MECHANIZED GAS METAL ARC WELDING

OF LIGHT PLATE

FEBRUARY, 1979

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FOREWORD

The purpose of this report is to present the results of one of the research and development programs which was initiated by the members of the Ship Production Committee of The Society of Naval Architects and Marine Engineers and financed largely by government funds through the cost sharing contract between the U.S. Maritime Administration and Bethlehem Steel Corporation. The effort of this project was directed to the development of improved methods and hardware applicable to shipyard welding in the U.S. shipyards.

Mr. W. C. Brayton, Bethlehem Steel Corporation, was the Program Manager. Mr. Malcolm T. Gilliland designed and directed the development work at the Gilliland plant at Peachtree City, Georgia.

Special acknowledgement is made to the members of Welding Panel SP-7 of the SNAME Ship Production Committee who served as technical advisors in the preparation of inquires and evaluation of sub-contract proposals.

DEVELOPMENT

BACKGROUND

The need for a low-cost, well-engineered, self-contained, unitized and mechanized gas metal arc/flux-core welding system for all-position welding of thin (1/8" - 5/8") steel and also aluminum alloy sheet and plate for shipbuilding applications has never been fulfilled.

One approach to the problem has been to purchase individual components from different vendors and to design and fabricate your own equipment.

The substantial initial expense and the inherent problems with maintenance and vendor responsibility have proved this approach to be impractical.

OBJECTIVE

Develop a prototype mechanized gas metal arc welding machine complete with motorized carriage, torch holders, and related accessories to consistently and reliably weld butts and/or fillet welds on mild steel and aluminum sheets ranging from 0.119 to 0.188 and plates ranging from 0.188 to 0.625.

APPROACH

Because this project encompasses a vast number of possibilities which could require lengthy evaluation and testing periods before the utmost in usable hardware could be available for actual use, we proposed to design and build a standard operating prototype which would incorporate the following features and specifications as an initial phase.

SPECIFICATIONS

1. Mechanized precision tractor to be consistent,reliable, and completely repeatable with welding speeds from 2 to 70 inches per minute.
2. All mechanisms and controls to be made in and self-contained in tractor housing assembly.
3. Track assemblies to be ultra lightweight and easy to roll form if required for operating on curved surfaces.
4. Unit to be portable yet rugged with complete voltage regulation giving constant performance under all conditions; but yet weighing only approximately 40 pounds less welding wire.
5. Wire feeding capability will range from .030 to 3/32" diameters of wire with a controlled speed of $\pm$ 1%.
6. Potentiometer for wire speed, travel speed, and oscillation speed will be 10 turns precision instruments.
7. A quick cable disconnect will be supplied to allow wire jogging and inching during setup.
8. Torch will have both vertical and lateral adjustments available prior to and during welding.
9. Torch oscillating mechanism will have both dwell and width controls which may be adjusted before or during the welding operation.
10. Both preflow and postflow of gas shielding media will be provided.
11. Fingertip current and voltage decay capabilities for trailing out weld to prevent crater cracking.
12. Torch shall be adjustable such as to either lead or trail direction of travel 15^{o} in either direction.

SPECIFICATIONS (cont'd.)

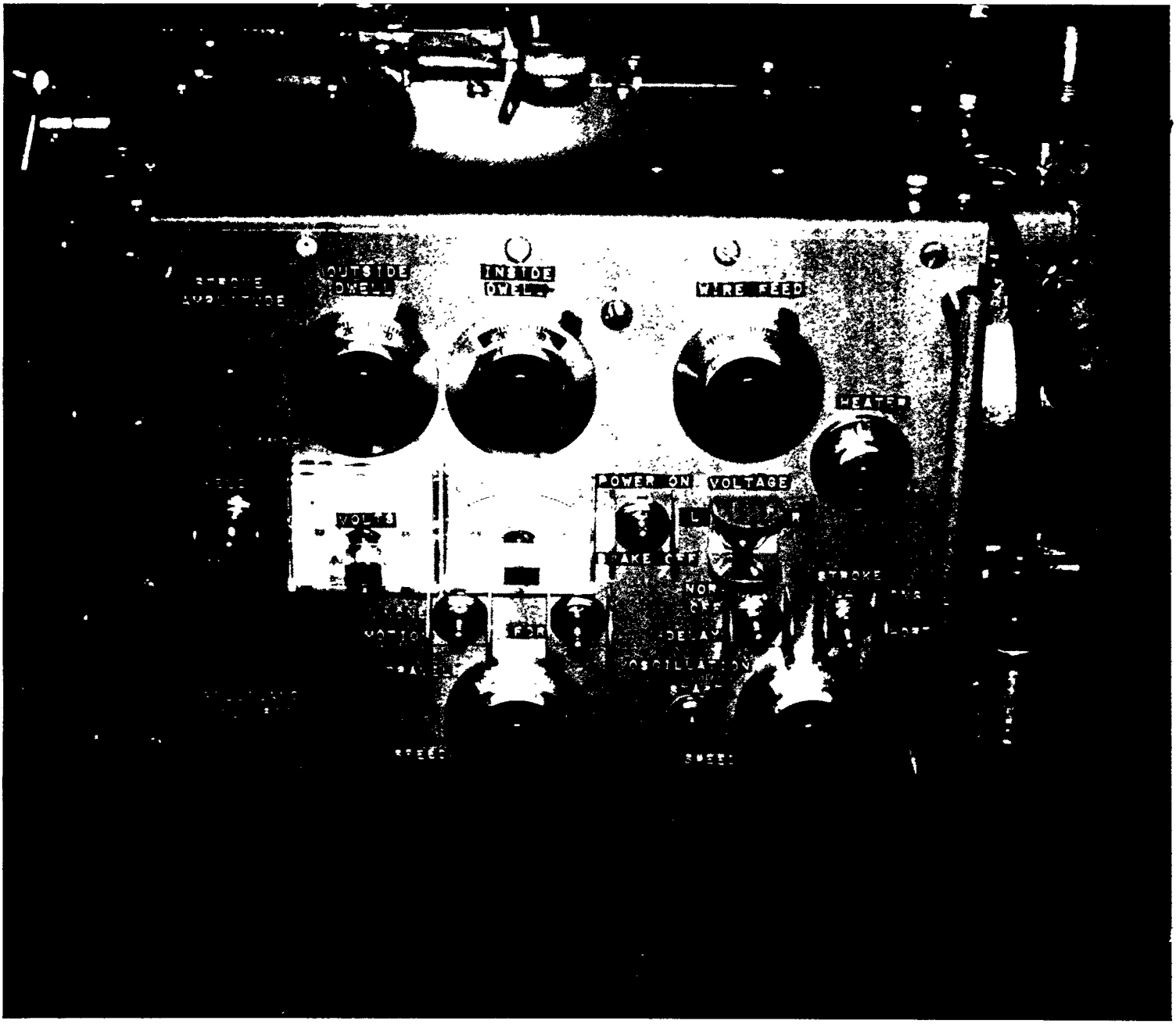
13. Start-stop switches will be provided for travel, oscillator mechanism, and wire feed.
14. Forward-reverse switches will be provided for travel.
15. Automatic arc striking capabilities shall be incorporated into all controls so as to make the machine easily adaptable to either constant voltage or constant current power sources, inorder to obtain the optimum conditions required for welding both aluminum and steel.
16. A heavy duty air-cooled welding troch capable of welding currents of 300 amps for Argon and 500 amps for CO2 at 100% duty cycle will be designed and made available on this unit.

