JOHN F. KENNEDY SPACE CENTER

MANUAL FOR OPERATION

OF

AUTOMATIC

PIPE AND TUBE WELDING MACHINE

DESIGN ENGINEERING DIRECTORATE

MECHANICAL SYSTEMS DIVISION

JOHN F. KENNEDY SPACE CENTER, NASA

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OF

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Design Engineering Directorate
Mechanical Systems Division

May 21, 1969

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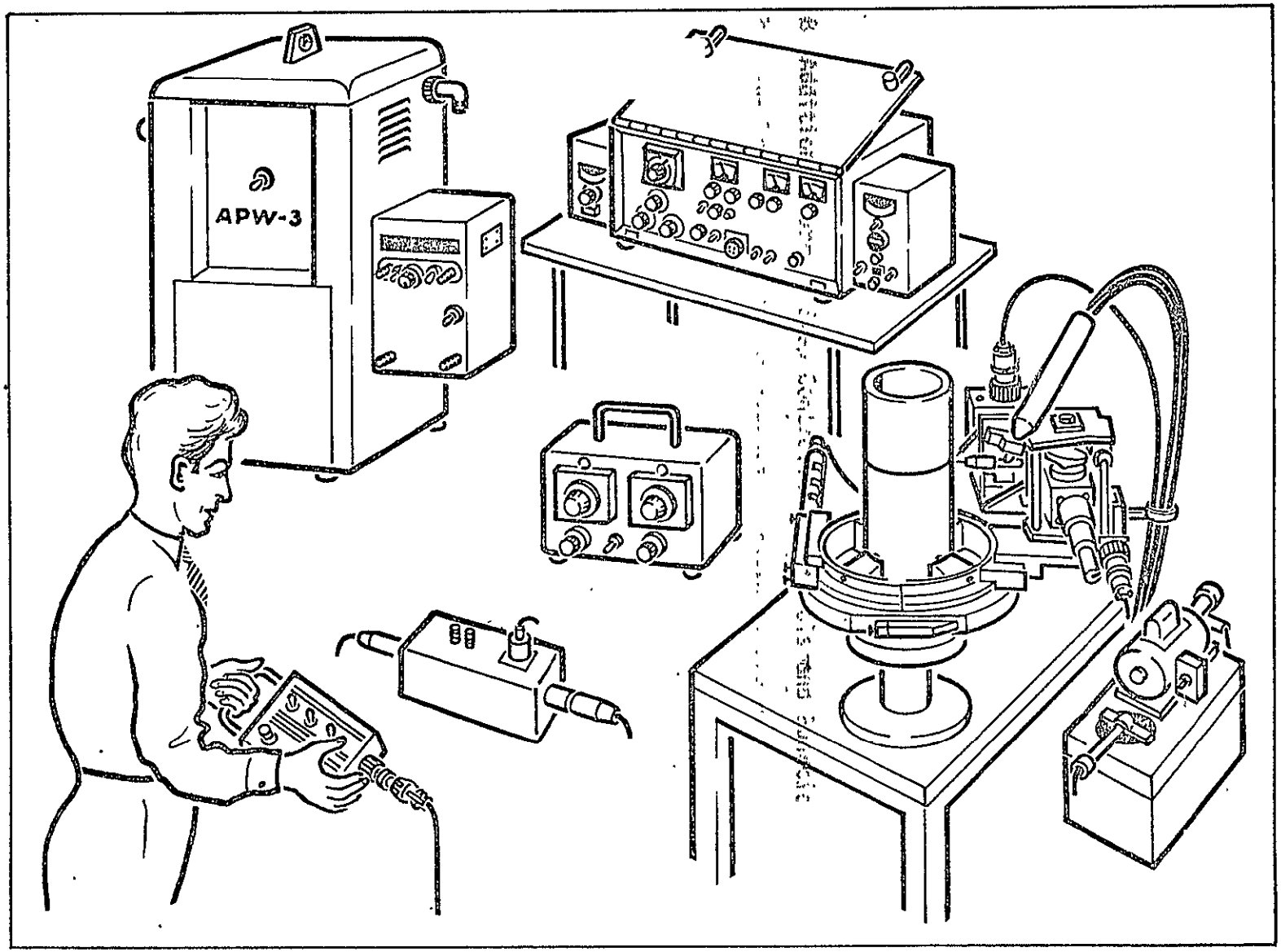


APW-3 (Modified) Automatic Pipe Welding System.

SECTION I. INTRODUCTION AND FUNCTIONAL DESCRIPTION

1.1 INTRODUCTION

1.1.1 Purpose.- This procedure manual provides a general description of, and procedures for, the operation of the APW-3 (Modified) Automatic Pipe Welding System to perform automatic welding of pipe and tubing utilized in the John F. Kennedy Space Center (KSC) Launch Support Systems.

1.1.2 Scope.- This general procedure manual contains introductory and descriptive information of the automatic pipe welding system and equipment within Section I. Section II contains the detailed instructions for the installation of the automatic pipe welding system and equipment. Section III introduces the welding operator to the operational sequences and procedural data necessary for production welding. Section IV contains general welding practices, and Section V contains recommended welding procedure data sheets for use as guidelines when performing specific welding tasks.

1.2 FUNCTIONAL DESCRIPTION OF THE APW-3 (MODIFIED) AUTOMATIC PIPE WELDING SYSTEM

The APW-3 (Modified) Automatic Pipe Welding System consists of three functional subsystems, each with attached and attachable functional components. The three subsystems are: the APW-3 power supply, the controls, and the carriage and torch assembly. The APW-3 Automatic Pipe Welding System may be operated with a large carriage and torch assembly or a small carriage and torch assembly.

1.2.1 Functional Description of the APW-3 Power Supply, Figure 1.- The APW-3 power supply consists of a power supply unit with an attached high frequency panel, a fuse assembly, and a shunt (connector) box which are attachable to the HF panel. The power supply operates from a 480 vac, 3-phase, 4-wire, 60 cycle single source power outlet, with a useful output voltage range of 5-40 vdc; 80 volts open circuit, and has a power factor of 0:74. The rated output is 230 amps DC at 100 percent duty cycle; 300 amps DC at 60 percent duty cycle, with a useful output current range of 6 - 450 amps DC at 25 percent duty cycle.

NOTE: The power supply unit contains a fail safe device.

1.2.1.1 APW-3 Power Supply Unit.- The APW-3 power supply is a portable unit with a built-in lift hook, a fail safe device under the top panel that limits maximum current, and a HF panel attached to its hinged right side panel. The supply unit is a major component of the supply system and functions to provide the automatic pipe welding system with a controlled output power supply.

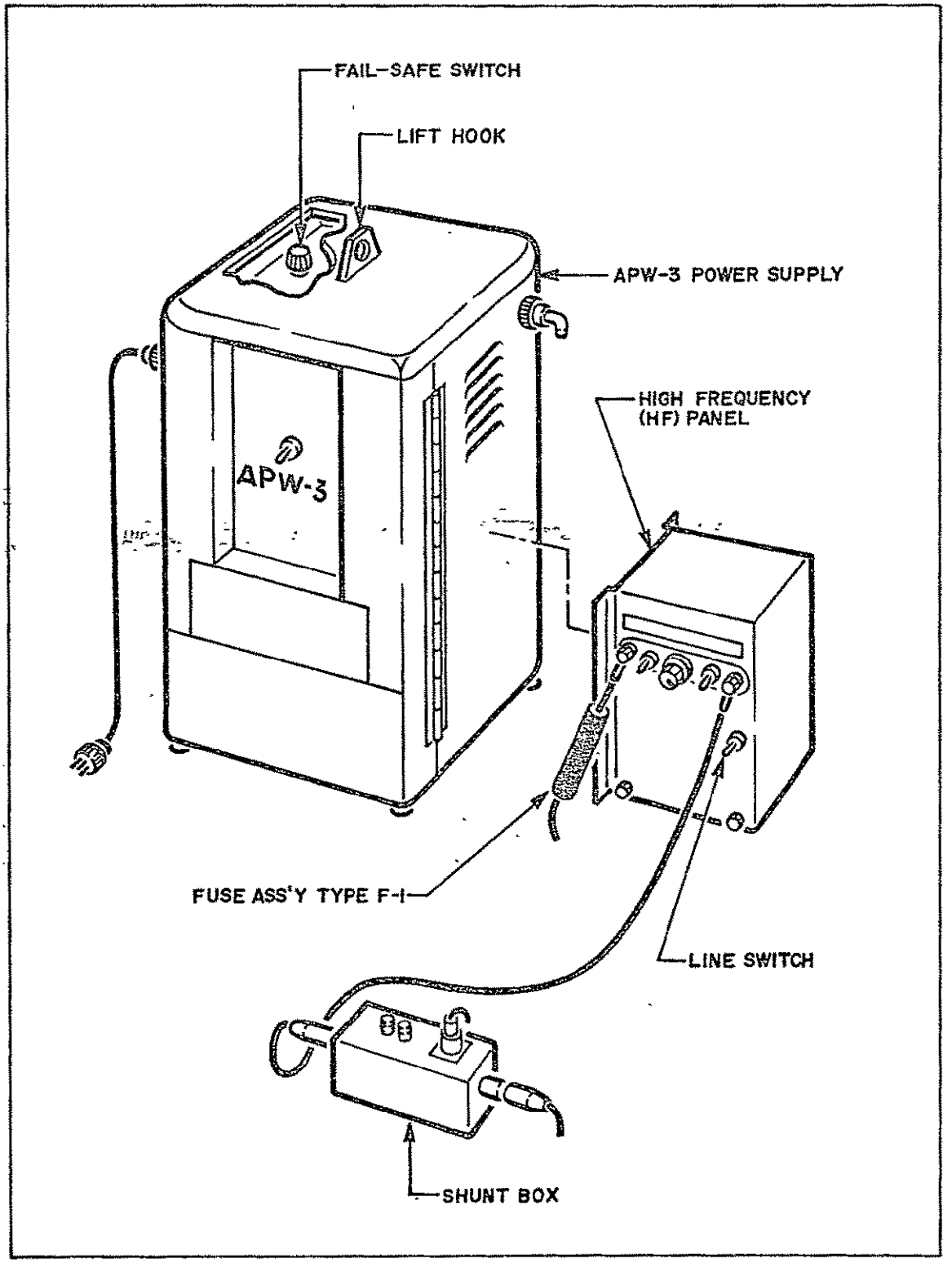


Figure 1. APW-3 Power Supply.

1.2.1.2 High Frequency Panel.- The high frequency (HF) panel is attached to the right side of the power supply unit and functions as a converter. The purpose for conversion is to give greater current control for arc initiation and a smoother operation, which would not be feasible under normal 60 cycle application.

1.2.1.3 Fuse Assembly Type F-1.- The F-1 fuse assembly is attached to and operates from the ELECTRODE post of the HF panel (applicable only when using the large 6-16 inch carriage), and is a part of the electrode cabling and water cooling system (1.2.3.3) and functions as a fuse safety device during the absence of cooling water. (The function of the fuse safety device is not related to the function of the fail safe device 1.2.1.1.)

1.2.1.4 Shunt(Connector) Box.- The shunt (connector) box functions as an electrical current diversion to the welding equipment for positive grounding. Current diversion through the shunt (connector) box provides definite grounding from the power supply (HF panel) to the control console and the workpiece, which assures additional safety.

1.2.2 Functional Description of the Control Console, Figure 2.- The control console consists of the control console unit with attached oscillation and voltage control boxes, a front panel (attachable) plug-in additional current step controller, and a rear panel (attachable) remote operator APW-3 pendant. The control console functions as an automatic time sequencing and current order programming device.

1.2.2.1 Control Console.- The control console unit contains solid state control and sequencing circuits, and a capability for establishing low and high/current order application for the pulsating mode. Slope functions as a control of the current decrease at the end of the weld cycle. The total weld time cycle timer functions to control the weld cycle from start of carriage travel to initiation of slope-out.

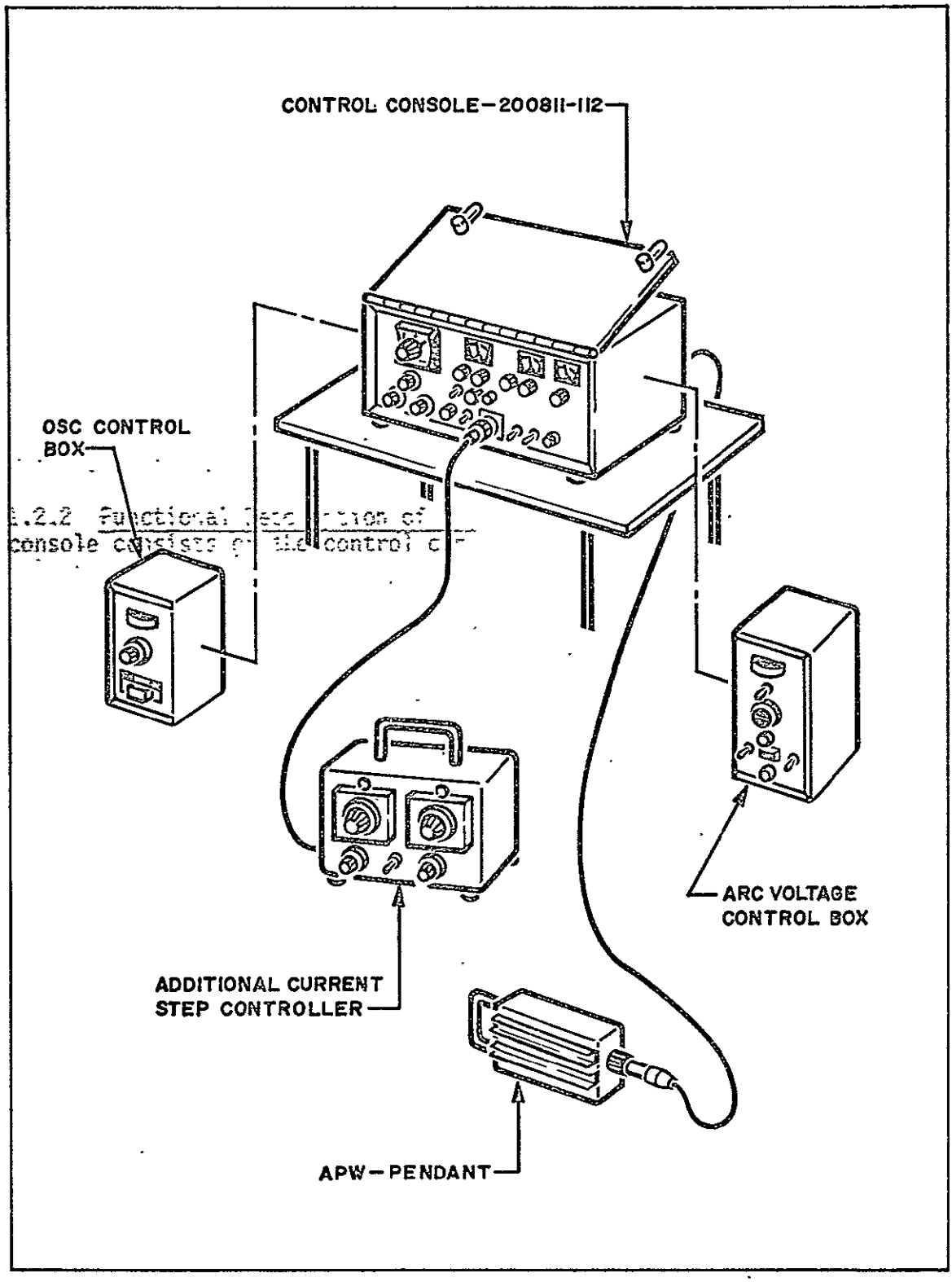


Figure 2. APW Control Console.

