1627	**3627**	**5627**		2-1/2		1-3/4	
1629	**3629**	**5629**		3		2-1/4	
16218	**36218**	**56218**		4		3-1/4	
1825	**3825**	**5825**		2		1-1/4	3
1829	**3829**	**5829**		3		2-1/4	
1925	**3925**	**5925**		2		1-1/4	4
1929	**3929**	**5929**		3		2-1/4	

CMW® 28 Part No.	CMW® 3 Part No.	CMW® 100 Part No.	Major Dia. A	Overall Length C	Taper D	Hole Depth G	Face Diam. H
Class 1	Class 2	Class 3					
1712	**3712**	**5712**	.482	1-1/4	4RW OR 1MT	3/4	3/16
1713	**3713**	**5713**		1-1/2		1	
1715	**3715**	**5715**		2		1-1/2	
1717	**3717**	**5717**		2-1/2		2	
1718	**3718**	**5718**		2-3/4		2-1/4	
1723	**3723**	**5723**	.625	1-1/2	5RW OR 2MT	3/4	1/4
1725	**3725**	**5725**		2		1-1/4	
1727	**3727**	**5727**		2-1/2		1-3/4	
1729	**3729**	**5729**		3		2-1/4	
17218	**37218**	**57218**		4		3-1/4	

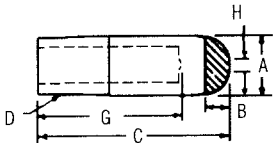
30° OFFSET NOSE

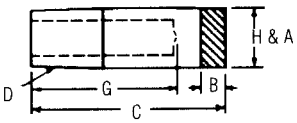


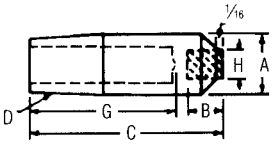
CMW® 28 Part No.	CMW® 3 Part No.	Major Dia. A	Overall Length C	Taper D	Hole Depth G	Face Dia. H
Class 1	Class 2					
16-2491	**16-2494**	.482	2	4RW 1MT	1-1/2	1/4
16-2492	**16-2495**	.625	2-1/2	5RW 2MT	2	3/8
16-2493	**16-2496**	.875	3	7RW 3MT	2-1/4	1/2

ELKONITE® AND ELKON® FACED STRAIGHT MORSE TAPER ELECTRODES

ELKONITE® 10W3 Face	ELKON® 100M Face	ELKON® 100W Face	Major Dia. A	ELKON® OR ELKONITE® Lg. B	Over all Lg. C	Taper D	Hole Depth G	Face Dia. H
ELKONITE® AND ELKON® DOME NOSE								
611050	**811050**	**911050**	.482	3/16	2	4RW 1MT	1-1/2	1/8
612050	**812050**	**912050**	.625	1/4	2	5RW 2MT	1-1/2	1/8
ELKONITE® AND ELKON® FLAT NOSE								
631050	**831050**	**931050**	.482	3/16	2	4RW 1MT	1-1/2	.482
632030	**832050**	**932050**	.625	1/4	1-1/2	5RW	1	5/8
632050					2		1-1/2	
632070					2-1/2	2MT	2	
16-1353			.625	1/4	2-1/2		5/8	
633050	**833050**	**933050**	.875	1/4	2	7RW 3MT	1-1/2	7/8
ELKON® CENTERED INSERT NOSE								
871050	**971050**	482	3/8	2		4RW 1MT	1-1/2	3/16
872050	**972050**	.625	3/8	2		5RW 2MT	1-1/2	1/4







Electrodes faced with material other than those shown on this page are available to special order.

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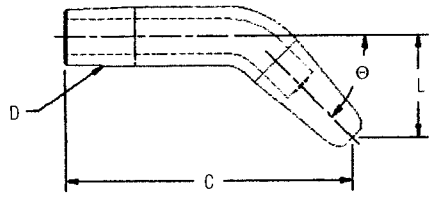
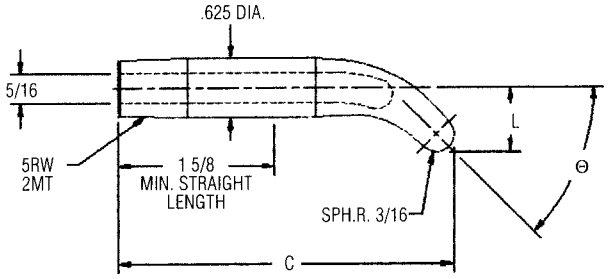
SINGLE BEND



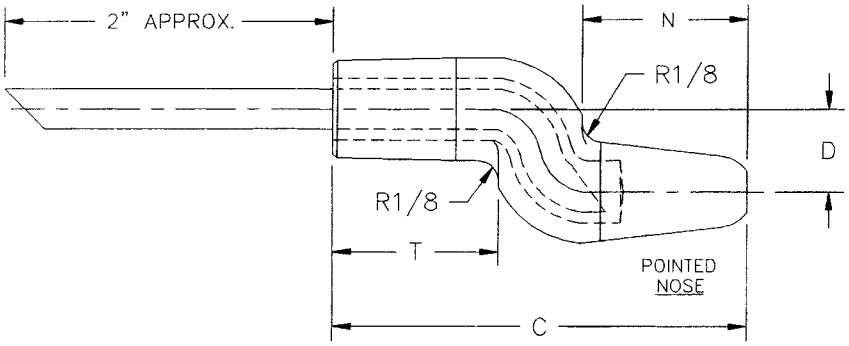
Part No.	Reference Length to £ of Face "C"	Taper "D"	Offset £ of Taper to £ of Face "L"	Bent Angle "Θ"
3214-04-15	1 11/16		1/4	15°
3219-04-15	2 15/16	4RW	1/4	
32118-13-15	3 7/8	1MT	13/16	
3225-04-15	1 7/8		1/4	
3229-04-15	2 7/8	5RW	1/4	
32218-10-15	3 13/16	2MT	5/8	
3215-07-30	1 7/8		7/16	30°
3219-07-30	2 7/8	4RW	7/16	
32118-23-30	3 5/8	1MT	1 7/16	
3226-09-30	2 1/16		9/16	
32212-09-30	3 1/16	5RW	9/16	
32220-24-30	3 13/16	2MT	1 1/2	
3215-10-45	1 11/16		5/8	45°
32112-12-45	2 7/8	4RW	3/4	
32118-33-45	3 1/8	1MT	2 1/16	
3228-17-45	2 1/16		1 1/16	
32214-17-45	3 1/16	5RW	1 1/16	
32220-33-45	3 13/16	2MT	2 1/16	
3218-23-60	2		1 7/16	60°
32116-23-60	3	4RW	1 7/16	
32118-40-60	2 5/8	1MT	2 1/2	
32212-25-60	2 3/8		1 9/16	
32218-25-60	3 1/8	5RW	1 9/16	
32220-38-60	3	2MT	2 3/8	
32216-35-75	2 5/16		2 3/16	75°
32220-37-75	2 11/16	5RW	2 5/16	
32220-43-75	2 3/8	2MT	2 11/16	

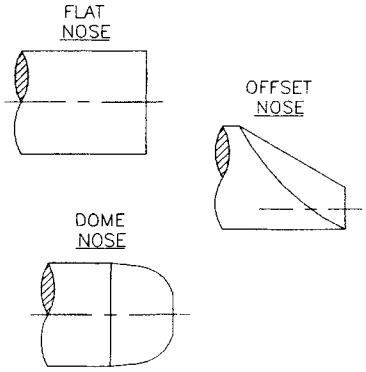
RADIUS BEND



Part No.	O.A.L. "C"	Offset £ of Taper to Top of Radius "L"	Bent Angle "Θ"
16-26015	3 11/16	3/8	15°
16-26030	3 5/8	33/64	30°
16-26045	3 1/2	43/64	45°
16-26060	3 3/8	27/32	60°
16-26075	3 5/32	1 1/32	75°
16-26090	2 13/16	1 1/4	90°

Radius bend electrodes are designed for use with 18-768 and 18-784 straight universal adapters shown on page 70.





TAPER
NOSE
MATERIAL

[X] [X] [X] — [XX] [XX] — [X] [X] [Z]

OFFSET (D) (TO CENTERLINE OF WELD FACE)
OVERALL LENGTH (C)
NOSE LENGTH (N)
TAPER LENGTH (T)
OPTIONAL WITHOUT WATER TUBE

1= CMW® 28
3=*CMW® 3
5= CMW® 100

1= DOME
2=*POINTED
3= FLAT
4= OFFSET

1=4RW 1MT
2=5RW 2MT

08 = 1/2"
12 = 3/4"
16 = 1"
20 = 1 1/4"
24 = 1 1/2"
28 = 1 3/4"

32 = 2"
36 = 2 1/4"
40 = 2 1/2"
44 = 2 3/4"
48 = 3"
52 = 3 1/4"
56 = 3 1/2"
60 = 3 3/4"

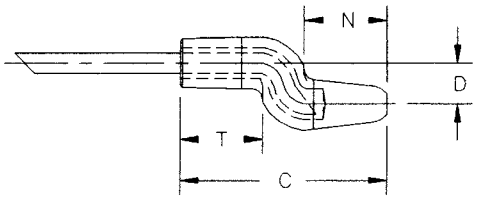
2 = 3/4"
3 = 7/8"
4 = 1"
** 5 = 1 1/8"
** 6 = 1 1/4"
** 7 = 1 1/2"
** 8 = 1 3/4"
** 9 = 2"

** MAY NOT BE A STOCK ITEM
STANDARD 4RW NOSE LENGTH = 3/4"
STANDARD 4RW TAPER LENGTH = 7/8"
STANDARD 5RW NOSE & TAPER LENGTH = 1"

* STANDARD

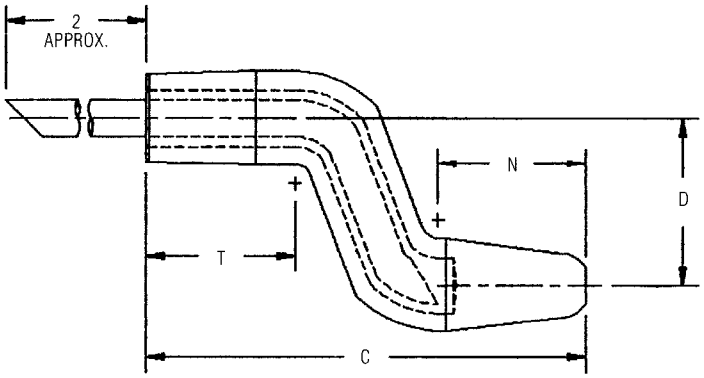
EXAMPLE:
322-0840-44

- 1" TAPER LENGTH (T)
- 1" NOSE LENGTH (N)
- 2 1/2" OVERALL LENGTH (C)
- 1/2" OFFSET (D)
- 5RW TAPER
- POINTED NOSE
- CMW 3 MATERIAL



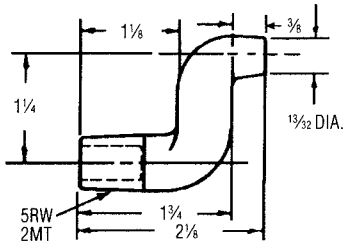
WATER TUBE SIZE:
4RW – 0.185 O.D.
5RW = 0.245 O.D.

BENT DIMENSIONS REFERENCE ONLY

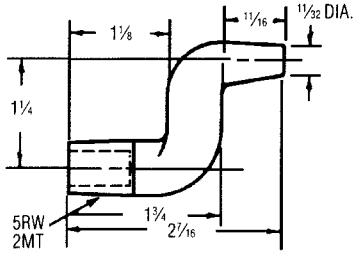


Offset "D"	Taper Size	Nose End "N"	Taper End "T"	Dome Pointed Flat O.A.L. "C"	Pointed Nose Part No.
1/2		3/4	7/8	2	**321-0832-23**
	4RW	3/4	7/8	2 1/2	**321-0840-23**
	1MT	2	7/8	3 1/4	**321-0852-93**
		1	1	2 1/2	**322-0840-44**
		1	1	2 3/4	**322-0844-44**
	5RW	1	1	3 1/4	**322-0852-44**
	2MT	2	1	3 1/2	**322-0856-94**
3/4		3/4	7/8	2	**321-1232-23**
	4RW	3/4	7/8	2 1/2	**321-1240-23**
	1MT	2	7/8	3 1/2	**321-1256-93**
		1	1	2 3/4	**322-1244-44**
	5RW	1	1	3	**322-1248-44**
	2MT	2	1	3 1/2	**322-1256-94**
1		3/4	7/8	2 1/4	**321-1636-23**
		3/4	7/8	2 3/4	**321-1644-23**
	4RW	1 3/4	7/8	3 1/4	**321-1652-83**
	1MT	3/4	7/8	3 1/2	**321-1656-23**
		1	1	2 3/4	**322-1644-44**
		1	1	3	**322-1648-44**
	5RW	1	1	3 1/2	**322-1656-44**
	2MT	1 3/4	1	3 1/2	**322-1656-84**
1 1/4		3/4	7/8	2 1/2	**321-2040-23**
	4RW	3/4	7/8	3	**321-2048-23**
	1MT	1 1/2	7/8	3	**321-2048-73**
		1	1	2 3/4	**322-2044-44**
		1	1	3 1/4	**322-2052-44**
	5RW	1	1	3 1/2	**322-2056-44**
	2MT	1 1/2	1	3 1/2	**322-2056-74**
		1 3/4	1	3 1/2	**322-2056-84**
1 1/2	5RW	1	1	2 3/4	**322-2444-44**
	2MT	1 1/4	1	3	**322-2448-64**
1 3/4	5RW	1	1	2 3/4	**322-2844-44**
	2MT	1 1/4	1	3	**322-2848-64**

WATER TUBE SIZE:
4RW – 0.185 O.D.
5RW = 0.245 O.D.



16-38661 CMW® 3
COLD FORMED*



16-3866 CMW® 3
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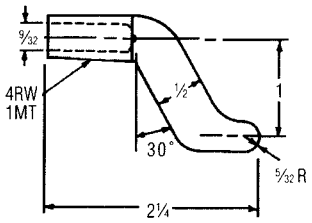
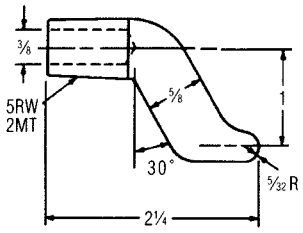


16-3835 CMW® 3
CASTING



16-3836 CMW® 3
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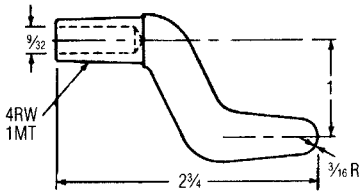

16-3837 CMW® 3
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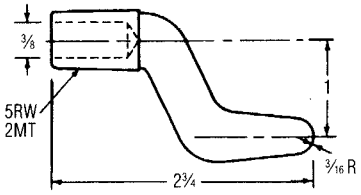

16-3838 CMW® 3
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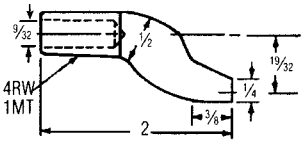
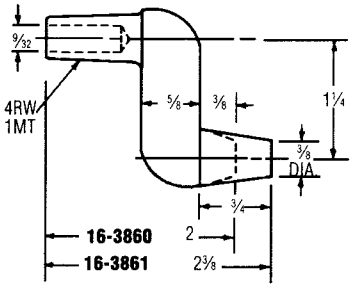
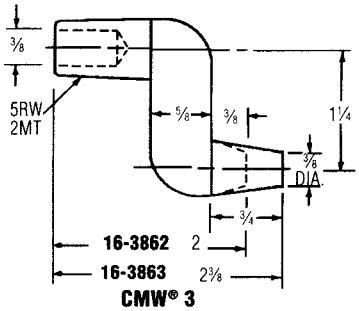


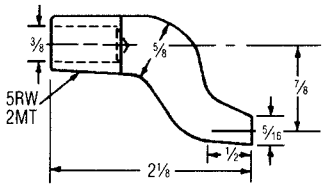
16-3870 CMW® 3
COLD FORMED*



CMW® 3
FORGED



CMW® 3
FORGED



16-3871 CMW® 3
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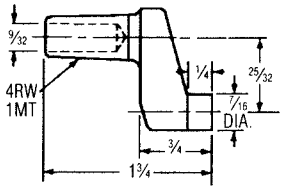

16-3873 CMW® 3
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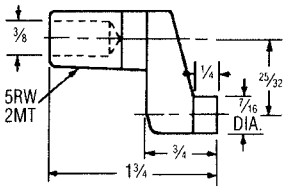

16-3874 CMW® 3
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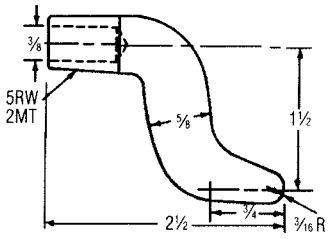

16-38351 CMW® 3
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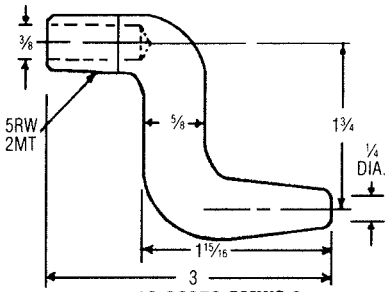

16-38352 CMW® 3
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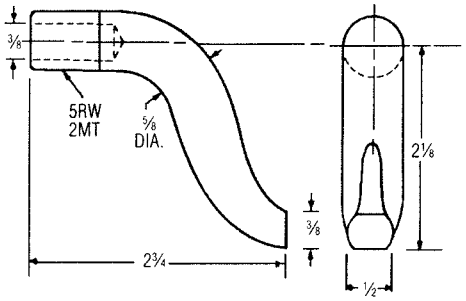
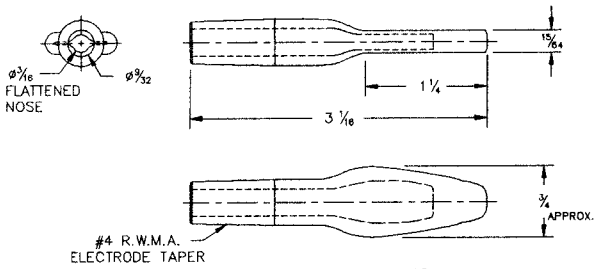


16-38353 CMW® 3
COLD FORMED*

BENT DIMENSIONS REFERENCE ONLY

SPADE ELECTRODES



16-38209 CMW® 3
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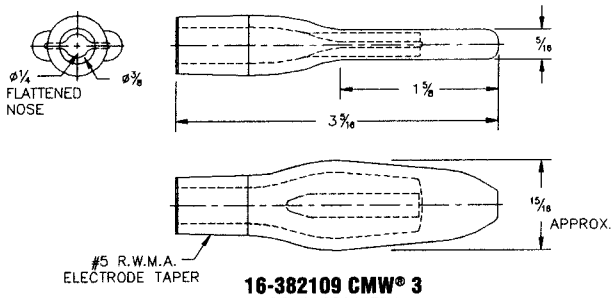

16-382109 CMW® 3
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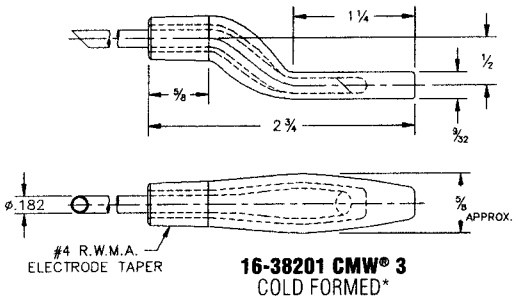

16-38201 CMW® 3
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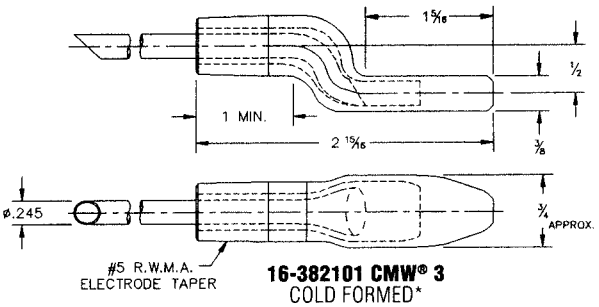

16-382101 CMW® 3
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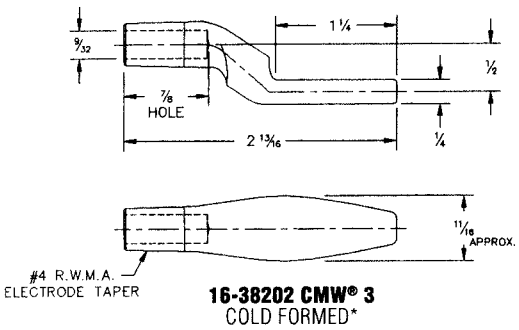

16-38202 CMW® 3
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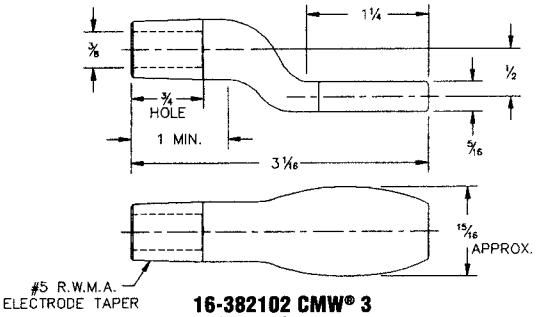
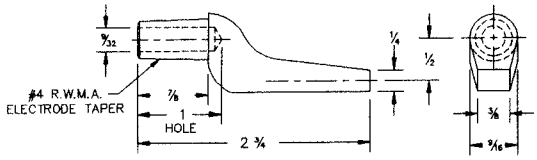
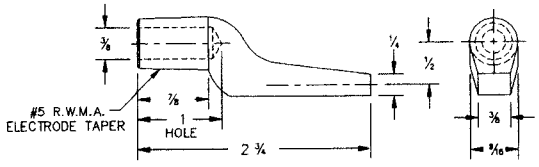


16-382102 CMW® 3
COLD FORMED*

GUN ELECTRODES



16-3820 CMW® 3
CASTING



16-3821 CMW® 3
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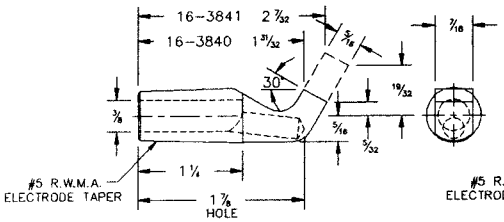
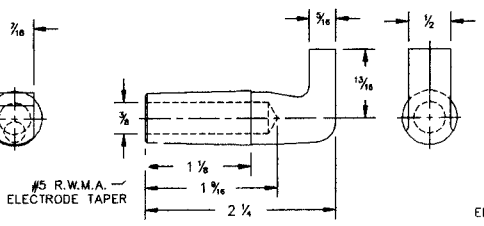
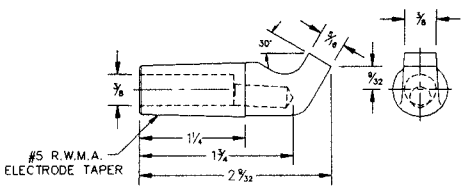


16-3840 AND
16-3841 CMW® 3
COLD FORMED*



16-382120 CMW® 3
CASTING

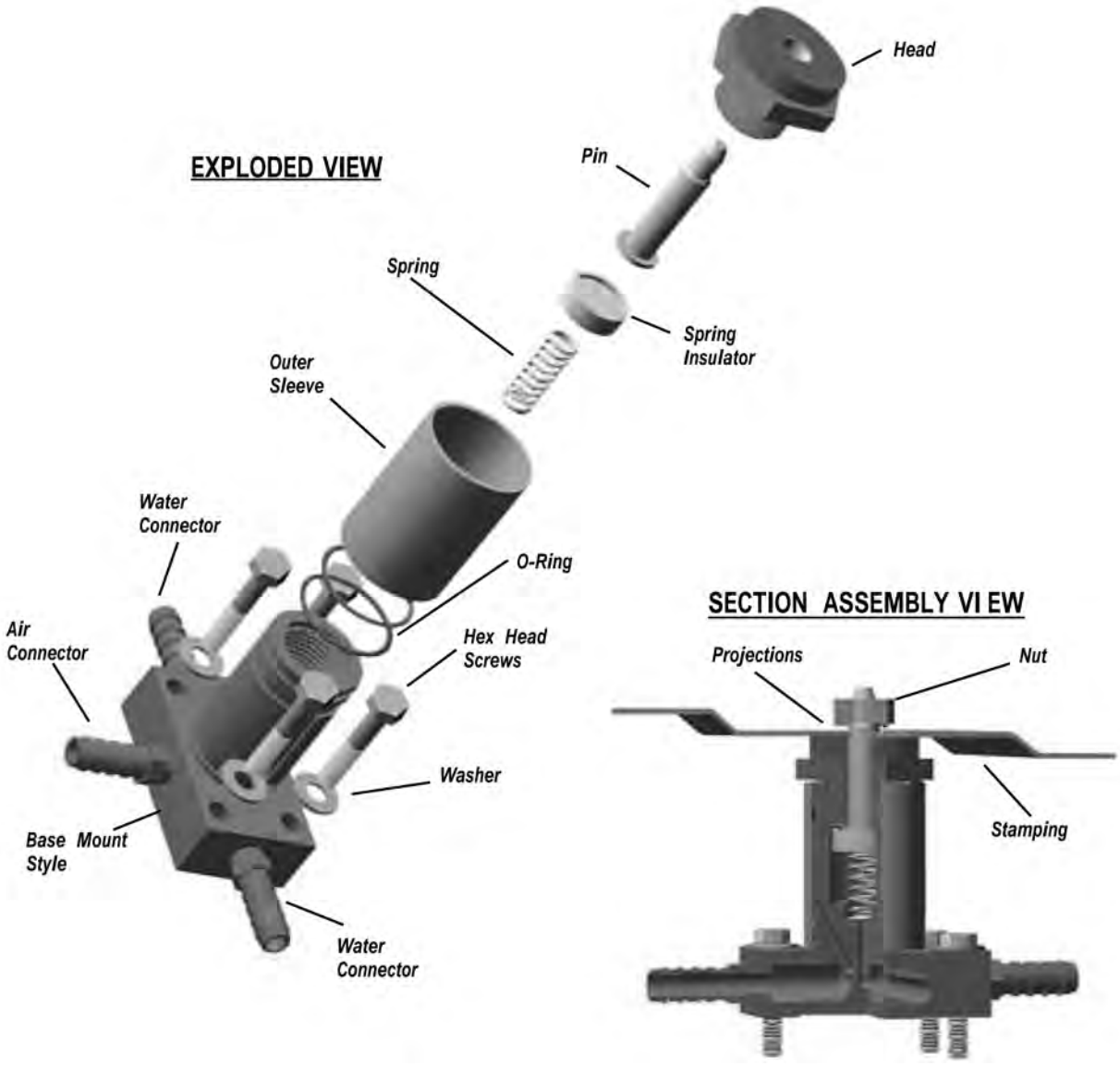


16-3847 CMW® 3
COLD FORMED*

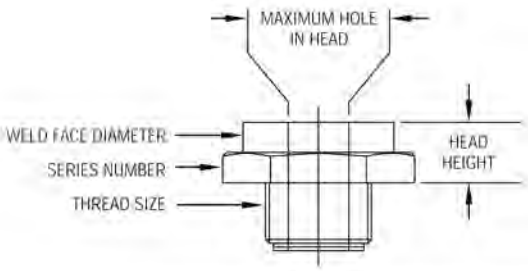
BENT DIMENSIONS REFERENCE ONLY

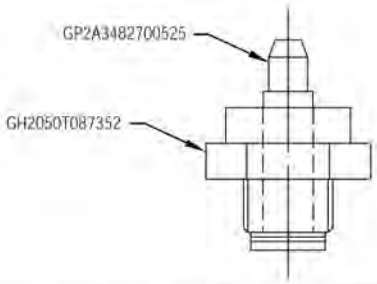
CenterLine manufactures a wide variety of stud & weld nut electrodes.
The high quality design and assembly provides a number of features and benefits including:

Accurate on center positioning of pilotless nuts provided automatically.
Insulated pin and sleeve prevents pin arcing in the threads.
Unit converts from welding nuts to studs in seconds by removal of pilot pin and/or welding head.
Used by automotive, mass transit, farm implement, stamping and appliance manufacturers.
Internal water cooling reduces heat build-up.
Minimum maintenance.



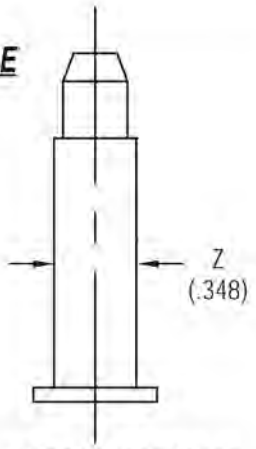
Nut Welding Heads





Series	Thread Size	Weld Face Diameter	Maximum Hole in Head*	Head Height
2	5/8-18	7/8 Standard	0.427 (10.85) ID	0.500
3	7/8-14	1-1/4 Standard	0.642 (16.31) ID	0.500
4	1-1/8-12	1-1/2 Standard	0.852 (21.64) ID	0.625
**Special weld nut electrodes are available for larger IDs and areas with clearance restrictions.*				

EXAMPLE



Pin # GP**2**A**348**2700525

Series Number

Major Diameter of Pin (Z dimension)

PART NUMBER INSTRUCTIONS

Example: **Z Dimension = .348**

Step 1 Establish the major diameter of pin **(Z dimension)**

Step 2 The final 3 digits in the nut welding head # are represented by the following formula.
Z (.348) + .002 = .350

Step 3 Lastly, insert the result from **Step 2** to the end of the **series part number prefix** below.

Final Nut Welding Head Number
Example Series 2 - GH2050T087350

Generate Your Own Number (Total 13 Characters)

Series	Part Number Prefix	Z + .002" Specify to 3 decimal places.
2	GH2050T087	
3	GH3050T125	
4	GH4062T150	

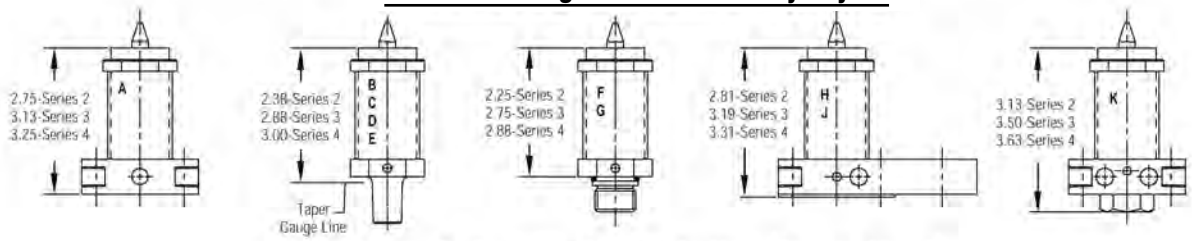
Stud & Weld Nut Model Number Breakdown

CODING EXAMPLE

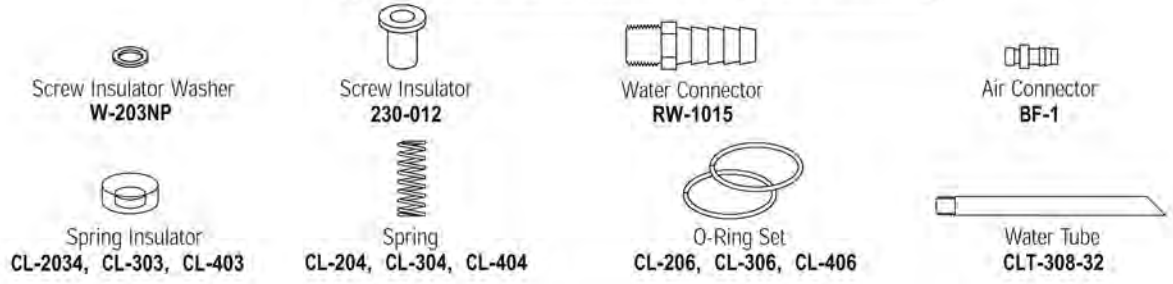
LENGTH	USE **U** FOR STANDARD LENGTH (SHOWN BELOW) USE X FOR EXTENDED LENGTH (.50 (12.70) LONGER THAN STANDARD LENGTH)
BODY STYLE	USE A FOR BASE MOUNT USE B FOR 4 RW TAPER USE C FOR 5 RW TAPER USE D FOR 6 RW TAPER USE E FOR 7 RW TAPER USE F FOR 7/8-14 THREAD USE G FOR 1-12 THREAD USE H FOR BASE MOUNT WITH CABLE LUG (17/32" clearance hole for 1/2 screw) USE J FOR BASE MOUNT WITH CABLE LUG (Tapped hole for 1/2-13 screw) USE K FOR BASE MOUNT WITH CONTACT (CL-200-37)
SERIES	USE 2 FOR SERIES 2 (.88" WELD FACE) USE 3 FOR SERIES 3 (1.25" WELD FACE) USE 4 FOR SERIES 4 (1.50" WELD FACE) USE R2 FOR RETRACTABLE PIN SERIES 2 (.88" WELD FACE) USE **R3** FOR RETRACTABLE PIN SERIES 3 (1.25" WELD FACE) USE R4 FOR RETRACTABLE PIN SERIES 4 (1.50" WELD FACE) ***Note: Leave blank if generating a complete nut of stud welding unit because information is contained in the pin or head number***
COMPONENTS	USE **NHP** FOR UNIT WITH NO HEAD OR PIN USE GENERATED PIN # FOR COMPLETE NUT WELDING UNIT USE GENERATED HEAD # FOR COMPLETE STUD WELDING UNIT

U C R3 NHP		Standard Length with 5 RW Body Style Retractable Series 3 with no Head or Pin.
X A	GH3050T125417	Extended Length, Base Mount Style, head #. This describes a complete stud welding unit.
U G	GP2A3482700525	Standard Length, 1-12 Threaded Body Style, pin #. This describes a complete nut welding unit.

Standard Length of Series Body Styles



Spare Parts List (Not including Pin or Head)



Screw Insulator Washer
W-203NP

Screw Insulator
230-012

Water Connector
RW-1015

Air Connector
BF-1

Spring Insulator
CL-2034, CL-303, CL-403

Spring
CL-204, CL-304, CL-404

O-Ring Set
CL-206, CL-306, CL-406

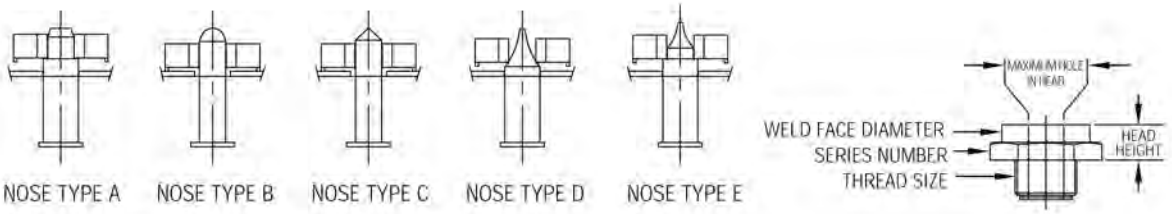
Water Tube
CLT-308-32

Manual Load Weld Nut Pins

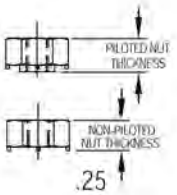
Pin Type	Description
GP	Stainless Steel Pin, Supported by spring and/or air
CP	Coated, D2 Steel Pin, Supported by spring and/or air
RP	Retractable, Stainless Steel Pin, Movement controlled by Air Pressure only. Special Application please contact CenterLine
KP	Coated Retractable, D2 Steel Pin, Movement controlled by Air Pressure only. Special Application please contact CenterLine

Series	Thread Size	Weld Face Diameter	Maximum Hole in Head*	Head Height
2	5/8-18	7/8 Standard	0.427 (10.85) ID	0.500
3	7/8-14	1-1/4 Standard	0.642 (16.31) ID	0.500
4	1-1/8-12	1-1/2 Standard	0.852 (21.64) ID	0.625
**Special weld nut electrodes are available for larger IDs and areas with clearance restrictions.*				

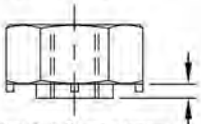
Nose Type	Description
A	Preferred when locating nut and stamping, no stamping contact during weld, no hole in upper electrode
B	Preferred when locating nut only, no stamping contact, no hole in upper electrode
C	Preferred when locating nut only, no stamping contact, no hole in upper electrode
D	Locates nut at a point on the pin nose. upper electrode requires clearance hole for pin tip
E	Preferred when locating nut and stamping, no hole in upper, good for hard to load applications



APPLICATION SIZES



CAUTION



DO NOT select B & C nose types when pilot thickness exceeds stamping thickness.

Generate Your Own Number (Total 14 Charachters)

Example	GP	2	A	348	270	05	25
Breakdown	Pin Type	Series Number	Nose Type	Hole in Stamping -.005 (3 Dec.) - see note below	Hole in Nut -.005 (3 Dec.) - see note below	Stamping Thickness (2 Dec.)	Nut Thickness (2 Dec.)
NOTE: For **B & C** style pins, the **Hole In Stamping** value is the **Hole In Nut** value (i.e GP2B2702700525)							
Part Nu mber							

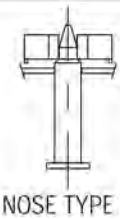
Auto Load Weld Nut Pins

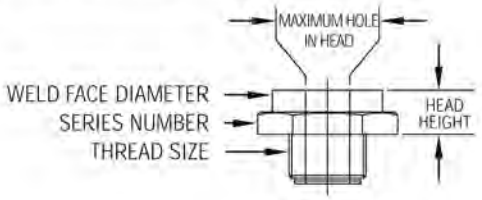
Pin Type	Description
GA	Stainless Steel Pin, Supported by spring and/or air
CA	Coated, D2 Steel Pin, Supported by spring and/or air
RA	Retractable, Stainless Steel Pin, Movement controlled by Air Pressure only, Special Application please contact CenterLine
KA	Coated Retractable, D2 Steel Pin, Movement controlled by Air Pressure only, Special Application please contact CenterLine

Series	Thread Size	Weld Face Diameter	Maximum Hole in Head*	Head Height
2	5/8-18	7/8 Standard	0.427 (10.85) ID	0.500
3	7/8-14	1-1/4 Standard	0.642 (16.31) ID	0.500
4	1-1/8-12	1-1/2 Standard	0.852 (21.64) ID	0.625

**Special weld nut electrodes are available for larger IDs and areas with clearance restrictions.*

Nose Type

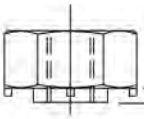
N	P
 NOSE TYPE N	 NOSE TYPE P
 STRAIGHT	 STRAIGHT
For auto loading nuts where the stamping is being located.	**For auto loading nuts where the stamping is not being located. Refer to caution note.**



CAUTION

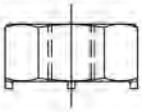
P Nose Types Only

PILOTED NUT

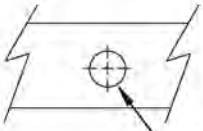


Caution: If pilot thickness exceeds stamping thickness, please see special application sheet

NON- PILOTED NUT

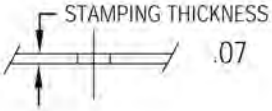


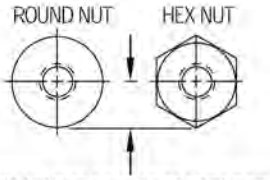
APPLICATION SIZES



HOLE IN STAMPING ONLY FOR N NOSE TYPES

HOLE IN NUT





EXAMPLE .502 .362

Generate Your Own Number (Total 14 Charachters)

Example	GA	3	N	497	357	07	47
Breakdown	Pin Type	Series Number	Nose Type	Hole in Stamping -.005 (3 Dec.) - see note below	Hole in Nut -.005 (3 Dec.) - see note below	Stamping Thickness (2 Dec.)	Measurement from Center to Outermost Edge (2 Dec.)
NOTE: For **P** style pins, the **Hole In Stamping** value is the **Hole in Nut** value (i.e GA3PB**357357**0747)							
Part Number							

Special Application Auto Load Weld Nut Pins

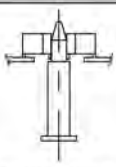
PinType	Description
GA	Stainless Steel Pin, Supported by spring and/or air
CA	Coated, D2 Steel Pin, Supported by spring and/or air
RA	Retractable, Stainless Steel Pin, Movement controlled by Air Pressure only, Special Application please contact CenterLine
KA	Coated Retractable, D2 Steel Pin, Movement controlled by Air Pressure only, Special Application please contact CenterLine

Series	Thread Size	Weld Face Diameter	Maximum Hole in Head*	Head Height
2	5/8-18	7/8 Standard	0.427 (10.85) ID	0.500
3	7/8-14	1-1/4 Standard	0.642 (16.31) ID	0.500
4	1-1/8-12	1-1/2 Standard	0.852 (21.64) ID	0.625

**Special weld nut electrodes are available for larger IDs and areas with clearance restrictions.*

Nose Type

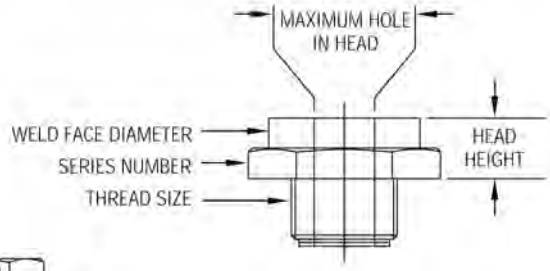
M



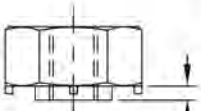
NOSE TYPE M

STRAIGHT

For auto loading nuts where the stamping is not being located and pilot thickness is greater than material thickness.



PILOTED NUT

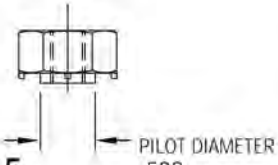


Use M nose type if pilot thickness exceeds stamping thickness, and pin is not used to locate stamping.