ACHIEVEMENT

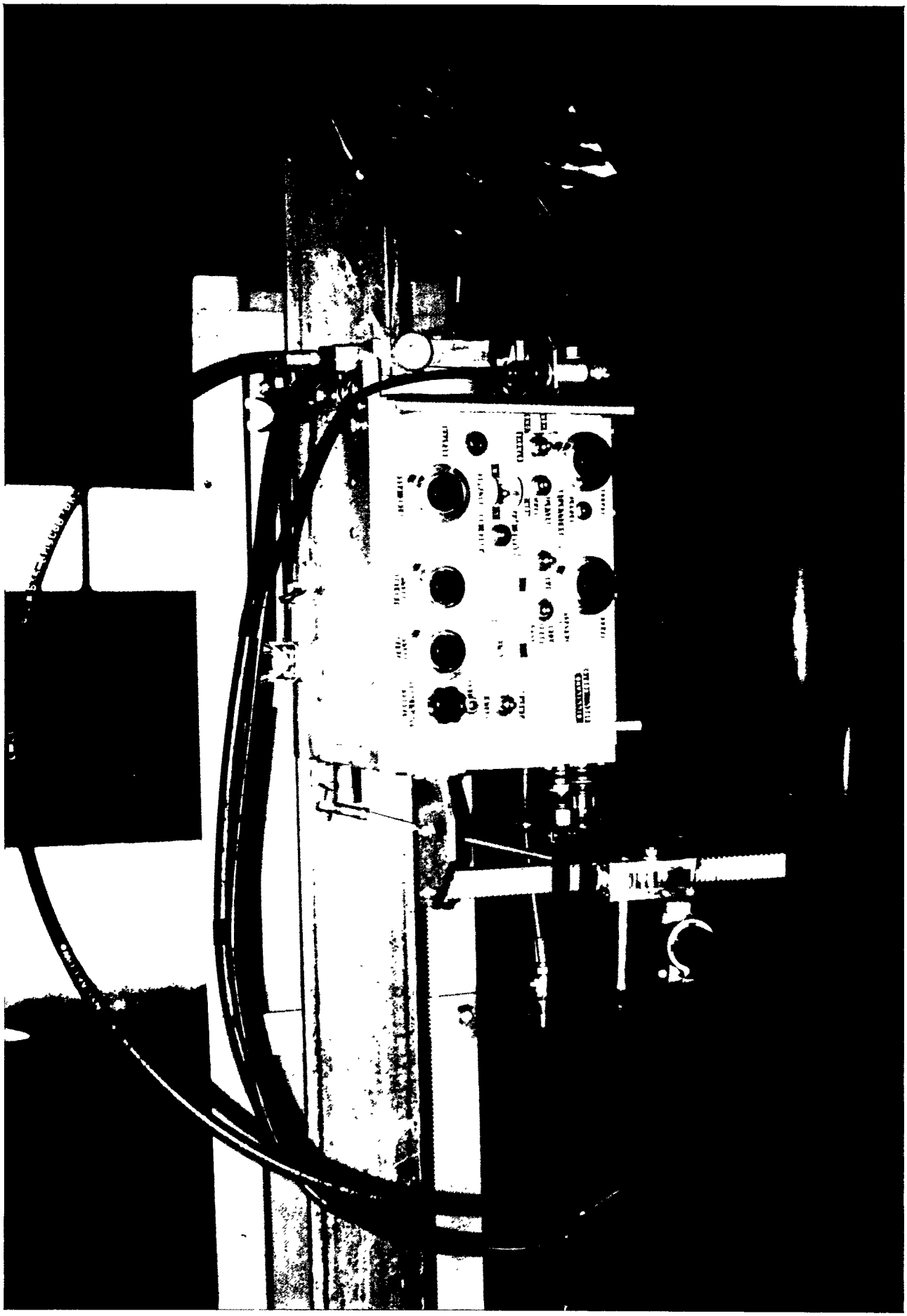
In February, 1978, a standard operating prototype was designed, manufactured, and tested at the Gilliland plant in Peachtree City, Georgia. The prototype unit was shipped to Todd Pacific Shipyards Corporation, Seattle Division for shipyard evaluation.

Portions of Todd's final report entitled: Shipyard Evaluation of Mechanized Gilliland GMAW/FCAW System for Welding Thin Sheet and Plate, are included in this report.