1.2.2.1.1 Control Console Time Sequencing.- The control console system contains four timers and several relays which are used to control the sequencing of all necessary operations. The functions that are sequenced include TRAVEL DELAY time, TOTAL WELD TIME (time required to travel 360° around the joint, tie-in, and overlap), current STEP TIME (initiate), and SAFETY TIME.

a. TRAVEL DELAY Timer.- The TRAVEL DELAY timer is a solid-state timing device which is adjustable from 1-30 seconds. The delay functions to control the time lapse that is required between the initiation of the welding current and the start of the carriage TRAVEL AND WIRE FEED.

b. TOTAL WELD TIME Timer.- The TOTAL WELD TIME (weld time cycle) timer is a synchronous motor type device which operates during that portion of the time cycle between the start of carriage TRAVEL through the point of tie-in and overlap. If manual slope-out is to be utilized, the setting shall exceed the anticipated weld time.

NOTE: Weld timer Type - HP55A6 (Model 4C68) may be used with the large or small carriages.

Weld timer Type - HP53A6 (Model 4F67) may be used with the small carriage only.

c. STEP TIME Timer.- The STEP TIME timer is another solid-state timer, adjustable from 1-5 minutes. The timer functions to initiate a change in the average welding current, if desired.

d. SAFETY TIME Timer.- The SAFETY TIME timer ensures a positive shutdown and reset in the event the arc is not extinguished by SLOPE action. Normally, the down slope will be sufficient to extinguish the arc, which results in a reset action.

1.2.2.1.2. Welding CURRENT STEP Program Functions.- The current step circuit is capable of introducing a change in the ordered welding current amplitudes. The current step also controls the amount of high current decrease that can be programmed into the welding cycle.

1.2.2.1.3 Weld CURRENT ORDER Pulser.- A pulse frequency switch is provided to disable the pulse generator, allowing the machine to be operated as a conventional DC power source. Four preset pulse frequency positions, "A" through "D", are available. Selection of the desired frequency is accomplished through the use of the pulse frequency rate selector switch. One position, "E", allows the frequency to be varied by an internal adjusting device. The cycles per second (cps) of the pulse frequency positions are as follows:

Position A.	2.5 cps
Position B.	3.5 cps
Position C.	5.25 cps
Position D.	7.25 cps
Position E.	Variable

1.2.2.1.4 SLOPE Controller.- The SLOPE controller is a solid-state integrating amplifier that controls the rate of current decrease at the end of the weld cycle

1.2.2.1.5 TRAVEL and WIRE FEED Potentiometers.

a. Separate potentiometers are provided for travel and wire feed, each is a solid-state electronic device, with a tachometer-generator-voltage feedback that provides a related voltage source which is utilized by the control to maintain the desired speed level.

b. The pre set TRAVEL and WIRE FEED speeds for the carriage travel motors are maintained constant to within ± 1 percent of the speed settings for all variations in load-up to 100 percent of the motor rating.

c. Two potentiometers, one TRAVEL and one WIRE FEED are located on the front panel of the console and are used to set the desired carriage travel and wire feed speeds. The two % SPEED indicating meters are calibrated from zero to 100 percent of full speed and are located directly above the TRAVEL and WIRE FEED potentiometers. The % SPEED meters indicate the feed-back voltages generated by the tachometers. Any deviations from the initial settings may be observed on these meters.

1.2.2.2 Oscillation and ARC Voltage Control Boxes.

1.2.2.2.1 Oscillation Control.- The electro-mechanical oscillation control and arc voltage control boxes attached to the side of the control console may be used only when welding large size pipe.

a. Initiation.- Oscillation is initiated when the travel begins, and terminates when slope-out commences in the automatic mode. (Jog may be used for manual operation.)

b. Frequency.- The oscillation frequency (0-150 cycles per minute) is determined by the speed of the oscillator motor.

c. Speed.- The oscillator motor speed is selected through the use of the oscillation potentiometer located on the control box panel.

d. Sweep.- The oscillation sweep is mechanically adjusted from 0-3/4 inch at the torch assembly through the use of the oscillation width adjustment screw.

e. Termination.- Oscillation may be terminated, as desired, through the use of the JOG (OFF) AUTO switch

1.2.2.2.2 Voltage Control.

a. Arc Voltage Control.- The ARC voltage is set by use of the digital dial located on the front panel of the ARC voltage control box.

b. Arc Initiation and Termination.- The voltage control is initiated after travel starts and is terminated as soon as the current slope begins.

1.2.2.3 Additional Current Step Controller.- The additional current step controller is a plug-in unit with a receptacle provided on the control console front panel and may be utilized when additional current steps are required.

1.2.2.4 Remote Operator APW-3 Pendant.- The APW-3 pendant is used by the operator during set-up, initiation of the welding process, and emergency termination of the welding cycle. The pendant is attachable to the rear of the control console and may be hand carried by the operator. It provides control START, TRAVEL, WIRE FEED, TAIL SLOPE, and STOP capabilities.

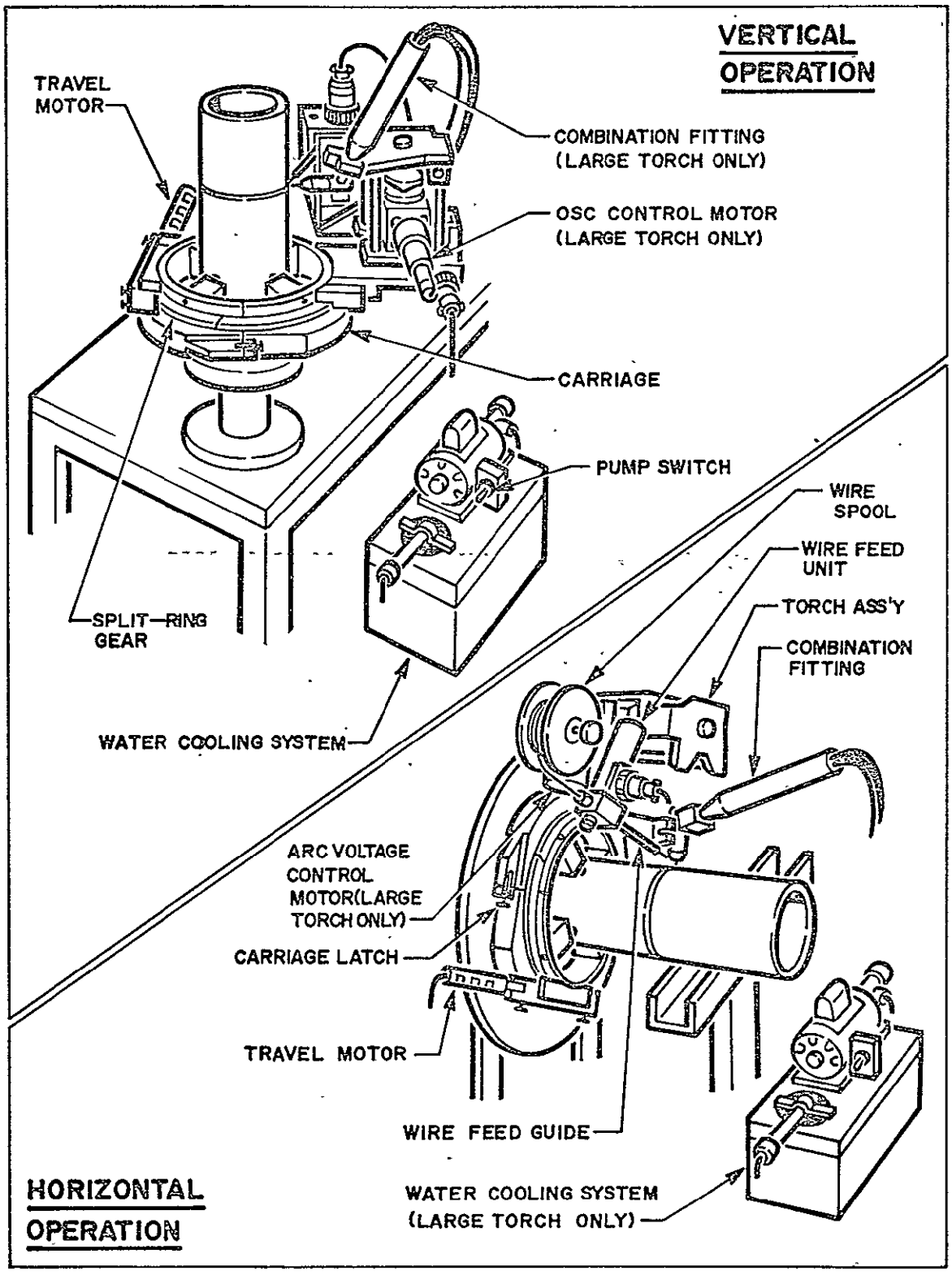


Figure 3. Large Carriage and Torch Assembly - Vertical and Horizontal.

1.2.3 Functional Description of the Carriage and Torch Assembly, Figure 3.- The APW-3 (Modified) automatic pipe welding systems carriage and torch assemblies consists of a large carriage and torch assembly that will accommodate piping (workpiece) from 6-16 inches in diameter and two small carriages (3/8-1 inch and 1-1/4 to 2-1/2 inches) and torch assemblies that will accommodate piping (workpiece) from 3/8-1 inch, and 1-1/4 to 2-1/2 inches. The large carriage and torch assembly utilizes a water cooling system that is not applicable to the small carriages and torch assemblies.

1.2.3.1 Welding Carriages.- The welding carriages consist of a travel motor and carriage that remain stationary during operation, a split-ring gear that accommodates the torch assembly, and a carriage latch and carriage adjustment set screws. The primary function of the welding carriage and split-ring gear is to rotate the torch assembly 360^{0} around the workpiece to facilitate circumferential welds of pipe and tubing. The carriages may be attached to a workpiece by opening the split-ring gear, placing the carriage on the workpiece and securing the carriage by use of the carriage latch.

1.2.3.2 Torch Assembly.- The torch assembly consists of a torch, torch cup, combination fitting, wire spool, and a wire feed unit. The large torch assembly also consists of an oscillation control motor and a voltage control motor which are not a part of the small torch assembly.

1.2.3.2.1 Wire Feed Unit.- The wire feed unit accepts hard or soft wire, (0.035 inches in diameter) at 65 inches per minute (maximum) from self-contained small diameter spools or a straight cut-lengths. The wire feed unit assures a proper welding-wire supply at the torch tip for incorporation into the workpiece.

1.2.3.2.2 Combination Fitting.- The combination fitting for the large torch culminates at the torch and includes the power line, the inert shield gas line and the water supply and return line from the water cooling system (applicable only to the large torch). The combination fitting for the small torch is in the power and gas lines to the torch.

1.2.3.3 Water Cooling System.- The water cooling system consists of a tank with a centrifugal pump that recirculates water to the torch and includes a fuse assembly Type F-1 on the electrode line. After installation, (Section II), the system is initiated by a pump switch.

SECTION II. INSTALLATION OF THE APW-3 (MODIFIED) AUTOMATIC PIPE WELDING SYSTEM

2.1 GENERAL

This section contains complete installation instruction for the APW-3 (Modified) automatic pipe welding system, which consists of component and cable connections and interconnection of the APW-3 power supply, the control console, the carriage and torch assembly, and the water cooling system. For set-up after shutdown (short and long duration), see Section III. Prior to installation of the APW-3 (Modified) automatic pipe welding system assure the availability of a 30 amps circuit, 480 vac, 3-phase, 4-wire, 60 cycle power source outlet and locate the APW-3 power supply unit, the control console, and the carriage and torch assembly in their appropriate position, accessible to the power source outlet. For detailed cable connections, listing of components, and cable identification numbers, see Figure 4.

2.2 INSTALLATION OF THE APW-3 POWER SUPPLY

Installation of the power supply consists of installing power supply unit (51E177-2), HF panel (52D192-2), and shunt (connector) box (200811-400).

2.2.1 Power Supply Unit - 51E177-2.

2.2.1.1 Connect power cable (200814-503) from power supply unit receptacle (J-210) to control console receptacle (J-102) on the console.

2.2.1.2 Ensure that the power supply unit ON-OFF switch is OFF and connect the primary power supply cable to the power source outlet, BUT DO NOT ENERGIZE.

2.2.2 High Frequency (HF) Panel - 52D192-2.

2.2.2.1 Connect a gas line from a regulated supply of applicable inert shielding gas to the input GAS fitting on the rear of the HF panel.

2.2.2.2 Connect the gas line from the torch combination fitting to the output GAS connection on the HF panel.

> **CAUTION**
>
> The WATER inlet and outlet connections on the front and rear of the HF panel are not applicable to KSC operations. If a water cooled torch is used, make connection to the ELECTRODE post of the HF panel with the F-1 fuse assembly cable and the water line from the water cooling system.

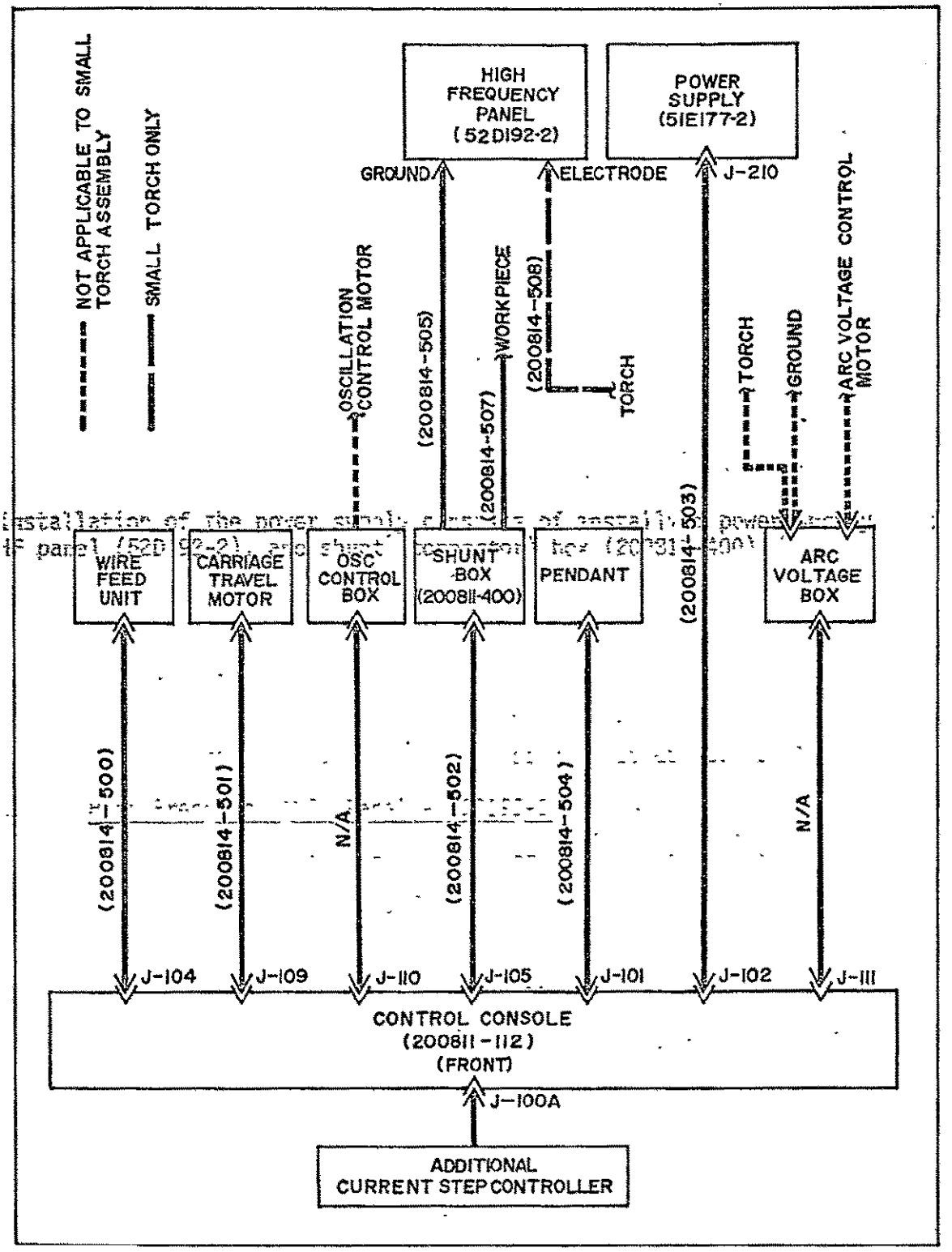


Figure 4. Installation Cable Wiring Diagram

2.2.2.3 Connect power cable (200814-508) from the torch for the small carriage to the ELECTRODE output terminal on the HF panel. The use of cable (200814-508) is applicable to the small torch only.