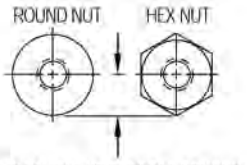
CAUTION

For M Nose Type pins Add .005 to the pilot diameter

APPLICATION SIZES

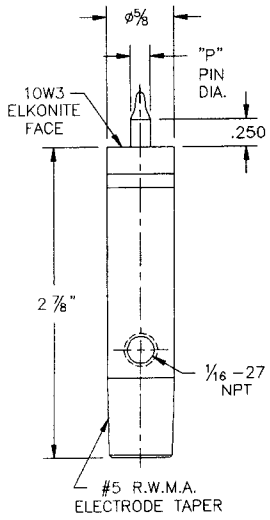


EXAMPLE

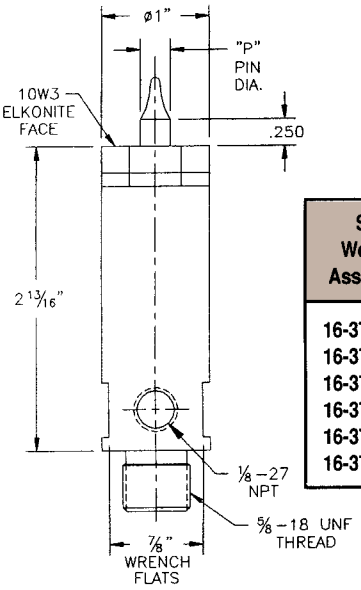


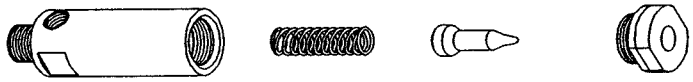
Generate Your Own Number (Total 14 Characters)

Example		3	M	507	357	07	47
Breakdown	Pin Type	Series Number	Nose Type	Pilot Diameter + .005" (3 Dec.)	Hole in Nut -.005" (3 Dec.)	Stamping Thickness (2 Dec.)	Measurement from Center to Outermost Edge (2 Dec.)
Part Number							

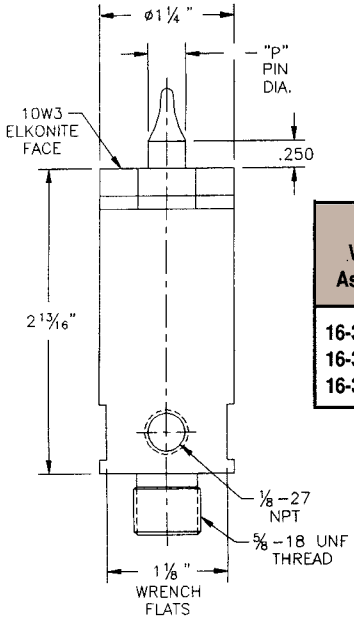


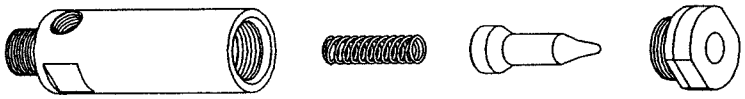
Nut Welding Assembles	Screw Thread Size	"P"	CMW® 3 Base	Spring	Ceramic Coated Stainless Steel Pin	Elkonite® Faced Cap
16-37725-04	#4	.142	16-37325	16-950078-01	16-950064-04	16-37725-C04
16-37725-05	#5	.158	16-37325	16-950078-01	16-950064-05	16-37725-C05
16-37725-06	#6	.173	16-37325	16-950078-01	16-950064-06	16-37725-C06
16-37725-M4	4MM	.187	16-37325	16-950078-01	16-950064-M4S	16-37725-CM4
16-37725-08	#8	.198	16-37325	16-950078-01	16-950064-08	16-37725-C08
16-37725-10	#10	.220	16-37325	16-950078-01	16-950064-10	16-37725-C10
16-37725-M5	5MM	.226	16-37325	16-950078-01	16-950064-M5S	16-37725-CM5
16-37725-12	#12	.250	16-37325	16-950078-01	16-950064-12	16-37725-C12
16-37725-M6	6MM	.266	16-37325	16-950078-01	16-950064-M6S	16-37725-CM6
16-37725-25	.250	.283	16-37325	16-950078-01	16-950064-25	16-37725-C25





Stud Welding Assembles	Screw Thread Size	"P"	CMW® 3 Base	Spring	Ceramic Coated Stainless Steel Pin	Elkonite® Faced Cap
16-37825-M4	4MM	.187	16-37825	16-950065-01	16-950064-M4	16-37825-CM4
16-37825-M5	5MM	.226	16-37825	16-950065-01	16-950064-M5	16-37825-CM5
16-37825-M6	6MM	.266	16-37825	16-950065-01	16-950064-M6	16-37825-CM6
16-37825-M7	7MM	.305	16-37825	16-950065-01	16-950064-M7	16-37825-CM7
16-37825-M8	8MM	.344	16-37825	16-950065-01	16-950064-M8	16-37825-CM8
16-37825-M9	9MM	.384	16-37825	16-950065-01	16-950064-M9	16-37825-CM9





Stud Welding Assembles	Screw Thread Size	"P"	CMW® 3 Base	Spring	Ceramic Coated Stainless Steel Pin	Elkonite® Faced Cap
16-37826-M10	10MM	.423	16-37826	16-950065-01	16-950064-M10	16-37826-CM10
16-37826-M11	11MM	.463	16-37826	16-950065-01	16-950064-M11	16-37826-CM11
16-37826-M12	12MM	.502	16-37826	16-950065-01	16-950064-M12	16-37826-CM12

FOR 5/8" DIA. • **USE COOLING CHAMBER 18-1340**

FOR 1" DIA. AND 1 1/4" DIA.
- **MAY BE USED WITH HOLDERS 18-169, 18-170, 18-171**
- **FOR USE WITH PLATEN MOUNTED HOLDERS USE ADAPTER 18-7743**
- **HOLDERS WITH 5RW TAPERS USE ADAPTERS 18-7741, 18-7742**
- **USE COOLING CHAMBERS 18-1342, 18-1343**

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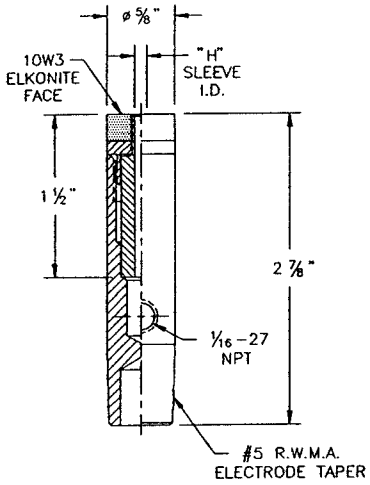
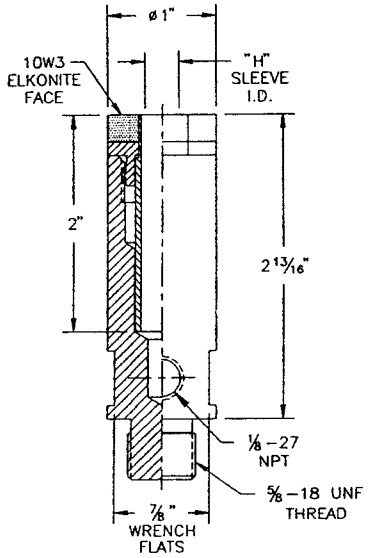
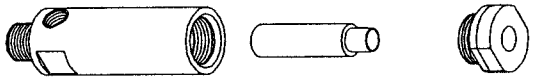
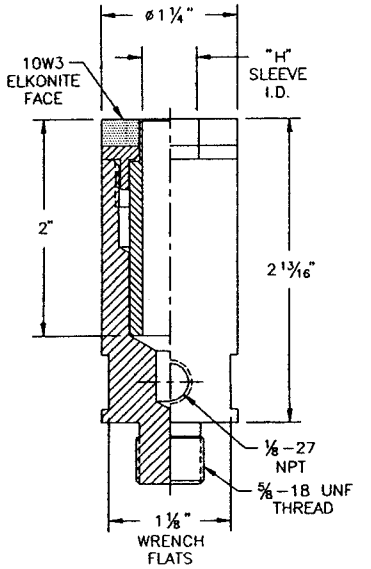


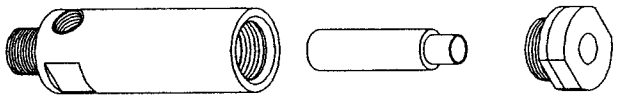
Stud Welding Assembles	Screw Thread Size	"H"	CMW® 3 Base	Ceramic Coated Stainless Steel Sleeve	Elkonite® Faced Cap
16-37325-116	#4	.116	16-37325	16-953116	16-37325-C116
16-37325-132	#5	.132	16-37325	16-953132	16-37325-C132
16-37325-140	#6	.140	16-37325	16-953140	16-37325-C140
16-37325-169	#8	.169	16-37325	16-953169	16-37325-C169
16-37325-169	4MM	.169	16-37325	16-953169	16-37325-C169
16-373250191	#10	.191	16-37325	16-953191	16-37325-C191
16-37325-204	5MM	.204	16-37325	16-953204	16-37325-C204
16-37325-220	#12	.220	16-37325	16-953220	16-37325C220
16-37325-243	6MM	.243	16-37325	16-953243S	16-37325-C243
16-37325-254	.250	.254	16-37325	16-953254S	16-37325-C254





Stud Welding Assembles	Screw Thread Size	"H"	CMW® 3 Base	Ceramic Coated Stainless Steel Sleeve	Elkonite® Faced Cap
16-37525-243	6MM	.243	16-37825	16-953243	16-37525-C243
16-37525-254	.250	.254	16-37825	16-953254	16-37525-C254
16-37525-320	.312	.320	16-37825	16-953320	16-37525-C320
16-37525-320	8MM	.320	16-37825	16-953320	16-37525-C320
16-37525-380	.375	.380	16-37825	16-953380	16-37525-C380





Stud Welding Assembles	Screw Thread Size	"H"	CMW® 3 Base	Ceramic Coated Stainless Steel Sleeve	Elkonite® Faced Cap
16-37526-399	10MM	.399	16-37526	16-953399	16-37526-C399
16-37526-444	.438	.444	16-37526	16-953444	16-37526-C444
16-37526-477	12MM	.477	16-37526	16-953477	16-37526-C477
16-37526-502	.500	.502	16-37526	16-953502	16-37526-C502
16-37526-630	.625	.630	16-37526	16-953630	16-37526-C630

FOR 5/8" DIA.
- USE COOLING CHAMBER 18-1340

FOR 1" DIA. AND 1 1/4" DIA.
- MAY BE USED WITH HOLDERS 18-169, 18-170, 18-171, PAGE 64
- FOR USE WITH PLATEN MOUNTED HOLDERS USE ADAPTER 18-7743, PAGE 62
- HOLDERS WITH 5RW TAPERS USED ADAPTERS 18-7741, 18-7742, PAGE 58
- USE COOLING CHAMBERS 18-1342, 18-1343, PAGE 59

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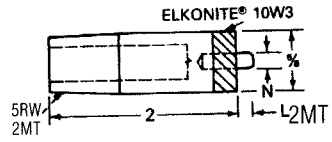
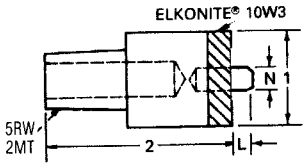
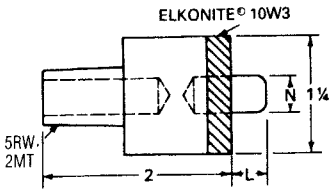
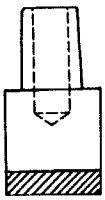
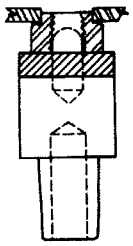
ASSEMBLED ELECTRODE	Taper Size D	Pilot Pin Dia. "N"	For Nut Thread Size "N"	Pilot Pin Length "L"	Part No.
16-3764-XX 	5RW	.082	#4	.093	**16-3764-04**
		.093	#5	.093	**16-3764-05**
		.100	#6	.093	**16-3764-06**
		.107	3.5 mm	.093	**16-3764-M3-5**
		.123	4.0 mm	.156	**16-3764-M4**
		.129	#8	.156	**16-3764-08**
		.143	#10	.156	**16-3764-10**
		.156	5.0 mm	.156	**16-3764-M5**
16-3765-XX 	5RW	.166	#12	.375	**16-3765-12**
		.189	6.0 mm	.375	**16-3765-M6**
		.192	1/4	.375	**16-3765-25**
	2MT	.223	7.0 mm	.375	**16-3765-M7**
		.252	8.0 mm	.375	**16-3765-M8**
		.257	5/16	.375	**16-3765-31**
		.291	9.0 mm	.375	**16-3765-M9**
16-3766-XX 	5RW	.306	3/8	.375	**16-3766-38**
		.320	10 mm	.375	**16-3766-M10**
		.359	11 mm	.375	**16-3766-M11**
		.361	7/16	.375	**16-3766-44**
	2MT	.388	12 mm	.375	**16-3766-M12**
		.415	1/2	.375	**16-3766-50**
		.455	14 mm	.375	**16-3766-M14**

Typical Set-Up for Self Piloting Nuts

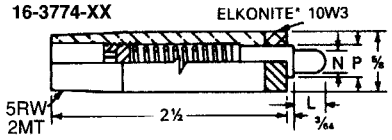
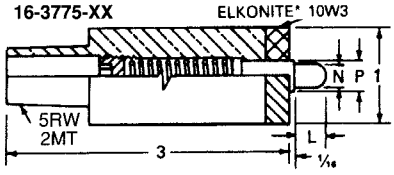
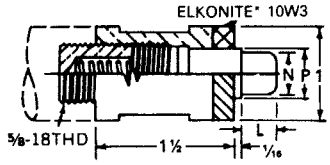
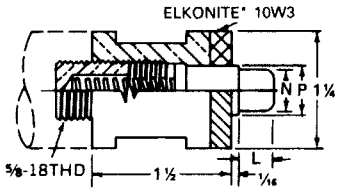


Upper Electrode

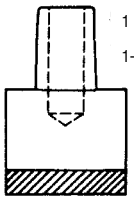
5/8 Dia. use **632050, pg. 43**
1 Dia. **16-1392, pg. 60**
1-1/4" use **16-1394, pg. 60**



Elkonite® is a registered trademark owned by CMW.

ASSEMBLED ELECTRODE	Taper or Thd. Size	Pin Dia. "N"	Pilot Length "L"	Pin Dia. "P"	For Nut Thread Size "N"	Part No.
16-3774-XX ELKONITE® 10W3 	5RW 2MT	.082	.312	.142	#4	**16-3774-04**
		.093	.312	.158	#5	**16-3774-05**
		.100	.312	.173	#6	**16-3774-06**
		.129	.312	.198	#8	**16-3774-08**
		.143	.312	.220	#10	**16-3774-10**
		.186	.312	.250	6mm	**16-3774-M6**
16-3775-XX ELKONITE® 10W3 	5RW 2MT	.166	.312	.250	#12	**16-3775-12**
		.186	.312	.250	6 mm	**16-3775-M6**
		.192	.312	.283	1/4	**16-3775-25**
		.252	.312	.283	8 mm	**16-3775-M8**
		.257	.312	.345	5/16	**16-3775-31**
		.322	.312	.347	10 mm	**16-3775-M10**
16-3785-XX ELKONITE® 10W3 	5/8-18 Thd.	.166	.375	.250	#12	**16-3785-12**
		.186	.375	.269	6 mm	**16-3785-M6**
		.192	.375	.283	1/4	**16-3785-25**
		.252	.375	.348	8 mm	**16-3785-M8**
		.257	.375	.345	5/16	**16-3785-31**
		.320	.375	.427	10 mm	**16-3785-M10**
		.359	.375	.466	11 mm	**16-3785-M11**
		.388	.375	.470	12 mm	**16-3785-M12**
16-3786-XX ELKONITE® 10W3 	5/8-18 Thd.	.166	.375	.250	#12	**16-3786-12**
		.186	.375	.269	6 mm	**16-3786-M6**
		.192	.375	.283	1/4	**16-3786-25**
		.252	.375	.348	8 mm	**16-3786-M8**
		.257	.375	.345	5/16	**16-3786-31**
		.306	.375	.408	3/8	**16-3786-38**
		.320	.375	.427	10 mm	**16-3786-M10**
		.359	.375	.466	11 mm	**16-3786-M11**
		.361	.375	.470	7/16	**16-3786-44**
		.388	.375	.470	12 mm	**16-3786-M12**
		.415	.375	.533	1/2	**16-3786-50**

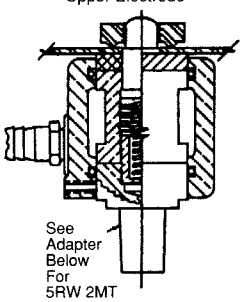
Typical Set-Up for Non Piloting Nuts



Upper Electrode

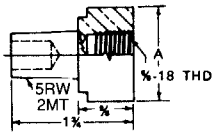
5/8 Dia. use **632050, pg. 43**
1 Dia. use **16-1392, pg. 60**
1-1/4" use **16-1394, pg. 60**

Pin is pushed down by the Upper Electrode



See Adapter Below For 5RW 2MT

Use with ⅝-18 Thread assemblies to convert to 5RW or 2MT Taper Shank



A	Part No.	Use With
1	**18-7741**	**16-3785**-XX
1 ¼	**18-7742**	**16-3786**-XX

Note: Electrode Assemblies 18-3785-XX and 18-3786-XX May also be used with 5/8-18 Thread Holders 18-169, 18-170 and 18-171 as shown on page 64.

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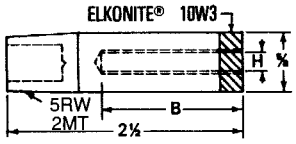
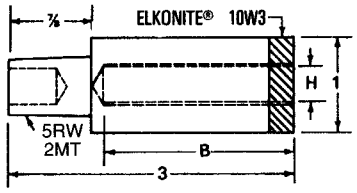
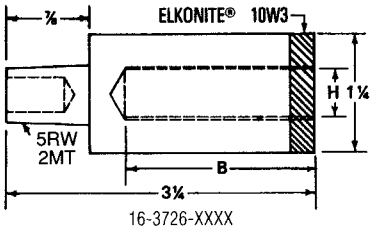
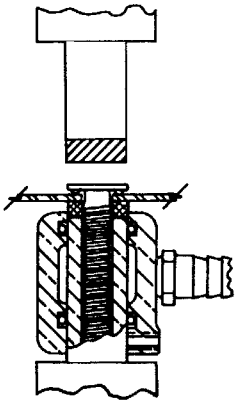
ASSEMBLED ELECTRODE	*Screw Thread Size	Insulation I.D. H.	Part No. Assembled Electrode		
See page 35 for Metric conversions See page 36 for Taper dimensions		Depth B	.375	.750	1.125
 16-3724-XXXX	#4 #5	.116 .132	16-3724-1161 16-3724-1321	16-3724-1162 16-3724-1322	16-3724-1163 16-3724-1323
		Depth B	.500	1.00	1.500
	#6 — — #8	.140 .150 .157 .169	16-3724-1401 16-3724-1501 16-3724-1571 16-3724-1691	16-3724-1402 16-3724-1502 16-3724-1572 16-3724-1692	16-3724-1403 16-3724-1503 16-3724-1573 16-3724-1693
		Depth B	.750	1.500	
	#10 #12 .250	.191 .220 .254	16-3724-1911 16-3724-2201 16-3724-2541	16-3724-1912 16-3724-2202 16-3724-2542	
 16-3725-XXXX		Depth B	.750	1.500	
	.250	.254	16-3725-2541	16-3725-2542	
		Depth B	1.00	2.00	
	— .312 — — .375	.277 .317 .339 .365 .380	16-3725-2771 16-3725-3171 16-3725-3391 16-3725-3651 16-3725-3801	16-3725-2772 16-3725-3172 16-3725-3392 16-3725-3652 16-3725-3802	
 16-3726-XXXX		Depth B	1.00	2.00	
	— — .437 .500	.401 .427 .444 .502	16-3726-4011 16-3726-4271 16-3726-4441 16-3726-5021	16-3726-4012 16-3726-4272 16-3726-4442 16-3726-5022	
		Depth B	1.00	2.00	
	— .625 — —	.552 .630 .676 .801	16-3726-5521 16-3726-6301 16-3726-6761 16-3726-8011	16-3726-5522 16-3726-6302 16-3726-6762 16-3726-8012	

For upper electrode use standard electrode:

⅝ Dia.	**632050**	page 43
1 Dia.	**16-1392**	page 60
1-¼ Dia.	**16-1394**	page 60

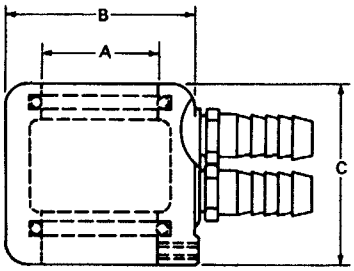
For Stud Electrode	Use Cooling Chamber
16-3724-XXXX	**18-1340**
16-3725-XXXX	**18-1342**
16-3726-XXXX	**18-1343**
See Above	See Above



CMW External Water Cooling Chambers are designed to provide supplementary cooling in special, hard-to-cool applications. These cast aluminum jackets are securely sealed and locked in position over the external surface of ⅝", ⅞", 1", or 1¼" diameter electrodes. Standard water nipples connect to the regular water inlet and outlet hoses of these external cooling chambers.

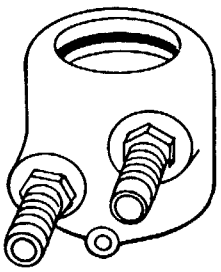
CMW External Water Cooling Chambers are also recommended for *additional* cooling capacity on internally cooled applications operating at elevated temperatures.

One Piece Aluminum Castings—Rubber "O" Ring Seals—Standard Water Nipples—Allen Head Set-Screw Lock-On.



EXTERNAL ELECTRODE COOLING CHAMBERS

PART NO.	To Fit A Dia. Electrode	O.D. B	Overall Length C
18-1340 **18-1341**	⅝ ⅞	1¼ 1½	1½ 1½
18-1342 **18-1343**	1 1¼	1¾ 2	1½ 1⅞



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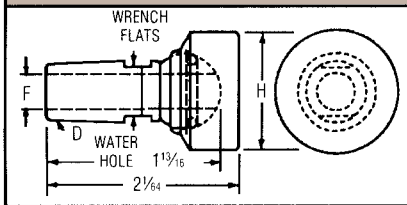
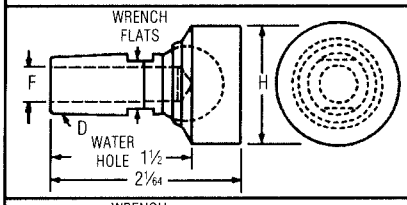
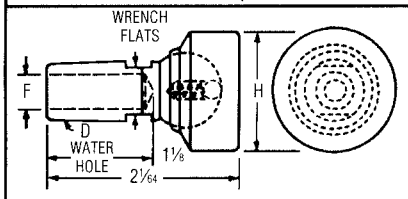
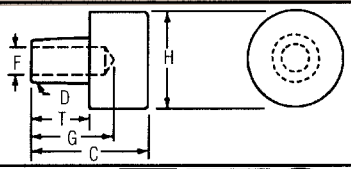
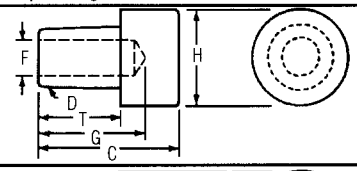
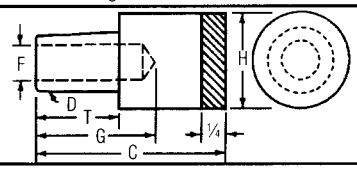
SWIVEL HEAD BACK-UP ELECTRODES

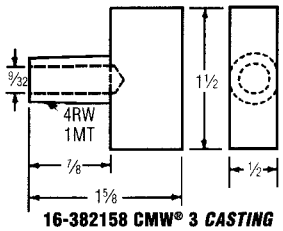
	Type	Part No.	Taper	Water Hole Dia.	Face Dia.
	Thru Hole "O" Ring	**16-2304** **16-2305**	4RW 1MT 5RW 2MT	9/32 3/8	7/8
		16-2302 **16-2303**	4RW 1MT 5RW 2MT	9/32 3/8	1
		16-2300 **16-2301**	4RW 1MT 5RW 2MT	9/32 3/8	1-1/4
		16-2306	5RW 2MT	3/8	1-1/2
	Blind Hole	**16-2314** **16-2315**	4RW 1MT 5RW 2MT	9/32 3/8	7/8
		16-2312 **16-2313**	4RW 1MT 5RW 2MT	9/32 3/8	1
		16-2310 **16-2311**	4RW 1MT 5RW 2MT	9/32 3/8	1-1/4
		16-2316	5RW 2MT	3/8	1-1/2
	Blind Hole With Spring and Ball	**16-23129** **16-23139**	4RW 1MT 5RW 2MT	9/32 3/8	1
		16-23109 **16-23119**	4RW 1MT 5RW 2MT	9/32 3/8	1-1/4
		16-23169 **16-23179**	4RW 1MT 5RW 2MT	9/32 3/8	1-1/2

LARGE DIAMETER FLAT FACED BACK-UP ELECTRODES

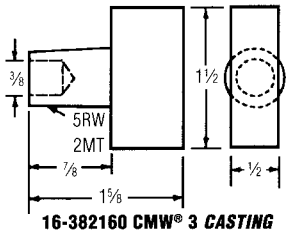
	Part No.	Weld Face Material	Overall Length C	Taper D	Water Hole Dia. F	Water Hole Depth G	Weld Face Dia. H	Shank Length T
	**16-3012**	CMW® 3	1-1/4	4RW or 1MT	9/32	7/8	3/4	5/8
	16-3010	CMW® 3					1	
	16-3030	CMW® 3					1-1/4	
	**16-3021**	CMW® 3	1-1/2	5RW or 2MT	3/8	1-1/8	7/8	7/8
	16-3020	CMW® 3					1	
	16-3040	CMW® 3					1-1/4	
	16-3050	CMW® 3					1-1/2	
	**16-1392**	ELKONITE® 10W3	2	5RW or 2MT	3/8	1-1/2	1	7/8
	16-1393	ELKONITE® 10W3	3			5/8	1	
	16-1394	ELKONITE® 10W3	2			1-1/2	1-1/4	
	16-1395	ELKONITE® 10W3	3-1/4			5/8	1-1/4	

SQUARE AND RECTANGULAR FACED BACK-UP ELECTRODES

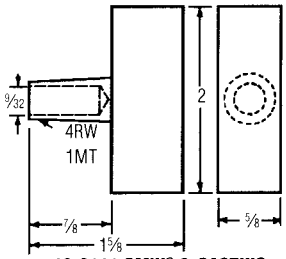
Electrodes of other tapers and alloys available upon application.



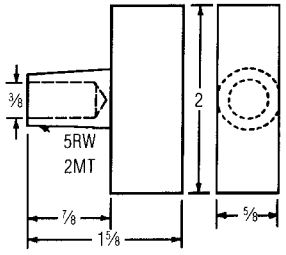
16-382158 CMW® 3 *CASTING*



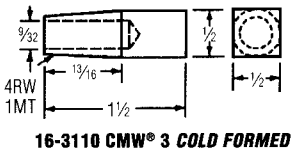
16-382160 CMW® 3 *CASTING*



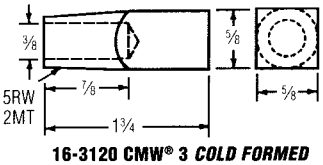
16-3111 CMW® 3 *CASTING*



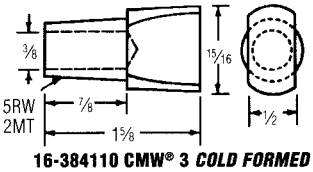
16-3121 CMW® 3 *CASTING*



16-3110 CMW® 3 *COLD FORMED*



16-3120 CMW® 3 *COLD FORMED*



16-384110 CMW® 3 *COLD FORMED*

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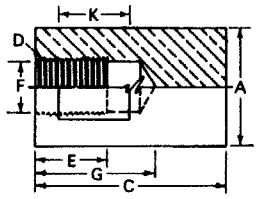
CMW®3 Female Threaded Electrodes

CMW® 3 Part No.	C Overall Length	D Thread	A Major Dia.	E Thread Depth	G Water Hole Depth	F Water Hole Dia.	Over Wrench Flats	K Wrench Flat Length	H Welding Face Dia.
336508	2	5/8-18	1	3/4	1 1/4	37/64	7/8	3/4	1
336510			1 1/4				1	3/4	1 1/4
336512			1 1/2				1 1/4	7/8	1 1/2
326508	2	5/8-18	1	3/4	1 1/4	37/64	7/8	3/4	3/8
326510			1 1/4				1	3/4	1/2
326512			1 1/2				1 1/4	7/8	5/8

FLAT



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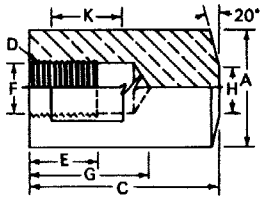
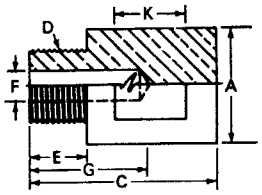


CMW®3 Male Threaded Electrodes

CMW® 3 Part No.	C Overall Length	D Thread	A Major Dia.	E Thread Depth	G Water Hole Depth	F Water Hole Dia.	Over Wrench Flats	K Wrench Flat Length	H Welding Face Dia.
330507	2	5/8-18	7/8	9/16	1 1/4	5/16	3/4	5/8	7/8
330508		5/8-18	1	9/16		5/16	7/8	5/8	1
335506		5/8-11	3/4	15/32		5/16	5/8	5/8	3/4
335507		5/8-11	7/8	15/32		5/16	3/4	3/4	7/8
335508		3/4-10	1	5/8		3/8	7/8	7/8	1
335510		3/4-10	1 1/4	5/8		3/8	1	3/4	1 1/4
335512		7/8-9	1 1/2	3/4		1/2	1 1/4	7/8	1 1/2
325506	2	5/8-11	3/4	15/32	1 1/4	5/16	5/8	1/2	1/4
325507		5/8-11	7/8	15/32		5/16	3/4	5/8	5/16
325508		3/4-10	1	5/8		3/8	7/8	5/8	3/8
325510		3/4-10	1 1/4	5/8		3/8	1	3/4	1/2

FLAT



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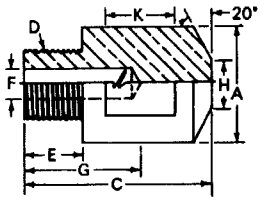
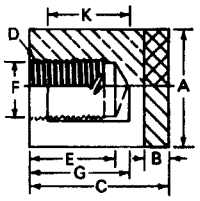


ELKONITE® Faced Female Threaded Electrodes

ELKONITE® 10W3 Part No.	C Overall Length	D Thread	A Major Dia.	E Thread Depth	G Water Hole Depth	F Water Hole Dia.	Over Wrench Flats	K Wrench Flat Length	H Welding Face Dia.	B ELKONITE Thickness
636308	1 1/2	5/8-18	1	3/4	1	37/64	7/8	1/2	1	1/4
636310			1 1/4				1	1/2	1 1/4	
636312			1 1/2				1 1/4	3/4	1 1/2	
626308	1 1/2	5/8-18	1	3/4	1	37/64	7/8	1/2	5/8	1/4
626310			1 1/4				1	1/2	5/8	

FLAT



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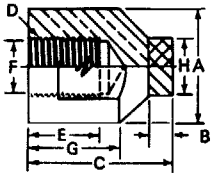
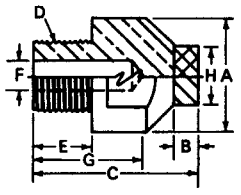


ELKONITE® Faced Male Threaded Electrodes

ELKONITE® 10W3 Part No.	C Overall Length	D Thread	A Major Dia.	E Thread Depth	G Water Hole Depth	F Water Hole Dia.	Over Wrench Flats	H Welding Face Dia.	B ELKONITE Thickness
620307	1 1/2	5/8-18	7/8	9/16	1	5/16	3/4	1/2	1/4
625206	1 1/4	5/8-11	3/4	15/32	7/8	5/16	5/8	1/2	3/16
625308	1 5/8	3/4-10	1	5/8	1 3/16	3/8	7/8	5/8	1/4

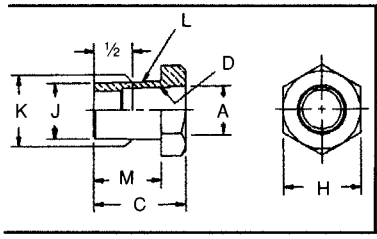
CENTERED



*Bodies for ELKONITE® Faced Electrodes are Class II Material

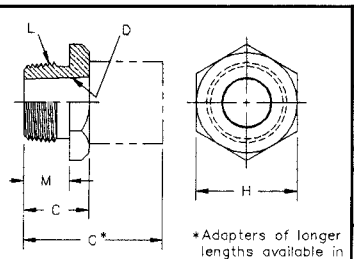
Elkonite® is a registered trademark owned by CMW.

MALE TAPER TO FEMALE TAPER ADAPTERS



ADAPTER PART NO.	MALE TAPER			FEMALE TAPER		Length Under Head	Hex. Over Flats	Overall Length
	Size L	Minor Dia. J	Dia. @ ½" K	Size D	Major Dia. A	M	H	C
18-741	5RW or 2MT	.588	.613	4RW or 1MT	.463	⅞	⅞	1 3/16
18-742	7RW or 3MT	.819	.844	5RW or 2MT	.625	1 3/16	1	1½
18-7414	6RW	.706	.731	5RW	.625	⅞	1	1 3/16
18-7415	4RW or 1MT	.438	.463	5RW or 2MT	.625	⅝	⅞	1¾
18-7416	5RW or 2MT	.588	.613	6RW	.750	⅞	1	2¼

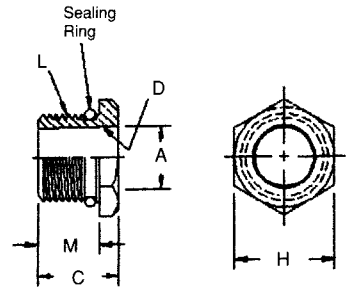
MALE PIPE THREAD TO FEMALE TAPER ADAPTERS



*Adapters of longer lengths available in 1/8" increments upon request

ADAPTER PART NO.	MALE THREAD Size L	FEMALE TAPER		Length Under Head M	Hex. Over Flats H	Overall Length C
		Size D	Major Dia. A			
18-746-07	½-14 pipe	4RW or 1MT	.463	⅝	1	⅞
18-747-07	½-14 pipe	5RW or 2MT	.625	⅝	1	⅞
18-7465-07	½-14 pipe	5RW MALE CAP	.414	9/16	⅞	⅞
18-748-06	⅝-14 pipe	4RW or 1MT	.463	9/16	1	¾
18-749-06	⅝-14 pipe	5RW or 2MT	.625	9/16	1	¾
18-756-09	¾-14 pipe	4RW or 1MT	.463	⅞	1¼	1⅛
18-757-09	¾-14 pipe	5RW or 2MT	.625	⅞	1¼	1⅛
18-7576-09	¾-14 pipe	6RW	.750	⅞	1¼	1⅛

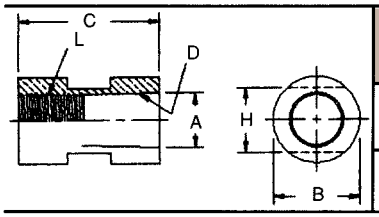
MALE THREAD TO FEMALE TAPER ADAPTERS



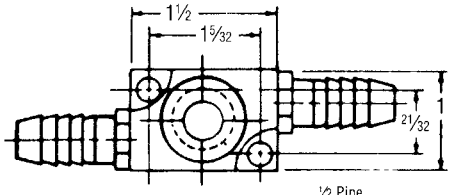
*This part has ¾" wrench flats.

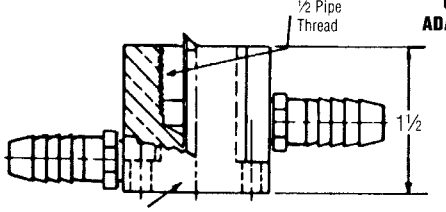
ADAPTER PART NO.	MALE THREAD Size L	FEMALE TAPER		Length Under Head M	Dia. Or Hex H	Overall Length C	Sealing Ring Part No.
		Size D	Major Dia. A				
18-750	⅝-18	4RW or 1MT	.463	9/16	⅞ Hex	13/16	18-10060-11
18-751	⅝-18	5RW or 2MT	.625	9/16	1 Hex	1 1/16	18-10060-11
***18-755**	¾-10	5RW or 2MT	.625	9/16	1 Dia.	1 3/16	18-10060-12
18-770	⅞-14	4RW or 1MT	.463	⅝	1 Hex	13/16	18-76460
18-771	⅞-14	5RW or 2MT	.625	⅝	1 Hex	13/16	18-76460
18-7743	1-14	5/8 - 18 THD	–	⅝	1¼ Hex	1	18-10060-17
18-785	1-14	4RW or 1MT	.463	9/16	1¼ Hex	13/16	18-10060-17
18-786	1-14	5RW or 2MT	.625	9/16	1¼ Hex	13/16	18-10060-17
18-7863	1-14	6RW	.750	¾	1¼ Hex	1¾	18-10060-17
18-787	1-14	7RW or 3 MT	.875	¾	1¼ Hex	2⅛	18-10060-17
18-7875	1-14	5RW or 2MT	.625	9/16	1¼ Dia.	1 1/16	18-10060-17
18-7876	1-14	6RW	.750	⅝	1¼ Dia.	⅞	18-10060-17

FEMALE THREAD TO FEMALE TAPER ADAPTERS



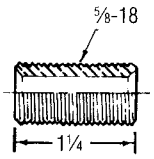
ADAPTER PART NO.	FEMALE THREAD Size L	FEMALE TAPER		Outside Dia. B	Over Wrench FLats H	Overall Length C
		Size D	Major Dia. A			
18-753	⅝-18	4RW or 1MT	.475	1¼	¾	1⅝
18-754	⅝-18	5RW or 2MT	.625	1¼	¾	1⅝
18-7591	¾-10	4RW or 1MT	.463	1¼ Hex	1¼	1¾
18-7592	¾-10	5RW or 2MT	.625	1¼ Hex	1¼	1¾

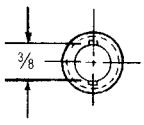




18-82650 ADAPTER ASSY 1/2 - 14 PIPE THD.

USE WITH 1/2 PIPE THREAD ADAPTERS LISTED ON THIS PAGE

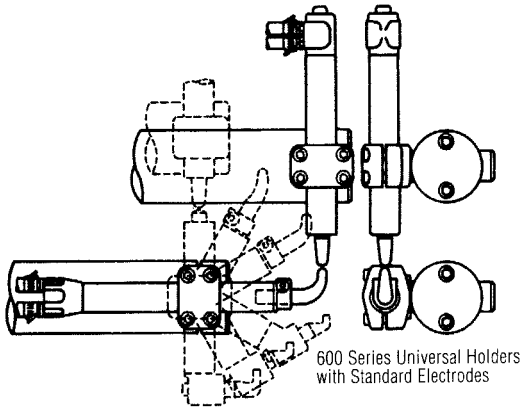


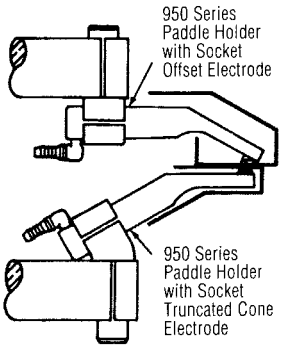


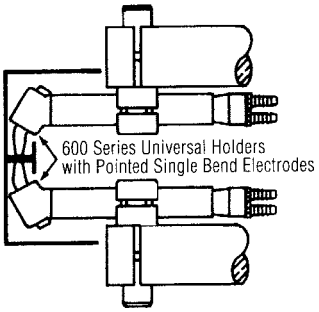
ADAPTER PART NO. 18-752

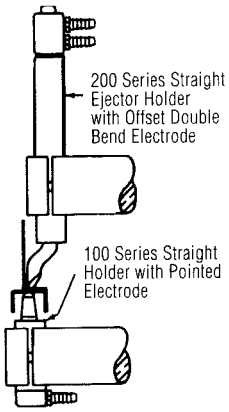
COMBINATIONS OF CMW® HOLDERS, ADAPTERS AND ELECTRODES CAN PERFORM MOST RESISTANCE WELDING APPLICATIONS

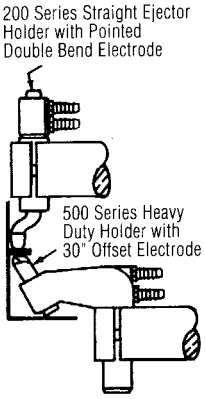
Many of these combinations make possible welding operations that could have been done heretofore only by the use of "expensive and special" holders and electrodes. A few ideas of the many possible combinations are shown for your guidance.

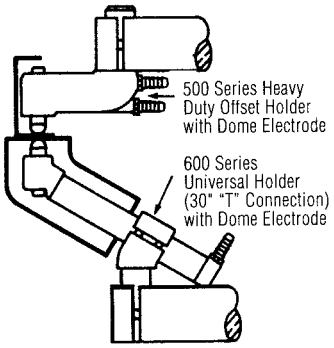


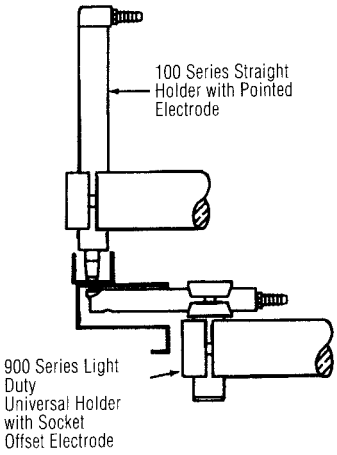


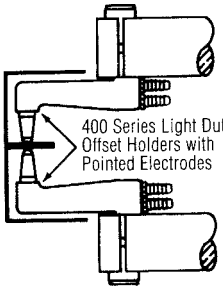


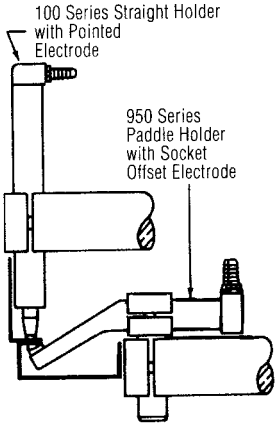


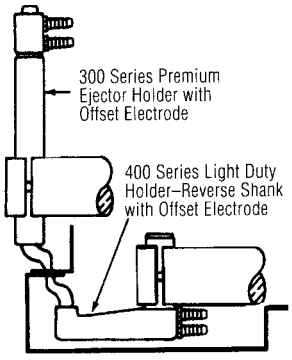


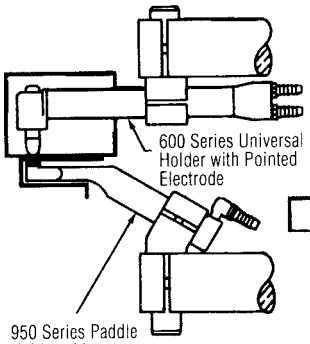


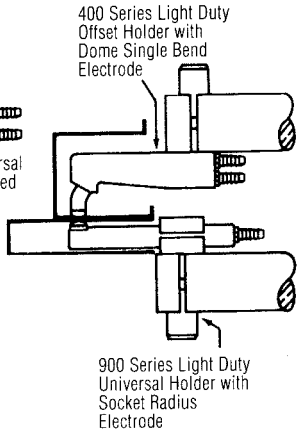


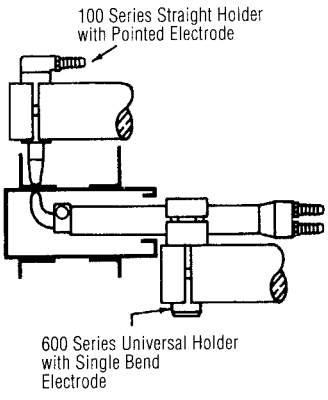


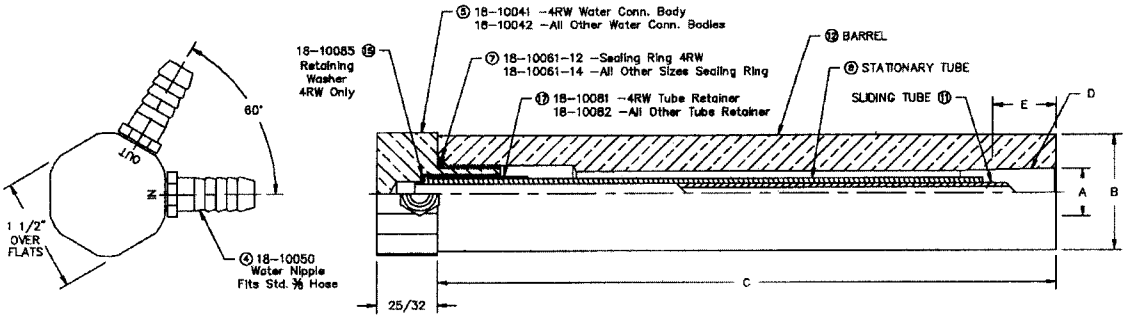




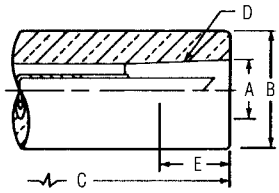




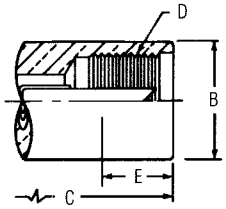




TAPERED

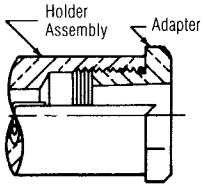


THREADED



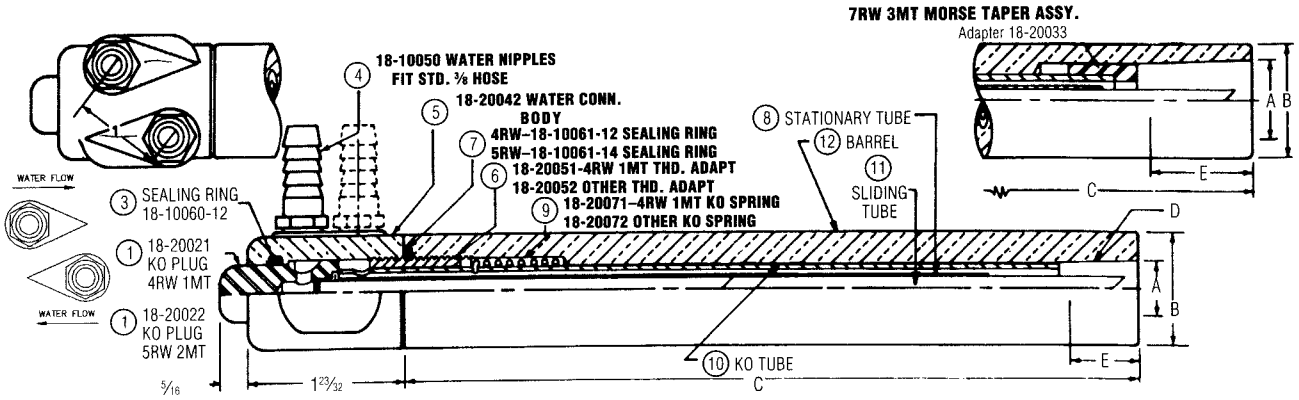
HOLDER ASSEMBLY PART NUMBER	HOLDER SIZE A Major Taper Dia.	B Barrel Dia.	C Barrel Length	D Taper Or Thread	E Engagement with Std. Electrode	Water Connection Head Sub-Assembly Include Parts: 4 5 7 8 15 17	⑧ Stationary Tube	⑪ Sliding Tube	⑫ Barrel
18-101 **18-102** **18-103** **18-104**	.463	¾ ⅞ 1 1¼	3	4RW 1MT	½	18-10091-3	18-10044-3	18-10046-3	18-11110-3 18-11210-3 18-11310-3 18-11410-3
18-106 **18-107** **18-108**	.625	1 1¼ 1½	3	5RW 2MT	¾	18-10092-3	18-10045-3	18-10047-3	18-11610-3 18-11710-3 18-11810-3
18-111 **18-112** **18-113** **18-114**	.463	¾ ⅞ 1 1¼	8	4RW 1MT	½	18-10091-8	18-10044-8	18-10046-8	18-11110-8 18-11210-8 18-11310-8 18-11410-8
18-116 **18-117** **18-118**	.625	1 1¼ 1½	8	5RW 2MT	¾	18-10092-8	18-10045-8	18-10047-8	18-11610-8 18-11710-8 18-11810-8
18-119 **18-120**	.875	1¼ 1½	8	7RW 3MT	1⅛	18-10092-8	18-10045-8	18-10047-8	18-11910-8 18-12010-8
18-131 **18-132** **18-133** **18-134**	.463	¾ ⅞ 1 1¼	12	4RW 1MT	½	18-10091-12	18-10044-12	18-10046-8	18-11110-12 18-11210-12 18-11310-12 18-11410-12
18-136 **18-137** **18-138**	.625	1 1¼ 1½	12	5RW 2MT	¾	18-10092-12	18-10045-12	18-10047-8	18-11610-12 18-11710-12 18-11810-12
18-169 **18-170** **18-171**	—	1 1¼ 1½	8	⅝-18	9/16	18-10092-8	18-10045-8	18-10047-8	18-16910-8 18-17010-8 18-17110-8
18-172 **18-173** **18-174**	—	1 1¼ 1½	8	⅞-14	9/16	18-10092-8	18-10045-8	18-10047-8	18-17210-8 18-17310-8 18-17410-8
18-175 **18-176**	—	1¼ 1½	8	1-14	¾	18-10092-8	18-10045-8	18-10047-8	18-17510-8 18-17610-8

ADAPTERS FOR USE WITH THREADED

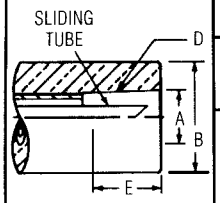


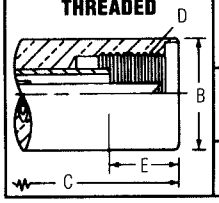
Holder Assembly No.		Adapter Part No.		Attachment Description
18-169 **18-170** **18-171**	Use With	18-750 18-751 18-752 18-811		4RW 1MT Female 5RW 2MT Female ⅝-18 M. Thd. #1 Size "Nu-Twist"®
18-172 **18-173** **18-174**	Use With	18-770 18-771		4RW 1MT Female 5RW 2MT Female
18-175 **18-176**	Use With	18-785 18-786 18-7863 18-787 18-812		4RW 1MT Female 5RW 2MT Female 6RW Female 7RW 3MT Female #2 Size "Nu-Twist"®

Adapter Part No.		Attachment Description
18-753 18-754		4RW 1MT Female 5RW 2MT Female
May also be used with universal Adapters having 7/8-14 Male thread, See page 70.		
May also be used with universal Adapters having 1-14 Male thread, See page 70.		