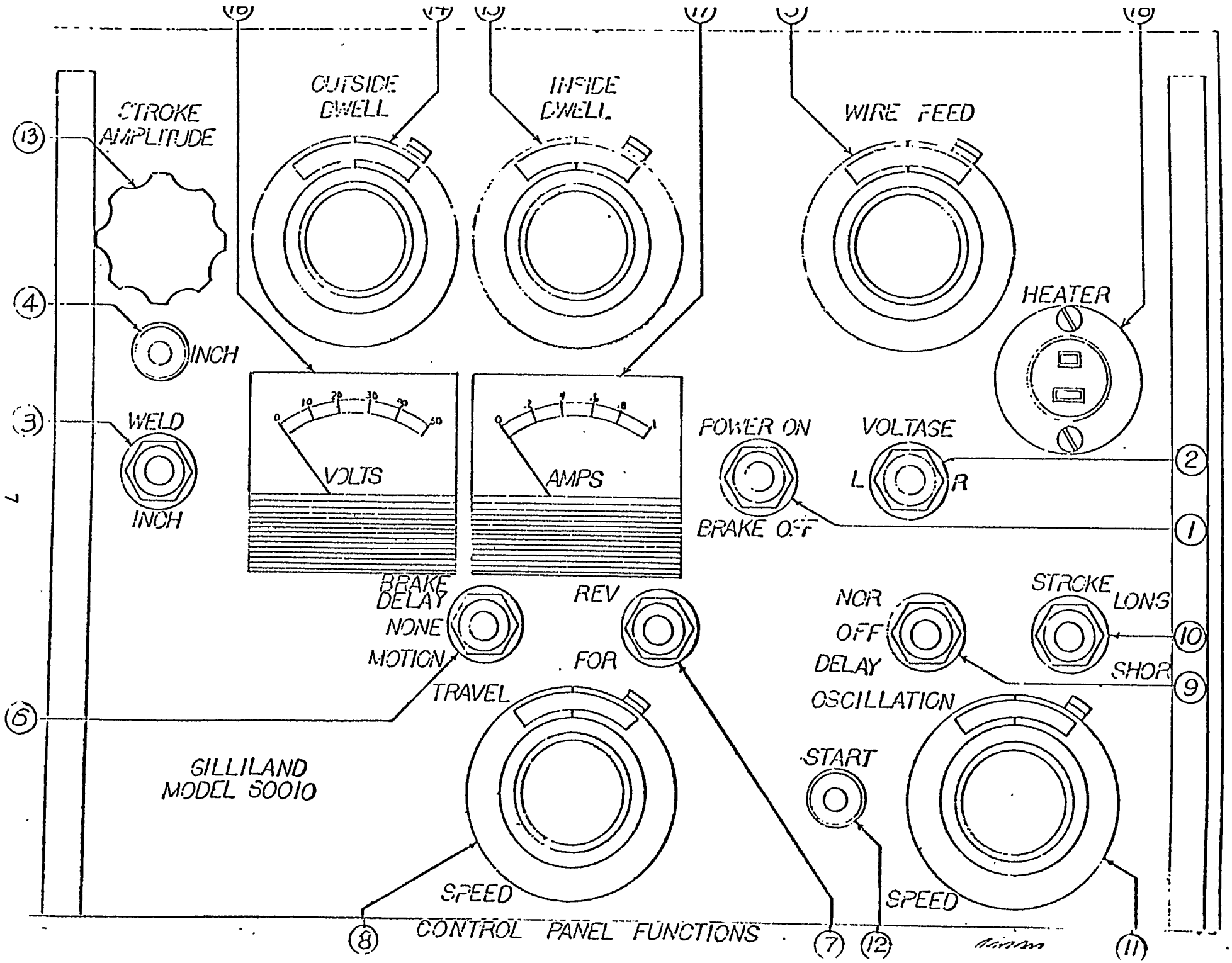
CONTROL PANEL/ FUNCTIONS



Prototype Front Panel, Gilliland Unit



Prototype Gilliland Unit, Mounted
for Vertical Welding


STROKE AMPLITUDE
OUTSIDE DWELL
INSIDE DWELL
WIRE FEED
HEATER
INCH
WELD
INCH
VOLTS
AMPS
POWER ON
VOLTAGE
L
R
BRAKE OFF
BRAKE DELAY
NONE
MOTION
REV
FOR
TRAVEL
NOR
OFF
DELAY
STROKE
LONG
SHORT
OSCILLATION
START
SPEED
SPEED
GILLILAND
MODEL 50010
CONTROL PANEL FUNCTIONS
13
4
3
6
2
1
10
9
8
7
12
11

MTG-6000 OSCILLATOR CONTROL PANEL FUNCTIONS

(1) POWER ON-OFF-BRAKE TOGGLE SWITCH;

ON position: All control circuits are activated.

BRAKE OFF position: All control circuits deactivated. This position is also used in conjunction with switch ⑥ , to apply braking to travel motor.

(2) VOLTAGE RAISE-LOWER TOGGLE SWITCH;

R position: Automatically increases welding voltage as long as switch is held in position.

L position: Automatically decreases welding voltage as long as switch is held in position.

(3) WELD-INCH TOGGLE SWITCH;

WELD position: Activates wire feed and welding voltage circuits.

INCH position: Deactivates wire feed and welding voltage circuits. To inch wire, depress pushbutton ④ . Wire will continue to inch until pushbutton ④ is released.

(4) INCH-PURGE PUSHBUTTON;

With Switch ③ in INCH position, depress inch pushbutton ④ to inch wire. This pushbutton is also used to purge gas lines.

(5) WIRE FEED SPEED CONTROL;

Wire feed speed is increased by turning control knob clockwise and is decreased by turning control knob counterclockwise. This dial will turn approximately 8½ turns with 100 marked increments in each turn. Dial may be locked at any desired setting by moving lock arm to the right. Dial range 0.00 - 8.70.

(6) TRAVEL BRAKE-DELAY-NONE-MOTION TOGGLE SWITCH;

MOTION position and with switch ⑨ in NORMAL position: Unit will advance along track without interruption as the gun oscillates back and forth across weld with no dwell time at end of stroke.

MOTION position and with switch ⑨ in DELAY position: Unit will advance along track as the gun oscillates across weld and will stop and restart when the gun dwells and reverses direction at each end of stroke.

DELAY position and with switch ⑨ in DELAY position: Unit will advance along track when the gun dwells on each end of stroke and will stop as the gun oscillates across weld.

DELAY position and with switch ⑨ in NORMAL position: Unit will remain stopped as gun constantly oscillates across weld.

NONE position: Travel circuit is deactivated.

BRAKE position and with switch ① in BRAKE position: Electro-dynamic braking is applied to travel motor to prevent unit from "DRIFTING" down track when it is used to weld vertically. The ON-OFF toggle switch at the power supply should be left ON for brake operation.