2.2.2.4 Connect short section of cable (200814-505) between the GROUND terminal on the HF panel and the shunt (connector) box.

2.2.3 Shunt (Connector) Box - 200811-400.

2.2.3.1 Connect cable (200814-502) between the shunt (connector) box and control console receptable (J-105).

2.2.3.2 Connect cable (200814-507) between the shunt (connector) box and the workpiece, as required.

2.2.3.3 Assure the connection of cable (200814-505).

2.3 INSTALLATION OF THE CONTROL CONSOLE

2.3.1 Installation of the Control Console - 200811-112.- The complete installation of the control console incorporates interconnections between the console connection panel (rear) and each component of the APW-3 (Modified) system. The connection of the additional current step controller is made at the front of the control console.

2.3.1.1 General.- Assure the connection of cable (200814-502) paragraph 2.2.3.1 and cable (200814-503) paragraph 2.2.1.1.

2.3.1.2 Wire Feed Unit.- Connect cable (200814-500) between console receptacle (J-104) and the wire feed unit receptacle.

2.3.1.3 Carriage Travel Motor.- Connect cable (200814-501) between console receptacle (J-109) and the carriage travel motor receptacle.

2.3.1.4 Oscillation Control Box.- Connect the applicable interconnection cable from the oscillation control box to console receptacle (J-110). Connect the applicable cable from the oscillation control box to the oscillation control motor at the torch assembly. Connection of the oscillation control box is not applicable to the operation of the small torch assembly.

2.3.1.5 Arc Voltage Control Box.- Connect the applicable interconnecting cable from console receptacle (J-111) to the ARC voltage box receptacle. Connect the applicable cable from the ARC voltage motor to the ARC voltage box. (ARC voltage control connection is not applicable to the operation of the small torch assembly.) Connect the voltage control 2 way lead from the torch and ground to the ARC voltage box.

2.3.2 Installation of the APW-3 Pendant.- Locate the APW-3 pendant cable (200814-504) near the control console and welding area, and connect between the pendant receptacle and console receptacle (J-101).

2.3.3 Installation of the Additional Current Step Controller.- Connect the current step controller to current step receptacle (J-100A) on the front of the console. (Use only when additional current steps are required.)

2.4 INSTALLATION OF THE CARRIAGE AND TORCH ASSEMBLY, AND THE WATER COOLING SYSTEM

2.4.1 General.- Installation of the carriage and torch assembly consists of installing the carriage with the travel motor, the torch assembly, and the water cooling system, as applicable.

2.4.2 Installation of the Carriage and Travel Motor, (Figure 3).

2.4.2.1 Mounting.- Mount and secure with the carriage latch, the travel motor and hinged carriage - with the selected spacers for the large carriage - to the workpiece. Assure the connection of cable (200814-501) paragraph 2-3-1-3. [illegible] the complete installation of the control console incorporates interconnections between the control

2.4.2.2 Center Screws.- Adjust the centering screws (8) to firmly secure the carriage to the selected workpiece.

2.4.3 Installation of the Torch Assembly.

2.4.3.1 Mounting.- Mount and secure the torch assembly to the split-ring gear and secure the torch (and combination fitting, as applicable) to the torch assembly assuring the connections of all leads from the torch.

2.4.3.2 Installation.- Assure the connection of cable (200814-500) to the wire feed unit. Assure the connection (as applicable) of the oscillation control and voltage control motors.

2.4.4 Installation of the Water Cooling System.- Connect the water line from the F-1 fuse assembly to the water system, connect the water line from the torch to the water pump, and connect water pump to a power source outlet (110 vac). Utilize pump switch to activate, when required.

SECTION III. OPERATION AND SHUTDOWN OF THE APW-3 (MODIFIED) AUTOMATIC PIPE WELDING SYSTEM

3.1 GENERAL

This section contains preliminary settings and equipment and preweld set-up for the operation of the installed APW-3 (Modified) automatic pipe welding system; operations and control functions of the APW-3 power supply, the control console, and the carriage and torch assembly; and instructions for system shutdown (short and long duration).

3.2 PRELIMINARY SETTINGS, AND EQUIPMENT AND PREWELD SET-UPS

Upon installation of an APW-3 (Modified) Automatic Pipe Welding System or after each system shutdown (short or long duration) the following preliminary settings, equipment set-up, and preweld set-up shall be performed.

3.2.1 Preliminary Settings.- The preliminary settings are applicable to the operations of either the large or small carriage.

3.2.1.1 APW-3 Power Supply.- Connect the power supply to the power source.

a. Main power switch..... .....ON

3.2.1.2 Shielding Gas.

a. Turn gas valve to.....OPEN
b. Set gas regulator to.....per applicable data sheet

3.2.1.3 High Frequency Panel.

a. HIGH FREQUENCY switch.....ON
b. LO-HI Intensity Amplitude.....50-60% full scale
c. LINE switch.....ON
d. GAS switch..... .....ON

3.2.1.4 Centrifugal Water Pump.

a. Power switch.....ON

NOTE: Use of water pump applicable to 6-16 inch carriage only.

3.2.1.5 Control Console.

a. Control console POWER switch.....ON

3.2.2 Equipment Set-up Preparation.

3.2.2.1 Carriage Preparation.

a. Install the desired adapters and/or carriage set screws.
b. Connect the cable to the carriage travel motor.

3.2.2.2 Torch Assembly Preparation.

a. Connect the cable to the wire-feed unit (2.3.1.2).
b. Connect the applicable torch power cable.
c. Connect the ground cable (2.3.1.5).
d. Attach the desired wire spool and operate the wire-feed unit to run the wire through the wire guide.
e. Check the electrode. Regrind and/or replace, if required.
f. Check the relationship of the wire guide, torch tip, and electrode. Refer to the applicable welding procedure data sheet for dimension.

3.2.3 Pre-Weld Set-Up Preparations.- Preweld set-up instructions (below) are applicable to the operations of both the large and small carriages. Specific instructions for the large and small carriage are contained in 3.2.3.1 and 3.2.3.2 respectively.

a. Install the carriage on the workpiece (2.4.2.1).
b. Center the carriage on the workpiece by use of the set screws (8).
c. Mount the torch assembly on the carriage (2.4.3).
d. Position the carriage, as required, to obtain the desired torch alignment.

3.2.3.1 Large Carriage and Torch Assembly.- The following preweld set-up is applicable only when using the large 6-16 inch carriage.

a. Place the arc voltage control switch in the ON position.
b. Move the torch tip close to the workpiece with the OUT-IN position switch on the voltage control box.
c. Set the oscillation sweep and frequency, as required.
d. Check the tracking of the torch around the workpiece. (Readjust the carriage position, as required.)

NOTE: For horizontal workpieces (pipe), torch will require in-out movement during the tracking check.

e. Move the torch tip away from the workpiece (b. above).
f. Operate the wire feed to extend the wire past the tip.
g. Adjust the distance between the tip and the extended filler wire, as specified in the applicable welding procedure data sheet.
h. Retract the wire to the end of the wire guide tube.
i. Rotate the torch assembly to the desired weld starting point.
j. Move the torch toward the workpiece to establish a gap of 3/32 - 1/8 inch.

3.2.3.2 Small Carriage(s) and Torch Assembly.- The following preweld set-up is applicable only when using the small carriage(s), 3/8 - 1 inch or 1-1/4 inches to 2-1/2 inches.

a. Rotate torch assembly around the workpiece (pipe) to check tracking and arc length. Check at four points, 90^{o} apart, and readjust set screws, as required, to obtain equal arc length at each point.

b. Rotate the torch assembly to the weld starting point.

3.3 OPERATIONS AND CONTROL FUNCTIONS, AND SHUTDOWNS

3.3.1 General.- The operations and control functions of each component of the APW-3 (Modified) automatic pipe welding system are as illustrated and set forth in Figure 5 APW-3 power supply, Figure 6 control console, Figure 7 APW-3 pendant, Figure 8 additional step current controller, and Figures 9 and 10 large and small carriage, and torch assembly, respectively.

3.3.2 Operations.- The following operations instructions are applicable to both the large and small carriage.

a. Set the console controls as specified on the welding procedure data sheet.
b. Establish inert gas purge, as required.

NOTE: Set the total weld timer to the maximum setting if the manual slope out is to be used.

c Position the current step and oscillator switches, as applicable.
d. Place or verify the travel switch in the FWD position.
e. Place or verify that the wire-feed switches are in the applicable positions.
f. Clean the torch tip lightly with a file or an emery cloth.
g. Depress the START button.

NOTE: Depress the STOP button and repeat steps f. and g. if the arc does not initiate within 5-6 seconds.

h. Monitor the welding action and make minor adjustments to the arc length and/or the torch alignment, as required.

CAUTION
Keep the cables from contacting obstacles during the weld cycle.

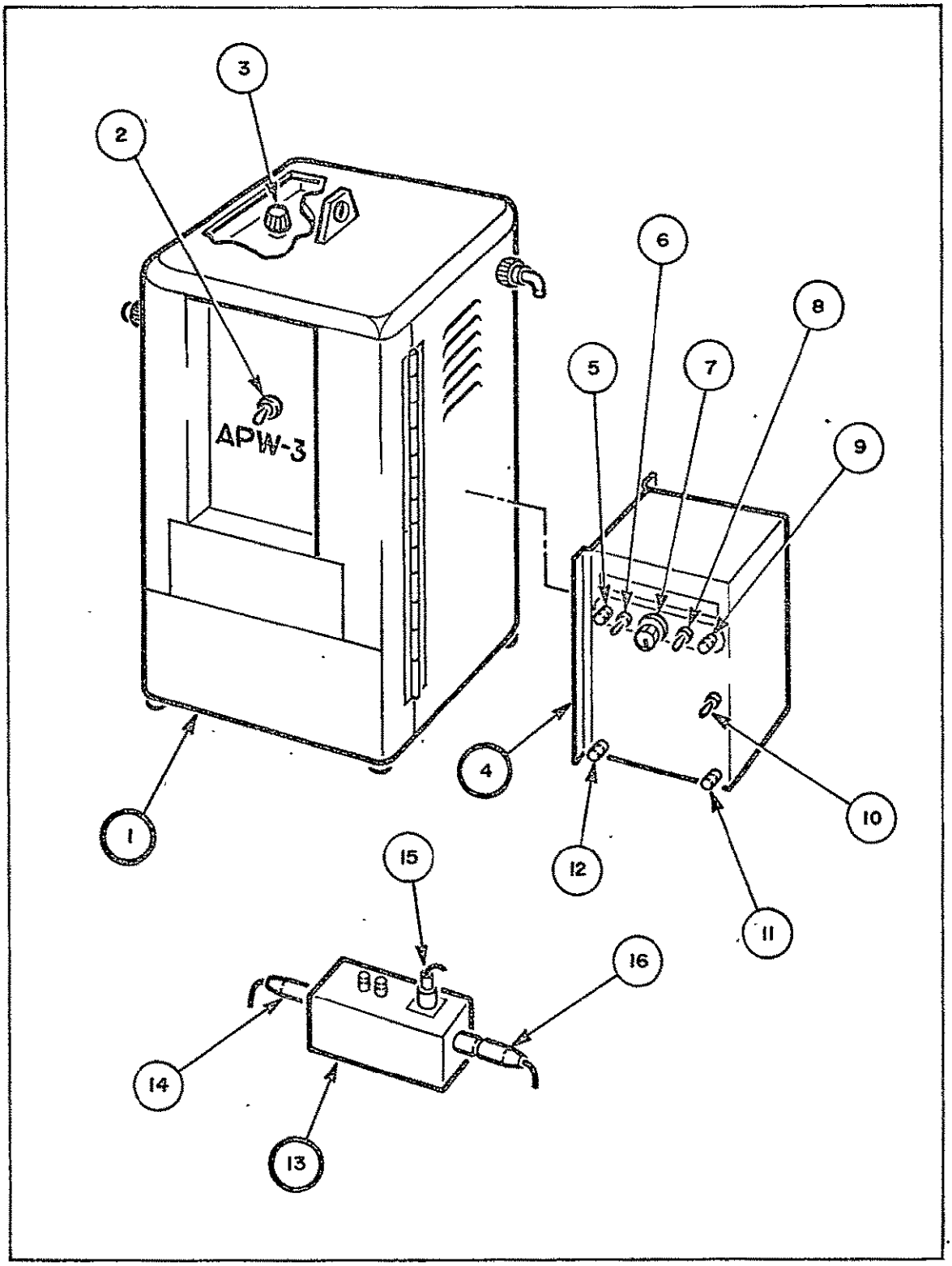


Figure 5. APW-3 Power Supply - Controls and Functions. (Sheet 1 of 2)

Figure 5 (Cont.) APW-3 Power Supply - Controls and Functions. (Sheet 2 of 2)

ITEM	CALLOUTS	FUNCTION
1	APW-3 POWER SUPPLY UNIT	
2	ON-OFF Power Switch.....	Energizes the power supply.
3	Fail Safe Device.....	Limits the maximum amount current.
4	HIGH FREQUENCY (HF) PANEL	
5	ELECTRODE Connector Post.....	Connection for the ELECTRODE output.
6	HIGH FREQUENCY On-Off Switch.....	Energizes the HF panel.
7	LO-HI INTENSITY Dial.....	Controls the INTENSITY of the high frequency.
8	GAS On-Off Switch.....	Energize the inert (Argon) shielding GAS output.
9	GROUND Connector Post.....	Connection for the system GROUND outlet.
10	Line On-Off Switch.....	Activates the gas preflow timer.
11	WATER Connector.....	Outlet for the water (not applicable for KSC operations).
12	GAS Connector.....	Outlet for the inert shielding gas.
13	SHUNT (CONNECTOR) BOX	
14	Connector from Ground.....	Cable connector from the Shunt (Connector) Box to the HF Panel.
15	Connector from Console.....	Cable connector from the Shunt (Connector) Box to the Control Console.
16	Connector from Workpiece.....	Cable connector from the Shunt (Connector) Box to the ground pipe (workpiece).

i. Depress the SLOPE button when the tie-in is complete, if the manual slope out is used.
j. Slope out and/or expiration of safety time completes the weld cycle.
k. Discontinue the inert gas purge (3.2.1.2).
m. Remove the torch assembly from the carriage (small carriages only unless final pass).
n. Clean the weld as required.
p. If a single-pass weld or final pass of a multi-pass weld was performed, remove the carriage from the pipe.
q. If additional passes are required, repeat steps d. through n.