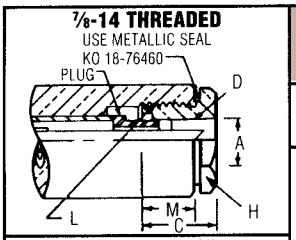


	HOLDER ASSEMBLY PART NUMBER	HOLDER SIZE A Major Taper Dia.	B Barrel Dia.	C Barrel Length	D Taper Or Thread	E Engmt. with/Std. Elect.	Water Conn. Hd. Sub-Assy. Include Parts: 1 3 4 5 6 7	KO Tube Sub-Assembly Include Parts: 8 9 10 11	(8) Stationary Tube	(10) KO Tube	(11) Sliding Tube	(12) Barrel
TAPERED	**18-201**	.463	¾	3	4RW	½	18-20091	18-20095-3	18-10044-3	18-20031-3	18-10046-3	18-11110-3
	18-202		⅞		1MT							18-11210-3
	18-203		1									18-11310-3
	18-204		1¼									18-11410-3
	18-206	.625	1	3	5RW	¾	18-20092	18-20096-3	18-10045-3	18-20032-3	18-10047-3	18-11610-3
	18-207		1¼		2MT							18-11710-3
	18-208		1½									18-11810-3
	18-211	.463	¾	8	4RW	½	18-20091	18-20095-8	18-10044-8	18-20031-8	18-10046-8	18-11110-8
	18-212		⅞		1MT							18-11210-8
	18-213		1									18-11310-8
	18-214		1¼									18-11410-8
	18-216	.625	1	8	5RW	¾	18-20092	18-20096-8	18-10045-8	18-20032-8	18-10047-8	18-11610-8
	18-217		1¼		2MT							18-11710-8
	18-218		1½									18-11810-8
	18-219	.875	1¼	8	7RW	1⅛	18-20092	18-20096-58	18-10045-8	18-20032-58 & 18-20033	18-10047-8	18-11910-8
	18-220		1½		3MT							18-12010-8
	18-231	.463	¾	12	4RW	½	18-20091	18-20095-12	18-10044-12	18-20031-12	18-10046-8	18-11110-12
	18-232		⅞		1MT							18-11210-12
	18-233		1									18-11310-12
	18-234		1¼									18-11410-12
	18-236	.625	1	12	5RW	¾	18-20092	18-20096-12	18-10045-12	18-20032-12	18-10047-8	18-11610-12
	18-237		1¼		2MT							18-11710-12
	18-238		1½									18-11810-12
THREADED	**18-236-18**	.625	1	18	5RW	¾	18-20092	18-20096-18	18-10045-12	18-20032-18	18-10047-29	18-11610-18
	18-237-18		1¼		2MT							18-11710-18
	18-238-18		1½									18-11810-18
	18-272	—	1	8	⅞-14	9/16	18-20092	18-20096-8	18-10045-8	18-20032-8	18-10047-8	18-17210-8
	18-273		1¼									18-17310-8
	18-274		1½									18-17410-8
	18-275	—	1¼	8	1-14	¾	18-20092	18-20096-8	18-10045-8	18-20032-8	18-10047-8	18-17510-8
	18-276		1½									18-17610-8





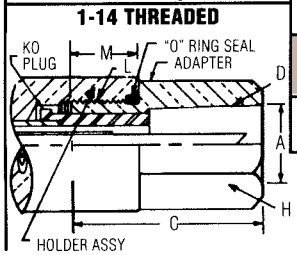
EJECTOR TYPE ADAPTERS ⅞-14 THREAD



ADAPTER PART NO.	MALE THREAD Size L	FEMALE TAPER Size D	FEMALE TAPER Major Diameter A	Length Under Head M	Hex Over Flats H	Overall Length C	Sealing Ring Part No.	KO Plug Part No.
18-7702	⅞-14	4RW 1MT	.463	5/8	1	13/16	18-76460	18-78501
18-7712	⅞-14	5RW 2MT	.625	1/2	1	1-1/16	18-76460	18-7712-3

Use With Threaded Ejector Holders to make Replaceable Taper Holders

Part No.	Description Threaded Holder
18-272	⅞-14 Fem. Thd. 1 Dia.
18-273	⅞-14 Fem. Thd. 1¼ Dia.
18-274	⅞-14 Fem. Thd. 1½ Dia.



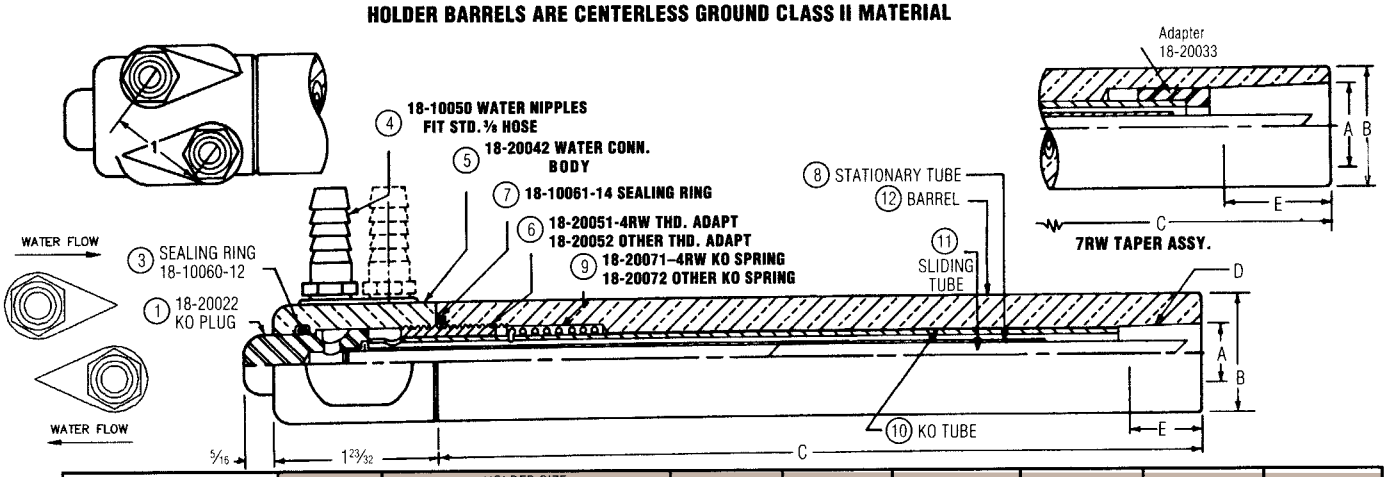
EJECTOR TYPE ADAPTERS 1-14 THREAD

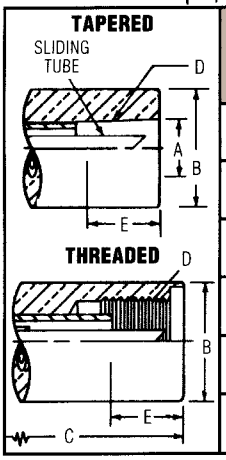
18-7852	1-14	4RW 1MT	.463	9/16	1-1/4	13/16	18-10060-17	18-78501
18-7862	1-14	5RW 2MT	.625	7/16	1-1/4	1-1/16	18-10060-17	18-7712-3
18-7864	1-14	6RW	.750	3/4	1-1/4	1-3/4	18-10060-17	18-78650
18-7872	1-14	7RW 3MT	.875	3/4	1-1/4	2-1/8	18-10060-17	18-78701

Use With Threaded Ejector Holders to make Replaceable Taper Holders

Part No.	Description Threaded Holder
18-275	1-14 Fem. Thd. 1¼ Dia.
18-276	1-14 Fem. Thd. 1½ Dia.

HOLDER BARRELS ARE CENTERLESS GROUND CLASS II MATERIAL

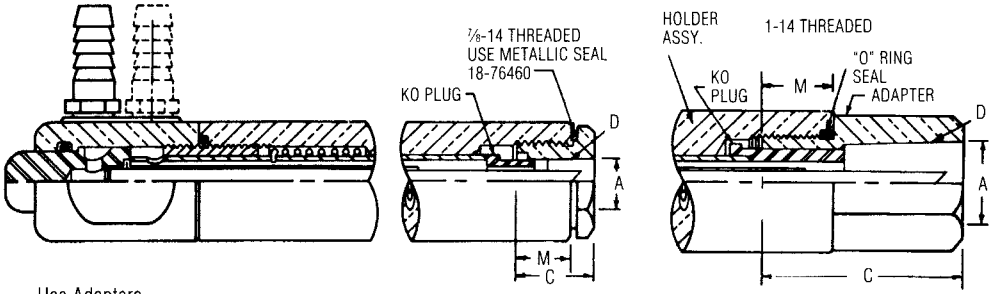




HOLDER ASSEMBLY PART NUMBER	HOLDER SIZE A Major Taper Dia.	B Barrel Dia.	C Barrel Length	D Taper or Thread	E Engmt. w/Std. Elect.	Water Conn. Hd. Sub-Assy. Include Pts. 1 3 4 5 6 7	KO Tube Sub-Assembly Include Parts: 8 9 10 11	(8) Stationary Tube	(10) KO Tube	(11) Sliding Tube	(12) Barrel
18-317		1¼		5RW							18-31710-8
18-318	.625	1½	8	2MT	¾	18-20092	18-20096-8	18-10045-8	18-20032-8	18-10047-8	18-31810-8
18-319		1¼		7RW					18-20032-58		18-31910-8
18-320	.875	1½	8	3MT	1⅛	18-20092	18-20096-58	18-10045-8	18-20033	18-10047-8	18-32010-8
18-337		1¼		5RW							18-31710-12
18-338	.625	1½	12	2MT	¾	18-20092	18-20096-12	18-10045-12	18-20032-12	18-10047-8	18-31810-12
18-339		1¼		7RW					18-20032-62		18-31910-12
18-340	.875	1½	12	3MT	1⅛	18-20092	18-20096-62	18-10045-12	& 18-20033	18-10047-8	18-32010-12
18-372		1									18-37210-8
18-373	—	1¼	8	⅞-14	9/16	18-20092	18-20096-8	18-10045-8	18-20032-8	18-10047-8	18-37310-8
18-375		1¼									18-37510-8
18-376	—	1½	8	1-14	¾	18-20092	18-20096-8	18-10045-8	18-20032-8	18-10047-8	18-37610-8

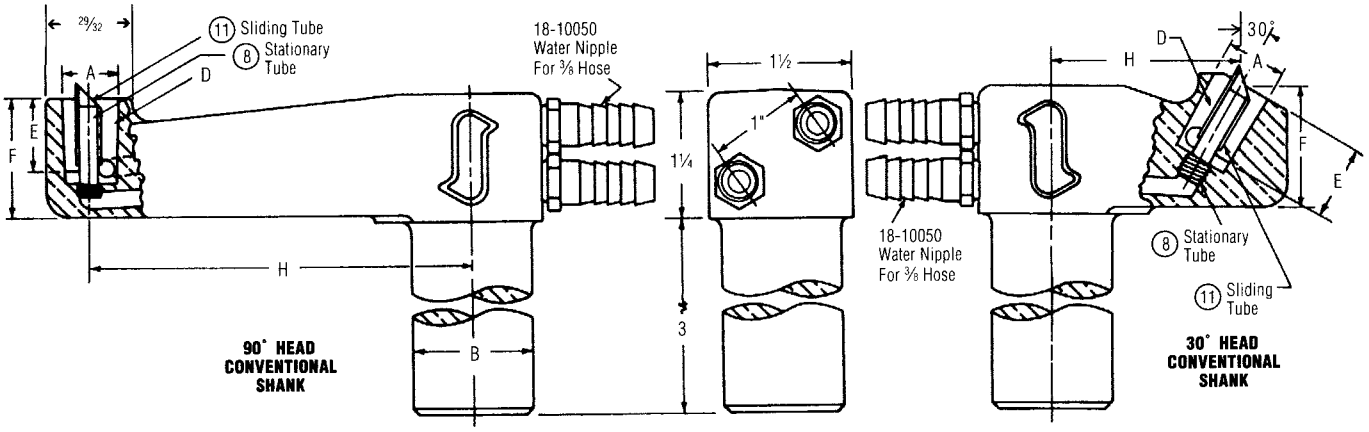
CMW PREMIUM HOLDER FEATURES

The Premium Electrode Holder Barrels are made from high strength Class II material, centerless ground to within .002" tolerance on diameter and Nickel Plated to resist wear and assure uniform contact resistance of a low magnitude. These factors, in addition to the sturdy construction of the ejector mechanisms, plus the ample, well constructed water cooling passage, make these holders ideally suited for use with low frequency, direct current welders, and conventional alternating current machines using high weld currents.



Use Adapters
18-7702 4RW 1MT
18-7712 5RW 2MT
} with ⅞-14 thd'd. Holders { 18-372 1 Dia. / 18-373 1¼ Dia.

Use Adapters
18-7852 4RW 1MT
18-7862 5RW 2MT
18-7864 6RW
18-7872 7RW 3MT
} with 1-14 thd'd. Holders { 18-375 1¼ Dia. / 18-376 1½ Dia.

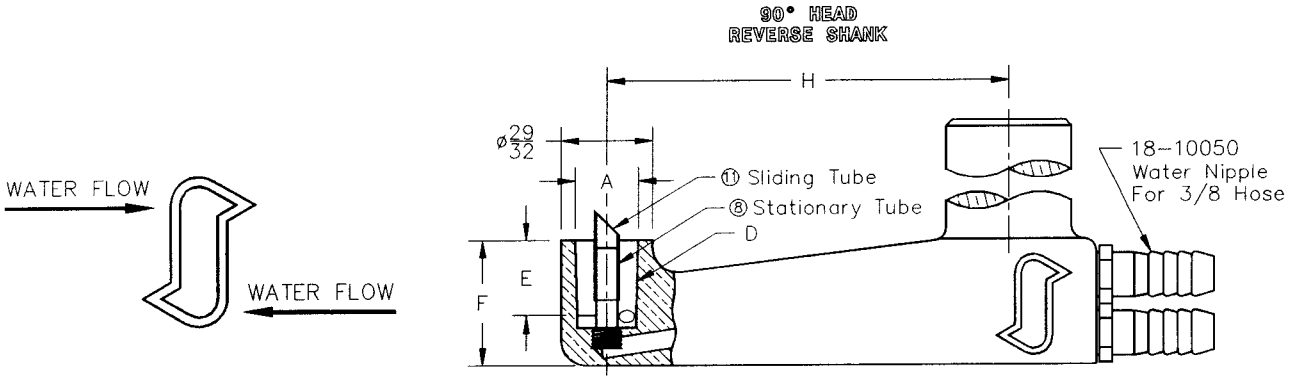


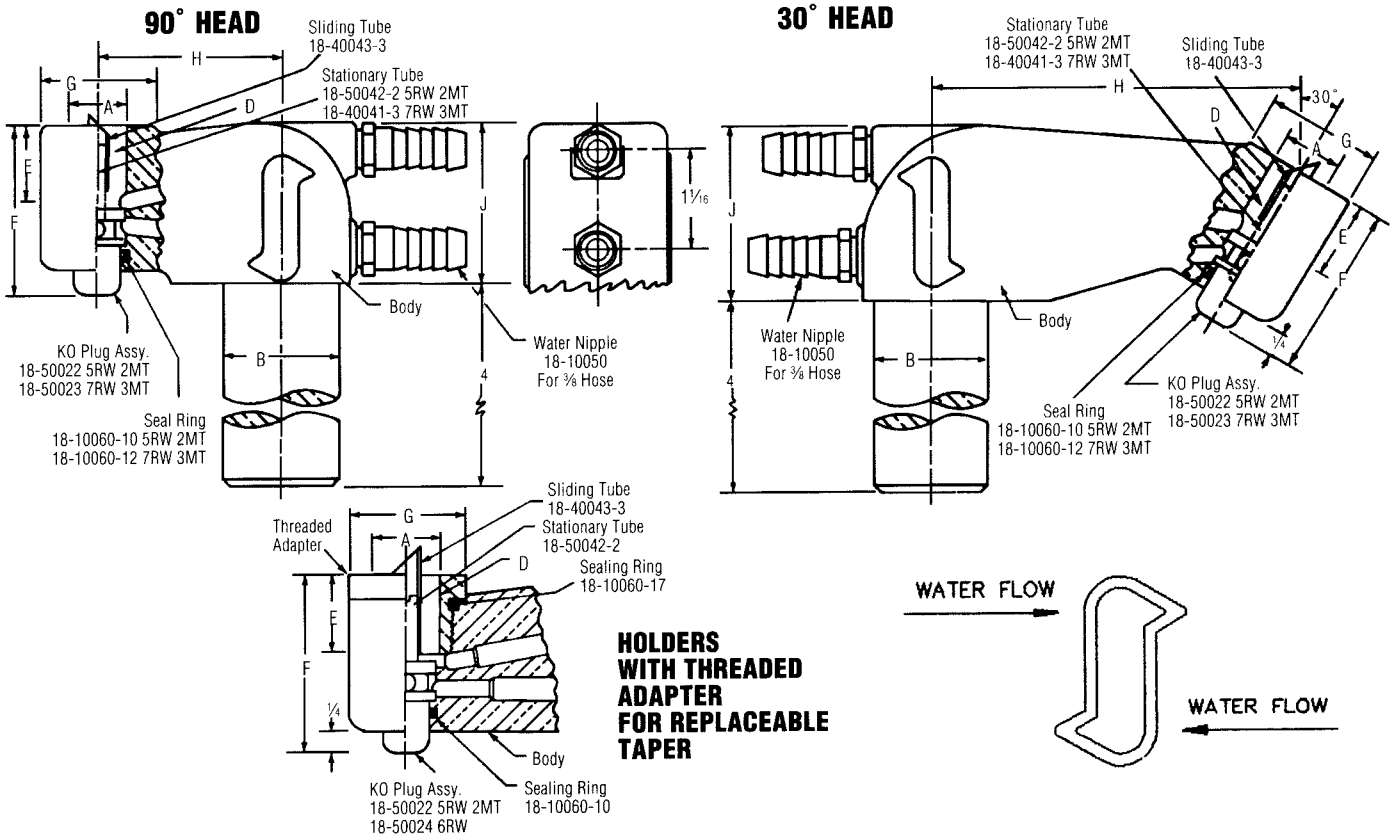
CONVENTIONAL SHANK

HOLDER ASSEMBLY NUMBER	Angle of Head	HOLDER SIZE A Major Taper Dia.	B Shank Dia.	D Taper	E Engagement with Std. Electrode	F Head Height	H Offset	8 Stationary Tube	11 Sliding Tube	Angle of Head	HOLDER ASSEMBLY NUMBER
18-402			7/8								
18-403	90°	.463	1	4RW	1/2	1-1/16	2	18-40041-1	18-40043-1	90°	
18-404			1-1/4	1MT							
18-407			7/8								
18-408	90°	.625	1	5RW	3/4	1-1/4	2	18-40041-1	18-40043-2	90°	
18-409			1-1/4	2MT							
18-422			7/8								
18-423	90°	.463	1	4RW	1/2	1-1/16	4	18-40041-1	18-40043-1	90°	**18-433**
18-424			1-1/4	1MT							
18-428			1	5RW							
18-429	90°	.625	1-1/4	2MT	3/4	1-1/4	4	18-40041-1	18-40043-2	90°	**18-439**
18-442			7/8								
18-443	30°	.463	1	4RW	1/2	1	2	18-40041-1	18-40043-1	30°	
18-444			1-1/4	1MT							
18-448			1	5RW							
18-449	30°	.625	1-1/4	2MT	3/4	1-1/4	2	18-40041-1	18-40043-2	30°	
18-462			7/8								
18-463	30°	.463	1	4RW	1/2	1	4	18-40041-1	18-40043-1	30°	
18-464			1-1/4	1MT							
18-468			1	5RW							
18-469	30°	.625	1-1/4	2MT	3/4	1-1/4	4	18-40041-1	1840043-2	30°	

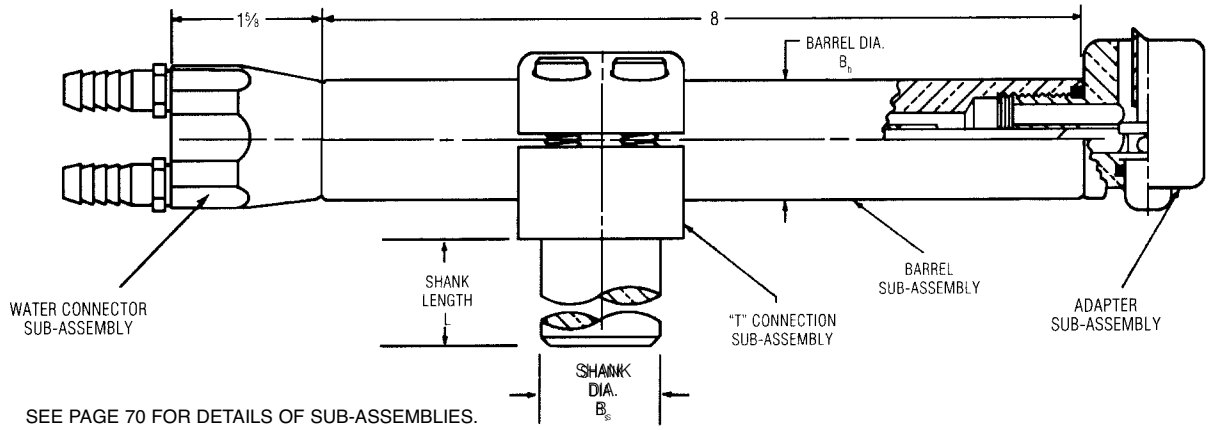
Holders of other shank diameters and lengths or tapers and with Reverse Shank are available on request.

REVERSE SHANK





HOLDER ASSEMBLY NUMBER	Angle of Head	Major Taper Dia. A	Shank Dia. B	Taper D	Std. Taper Engage-ment E	Head Height F	Head Dia. G	C.L. Shank Offset H	Head Thickness J	Threaded Adapter Part No.
HOLDERS										
18-502 **18-503** **18-504**	90°	.625	1 1¼ 1½	5RW 2MT	¾	1 13/16	1¼	2	1 23/32	——— ——— ———
18-505 **18-506**	90°	.875	1¼ 1½	7RW 3MT	1⅛	2 7/32	1½	2		——— ———
18-522 **18-523** **18-524**	90°	.625	1 1¼ 1½	5RW 2MT	¾	1 13/16	1¼	4	1⅞	——— ——— ———
18-525 **18-526**	90°	.875	1¼ 1½	7RW 3MT	1⅛	2 7/32	1½	4		——— ———
18-562 **18-563** **18-564**	30°	.625	1 1¼ 1½	5RW 2MT	¾	1 13/16	1 5/16	4		——— ——— ———
18-565 **18-566**	30°	.875	1¼ 1½	7RW 3MT	1⅛	2 7/32	1 9/16	4		——— ———
HOLDERS WITH THREADED ADAPTER										
18-5035 **18-5036**	90°	.625 .750	1¼	5RW 2MT 6RW	¾ ⅞	1 13/16 1 15/16	1¼	2	1 23/32	**18-7875** **18-7876**
18-5045 **18-5046**	90°	.625 .750	1½	5RW 2MT 6RW	¾ ⅞	1 13/16 1 15/16	1¼	2		**18-7875** **18-7876**
18-5235 **18-5236**	90°	.625 .750	1¼	5RW 2MT 6RW	¾ ⅞	1 13/16 1 15/16	1¼	4	1⅞	**18-7875** **18-7876**
18-5245 **18-5246**	90°	.625 .750	1½	5RW 2MT 6RW	¾ ⅞	1 13/16 1 15/16	1¼	4		**18-7875** **18-7876**
18-5635 **18-5636**	30°	.625 .750	1¼	5RW 2MT 6RW	¾ ⅞	1 13/16 1 15/16	1¼	4		**18-7875** **18-7876**
18-5645 **18-5646**	30°	.625 .750	1½	5RW 2MT 6RW	¾ ⅞	1 13/16 1 15/16	1¼	4		**18-7875** **18-7876**



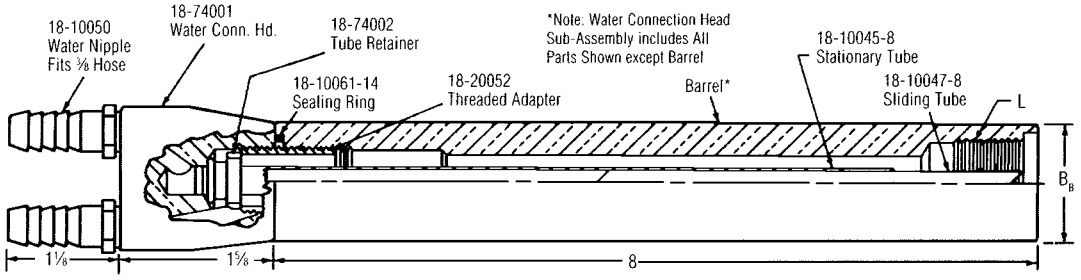
SEE PAGE 70 FOR DETAILS OF SUB-ASSEMBLIES.

Part No.	Head Angle	Bbl. Dia. B_b	Shank Dia. B_s	Shank Length L	Head Assy.	Bbl. Assy.	"T" Conn. Assy.
4RW 1MT							
18-601	90°				18-764		
18-602	30°	1	7/8	3	18-765		18-725
18-603	90°				18-764	18-701	
18-604	30°	1	1	3	18-765		18-726
18-605	90°				18-764		
18-606	30°	1¼	1¼	3½	18-765		18-727
18-607	90°				18-764	18-702	
18-608	30°	1¼	1½	4	18-765		18-730
5RW 2MT							
18-611	90°				18-766		
18-612	30°	1	7/8	3	18-767		18-725
18-613	90°				18-766	18-701	
18-614	30°	1	1	3	18-767		18-726
18-615	90°				18-766		
18-616	30°	1¼	1¼	3½	18-767		18-727
18-617	90°				18-766	18-702	
18-618	30°	1¼	1½	4	18-767		18-730
18-621	Str.	1	7/8				18-725
18-622	Str.	1	1	3		18-701	18-726
18-623	Str.	1¼	1¼	3½	18-768		18-727
18-624	Str.	1¼	1½	4		18-702	18-730
18-651	90°				18-780		
18-652	30°	1¼	1¼	3½	18-781		18-727
18-657	90°				18-780	18-704	
18-658	30°	1¼	1½	4	18-781		18-730

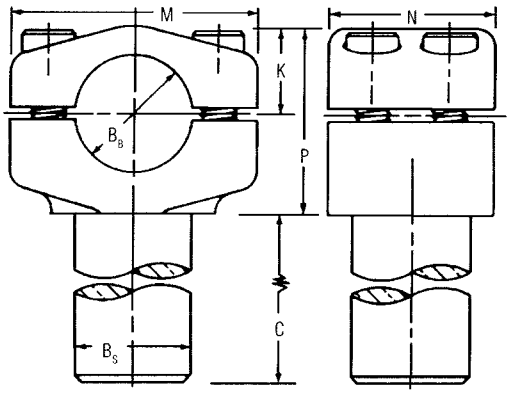
Part No.	Head Angle	Bbl. Dia. B_b	Shank Dia. B_s	Shank Length L	Head Assy.	Bbl. Assy.	"T" Conn. Assy.
5RW 2MT							
18-655	90°				18-780		
18-656	30°	1½	1¼	4	18-781	18-705	18-728
18-653	90°				18-780		
18-654	30°	1½	1½	4	18-781	18-705	18-729
18-671	Str.	1¼	1¼	3½		18-704	18-727
18-672	Str.	1½	1½	4		18-705	18-729
18-673	Str.	1½	1¼		18-784	18-705	18-728
18-674	Str.	1¼	1½	4		18-704	18-730
5RW 2MT with Threaded Adapter							
18-6515	90°				18-7805		
18-6525	30°	1¼	1¼	3½	18-7815	18-704	18-727
18-6535	90°				18-7805		
18-6545	30°	1½	1½	4	18-7815	18-705	18-729
6RW with Threaded Adapter							
18-6516	90°				18-7806		
18-6526	30°	1¼	1¼	3½	18-7816	18-704	18-727
18-6536	90°				18-7806		
18-6546	30°	1½	1½	4	18-7816	18-705	18-729
7RW 3MT							
18-661	90°				18-782		
18-662	30°	1¼	1¼	3½	18-783	18-704	18-727
18-665	90°				18-782		
18-666	30°	1½	1¼	4	18-783	18-705	18-728
18-663	90°				18-782		
18-664	30°	1½	1½	4	18-783	18-705	18-729

BARREL SUB. ASSY.	BARREL PART NO.	WATER CONNECT. SUB ASSY.
18-701	18-37210-8	18-74000-8
18-702	18-37310-8	
18-704	18-37510-8	
18-705	18-37610-8	

SUB-ASSEMBLIES AND PARTS



UNIVERSAL BARREL (HOLDER) SUB-ASSEMBLY NO.	L Thread Size	B_B Barrel Dia.	Barrel Part No.*	Water Conn.* Sub-Assembly Part No.
18-701		1	18-37210-8	
18-702	⅞-14	1¼	18-37310-8	18-74000-8
18-704		1¼	18-37510-8	
18-705	1-14	1½	18-37610-8	18-74000-8



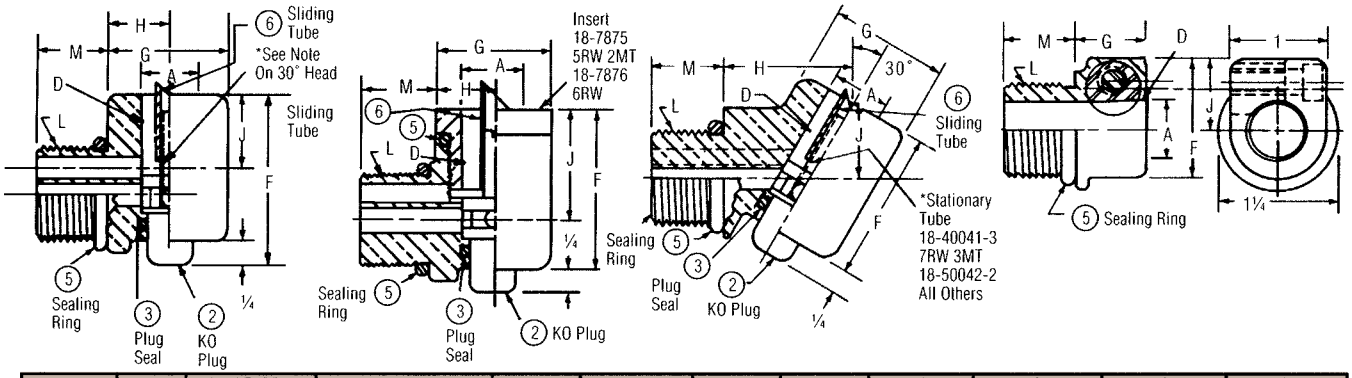
"T" CONNECTORS FOR HOLDERS

"T" CONNECTOR ASSEMBLY NO.	B_B Hole Dia.	B_S Shank Dia.	C Shank Length	P Head Height	K ℄ Hole Over Top	M Length	N Width	
18-725	1	⅞	3	1¾	¾	2 5/16	1½	2
18-726	1	1	3	1¾	¾	2 5/16	1½	BOLT
18-727	1¼	1¼	3½	2	15/16	2⅜	1¾	
18-728	1½	1¼	4	2 5/16	1⅛	2⅛	2	4
18-729	1½	1½	4	2 5/16	1⅛	2⅛	2	BOLT
18-730	1¼	1½	4	2 5/16	1⅛	2⅛	2	

SEE PAGE 49 FOR 30° AND SMALL 90° "T" CONNECTIONS.

MALE THREAD TO FEMALE TAPER ADAPTERS

90° TYPE **ADAPT WITH INSERT** **30° TYPE** **STRAIGHT TYPE**



ASSEMBLY PART NO.	Adapter Angle	MALE THREAD L Size Thd.	MALE THREAD M Length	FEMALE TAPER D Size	FEMALE TAPER A Major Dia.	F Overall Head Height	G Head Length	H End B'bl. to C.L. of Taper	J C.L. Barrel to C.L. of Taper	② K.O. Plug Part No.	③ K.O. Plug Seal Part. No.	⑤ Sealing Ring Part No.	⑥ Sliding Tube Part No.
18-764	90°			4RW				19/32	13/16				
18-765	30°	⅞-14	9/16	1MT	.463	1 9/16	1 Dia.	1 1/16	15/32	18-50021	18-10060-8	18-76460	18-50041-1
18-766	90°					1 13/16	1 Dia.	19/32	1 1/16	18-50022			18-40043-3
18-767	30°	⅞-14	9/16	5RW	.625	1 13/16	1 1/16 Dia.	1 11/32	53/64	18-50022	18-10060-10	18-76460	18-40043-3
18-768	Str.			2MT		1¼	¾	—	¾	—	—		—
18-780	90°					1 13/16	1¼ Dia.	21/32	1 1/16	18-50022			18-40043-3
18-781	30°	1-14	¾	5RW	.625	1 13/16	1 5/16 Dia.	1⅜	13/16	18-50022	18-10060-10	18-10060-17	18-40043-3
18-784	Str.			2MT		1¼	¾	—	¾	—	—		—
18-782	90°			7RW			1½ Dia.	25/32	1 3/16				18-40043-4
18-783	30°	1-14	¾	3MT	.875	2 3/16	1 9/16 Dia.	1⅜	13/16	18-50023	18-10060-12	18-10060-17	18-40043-4
***18-7805**	90°			5RW			1¼ Dia.	21/32	1 1/16				18-40043-3
***18-7815**	30°	1-14	¾	2MT	.625	1 13/16	1 5/16 Dia.	1⅜	13/16	18-50022	18-10060-10	18-10060-17	18-40043-3
***18-7806**	90°						1¼ Dia.	21/32	1 3/16				18-40043-3
***18-7816**	30°	1-14	¾	6RW	.750	1 15/16	1 5/16 Dia.	1 7/16	59/64	18-50022	18-10060-10	18-10060-17	18-40043-3

* These adapters have threaded inserts 18-7875—5RW 2MT or 18-7876—#6 RW Taper.

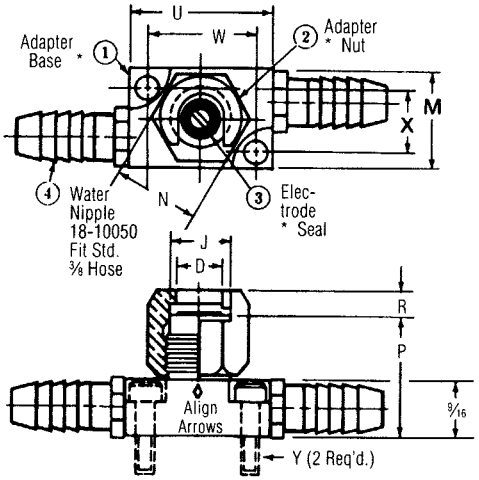
MAKE JOB CHANGES QUICKLY AND EASILY—WITHOUT COSTLY LOSS OF PRODUCTION

CMW "*Nu-Twist*"® FEATURES

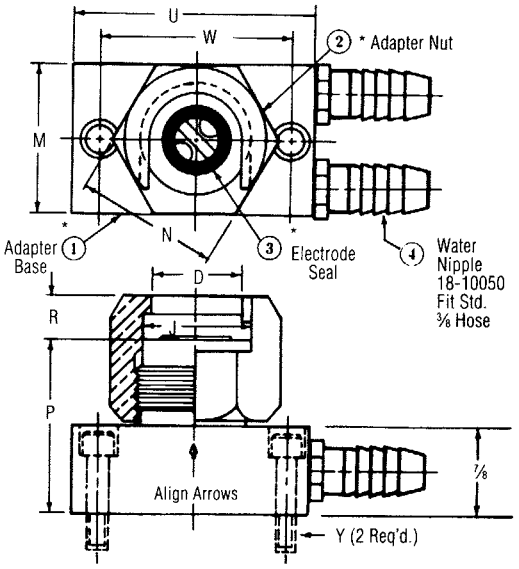
1. The hex locking nut may be tightened or loosened effectively by hand or wrench for easy replacement of electrodes.
2. "O" ring seals provide water tight connections.
3. Double groove construction in bore or locking nut accurately aligns and locks the electrode in position with a maximum of a turn and one half.
4. Through use of baffles in adapters and in electrodes over 1" long efficient cooling is effectively achieved.
5. All components are of corrosion-resistant alloys.
6. Maintenance costs are unusually low.

SURFACE MOUNTED ADAPTERS

NUMBER 1 SIZE

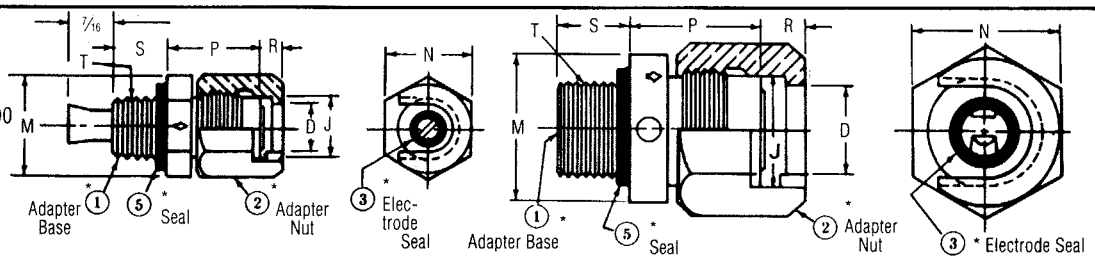


NUMBER 2 and 4 SIZES



THREADED ADAPTERS

May be used with 100-200 and 300 Series Holders to make "Nu-Twist"® Holder.

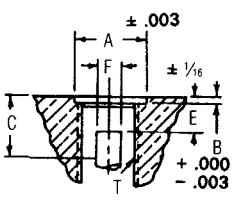


ADAPTER BASES ARE CLASS II MATERIAL

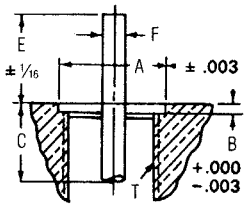
ADAPTER ASSEMBLY NUMBER			ADAPTER SIZE												① Adapter Base	② Adapter Nut	③ Electrode Seal	⑤ Seal
SIZE	Surface Mounted	Threaded	D	J	M	N	P	R	S	T Thread	U	W	X	Y				
1	**18-801**	—	½	⅝	1	⅞	1¼	¼	—	—	1½	1⅝2	2⅟32	No. 10-24 Scr.	18-80110	18-80150	18-10060-5	—
1	—	**18-811**					1⅝16		9/16	⅝-18	—	—	—	—	18-81110			18-10060-11
2	**18-802**	—	1⅝16	1⅛	1½	1½	1¹³/16	7/16	—	—	2½	2	—	No. ¼-20 Scr.	18-80210	18-80250	18-10060-1	—
2	—	**18-812**					1⅝16		¾	1-14	—	—	—	—	18-81210		18-10061-10	18-10060-17
4	**18-804**	—	1⅞16	1⅝	2	2	1¹³/16		—	—	3	2⅜	—	No. ¼-20 Scr.	18-80410	18-80450	18-10061-14	—
4	—	**18-814**					1⅝16		¾	1½-12	—	—	—	—	18-81410			18-10060-25

"Nu-Twist"® • Holders are available by combining Adapter 18-811 or 18-812 with Holders on pages 64, 65 and 66.
Non-Stock Holder Designs are available for use with 18-814.

MOUNTING INFORMATION FOR THREADED ADAPTERS



NUMBER 1 SIZE

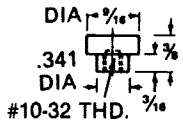


NUMBER 2 AND 4 SIZE

SIZE	THREADED ADAPTER ASSEMBLY NO.	A Dia. ±.003	B +.000 -.003	C Min.	E ±1/16	F Dia.	T
1	**18-811**	.750	.083	⅝	⅜	.244	⅝-18
2	**18-812**	1.126	.113	13/16	15/16	.244	1-14
4	**18-814**	1.626	.173	13/16	15/16	.375	1½-12

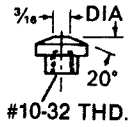
Adapters of other sizes are available on request.

"Nu-Twist"® is a registered trademark owned by CMW.