⑦ TRAVEL FORWARD-REVERSE TOGGLE SWITCH;

FORWARD position: Unit will advance to RIGHT as you face control panel.

REVERSE position: Unit will advance to LEFT as you face control panel.

⑧ TRAVEL SPEED CONTROL;

Travel speed is increased by rotating knob clockwise and is decreased by rotating knob counterclockwise. Dial may be locked at any desired setting by moving locking arm to the right. Dial range 0.00 - 8.70. This dial will turn approximately 8½ turns with 100 marked increments in each turn.

⑨ OSCILLATION NORMAL-OFF-DELAY TOGGLE SWITCH;

OFF position: Oscillation circuit deactivates

NORMAL position: Gun will oscillate back and forth across weld with no dwell time at end of stroke.

DELAY position: Gun will oscillate back and forth across weld and will dwell for a period of time at each extreme end of stroke. Dwell time periods are set with dials ⑭ and ⑮ .

⑩ OSCILLATION STROKE, LONG-SHORT;

LONG STROKE position: The gun has a slower rate of speed as it passes across center of weld. This setting primarily used when making a wide pass such as a cap pass.

SHORT STROKE position: The gun has a faster rate of speed as it passes across center of weld. This setting is primarily used where a relatively narrow pass is required.

⑪ OSCILLATION SPEED CONTROL;

Oscillation speed is increased by rotating knob clockwise and decreased by rotating knob counterclockwise. Dial may be locked at any desired setting by moving lock arm to the right dial range; 0.00 - 0.87.

(12) OSCILLATION START PUSHBUTTON;
Depress pushbutton for ten seconds or until gun begins to oscillate. This will begin sequence control circuits to start gun oscillation.

(13) STROKE AMPLITUDE;
This knob is used to adjust the width that the gun travels as it oscillates across weld. Turn knob clockwise to increase stroke amplitude and turn knob counterclockwise to decrease stroke amplitude.
NOTE: It is normal for knob to rotate when oscillating.

(14) OUTSIDE DWELL CONTROL;
This control sets the gun dwell time at the end of the stroke toward the bottom as you face the control panel.
Dial range: 0.00 - 0.87.

(15) INSIDE DWELL CONTROL;
This control sets the gun dwell time at the end of the stroke toward the top as you face the control panel.
Dial range: 0.00 - 0.87.

(16) VOLTMETER

(17) AMP METER

(18) HEATER;
115 volt @ 125 watts maximum receptacle to be used for powering a heater coil inside a wire canister. Primarily for use with critical types of aluminum wire.

TODD SHIP'S REPORT

SHIPYARD EVALUATION OF MECHANIZED GILLILAND GMAW/FCAW SYSTEM

FOR WELDING THIN SHEET AND PLATE

PURPOSE: The purpose of this report is to cover the evaluation of the mechanized gas metal arc welding (GMAW) flux-cored arc welding (FCAW) system for welding thin (1/8" - 5/8") steel and also aluminum alloy sheet and plate for shipbuilding applications.

This report covers the field production weld testing of the mechanized Gilliland GMAW/FCAW system for all-position welding of thin steel and aluminum alloy sheets and plates used for shipbuilding. For clarity's sake, the basic welding variables are covered under each heading together with test reports, conclusions, and recommendations.

A. EQUIPMENT

In mid-February 1978, the following equipment was received from M. T. Gilliland, Inc. These were as follows:

- One only 500 ampere MTG 6010 welding power source. (Serial #012078)
- One only MTG 6020 automatic control unit.
- One only MTG 6030 automatic oscillating-type welding head.
- One only 150 ft. length stretch cable consisting of electrode cable, control cable, and gas hose complete with quick disconnect fittings.
- Three only ten (10) ft. sections of super lightweight track assembly.
- One only MTG 4005 automatic gun and cable assembly.

1. POWER SOURCE

The welding power source was a Gilliland MTG 6010, 600 ampere constant voltage type machine.

2. CONTROL PANEL

The control panel Figure 1 and its functions are listed below:

1) Power on-off-brake toggle switch
2) Voltage: raise-lower toggle switch
3) Weld/inch toggle switch
4) Inch/pre-purge push button
5) Wire feed speed control potentiometer

TRACTOR TRAVEL

6) Tractor Travel: Break-delay-none-motion toggle switch
7) Tractor Travel: Forward-reverse toggle switch
8) Tractor Travel Speed Control

OSCILLATION

9) Oscillation normal-off-delay toggle switch
10) Oscillation stroke: long-short

11) Oscillation speed control
12) Oscillation start push button
13) Stroke amplitude
14) Outside dwell control
15) Inside dwell control
16) Voltmeter
17) Ampmeter
18) Heater (Plug)

3. TRACTOR

From a shipyard application viewpoint, the basic size or envelope of the tractor appears good. The basic tractor dimensions are: 9 inches wide x 11 inches high x 13 inches long and with the wire spool mounted and the torch fully extended: 17 inches wide x 17 inches high x 26 inches long.

Although the Gilliland tractor does have a method to mount the tractor on the middle of the rail length, it certainly does not offer easy - quick-on/disconnect capabilities to mate to the rails. This is a great disadvantage, for example, when preparing for a vertical-up welding set-up from a scaffold.

4. TRAVEL SPEED

Actual travel speed of the Gilliland tractor was plotted against the travel speed potentiometer settings in both the forward (right) and the reverse (left) directions. Figures 2 and 3 respectively show the results. The data indicates that the travel speed is not linear. However, travel speed in the 5-50 inches per minute range is fair. No travel is initiated until the travel speed potentiometer is increased from "0" to almost "I". It is our opinion that this can be improved by using a tachometer generator type arrangement or by using a bull gear system.

5. OSCILLATOR

When using 1/16 inch diameter solid or flux-cored wire with the GMAW or FCAW process, there are many butt and fillet weld joints that cannot be filled in a single pass and require multiple pass deposits for fill. For the flat position, the submerged arc process may be used as an alternative to cut down the numbers of weld passes. But, for all-position GMA & FCA welding (especially vertical-up), torch oscillation has become a necessity for improving welding deposition rates and efficiency.