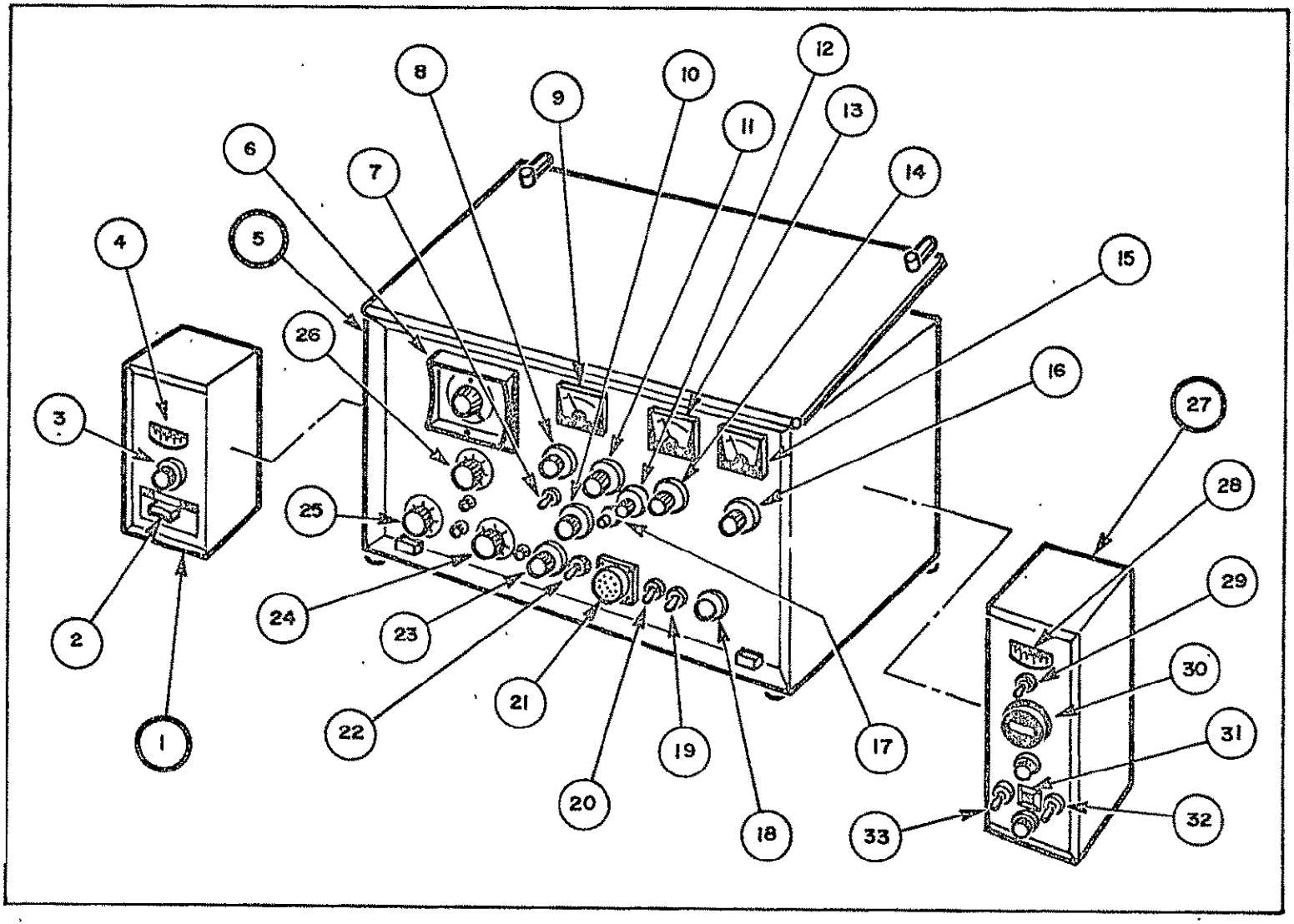
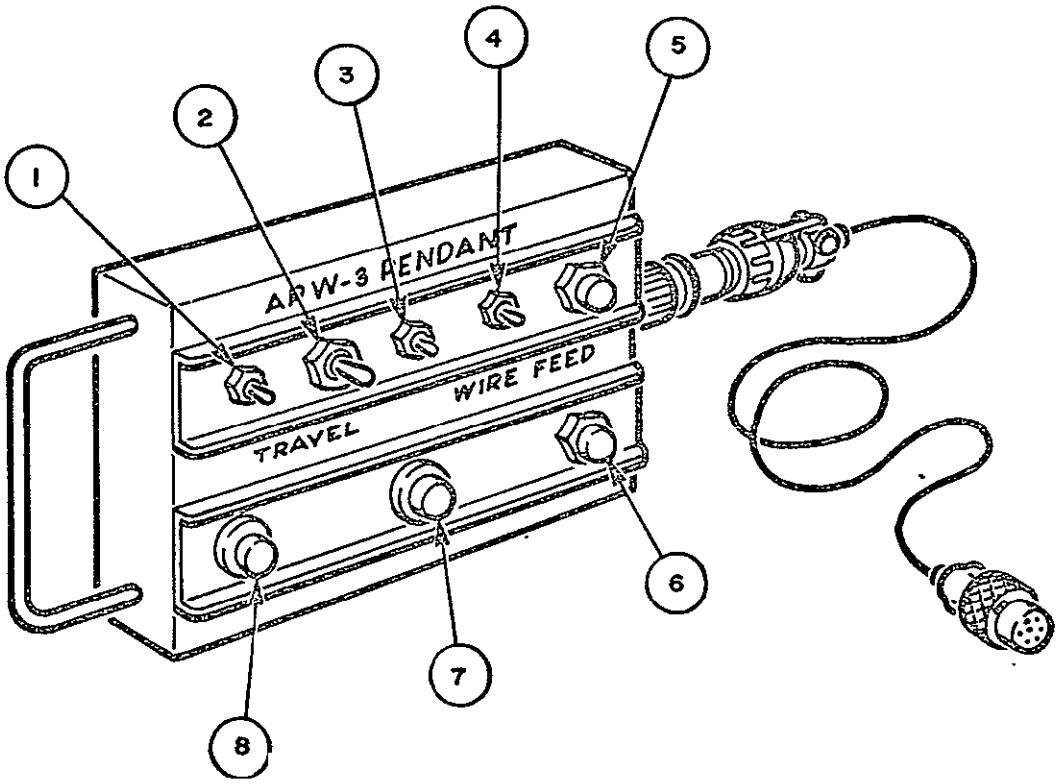


Figure 6. AWS Controle Console - Controls and Functions. (Sheet 1 of 2)

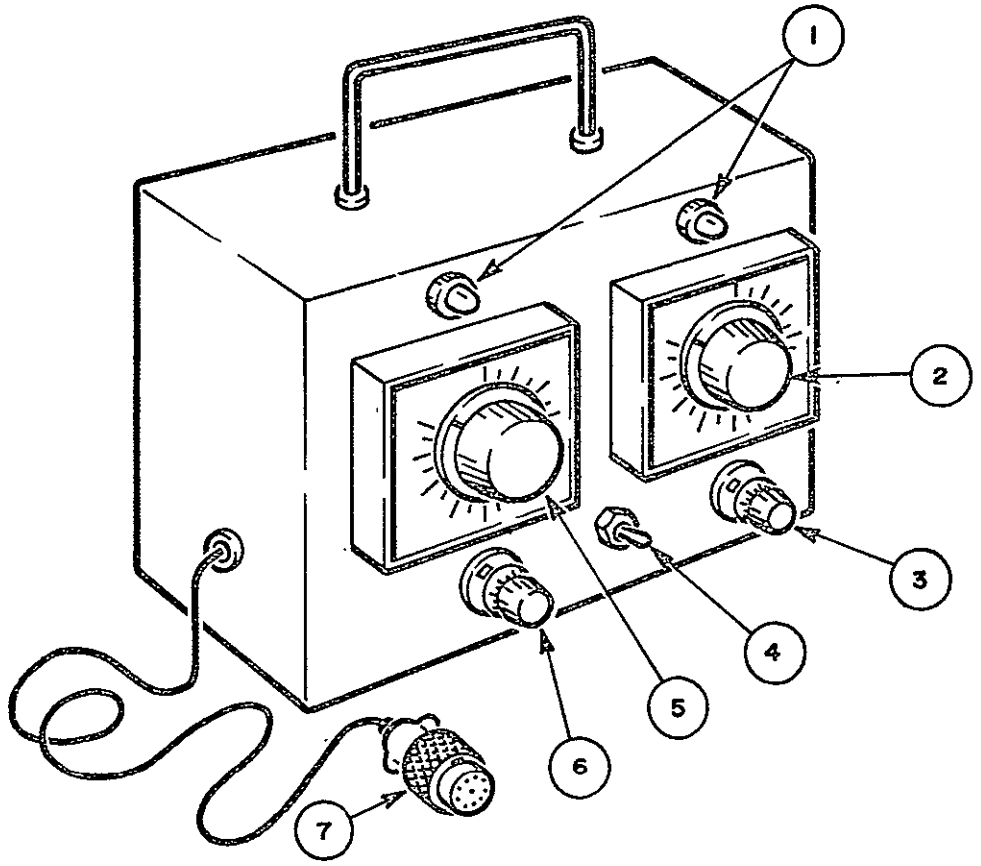
Figure 6 (Cont.). APW Control Console - Controls and Functions (Sheet 2 of 2)

ITEM	CONTROLS	FUNCTIONS
1	OSCILLATION CONTROL BOX	
2	JOG-(Off)-AUTO Oscillation Switch. .	To select the oscillation mode.
3	Oscillator Potentiometer.	Controls the frequency of desired oscillation.
4	Indicator.	Indicates the oscillation frequency.
5	CONTROL CONSOLE	
6	Total Weld Time Timer.	Controls the weld cycle from the start of carriage travel to initiation of slope out.
7	Pulse Switch.	Energizes the pulse circuit.
8	Low/Current Order. . . . . Adjust Potentiometer	Controls the LOW/CURRENT
9	Welding Current Ammeter.	Indicates 0-300 Amp LOW/HIGH/CURRENT ORDER output.
10	Slope Rate Adjust Potentiometer. . .	Controls the rate of decrease of the average welding current.
11	High/Current Order. . . . . Adjust Potentiometer	Controls the HIGH CURRENT.
12	Pulse Frequency Rate Switch. . . .	Selects the Pulse Frequency.
13	Travel Indicating Meter Speed. . . .	Indicates the carriage travel.
14	Travel Speed Adjust Potentiometer. .	Controls the speed of the carriage.
15	Wire Feed Speed Indicating Meter. . .	Indicates 0-100% speed of the WIRE FEED.
16	Wire Feed Speed. . . . . Adjust Potentiometer	Controls the rate of wire feed.
17	High/Current Order Hold Button. . . .	Use the HOLD button for the HIGH/CURRENT ORDER.
18	Power Indicator Light (Red).	Indicates that control console is POWER ON.
19	Power ON-OFF Switch.	Controls Power activation of the control console.
20	Current Step Selector.	Selects single or additional CURRENT STEPS (when connected).
21	Additional Current Step Controller Receptacle.	Connection for the additional Current Step Controller.
22	Step Current Select Switch.	Energizes the STEP circuit.
23	Step Current Adjust Potentiometer. .	Controls the amount of change in the high current.
24	Safety Time Timer.	Controls shutdown and reset, if SLOPE action fails or the ARC fails to extinguish when selected.
25	Travel Delay Timer.	Determines the delay between initiation of the welding current and start of the Torch Travel and Wire Feed.
26	Step Time Timer.	Initiates a change in welding current, as desired.
27	ARC VOLTAGE CONTROL BOX	
28	Arc Gauge.	Indicates the ARC size.
29	Arc Reference Switch.	Selects the ARC or REF readout on the gauge.
30	Arc Voltage Digital Dial.	Controls the ARC length (large carriage).
31	AVC Indicator Light.	
32	Torch IN-OUT Adjustment.	Manual IN-OUT movement of the Torch at workpiece.
33	Arc Voltage ON-OFF Switch.	Energizes the ARC VOLTAGE CONTROL unit.



ITEM	CONTROLS	FUNCTIONS
1	Travel FWD-REV Switch.....	Selects forward (FWD) or reverse (REV) Travel of Torch Assembly.
2	Travel JOG Switch.....	Manual Operation of Travel.
3	Wire Feed ON-OFF Switch.....	Energizes Wire Feed Unit.
4	Wire Feed FWD-REV Switch.....	Selects forward (FWD) or reverse (REV) WIRE FEED
5	Wire Feed JOG Pushbutton.....	Manual Operation of Wire Feed Unit.
6	Weld Cycle START Pushbutton...	Initiates START of weld cycle.
7	TAIL SLOPE Pushbutton.....	Manual SLOPE of weld and extinguishing of ARC.
8	Emergency STOP Pushbutton.....	For emergency STOPPING of work.

Figure 7. APW-3 Pendant - Controls and Functions.



ITEM	CONTROLS	FUNCTIONS
1	2nd and 3rd Step Current Indicator Lights	Indicates when the 2nd and 3rd Step Current Timers are in operation.
2	3rd Step Current Timer	Controls the time when 3rd step is initiated.
3	3rd Step Current Control	Controls Current Decrease for 3rd step.
4	Step Selector Switch	Selects 2nd or 2nd and 3rd Current Steps.
5	2nd Step Current Timer	Controls the time when 2nd step is initiated.
6	2nd Step Current Control	Controls Current Decrease for 2nd step.
7	Plug-In Receptacle	For connecting Controller to Console

Figure 8. Additional Current Step Controller - Controls and Functions.

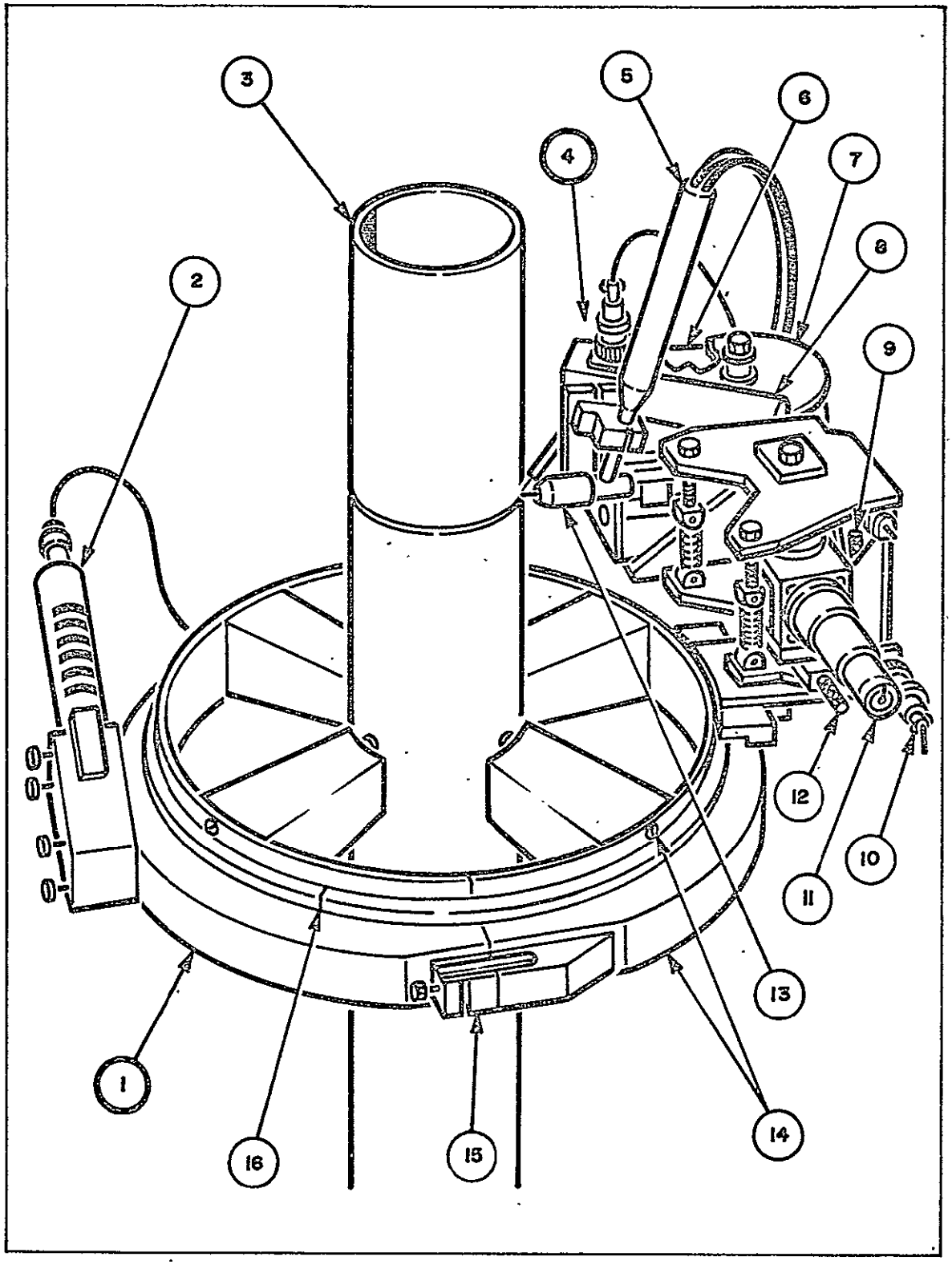


Figure 9. Large Carriage and Torch Assembly - Controls and Functions. (Sheet 1 of 2)

Figure 9 (Cont.). Large Carriage and Torch Assembly - Controls and Functions. (Sheet 2 of 2)

ITEM	CALLOUTS	FUNCTION
1	CARRIAGE	Rotates the torch assembly 360° around the workpiece.
2	Travel Motor	An integral part of the carriage and acts as a drive motor for the split-ring gear.
3	Workpiece	Two sections of pipe, used for butt welding test.
4	TORCH ASSEMBLY	Rotates 360° around the workpiece.
5	Combination Fitting	Accepts all line leads into the torch.
6	ARC Voltage Control Motor	Moves torch assembly IN to or OUT from the workpiece.
7	Wire Spool	Supplies the filler metal to the workpiece.
8	Wire-Feed Unit	Controls the rate at which the filler metal is added during the welding operation.
9	Torch Assembly Adj. Screw (Lateral)	Allows lateral movement of the torch assembly.
10	Oscillation Connector	Accepts the cable from the oscillation control box.
11	Oscillation Control Motor	Drives the motor for the oscillation function.
12	Oscillation Adj. Screw (Width)	Mechanical adjustment of the oscillation from 0-3/4 inches.
13	Torch Cup	Controls the concentration of the shielding gas at the torch.
14	Carriage Adj. Set Screws (8)	Adjustment screws for securing the carriage to the pipe.
15	Carriage Latches	For attachment and removal of the carriage to and from the workpiece.
16	Split-Ring Gear	Driven by the travel motor and rotates the torch assembly around the workpiece.