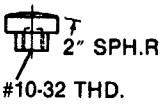
CMW® 28	18-970
CMW® 3	18-980
CMW® 100	18-990

FLAT FACE



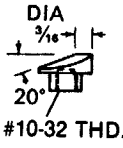
CMW® 28	18-971
CMW® 3	18-981
CMW® 100	18-991

TRUNCATED FACE



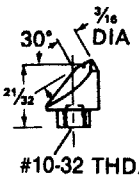
CMW® 28	18-972
CMW® 3	18-982
CMW® 100	18-992

RADIUS FACE



CMW® 28	18-973
CMW® 3	18-983
CMW® 100	18-993

OFFSET FACE



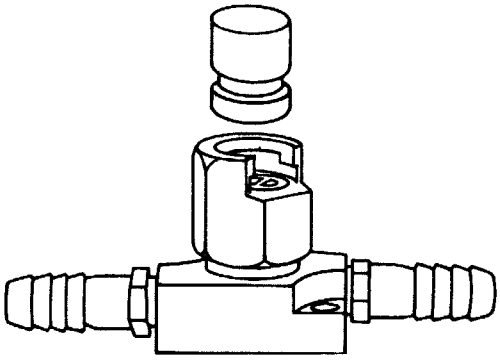
CMW® 28	18-974
CMW® 3	18-984
CMW® 100	18-994

30° OFFSET FACE

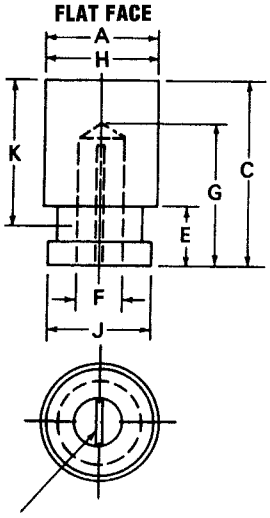
CMW "Nu-Twist"®, Class II and Class III Welding Electrodes

(Use with 800 Series)

No tapers or threads
Can be extracted with a simple turn of hexagon locking nut
Any contour in electrode face can be located or relocated in a given position
Water circulated to end of electrode for maximum cooling
Silver plated contact surfaces on electrode and base for maximum conductivity
Provides a simple, low-cost electrode for most special applications
Electrodes shown can be modified with contours to provide faces required for most resistance welding applications



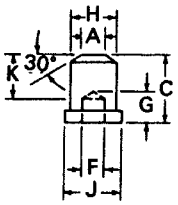
FLAT FACE



*This baffle is used in electrodes over 1" long to assure water circulation

"Nu-Twist"® ELECTRODES

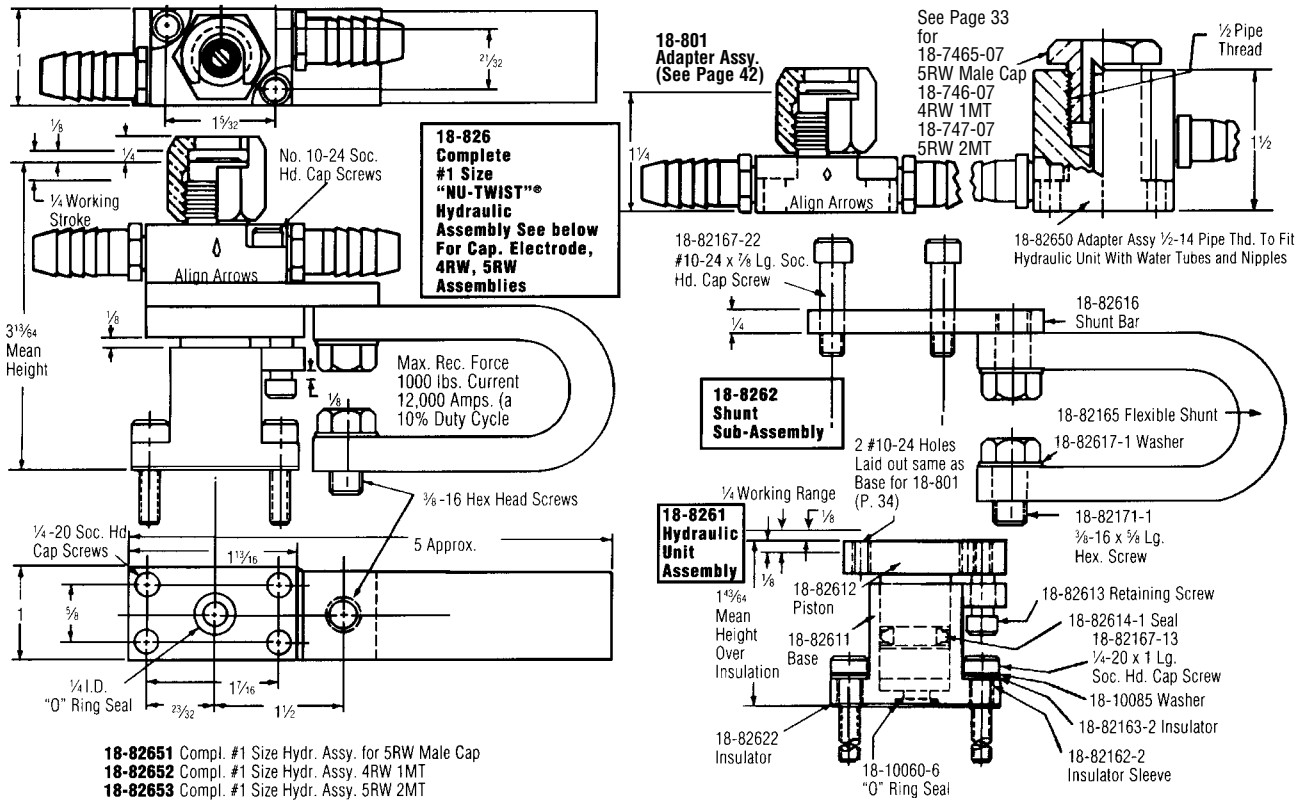
Size	Type	ELECTRODE PART NO. CMW® 3	ELECTRODE PART NO. CMW® 100	H Body Dia.	A Welding Face Dia.	C Overall Length	E Adapter Clearance	F Water Hole Dia.	G Water Hole Depth	J Electrode Seat Dia.	K Electrode Ext. From Adapt.
1	0	**338750**	**538750**	½	½	¾	—	¼	⅜	.625	½
	Flat	**338030**	**538030**	½	½	1½	—	¼	1⅛	.625	1¼
1	0	**378750**	**578750**	½	¼	¾	—	¼	⅜	.625	½
	Trunc.	**378030**	**578030**	½	¼	1½	—	¼	1⅛	.625	1¼
1		**338751**	**538751**	⅝	⅝	¾	5⁄16	¼	⅜	.625	½
	Flat	**338031**	**538031**	⅝	⅝	1½	5⁄16	¼	1⅛	.625	1¼
2		**338012**	**538012**	1¼	1¼	1	⅝	½	½	1.125	½
	Flat	**338052**	**538052**	1¼	1¼	2	⅝	½	1½	1.125	1½
4		**338014**	**538014**	1¾	1¾	1	⅝	¾	½	1.625	½
	Flat	**338054**	**538054**	1¾	1¾	2	⅝	¾	1½	1.625	1½



0 FLAT AND 0 TRUNCATED TYPES

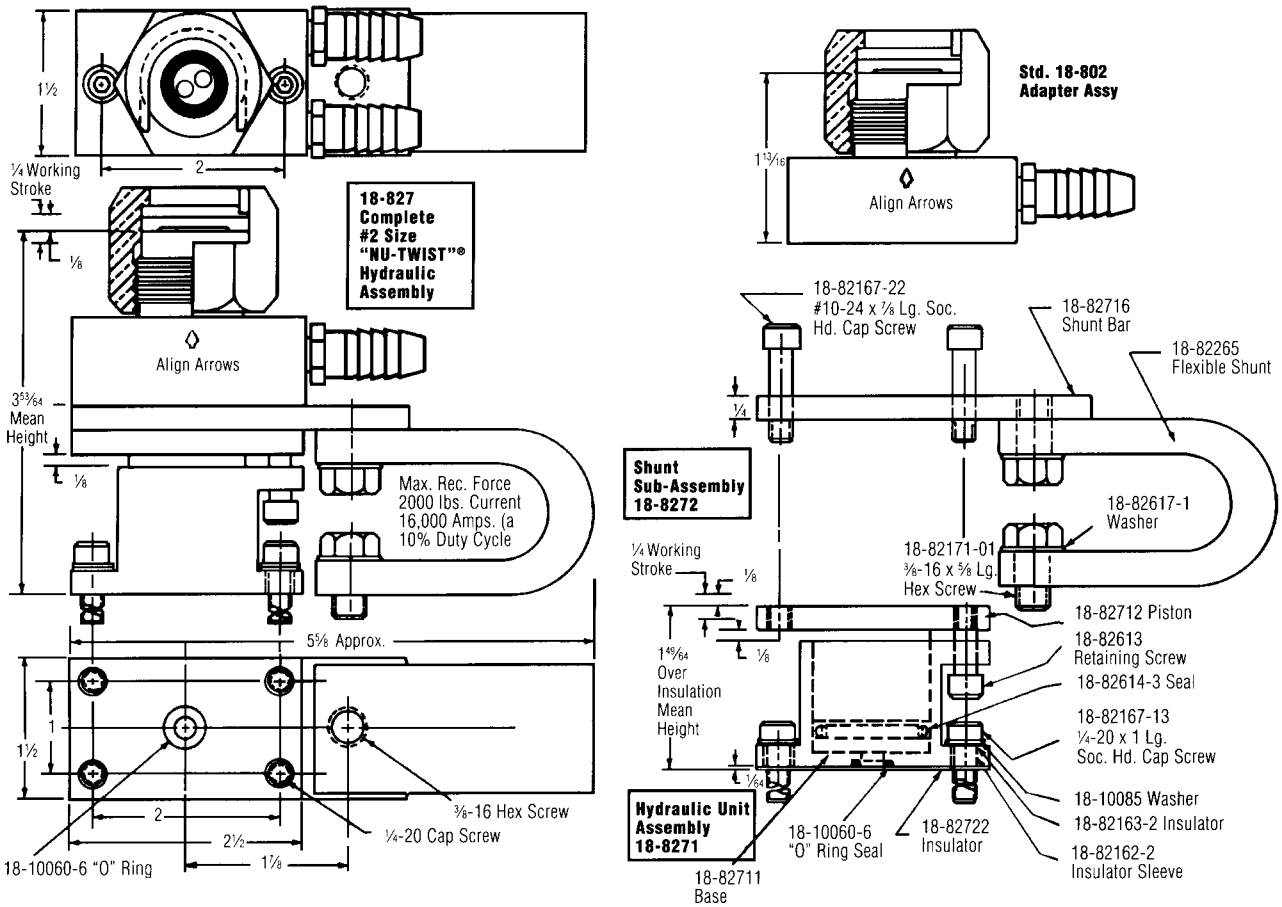
"Nu-Twist"® is a registered trademark owned by CMW.

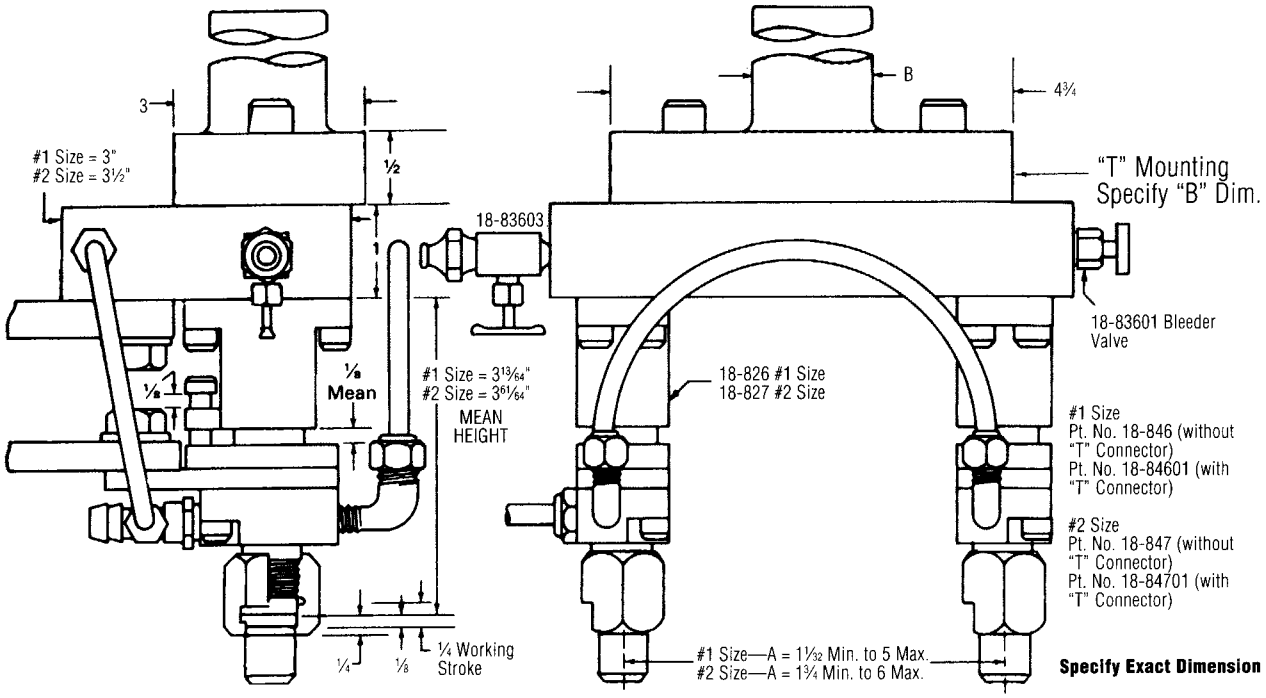
CMW® Hydraulic Equalizing Adapter units are used to equalize the weld force when two or more welds are required simultaneously. The equalizing action is developed in a closed hydraulic system—and is accomplished by hydraulically interconnecting two or more units.



18-82651 Compl. #1 Size Hydr. Assy. for 5RW Male Cap
18-82652 Compl. #1 Size Hydr. Assy. 4RW 1MT
18-82653 Compl. #1 Size Hydr. Assy. 5RW 2MT

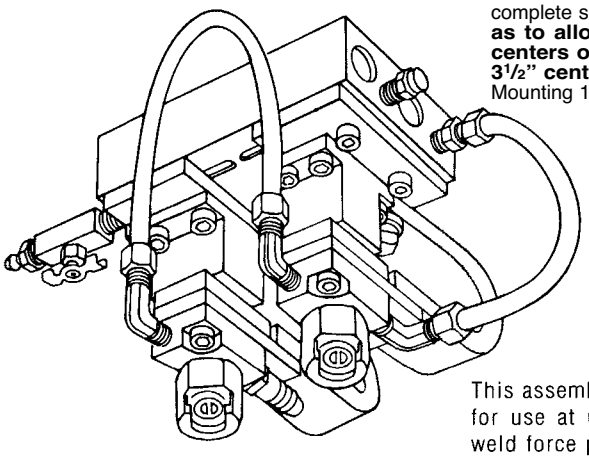
We recommend using a Fire Resistant Hydraulic Fluid compatible with BUNA "N" such as HOUGHTO-SAFE #620, 1120 or equivalent.



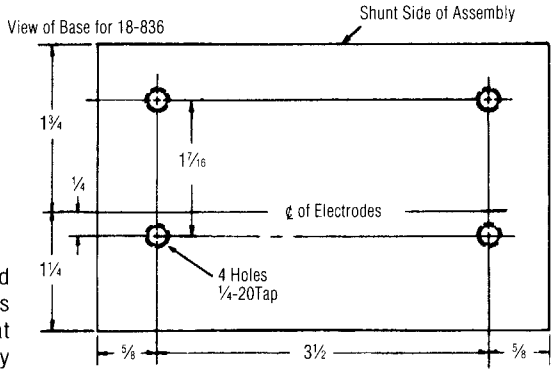


MAXIMUM RECOMMENDED WELD FORCE: #1 Size 1000# per 18-826 Unit 12,000 Amps. @ 10% Duty Cycle
#2 Size 2000# per 18-827 Unit 16,000 Amps. @ 10% Duty Cycle

Part No. 18-836 (shown below) is a typical assembly using two 18-826 assemblies set up as a complete self-contained unit for making two spot welds at one time. **This unit is so arranged as to allow the center distance to be readily adjusted from 1¹⁄₃₂" centers to 2¼" centers or by rearranging of the same parts centers may be adjusted from 2¼" to 3½" centers.** This set up also includes facilities for filling and bleeding the hydraulic units. "T" Mounting 18-83614 is available to order for Assembly 18-836.

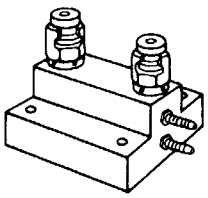


This assembly is recommended for use at up to 1000 pounds weld force per electrode and at up to 12,000 amperes secondary weld current at 10% duty cycle.

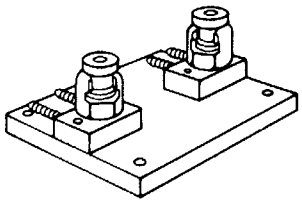


"Nu-Twist"® ADAPTERS BUILDING BLOCKS FOR DIES AND BACKUPS

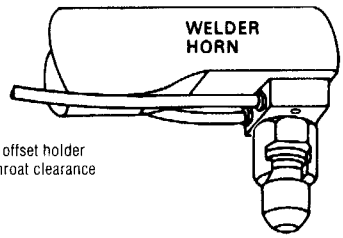
Easy electrode changeover for minimum downtime
Uniform height of electrode easily maintained for equal backup height
Easily located for stepped or irregular shapes
Provides low-cost standard building block for backup or die insert
Permit building of lower-cost water-cooled die bases or backup dies
Side removal requires minimum clearance for electrode replacement



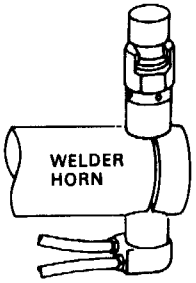
Near-flush mounting
water is brought through base



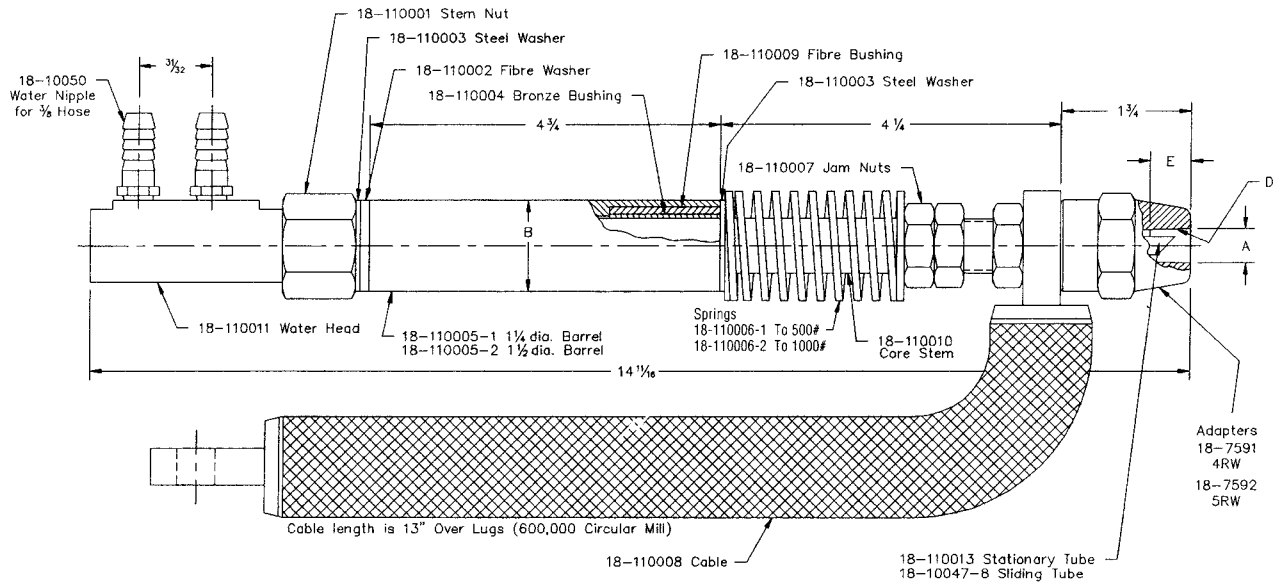
Permit use of
simple plate-type die base



Use of welder horn as offset holder
for minimum welder throat clearance



Use with standard 18-100 and 18-200 and 18-300 series holders as "Nu-Twist" holders on standard machines.



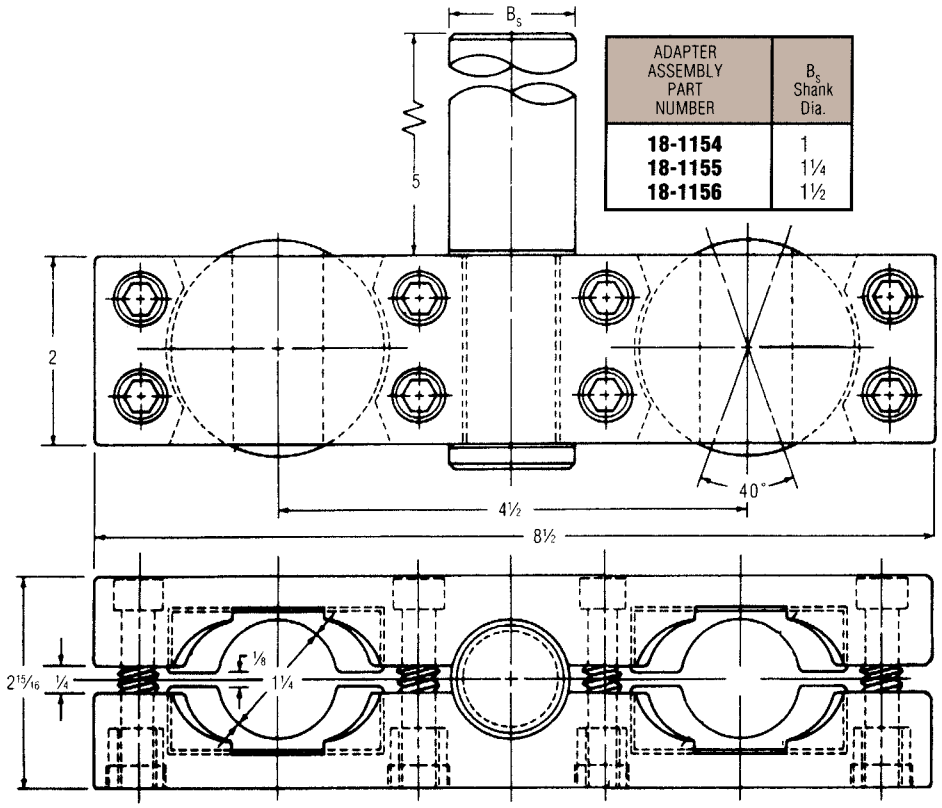
Like other low-inertia holders the heavy duty Adjust-A-Pressure Holders are used for multiple spot and projection welding, and are excellent for indirect welding when mounted in the Adjust-A-Angle Adapter.

Electrical current is conducted through heavy flexible cables and the holder is insulated to prevent any damaging effects to the spring mechanism. Light duty springs supplied to order.

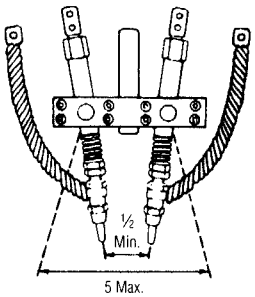
HOLDER ASSEMBLY PART NUMBER	A Major Taper Dia.	B Barrel Dia.	D Taper	E Standard Electrode Taper Engagement	PRESSURE Range (Pounds)
18-1101	.463	1¼	4RW 1MT	½	TO 500
18-1102	.625		5RW 2MT	¾	
18-1103	.463	1½	4RW 1MT	½	
18-1104	.625		5RW 2MT	¾	

STANDARD ASSEMBLY USES
18-110006-1 SPRING

1150 SERIES ADJUST-A-ANGLE ADAPTERS



ADAPTER ASSEMBLY PART NUMBER	B_S Shank Dia.
18-1154	1
18-1155	1¼
18-1156	1½

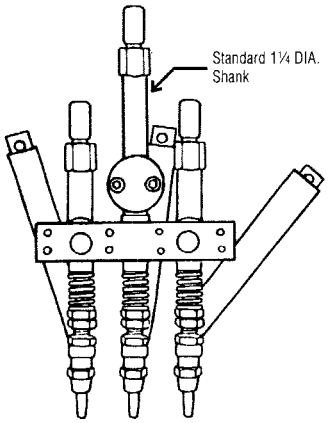


1100 SERIES HOLDERS ASSEMBLED IN 1150 SERIES ADAPTER

1150 series adjust-a-angle adapters are adaptable for use with spring type low inertia holders 1100 series as well as straight holders 100, 200, and 300 series.

ADAPTERS FOR BARREL SIZES OTHER THAN 1¼ DIA. MADE ONLY TO SPECIAL ORDER

Typical Set Up For
3 Spots at a time in Parallel

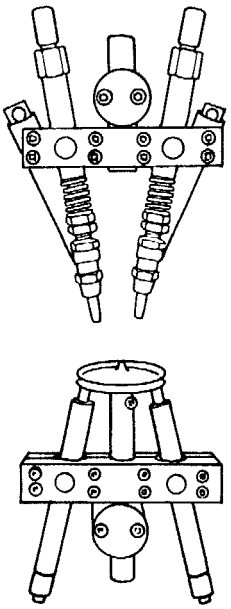


1 CMW Std. 1150 Series Adapter
2 CMW Std. 1100 Series Holders
1 CMW Special 1100 Series Holder

4RW-16-582011-01
5RW-16-582012-01

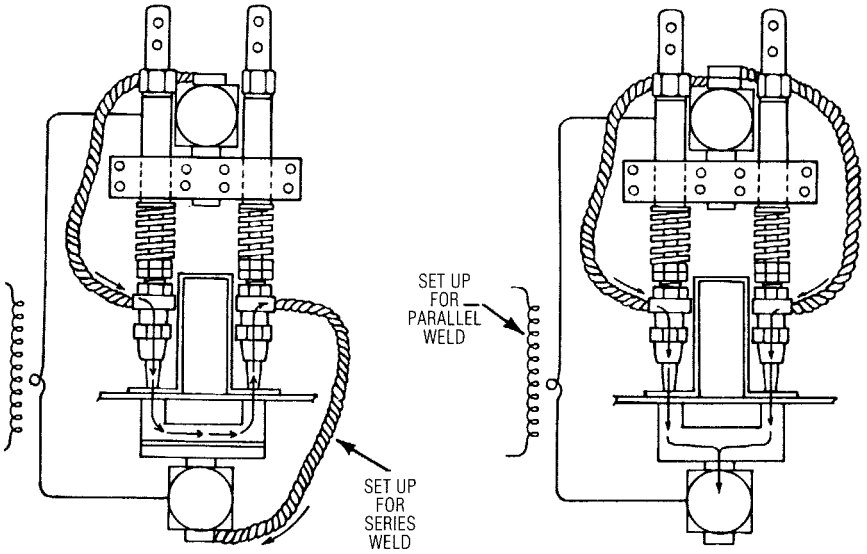
1¼" Dia. Shank Standard

Typical Set Up for
2 spots simultaneously
in parallel



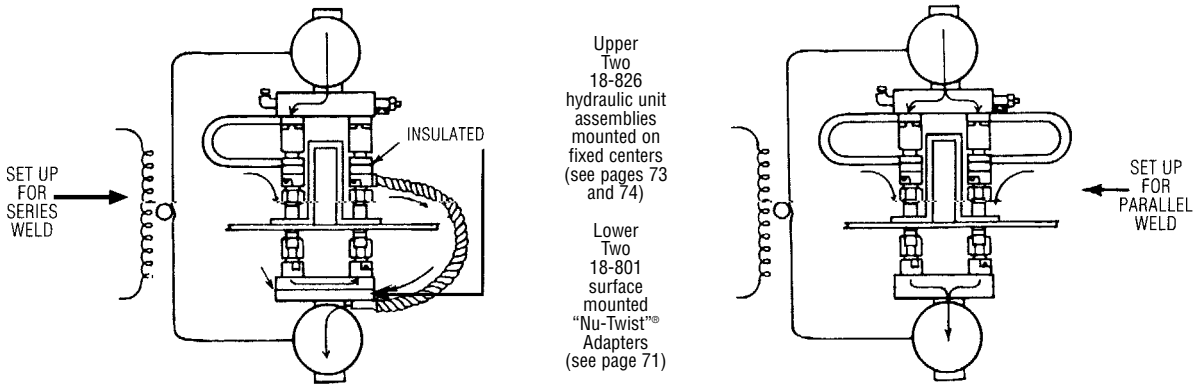
Upper
2-1100 Series Holders
1-1150 Series Adapter

Lower
2-100, 200 or 300 Series Holders
1-1150 Series Adapter with special center shank



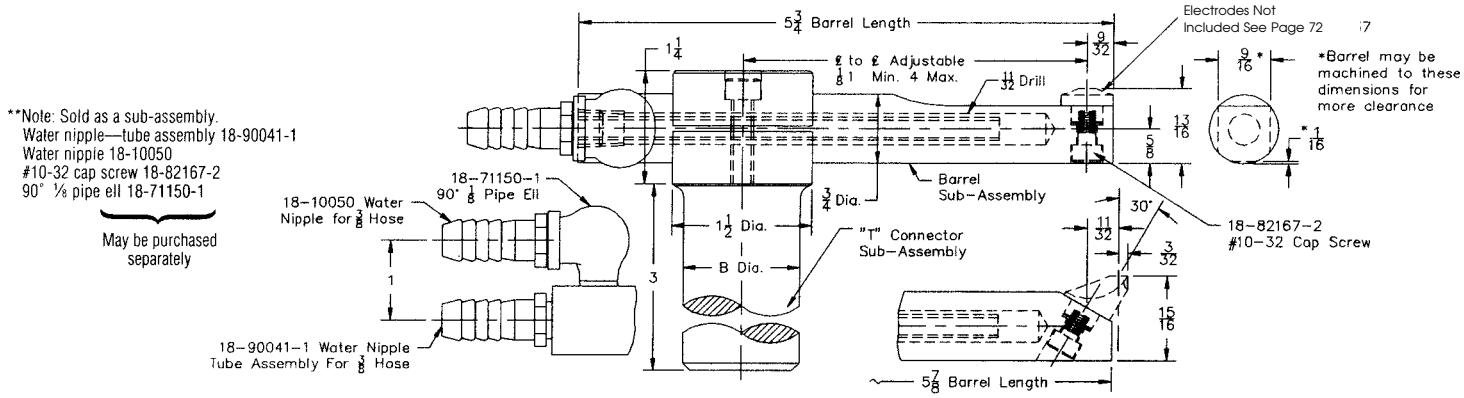
TYPICAL SET UP OF 800 SERIES *"Nu-Twist"*® UNITS

For dual spot welding using hydraulic *"Nu-Twist"*® pressure equalizing subassemblies and surface mounted adapters as basic building blocks



Upper
Two
18-826
hydraulic unit
assemblies
mounted on
fixed centers
(see pages 73
and 74)

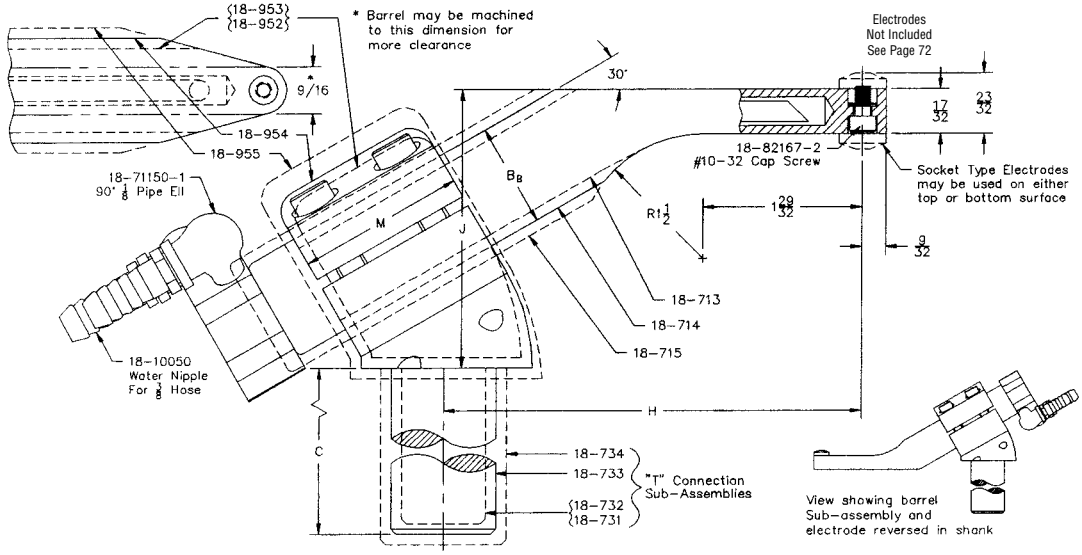
Lower
Two
18-801
surface
mounted
"Nu-Twist"®
Adapters
(see page 71)



HOLDER ASSEMBLY PART NUMBER	Holder Angle	B Shank Dia.	Barrel Sub-Assembly**	"T" Connection*	Barrel*
18-901	90°	¾	18-709	18-720	18-70910-1
18-902	30°		18-710		18-71010-1
18-903	90°	⅞	18-709	18-721	18-70910-1
18-904	30°		18-710		18-71010-1
18-905	90°	1	18-709	18-722	18-70910-1
18-906	30°		18-710		18-71010-1
18-907	90°	1¼	18-709	18-723	18-70910-1
18-908	30°		18-710		18-71010-1

Holders of Other Shank Diameters and Lengths or Design Modifications Are Available on Request as Specials.

950 SERIES WATER COOLED PADDLE HOLDER



The Paddle Holder's heavy duty construction enables it to be used at high pressures in hard to reach spots. A minimum clearance is required. The barrel is adjustable in the "T" connection by both rotation and amount of offset.

HOLDER ASSEMBLY PART NUMBER	HOLDER SIZE						Barrel Sub-Assembly**	"T" Connector
	B_R Barrel Dia.	B_S Shank Dia.	C Shank Length	H Offset Range	J Height Range	M "T" Width		
18-952	1	⅞	3	3⅜ to 5³⁄₃₂	2¹⁄₁₆ to 3¹⁄₁₆	1½	18-713	18-731
18-953		1						18-732
18-954	1¼	1¼	3½	4-5²³⁄₃₂	2¾-3¾	1¾	18-714	18-733
18-955	1½	1½	4	4⁷⁄₃₂-5¹⁵⁄₁₆	2⅞-3⅞	2	18-715	18-734

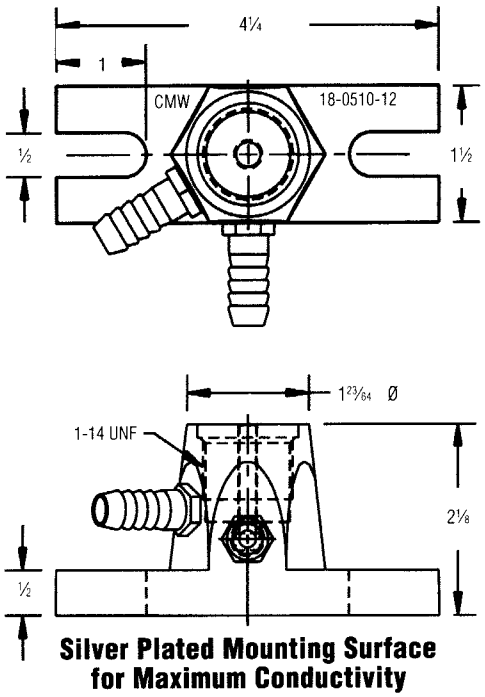
Holders of other Shank Dia. and Lengths or Design Modifications are available on request as Specials.

**Note: Sold as a sub-assembly
Water nipples 18-10050
90° ⅛ pipe ells 18-71150-1
#10-32 cap screw 18-82167-2
May be purchased separately.

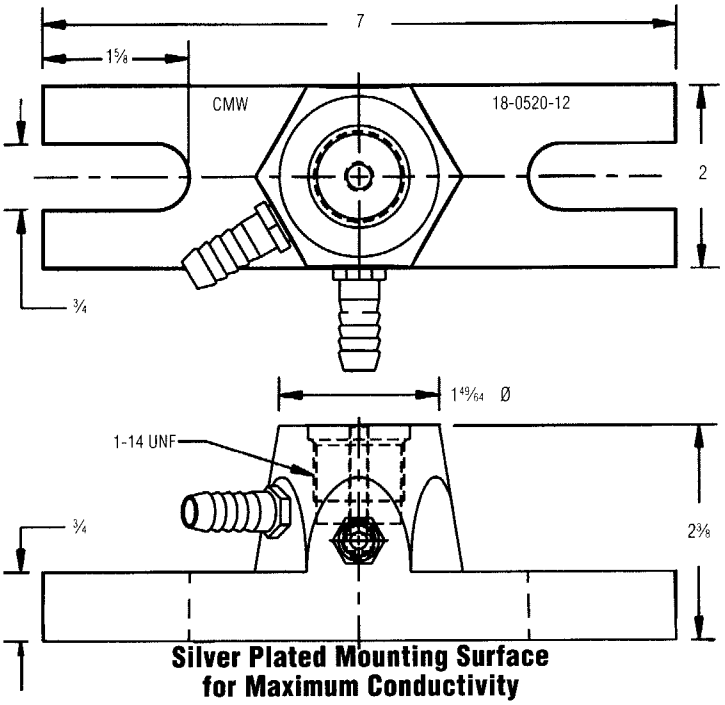
These 30° "T" connector may be interchanged with the 90° Universal Type "T" Conn. Page 70. See page 63 for suggested set ups.

CMW platen mounted electrode holders provide an economical means of mounting a wide range of electrodes in all the popular sizes to your press type welder platens. They are machined R.W.M.A. Class II material to provide years of reliable service.

Part No. 18-0510-12



Part No. 18-0520-12



CMW platen mounted electrode holders are machined from RWMA Class II chrome copper castings. They are designed to mount to press type welder platens from size #1 with the small holder to sizes #2 and #3 with the large holder. Both holders are provided with a 1 - 14 internal threads which will accept the standard male thread to female taper adapters. #4RW, #5RW, #6RW, and #7RW, as shown on page 31 of this catalog, and the #2 size "Nu-Twist"® threaded adapter. Both holders are provided with inlet and outlet water nipples for standard 3/8" water lines and a stationary water tube. Adapters and sliding water tubes must be ordered separately, by part number as required (see fig. #1).

The CMW platen mounted holder, as indicated in figure #2, has the inlet water nipple at position #1 and the outlet water nipple at position #2, any other combinations may be special ordered by changing the last two digits of the part number. The first of the last two digits indicates the location of the outlet nipple.

Example; part #18-0510-56 would place the inlet water nipple at position #5 and the outlet water nipple at position at #6

When ordering PM holder also specify the adapter(s) and sliding tube(s) required for your application.

1-14 male thd to female taper adpt. as shown on page 27 of this catalog.	ATTACHMENT	SLIDING TUBE	SLIDING TUBE O.A.L.
18-785	4RW	18-50041-3	1 3/8
18-786	5RW	18-40043-11	1 3/8
18-7863	6RW	18-40043-14	2 1/8
18-787	7RW	18-40043-15	2 3/8
18-812	#2 SIZE "Nu-Twist"®	NONE	-

STATIONARY WATER TUBE
18-40041-5

Additional Sliding Tubes Available	O.A.L.	FOR TAPER
18-50041-2	2 1/2	4RW
18-40043-5	2	5RW
18-40043-9	4	5RW,6RW,7RW

18-7743

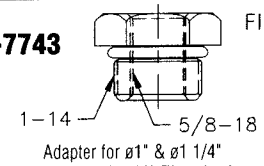
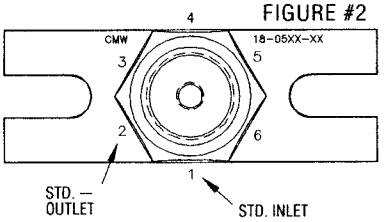


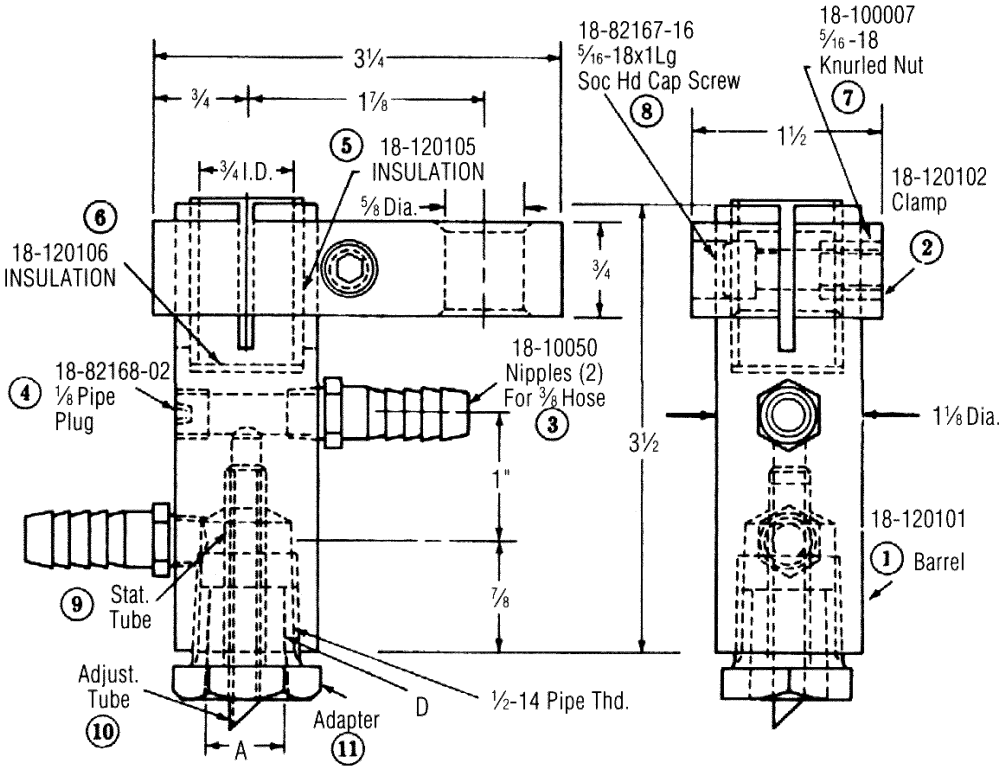
FIGURE #1

Adapter for ø1" & ø1 1/4" Chameleon/Max-Life™ projection welding electrodes and 18-811, #1 size threaded "Nu-Twist"® adapter

FIGURE #2



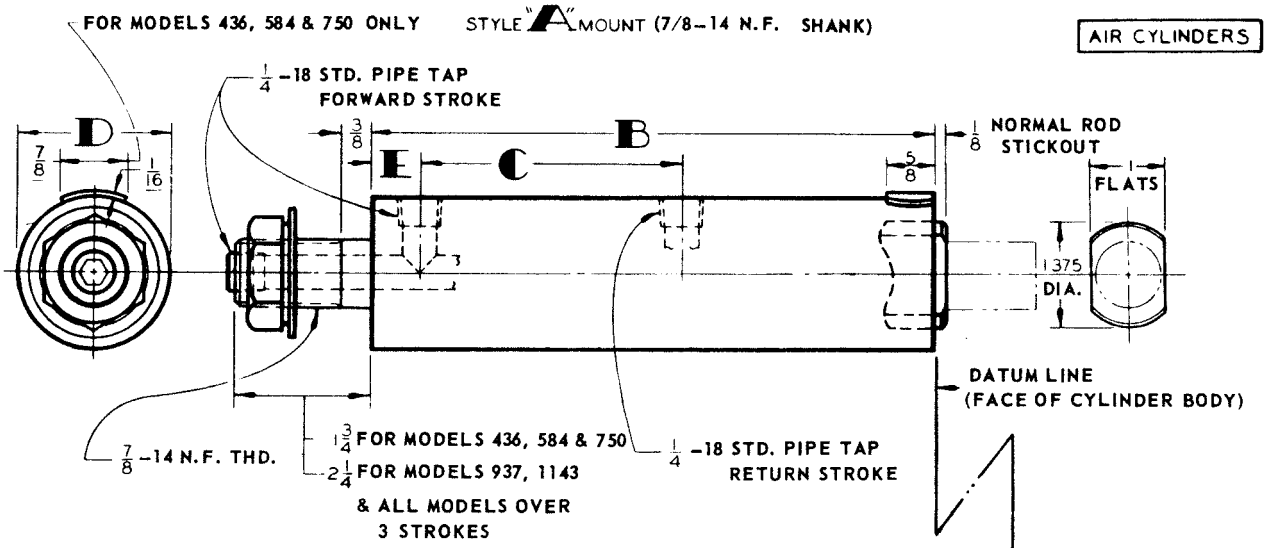
DIMENSIONS ARE IN INCHES.

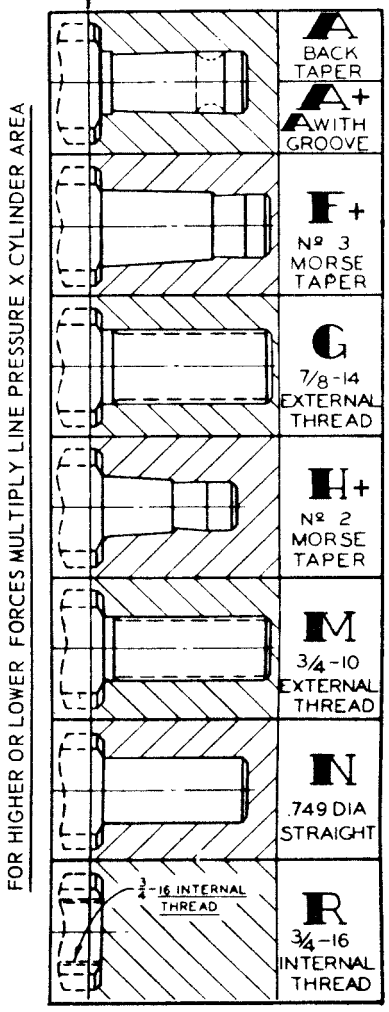


ASSEMBLY PART NO.	(D) Attachment Dia.	(A) Major Taper Part No.	(9) Stat. Tube Part No.	(10) Adj. Tube Part No.	(11) Adapter Part No.
18-1201	½-14 NPT	—	18-50046-1	18-10046-23	—
18-1202	5RW 2MT Male Cap	.4145	18-50046-1	—	18-7465-07
18-1203	4RW 1MT	.463	18-50046-1	18-10046-23	18-746-07
18-1204	5RW 2MT	.625	18-50046-1	18-10046-23	18-747-07

See page 62 for detailed description. All assemblies include 1, 2, 3, 4, 5, 6, 7, 8 and 9.

DUAL PISTON CYLINDER





*NOTE
ADD PISTON ROD END SERIES LETTER TO MODEL NO. WHEN ORDERING – SUCH AS "A", OR "F", ETC.