The oscillator developed by Gilliland is a controlled oscillation device and the number of oscillation patterns that may be generated are limited. Tests with the oscillator revealed the following:

1) The Gilliland oscillator is a compact line weaver with infinitely adjustable amplitude (during operation) of 1/4 inch to 2 inches. Amplitude is the distance normal to the direction of welding between the outermost positions which the electrode tip reaches while oscillating.

2) The outside and inside dwell controls set the gun dwell time at the ends of each stroke. Dwell is the time during which the electrode rests at any point in each oscillating swing or traverse. The oscillation normal-off-delay toggle switch must be in the delay position so that the gun will oscillate back and forth transversely across the weld/joint axis and will dwell for a period of time at each end of the stroke.

3) The frequency of oscillation is increased by rotating the oscillation speed control knob clockwise and decreased by rotating the knob counter-clockwise. Frequency is the completed number of cycles which the oscillating head makes in one minute or other specified time increments.

4) Figure 4 illustrates the oscillator in the constant dwell (0), amplitude mode, but the travel speed increased from left to right.

5) Figure 5 shows the oscillator in the constant amplitude, weaving speed, and dwellmodes; but the tractor travel speed was increased gradually.

6) Figure 6 shows the oscillator in the constant amplitude, tractor travel speed, and frequency mode; but the dwell was increased from left to right.

7) Figure 7 shows the oscillator in constant amplitude, weaving speed mode, but the insde and outside dwell increased gradually from left to right.

8) Figure 8 illustrates the oscillator in the constant amplitude and weaving speed mode, but the outside dwell increased only two cycles then subsequently increased the inside dwell to the same magnitude as the outside dwell.

B. PRODUCTION WELDING TESTS

1. BY-80/HY-80 MECHANIZED WELDING PROCEDURE QUALIFICATION

The Gilliland system was used to qualify the mechanized welding procedure qualification tests for gas metal arc welding(GMAW) of HY-80/HY-80 steel hull plating.

Todd Welding Procedure Specification 9761504, "Mechanized Gas Metal Arc Welding (GMAW) of HY-80 to HY-80 Steel and to Carbon Steels" was generated from the qualification test data. This procedure is applicable for materials ranging from 1/8 inch to 1 inch thickness. Solid filler wire of 1/16th inch diameter per MIL-E-23765/2-composition MIL-100S-1 was used. Shielding gas was 98% Argon, 2% Oxygen. This covered welding in the flat and horizontal positions only. The basic welding parameters were as follows:

27-30 Volts
320-380 Amperes
11-20 inches per minute/Travel Speed

The tempering bead technique was utilized and the Joules per inch (heat input) was carefully monitored. See Figures 9 and 10 for the test summary sheets. Also see Figure 11 for mechanized properties test report, Figure 12 for radiographic inspection report, and also Figure 13 for magnetic particle inspection report.

2. NAVY FFG-10 ERECTION UNITS: STEEL

The four longitudinal seam welds in the lower erection unit A2-001, Frames 241-271, were welded with the Gilliland system. The sketch in Figure 14 shows the longitudinal seam weld locations on the hull and also the weld joint configurations and material thicknesses welded. Figures 15 thru 20 are photographs of the Gilliland System being used to flux-cored arc weld the four seam weld joints illustrated in the preceding sketch.

Figure 15 illustrates the Gilliland tractor oscillator, torch, controls, and flux-cored wire (25 lbs. spool) mounted on the Gilliland rails with magnet attachments. These compact magnet assemblies are cleverly swivel mounted for quick on/off convenience.

Figure 16 is a close-up view of the control panel located on the Gilliland tractor.

Figure 17 and 18 shows the tractor unit flux-cored arc welding the seam.

Figure 19 and 20 illustrates the completed welds with the Gilliland unit adjacent to the completed flux-cored arc welding seam joint.

Figures 21, 22 and 23 illustrates the Gilliland machine settings covering the 3 pass flux-cored arc welding on the 1st side. (i.e. root pass, second pass, and fill pass) The second side was arc gouged and manually welded overhead.

C. LABORATORY WELDING EVALUATION

1. VERTICAL-UP WELDING

At this point during the course of this study, it was decided to bring the Gilliland Welding Systems back into the laboratory. This was necessary to determine and establish firm welding machines settings for the vertical-up and overhead positions prior to going back on production application. Oscillation of the welding torch for vertical-up welding appears to be a critical variable when AWS E 70 TG flux cored wire is utilized. Various oscillation patterns were used however the addition of the 2% nickel in this all position wire made the weld puddle extremely fluid in the vertical-up mode.

Figure 24 shows the machine settings established on vertical-up welding: 200-240 amperes; 24-26 volts; and 6-6½ inch travel speed.

Figures 25, 26, 27 and 28 illustrates the Gilliland Welding System in the vertical-up weld test set-up. The flux cored all position filler wire was Chemetron 8000 2Ni, in the 0.045 inch diameter.

2. OVERHEAD WELDING

Figure 29 shows the machine settings established for the overhead welding position. Amperage ranged from 210-230; voltage; 27-30; and travel speeds 10-12 inches per minute. Weld filler wire used was the same as for the vertical-up tests; 0.045 inch diameter Chemetron 8000 2Ni, AWS E 70 TG.

Figures 30, 31 and 32 illustrates the weld test set-up for overhead welding.