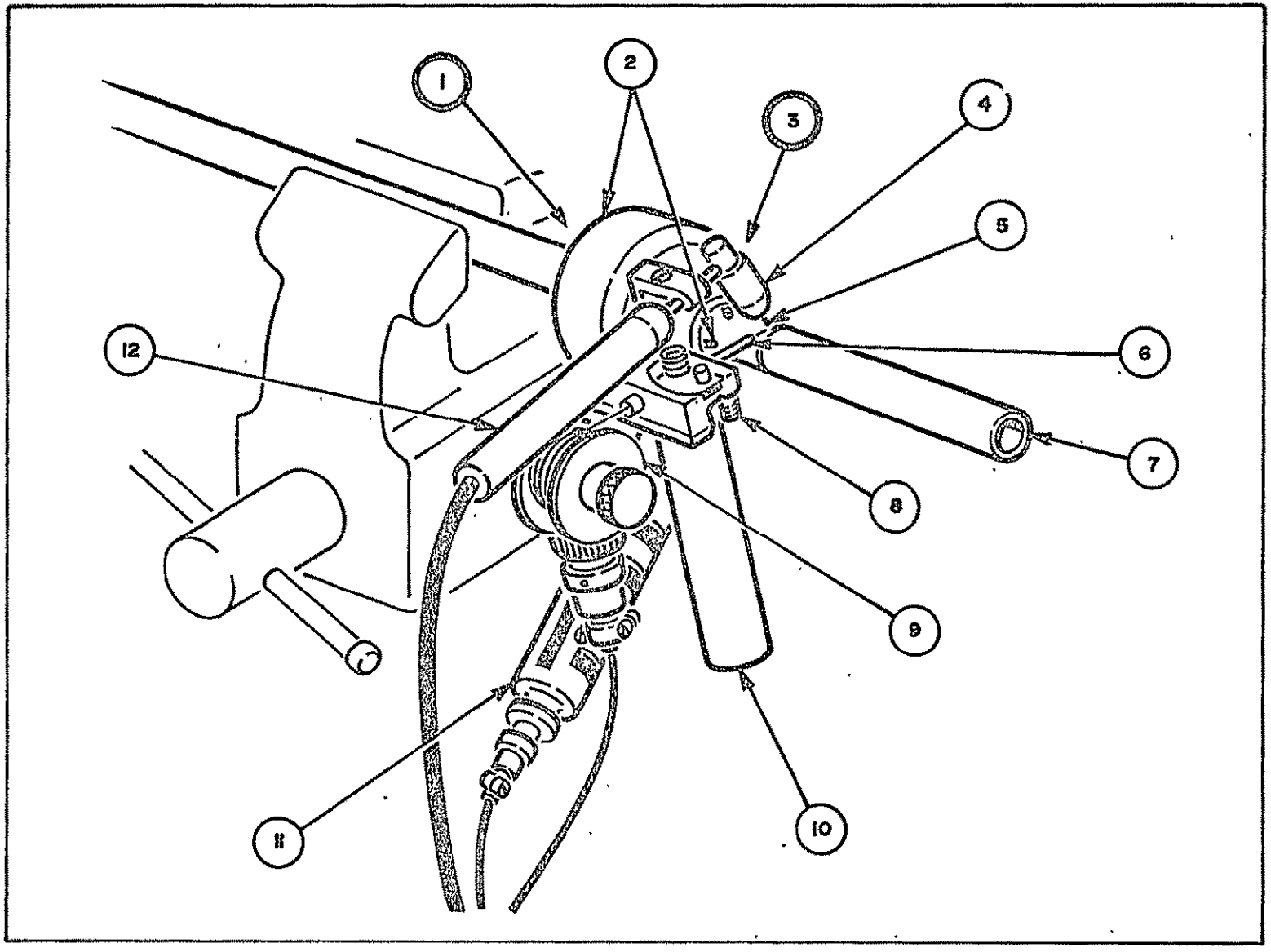


Figure 10. Small Carriage and Torch Assembly - Controls and Functions. (Sheet 1 of 2)

Figure 10 (Cont.). Small Carriage and Torch Assembly - Controls and Functions. (Sheet 2 of 2)

ITEM	CALLOUTS	FUNCTION
1	CARRIAGE	Rotates the torch assembly 360° around the workpiece.
2	Carriage Adj. Set Screw(s)	Adjustment screws for alignment of carriage.
3	TORCH ASSEMBLY	Rotates 360° around the workpiece.
4	Torch Cup	Assures concentration of the shielding gas at the torch.
5	Torch Tip	Establishes current at the workpiece.
6	Wire Guide	Directs the filler metal to the workpiece.
7	Workpiece	Two sections of pipe, used for butt welding test.
8	Torch Assembly Adjustment	Moves assembly "in" or "out."
9	Wire Spool	Supplies filler metal.
10	Wire Feed Unit	Controls the rate at which the filler metal is added during the welding operation.
11	Travel Motor	An integral part of the carriage and acts as a drive motor for the split-ring gear.
12	Torch	Performs welding process.

3.3.3 System Shutdown (Short and Long Duration).- The following system shutdown instructions are applicable to both the large and small carriage and torch assemblies.

3.3.3.1 System Shutdown (Short Duration).-

a. Place the main power switch in the OFF position.
b. Turn the shielding gas to the OFF position.
c. Place the pump switch in the OFF position.
d Place the torch assembly in a safe location.
e. Disconnect the power supply unit from the power source.

3.3.3.2 System Shutdown (Long Duration).-

a. Latch the carriage halves together and disconnect the travel motor cable.
b. Remove the torch (small carriages only) and disconnect the torch cable.
c. Disconnect the wire-feed unit cable.

SECTION IV. PROCEDURAL INFORMATION

4.1 GENERAL

All automatic welding of stainless steel pipe and tubing, Invar 36 pipe, carbon steel pipe, and aluminum pipe shall meet the requirements of Specification KSC-SPEC-Z-0016.

4.1.1 Weld Process - The operating principle employed in the method and equipment described herein consists of a pulsating-arc tungsten inert gas welding process. The APW-3 is an abbreviation for automatic pipe welding - 300 ampere power source. The addition of (modified) following the APW-3 indicates that electrical modifications were made in the power source to provide the pulsating-arc feature.

4 1.2 Qualifications. - All welding operators shall be qualified in accordance with Specification KSC-SPEC-Z-0016.

4.1.2.1 Manual Welders.- All manual welders incorporating weld beads in the final weld shall be qualified to Specification KSC-SPEC-Z-0002 for aluminum or KSC-SPEC-Z-0003 for stainless steel and invar or ASME Boiler and Pressure Vessel Code, Section IX for carbon steel, whichever is applicable.

4.1.2.2 Tack Welders.- All tack welders shall be competent, but not necessarily qualified welders.

4.2 RECORDS

Records of all tests and related data shall be kept on file and available to all authorized Government representatives.

4.3 MATERIALS

4.3.1 Base Metals and Filler Metals.- All base metals and filler metals shall be in accordance with the requirements of Specification KSC-SPEC-Z-0016. Filler metal diameter shall be 0.035 inch.

4.3.2 Tungsten Electrodes.- Tungsten electrodes shall be 3/32 inch diameter, 2 percent thoriated and shall conform to ASTM B297.

4.3.3 Shielding and Purging Gases.- Only argon or helium or a combination of argon and helium gases shall be used. The type of shielding and purging gas, and their corresponding flow rates, shall be in accordance with the applicable welding procedure data sheet.

4.3.3.1 Argon.- Argon gas shall conform to MIL-A-18455.

4.3.3 2 Helium.- Helium gas shall conform to MIL-P-27407.

4.3.4 Consumable Inserts.- When used, consumable inserts shall conform to MIL-I-23413. Consumable inserts shall be as specified on each respective welding procedure data sheet, see Section V.

NOTE: Welding procedure data sheets in Section V give the joint design, weld sequence, equipment settings, and unique information for each specific weld. Welds are classified by base metal, pipe diameter, wall thickness and welding position. See 5.2, Index of Effective Welding Procedure Data Sheets, for easy location.

4.4 JOINT PREPARATION

4.4.1 Joint Design.- Joint ends shall be prepared by machining, grinding or filing as shown on each respective data sheet, see Section V.

4.4.2 PreWeld Cleaning.- Prior to welding, all foreign matter that may be detrimental to the weld shall be cleaned for a distance of 1 inch on the inside and outside of each joint. Solvent cleaning shall be used. All cleaning shall be done before assembly of the joint. Solvents shall not be used after joint is assembled. nless steel and invar or ASME Boiler and Pressure

4.4.3 Joint Fit-Up.- Abutting joint ends shall be aligned so as to minimize mismatch. The joint gap shall be as shown on each respective welding procedure data sheet, see Section V.

4.4.4 Tack Weld.- Using either the manual tungsten inert gas or the pulsating-arc tungsten inert gas process, the joint shall be tack welded to prevent movement of the pipe or tube. The number and size of tack welds will be determined by the size of the pipe or tube. Tack welds to be incorporated in the final weld shall be sound, fully penetrated, and free from surface defects. All defective tack welds shall be removed and replaced before welding of root pass.

4.5 Weld SEQUENCE

The number and placement of passes are shown on each respective welding procedure data sheet, see Section V.

4.5.1 Root Pass.- In the horizontal fixed pipe position, the root pass shall be initiated at the position listed on each respective welding procedure data sheet, see Section V, and continued counter-clockwise until pass is completed. In the vertical fixed pipe position, the root pass may be started at any location.

4.5.2 Interpass Inspection and Cleaning.- All weld beads shall be visually inspected for fusion, weld contour, and surface defects. All defects shall be removed before initiation of next bead. All locations shall be feathered flush by grinding where the arc has been broken. Prior to welding each successive pass, the joint shall be thoroughly cleaned by brushing with a stainless steel wire brush.

4.6 INSPECTION

4.6.1 Visual Inspection.- The completed weld shall be visually inspected for fusion, undercutting, weld contour, and surface defects in accordance with the requirements of Specification KSC-SPEC-Z-0016.

4.6.2 Liquid Penetrant Inspection.- When required the completed weld shall be liquid penetrant inspected in accordance with the requirements of Specification KSC-SPEC-Z-0016.

4.6.3 Radiographic Inspection.- The completed weld shall be 100 percent radiographically inspected in accordance with the requirements of KSC-SPEC-Z-0016.

SECTION V. WELDING PROCEDURE DATA SHEETS

5.1 GENERAL

This section contains the welding procedure data sheets for the APW-3 (Modified) Automatic Pipe Welding System in performing the specific welds listed in paragraph 5.2. The welds are identified by base material, diameter, wall thickness and welding position. Each data sheet describes the materials used, such as the type and size of filler metal and insert if used, the type and flow rate of shielding and purging gases, and the type, size and extension of nonconsumable electrode. Also incorporated are the joint design, welding sequence and the equipment settings and temperature control for each pass.

5.2 INDEX OF EFFECTIVE WELDING PROCEDURE DATA SHEETS

5.2.1 Tubing.

Material	Diameter (Inches)	Wall Thickness (Inches)	Welding Position	Page
Stainless Steel	3/8	.035	Horizontal	5-3/5-4
Stainless Steel	3/8	.035	Vertical	5-5/5-6
Stainless Steel	1/2	.049	Horizontal	5-7/5-8
Stainless Steel	1/2	.049	Vertical	5-9/5-10
Stainless Steel	1/2	.065	Horizontal	5-11/5-12
Stainless Steel	3/4	.049	Horizontal	5-13/5-14
Stainless Steel	1	.095	Horizontal	5-15/5-16
Stainless Steel	1	.095	Vertical	5-17/5-18
Stainless Steel	1-1/2	.040	Horizontal	5-19/5-20

5.2.2 Piping.

Material	Diameter (Inches)	Wall Thickness Schedule	Welding Position	Page
Carbon Steel	2-1/2	XXS	Horizontal	5-21/5-22
Carbon Steel	2-1/2	XXS	Vertical	5-23/5-24
Stainless Steel	1-1/4	5S	Horizontal	5-25/5-26
Stainless Steel	1-1/4	5S	Vertical	5-27/5-28
Stainless Steel	1-1/4	160	Horizontal	5-29/5-30
Stainless Steel	1-1/4	160	Vertical	5-31/5-32
Stainless Steel	2-1/2	XXS	Horizontal	5-33/5-34
Stainless Steel	2-1/2	XXS	Vertical	5-35/5-36
Stainless Steel	8	10S	Vertical	5-39/5-40
Stainless Steel	10	40S	Vertical	5-41/5-44
Invar 36	8	10S	Vertical (I)	5-45/5-46
Invar 36	8	10S	Vertical (II)	5-47/5-48
Invar to Stainless Steel	8	10S	Vertical	5-49/5-50

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 304 Stainless Steel

SIZE: 3/8 inch diameter -.035 inch Wall

WELDING POSITION: Horizontal

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 3-4

JOINT DESIGN AND WELD SEQUENCE: 1 Pass, Square Butt, No Gap

	PASS NO. 1		PASS NO.		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308					
FILLER METAL SIZE (inches)	.035					
ELECTRODE TYPE	2% TH					
ELECTRODE DIAMETER (inches)	3/32					
ELECTRODE EXTENSION(inches)	5/16					
STARTING POSITION	12:00					
LOW CURRENT		050 ± 5				
HIGH CURRENT		045 ± 5				
TRAVEL (% SPEED)		1000				
WIRE FEED (% SPEED)		080 ± 10				
TRAVEL DELAY (seconds)		1-1/2 ±1/2				
WELD CYCLE TIME (seconds)	22 ± 2					
SLOPE Setting		1000				
SAFETY TIME (seconds)		4 ± 1				
CURRENT STEP		N/A				
STEP TIME (seconds)		N/A				
ARC LENGTH (inches)	1/16					
AUTO. VOLTAGE CONTROL		N/A				
OSCILLATOR SETTING		N/A				
PREHEAT TEMP. °F	AMB					
INTERPASS TEMP. °F	N/A					
PULSE FREQUENCY, CPS.		B				