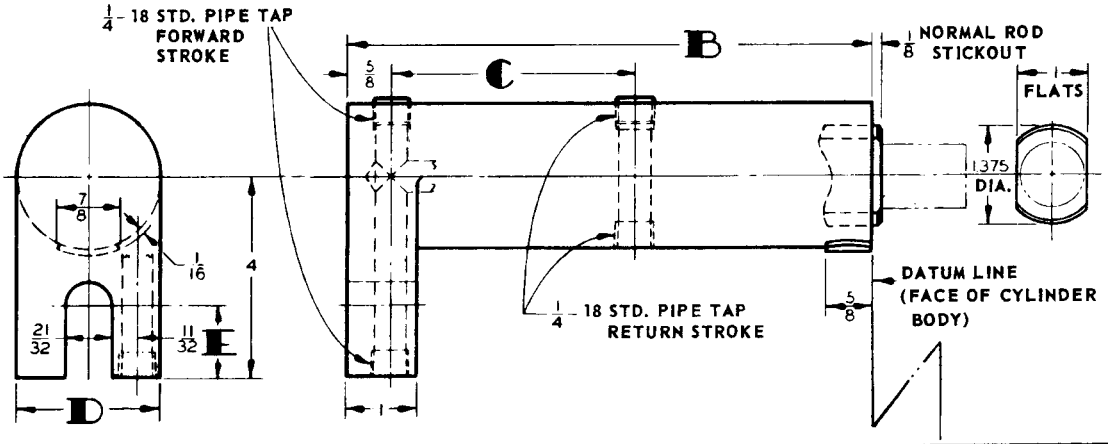
EXAMPLE OF CODE					TABULATED DIMENSIONS				PISTON AREA		FORCE AT LINE PRESSURE		
mounting style	mfgrs. std.	nominal sq. in. area	stroke in 1/4 increments	rod end series									
A	G	436	8	See Note*	B	C	D	E					
BORE	MODEL NO.	STROKE							FOR-WARD	RE-TURN	60	70	80
1-3/4 Dual Piston	A-G- 436- 2* A-G- 436- 4* A-G- 436- 6* A-G- 436- 8* A-G- 436-10* A-G- 436-12*	1/2 1 1-1/2 2 2-1/2 3			4-1/4 5-1/4 6-1/4 7-1/4 8-1/4 9-1/4	1-7/8 2-3/8 2-7/8 3-3/8 3-7/8 4-3/8	1.993	5/8	4.36 sq.in.	1.96 sq.in.	262 lbs.	305 lbs.	350 lbs.
2 Dual Piston	A-G- 584- 2* A-G- 584- 4* A-G- 584- 6* A-G- 584- 8* A-G- 584-10* A-G- 584-12*	1/2 1 1-1/2 2 2-1/2 3			4-1/4 5-1/4 6-1/4 7-1/4 8-1/4 9-1/4	1-7/8 2-3/8 2-7/8 3-3/8 3-7/8 4-3/8	2.243	5/8	5.84 sq.in.	2.70 sq. in.	350 lbs.	409 lbs.	467 lbs.
2-1/4 Dual Piston	A-G- 750- 2* A-G- 750- 4* A-G- 750- 6* A-G- 750- 8* A-G- 750-10* A-G- 750-12*	1/2 1 1-1/2 2 2-1/2 3			4-1/4 5-1/4 6-1/4 7-1/4 8-1/4 9-1/4	1-7/8 2-3/8 2-7/8 3-3/8 3-7/8 4-3/8	2.493	5/8	7.50 sq.in.	3.53 sq.in.	450 lbs.	525 lbs.	600 lbs.
2-1/2 Dual Piston	A-G- 937- 2* A-G- 937- 4* A-G- 937- 6* A-G- 937- 8* A-G- 937-10* A-G- 937-12*	1/2 1 1-1/2 2 2-1/2 3			4-1/4 5-1/4 6-1/4 7-1/4 8-1/4 9-1/4	1-7/8 2-3/8 2-7/8 3-3/8 3-7/8 4-3/8	2.743	1/2	9.37 sq.in.	4.46 sq.in.	562 lbs.	655 lbs.	749 lbs.
2-3/4 Dual Piston	A-G-1143- 2* A-G-1143- 4* A-G-1143- 6* A-G-1143- 8* A-G-1143-10* A-G-1143-12*	1/2 1 1-1/2 2 2-1/2 3			4-1/4 5-1/4 6-1/4 7-1/4 8-1/4 9-1/4	1-7/8 2-3/8 2-7/8 3-3/8 3-7/8 4-3/8	2.993	1/2	11.43 sq.in.	5.50 sq.in.	685 lbs.	800 lbs.	914 lbs.

FOR EACH ADDITIONAL 1/2" OF STROKE LONGER THAN SHOWN, ADD 1" TO DIM. B

DUAL PISTON CYLINDER

STYLE "C" MOUNT

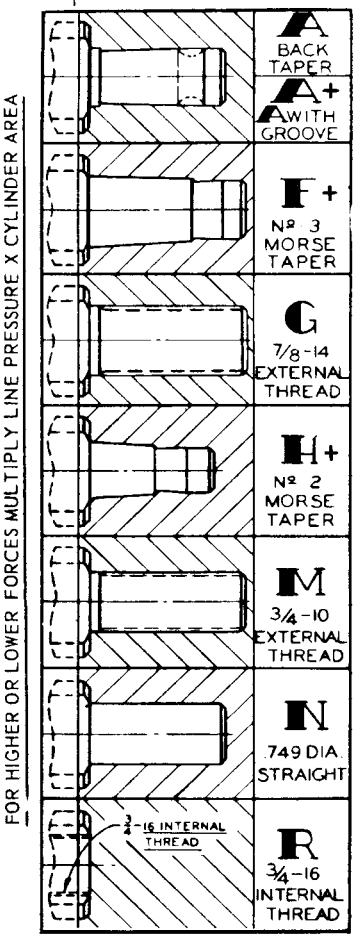
AIR CYLINDERS

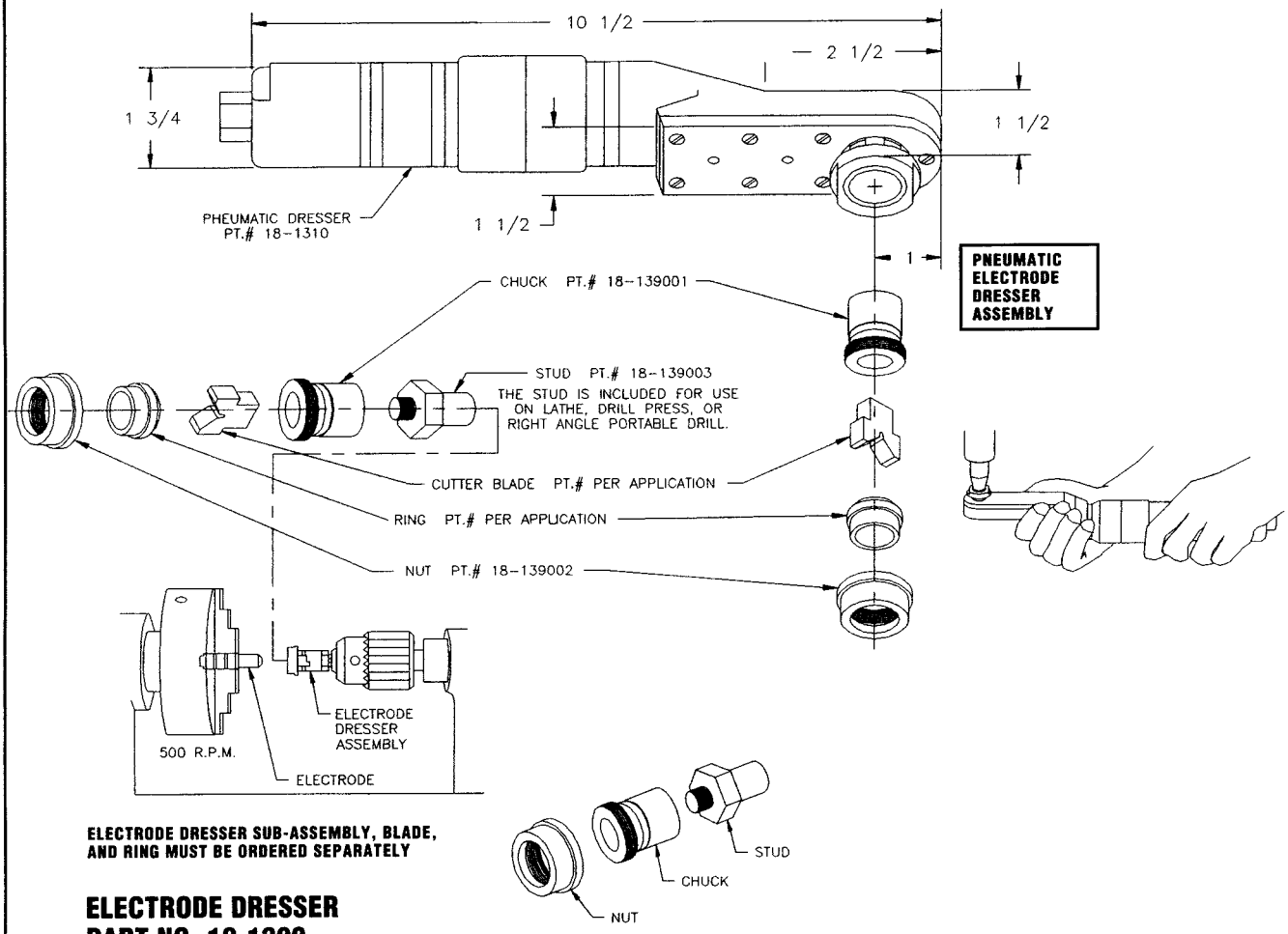


*NOTE
ADD PISTON ROD END SERIES LETTER TO MODEL NO. WHEN ORDERING – SUCH AS "A", OR "F", ETC.

EXAMPLE OF CODE					TABULATED DIMENSIONS				PISTON AREA		FORCE AT LINE PRESSURE		
mounting style	mfgrs. std.	nominal sq. in. area	stroke in 1/4 increments	rod end series	B	C	D	E					
C — G — 436 — 8 — See Note*									FOR-WARD	RE-TURN	60	70	80
BORE	MODEL NO.	STROKE											
1-3/4 Dual Piston	C-G- 436- 2*	1/2	4-1/4	1-7/8	1.993	2-1/4	4.36 sq.in.	1.96 sq.in.	262 lbs.	305 lbs.	350 lbs.		
	C-G- 436- 4*	1	5-1/4	2-3/8									
	C-G- 436- 6*	1-1/2	6-1/4	2-7/8									
	C-G- 436- 8*	2	7-1/4	3-3/8									
	C-G- 436-10*	2-1/2	8-1/4	3-7/8									
	C-G- 436-12*	3	9-1/4	4-3/8									
2 Dual Piston	C-G- 584- 2*	1/2	4-1/4	1-7/8	2.243	2-1/4	5.84 sq.in.	2.70 sq. in.	350 lbs.	409 lbs.	467 lbs.		
	C-G- 584- 4*	1	5-1/4	2-3/8									
	C-G- 584- 6*	1-1/2	6-1/4	2-7/8									
	C-G- 584- 8*	2	7-1/4	3-3/8									
	C-G- 584-10*	2-1/2	8-1/4	3-7/8									
	C-G- 584-12*	3	9-1/4	4-3/8									
2-1/4 Dual Piston	C-G- 750- 2*	1/2	4-1/4	1-7/8	2.493	2-1/4	7.50 sq.in.	3.53 sq.in.	450 lbs.	525 lbs.	600 lbs.		
	C-G- 750- 4*	1	5-1/4	2-3/8									
	C-G- 750- 6*	1-1/2	6-1/4	2-7/8									
	C-G- 750- 8*	2	7-1/4	3-3/8									
	C-G- 750-10*	2-1/2	8-1/4	3-7/8									
	C-G- 750-12*	3	9-1/4	4-3/8									
2-1/2 Dual Piston	C-G- 937- 2*	1/2	4-1/4	1-7/8	2.743	2	9.37 sq.in.	4.46 sq.in.	562 lbs.	655 lbs.	749 lbs.		
	C-G- 937- 4*	1	5-1/4	2-3/8									
	C-G- 937- 6*	1-1/2	6-1/4	2-7/8									
	C-G- 937- 8*	2	7-1/4	3-3/8									
	C-G- 937-10*	2-1/2	8-1/4	3-7/8									
	C-G- 937-12*	3	9-1/4	4-3/8									
2-3/4 Dual Piston	C-G-1143- 2*	1/2	4-1/4	1-7/8	2.993	1-7/8	11.43 sq.in.	5.50 sq.in.	685 lbs.	800 lbs.	914 lbs.		
	C-G-1143- 4*	1	5-1/4	2-3/8									
	C-G-1143- 6*	1-1/2	6-1/4	2-7/8									
	C-G-1143- 8*	2	7-1/4	3-3/8									
	C-G-1143-10*	2-1/2	8-1/4	3-7/8									
	C-G-1143-12*	3	9-1/4	4-3/8									

FOR EACH ADDITIONAL 1/2" OF STROKE LONGER THAN SHOWN, ADD 1" TO DIM. B





ELECTRODE DRESSER SUB-ASSEMBLY, BLADE, AND RING MUST BE ORDERED SEPARATELY

ELECTRODE DRESSER PART NO. 18-1390

For dressing worn electrodes with standard cutters on standard shop equipment

In many applications, the use of lathes, drill presses, or right angle portable drills for dressing electrodes is the most economical and efficient—saving down time on production welding—reducing "overdressing"—and providing uniformly dressed electrodes to produce welds of maximum quality.

The Electrode Dresser features a "floating blade" action and is designed to assemble in the pneumatic electrode dresser shown above.

The Electrode Dresser is supplied without ring and cutter blade. When ordering, specify by part number the ring' (s) and cutter blade' (s) desired.

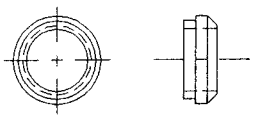
PNEUMATIC ELECTRODE DRESSING TOOL PART NO. 18-1310

Light weight and rugged construction, this Pneumatic Dresser requires a clearance of only 1 1/2" with a standard ring and 2" with an extended ring. Operating at a cutting speed of 1200 RPM, enables the operator to dress electrodes quickly and accurately. Cutters are easily replaced and are available for dressing electrodes to the contours.

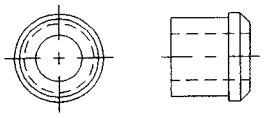
Electrode Dresser 18-1310 is supplied without blade holder, ring and cutter blade. When ordering, specify blade holder, ring and cutter blade by part number only. Special cutters can be furnished upon request.

See page 83 & 84 for cutter blades.

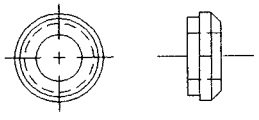
RINGS



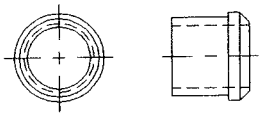
18–139401
STD. RING FOR
.482 DIA. ELECTRODES



18–139402
EXTENDED RING FOR
.482 ELECTRODES
POINTED NOSE ONLY



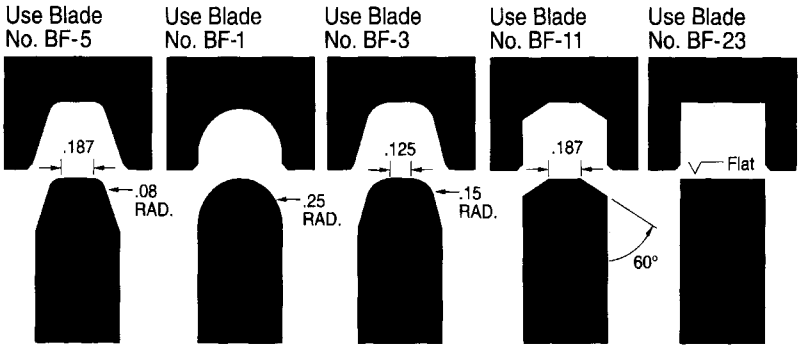
18–139501
STD. RING FOR
5/8 DIA. ELECTRODES



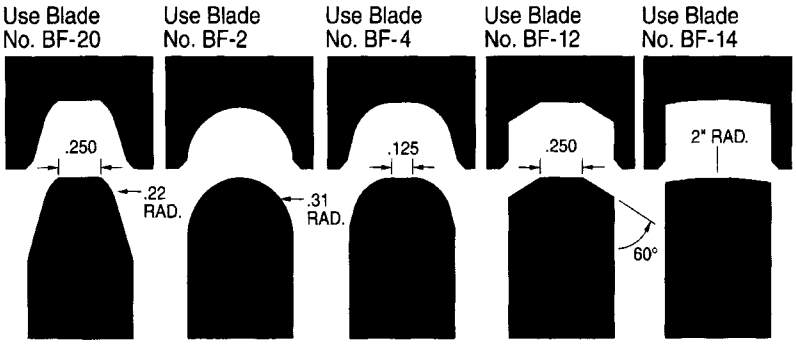
18–139502
EXTENDED RING FOR
5/8 DIA. ELECTRODES
POINTED NOSE ONLY

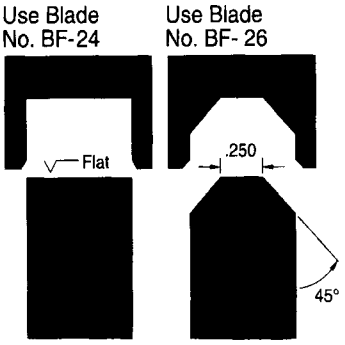
FLUSH TYPE STRAIGHT

For No. 4RW Electrodes
Use chuck No. C-6 for all.



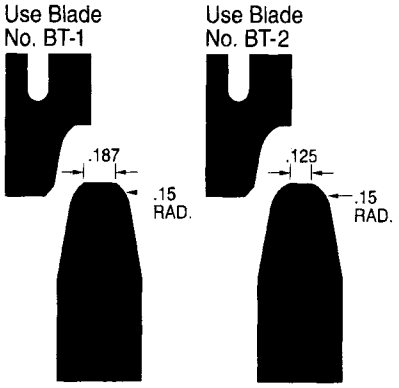
For No. 5RW Electrodes
Use chuck No. C-5 for all



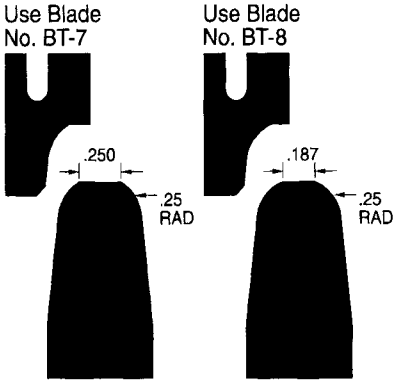


FLUSH TYPE TAPERED

For No. 4RW Electrodes
Use chuck No. C-3 for all.



For No. 5RW Pointed Electrodes
Use chuck No. C-4 for all



Solid Style Cutters, 1 Piece
For #4 & #5RW Electrodes

Flush Style Solid Cutter

Extended Solid Cutter

Lathe or Drill Press Adaptor

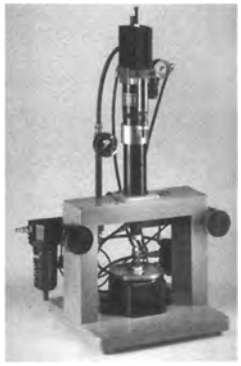
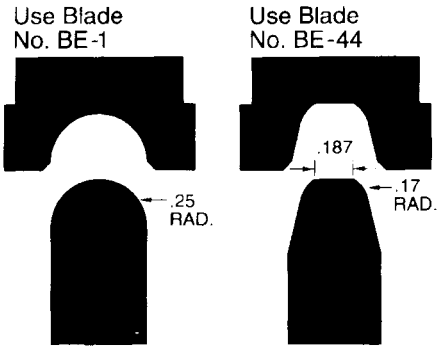


Table Dresser

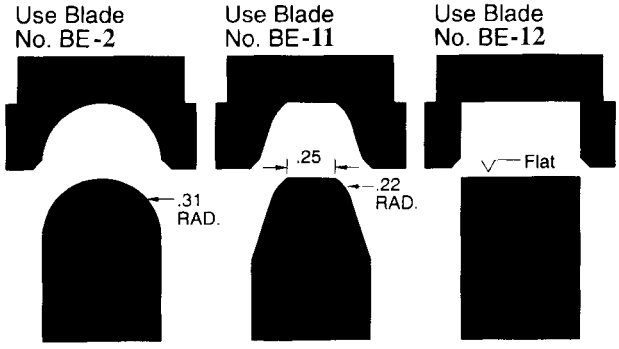
This off-line table dresser is perfect for high production redressing of cap tips. This machine will accomodate both male and female caps (with available tooling)

PART # **DT-1**

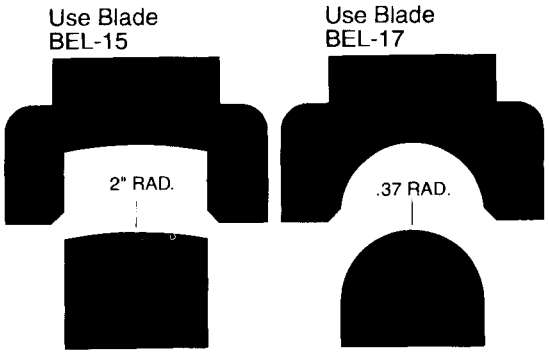
For No. 4RW Electrodes
Use Chuck No. C-1; Nut N-1, Ring No. R-2

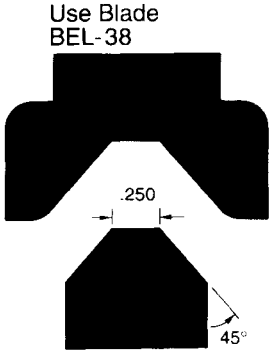


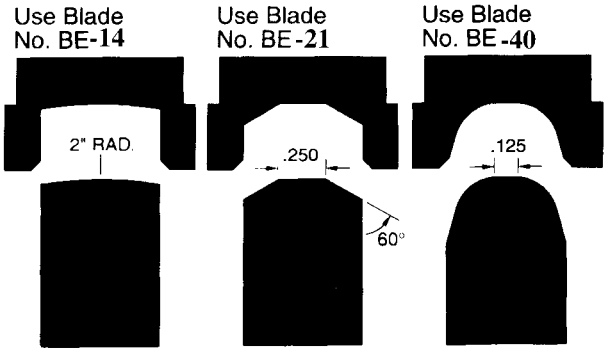
For No. 5RW Electrodes
Use Chuck No. C-1; Nut N-1. Ring No. R-1



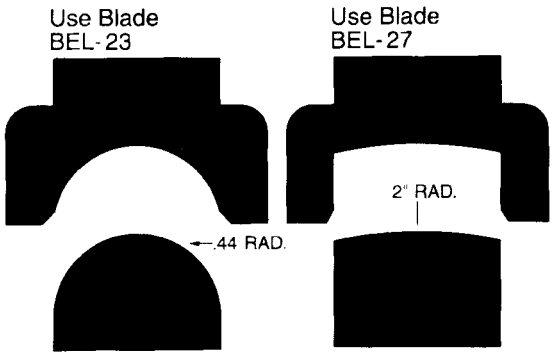
For No. 6RW Electrodes
Use Chuck No. C-2; Nut N-2







For No. 7RW Electrodes
Use Chuck No. C-2; Nut N-3



REAMERS

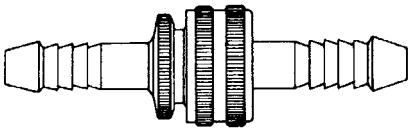
High Speed steel reamers to rework worn tapers in holders are available for standard 4RW, 1MT, 5RW, 2MI, 6RW, and 7RW 3MT, and 4RW 1MT, 5RW 2MT, and 6RW Cap tapers. All reamers except for the 4RW 1MI are hollow, making it possible to recondition worn holder tapers without removing the water tubes.

4RW 1MT	**Part No. 18-1322**
5RW 2MT	**Part No. 18-1323**
6RW	**Part No. 18-1321**
7RW 3MI	**Part No. 18-1324**
4RW 1MT cap taper	**Part No. 18-1327**
5RW 2MI cap taper	**Part No. 18-1328**
6RW cap taper	**Part No. 18-1329**

WATER COOLING HOSE PART NO. 18-1350

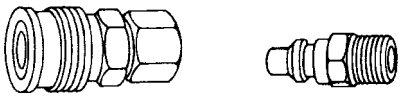
CMW water-cooling hose is the finest available. made by a prominent hose manufacturer. this hose is 3/8" diameter which properly fits the water nipples on CMW holders. It is available in 50-foot coils or can be cut to length.

HOSE CONNECTOR FOR 3/8 HOSE PART NO. 18-1351



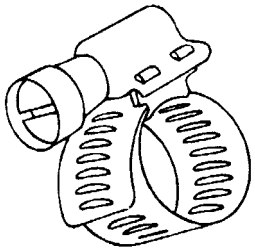
This hose connector, placed in the water-cooling hose line, facilities quick change of holders or dies. The male and female ends of these connectors should be reversed in the inlet and outlet lines to eliminate confusion in changing set-ups.

QUICK CONNECTIVE COUPLING ASSEMBLY PART NO. 18-1352



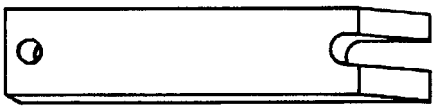
The plug of this coupling can be mounted on CMW holders converting them for quick hose changes. An automatic water shut-off valve is built into the coupling.

HOSE CLAMP PART NO. 18-1353



This aircraft type hose clamp gives positive tightening action which eliminates water leakage. It is easy to install and remove from Standard 3/8" Water Hose.

CAP ELECTRODE EXTRACTOR FORK 18-1381-1 FOR 4RW CAPS, 18-1381-2 FOR 4RW CAPS



These hardened steel wedge type forks will make the removal of electrode caps quick and easy. They can be used on both female and male caps.

Order replaceable cutters by—18-130701
Order replaceable handle by—18-130702

Electrode Dresser– Part No. 18-1307

The Electrode Dresser quickly removes the "mushroomed" portions of spot welding electrodes and renews 4RW or 5RW Taper, dome or pointed electrodes with the proper operating contour.

The Electrode Dresser re-machines both upper and lower electrodes to the correct profile "on the job"—provided both electrodes are identical—without removal of the electrodes from their holders. The Dresser is 10" long, with a cutter of hardened tool steel.

STOCK FORCE GAUGES

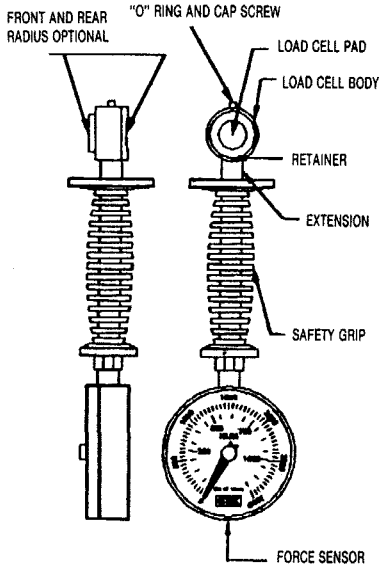
Standard **Part Number LC2564-73**
2½" sensor, 5.0" grip, 2,000 lbs. of force, ¾" poly locator

Deluxe **Part Number LC2164-7393**
2½" sensor, 5.0" grip, 2,000 lbs. of force, 15° flexible swivel connection, ¾" poly locator, insulated back pad

AVAILABLE ON REQUEST

Digital **Part Number LC8568-73**
3½" sensor, 5.0" grip, 5,000 lbs. of force, ¾" poly locator

REPAIR AND REPLACEMENT PARTS



FORCE GAUGE OPTIONS

SENSOR	CONNECTOR	FORCE RANGE	PAD	REAR PAD
2.5" w/o pointer	15° flex swivel 11.0" OAL*	300	Flat Poly	Flat
2.5" w/pointer†*	90° flex swivel 15.0" OAL	600	Flat SS	
4.0" w/o pointer	180° flex swivel 19.0" OAL	1,000	¾" Locator Poly †*	¾" poly*
4.0" w/pointer		2,000†*	¾" Locator SS	
4.5" process	Standard 5.0" grip	3,000	5.0" Radius Poly	5.0" Radius Poly
4.5" w/pointer	6.0" OAL w/o grip	5,000[1]	5.0" Radius SS	
	Under 7.0" OAL	10,000[2]	Thin (low profile)	
Digital	Swivel only	[1]Must add SS live pad	Thin Poly	
		[2]SS live pad and flat rear pad	Thin SS	

† = Standard * = Deluxe

APPROXIMATE PRESSURE EXERTED BY AIR CYLINDER SIZE

DIAMETER		CYLINDER AREA SQ. INCHES				
4"	=	12.5	x		=	
5"	=	19.5	x	WELDER GAUGE	=	ELECTRODE FORCE
6"	=	28.0	x	PRESSURE	=	PRESSURE
8"	=	50.0	x		=	

THE KV LINE OF INDUSTRIAL CHILLERS

Typical Applications Include: Spot Welders, Induction Heating Equipment, Waterjets, Chill Rolls, Molds, Jackets, Heat Exchangers, & Other Industrial Processes & Equipment.

Designed for Water and Water-Glycol Fluids

Over 15 Features Included as Standard Items!
Many Units are in Stock for Immediate Delivery!

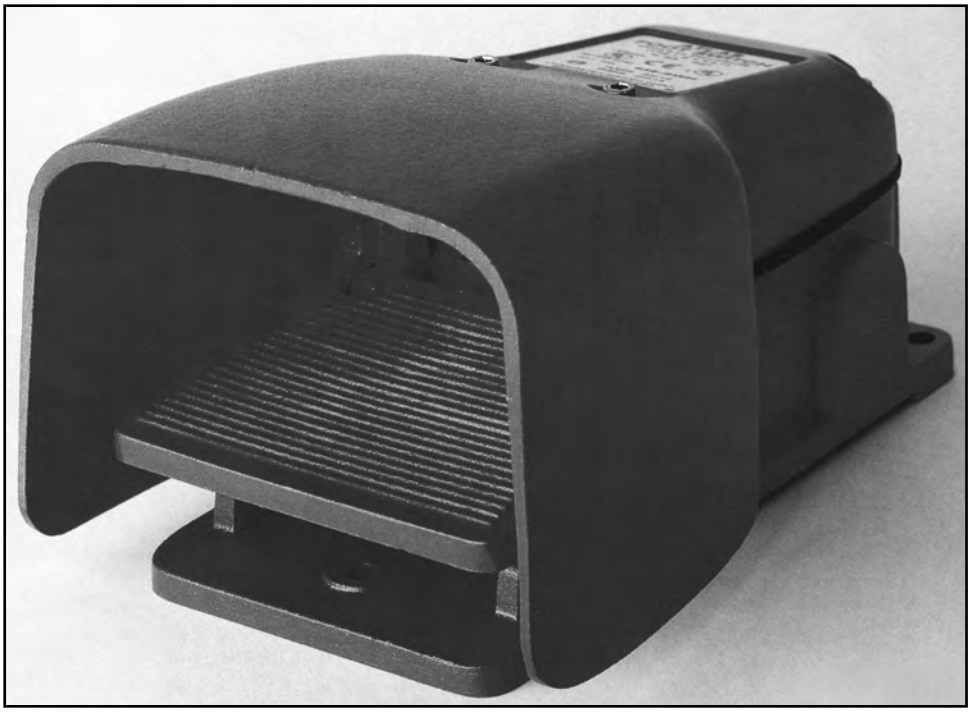
JT MODEL INDUSTRIAL CHILLERS

Typical Applications Include: Small Lasers, Spot Welders, Spindles,
Induction Heaters, & Other Industrial Processes & Equipment.
Many Units are in Stock for Immediate Delivery!

CAPACITIES FROM 1,500 BTU/HR. TO 13,900 BTU/HR.

Features Include Non-ferrous Wetted Components, Stainless Steel Cabinet,
High Pressure Recirculating Pump and More!

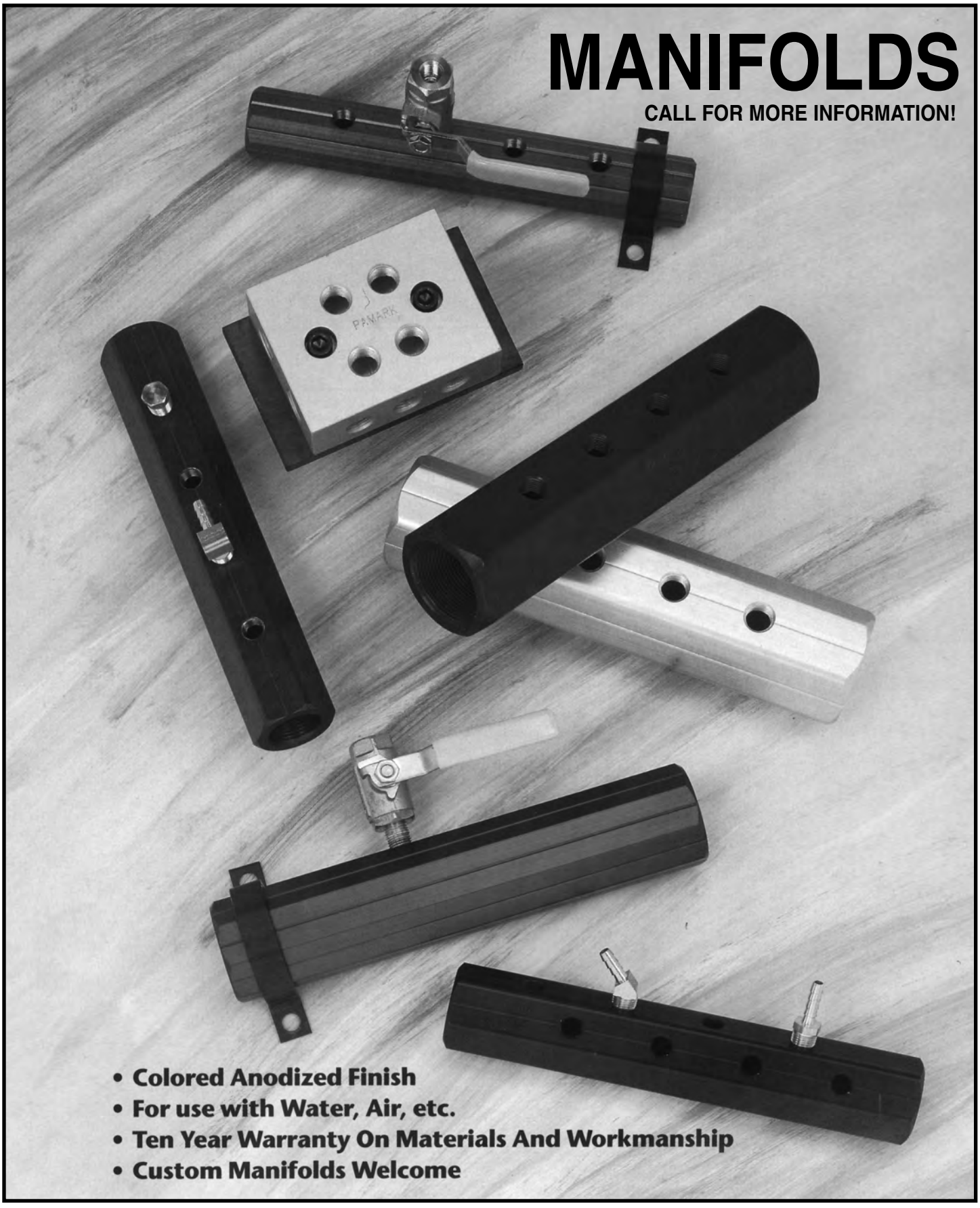
ATLAS "OLD" 54 ACCESSORIES



SPECIFICATIONS (Special variations are available to the O.E.M. on special order on the models listed below)

	FULL SHIELD	"O" SHIELD	WITHOUT GUARD	STAGE	CIRCUIT	ELECTRICAL RATINGS
	531-SWH	531-SWHO	531-SWN	Single	SPDT	
	571-DWH	571-DWHO	571-DWN	Single	SPDT	
	532-SWH	532-SWHO	532-SWN	Single	DPDT	
	572-DWH	572-DWHO	572-DWN	Single	DPDT	
	533-SWH	533-SWHO	533-SWN	Single	TPDT	20 A
	573-DWH	573-DWHO	573-DWN	Single	TPDT	125-250 VAC
	534-SWH	534-SWHO	534-SWN	Two	SPDT	1 H.P.
	574-DWH	574-DWHO	574-DWN	Two	SPDT	125-250 VAC
	574-DWHA*	574-DWHOA*		Two	SPDT	Heavy Pilot Duty
	574-DWHD**	574-DWHOD**		Two	SPDT	250 VAC Max.
	535-SWH	535-SWHO	535-SWN	Three	SPDT	
	575-DWH	575-DWHO	575-DWN	Three	SPDT	
	575-DWHA***	575-DWHOA***		Three	SPDT	
	536-SWH	536-SWHO	536-SWN	Single	SPDT DB†	
	576-DWH	576-DWHO	576-DWN	Single	SPDT DB†	15 A
	537-SWH	537-SWHO	537-SWN	Single	DPDT DB†	125-250 VAC
	577-DWH	577-DWHO	577-DWN	Single	DPDT DB†	½H.P. 125 VAC
	538-SWH	538-SWHO	538-SWN	Two	SPDT DB†	1 H.P. 250 VAC
	578-DWH	578-DWHO	578-DWN	Two	SPDT DB†	Heavy Pilot Duty
	578-DWHA*	578-DWHOA*		Two	SPDT DB†	250 VAC Max.
	578-DWHD**	578-DWHOD**		Two	SPDT DB†	
	541-SWH			Single	SPDT	
	581-DWH			Single	SPDT	10 A
	542-SWH			Single	DPDT	125 VDC-VAC
	582-DWH			Single	DPDT	

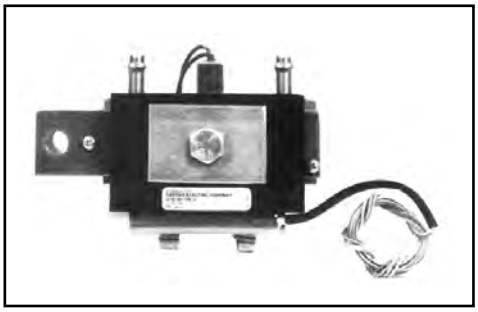
*1st stage Maintained 2nd stage Momentary. **1st stage Momentary 2nd stage Maintained. ***1st stage Maintained 2nd & 3rd stage Momentary.


MANIFOLDS
CALL FOR MORE INFORMATION!
• Colored Anodized Finish
• For use with Water, Air, etc.
• Ten Year Warranty On Materials And Workmanship
• Custom Manifolds Welcome

DIRECT WATER COOLED

Undoubtedly the most popular resistance welding contractor for the past twenty years are DARRAH's direct water-cooled SCR Contractors. The selections shown are in stock in welding current ratings to 3200 Amps RMS. Choose between single or double sided cooled, and in SCR voltages to 2000 Volts. These are the workhorses in medium to heavy KVA welding controllers.

DARRAH PART NUMBER	WELDING RATING Amps. RMS AT 50% DUTY CYCLE	WELDING RATING Amps. RMS A 100% DUTY CLCLE	SGL. CYCLE SURGE CURRENT (ITSM)	SCR VOLTAGE RATING (PIV) (VRRM)	WATER COOLED	
					SGL SIDE	DBL SIDE
D09ST15	900	400	5500	1500	X	-
D09ST18	900	400	5500	1800	X	-
D13DT15	1300	700	5500	1500	-	X
D13DT18	1300	700	5500	1800	-	X
D13SE18	1300	610	7500	1800	X	-
D13SE20	1300	610	7500	2000	X	-
D18SM18	1800	975	11200	1800	X	-
D18SM20	1800	975	11200	2000	X	-
D18DE18	1800	970	7500	1800	-	X
D18DE20	1800	970	7500	2000	-	X
D21DM18	2100	1225	9000	1800	-	X
D21DM20	2100	1225	9000	2000	-	X
D22SN18	2200	1300	21000	1800	X	-
D22SN20	2200	1300	21000	2000	X	-
D23DM20	2300	1425	11200	1800	-	X
D23DM20	2300	1425	1200	2000	-	X
D26DN18	2600	1710	16400	1800	-	X
D26DN20	2600	1710	16400	2000	-	X
D32DN18	3200	2075	21000	1800	-	X



Water Requirements: Amps RMS is achieved with a cooling flow rate of 1.2 gallons (4.5 liters) per minute at 40ºC water temperature.

Water Connection: Fits 3/8 inch hoses.

Thermostat: If required add suffix J to part number.

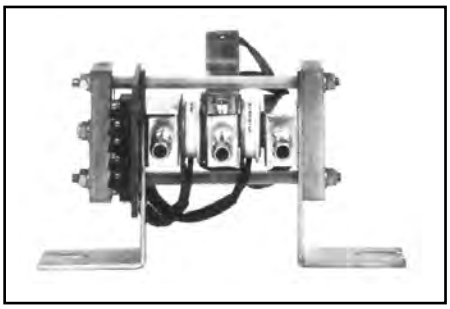
MOV: For MOV add suffix M to part number.

Example: 13DT15JM, 1300 Amps RMS, 1500 Volt, with thermostat and MOV.

HS-6 DESIGN

DARRAH HS-6 design direct double sided cooled SCR Contractors have proven to be dependable for years in resistance welding controllers. Choose between two popular current ratings with SCR voltages to 1800 Volts.

DARRAH PART NUMBER	WELDING RATING AMPS. RMS AT 50% DUTY CYCLE	WELDING RATING AMPS. RMS AT 100% DUTY CYCLE	SGL.CYCLE SURGE CURRENT (ITSM)	SCR VOLTAGE RATING (PIV) (VRRM)
DO8HS6-12	1200	800	5500	1200
DO8HS6-14	1200	800	5500	1400
DO8HS6-16	1200	800	5500	1600
D12HS6-12	1800	1200	7500	1200
D12HS6-14	1800	1200	7500	1400
D12HS6-16	1800	1200	7500	1600
D12HS6-18	1800	1200	7500	1800



Water Requirements: Amps RMS is achieved with a cooling flow rate of 1.2 gallons (4.5 liters) per minute at 40º C water temperature.

Water Connection: For 3/8 inch add suffix A to part number. For 1/2 inch add suffix B to part number.

Thermostat: If required add suffix J to part number.

MOV: For MOV add suffix M to part number.

Terminal Board: For SCR gate cathode leads add suffix T to part number.

Example: DO8HS6-12AJ, 1200 Amps RMS, 1200 Volt, with 3/8 inch water connection and thermostat.

AUTOMOTIVE STYLE SCR CONTACTORS HOSE TYPE

DARRAH Automotive Style SCR Contactors are the chosen favorite among high current/high voltage resistance welding users. All Contactors are rated at 100% continuous and are provided with 2600 Volt SCR's.

This Series is popular for frequency converter, seam, and flash butt welding applications.

DARRAH PART NUMBER	WELDING RATING Amps RMS AT 100% DUTY CYCLE	SGL. CYCLE SURGE CURRENT (ITSM)	SCR VOLTAGE RATING (PIV) (VRRM)	TANG TYPE
DPH7825-468	1200	10,000	2600	C
DPH7330-468	1700	10,000	2600	A
DPH7331-468	1700	10,000	2600	B
DPH7844-468	1700	10,000	2600	C
DPH7845-468	1750	18,000	2600	C
DPH7517-468	2500	18,000	2600	A
DPH7477-468	2500	18,000	2600	B
DPH7824-468	2500	18,000	2600	C

TANG TYPE DESCRIPTION

A) Single Hole: Chrysler design, one .5" diameter hole centered in bus tang.

B) Four Hole: General Motors design, four holes on 1.06" centers.

C) Four Hole Plus Slot: Fisher/Ford design, four holes on 1.06" centers .5" x .75" center slot.

Water Requirements: Amps RMS is achieved with a cooling flow rate of 1.2 gallons (4.5 liters) per minute at 40° C water temperature.

Water Connection: 1/4-18 NPT tapped holes.

Thermostat: All contractors are supplied with a thermostat sensor, 70°C open on rise, re-closes at 58°C, and is isolated to base 2000 Volts. Thermostat leads are 12 inches long.

MOV: For MOV add suffix M to part number.

Example: DPH7824-468M, 2500 Amps RMS, 2600 Volt, with MOV.

Service Tip: It is recommended that power not be left on while water flow is off, as this is a cause for hose rupturing due to internal heating and arching where water resistivity is low.

WATER QUALITY

Cooling water requirements for trouble-free operation and reduced maintenance for the DPH Automotive Hose Type design require the following water conditions:

- Resistivity greater than 2000 ohms-CM @ 25°C.
- pH between 7 and 8 (neutral or slightly alkaline).
- Mineral content to be not more than 20 ppm, chlorides.
- 10 ppm, nitrates; 100 ppm, sulfate.
- Total solids content not more than 250 ppm.
- Total hardness (as calcium carbonate) not more than 250 ppm.

SOLID STATE IGNITRON TUBE REPLACEMENTS
ONE DARRAH SCR UNIT REPLACES TWO IGNITRON TUBES!

NO MORE MERCURY! NO MORE IGNITRON TUBES! NO MORE WORN OUT CONTACTS! NO MORE HIGH PRICES!

Now you can quickly replace all your ignitron tubes or mechanical contractors with DARRAH's solid state replacements.

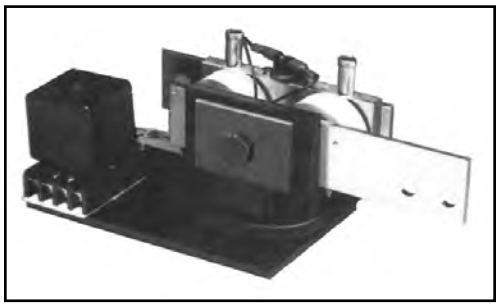
DARRAH provides a complete line of SOLID STATE SCR IGNITRON TUBE REPLACEMENTS. Replacements are available in both water cooled and air cooled designs, and easily mount on existing Ignitron Tube brackets.

DARRAH's replacements are engineered so that no modifications are required to existing controls or timer. All wiring and assembly is complete and Darrah Ignitron Tube Replacements are supplied with MOV and normally closed thermostat.

Installation instructions are provided upon request.

WATER COOLED-DHE SERIES

IGNITION SIZE	DARRAH PART NUMBER	WELDING TRANSFORMER SIZE	WELDING RATING Amps. RMS AT 50% DUTY CYCLE	SGL CYCLE SURGE CURRENT (ITSM)	SCR VOLTAGE RATING (PIV) (VRRM)
A/B	DHE800-22M	100KVA	1300	7500	2200
C	DHE1200-22M	200KVA	1700	9000	2200
J/C	DHE1500-22M	300KVA	1800	11,200	2200
D	DHE1700-22M	550KVA	2300	11,200	2200
D/E	DHE2500-22M	650KVA	2600	16,400	2200
E	DHE3300-22M	750KVA	3200	21,000	2200
Super E	DHE7847-22M	1500KVA	6526	40,000	2200



Single Side Water Cooled Unit

Water Requirements: Amps RMS is achieved with a cooling flow rate of 1.2 gallons (4.5 liters) per minute at 40° C water temperature.