FIGURES

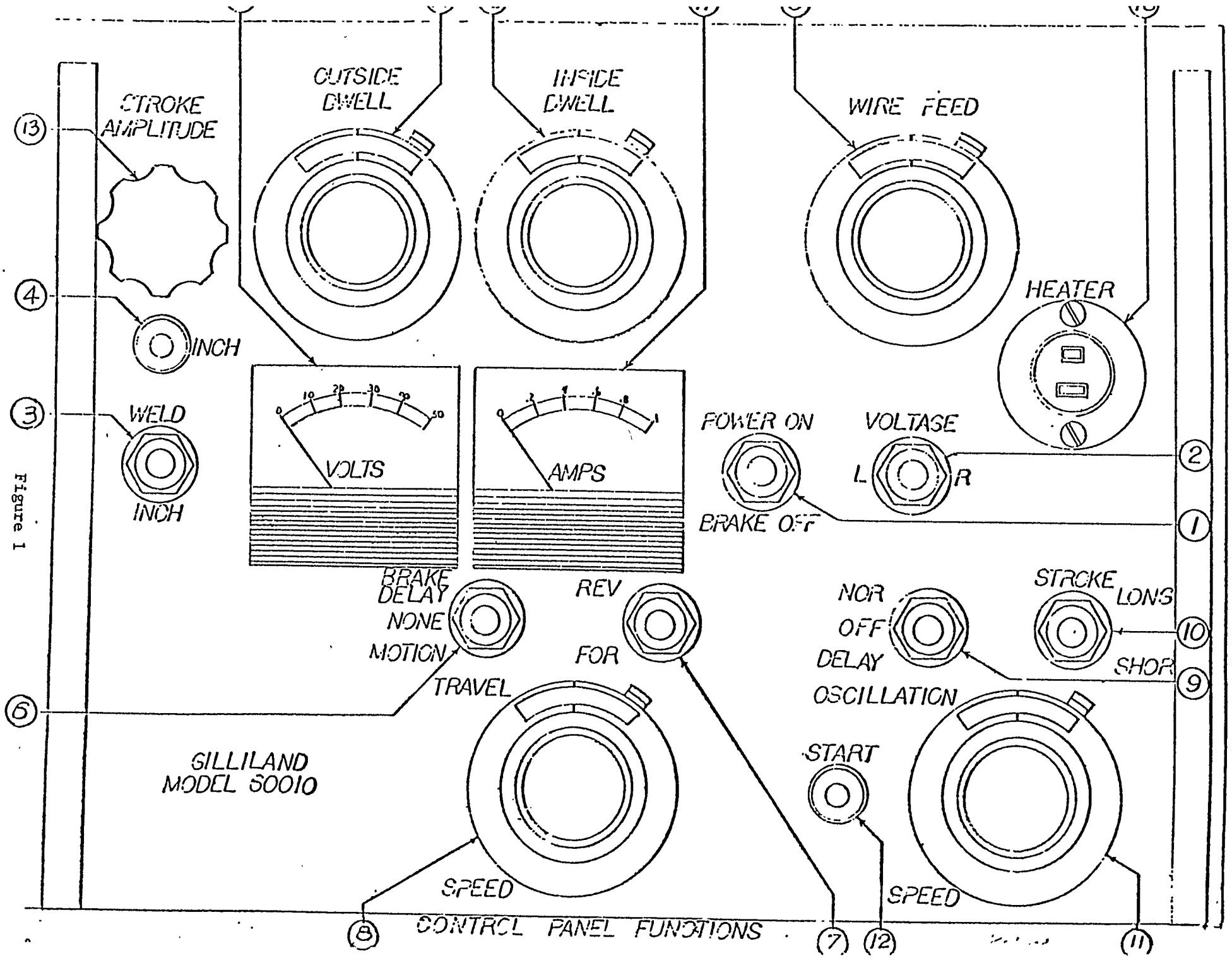


Figure 1 CONTROL PANEL FUNCTIONS

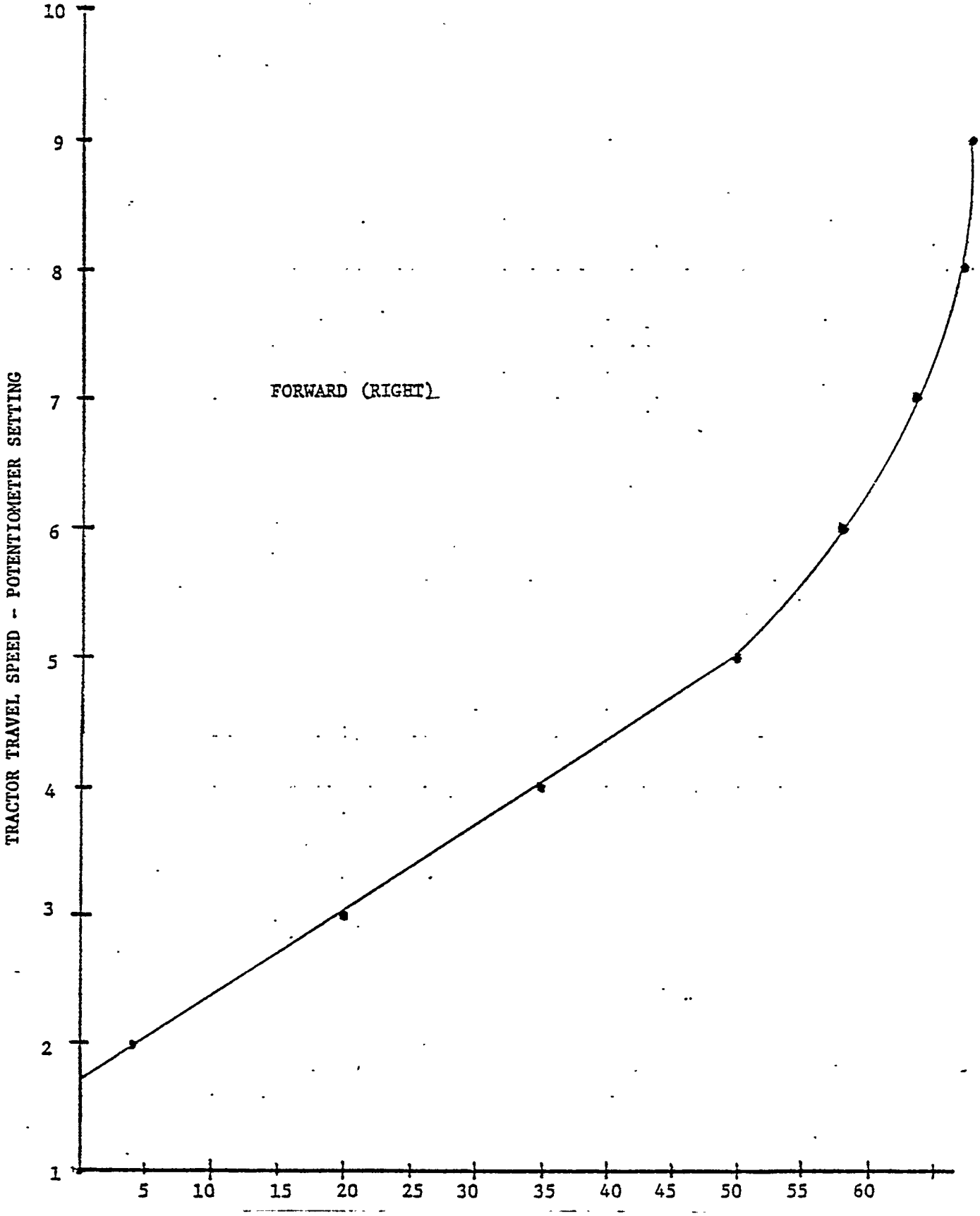

TRACTOR TRAVEL SPEED - POTENTIOMETER SETTING
10
9
8
7
6
5
4
3
2
1
FORWARD (RIGHT)
5
10
15
20
25
30
35
40
45
50
55
60
ACTUAL FORWARD TRAVEL SPEED, IPM
GILLILAND TRACTOR