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 304 Stainless Steel

SIZE: 3/8 inch diameter - .035 inch Wall

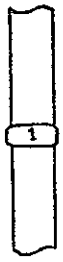
WELDING POSITION: Vertical

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 3-4

JOINT DESIGN AND WELD SEQUENCE: 1 Pass, Square Butt, No Gap



	PASS NO. 1		PASS NO.		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308					
FILLER METAL SIZE (inches)	.035					
ELECTRODE TYPE	2% TH					
ELECTRODE DIAMETER (inches)	3/32					
ELECTRODE EXTENSION(inches)	5/16					
STARTING POSITION	N/A					
LOW CURRENT		050 ± 5				
HIGH CURRENT		038 ± 4				
TRAVEL (% SPEED)		1000				
WIRE FEED (% SPEED)		080 ± 10				
TRAVEL DELAY (seconds)		1-1/2±1/2				
WELD CYCLE TIME (seconds)	22 ± 2					
SLOPE Setting		1000				
SAFETY TIME (seconds)		4 ± 1				
CURRENT STEP		N/A				
STEP TIME (seconds)		N/A				
ARC LENGTH (inches)	1/16					
AUTO. VOLTAGE CONTROL		N/A				
OSCILLATOR SETTING		N/A				
PREHEAT TEMP. °F	AMB					
INTERPASS TEMP. °F	N/A					
PULSE FREQUENCY, CPS.		B				

WELDING PROCEDURE DATA SHEET

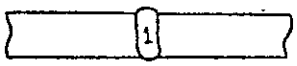
MATERIAL: Type 304 Stainless Steel

JOINT DESIGN AND WELD SEQUENCE: 1 Pass, Square Butt, No Gap

SIZE: 1/2 inch diameter - .049 inch Wall

WELDING POSITION: Horizontal

INSERT SIZE: None



SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 5

	PASS NO. 1		PASS NO.		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308					
FILLER METAL SIZE (inches)	.035					
ELECTRODE TYPE	2% TH					
ELECTRODE DIAMETER (inches)	3/32					
ELECTRODE EXTENSION(inches)	5/16					
STARTING POSITION	12:00					
LOW CURRENT		080 ± 8				
HIGH CURRENT		080 ± 8				
TRAVEL (% SPEED)		650 ± 25				
WIRE FEED (% SPEED)		130 ± 20				
TRAVEL DELAY (seconds)		2-1/2±1/2				
WELD CYCLE TIME (seconds)	27 ± 3					
SLOPE Setting		1000				
SAFETY TIME (seconds)		7 ± 2				
CURRENT STEP		500 ± 50				
STEP TIME (seconds)		12 ± 2				
ARC LENGTH (inches)	1/8					
AUTO. VOLTAGE CONTROL		N/A				
OSCILLATOR SETTING		N/A				
PREHEAT TEMP. °F	AMB					
INTERPASS TEMP. °F	N/A					
PULSE FREQUENCY, CPS.		B				

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 304 Stainless Steel

SIZE: 1/2 inch diameter - .049 inch Wall

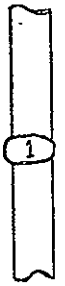
WELDING POSITION: Vertical

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. .5

JOINT DESIGN AND WELD SEQUENCE: 1 Pass, Square Butt No Gap



	PASS NO. 1		PASS NO.		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308					
FILLER METAL SIZE (inches)	.035					
ELECTRODE TYPE	2% TH					
ELECTRODE DIAMETER (inches)	3/32					
ELECTRODE EXTENSION(inches)	5/16					
STARTING POSITION	N/A					
LOW CURRENT		080 ± 8				
HIGH CURRENT		080 ± 8				
TRAVEL (% SPEED)		650 ± 25				
WIRE FEED (% SPEED)		130 ± 20				
TRAVEL DELAY (seconds)		2-1/2+1/2				
WELD CYCLE TIME (seconds)	27 ± 3					
SLOPE Setting		1000				
SAFETY TIME (seconds)		7 ± 2				
CURRENT STEP		500 ± 50				
STEP TIME (seconds)		12 ± 2				
ARC LENGTH (inches)	1/8					
AUTO. VOLTAGE CONTROL		N/A				
OSCILLATOR SETTING		N/A				
PREHEAT TEMP. °F	AMB					
INTERPASS TEMP. °F	N/A					
PULSE FREQUENCY, CPS.		B				

WELDING PROCEDURE DATA SHEET

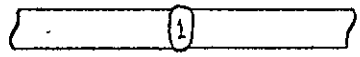
MATERIAL: Type 304 Stainless Steel

SIZE: 1/2 inch diameter - .065 inch Wall

JOINT DESIGN AND WELD SEQUENCE: 1 Pass, Square Butt, No Gap

WELDING POSITION: Horizontal

INSERT SIZE: None



SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 5

	PASS NO. 1		PASS NO.		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308					
FILLER METAL SIZE (inches)	.035					
ELECTRODE TYPE	2% TH					
ELECTRODE DIAMETER (inches)	3/32					
ELECTRODE EXTENSION(inches)	5/16					
STARTING POSITION	10:00					
LOW CURRENT		100 ± 10				
HIGH CURRENT		140 ± 15				
TRAVEL (% SPEED)		660 ± 40				
WIRE FEED (% SPEED)		280 ± 25				
TRAVEL DELAY (seconds)		3 ± 1				
WELD CYCLE TIME (seconds)	29 ± 2					
SLOPE Setting		600 ± 100				
SAFETY TIME (seconds)		5 ± 1				
CURRENT STEP		470 ± 10				
STEP TIME (seconds)		12 ± 1				
ARC LENGTH (inches)	1/8					
AUTO. VOLTAGE CONTROL		N/A				
OSCILLATOR SETTING		N/A				
PREHEAT TEMP. °F	AMB					
INTERPASS TEMP. °F	N/A					
PULSE FREQUENCY, CPS.		B				

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 304 Stainless Steel

SIZE: 3/4 inch diameter - .049 inch Wall

WELDING POSITION: Horizontal

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 4-5

JOINT DESIGN AND WELD SEQUENCE: 1 Pass, Square Butt, No Gap

	PASS NO. 1		PASS NO.		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308					
FILLER METAL SIZE (inches)	.035					
ELECTRODE TYPE	2% TH					
ELECTRODE DIAMETER (inches)	3/32					
ELECTRODE EXTENSION(inches)	5/16					
STARTING POSITION	11:00					
LOW CURRENT		083 ± 10				
HIGH CURRENT		076 ± 10				
TRAVEL (% SPEED)		400 ± 25				
WIRE FEED (% SPEED)		180 ± 20				
TRAVEL DELAY (seconds)		3 ± 1				
WELD CYCLE TIME (seconds)	49 ± 5					
SLOPE Setting		900 ± 100				
SAFETY TIME (seconds)		7 ± 1				
CURRENT STEP		500 ± 50				
STEP TIME (seconds)		30 ± 3				
ARC LENGTH (inches)	1/8					
AUTO. VOLTAGE CONTROL		N/A				
OSCILLATOR SETTING		N/A				
PREHEAT TEMP. °F	AMB					
INTERPASS TEMP. °F	N/A					
PULSE FREQUENCY, CPS.		B				

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 304 Stainless Steel JOINT DESIGN AND WELD SEQUENCE: 1 Pass, Square Butt, No Gap

SIZE: 1 inch diameter - .095 inch Wall

WELDING POSITION: Horizontal

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 5

	PASS NO. 1		PASS NO.		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308					
FILLER METAL SIZE (inches)	.035					
ELECTRODE TYPE	2% TH					
ELECTRODE DIAMETER (inches)	3/32					
ELECTRODE EXTENSION(inches)	5/16					
STARTING POSITION	11:00					
LOW CURRENT		130 ± 15				
HIGH CURRENT		220 ± 20				
TRAVEL (% SPEED)		300 ± 20				
WIRE FEED (% SPEED)		140 ± 15				
TRAVEL DELAY (seconds)		4 ± 1				
WELD CYCLE TIME (seconds)	57 ± 4					
SLOPE Setting		800 ± 100				
SAFETY TIME — (seconds)		6 ± 1				
CURRENT STEP		600 ± 15				
STEP TIME (seconds)		25 ± 5				
ARC LENGTH (inches)	3/32					
AUTO. VOLTAGE CONTROL		N/A				
OSCILLATOR SETTING		N/A				
PREHEAT TEMP. °F	AMB					
INTERPASS TEMP. °F	N/A					
PULSE FREQUENCY, CPS.		B				

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 304 Stainless Steel

SIZE: 1 inch diameter - .095 inch Wall

WELDING POSITION: Vertical

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 5

JOINT DESIGN AND WELD SEQUENCE: 1 Pass Square Butt, No Gap

	PASS NO. 1		PASS NO.		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308					
FILLER METAL SIZE (inches)	.035					
ELECTRODE TYPE	2% TH					
ELECTRODE DIAMETER (inches)	3/32					
ELECTRODE EXTENSION(inches)	5/16					
STARTING POSITION	N/A					
LOW CURRENT		130 ± 15				
HIGH CURRENT		220 ± 20				
TRAVEL (% SPEED)		300 ± 20				
WIRE FEED (% SPEED)		140 ± 15				
TRAVEL DELAY (seconds)		4 ± 1				
WELD CYCLE TIME (seconds)	57 ± 4					
SLOPE Setting		800 ± 100				
SAFETY TIME (seconds)		6 ± 1				
CURRENT STEP		650 ± 15				
STEP TIME (seconds)		25 ± 5				
ARC LENGTH (inches)	3/32					
AUTO. VOLTAGE CONTROL		N/A				
OSCILLATOR SETTING		N/A				
PREHEAT TEMP. °F	AMB					
INTERPASS TEMP. °F	N/A					
PULSE FREQUENCY, CPS.		B				

WELDING PROCEDURE DATA SHEET

MATERIAL: Carbon Steel

SIZE: 2-1/2" diameter Schedule XXS

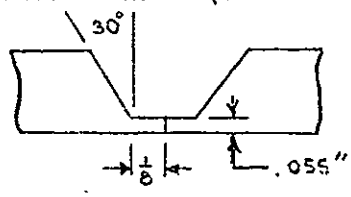
WELDING POSITION: Horizontal

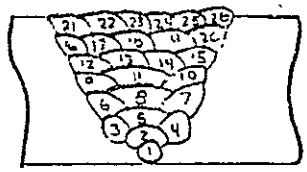
INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15 - 25

PURGING GAS: Argon FLOW RATE, C.F.H. 5

JOINT DESIGN AND WELD SEQUENCE: 26 Passes
No Gap





DESCRIPTION	PASS NO. 1		PASS NO 2 & 3		PASS NO. 4	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	L 65		L 65		L 65	
FILLER METAL SIZE (inches)	.035		.035		.035	
ELECTRODE TYPE	2% TH		2% TH		2% TH	
ELECTRODE DIAMETER (inches)	3/32		3/32		3/32	
ELECTRODE EXTENSION(inches)	5/16		5/16		5/16	
STARTING POSITION	9:00		9:00		9:00	
LOW CURRENT		213±20		213±20		213±20
HIGH CURRENT		433±45		380±40		380±40
TRAVEL (% SPEED)		250±15		250±15		250±15
WIRE FEED (% SPEED)		290±20		290±20		290±20
TRAVEL DELAY (seconds)		5±1		5±1		5±1
WELD CYCLE TIME (seconds)	160±10		160±10		160±10	
SLOPE Setting		600±100		600±100		600±100
SAFETY TIME (seconds)		11±2		11±2		11±2
CURRENT STEP	(2)	830/750	(2)	830/750		830±80
STEP TIME (seconds)	(2)	45/65	(2)	45/65		45±5
ARC LENGTH (inches)	3/32		3/32		3/32	
AUTO. VOLTAGE CONTROL		N/A		N/A		N/A
OSCILLATOR SETTING		N/A		N/A		N/A
PREHEAT TEMP. °F	AMB		N/A		N/A	
INTERPASS TEMP. °F	N/A		N/A		N/A	
PULSE FREQUENCY, CPS.		B		B		B

WELDING PROCEDURE DATA SHEET

MATERIAL: Carbon Steel

SIZE: 2-1/2" diameter Schedule XXS

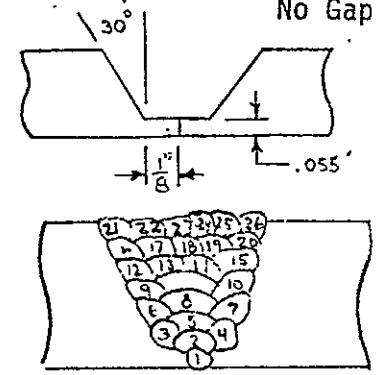
WELDING POSITION: Horizontal

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15- 25

PURGING GAS: Argon FLOW RATE, C.F.H. 5

JOINT DESIGN AND WELD SEQUENCE: 26 Passes No Gap



DESCRIPTION	PASS NO. 5-12		PASS NO. 13-26		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	L 65		L65			
FILLER METAL SIZE (inches)	.035		.035			
ELECTRODE TYPE	2% TH		2% TH			
ELECTRODE DIAMETER (inches)	3/32		3/32			
ELECTRODE EXTENSION(inches)	5/16		5/16			
STARTING POSITION	9:00		9:00			
LOW CURRENT		260±25		260±25		
HIGH CURRENT		455±45		455±45		
TRAVEL (% SPEED)		250±15		200±15		
WIRE FEED (% SPEED)		290±20		290±20		
TRAVEL DELAY (seconds)		5±1		5±1		
WELD CYCLE TIME (seconds)	160±10		188±10			
SLOPE Setting		600±100		600±100		
SAFETY TIME (seconds)		11±2		11±2		
CURRENT STEP		830±80		830±80		
STEP TIME (seconds)		45±5		45±5		
ARC LENGTH (inches)	3/32		3/32			
AUTO. VOLTAGE CONTROL		N/A		N/A		
OSCILLATOR SETTING		N/A		N/A		
PREHEAT TEMP. °F	N/A		N/A			
INTERPASS TEMP. °F	N/A		N/A			
PULSE FREQUENCY, CPS.		B		B		

WELDING PROCEDURE DATA SHEET

MATERIAL: Carbon Steel

SIZE: 2-1/2 inch diameter - Schedule XXS

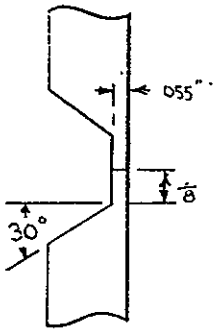
WELDING POSITION: Vertical

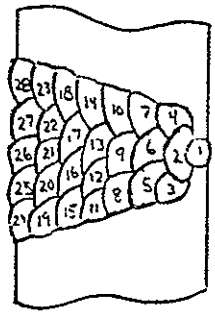
INSERT SIZE: Argon

SHIELDING GAS: Argon FLOW RATE, C.F.H. 20

PURGING GAS: FLOW RATE, C.F.H. 5

JOINT DESIGN AND WELD SEQUENCE: 28 Passes
No Gap





	PASS NO. 1		PASS NO. 2-3		PASS NO. 4-22	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	L65		L65		L65	
FILLER METAL SIZE (inches)	.035		.035		.035	
ELECTRODE TYPE	2% TH		2% TH		2% TH	
ELECTRODE DIAMETER (inches)	3/32		3/32		3/32	
ELECTRODE EXTENSION(inches)	3/8		3/8		3/8	
STARTING POSITION	N/A		N/A		N/A	
LOW CURRENT		230 ± 20		230 ± 20		230 ± 20
HIGH CURRENT		455 ± 45		420 ± 40		480 ± 45
TRAVEL (% SPEED)		300 ± 20		300 ± 20		300 ± 20
WIRE FEED (% SPEED)		300 ± 30		330 ± 30		450 ± 45
TRAVEL DELAY (seconds)		5 ± 1		5 ± 1		5 ± 1
WELD CYCLE TIME (seconds)	142 ±10		142±10		140±10	
SLOPE Setting		500 ±100		500± 100		500 ± 100
SAFETY TIME (seconds)		10 ±2		10± 2		10 ± 1
CURRENT STEP		N/A		N/A		N/A
STEP TIME (seconds)		N/A		N/A		N/A
ARC LENGTH (inches)	1/8		1/8		1/8	
AUTO. VOLTAGE CONTROL		N/A		N/A		N/A
OSCILLATOR SETTING		N/A		N/A		N/A
PREHEAT TEMP. °F	AMB		AMB		AMB	
INTERPASS TEMP. °F	N/A		N/A		N/A	
PULSE FREQUENCY, CPS.		B		B		B