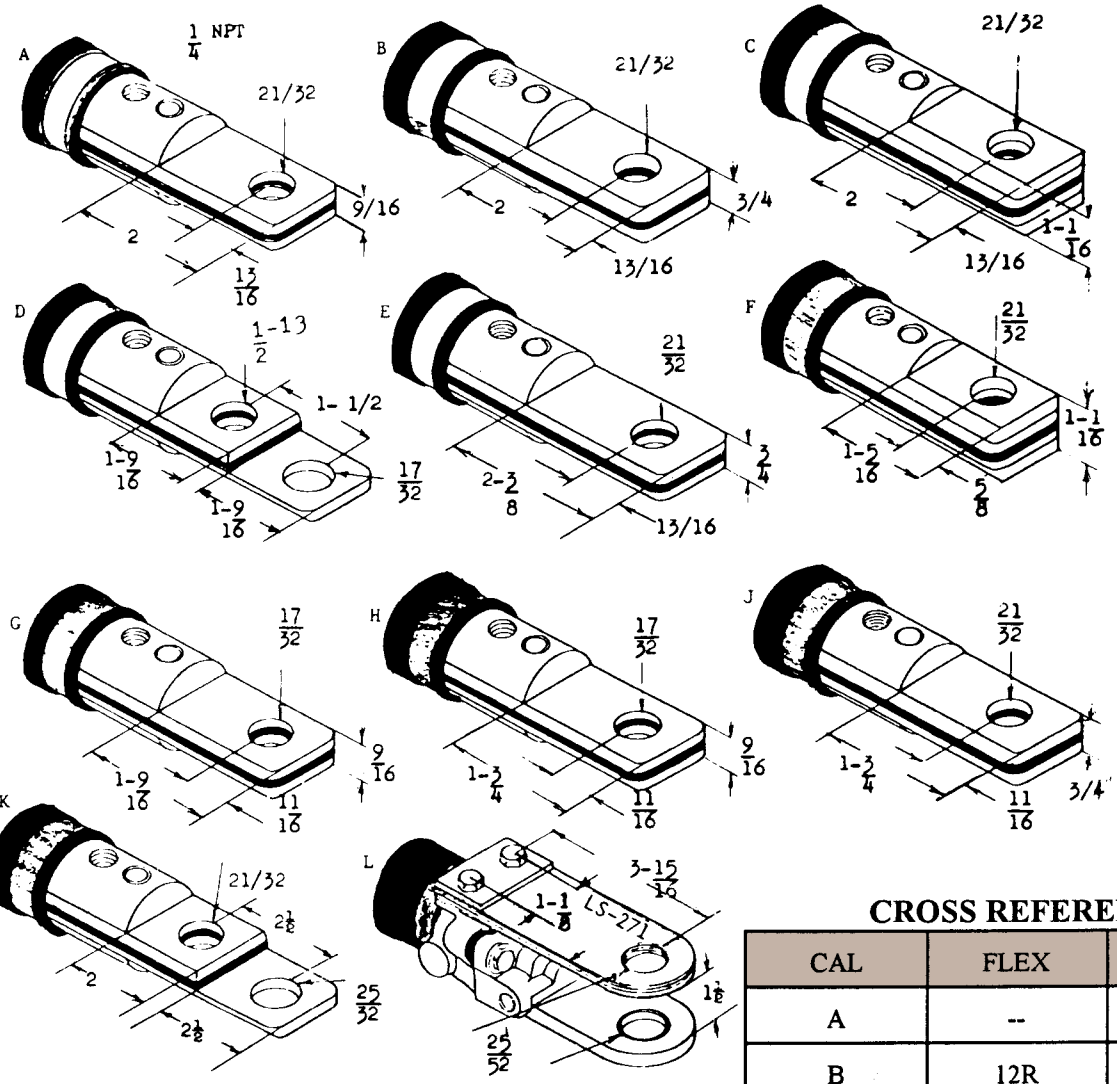
Water Connection: Fits 3/8 inch hoses.

Welding Ratings: Suggested transformer KVA is based on the maximum secondary voltage at 50% duty cycle, 460 Volt incoming A.C. line or higher; typically, spotwelding applications.

Thermostat: All switches are supplied with a thermostat sensor, 50° C open on rise and isolated to base for 2000 Volts. Thermostat leads are 12 inches long.

MOV: Included.

Consult factory for seam, projection, or frequency converter, welding requirements.

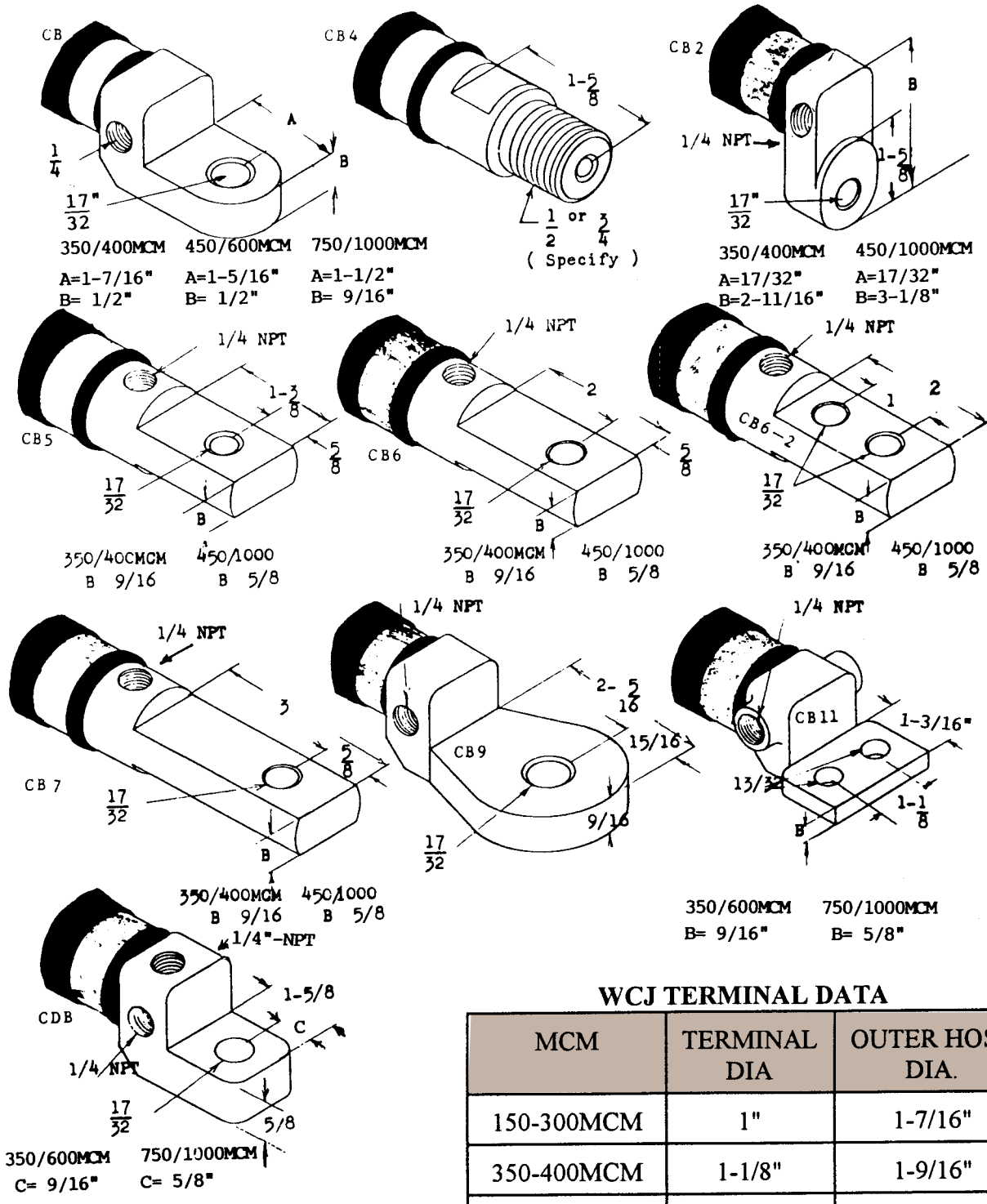


TERMINAL DATA

MCM	TERMINAL DIA.	OUTER HOSE DIA.
257 and 300	1-3/8"	1-15/16"
400 and 450	1-5/8"	2-3/16"
500	1-5/8"	2-9/16"
600 and 650	1-7/8"	2-9/16"
800	2"	2-9/16"

CROSS REFERENCE

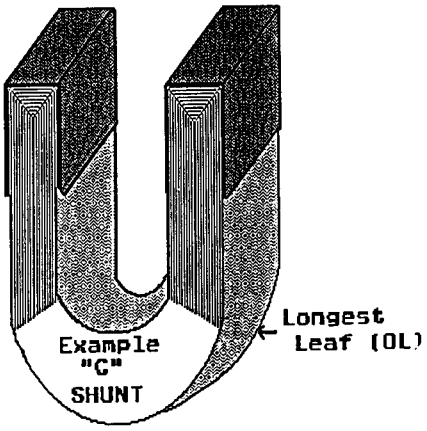
CAL	FLEX	UNIFLEX
A	--	--
B	12R	F-75
C	17H	F
D	17T	FIT
E	12RX	F-75-L
F	17HC	FA
G	9L	N
H	9L4	LN
J	12R2	LF
K	--	--
L	--	--

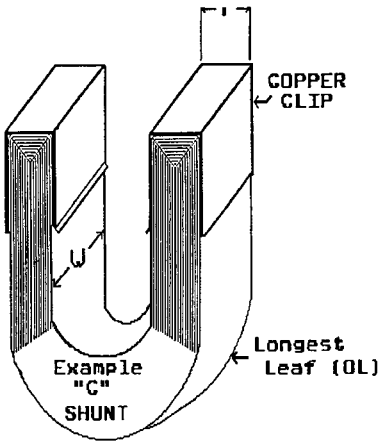


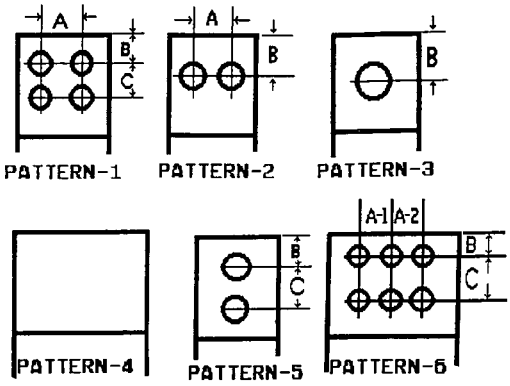
Terminals Furnished as shown UNLESS changes are specified.

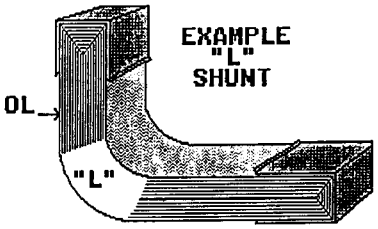
WCJ TERMINAL DATA

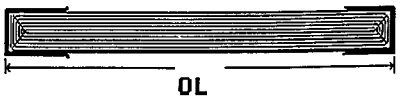
MCM	TERMINAL DIA	OUTER HOSE DIA.
150-300MCM	1"	1-7/16"
350-400MCM	1-1/8"	1-9/16"
450-600MCM	1-1/4"	1-11/16"
750 MCM	1-3/8"	1-13/16"
1000MCM	1-1/2"	1-15/16"











To order, Please include details below.

All shunts are made from .005" Laminations, with 1/16" copper clips riveted in place, UNLESS Otherwise ordered (please specify) =

Type of Shunt
(check one)

Type-C _____
Type-J _____
Type-L _____
Type-F _____

Special _____

Shunt Dimensions

Length of Longest Sheet (OL) _____

Width . . . . . _____

Thickness (less clips) . . . . . _____

Hole Size (Clearance) . . . . . _____

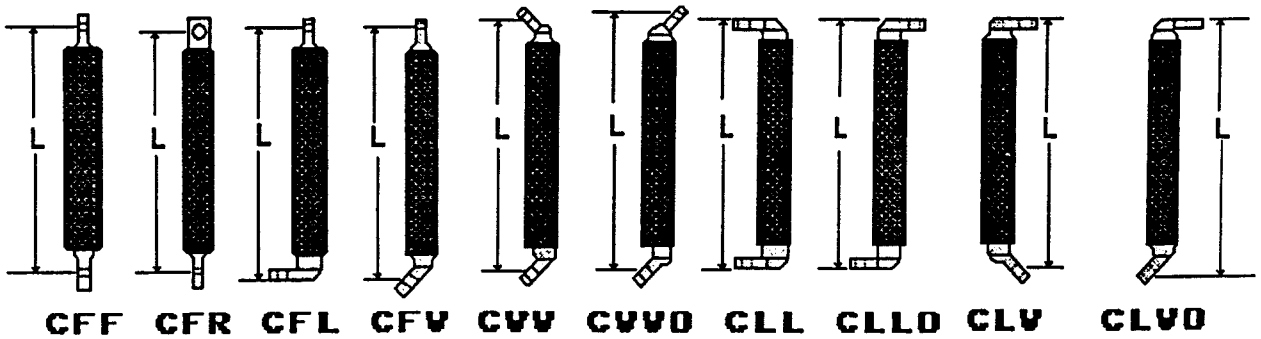
PLEASE SHOW DRILL PATTERN

Air-cooled jumpers are available in circular mill sizes from 400MCM to 2000MCM as a standard. Other circular sizes upon request.

Terminals can be furnished with any desired angle. See terminal style (angle) and dimension chart below.

As a standard and unless otherwise ordered: (1) the 1-1/4" width and corresponding thickness will be furnished up to and including the 1200MCM size, (2) the 1500MCM size will be furnished in the 1-3/8" width and (3) the 2000MCM size will be furnished in the 1-1/2" width. When so ordered, Automotive standards will automatically be met – such as Ford-WKA series and GM-CBL.

TERMINAL (ANGLE) DATA



TERMINAL THICKNESS			
MCM	1-1/4" Wide	1-3/8" Wide	1-1/2" Wide
400	3/8		
500	7/16		
600	½	7/16	
750	5/8	9/16	
1000	3/4	11/16	5/8
1200	7/8	1316	3/4
1500		1-1/6	1
2000			1-7/16

TERMINAL LENGTH

The contact surface length of the air-cooled jumpers is 1-9/16". Other lengths can be furnished if ordered.

BOLT HOLE SIZE

All air-cooled jumpers are drilled 17/32 unless otherwise ordered.

WHEN ORDERING AIR-COOLED JUMPERS:

Example:	50 pcs.	ACJ/750MCM	Terminal CFF - 18", or if special,
	50 pcs.	ACJ/750MCM	Terminal WKAFF - 18" - etc.

DUAL CONDUCTOR CABLES

Based on 2 g.p.m. @100° temperature rise
Maximum temperature 167° F. OHM's per foot cable-both leads.

Cable Size MCM	300	400	500	600	650	800
Resistance per foot (D.C.) OHMS x 10^{-6}	69.66	52.4	43.	38.8	33.1	27.32
Impedance OHMS x 10^{-6}	78.7	59.5	48.3	41.2	37.8	30.1

Duty Cycle	Multi-Plier
100%	1.00
90%	.95
80%	.90
70%	.84
60%	.78
50%	.71
40%	.63
30%	.55
20%	.45
10%	.32
5%	.22
3%	.17
2%	.14

DETERMINING THE MCM SIZE REQUIRED

To determine the required MCM rating, it is first necessary to know (a) the duty cycle, (b) current to be used and (c) length of the cable to be used, measured bolt hole center to bolt hole center.

Once this has been determined, proceed as follows, assuming the duty cycle has been set at 20%, the current at 20,000 amperes and the cable length at 7 feet.

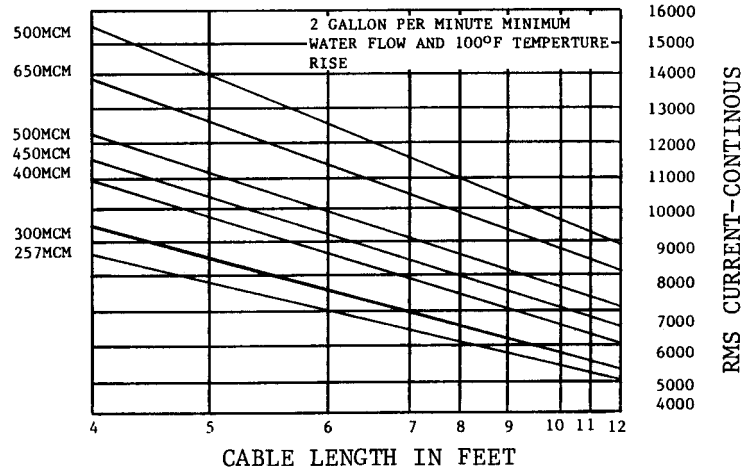
(1) Consult the multiplier chart, above and at the 20% duty cycle line you find the multiplier of .45.

(2) Multiply the current required, 20,000 amperes, by .45 and you have the continuous duty current of the cable, 9,000 amperes.

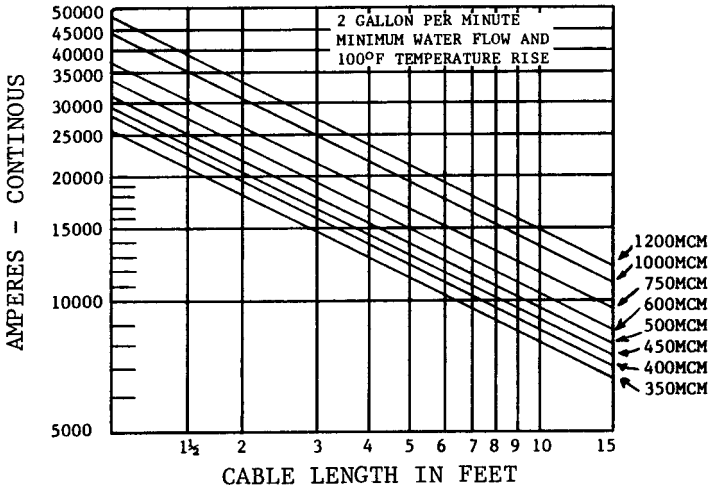
(3) Refer to the Dual Conductor selection chart, page 99, and find the cable length, 7 feet. Looking up this 7 foot line, find the horizontal line nearest to the continuous duty current of 9,000 amperes, in this case 9,100. Follow the angular line to the side of the chart which then shows the MCM rating required, in this case 500MCM.

(4) While the above procedure uses a Dual Conductor cable, seven feet long, as an example, the same procedure is used for Single Conductor water-cooled cable jumpers and for air-cooled cable jumpers using the appropriate chart.

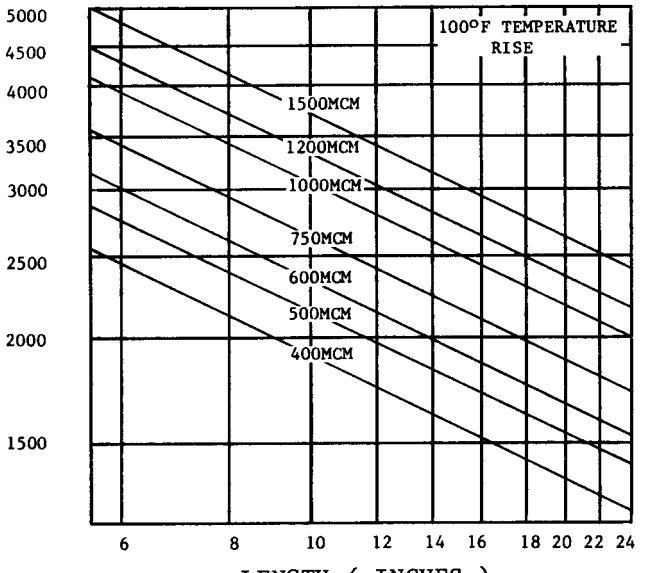
DUAL CONDUCTOR CABLE SELECTION CHART

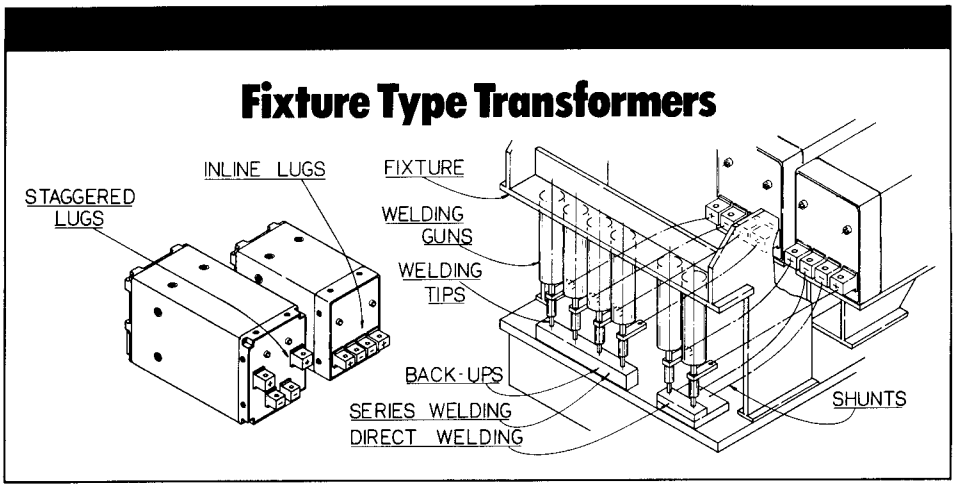


WATER-COOLED CABLE JUMPER SELECTION CHART



AIR-COOLED CABLE JUMPER SELECTION CHART



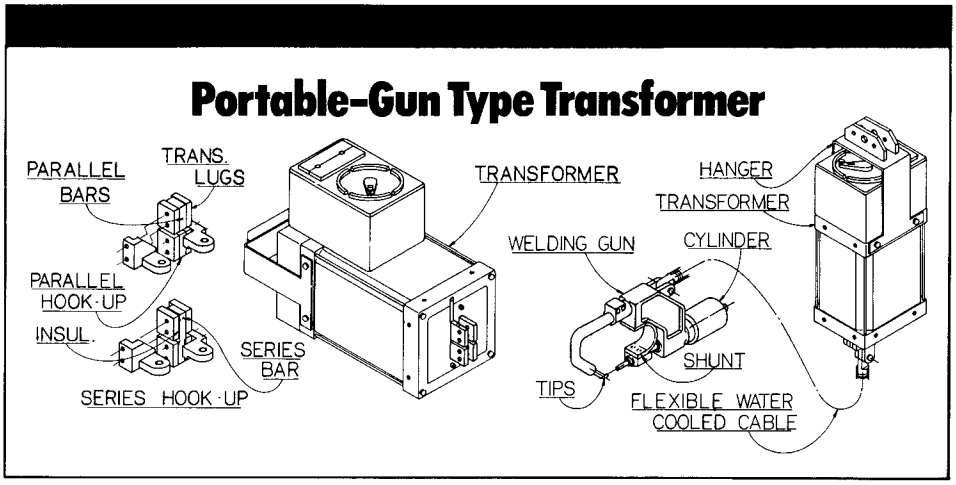


GENERAL INFORMATION: FIXTURE TYPE TRANSFORMERS

Typical Features: Transformers of different KVA Ratings and Secondary Voltages are grouped in families with identical frame cross sections and secondary connections. Two isolated and impedance balanced secondaries are provided. Various tap switch mounting positions and primary disconnect plugs are available.

Typical Applications: Multi-Spot Welding Fixtures. Generally Air-or Watercooled Single Conductor Cables are used to connect the transformer to the welding tool.

Available KVA Ratings: 35 to 200 KVA

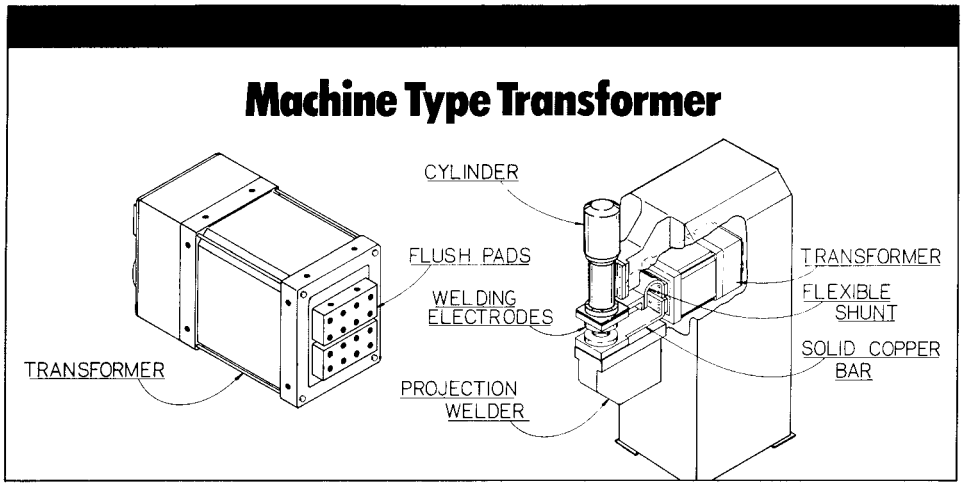


GENERAL INFORMATION: PORTABLE-GUN TYPE TRANSFORMER

Typical Features: The Secondary Connections are designed to accept Low Reactance Dual Conductor welding cables. The Secondaries of the Transformer can readily be changed from series to parallel connections. Transformers are supplied with a hanger for suspension of the Transformer from an overhead structure.

Typical Applications: Resistance welding installations using portable welding guns. The transformer is generally connected to the welding tool with a dual conductor low reactance cable.

Available KVA Ratings: 50 KVA to 200 KVA

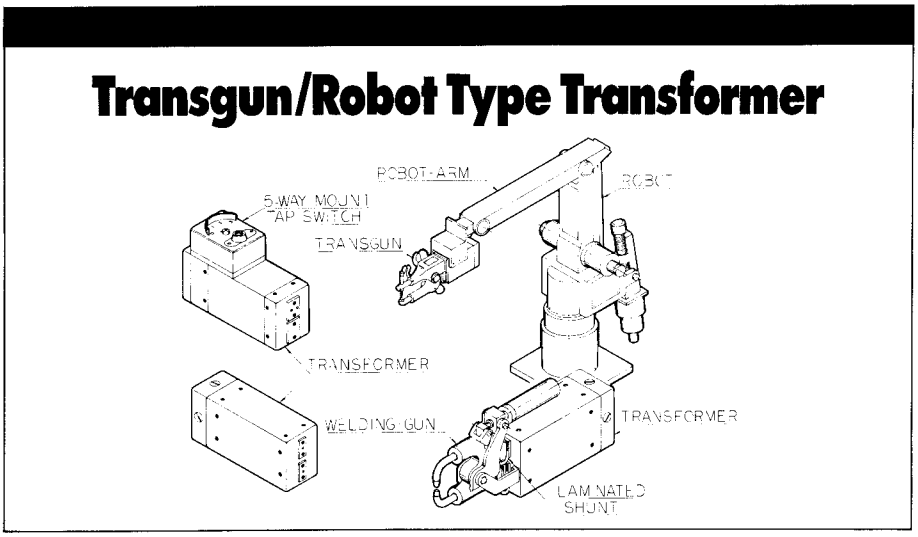


GENERAL INFORMATION: MACHINE TYPE TRANSFORMER

Typical Features: The Transformer is supplied with Secondary Connection Pads conforming to RWMA standards. The Secondary Voltage range covers up to 50% of the high tap voltage. The secondary end of the transformer is potted with epoxy resin to seal out contaminant's such as weldflash and to provide extra support to the secondary connections.

Typical Applications: The Transformer is intended for use in standard spot-, projection-, and seam- welding machines. It is generally connected with bus or laminated shunts to the welding tooling mounted to the upper and lower knee of a welding machine.

Available KVA Ratings: 20 KVA to 500 KVA.



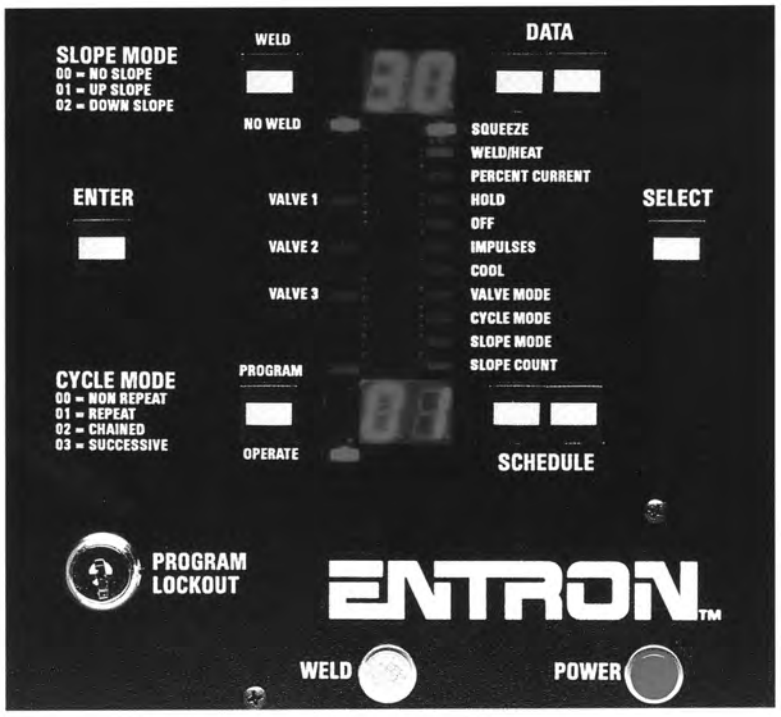
GENERAL INFORMATION: TRANSGUN/ROBOT TYPE TRANSFORMER

Typical Features: These transformers distinguish themselves by their compact and light-weight designs. This features makes the transformers suitable for close coupled transformer-welding gun mounting from which the name "transgun" is derived. Transformers of different KVA ratings and secondary voltages are grouped in families with identical frame cross-sections and secondary connections. Generally, a single secondary voltage is provided, however, some models are equipped with a secondary voltage range and tap switch.

Typical Applications: Resistance welding transguns for robots or multi-spot fixtures are typical applications. Generally, leaf shunts and shunt adapters are used to connect the transformer to the welding tool.

Available KVA Ratings: 20 to 80 KVA.

ENTRON™ CONTROLS FOR RESISTANCE WELDING
EN1000
SINGLE CONTACTOR CONTROLS



• Simple to Program
Push buttons and a short three-step procedure make easy work of programming any possible welding schedule.

• New Design Reduces Cost
Simplified design significantly reduces production costs which are passed on to you.

• 2 Year Warranty
A two year warranty is offered on all ENTRON parts and assemblies. Expert phone support and application service are available at no cost.

• Application Flexibility
Designed for use with single phase welding machines, rocker arm and press type welders, brazing and robotic equipment, and special machines.

FEATURES

Spot Sequence • Pulsation Sequence • Up & Down Slope • Quench/Temper • Forge Delay • Multiple Weld/Multiple Current • Sequence Preheat/Postheat • External Schedule Select • Process & Error Outputs • Seam Sequence

CAPABILITIES

50 Unique Schedules • Chained & Successive Modes • Repeat & Non Repeat • Weld & Valve Control Relays • 3 Valve Output • Multiple Weld Programed • Multiple Job Set-Ups • Easily Programming • Program Only the Functions Required

EN1000 SINGLE CONTACTOR CONTROLS
ADVANTAGES

- **Design Simplicity**
  Design simplicity is the key to our ability to manufacture the highest quality weld control with the best delivery, least maintenance, and lowest out of warranty service in the industry.

- **Field Expandable**
  Entron can provide retrofit controls suitable for any manufacturer's controls of any age, type or sequence for installation in the field.

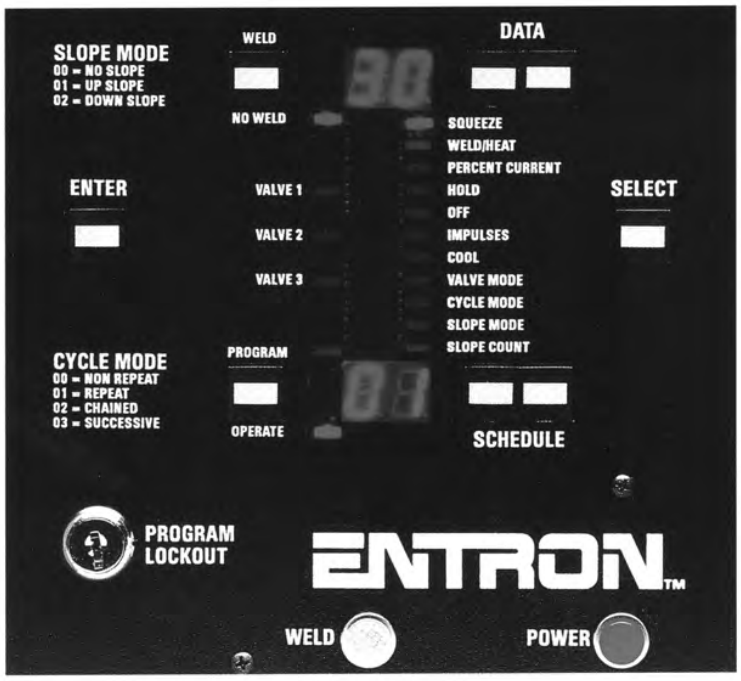
- **Vault Closing Door Mechanism**
  D&T cabinet doors equipped with vault locking mechanism to ensure security.

- **Flexible Applications**
  EN1000 Single Contactor Controls can be applied to spot welders, seam welders, special machines, or robotic equipment for welding materials of unequal thickness and coated materials.

- **Multiple Cabinet Options**
  Available in D, T, E, S cabinet styles with front or side-mounted control panels.

- **Available Options**
  Remote Data Entry, Program Lockout Switch, RS 232 Port Interface, Schedule Select, Valve Select (1 of 7) Option.

NTRON CONTROLS FOR RESISTANCE WELDING
EN1200
INVERTER BENCH CONTROL



- **Simple to Program**
  Using the familiar and intuitive EN1000 platform, push-buttons and a short three-step procedure make easy work of programming any possible welding schedule.

- **2 Year Warranty**
  A two year warranty is offered on all ENTRON parts and assemblies. Expert phone support and application service are available at no cost.

- **Application Flexibility**
  Designed for use on high accuracy welding applications with short weld times. Higher frequency allows for smaller welding transformers typically con figured with a rectified output. When transformer outputs are rectified, secondary losses are reduced.

Features

• Spot Sequence • Pulsation Sequence • Up Slope/Down Slope • Quench/Temper • Forge Delay • Multiple Weld/ Multiple Current Sequence • Preheat/Postheat • External Schedule Select • Process & Error Outputs • Weld time programmable in cycles independent of operating frequency • Seam Sequence

Capabilities

• 50 Unique Schedules • Chained & Successive Modes • Repeat & Non Repeat Modes • Weld & Valve Control Relays • 3 Valve Output Circuits • Multiple Weld Programming • Multiple Job Set-ups • Easily Programmed • Program Only the Functions Required

EN1000 SINGLE CONTACTOR CONTROLS ADVANTAGES

• **Design Simplicity**

Design simplicity is the key to our ability to manufacture the highest quality weld control with the best delivery, least maintenance, and lowest out of warranty service in the industry.

• **Advanced Design**

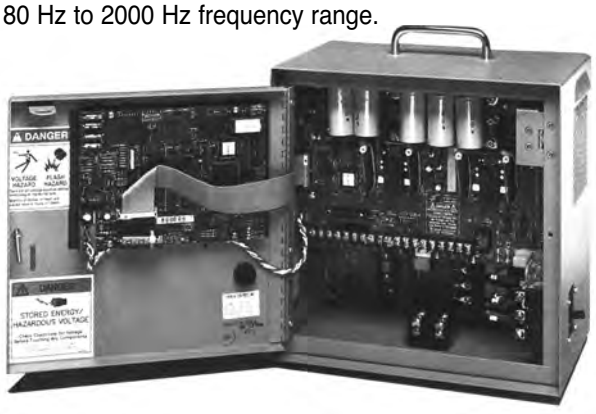
IGBT's switch with minimal loss and thus run cooler. Simple modular two board design. Uses proven EN1000 Series Control board. LED Status indicators standard. No high capacitance value capacitors to discharge, fail or replace. No calibration required.

• **Other**

30 Amp disconnect standard. 240 VAC 3 Phase line required. Air cooled IGBT's. 50 VA valve transformer included. Complete with all standard RWMA/NEMA programmable functions. 50 schedules. Inverter Over-Current detection. One control covers operation across a broad range of applications. 500 to 10,000 secondary amps. 180 Hz to 2000 Hz frequency range.

• **Available Options**

Remote Data Entry
Program Lockout Switch



• **Welding Transformers**

Welding Transformers are available through standard sources.

• **Programming**

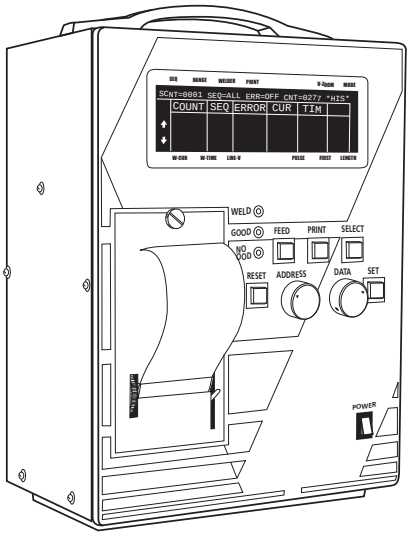
Simple and intuitive front panel access. Program weld and cool times in increments of cycles for frequency independent timing. 3 Fully programmable valve outputs.

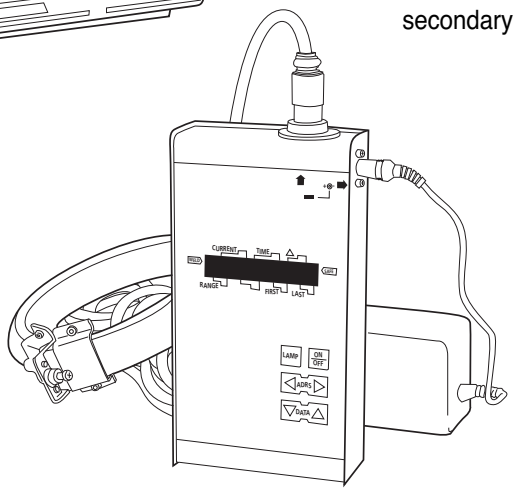
• **Higher Frequencies**

Higher weld heat resolution. More control over weld heat pattern. Smaller lighter transformers. DC secondary current dramatically reduces secondary losses.

• **Ideal Applications**

EN1200 Dual IGBT Controls can be applied to small heads, portable weld guns, tweezers, special machines, switch welders or robotic equipment. For welding materials of unequal thickness, coated materials and dissimilar metals. Housed in a compact light weight air-cooled cabinet with front door mounted control panel.





WELDSCOPE

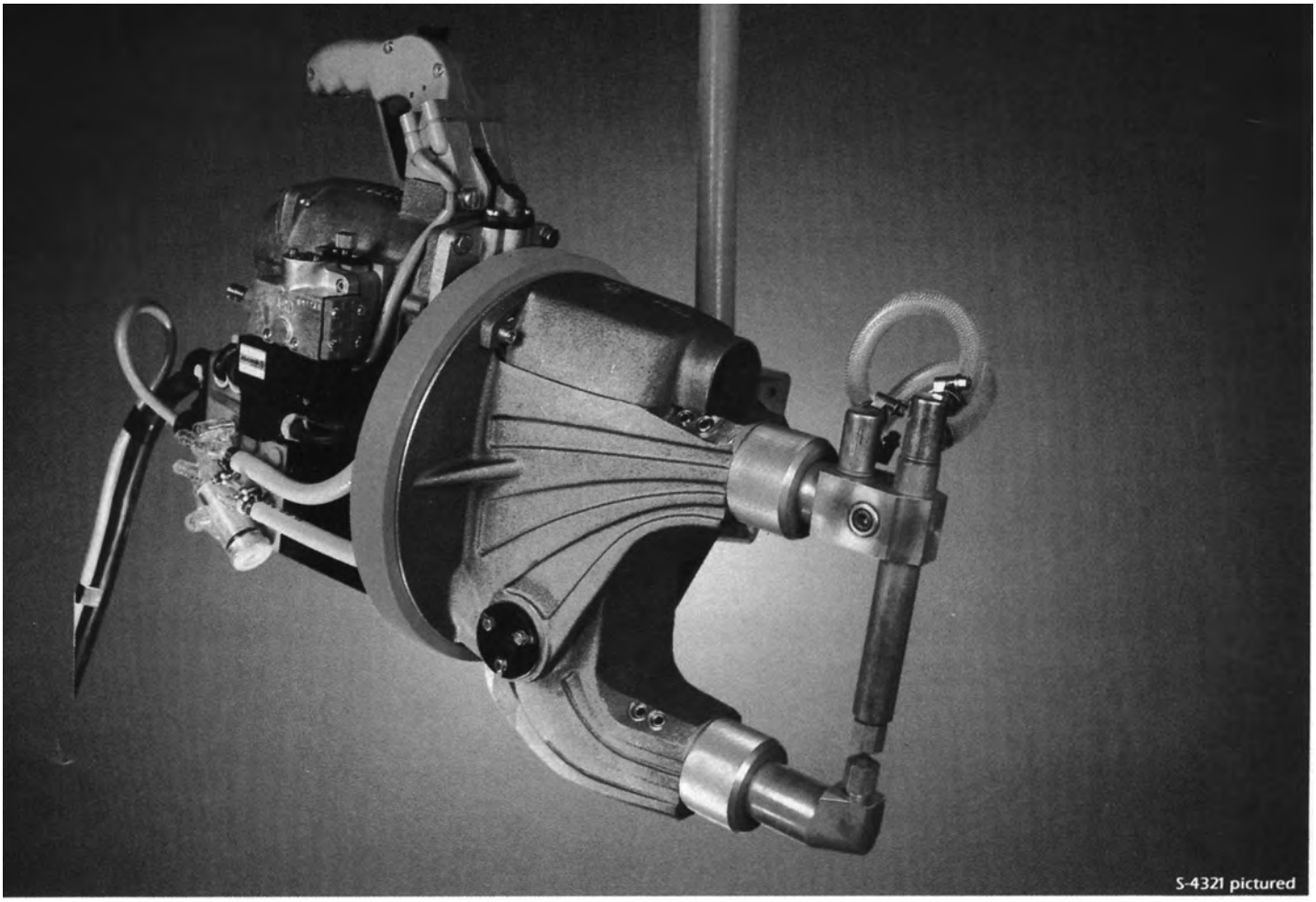
WS-25 Weldscope

This vital maintenance tool accurately measures and monitors weld current and time. Measured results on this portable scope are shown on a bright, fluorescent display window, making information easily seen in any light.

WS-10M Weldscope

Can measure an entire weld cycle or any one of fifty selected impulses, providing an instant, accurate dual line 16-character LCD read-out of RMS current. Battery operated, easy to use and designed to measure secondary RMS resistance weld current and weld time.

SPOT WELDING GUN
S-4321/S-4322 AIR OPERATED/WATER COOLED



The S-4321 series guns are designed for high production with either single spot or repeat operation. They are compact and highly maneuverable on three planes of operation. Built for production line use, they have the capacity to weld two pieces of 8 gauge mild steel at 6.69" throat depth.