FIGURE 2

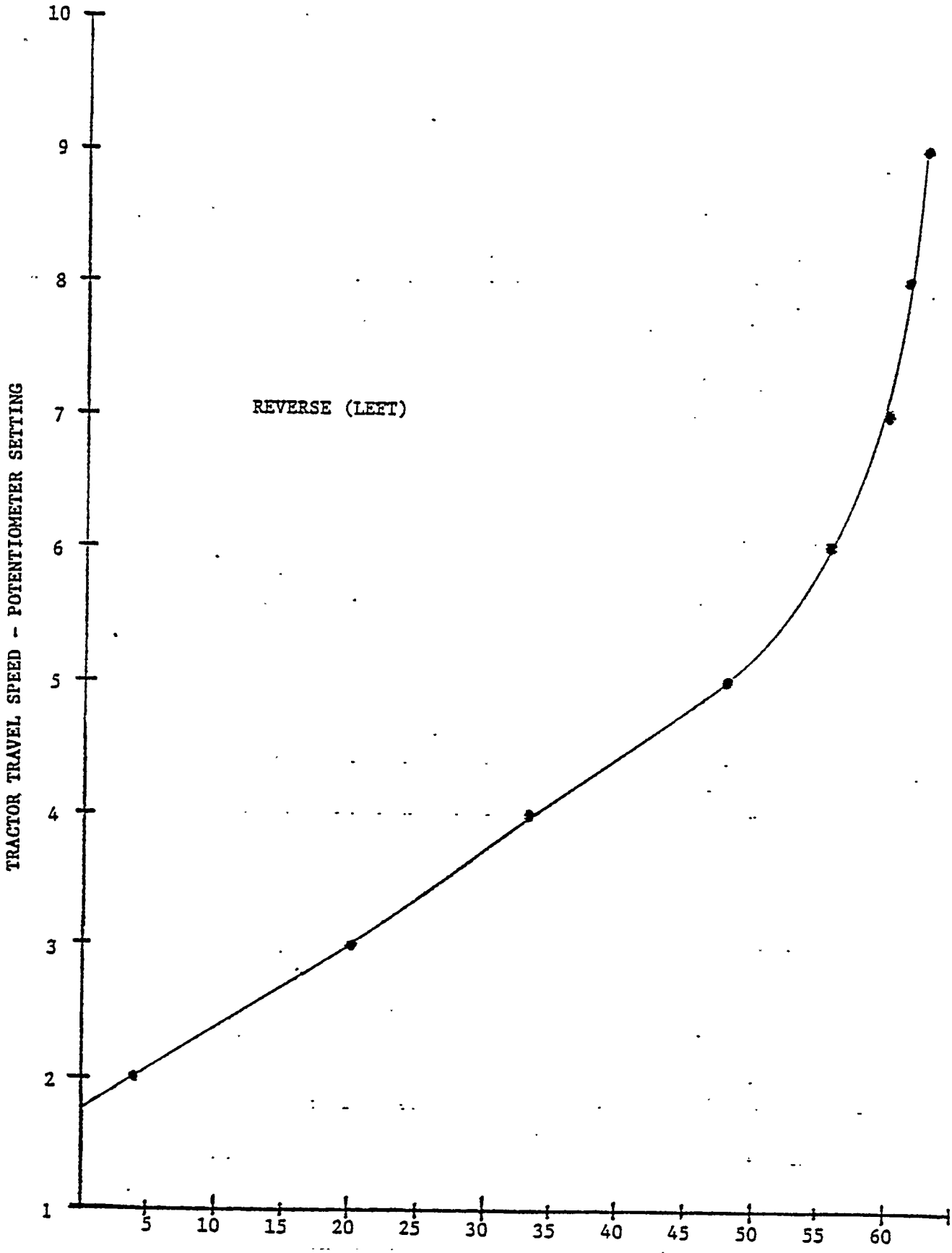
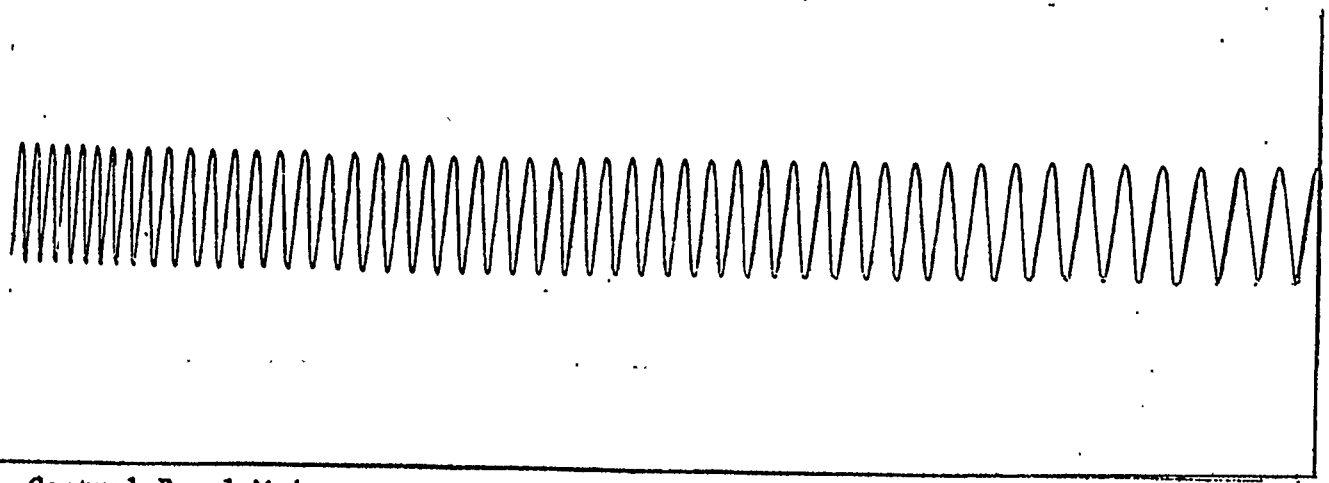