WELDING PROCEDURE DATA SHEET

MATERIAL: Carbon Steel

JOINT DESIGN AND WELD SEQUENCE: 28 Passes-No Gap

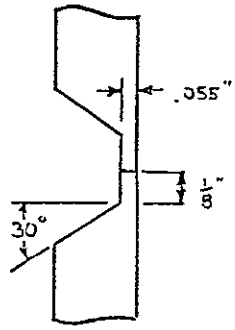
SIZE: 2-1/2 inch diameter - Schedule XXS

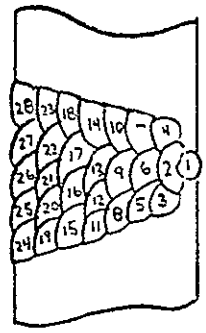
WELDING POSITION: Vertical

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 20

PURGING GAS: Argon FLOW RATE, C.F.H. 5





	PASS NO. 23 - 28		PASS NO.		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	L65					
FILLER METAL SIZE (inches)	.035					
ELECTRODE TYPE	2% TH					
ELECTRODE DIAMETER (inches)	3/32					
ELECTRODE EXTENSION(inches)	3/8					
STARTING POSITION	N/A					
LOW CURRENT		250 ± 15				
HIGH CURRENT		450 ± 45				
TRAVEL (% SPEED)		300 ± 20				
WIRE FEED (% SPEED)		450 ± 45				
TRAVEL DELAY (seconds)		5 ± 1				
WELD CYCLE TIME (seconds)	142 ±10					
SLOPE Setting		500 ± 100				
SAFETY TIME (seconds)		10 ± 2				
CURRENT STEP		N/A				
STEP TIME (seconds)		N/A				
ARC LENGTH (inches)	1/8					
AUTO. VOLTAGE CONTROL		N/A				
OSCILLATOR SETTING		N/A				
PREHEAT TEMP. °F	AMB					
INTERPASS TEMP. °F	N/A					
PULSE FREQUENCY, CPS.		B				

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 304 Stainless Steel JOINT DESIGN AND WELD SEQUENCE: 1 Pass, Square Butt, No Gap

SIZE: 1-1/4 inch diameter - Schedule 5S

WELDING POSITION: Horizontal

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 5

	PASS NO. 1		PASS NO.		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308					
FILLER METAL SIZE (inches)	.035					
ELECTRODE TYPE	2% TH					
ELECTRODE DIAMETER (inches)	3/32					
ELECTRODE EXTENSION(inches)	3/8					
STARTING POSITION	10:00					
LOW CURRENT		100 ± 10				
HIGH CURRENT		185 ± 20				
TRAVEL (% SPEED)		500 ± 30				
WIRE FEED (% SPEED)		170 ± 15				
TRAVEL DELAY (seconds)		4 ± 1				
WELD CYCLE TIME (seconds)	82 ± 7					
SLOPE Setting		750 ± 100				
SAFETY TIME (seconds)		7 ± 2				
CURRENT STEP		850 ± 85				
STEP TIME (seconds)		60 ± 5				
ARC LENGTH (inches)	1/8					
AUTO. VOLTAGE CONTROL		N/A				
OSCILLATOR SETTING		N/A				
PREHEAT TEMP. °F	AMB					
INTERPASS TEMP. °F	N/A					
PULSE FREQUENCY, CPS.		B				

5-25/5-26

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 304 Stainless Steel

SIZE: 1-1/4 inch diameter - Schedule 5S

WELDING POSITION: Vertical

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 5

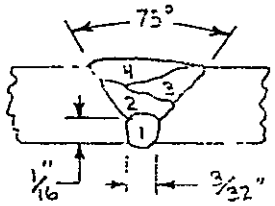
JOINT DESIGN AND WELD SEQUENCE: 1 Pass, Square Butt, No Gap

	PASS NO. 1		PASS NO.		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308					
FILLER METAL SIZE (inches)	.035					
ELECTRODE TYPE	2% TH					
ELECTRODE DIAMETER (inches)	3/32					
ELECTRODE EXTENSION(inches)	3/8					
STARTING POSITION	N/A					
LOW CURRENT		100 ± 10				
HIGH CURRENT		170 ± 15				
TRAVEL (% SPEED)		500 ± 30				
WIRE FEED (% SPEED)		170 ± 15				
TRAVEL DELAY (seconds)		4 ± 1				
WELD CYCLE TIME (seconds)	82 ± 5					
SLOPE Setting		750 ± 100				
SAFETY TIME (seconds)		7 ± 2				
CURRENT STEP		850 ± 85				
STEP TIME (seconds)		60 ± 4				
ARC LENGTH (inches)	3/32					
AUTO. VOLTAGE CONTROL		N/A				
OSCILLATOR SETTING		N/A				
PREHEAT TEMP. °F	AMB					
INTERPASS TEMP. °F	N/A					
PULSE FREQUENCY, CPS.		R				

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 316 Stainless Steel JOINT DESIGN AND WELD SEQUENCE: 4 Passes

SIZE: 1-1/4" diameter Schedule 160



WELDING POSITION: Horizontal

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15-20

PURGING GAS: Argon FLOW RATE, C.F.H. 5

DESCRIPTION	PASS NO. 1		PASS NO 2 & 3		PASS NO 4	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	316		316		316	
FILLER METAL SIZE (inches)	.035		.035		.035	
ELECTRODE TYPE	2% TH		2% TH		2% TH	
ELECTRODE DIAMETER (inches)	3/32		3/32		3/32	
ELECTRODE EXTENSION(inches)	7/16		7/16		7/16	
STARTING POSITION	8:00		N/A		N/A	
LOW CURRENT		200±20		225±20		225±20
HIGH CURRENT		345±35		460±45		430±45
TRAVEL (% SPEED)		450±25		450±25		450±25
WIRE FEED (% SPEED)		540±30		540±30		420±30
TRAVEL DELAY (seconds)		3±1		6±2		6±2
WELD CYCLE TIME (seconds)		90±5		90±5		90±5
SLOPE Setting		500±100		500±100		500±100
SAFETY TIME (seconds)		11±4		11±4		11±4
CURRENT STEP		930±20		930±20		930±20
STEP TIME (seconds)		20&60±5		20&60±5		20&60±5
ARC LENGTH (inches)	3/32		3/32		3/32	
AUTO. VOLTAGE CONTROL		N/A		N/A		N/A
OSCILLATOR SETTING		N/A		N/A		N/A
PREHEAT TEMP. °F	AMB		N/A		N/A	
INTERPASS TEMP. °F	N/A		100-250		100-250	
PULSE FREQUENCY, CPS.		B		B		B

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 316 Stainless Steel JOINT DESIGN AND WELD SEQUENCE: 5 Passes

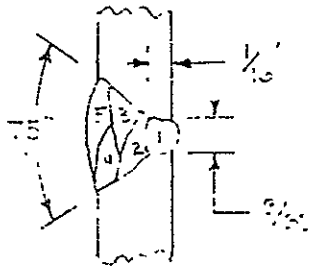
SIZE: 1-1/4" idameter Schedule 160

WELDING POSITION: Vertical

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 5



DESCRIPTION	PASS NO. 1		PASS NO. 2		PASS NO. 3	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	316		316		316	
FILLER METAL SIZE (inches)	.035		.035		.035	
ELECTRODE TYPE	2% TH		2% TH		2% TH	
ELECTRODE DIAMETER (inches)	3/32		3/32		3/32	
ELECTRODE EXTENSION(inches)	7/16		7/16		7/16	
STARTING POSITION	N/A		N/A		N/A	
LOW CURRENT		210±20		225±20		225±20
HIGH CURRENT		360±35		460±45		460±45
TRAVEL (% SPEED)		450±25		450±25		450±25
WIRE FEED (% SPEED)		500±30		600±35		400±25
TRAVEL DELAY (seconds)		3±1		5±2		7±2
WELD CYCLE TIME (seconds)	90±5		90±5		90±5	
SLOPE Setting		500±100		500±100		500±100
SAFETY TIME (seconds)		9±2		9±2		9±2
CURRENT STEP		N/A		N/A		N/A
STEP TIME (seconds)		N/A		N/A		N/A
ARC LENGTH (inches)	3/32		3/32		3/32	
AUTO. VOLTAGE CONTROL		N/A		N/A		N/A
OSCILLATOR SETTING		N/A		N/A		N/A
PREHEAT TEMP. °F.	AMB		N/A		N/A	
INTERPASS TEMP. °F	N/A		250max		250max	
PULSE FREQUENCY, CPS.		B		B		B

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 316 Stainless Steel JOINT DESIGN AND WELD SEQUENCE: 5 Passes

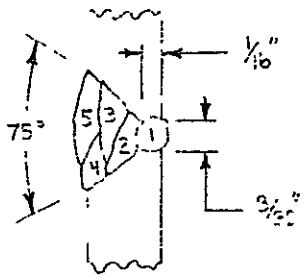
SIZE: 1-1/4" diameter Schedule 160

WELDING POSITION: Vertical

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 5



DESCRIPTION	PASS NO. 4 & 5		PASS NO.		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	316					
FILLER METAL SIZE (inches)	.035					
ELECTRODE TYPE	2% TH					
ELECTRODE DIAMETER (inches)	3/32					
ELECTRODE EXTENSION(inches)	7/16					
STARTING POSITION	N/A					
LOW CURRENT		210±20				
HIGH CURRENT		460±45				
TRAVEL (% SPEED)		450±25				
WIRE FEED (% SPEED)		240±20				
TRAVEL DELAY (seconds)		5±20				
WELD CYCLE TIME (seconds)	90±5					
SLOPE Setting		500±100				
SAFETY TIME (seconds)		9±2				
CURRENT STEP		N/A				
STEP TIME (seconds)		N/A				
ARC LENGTH (inches)	3/32					
AUTO. VOLTAGE CONTROL		N/A				
OSCILLATOR SETTING		N/A				
PREHEAT TEMP. °F	N/A					
INTERPASS TEMP. °F	250 max.					
PULSE FREQUENCY, CPS.		B				

W E L D I N G P R O C E D U R E D A T A S H E E T

MATERIAL: Type 304 Stainless Steel

SIZE: 2-1/2 inch diameter - Schedule XXS

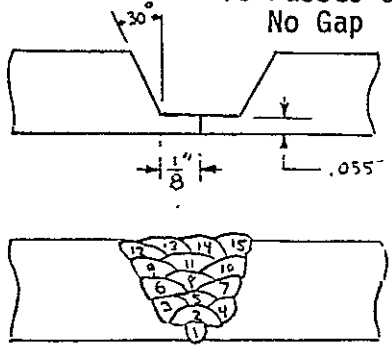
WELDING POSITION: Horizontal

INSERT SIZE: 5/32 inches

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15-25

PURGING GAS: Argon FLOW RATE, C.F.H. 4-5

JOINT DESIGN AND WELD SEQUENCE: 15 Passes and up



	PASS NO. 1		PASS NO. 2 - 4		PASS NO. 5 - 9	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308		308		308	
FILLER METAL SIZE (inches)	.035		.035		.035	
ELECTRODE TYPE	2% TH		2% TH		2% TH	
ELECTRODE DIAMETER (inches)	3/32		3/32		3/32	
ELECTRODE EXTENSION(inches)	5/16		5/16		5/16	
STARTING POSITION	1:00		N/A		N/A	
LOW CURRENT		220 ± 20		220 ± 20		220 ± 20
HIGH CURRENT		275 ± 25		275 ± 25		460 ± 45
TRAVEL (% SPEED)		300 ± 20		300 ± 20		240 ± 15
WIRE FEED (% SPEED)				360 ± 35		500 ± 50
TRAVEL DELAY (seconds)		3 ± 1		3 ± 1		5 ± 1
WELD CYCLE TIME (seconds)	135 ± 10		135±10		165± 10	
SLOPE Setting		500 ± 100		500 ± 100		500 ± 100
SAFETY TIME (seconds)		9 ± 2		9 ± 2		9 ± 2
CURRENT STEP		N/A		N/A		N/A
STEP TIME (seconds)		N/A		N/A		N/A
ARC LENGTH (inches)	3/32		3/32		1/8	
AUTO. VOLTAGE CONTROL		N/A		N/A		N/A
OSCILLATOR SETTING		N/A		N/A		N/A
PREHEAT TEMP. °F	AMB		N/A		N/A	
INTERPASS TEMP. °F	N/A		100-250		100-250	
PULSE FREQUENCY, CPS.		B		B		B

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 304 Stainless Steel

SIZE: 2-1/2 inch diameter - Schedule XXS

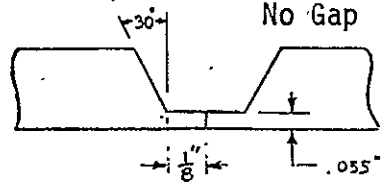
WELDING POSITION: Horizontal

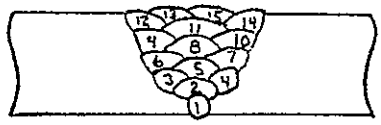
INSERT SIZE: 5/32 inches

SHIELDING GAS: Argon FLOW RATE, C.F.H.15-25

PURGING GAS: Argon FLOW RATE, C.F.H. 4-5

JOINT DESIGN AND WELD SEQUENCE:15 Passes and up





	PASS NO. 10 - 14		PASS NO. 15 & up		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308		308			
FILLER METAL SIZE (inches)	.035		.035		.035	
ELECTRODE TYPE	2% TH		2% TH			
ELECTRODE DIAMETER (inches)	3/32		3/32			
ELECTRODE EXTENSION(inches)	5/16		5/16			
STARTING POSITION	N/A		N/A			
LOW CURRENT		220 ± 20		220 ± 20		
HIGH CURRENT		460 ± 45		460 ± 45		
TRAVEL (% SPEED)		210 ± 15		190 ± 10		
WIRE FEED (% SPEED)		500 ± 50		500 ± 50		
TRAVEL DELAY (seconds)		5 ± 1		5 ± 1		
WELD CYCLE TIME (seconds)	180 ±15		200±15			
SLOPE Setting		500±100		500 ± 100		
SAFETY TIME (seconds)		9±2		9 ± 2		
CURRENT STEP		N/A		N/A		
STEP TIME (seconds)		N/A		N/A		
ARC LENGTH (inches)	1/8		1/8			
AUTO. VOLTAGE CONTROL		N/A		N/A		
OSCILLATOR SETTING		N/A		N/A		
PREHEAT TEMP. °F	N/A		N/A			
INTERPASS TEMP. °F	100-250		100-250			
PULSE FREQUENCY, CPS.		B		B		

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 304 Stainless Steel

SIZE: 2-1/2 inch diameter - Schedule XXS

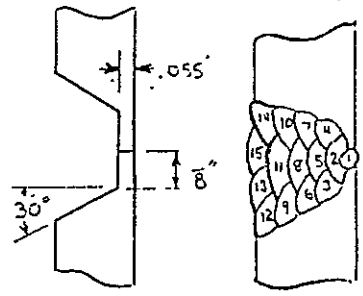
WELDING POSITION: Vertical

INSERT SIZE: 5/32 inch

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15-25

PURGING GAS: Argon FLOW RATE, C.F.H. 4-5

JOINT DESIGN AND WELD SEQUENCE: 9 Passes and up
No Gap



	PASS NO. 1		PASS NO. 2-4		PASS NO. 5-8	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308		308		308	
FILLER METAL SIZE (inches)	.035		.035		.035	
ELECTRODE TYPE	2% TH		2% TH		2% TH	
ELECTRODE DIAMETER (inches)	3/32		3/32		3/32	
ELECTRODE EXTENSION(inches)	5/16		5/16		5/16	
STARTING POSITION	N/A		N/A		N/A	
LOW CURRENT		220 ± 20		220 ± 20		220 ± 20
HIGH CURRENT		275 ± 25		275 ± 25		385 ± 40
TRAVEL (% SPEED)		310 ± 20		310 ± 20		240 ± 15
WIRE FEED (% SPEED)		--		360 ± 35		420 ± 40
TRAVEL DELAY (seconds)		4 ± 1		4 ± 1		4 ± 1
WELD CYCLE TIME (seconds)	135 ±10		135±10		165±10	
SLOPE Setting		500 ±100		500 ± 100		500 ± 100
SAFETY TIME — (seconds)		9 ±2		9 ± 2		9 ± 2
CURRENT STEP		N/A		N/A		N/A
STEP TIME (seconds)		N/A		N/A		N/A
ARC LENGTH (inches)	3/32		3/32		3/32	
AUTO. VOLTAGE CONTROL		N/A		N/A		N/A
OSCILLATOR SETTING		N/A		N/A		N/A
PREHEAT TEMP. °F	AMB		N/A		N/A	
INTERPASS TEMP. °F	N/A		250max		250max	
PULSE FREQUENCY, CPS.		B		B		B