Features

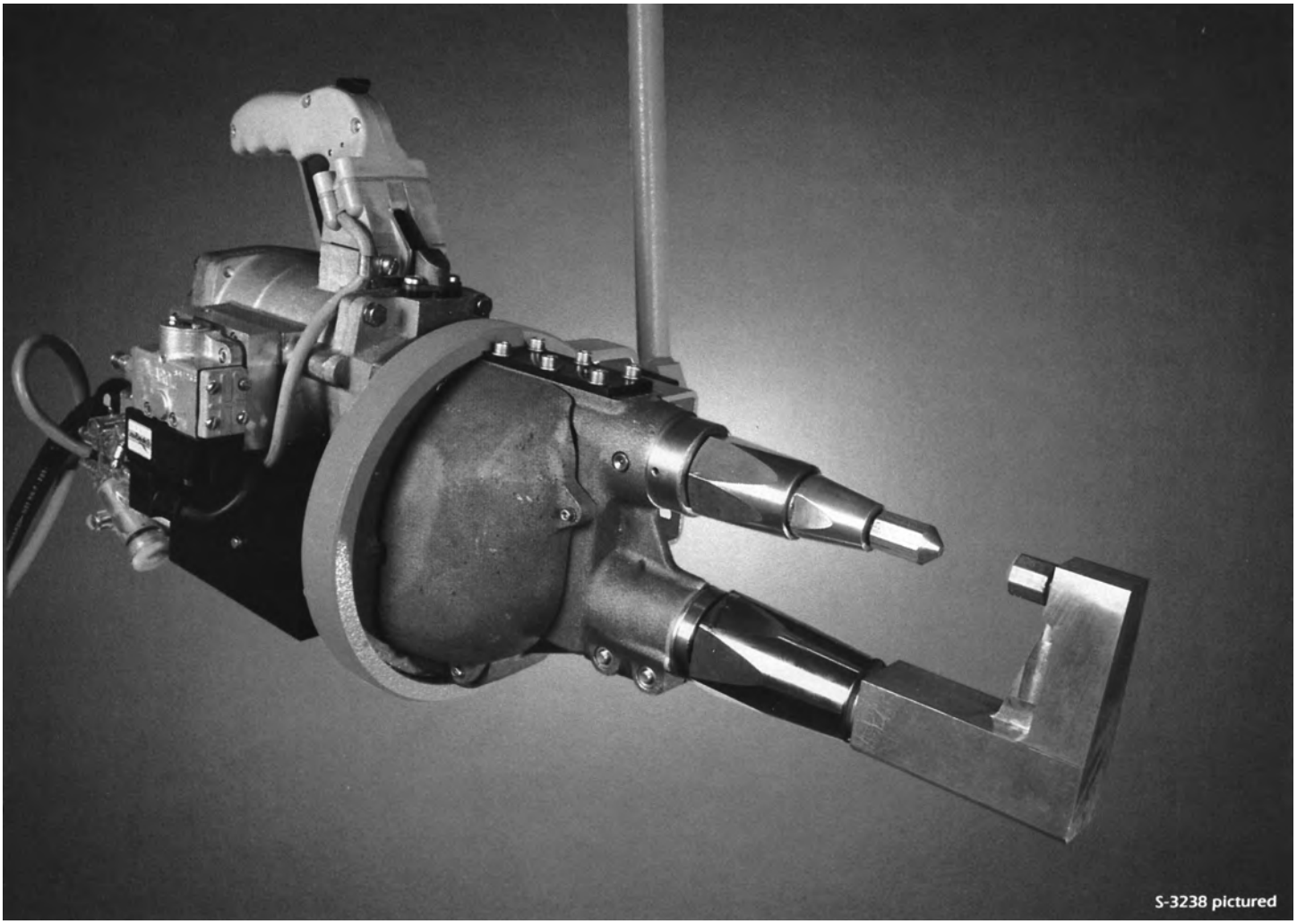
- Rated 31KVA with 25,000 amps secondary short circuit current.
- Maximum electrode force of 1120 lbs. at 85 p.s.i. and shortest throat depth.
- Ball-race type gyroscopic suspension allows easy rotation.
- Interchangeable standard arms provide throat depths of 6.69 in. through 31.50 in.
- Special arms designed upon request.
- Standard cable length 50 ft.
- Trigger controlled retraction for extra electrode clearance to work stroke.
- Ideally suited for production line use.
- Capable of welding two pieces of 8 ga. mild steel at 6.69" throat.
- Double action air cylinder for fast operation.
- Fully water cooled.
- Epoxy-resin encapsulated transformer.
- Weight 132 lbs. with short arms.

SPOT WELDING GUN
S-2178/S-3238/S-3328 AIR OPERATED/WATER COOLED

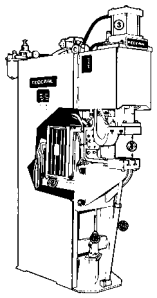
These guns provide the identical features found in ARO scissors guns in a “C” type configuration. Designed to provide compact, versatile units for joining sheet steel.

Features

- S-2178 rated at 15,500 amps secondary short circuit current.
- S-3238 rated at 18,000 amps secondary short circuit current.
- S-3328 rated at 25,000 amps secondary short circuit current.
- Ball-race type gyroscopic suspension allows easy rotation.
- Control by insulated plug-in handle (two possible positions).
- Trigger controlled retraction for extra electrode clearance to work stroke.
- Designed for single spot or automatic repeat with appropriate controls.
- Fully water cooled.
- Epoxy-resin encapsulated transformer.
- 50 foot cable length standard.


S-3238 pictured

PRESS TYPE WELDERS



KVA	Type	Projection Welder Data					Spot Welder Data					Cylinder Diameter (All 4" Stroke)	Maximum Weld Force (80 PSI)	Dimensions				Approximate Weight (Without Control)
		Throat Depth-Projection	Maximum Short Circuit Secondary Amps- Proj.	Platen Area	Platen Spacing (Shut Height)	T-Slot Centers	Throat Depth-Spot	Maximum Short Circuit Secondary Amps- Spot	Horn Diameter Upper	Horn Diameter Lower	Electrode Holder Diameter			Depth- (Spot)	Depth- (Projection)	Width	Height	
30	PA-1	12"	31,000	6" x 6"	6" to 12"	3.5"	18"	20,800	2.50"	2.50"	1.25"	6"	2,250 lbs.	53"	47"	16"	78"	1,700 lbs.
		18"	24,000				24"	17,500				6"	2,250 lbs.	59"	53"			1,800 lbs.
		24"	21,000				30"	15,300				5"	1,550 lbs.	65"	59"			1,900 lbs.
		30"	18,500				36"	14,200				5"	1,550 lbs.	71"	65"			2,000 lbs.
		36"	17,000				42"	13,100				5"	1,550 lbs.	77"	71"			2,100 lbs.
50	PA-1	12"	38,000	6" x 6"	6" to 12"	3.5"	18"	26,300	2.50"	2.50"	1.25"	6"	2,250 lbs.	53"	47"	16"	78"	1,800 lbs.
		18"	31,000				24"	21,900				6"	2,250 lbs.	59"	53"			1,900 lbs.
		24"	27,000				30"	19,700				5"	1,550 lbs.	65"	59"			2,000 lbs.
		30"	24,000				36"	18,600				5"	1,550 lbs.	71"	65"			2,100 lbs.
		36"	22,000				42"	17,500				5"	1,550 lbs.	77"	71"			2,200 lbs.
75	PA-1	12"	47,000	6" x 6"	6" to 12"	3.5"	18"	31,800	2.50"	2.50"	1.25"	6"	2,250 lbs.	53"	47"	16"	78"	1,900 lbs.
		18"	38,300				24"	27,500				6"	2,250 lbs.	59"	53"			2,000 lbs.
		24"	33,000				30"	24,600				5"	1,550 lbs.	65"	59"			2,100 lbs.
		30"	29,700				36"	22,400				5"	1,550 lbs.	71"	65"			2,200 lbs.
		36"	27,000				42"	20,700				5"	1,550 lbs.	77"	71"			2,300 lbs.
100	PA-1	12"	54,700	6" x 6"	6" to 12"	3.5"	18"	40,800	2.50"	2.50"	1.25"	6"	2,250 lbs.	53"	47"	16"	78"	2,000 lbs.
		18"	44,600				24"	35,300				6"	2,250 lbs.	59"	53"			2,100 lbs.
		24"	38,600				30"	31,500				5"	1,550 lbs.	65"	59"			2,200 lbs.
		30"	34,500				36"	28,800				5"	1,550 lbs.	71"	65"			2,300 lbs.
		36"	31,500				42"	26,700				5"	1,550 lbs.	77"	71"			2,400 lbs.
100	PA-2	12"	61,000	8" x 8"	6" to 12"	5"	18"	42,000	3.0"	3.0"	1.50"	8"	4,000 lbs.	53"	47"	16"	78"	2,700 lbs.
		18"	49,700				24"	36,400				8"	4,000 lbs.	59"	53"			2,800 lbs.
		24"	43,100				30"	32,500				8"	4,000 lbs.	65"	59"			2,900 lbs.
		30"	38,500				36"	29,700				6"	2,250 lbs.	71"	65"			3,000 lbs.
		36"	35,200				42"	27,500				6"	2,250 lbs.	77"	71"			3,100 lbs.
150	PA-2	12"	70,500	8" x 8"	6" to 12"	5"	18"	48,900	3.0"	3.0"	1.50"	8"	4,000 lbs.	53"	47"	16"	78"	2,800 lbs.
		18"	57,500				24"	42,300				8"	4,000 lbs.	59"	53"			2,900 lbs.
		24"	49,800				30"	37,800				8"	4,000 lbs.	65"	59"			3,000 lbs.
		30"	44,600				36"	34,600				6"	2,250 lbs.	71"	65"			3,100 lbs.
		36"	40,700				42"	32,000				6"	2,250 lbs.	77"	71"			3,200 lbs.
200	PA-2	12"	82,000	8" x 8"	6" to 12"	5"	18"	51,500	3.0"	3.0"	1.50"	8"	4,000 lbs.	53"	47"	16"	78"	2,900 lbs.
		18"	66,900				24"	44,600				8"	4,000 lbs.	59"	53"			3,000 lbs.
		24"	58,000				30"	39,800				8"	4,000 lbs.	65"	59"			3,100 lbs.
		30"	51,800				36"	36,400				6"	2,250 lbs.	71"	65"			3,200 lbs.
		36"	47,300				42"	33,700				6"	2,250 lbs.	77"	71"			3,300 lbs.
150	PA-3	12"	83,300	10" x 10"	6" to 12"	6"	18"	53,400	3.0"	3.0"	1.50"	12"	9,100 lbs	65"	58"	20"	81"	3,400 lbs.
		18"	67,900				24"	46,200				10"	6,300 lbs.	71"	64"			3,550 lbs.
		24"	58,900				30"	41,300				10"	6,300 lbs.	77"	70"			3,700 lbs.
		30"	52,600				36"	37,700				8"	4,000 lbs.	83"	76"			3,850 lbs.
		36"	48,000				42"	34,900				8"	4,000 lbs.	89"	82"			4,000 lbs.
200	PA-3	12"	86,000	10" x 10"	6" to 12"	6"	18"	54,000	3.0"	3.0"	1.50"	12"	9,100 lbs.	65"	58"	20"	81"	3,500 lbs.
		18"	80,000				24"	46,500				10"	6,300 lbs.	71"	64"			3,650 lbs.
		24"	61,000				30"	42,000				10"	6,300 lbs.	77"	70"			3,800 lbs.
		30"	54,500				36"	38,000				8"	4,000 lbs.	83"	76"			3,950 lbs.
		36"	49,000				42"	35,500				8"	4,000 lbs.	89"	82"			4,100 lbs.
250	PA-3	12"	95,000	10" x 10"	6" to 12"	6"	18"	60,000	3.0"	3.0"	1.50"	12"	9,100 lbs.	65"	58"	20"	81"	3,600 lbs.
		18"	77,000				24"	52,000				10"	6,300 lbs.	71"	64"			3,750 lbs.
		24"	67,000				30"	46,500				10"	6,300 lbs.	77"	70"			3,900 lbs.
		30"	60,000				36"	42,500				8"	4,000 lbs.	83"	76"			4,050 lbs.
		36"	55,000				42"	39,000				8"	4,000 lbs.	89"	82"			4,200 lbs.
300	PA-3	12"	107,000	10" x 10"	6" to 12"	6"	18"	65,500	3.0"	3.0"	1.50"	12"	9,100 lbs.	65"	58"	20"	81"	3,700 lbs.
		18"	87,500				24"	56,500				10"	6,300 lbs.	71"	64"			3,850 lbs.
		24"	75,600				30"	50,000				10"	6,300 lbs.	77"	70"			4,000 lbs.
		30"	68,000				36"	47,000				8"	4,000 lbs.	83"	76"			4,150 lbs.
		36"	61,800				42"	43,000				8"	4,000 lbs.	89"	82"			4,300 lbs.
300	PA-4	12"	109,000	12" x 12"	6" to 12"	6"	Not Available					14"	12,500 lbs.	Not Available	58"	20"	81"	5,900 lbs.
		18"	88,900									14"	12,500 lbs.		64"			6,200 lbs.
		24"	77,000									12"	9,100 lbs.		70"			6,500 lbs.
		30"	68,900									12"	9,100 lbs.		76"			6,800 lbs.
400	PA-4	12"	118,000	12" x 12"	6" to 12"	6"	Not Available					14"	12,500 lbs.		58"	20"	81"	6,200 lbs.
		18"	96,000									14"	12,500 lbs.		64"			6,500 lbs.
		24"	83,500									12"	9,100 lbs.		70"			6,800 lbs.
		30"	74,400									12"	9,100 lbs.		76"			7,100 lbs.
500	PA-4	12"	123,000	12" x 12"	6" to 12"	6"	Not Available					14"	12,500 lbs.		58"	20"	81"	6,500 lbs.
		18"	114,000									14"	12,500 lbs.		64"			6,800 lbs.
		24"	98,500									12"	9,100 lbs.		70"			7,100 lbs.
		30"	88,500									12"	9,100 lbs.		76"			7,400 lbs.

RA Type Spot Welder Specifications

RWMA Size	Type	Throat Depth	KVA	Maximum Weld Force at 80 PSI	Horn Diameter	Electrode Holder Diameter	Maximum Short Circuit Amperes	Cylinder Diameter	Cylinder Stroke	Maximum Tip Opening	Spacing Inside Horns	Width	Depth	Height	Weight Less Controls
2	RA-2	12'' 18'' 24'' 30'' 36''	30	2050 lbs. 1400 lbs. 1100 lbs. 900 lbs. 750 lbs.	2.50''	1.25''	20,800 16,800 14,900 13,100 12,100	4''	3''	1.50'' 2.12'' 2.75'' 3.37'' 4.00''	8'' - 14''	14''	50'' 56'' 62'' 68'' 74''	52''	920 lbs. 940 lbs. 960 lbs. 980 lbs. 1000 lbs.
3	RA-3	12'' 18'' 24'' 30'' 36''	50	3200 lbs. 2250 lbs. 1700 lbs. 1400 lbs. 1150 lbs.	2.50''	1.25''	27,400 22,100 19,600 17,300 15,700	5''	3''	1.50'' 2.12'' 2.75'' 3.37'' 4.00''	8'' - 14''	14''	50'' 56'' 62'' 68'' 74''	52''	960 lbs. 980 lbs. 1000 lbs. 1020 lbs. 1040 lbs.
3	RA-3	12'' 18'' 24'' 30'' 36''	75	3200 lbs. 2250 lbs. 1700 lbs. 1400 lbs. 1150 lbs.	2.50''	1.25''	31,900 25,900 23,000 20,200 18,400	5''	3''	1.50'' 2.12'' 2.75'' 3.37'' 4.00''	8'' - 14''	14''	50'' 56'' 62'' 68'' 74''	52''	1020 lbs. 1040 lbs. 1060 lbs. 1080 lbs. 1100 lbs.
N/A	RA-4	12'' 18'' 24'' 30'' 36''	100	4600 lbs. 3200 lbs. 2450 lbs. 2000 lbs. 1700 lbs.	3.00''	1.25''	36,500 29,700 26,300 23,200 21,100	6''	3''	1.50'' 2.12'' 2.75'' 3.37'' 4.00''	8'' - 14''	14''	50'' 56'' 62'' 68'' 74''	52''	1240 lbs. 1270 lbs. 1300 lbs. 1330 lbs. 1360 lbs.

Accessories available

Transformer configuration:
- 220 volts or 440 volts
- Series/Parallel switching
- Temperature sensors

Initiation options:
- Dual palm buttons
- Anti-tie down, anti-repeat
- Dual stage foot switch

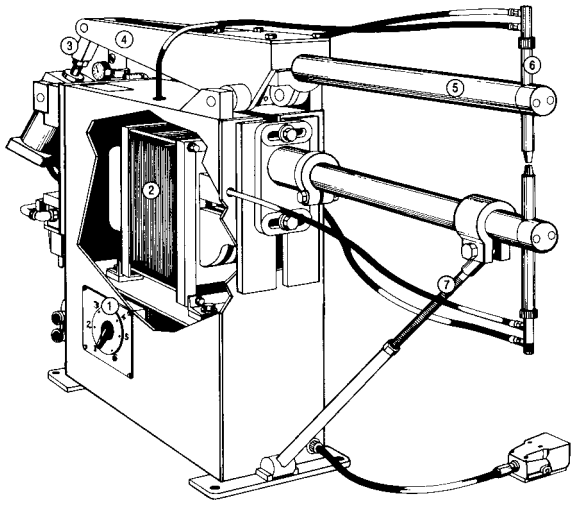
Pneumatic options:
- Tip dress
- Mufflers
- Pressure switch firing

Cylinder configurations:
- Adjustable/Retractable
- Bucking pressure
- Speed controls

Water:
- Automatic water economizer
- Closed systems with flow indicators
- Water chillers

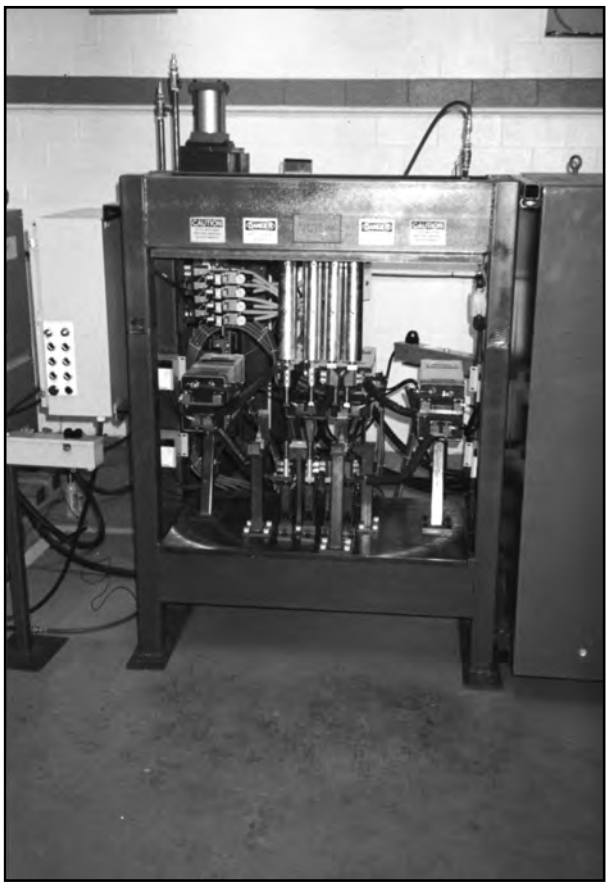
Miscellaneous:
- Universal horns
- Special length holders
- Special adjustment features

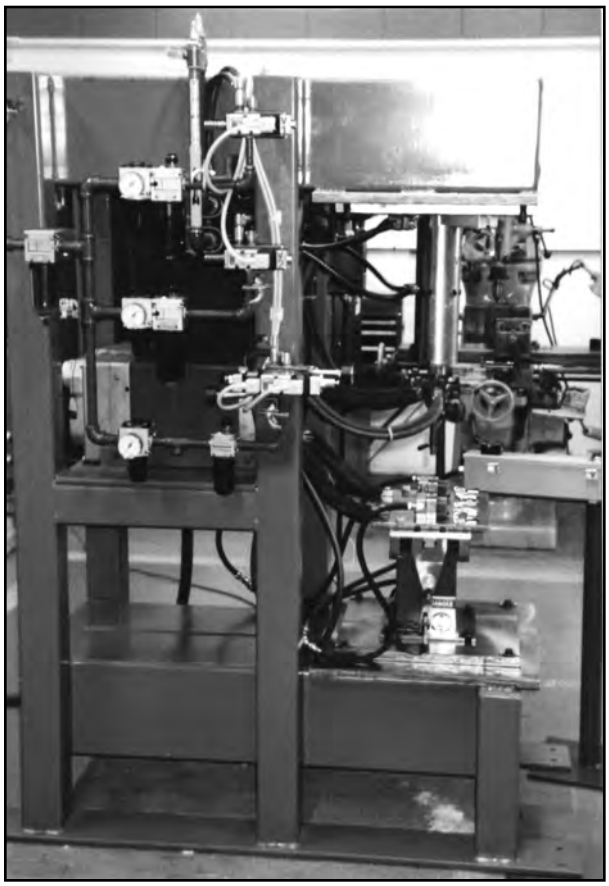
Typical rocker arm welder arrangement



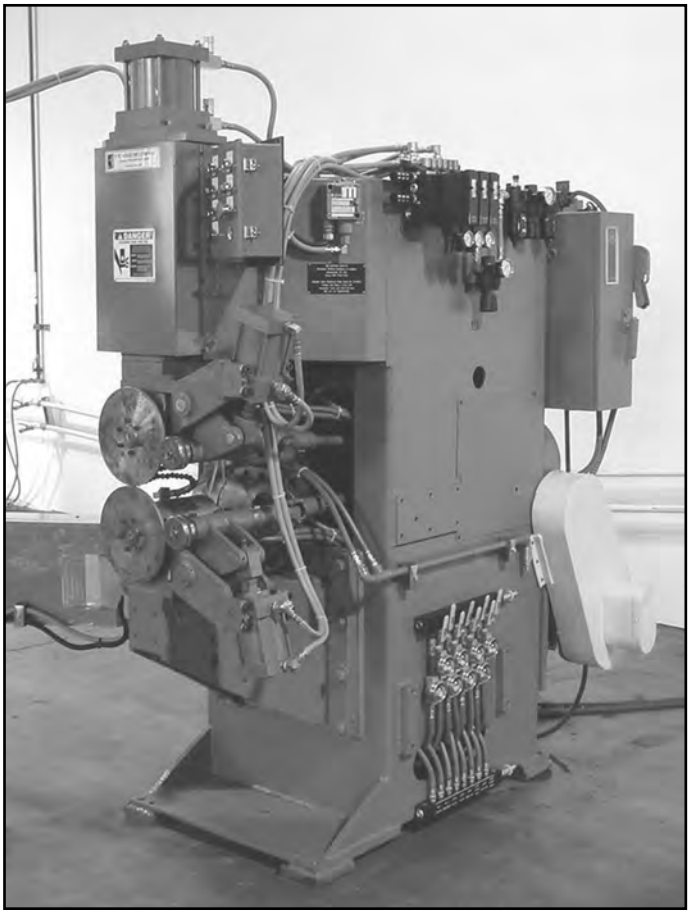
1. Tap Switch
2. Transformer
3. Cylinder
4. Rocker Arm
5. Horn
6. Tip Holder
7. Brace

SPECIAL MACHINES & TOOLING





WELD HEADS

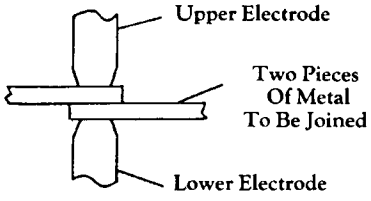


What is Resistance Welding? Resistance welding is one of many methods of fastening two or more pieces of metal together. Some of these methods are listed below in order to illustrate how resistance welding differs from the others.

1. Bolting
2. Riveting
3. Soldering
4. Arc Welding
5. Resistance Welding

Bolting, riveting, soldering and arc welding all require some additional material to be added to the metal being fastened together. Additionally, bolting and riveting require holes to be made into the metal for the rivets or bolts to fit. Resistance welding requires neither additional material nor holes in the metal.

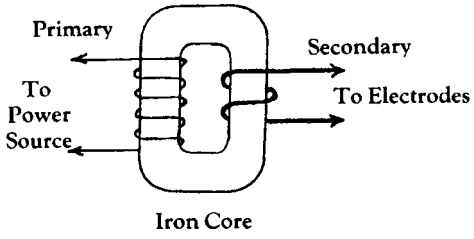
How is a resistance weld made? The two pieces of metal to be joined are squeezed together by the electrodes on the welding machine so they are in good electrical contact. Then electrical current is passed through them, heating them until they begin to melt at the spot where they are in contact. The molten metal from the two pieces flows together; then the current is turned off and the molten metal solidifies, forming a solid metallic connection between the two pieces. The term "Resistance Welding" comes from the fact that it is the electrical property of resistance of the metal being welded that causes heat to be generated when current flows through it.



What are the important factors in making a weld? Important to the proper formation of the molten area between the pieces of metal being welded is the magnitude of current, the length of time it flows, and the force squeezing the parts together. The optimum value of these parameters varies with the type of metal and its thickness. For commonly used low-carbon steel 1/16" thick, a typical value of current is 10,000 amps, for a time of 1/4 of a second, and 600 pounds electrode force. Resistance welding schedules are available through American Welding Society, Resistance Welder Manufacturers Association, and from most welding machine manufacturers.

How is adequate current obtained? A current of 10,000 amps is not readily available from any standard electrical outlet. Fifteen amps is the maximum current available from common household and office outlets. Even in factories where large amounts of electrical energy is used, 200 amps is typical of the current available from electrical distribution circuits. Therefore, to get the 10,000 amps needed for resistance welding, some device must be used to step the current up from the relatively low level available from the power line.

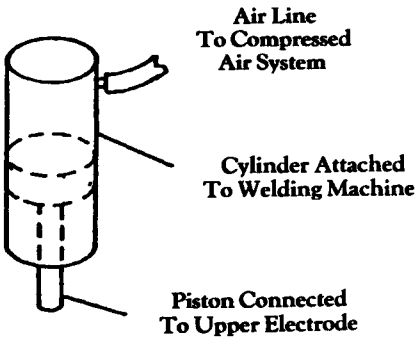
What devise is used? The devise generally used is a transformer. Transformers are usually thought of as stepping voltage up or down, but current can also be transformed in the same way. A transformer consists of two coils of wire, called the primary and secondary, wound around an iron core. Power is transferred from primary to secondary via the magnetic properties of the iron. The factor by which the current or voltage is stepped up or down is roughly equal to the ratio between the number of turns of wire in the coils forming the primary and secondary windings of the transformer. In the preceding example, where 10,000 amps was required, a transformer could be make with one hundred turns on the primary and two turns on the secondary; a "turn ratio" of fifty. A two hundred amp current in the primary would be transformed into two hundred times fifty, or 10,000 amps in the secondary, enough to do the welding job.



How is the time controlled? The length of time the welding current flows through the two pieces of metal to be welded is also important. Therefore, the device used to turn the current on and off is a critical part of the system. A relay or hand operated switch might be considered as a switching device, but either would be unsuitable because of the relatively slow speed of operation. In the preceding example the current must be on for only 1/4 of a second. It is very difficult to turn a switch on and off again in 1/4 of a second, and even more difficult to do it consistently. Therefore, some electronic device with no moving parts should be used. Two such devices are available. The ignitron tube, which has been used for many years, is one and the silicon controlled rectifier (SCR), a more recent

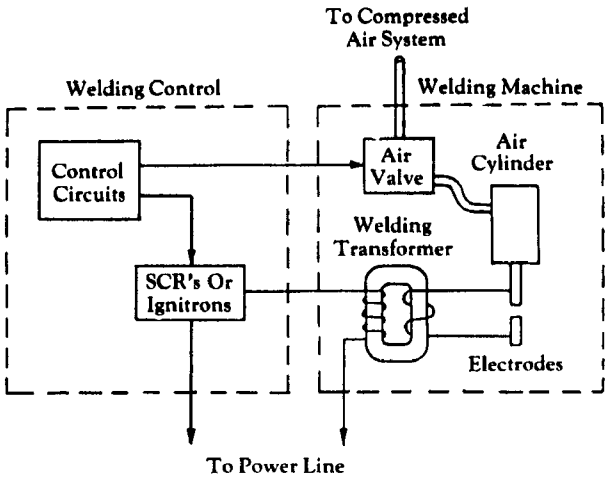
development, is another. Both operate by virtue of the fact that a small electrical signal applied to the device allows it to turn on in a small fraction of a second and conduct a large amount of current. Removing the electrical signal allows the device to turn off again. Fast turn-on and turn-off are possible because there are no mechanical moving parts. Ignitron tubes operate on the principle of ionization of mercury vapor, while silicon controlled rectifiers operate on solid-state semi-conductor principles similar to transistors.

How is the electrode force obtained? The third critical factor in resistance welding is the force squeezing the metal parts together (Electrode Force). This force is necessary to assure good electrical contact between the parts being welded, and to hold the parts steady until the molten metal forming the welded joint has time to solidify. Depending on the size and type of welding machine, various methods of developing the electrode force are used, but the most common is to use compressed air in a cylinder and piston arrangement. The cylinder is rigidly attached to the welding machine frame, and the moveable piston is connected to the upper electrode. Compressed air introduced into the cylinder develops a force on the piston which, in turn, pushes the electrode down against the metal being welded. The amount of force applied depends on the area of the piston and the pressure of the compressed air. In the preceding example where six hundred pounds of electrode force was required, a five inch diameter piston would require an air pressure of thirty pounds per square inch.



What is a resistance welding control? It may be concluded from the preceding paragraphs that it is important to apply the welding current at the proper time during the operation of the welding machine. This is the function of the welding control; in fact, the purpose of a welding control is to coordinate the application of welding current with the mechanical motion of the welding machine. More specifically, it tells the electrodes when to close and when to open, and it tells the welding current when to start and when to stop. The welding control may be thought of as the "brains" and the machine as the "muscle" of the overall resistance welding system.

How is a welding control connected to the welding machine? Since the welding control provides control of both welding current and machine motion, it must produce two control signals; one to turn the SCR's or ignitrons on and off (for current control) and one to turn an electrically operated air valve on and off (for machine control). The SCR's or ignitrons perform basically as a switching function and so are connected in series with the welding transformer in much the same way as any switch is connected in series with its load. Note also that they are connected in the primary rather than the secondary circuit of the transformer because the current requirements are lower in the primary.



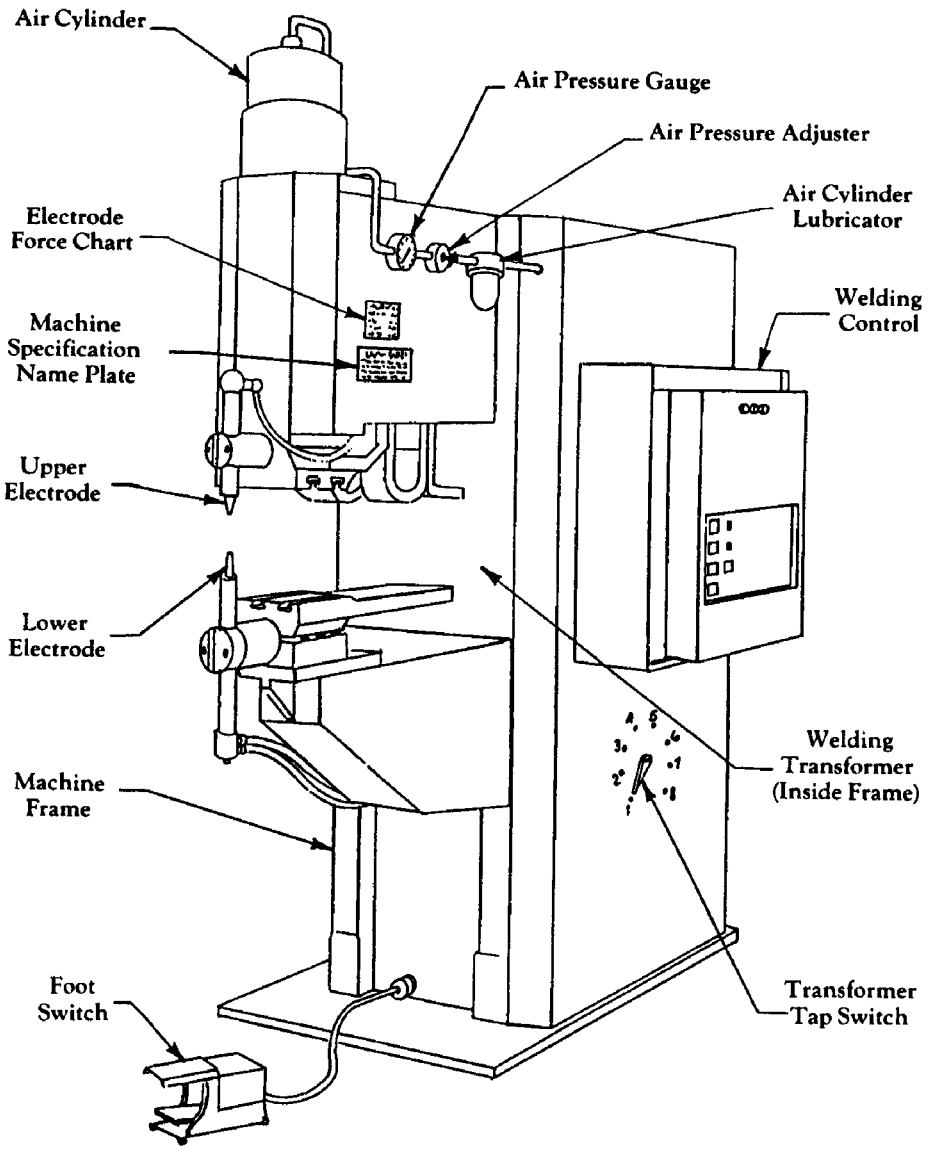

Air Cylinder
Air Pressure Gauge
Air Pressure Adjuster
Air Cylinder Lubricator
Electrode Force Chart
Welding Control
Machine Specification Name Plate
Upper Electrode
Lower Electrode
Welding Transformer (Inside Frame)
Machine Frame
Foot Switch
Transformer Tap Switch

Figure 1

Figure 2 explains with a line drawing a typical welding sequence. The "Welding Process Time" at the top describes the welding machine operating time intervals, while the "Control Timers" line at the bottom refers to the dial settings on the welding control. The following definitions may helpful in understanding this drawing:

Squeeze Time is the time interval between the initial application of the electrode force on the work and the first application of current. Note that this is the process definition. The control definition is the time interval between sequence initiation and beginning of weld current. Squeeze time is necessary to delay the weld current until the electrode force has built up to the desired level.

Weld Time is the time during which welding current is applied to the work in making a weld. It is measured in cycles of line voltage as are all timing functions. One cycle is 1/60 of a second in a 60 Hz power system.

Hold Time is the time during which the electrode force is maintained on the work after the last impulse of welding current ceases. Hold time is necessary to allow the weld nugget to solidify before releasing the welded parts.

Off Time is the time during which the electrodes are off the work. The term is only applicable where the weld cycle is repetitive (control set on "REPEAT").

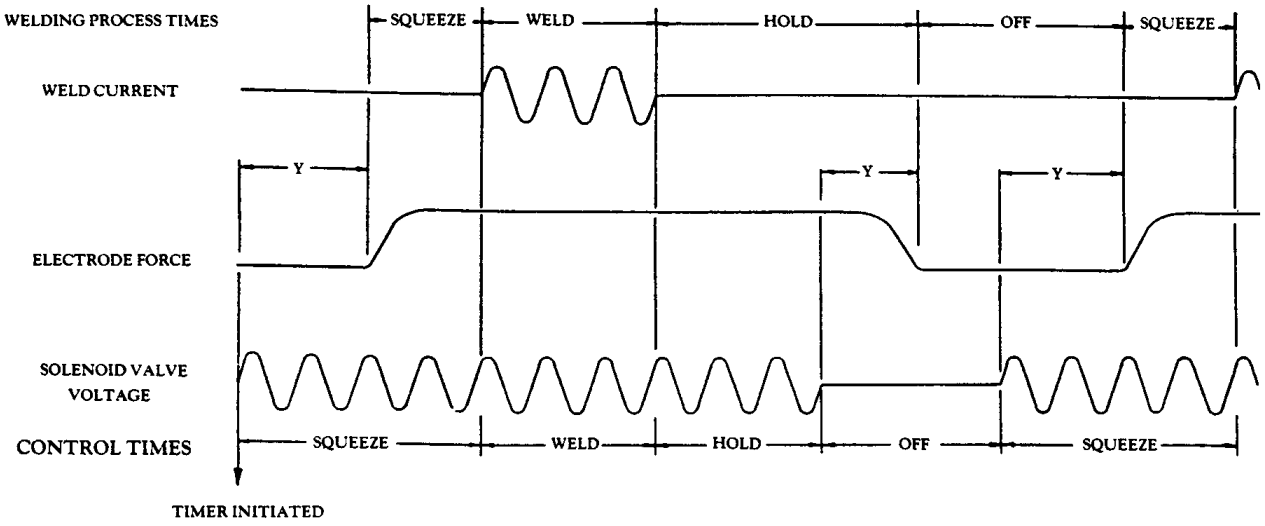
Weld Current is the current in the welding circuit during the making of a weld. The amount of weld current is controlled by two things; first, the setting of the transformer tap switch determines the maximum amount of weld current available; second, the percent of current control determines the percent of the available current to used for making the weld. Low percent current settings are not normally recommended. Adjust the tap switch so that proper welding current can be obtained with the percent current set between seventy and ninety percent. The only time the percent current should be set below seventy percent is when the tap switch is on its lowest setting and seventy percent current is still too high.

Electrode Force is the result of air pressure applied to the air piston connected directly to the head. The actual amount of electrode force depends on the effective air pressure, weight of the head, and the piston diameter. Most welders have electrode force charts on the side of the machine, tabulating air pressure versus electrode force. If there is not chart available for the machine, use the following formula:

Electrode Force = .78 x D^2 x P
D is the Piston Diameter in inches.
P is the air pressure in pounds per square inch.
Electrode Force is in pounds.

This does not allow for dead weights and friction. It may be necessary, when changing electrode force from one value to another greatly different value, to re-adjust the speed control valves. Too slow an approach wastes time and may require a much longer squeeze time. Too fast an approach impacts the electrodes and shortens their life, and may also damage the electrode holders or the head. When projection welding, high impact will damage the projection before welding and result in poor projection welds even when all other settings are correct.

The Solenoid Valve is an electrically operated air valve in the compressed air line connected to the air cylinder on the welding machine. When the welding control applies voltage to this valve it opens, allowing compressed air to enter the air cylinder to develop the electrode force.



TYPICAL RESISTANCE WELDING SEQUENCE

Y = Machine Operating Time

Figure 2

The table in Figure 3 is usually the best schedule to follow. If for some reason this schedule cannot be followed, contact your welding machine manufacturer or refer to R.W.M.A. or A.W.S. standards for resistance welding.

Column 1 — Column one specifies the thickness to be welded. Note that this value is the thinnest of two or more sheets to be welded together. This also means that if no marking is allowed, the flat electrode must be used against the thicker material. The controlled tip or electrode must be against the thinner material.

Column 2 — Column two gives the maximum size of the contact face (small "d"). Notice that the angle beyond the contact face is small (30ø). A small angle here will give longer electrode life, (lower rate of spreading out into too much contact area, called "mushrooming"). This dimension, (d) is very important. If it gets too large, weak welds will be made unless the weld current is turned higher and higher accordingly. Should this face, (d), be too small, electrode force and current would have to be lowered, resulting in a too-small spot. The diameter can be easily measured by measuring the diameter of the marking on the part.

Column 3 — Column three is the minimum recommended size of the electrode to carry the welding current without undue wear or rapid change of electrode contact area.

Column 4 — Column four is used where best appearance is desired. This shape of electrode must be turned on a lathe. Electrode life can be extended by the use of proper tip dressing tools.

Column 5 — Column five indicates the proper tapered holder to use to insure that the electrode force does not bury the electrode into the holder.

Column 6 — Column six specifies actual electrode force. Here the air gauge reading must be translated into electrode force. Refer to "electrode force" definition in the preceding section.

Column 7 — Column seven is the weld time. This is the length of time weld current flows and can be set exactly to these values on the weld time thumbwheel.

Column 8 — Column eight - "Hold Time", must not be set shorter than these values. To do so may result in cracked or damaged welds and bad surface discoloration. Longer hold times will not do harm except to take a little longer for the over-all weld sequence.

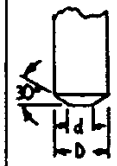
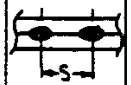
Column 9 — Column nine, welding current, is the last setting to make and check out. This setting, assuming all preceding adjustments are correct, will determine the size of the spot. Therefore, it is not necessary to know the actual current in amperes because you will arrive at or near these tabulated values if the spot is the correct size or strength. (See Columns 10 and 11). Check the electrode contact area from time to time and make the necessary changes in percent current as the electrodes wear. Re-dress electrodes as required.

Column 10 — Column ten specifies the minimum shear strength of a single spot weld using test strips at least as wide as specified in Column 13 (L).

Column 11 — Column eleven is the diameter of the fused zone. This can be checked two ways. One; peel the test strip and measure the nugget size. Two; place two test strips in "V" formation and spot weld at the bottom. Then twist the single spot in shear and measure the diameter of the fused zone.

Column 12 — Column twelve sets up the minimum spot spacing. This means that if a spot is placed any closer, there will be undue shunting of current into previously made spots. This in turn will result in smaller spot sizes beyond safe limits for the subsequent spots to be made. This is one of the reasons test strips should be made at the same spacing as would be made on the assembly.

Column 13 — Column thirteen specifies the minimum overlap of the parts for best quality welds. This must be followed for test welds, especially for shear tests.

1	2	3	4	5	6	7	8	9	10	11	12	13
	Electrode Diameters and Shape *											
Thickness of Thinest Outside Piece (Inches)	Flat Face  Maximum d (Inches)	Min. D (Inches)	Radius Face  Radius R (Inches)	Recommended Minimum Standard Electrode Size	Weld Force (Lbs.)	Weld Time (Cycles) (60 Cycles per Sec.)	Hold Time (Cylces) Min.	Welding Current (Amps.) (Approx.)	Weld Sheer Strenth (For Steels Having Ultimate Tensile Strengths of 90,000 PSI and below) Minimum Strength (Lbs./Weld)	Diameter of Fused Zone (Approx.)  DW (Inches)	Minimum Weld Spacing  S (Inches)	Minimum Contacting Overlap  L (Inches)
0.010	0.125	1/2	2	Morse Taper No. 1	160	4	5	4,000	130	0.113	1/4	3/8
0.021	0.187	1/2	2	Morse Taper No. 1	244	6	8	6,500	300	0.139	3/8	7/16
0.031	0.187	1/2	2	Morse Taper No. 1	326	8	10	8,000	530	0.161	1/2	7/16
0.040	0.250	5/8	3	Morse Taper No. 2	412	10	12	8,800	812	0.181	3/4	1/2
0.050	0.250	5/8	3	Morse Taper No. 2	554	14	16	9,600	1,195	0.210	7/8	9/16
0.062	0.250	5/8	3	Morse Taper No. 2	670	18	20	10,600	1,717	0.231	1	5/8
0.078	0.312	5/8	3	Morse Taper No. 2	903	25	30	11,800	2,365	0.268	1 1/8	11/16
0.094	0.312	5/8	4	Morse Taper No. 3	1,160	34	35	13,000	3,054	0.304	1 1/4	3/4
0.109	0.375	7/8	4	Morse Taper No. 3	1,440	45	40	14,200	3,672	0.338	1 5/16	13/16
0.125	0.375	7/8	4	Morse Taper No. 3	1,760	60	45	15,600	4,300	0.375	1 1/2	7/8
0.156	0.500	7/8	6	Male or Female Threaded	2,500	93	50	18,000	6,500	0.446	1 3/4	1
0.187	0.625	1	6	Male or Female Threaded	3,340	130	55	20,500	9,000	0.516	2	1 1/4
0.250	0.750	1 1/4	6	Male or Female Threaded	5,560	230	60	26,000	18,000	0.660	4	1 1/2

* Electrode Material - RWMA Class 2.

Figure 3

1. **Too short squeeze** time can result in metal expulsion, burned electrodes, bad welds, marked work, and damage ignitron tubes or SCRs.

2. **Too long a weld time** will shorten the life of the electrodes, cause excessive indentation and cause internal cracks which can result in weld failures.

3. **Weld quality**, you cannot judge weld quality by looking at the finished weld. If non-destructive testing is used, test strips of the same material and combination must be used.

4. **Too short weld time** will result in low weld strength, assuming all other factors are normal.

5. **Too short hold time** can result in surface expulsion, electrodes sticking, internal cracks in weld nuggets, and sometimes even cracks in parent metal. Follow the tables provided for minimum time.

6. **Weld pressure too low** can result in expulsion of metal, electrode damage (sticking), short electrode life, internal cracks in weld nugget, and sometimes excessive indentation.

7. **Weld pressure too high** can result in low or variable weld strength, excessive weld current requirements, mushrooming of electrodes, and excessive indentation.

8. **With all other settings** correct, adjust weld current to meet weld quality standards.

9. **Electrode contact face too small** will result in too small a spot, excessive electrode mushrooming, and excessive indentation. Too large an electrode contact area will result in too large a weld (assuming current is set accordingly), and internal cracks.

10. **Electrode misalignment** or miss-matched will result in expulsion and displaced weld nugget and accelerated electrode wear.

11. **Insufficient cooling** will result in mushroomed and short life electrodes, cracks on the surface, and excessive indentation in some cases. It is very important that the water flows in through the water quill and back out the outside of the quill. Also, the water quill must be bottomed gently against the inside of the electrode cavity every time an electrode is replaced.

12. **Dirty material** - Dirt sticking on the surface of the electrode will shorten electrode life and mark and burn the work surface.

13. **Excessive electrode approach speed** will accelerate electrode wear and damage the equipment. On projection welding, it can damage the projection, resulting in poor weld quality.

14. **Do not make a weld over the same spot twice** to try to cover up for a bad weld. To do so effectively, the work must cool and then be hit with a much higher current. If you cannot get a weld with one hit, either the set-up of the machine is incorrect or you are not using a machine of sufficient size to make the weld.

DO'S

1. Use the proper electrode material for the job you are doing.
2. Use Standard Electrodes whenever possible.
3. Use the most suitable tip diameter for the thickness of stock being welded.
4. Use open sight drains to observe more readily the water flow through the holders.
5. Connect the water inlet hose to the proper holder inlet so that the water flows through the center cooling tube first.
6. Internally cool the spot welding tips with cool water flowing at a rate of at least 1½ gallons per minute through each tip.
7. Be sure the internal water cooling tube of the holder projects into the tip water hole to within 1/4" of the tip hole bottom.
8. Adjust the internal water cooling tube of the holder to the proper height when changing to a different length tip.
9. Be sure the top of adjustable water cooling tube in the holder is cut at an angle so as to avoid jamming tip down and shutting water off.
10. Place a thin film of cup grease on the tip taper prior to inserting it in the holder, to make it easier to remove.
11. Use ejector type holders for easy removal of tips and to avoid damage to tip walls.
12. Keep the tip taper and holder clean, smooth and free of foreign deposits.
13. Dress spot welding electrodes frequently enough to maintain the quality of the welds.
14. Dress electrodes in a lathe to their original contour whenever possible.
15. Use a rawhide or rubber mallet for striking holder or tips in aligning operations.
16. Provide flood cooling on both sides of the seam welding wheel.
17. Use properly designed knurling wheels to maintain proper seam welding wheel shape.

DON'TS

1. Never use unidentified electrodes or electrode materials.
2. Avoid special, offset or irregular tips when the job can be done with a standard straight tip.
3. Do not use small tips on heavy gauge welding jobs or large tips on small work.
4. Do not forget to turn on the cooling water full force before starting to weld.
5. Never use a water hose that will not fit the holder water connection nipples snugly.
6. Do not allow water connections to become leaky, clogged or broken.
7. Avoid using holders with leaking or deformed tapers.
8. Never use electrode holders that do not have an adjustable internal water cooling tube.
9. Do not permit adjustable water tube to be "frozen" by accumulation of deposits. A few drops of oil periodically will keep the tube free.
10. Do not allow electrodes to remain idle in tapered holder seats for extended periods.
11. Do not use pipe wrenches or similar tools in removing electrodes.
12. Avoid using white lead or similar compounds to seal a leaking taper.
13. Never permit a spot welding tip to mushroom enough to make dressing difficult.
14. Never dress electrode with a coarse file.
15. Do not pound on the holder or tip with a steel hammer in aligning the welder arms.
16. Avoid the use of seam welder wheels too thin to stand the heat of pressure of your job.
17. Do not permit seam welding wheels to run off the corners of the work being welded.

ROD & BAR STOCK

SIZE (Diameter or thickness)		Tolerance Round Rods Diameter	Tolerance Over Flats Hexagonal	TOLERANCE ON RECTANGLES								
				Up to 1/2" Wide		1/2" to 1" Wide		1" to 2" Wide		2" to 4" Wide		
				Width	Thickness	Width	Thickness	Width	Thickness	Width	Thickness	
CLASS I CLASS II	Up to 5/8", incl.	± .002	± .004	± .005	± .005	± .007	± .005	_____	_____	_____	_____	
	5/8" to 1", incl.	± .003	± .005	_____	_____	± .007	± .006	± .009	± .007	± 0.50%	± .008	
	1" to 2-1/2", incl.	± .004	± .006	_____	_____	_____	_____	± .009	± .007	± 0.50%	± .009	
	2-1/2" to 3-1/8", incl.	± .006	± .012	_____	_____	_____	_____	_____	_____	± 0.50%	± 0.50%	

CLASS III and IV — Add ± .001 to above up to .015, all ± .002 for tolerance over .015.

CASTINGS

	SIZE OF CASTING	TOLERANCE AS CAST	ALLOWANCE FOR FINISH
CLASS II	Plate patterns - all weights	± 1/32" on all dimensions	1/16" to 1/8"
CLASS III	Loose paterns - up to 50#	± 1/16" on all dimensions	1/8" to 3/16"
CLASS IV	- 50 to 100#	± 3/32" on all dimensions	3/16" to 1/4" (50 to 500#)
CLASS V	- 100 and over	± 1/8" on all dimensions	5/16" to 3/8" (over 500#)

Recommended Minimum Amount of Material to Be Over Tube When Tube is Cast Intergrally In Castings:

0 to 25 lb. Castings	1/4"
25 to 100 lb. Castings	3/8"
100 lbs. and over Casting	1/2"

RINGS & DISCS

DIAMETER	ALLOWANCE		
	O.D.	I.D.	THICK
0" Incl. 12"	1/2 ± 1/8	1/2 ± 1/8	1/4 ± 1/16
12" Incl. 20"	3/4 ± 1/8	5/8 ± 1/4	5/16 ± 1/8
20" Incl. 30"	7/8 ± 1/4	3/4 ± 1/4	1/2 ± 3/16
30" Incl. 36"	1-1/4 ± 1/4	1-1/4 ± 1/4	3/4 ± 1/4
Over 36"	1-1/2 ± 3/8	1-1/2 ± 3/8	1 ± 1/4

FINISH TOLERANCE		
O.D. ± 1/64		
I.D. Up to 6"	-.000	+.002
6" to 10"	-.000	+.003
10" Up	-.000	+.004
THICKNESS	± .010	

FORGINGS

ROUND BARS — ALLOWANCE ON DIAMETER

FINISH DIA.	LENGTH Incl. 48"	LENGTH Incl. 60"	LENGTH Over 60"
Incl. 3"	3/8 ± 1/8	1/2 ± 1/8	5/8 ± 1/8
Over 3"	1/2 ± 1/8	5/8 ± 1/8	3/4 ± 1/8

AVERAGE ALLOWANCE ON LENGTH

LENGTH	ALLOW.
Up to 6" Incl.	1/2"
Over 6" to 12" Incl.	1"
Over 12" to 18" Incl.	1-1/2"
Over 18" to 30" Incl.	2"
Over 30"	2-1/4"

RECTANGULAR BARS

ALLOWNCE ON THICKNESS

FINISH THICKNESS	INCL. 4" WIDE	OVER 4" WIDE
Inc. 1-1/2"	1/4 ± 1/8	3/8 ± 1/8
Over 1-1/2"	3/8 ± 1/8	3/8 ± 1/8

WIDTH	ALLOWANCE ON WIDTH
Incl. 1-1/2"	1/4 ± 1/8
Over 1-1/2"	3/8 ± 1/8

LENGTH - ALLOWNACE SAME AS ROUND BARS

	FINISH TOLERANCE ON DIA. WIDTH OR THICKNESS	
	Up to 12" long	± .005
	Over 12" long	± .010

The above tolerance and finish allowances are general.
Specific parts will vary according to nature of part.

COPPER BASE ALLOYS	CLASS 1	CLASS 2	CLASS 3	CLASS 1	CLASS 2	CLASS 3	CLASS 1	CLASS 2	CLASS 3	CLASS 1	CLASS 2	CLASS 3	CLASS 1	CLASS 2	CLASS 3
ROD DIAMETER	ROUND ROD STOCK														
Up to 1" Dia.	17,500	35,000	50,000	$65^{R}b$	$75^{R}b$	$90^{R}b$	80%	75%	45%	60,000	65,000	100,000	13%	13%	9%
Over 1" to 2" Dia.	15,000	30,000	50,000	$60^{R}b$	$70^{R}b$	$90^{R}b$	80%	75%	45%	55,000	59,000	100,000	14%	13%	9%
Over 2" to 3"	15,000	25,000	50,000	$55^{R}b$	$65^{R}b$	$90^{R}b$	80%	75%	45%	50,000	55,000	95,000	15%	13%	9%
THICKNESS	SQUARE, RECTANGULAR AND HEXAGONAL BAR STOCK														
Up to 1"	20,000	35,000	50,000	$55^{R}b$	$70^{R}b$	$90^{R}b$	80%	75%	45%	60,000	65,000	100,000	13%	13%	9%
Over 1"	15,000	25,000	50,000	$50^{R}b$	$65^{R}b$	$90^{R}b$	80%	75%	45%	50,000	55,000	100,000	14%	13%	9%
THICKNESS	FORGINGS														
Up to 1"	20,000	22,000*	50,000	$55^{R}b$	$65^{R}b$	$90^{R}b$	80%	75%	45%	45,000	55,000	94,000	12%	13%	9%
Over 1" to 2"	15,000	21,000*	50,000	$50^{R}b$	$65^{R}b$	$90^{R}b$	80%	75%	45%	40,000	55,000	94,000	13%	13%	9%
Over 2"	15,000	20,000*	50,000	$50^{R}b$	$65^{R}b$	$90^{R}b$	80%	75%	45%	40,000	55,000	94,000	13%	13%	9%
	CASTINGS														
ALL		20,000	45,000		$55^{R}b$	$90^{R}b$		70%	45%		45,000	85,000		12%	5%

GROUP A COPPERBASE ALLOYS		PROPORTIONAL LIMIT TENSION P.S.I.	HARDNESS ROCKWELL	CONDUCTIVITY % I.A.C.S.	ULTIMATE TENSILE STRENGTH P.S.I.	ELONGATION % IN 2" OR 4 DIAMETERS
CLASS 4	Alloys					
	Cast	60,000	$33^{R}C$	18%(Average)	90,000	0.5%
	Wrought	85,000	$33^{R}C$	20%(Average)	140,000	0.5%
CLASS 5	Alloys					
	Cast	12,000 to 16,000	$65^{R}b$ to $85^{R}b$	10% to 15%	65,000 to 75,000	10% to 2%
GROUP B REFRACTORY METALS					Ultimate Compression Strength PSI	
CLASS 10—	Rods, Bars and Inserts		$72^{R}b$	35%	135,000	
CLASS 11—	Rods, Bars and Inserts		$94^{R}b$	28%	160,000	
CLASS 12—	Rods, Bars and Inserts		$98^{R}b$	27%	170,000	
CLASS 13—	Rods, Bars and Inserts		$69^{R}a$	30%	200,000	
CLASS 14—	Rods, Bars and Inserts		$85^{R}b$	30%	——	

*Hot-Worked and Heat Treated – t Cold Worked

GCAP® ELECTRODE WELD SCHEDULE FOR GALVANIZED STEEL

Metal Thickness	.020	.030	.035	.040	.050	.060	.078	.093	.125
GCAP	244	254	254	254	255	255	266	266	266
Pressure	300	400	500	650	750	800	1000	1200	1400
Squeeze cycle	25	25	25	25	30	30	30	35	35
Up-Slope cycle					4	4	4	4	5
Upslope Kiloamps					2.0 to S.C.*	2.0 to S.C.*	2.0 to S.C.*	2.0 to S.C.*	2.0 to S.C.*
Weld cycle	6	8	9	10	7	8	10	12	10
Kiloamps	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.5	13.5
Cool cycle					1	1	1	1	1
Weld cycle					7	8	10	12	10
Kiloamps					10.5	11.0	11.5	12.5	13.5
Cool cycle									1
Weld cycle									10
Kiloamps									13.5
Hold cycle	3	4	4	5	5	10	10	15	20

* S.C. – Starting Weld Current

GCAP® LINEAR STEPPER

Total Weld Count	500	1,000	3,000	5,000	7,500	10,000	12,000
Total Amps Boost	600	1000	3000	5000	6800	8400	9200
Amps Boost Per Weld	1.20		.88			.60	

The above schedules and stepper is only meant to be a guide and will require adjustments to fit the application.

SPOT WELDING DATA

OPTIMUM CONDITIONS

SCHEDULES FOR SPOT WELDING LOW CARBON STEEL—SAE 1010

Thickness of Thinnest Outside Piece (Inches)	Electrode Diameters and Shape* Flat Face Maximum d (Inches)	Flat Face Min. D (Inches)	Radius Face Radius R (Inches)	Recommended Minimum Standard Electrode Size	Weld Force (Lbs.)	Weld Time (Cycles) (60 Cycles per Sec.)	Hold Time (Cycles) Min.	Welding Current (Amps.) (Approx.)	Weld Shear Strength (For Steels Having Ultimate Tensile Strength of 90,000 psi and below) Minimum Strength (Lbs/Weld)	Diameter of Fused Zone (Approx.) Dw (Inches)	Minimum Weld Spacing S (Inches)	Minimum Contacting Overlap L (Inches)
0.010	0.125	½	2	4RW 1MT	160	4	5	4,000	130	0.113	¼	⅜
0.021	0.187	½	2	4RW 1MT	244	6	8	6,500	300	0.139	⅜	7/16
0.031	0.187	½	2	4RW 1MT	326	8	10	8,000	530	0.161	½	7/16
0.040	0.250	⅝	3	5RW 2MT	412	10	12	8,800	812	0.181	¾	½
0.050	0.250	⅝	3	5RW 2MT	554	14	16	9,600	1,195	0.210	⅞	9/16
0.062	0.250	⅝	3	5RW 2MT	670	18	20	10,600	1,717	0.231	1	⅝
0.078	0.312	⅝	3	5RW 2MT	903	25	30	11,800	2,365	0.268	1⅛	11/16
0.094	0.312	⅝	4	7RW 3MT	1,160	34	35	13,000	3,054	0.304	1¼	¾
0.109	0.375	⅞	4	7RW 3MT	1,440	45	40	14,200	3,672	0.338	1 5/16	13/16
0.125	0.375	⅞	4	7RW 3MT	1,760	60	45	15,600	4,300	0.375	1½	⅞
0.156	0.500	⅛	6	Male or Female Threaded	2,500	93	50	18,000	6,500	0.446	1¾	1
0.187	0.625	1	6	Male or Female Threaded	3,340	130	55	20,500	9,000	0.516	2	1½
0.250	0.750	1¼	6	Male or Female Threaded	5,560	230	60	26,000	18,000	0.660	4	1½

PERMISSIBLE SCHEDULE VARIATIONS FOR SPOT WELDING LOW CARBON STEEL

Low Carbon Steel Spot Welding Data Chart—Single Impulse Welding

DATA COMMON TO ALL CLASSES OF SPOT WELDS					WELDING SET-UP FOR BEST QUALITY—CLASS A WELDS					WELDING SET-UP FOR MEDIUM QUALITY—CLASS B WELDS					WELDING SET-UP FOR GOOD QUALITY—CLASS C WELDS				
Thickness of Each of the Two Work Pieces Inches	Electrode Diam. & Shape Min. D Inches	Max. d Inches	Min. Weld Spacing (Note 4) Inches	Min. Contacting Overlap (Note 6) Inches	Weld Time (Note 7) Cycles	Electrode Force Pounds	Welding Current Amps.	Diam. of Fused Zone Inches	Average Tensile Shear Strength ±14% Pounds	Weld Time (Note 7) Cycles	Electrode Force Pounds	Welding Current Amps.	Diam. of Fused Zone Inches	Average Tensile Shear Strength ±17% Pounds	Weld Time (Note 7) Cycles	Electrode Force Pounds	Welding Current Amps.	Diam. of Fused Zone Inches	Average Tensile Shear Strength ±20% Pounds
.010	½	⅛	¼	⅜	4	200	4000	.13	235	5	130	3700	.12	200	15	65	3000	.11	160
.021	½	3/16	⅜	7/16	6	300	6100	.17	530	10	200	5100	.16	460	22	100	3800	.14	390
.031	½	3/16	½	7/16	8	400	8000	.21	980	15	275	6300	.20	850	29	135	4700	.18	790
.040	⅝	¼	¾	½	10	500	9200	.23	1305	21	360	7500	.22	1230	38	180	5600	.21	1180
.050	⅝	¼	⅞	9/16	12	650	10300	.25	1820	24	410	8000	.23	1700	42	205	6100	.22	1600
.062	⅝	¼	1	⅝	14	800	11600	.27	2350	29	500	9000	.26	2150	48	250	6800	.25	2050
.078	⅝	5/16	1⅛	11/16	21	1100	13300	.31	3225	36	650	10400	.30	3025	58	325	7900	.28	2900
.094	⅝	5/16	1¼	¾	25	1300	14700	.34	4100	44	790	11400	.33	3900	66	390	8800	.31	3750
.109	⅞	⅜	1 5/16	13/16	29	1600	16100	.37	5300	50	960	12200	.36	5050	72	480	9500	.35	4850
.125	⅞	⅜	1½	⅞	30	1800	17500	.40	6900	60	1140	12900	.39	6500	78	570	10000	.37	6150

NOTES:

1. Low Carbon Steel as hot rolled, pickled, and slightly oiled with an ultimate strength of 42,000 to 45,000 PSI Similar to SAE 1005—SAE 1010.
2. Electrode Material is Class II.
3. Surface of steel is lightly oiled but free from grease, scale or dirt.
4. Minimum weld spacing is that distance for which no increase in welding current is necessary to compensate for the shunted current effect in adjacent welds.
5. Radius Face electrodes may be used:
   0.010 to 0.031 — 2" Radius
   0.031 to 0.078 — 3" Radius
   0.078 to 0.125 — 4" Radius
6. 
7. Weld time is indicated in cycles of 60 cycle frequency.
8. Tensile shear strength values are based on recommended test sample sizes:

Direction of Force	Thickness	Width	Length
	.000" to .029"	⅛"	3"
	.030" to .058"	1"	4"
	.059" to .115"	1½"	5"
	.116" to .190"	2"	6"

9. Tolerance for machining of electrode diameter "d" is ±.015" of specified dimension.
10. Electrode force does not provide for force to press ill-fitting parts together.

PROJECTION WELDING DATA

DESIGN AND WELDING DATA FOR PROJECTION WELDING LOW CARBON STEELS

Thickness of Thinnest Outside Piece Inches	PROJECTION DESIGN: Base Diameter of Projection Dp Inches	PROJECTION DESIGN: Height of Projection H Inches	ELECTRODE DIAMETERS (d=2 x Projection Diameter): Minimum d Inches	ELECTRODE DIAMETERS (d=2 x Projection Diameter): Minimum D Inches	Electrode Force Pounds	Weld Time (Cycles) 60 Cycles per Sec.	Hold Time (Cycles) Minimum	Welding Current Amperes (Approx.)	Diameter of Fused Zone Dw Inches	Minimum Shear Strength (Single Projection Only) (For Steels Having Strength of 100,000 psi and below) Pounds	Minimum Contacting Overlap L Inches
0.010	0.055	0.015	0.125	½	50	3	3	2,800	0.112	150	⅛
0.012	0.055	0.015	0.125	½	80	3	3	3,100	0.112	200	⅛
0.014	0.055	0.015	0.125	½	100	3	3	3,400	0.112	250	⅛
0.016	0.067	0.017	0.187	½	115	4	4	3,600	0.112	285	5/32
0.021	0.067	0.017	0.187	½	150	6	6	4,000	0.140	380	5/32
0.025	0.081	0.020	0.187	½	200	6	8	4,500	0.140	525	3/16
0.031	0.094	0.022	0.187	½	300	8	8	5,100	0.169	740	7/32
0.034	0.094	0.022	0.187	½	350	10	10	5,400	0.169	900	7/32
0.044	0.119	0.028	0.250	⅝	480	13	14	6,500	0.169	1,080	9/32
0.050	0.119	0.028	0.250	⅝	580	16	16	7,100	0.225	1,500	9/32
0.062	0.156	0.035	0.312	⅞	750	21	20	8,400	0.225	2,100	⅜
0.070	0.156	0.035	0.312	⅞	900	24	24	9,200	0.281	2,550	⅜
0.078	0.187	0.041	0.375	⅞	1,050	26	30	10,500	0.281	2,950	7/16
0.094	0.218	0.048	0.500	⅞	1,300	32	30	11,800	0.281	3,700	½
0.109	0.250	0.054	0.500	⅞	1,650	38	36	13,300	0.338	4,500	⅝
0.125	0.281	0.060	0.500	⅞	1,800	45	40	15,000	0.338	5,200	11/16
0.140	0.312	0.066	0.625	1	2,300	60	45	15,700	0.437	6,000	¾
0.156	0.343	0.072	0.625	1	2,800	80	50	17,250	0.500	7,500	13/16
0.171	0.375	0.078	0.750	1	3,300	105	50	18,600	0.562	8,500	⅞
0.187	0.406	0.085	0.750	1	3,800	125	50	20,000	0.562	10,000	15/16
0.203	0.437	0.091	0.875	1¼	4,500	145	55	21,500	0.625	12,000	1
0.250	0.531	0.110	1.000	1¼	6,600	230	60	26,000	0.687	15,000	1¼

NOTES:

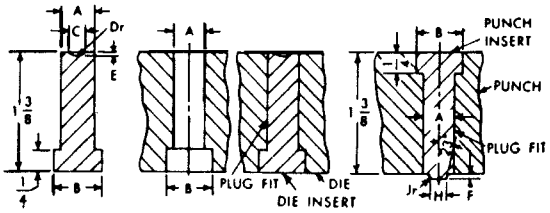
1. Type of Steel—Low Carbon SAE 1010—0.15% Carbon Maximum.
2. Material free of scale, oxide, paint, dirt, etc.
3. Size of projection determined by thickness of thinnest piece and projection should be on thickest piece.
4. Data is based on thickness of thinnest sheet for two thicknesses only. Maximum ratio between two thicknesses = 3 to 1.
5. See TABLE BELOW for design of punch and die for making projections.
6. Contacting overlap does not include any radii from forming.
7. Projection should be located in center of overlap.
8. Tolerance for Projection Dimensions:

Dimension	Thickness Up to 0.050"	Thickness Over 0.050"
Diameter "D"	±0.003"	±0.007"
Height "H"	±0.002"	±0.005"

9. Electrode Material:
   Class III ELKONITE®TC-10 ELKONITE®10W3

From American Welding Society "Recommended Practices for Resistance Welding"

PUNCH AND DIE DESIGN FOR FORMING WELDING PROJECTIONS



Mat Thickness	Pt. No.	A	B	±002 C	Dr	±001 E	±001 F	±001 H	Jr
0.010-0.015	1	⅜	9/16	.055	.033	.015	.015	.035	.005
0.016-0.021	2	⅜	9/16	.067	.042	.017	.020	.039	.005
.025	3	⅜	9/16	.081	.050	.020	.025	.044	.005
.031	4	⅜	9/16	.094	.062	.022	.030	.050	.005
.034	5	⅜	9/16	.094	.062	.022	.030	.050	.005
.044	6	⅜	9/16	.119	.078	.028	.035	.062	.005
.050	7	⅜	9/16	.119	.078	.028	.035	.062	.005
.062	8	⅜	9/16	.156	.105	.035	.043	.081	.005
.070	9	⅜	9/16	.156	.105	.035	.043	.081	.005
.078	10	⅜	9/16	.187	.128	.041	.055	.104	.010

Mat Thickness	Pt. No.	A	B	±002 C	Dr	±001 E	±001 F	±001 H	Jr
.094	11	½	11/16	.218	.148	.048	.065	.115	.010
.109	12	½	11/16	.250	.172	.054	.075	.137	1/64
.125	13	½	11/16	.281	.193	.060	.085	.154	1/64
.140	14	½	11/16	.312	.217	.066	.096	.172	1/64
.156	15	⅝	13/16	.343	.243	.072	.107	.191	1/64
.171	16	⅝	13/16	.375	.265	.078	.118	.210	1/64
.187	17	⅝	13/16	.406	.285	.085	.130	.229	1/64
.203	18	11/16	⅞	.437	.308	.091	.143	.240	.020
.250	19	13/16	1	.531	.375	.110	.175	.285	.025

Material: Tool Steel. Finish all over and harden to 65-68 Rockwell "C" scale.

Note: All working surfaces of die unit must be polished.

From American Welding Society "Recommended Practices for Resistance Welding"

SCHEDULE FOR SPOT WELDING STAINLESS STEEL

THICKNESS "T" of THINNEST OUTSIDE PIECE (See Notes 1, 2, 3 and 4 Below)	ELECTRODE DIAMETER AND SHAPE (See Note 5)		ELECTRODE FORCE	WELD TIME	WELDING CURRENT (Approx.) AMPS		MINIMUM CONTACTING OVERLAP	MINIMUM WELD SPACING (See Note 6 Below)	DIAMETER OF FUSED ZONE	MINIMUM SHEAR STRENGTH LB.		
										Ultimate Tensile Strength of Metal		
	D, IN., Min.	d, IN., Max.	LB.	CYCLES (60 Per Sec.)	Tensile Strength Below 150000 Psi	Tensile Strength 150000 Psi and Higher	IN.	IN.	IN. Approx.	70000 Up to 90000 Psi	90000 Up to 150000 Psi	150000 Psi and Higher
0.006	3/16	3/32	180	2	2000	2000	3/16	3/16	0.045	60	70	85
0.008	3/16	3/32	200	3	2000	2000	3/16	3/16	0.055	100	130	145
0.010	3/16	1/8	230	3	2000	2000	3/16	3/16	0.065	150	170	210
0.012	1/4	1/8	260	3	2100	2000	1/4	1/4	0.076	185	210	250
0.014	1/4	1/8	300	4	2500	2200	1/4	1/4	0.082	240	250	320
0.016	1/4	1/8	330	4	3000	2500	1/4	5/16	0.088	280	300	380
0.018	1/4	1/8	380	4	3500	2800	1/4	5/16	0.093	320	360	470
0.021	1/4	5/32	400	4	4000	3200	5/16	5/16	0.100	370	470	500
0.025	3/8	5/32	520	5	5000	4100	3/8	7/16	0.120	500	600	680
0.031	3/8	3/16	650	5	6000	4800	3/8	1/2	0.130	680	800	930
0.034	3/8	3/16	750	6	7000	5500	7/16	9/16	0.150	800	920	1100
0.040	3/8	3/16	900	6	7800	6300	7/16	5/8	0.160	1000	1270	1400
0.044	3/8	3/16	1000	8	8700	7000	7/16	11/16	0.180	1200	1450	1700
0.050	1/2	1/4	1200	8	9500	7500	1/2	3/4	0.190	1450	1700	2000
0.056	1/2	1/4	1350	10	10300	8300	9/16	7/8	0.210	1700	2000	2450
0.062	1/2	1/4	1500	10	11000	9000	5/8	1	0.220	1950	2400	2900
0.070	5/8	1/4	1700	12	12300	10000	5/8	1 1/8	0.250	2400	2800	3550
0.078	5/8	5/16	1900	14	14000	11000	11/16	1 1/4	0.275	2700	3400	4000
0.094	5/8	5/16	2400	16	15700	12700	3/4	1 3/8	0.285	3550	4200	5300
0.109	3/4	3/8	2800	18	17700	14000	13/16	1 1/2	0.290	4200	5000	6400
0.125	3/4	3/8	3300	20	18000	15500	7/8	2	0.300	5000	6000	7600

NOTES:

1. Types of Steel—301, 302, 303, 304, 308, 309, 310, 316, 317, 321, 347 and 349
2. Material should be free from scale, oxides, paint, grease and oil.
3. Welding conditions determined by thickness of thinnest outside piece "T."
4. Data for total thickness of pile-up not exceeding 4 "T". Maximum ratio between two thicknesses 3 to 1.
5. Electrode Material, Class II, Class III or ELKONITE® 10W3
6. Minimum weld spacing is that spacing for two pieces for which no special precautions need be taken to compensate for shunted current effect of adjacent welds. For three pieces increase spacing 30 per cent.

SCHEDULE FOR SEAM WELDING STAINLESS STEEL

THICKNESS "T" OF THINNEST OUTSIDE PIECE (See Notes 1, 2, 3 and 4 Below)	ELECTRODE WIDTH AND SHAPE (See Note 5 Below)	ELECTRODE FORCE	ON TIME	OFF TIME FOR MAXIMUM SPEED (Pressure-Tight) CYCLES		MAXIMUM WELD SPEED IN. PER MINUTE		WELDS PER INCH		WELDING CURRENT (Approx.)	MINIMUM CONTACTING OVERLAP (See Note 6 Below)
				2 "T"	4 "T"	2 "T"	4 "T"	2 "T"	4 "T"		
INCHES	W, IN., Min.	LB.	CYCLES (60 Per Sec.)							AMPS.	IN.
0.006	3/16	300	2	1	1	60	67	20	18	4000	1/4
0.008	3/16	350	2	2	2	67	56	18	16	4600	1/4
0.010	3/16	400	3	2	2	45	51	16	14	5000	1/4
0.012	1/4	450	3	2	2	48	55	15	13	5600	5/16
0.014	1/4	500	3	2	3	51	46	14	13	6200	5/16
0.016	1/4	600	3	2	3	51	50	14	12	6700	5/16
0.018	1/4	650	3	2	3	55	50	13	12	7300	5/16
0.021	1/4	700	3	2	3	55	55	13	11	7900	3/8
0.025	3/8	850	3	3	4	50	47	12	11	9200	7/16
0.031	3/8	1000	3	3	4	50	47	12	11	10600	7/16
0.040	3/8	1300	3	4	5	47	45	11	10	13000	1/2
0.050	1/2	1600	4	4	5	45	44	10	9	14200	5/8
0.062	1/2	1850	4	5	7	40	41	10	8	15100	5/8
0.070	5/8	2150	4	5	7	44	41	9	8	15900	11/16
0.078	5/8	2300	4	6	7	40	41	9	8	16500	11/16
0.094	5/8	2550	5	6	7	36	38	9	8	16600	3/4
0.109	3/4	2950	5	7	9	38	37	8	7	16800	13/16
0.125	3/4	3300	6	6	8	38	37	8	7	17000	7/8

NOTES:

1. Types of Steel—301, 302, 303, 304, 308, 309, 310, 316, 317, 321, 347 and 349
2. Material should be free from scale, oxides, paint, grease and oil.
3. Welding conditions determined by thickness of thinnest outside piece "T."
4. Data for total thickness of pile-up not exceeding 4 "T". Maximum ratio between two thicknesses 3 to 1.
5. Electrode material, Class III
6. For large assemblies minimum contacting overlap indicated should be increased 30 per cent.

From American Welding Society "Recommended Practices for Resistance Welding"

Spot welding galvanized low-carbon steel

Material Thickness notes 1, 2, & 3	Electrode Diameter And Shape note 4			Net Electrode Force	Welding Current (Approx.)	Weld Time	Weld Nugget Size	Minimum Tension-Shear Strength	Minimum Weld Spacing	Minimum Contacting Overlap
	D	d	Oc							
Inches	In.	In.	Deg.	Lb.	Amps.	Cycles	In.	Lb.	Inches	Inches
0.022	5/8	3/16	120	300	13000	8	0.15	550	5/8	5/8
0.030	5/8	3/16	120	400	13000	10	0.16	1000	5/8	5/8
0.036	5/8	1/4	120	500	13500	12	0.19	1180	3/4	5/8
0.039	5/8	1/4	120	650	14000	13	0.21	1400	3/4	5/8
0.052	5/8	1/4	120	725	14500	18	0.22	1700	7/8	11/16
0.063	3/4	1/4	120	850	15500	22	0.24	2500	1-1/8	3/4
0.078	3/4	5/16	120	1200	19000	24	0.28	3200	1-1/4	7/8
0.093	3/4	3/8	120	1400	21000	30	0.34	4200	1-1/2	1
0.108	7/8	3/8	120	1750	20000	37	0.40	5900	1-3/4	1-1/8
0.123	7/8	3/8	120	2000	20000	42	0.48	7200	2	1-1/8

NOTES:

1. Material must be free from dirt, grease, paint etc. prior to welding, but may have light oil.
2. Two equal metal thicknesses of each gage.
3. Commercial coating weight is 1.25 oz. per square foot.
4. Electrode Material-RWMA Group A, Class 2. Class II.
5. Water Cooling: 2 gallons per minute.

   Projections should be larger in diameter for galvanized than for uncoated material.

Projection welding galvanized low-carbon steel

Material Thickness notes 1, 2, & 3	Electrode Diameter And Shape note 4		Net Electrode Force	Welding Current (Approx.)	Weld Time	Weld Nugget Size	Minimum Tension-Shear Strength (For Single Projectsions Only)	Projection Size	
	D	d						Diameter	Height
Inches	In.	In.	Lb.	Amps.	Cycles	In.	Lb.	In.	In.
0.039	5/8	3/8	250	10000	15	0.15	925	0.187	0.041
0.063	5/8	7/16	400	11500	20	0.25	2050	0.218	0.048
0.078	3/4	1/2	550	16000	25	0.25	2700	0.250	0.054
0.093	3/4	1/2	750	16000	30	0.30	4300	0.250	0.054
0.108	7/8	1/2	950	22000	33	0.31	4900	0.250	0.054

Seam welding galvanized low-carbon steel

Material Thickness notes 1, 2, & 3	Electrode Width And Shape note 4		Net Electrode Force	Welding Current (Approx.)	Weld Time		Welding Speed	Welds Per Inch	Minimum Contacting Overlap
					Heat Time	Cool Time			
	W	E							
Inches	In.	In.	Lb.	Amps.	Cycles	Cycles	In./Min.	W/In.	Inches
0.015	3/8	1/4	900	15000	2	2	120	7.5	3/8
0.036	1/2	1/4	1100	18000	4	2	60	10.0	1/2
0.039	1/2	1/4	1200	19000	4	3	60	9.0	1/2
0.052	1/2	1/4	1350	20000	5	1	90	7.0	9/16
0.063	1/2	5/16	1500	19800	8	2	54	7.0	5/8
0.078	5/8	5/16	1850	23000	10	7	30	7.0	11/16

NOTES:

1. Material must be free from dirt, grease, paint etc. prior to welding, but may have light oil.
2. Two equal metal thicknesses of each gage.
3. Commercial coating weight is 1.25 oz. per square foot.
4. Electrode Material-RWMA Group A, Class 2. Class II.
5. Pressure-tight joints require stripping the zinc coating prior to welding.
6. Nominal electrode diameter ranges between 8 to 10 inches.

   From American Welding Society "Recommended Practices for Resistance Welding."

WELDING DATA CHART

CROSSED WIRE WELDING OF LOW CARBON STEEL WIRE

WIRE DIA. IN.	COLD DRAWN WIRE				HOT DRAWN WIRE			
	WELD TIME CYCLES	WELD FORCE LBS.	WELD CURRENT AMPS.	WELD STRENGTH LBS.	WELD TIME CYCLES	WELD FORCE LBS.	WELD CURRENT AMPS.	WELD STRENGTH LBS.
15% SET-DOWN					15% SET-DOWN			
1/16	5	100	600	450	5	100	600	350
1/8	10	125	1,800	975	10	125	1,850	750
3/16	17	360	3,300	2,000	17	360	3,500	1,500
1/4	23	580	4,500	3,700	23	580	4,900	2,800
5/16	30	825	6,200	5,100	30	825	6,600	4,600
3/8	40	1,100	7,400	6,700	40	1,100	7,700	6,200
7/16	50	1,400	9,300	9,600	50	1,400	10,000	8,800
1/2	60	1,700	10,300	12,200	60	1,700	11,000	11,500
30% SET-DOWN					30% SET-DOWN			
1/16	5	150	800	500	5	150	800	400
1/8	10	260	2,650	1,125	10	260	2,770	850
3/16	17	600	5,000	2,400	17	600	5,100	1,700
1/4	23	850	6,700	4,200	23	850	7,100	3,000
5/16	30	1,450	9,300	6,100	30	1,450	9,600	5,000
3/8	40	2,060	11,300	8,350	40	2,060	11,800	6,800
7/16	50	2,900	13,800	11,300	50	2,900	14,000	9,600
1/2	60	3,400	15,800	13,600	60	3,400	16,500	12,400
50% SET-DOWN					50% SET-DOWN			
1/16	5	200	1,000	550	5	200	1,000	450
1/8	10	350	3,400	1,250	10	350	3,500	900
3/16	17	750	6,000	2,500	17	750	6,300	1,800
1/4	23	1,240	8,500	4,400	23	1,240	9,000	3,100
5/16	30	2,000	11,400	6,500	30	2,000	12,000	5,300
3/8	40	3,000	14,400	8,800	40	3,000	14,900	7,200
7/16	50	4,450	17,400	11,900	50	4,450	18,000	10,200
1/2	60	5,300	21,000	14,600	60	5,300	22,000	13,000

RECOMMENDED ELECTRODE MATERIALS

The process of resistance welding makes it possible to join most metals, similar or dissimilar. Bonds of adequate strength are obtainable for an extremely wide range of applications. Selecting electrodes of the proper alloy is a most important consideration in producing good welds at the required speed. The chart below is a valuable guide to this selection.

The weldability of two materials as expressed in the following chart has been derived after careful laboratory study and field survey of many factors which influence the welding or resultant weld of the metals. The factors include:

1. Thermal and electrical conductivity
2. Metallurgical properties
3. Nature of resultant weld or alloy
4. Weld strength
5. Relative accuracy in control of welding conditions necessary

The weldability of metals as shown in the chart applies only when conventional spot welding methods are used on similar thicknesses of material. However, many metal combinations which are listed as having a "poor weldability" may be satisfactorily joined by using a special setup or procedure.

Electrode Materials For SPOT WELDING Similar and Dissimilar Metals

	Tungsten Molyb-denum	Mag-nesium	Nickel Alloys	Nickel	Stainless Steel	Chrome Steel	Cad-mium Plate	Galva-nized Steel Zn. Plate	Terne Plate	Tin Plate	Scaly Steel	C. R. Steel	Phos-phor Bronze	Silicon Bronze	Nickel Silver	Cupro Nickel	Brass Yellow	Brass Red	Copper	Alu-minum Alloys	Alu-minum	C. P. Tita-nium
Commercially Pure Titanium																						A II (II) / II (II) 1
Aluminum 2S-3S		C I 1 5	E II 2 5	E II 2 3	H I 2 3 4	H II 3 8	E I 3 4 9	D I 3 4 9	D I 3 4 9	D I 3 4 9		E II 3 4	D II 2 5	D II 2 5			D II 5	E II 2	H V 2	C I 1	C I 1	
Aluminum Alloys Duralumin 52S-17S-24S		C I 1 5	E II 2	E II 2 3	H I 2 3 4	H II 3 8	E I (II) 3 4 9	D I 3 4 9	D I 3 4 9	D I 3 4 9		E II 3 4	D II 2 5	D II 2 5			D II 6	E II 2	E V 2	D I 1		
Copper—Pure	H II V 3	H I V 5	E II V	E II V 3 6	H I V 2 3 4	H II V 3 4	E I (II) V 3 4 9	H I V 3 4	H I V 3 4	H I V 3 4		E II V 3 4	D II V 5 6	D II V 5 6	D II V 5 6	D II V 5 6	D II V 6	E II V 6	K V 2			
Brass—Red 5-25% Zinc		H I II 5	D II V 6	D II V 6	H II V	H II V	E I (II) V	H I V 6	H I V 6	H I V 6		H II II 3 4	D II V 6	D II V 6	D II V 6	D II V	D II II	E II II 5 6				
Brass—Yellow 25-40% Zinc		E I II 5	D II IV 6	D II II 6	H II IV	H II IV	E I (II) IV 6	E I IV 6	E I (II) IV 6	E I IV 6		E II IV 3 4	C II IV 1	C II IV 1	C II IV 1	C II IV 1	C II II 1					
Cupro-Nickel		D I II 2 5	C II II	C VI II	E II (I) 2	E II II 2 8	E I (II) 2	E I II 2	E I (II) 2	E I II 2	H I (II) 7	E II II 3	C II II 1	C II II 1	C II II	B II II 1						
Nickel Silver		D I II 2 5	C II II	C VI II	E II (I) 2	E II II 2 8	E I (II) 2	E I II 2	E I (II) 2	E I II 2	H I (II) 7	E II II 3	C II II 1	C II II 1	B II II 1							
Silicon Bronze		D I II 2 5	C II II	D II II	E II (I) II 8	E II II	E I (II) II	E I II	E I (II) II	E I II	H I (II) 7	D II II 3	C II II 1	B II II 1								
Phosphor Bronze Grades A, C, & D		E I II 2 5	D II II	D II II	E II (I) II 8	E II II	E I (II) II	E I II	E I (II) II	E I II	H I (II) 7	D II II 3	B II II 1									
C. R. Steel H. R. Steel—Clean	D II II 3			D II II 3	D II II 3	B II III	B II II 8	C II II	C I II	B I (II) II 6	C I (II) II	E I (II) II 7	A II II 1									
Scaly H. R. Steel	H II (II) 3 7						D II (I) (II) 7	D II I (II) 7 8	D II I (II) 7	D I I (II) 6 7	D I (II) 6 7	E I (II) 7										
Tin Plate	E II I (II) 9	E I I 5 9	D I I 3 9	D II I 9	C I (II)	C II I 8	D I (II) 9	C I I (II) 6 9	D I (II) 6 9	D I 6 9												
Terne Plate	E II I (II) 9	E I I 5 9	D I I 3	D II I 9	C II I	C II I 8	C I (II)	C I I 6	C I I 6													
Galvanized Steel Zinc Plate	E II I (II) 9	E I I (II) 5 9	D II I (II) 3	D II II 9	C II I	C II I 8 9	C I I 9	C I I (II) 9														
Cadmium Plate	E II I (II) 9	E I I 5	D I I 3	D II I 9	C II I	C II I 8	C I I 9															
Chrome Plate	D II II 8			D II II 8	D II II 8	B III II 8	B II II 8															
Stainless Steel 18-8 Type	D II I 2 5			D II II	D III (I)	A III (II) 1																
Nickel Grade A	D II II 2 5			C II II 1	B II II 1																	
Nickel Alloys Monel Nichrome (High Res.)	D II II 2 5			B II II 1																		
Magnesium Alloys			D I I 1 5																			
Molybdenum Tungsten	D II II 2 5																					

BLOCK INTERPRETATION

WELD-ABILITY	ELECTRODE AGAINST
ELECTRODE AGAINST	SPECIAL INFORMA-TION

WELDABILITY

As a basis for comparison cold rolled (mild) steel has been chosen and its weldability designated as "excellent."

A—Excellent
B—Very Good
C—Good
D—Fair
E—Poor
H—Very Poor
K—Impractical

ELECTRODES

I– Class I
II– Class II
III– Class III
IV–ELKONITE® 10W3
V–ELKON® 100M*
VI–ELKONITE® 1W3 or TC-5

***ELKON® 100 W may be substituted.**
ΔELKONITE® 10W3 or TC-10 may be substituted.
Electrode materials in circles are second choice.

SPECIAL INFORMATION

1. Good weld strength.
2. May be welded under special conditions.
3. Low weld strength.
4. No actual weld nugget occurs, a "stick" is obtained.
5. Welding conditions must be accurately controlled.
6. Keep electrode clean to prevent sticking to the work.
7. Good practice recommends cleaning steel before welding.
8. Use one flat tip to minimize distortion or discoloration.
9. Coating may dissolve in other metals or burn away.

This Chart shows graphically the importance of Electrode maintenance. This is not only important from the quality of the weld, which is of first importance, also extra load added to the welding machine and equipment. Read the data on the chart, you can then draw your own conclusions.

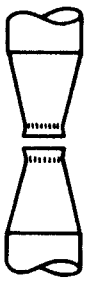
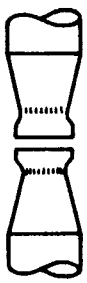
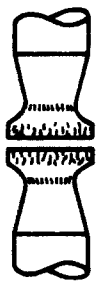
YOU CAN'T AFFORD TO NEGLECT YOUR ELECTRODES !

Keep your Electrodes dressed for maximum production and quality welds.

A TIP DRESSER WILL PAY DIVIDENDS !

We can supply you with hand operated Tip Dressers or Pneumatic Power Driven Dressers. Design or type will depend on your production requirements.

RESISTANCE WELDING

400% TOO SMALL (A)	PROPER NEW TIPS (B)	56% TOO LARGE (C)	125% TOO LARGE (D)	300% TOO LARGE (E)	525% TOO LARGE (F)	800% TOO LARGE (G)
						
Approx. 1/81 sq. in. at 1/8" Dia.	Approx. 1/20th sq. in. at 1/4" Dia.	Approx 1/13th sq. in. at 5/16" Dia.	Approx. 1/9th sq. in. at 3/8" Dia.	Approx. 1/5th sq. in. at 1/2" Dia.	Approx. 1/3rd sq. in. at 5/8" Dia.	Approx. 1/2 sq. in. at 3/4" Dia.
2,460 amperes only would be required (†)	9,823 amperes would be required (†)	15,337 amperes would be required (†)	22,100 amperes would be required (†)	39,300 amperes would be required (†)	61,350 amperes would be required (†)	88,500 amperes would be required (†)
127,640 lbs. sq. in. pressure (*)	31,960 lbs. sq. in. pressure (*)	20,470 lbs. sq. in. pressure (*)	14,200 lbs. sq. in. pressure (*)	7,990 lbs. sq. in. pressure (*)	5,120 lbs. sq. in. pressure (*)	3,500 lbs. sq. in. pressure (*)
RESULT: Four times too much pressure, current. Very severe indentation and spitting from high current density. **CORRECTION:** Cut pressure to 1/4 Cut current to 1/4	**RESULT:** Correct pressure, current, tips. Excellent weld. This is the size tip (new) for which the pressure, time, and current are adjusted.	**RESULT:** Only 60% of proper pressure, current. Borderline weld. Lower strength. Last diameter size tolerated unless current and pressure were set between the 1/4 and 5/16 size tips.	**RESULT:** Only 45% of the required pressure and current. Welds would be unacceptable. If the current or time were increased with tips in this condition a large weak weld would result.	**RESULT:** Only 25: of required current and pressure. No weld would be made if tips were left in this condition.	**RESULT:** Only 16% of required current and pressure. This is a very serious condition and the only cure is to dress the tips back to (B) condition.	**RESULT:** Only 11% of needed current and pressure. This is an absurd (though often seen) condition that only heats a spot.

(†) Current density required for this gage to be 200,000 amps per sq. in. Setting is 9,900 amps for condition (B)

(*) Five inch diameter air cylinder A 80 lbs. air pressure—1570 lbs. on ram.

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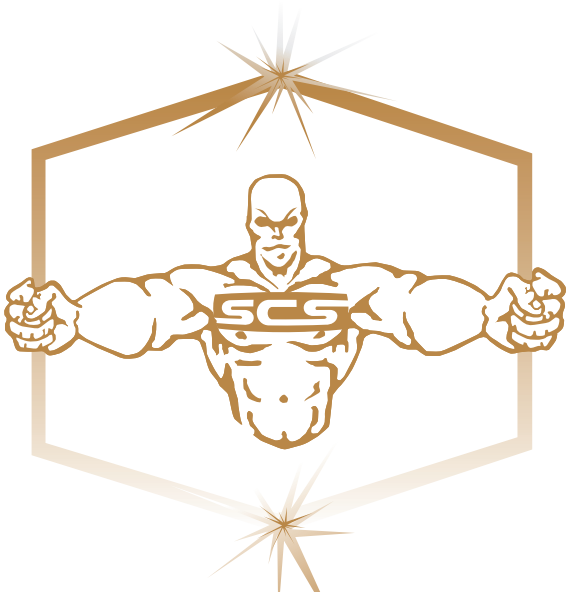

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