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 304 Stainless Steel JOINT DESIGN AND WELD SEQUENCE: 9 Passes and Up No Gap

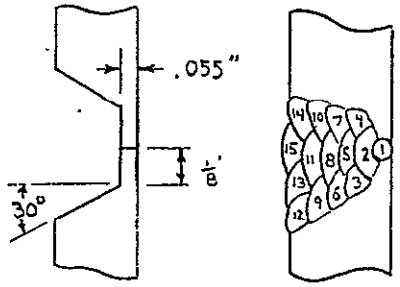
SIZE: 2-1/2 inch diameter - Schedule XXS

WELDING POSITION: Vertical

INSERT SIZE: 5/32 inch

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15-25

PURGING GAS: Argon FLOW RATE, C.F.H. 4-5



	PASS NO. 9 & up		PASS NO.		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308					
FILLER METAL SIZE (inches)	.035					
ELECTRODE TYPE	2% TH					
ELECTRODE DIAMETER (inches)	3/32					
ELECTRODE EXTENSION(inches)	5/16					
STARTING POSITION	N/A					
LOW CURRENT		220± 20				
HIGH CURRENT		460 ± 45				
TRAVEL (% SPEED)		240 ± 15				
WIRE FEED (% SPEED)		500 ± 50				
TRAVEL DELAY (seconds)		4 ± 1				
WELD CYCLE TIME (seconds)	165±10					
SLOPE Setting		500±100				
SAFETY TIME (seconds)		9 ± 2				
CURRENT STEP		N/A				
STEP TIME (seconds)		N/A				
ARC LENGTH (inches)	1/8					
AUTO. VOLTAGE CONTROL		N/A				
OSCILLATOR SETTING		N/A				
PREHEAT TEMP. °F	N/A					
INTERPASS TEMP. °F	250max.					
PULSE FREQUENCY, CPS.		B				

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 304 Stainless Steel

SIZE: 8 inch diameter - Schedule 10 S

JOINT DESIGN AND WELD SEQUENCE: 1 Pass, Square Butt, No Gap

WELDING POSITION: HORIZONTAL

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 5-7

	PASS NO. 1		PASS NO.		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308					
FILLER METAL SIZE (inches)	.035					
ELECTRODE TYPE	2% TH					
ELECTRODE DIAMETER (inches)	3/32					
ELECTRODE EXTENSION(inches)	3/8					
STARTING POSITION	12:00					
LOW CURRENT		210 ± 20				
HIGH CURRENT		270 ± 25				
TRAVEL (% SPEED)		400 ± 25				
WIRE FEED (% SPEED)		140 ± 15				
TRAVEL DELAY (seconds)		11 ± 2				
WELD CYCLE TIME (seconds)	14 ± 2					
SLOPE Setting		600 ± 100				
SAFETY TIME (seconds)		11 ± 2				
CURRENT STEP (2)		1000-900				
STEP TIME (seconds)		5 -- 8½				
ARC LENGTH (inches)	3/32					
AUTO. VOLTAGE CONTROL		37.5				
OSCILLATOR SETTING		N/A				
PREHEAT TEMP. °F	AMB					
INTERPASS TEMP. °F	N/A					
PULSE FREQUENCY, CPS.		B				

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 304 Stainless Steel

SIZE: 8" diameter Schedule 10S

WELDING POSITION: Vertical

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 5

JOINT DESIGN AND WELD SEQUENCE: Square Butt, No Gap 3 Passes

3-Fusion Pass Only

DESCRIPTION	PASS NO. 1		PASS NO. 2		PASS NO. 3	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308		308		308	
FILLER METAL SIZE (inches)	.035		.035		.035	
ELECTRODE TYPE	2% TH		2% TH		2% TH	
ELECTRODE DIAMETER (inches)	3/32		3/32		3/32	
ELECTRODE EXTENSION(inches)	5/16		5/16		5/16	
STARTING POSITION	N/A		N/A		N/A	
LOW CURRENT		200±20		200±20		220±20
HIGH CURRENT		440±45		240±25		300±30
TRAVEL (% SPEED)		300±20		300±25		360±25
WIRE FEED (% SPEED)		265±20		190±15		N/A
TRAVEL DELAY (seconds)		12±2		6±1		6±1
WELD CYCLE TIME (seconds)	-		-		-	
SLOPE Setting		750±100		750±100		750±100
SAFETY TIME (seconds)		11±2		11±2		11±2
CURRENT STEP		N/A		N/A		N/A
STEP TIME (seconds)		N/A		N/A		N/A
ARC LENGTH (inches)	3/32		3/32		3/32	
AUTO. VOLTAGE CONTROL		41.0		41.5		41.5
OSCILLATOR SETTING		N/A		N/A		N/A
PREHEAT TEMP. ^{o}F	AMB		N/A		N/A	
INTERPASS TEMP. ^{o}F	N/A		250		250	
PULSE FREQUENCY, CPS.		B		B		B

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 304 Stainless Steel

SIZE: 10" diameter Schedule 40S

WELDING POSITION: Vertical

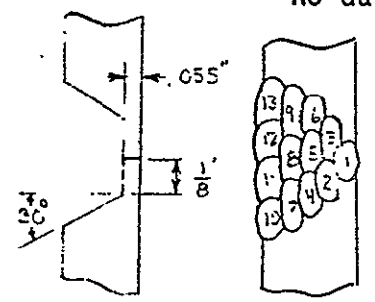
INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 5

JOINT DESIGN AND WELD SEQUENCE: 13 Passes

No Gap



DESCRIPTION	PASS NO. 1		PASS NO 2 & 3		PASS NO. 4	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308		308		308	
FILLER METAL SIZE (inches)	.035		.035		.035	
ELECTRODE TYPE	2% TH		2% TH		2% TH	
ELECTRODE DIAMETER (inches)	3/32		3/32		3/32	
ELECTRODE EXTENSION(inches)	5/16		5/16		5/16	
STARTING POSITION	10:00		N/A		N/A	
LOW CURRENT		150±15		143±15		150±15
HIGH CURRENT		263±25		247±25		320±30
TRAVEL (% SPEED)		475±30		475±30		475±30
WIRE FEED (% SPEED)		220±20		220±20		220±20
TRAVEL DELAY (seconds)		5±1		5±1		5±1
WELD CYCLE TIME (seconds)	-		-		-	
SLOPE Setting		600±100		600±100		600±100
SAFETY TIME (seconds)		10±2		10±2		10±2
CURRENT STEP		N/A		N/A		N/A
STEP TIME (seconds)		N/A		N/A		N/A
ARC LENGTH (inches)	3/32		3/32		3/32	
AUTO. VOLTAGE CONTROL		41.0		41.0		41.0
OSCILLATOR SETTING		N/A		N/A		N/A
PREHEAT TEMP. °F	AMB		N/A		N/A	
INTERPASS TEMP. °F	N/A		250max		250max	
PULSE FREQUENCY, CPS.		A		A		A

WELDING PROCEDURE DATA SHEET

MATERIAL: Type 304 Stainless Steel JOINT DESIGN AND WELD SEQUENCE: 13 Passes No Gap

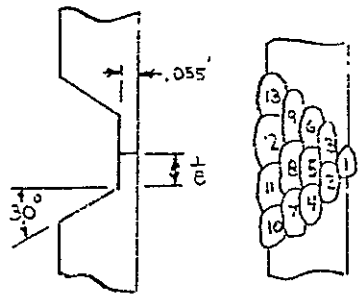
SIZE: 10" diameter Schedule 40S

WELDING POSITION: Vertical

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 5



DESCRIPTION	PASS NO. 5		PASS NO 6		PASS NO 7	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	308		308		308	
FILLER METAL SIZE (inches)	.035		.035		.035	
ELECTRODE TYPE	2% TH		2% TH		2% TH	
ELECTRODE DIAMETER (inches)	3/32		3/32		3/32	
ELECTRODE EXTENSION(inches)	5/16		5/16		5/16	
STARTING POSITION	N/A		N/A		N/A	
LOW CURRENT		200±20		200±20		225±25
HIGH CURRENT		300±30		300±30		470±45
TRAVEL (% SPEED)		475±30		475±30		475±30
WIRE FEED (% SPEED)		270±20		270±20		500±30
TRAVEL DELAY (seconds)		5±1		5±1		5±1
WELD CYCLE TIME (seconds)	-		-		-	
SLOPE Setting		600±100		600±100		600±100
SAFETY TIME (seconds)		10±2		10±2		10±2
CURRENT STEP		N/A		N/A		N/A
STEP TIME (seconds)		N/A		N/A		N/A
ARC LENGTH (inches)	3/32		3/32		3/32	
AUTO. VOLTAGE CONTROL		41.0		41.0		41.0
OSCILLATOR SETTING		N/A		N/A		N/A
PREHEAT TEMP. °F	N/A		N/A		N/A	
INTERPASS TEMP. °F	250max.		250max.		250max.	
PULSE FREQUENCY, CPS.		A		A		A

WELDING PROCEDURE DATA SHEET

MATERIAL: Invar 36

SIZE: 8 inch diameter - Schedule 10S

WELDING POSITION: Vertical I

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 7

JOINT DESIGN AND WELD SEQUENCE: 2 Passes, Square Butt, No Gap

	PASS NO. 1		PASS NO. 2		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	Invar		Invar			
FILLER METAL SIZE (inches)	.035		.035			
ELECTRODE TYPE	2% TH		2% TH,			
ELECTRODE DIAMETER (inches)	3/32		3/32			
ELECTRODE EXTENSION(inches)	1/8		1/8			
STARTING POSITION	N/A		N/A			
LOW CURRENT		220 ± 20		200 ± 20		
HIGH CURRENT		470 ± 45		240 ± 25		
TRAVEL (% SPEED)		300 ± 20		360 ± 20		
WIRE FEED (% SPEED)		265 ± 25		205 ± 20		
TRAVEL DELAY (seconds)		10 ± 2		8 ± 2		
WELD CYCLE TIME (minutes)	18.6± 1		18.6± 1			
SLOPE Setting		750 ± 75		750 ± 75		
SAFETY TIME (seconds)		15 ± 3		15 ± 3		
CURRENT STEP		N/A		N/A		
STEP TIME (seconds)		N/A		N/A		
ARC LENGTH (inches)	3/32		3/32			
AUTO. VOLTAGE CONTROL		41.0		41.8		
OSCILLATOR SETTING		N/A		N/A		
PREHEAT TEMP. °F	AMB		N/A			
INTERPASS TEMP. °F	N/A		80			
PULSE FREQUENCY, CPS.		B		B		

WELDING PROCEDURE DATA SHEET

MATERIAL: Invar 36

SIZE: 8 inch diameter - Schedule 10S

WELDING POSITION: Vertical (II)

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 7

JOINT DESIGN AND WELD SEQUENCE: 2 Passes, 0.055 inch Land, 37-1/2° Bevel

	PASS NO. 1		PASS NO. 2		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	Invar		Invar			
FILLER METAL SIZE (inches)	.035		.035			
ELECTRODE TYPE	2% TH		2% TH			
ELECTRODE DIAMETER (inches)	3/32		3/32			
ELECTRODE EXTENSION(inches)	5/16		5/16			
STARTING POSITION	N/A		N/A			
LOW CURRENT		200 ± 20		200 ± 20		
HIGH CURRENT		440 ± 45		330 ± 30		
TRAVEL (% SPEED)		300 ± 20		360 ± 25		
WIRE FEED (% SPEED)		265 ± 25		320 ± 30		
TRAVEL DELAY (seconds)		11 ± 2		7 ± 2		
WELD CYCLE TIME (seconds)	--		--			
SLOPE Setting		750 ± 100		750 ± 100		
SAFETY TIME (seconds)		12 ± 2		12 ± 2		
CURRENT STEP		N/A		N/A		
STEP TIME (seconds)		N/A		N/A		
ARC LENGTH (inches)	3/32		3/32			
AUTO. VOLTAGE CONTROL		41.8		42.3		
OSCILLATOR SETTING		N/A		N/A		
PREHEAT TEMP. °F	AMB		N/A			
INTERPASS TEMP. °F	N/A		80			
PULSE FREQUENCY, CPS.		B		B		

WELDING PROCEDURE DATA SHEET

MATERIAL: Invar 36 to 304 Stainless Steel

SIZE: 8 inch diameter - Schedule 10S

JOINT DESIGN AND WELD SEQUENCE: 2 Passes Square Butt, No Gap

WELDING POSITION: Vertical

INSERT SIZE: None

SHIELDING GAS: Argon FLOW RATE, C.F.H. 15

PURGING GAS: Argon FLOW RATE, C.F.H. 7

	PASS NO. 1		PASS NO. 2		PASS NO.	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE	INCO 82		INCO 82			
FILLER METAL SIZE (inches)	.035		.035			
ELECTRODE TYPE	2% TH		2% TH			
ELECTRODE DIAMETER (inches)	3/32		3/32			
ELECTRODE EXTENSION(inches)	3/8		3/8			
STARTING POSITION	N/A		N/A			
LOW CURRENT		200 ± 20		200 ± 20		
HIGH CURRENT		420 ± 40		260 ± 25		
TRAVEL (% SPEED)		330 ± 20		360 ± 20		
WIRE FEED (% SPEED)		265 ± 25		200 ± 20		
TRAVEL DELAY (seconds)		10 ± 2		10 ± 2		
WELD CYCLE TIME (seconds)	--		--			
SLOPE Setting		600 ± 100		600 ± 100		
SAFETY TIME (seconds)		11 ± 2		11 ± 2		
CURRENT STEP		N/A		N/A		
STEP TIME (seconds)		N/A		N/A		
ARC LENGTH (inches)	3/32		3/32			
AUTO. VOLTAGE CONTROL		41.0		41.0		
OSCILLATOR SETTING		N/A		N/A		
PREHEAT TEMP. ^{o}F	AMB		AMB			
INTERPASS TEMP. ^{o}F	N/A		N/A			
PULSE FREQUENCY, CPS.		B		B		

APPENDIX I

REFERENCES

Listed below are some of the applicable references to be utilized when performing automatic welding with the APW-3 (Modified) Automatic Pipe Welding System.

SPECIFICATIONS

Military

MIL-A-18455	Argon, Technical
MIL-I-23413	Inserts, Welding Coiled, Filler Material, Solid Rings
MIL-P-27407	Propellant Pressuring Agent, Helium

John F. Kennedy Space Center, NASA

KSC-SPEC-Z-0002	Welding, Aluminum Alloy Pipe, Tubing and Associated Fittings, Specification for
KSC-SPEC-Z-0003	Welding, Stainless Steel and Invar 36 Pipe, Tubing and Associated Fittings, Specification for
KSC-SPEC-Z-0016	Automatic Welding Stainless Steel Pipe and Tubing, Invar 36 Pipe, Carbon Steel Pipe, Aluminum Pipe and Tubing, Specification for

OTHER REFERENCES

American Society of Testing and Materials (ASTM)

B-297	Tungsten Arc-Welding Electrodes, Specification for

American Society of Mechanical Engineers

ASME	Boiler and Pressure Vessel Code, Section IX

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MANUAL FOR OPERATION
OF
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