10
9
8
7
6
5
4
3
2
1
REVERSE (LEFT)
TRACTOR TRAVEL SPEED - POTENTIOMETER SETTING
5
10
15
20
25
30
35
40
45
50
55
60
ACTUAL REVERSE TRAVEL SPEED, IPM
GILLILAND TRACTOR

FIGURE 3



Control Panel Mode:

Power on - [✓]

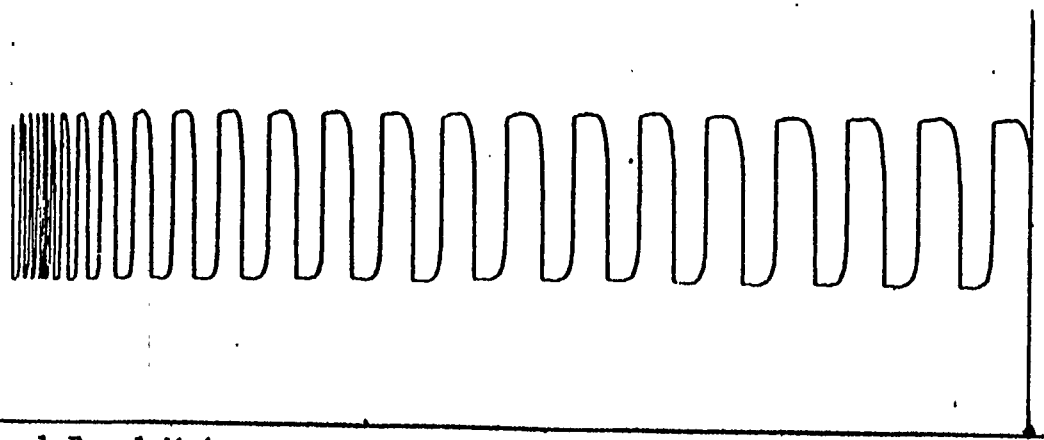
Weld/inch toggle switch: Weld [✓]
Inch/pre-purge push button: Pre-Purge [ ]
Wire feed speed control potentiometer [ ]

Tractor Travel: Break-delay [ ] motion [✓]
Tractor Travel: Left [ ] Right [✓]
Tractor Travel Speed Control: [2.40] to 3.25

Oscillation: normal [✓] delay [ ]
Oscillation stroke: long [✓] short [ ]
Oscillation speed control [.30]
Stroke amplitude [OPEN] Outside dwell control [0] Inside dwell control [0]

FIGURE 4

CONSTANT DWELL (0), AMPLITUDE; BUT TRAVEL SPEED INCREASED FROM LEFT TO RIGHT.



Control Panel Mode:
Power on - [V]

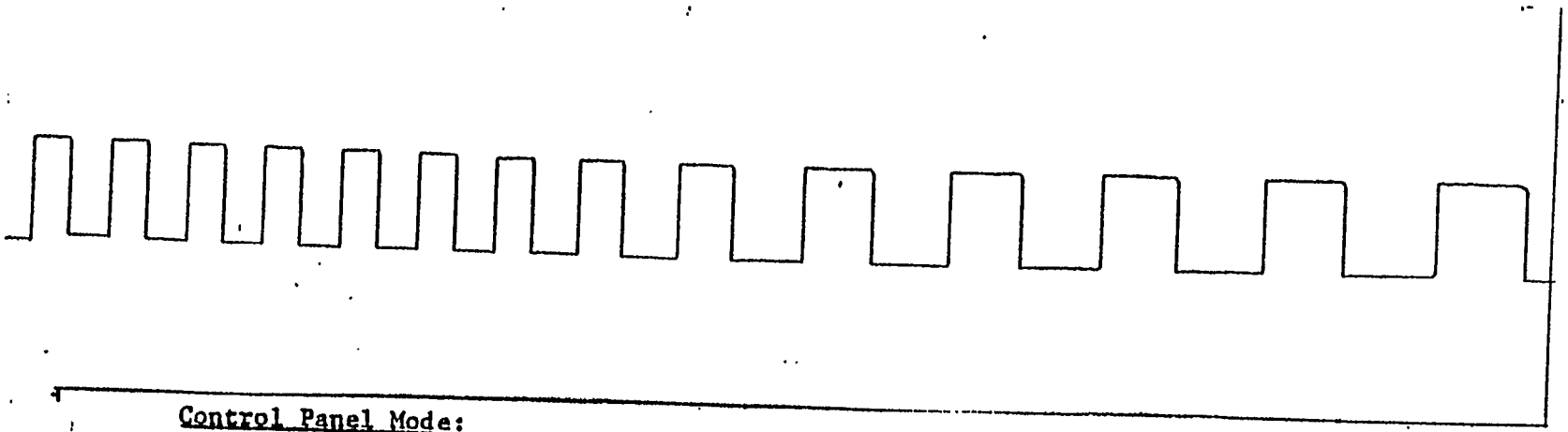
Weld/inch toggle switch: Weld [—]
Inch/pre-purge push button: Pre-Purge [—]
Wire feed speed control potentiometer [—]

Tractor Travel: Break-delay [V] motion [ ]
Tractor Travel: Left [ ] Right [V]
Tractor Travel Speed Control: [1.70] to 9.98

Oscillation: normal [ ] delay [V]
Oscillation stroke: long [V] short [ ]
Oscillation speed control [.40]
Stroke amplitude [OPEN] Outside dwell control [.10] Inside dwell control [.12]

FIGURE 5

CONSTANT AMPLITUDE, WEAVING SPEED AND DWELL
BUT TRAVEL SPEED INCREASED GRADUALLY



Control Panel Mode:

Power on - [V]

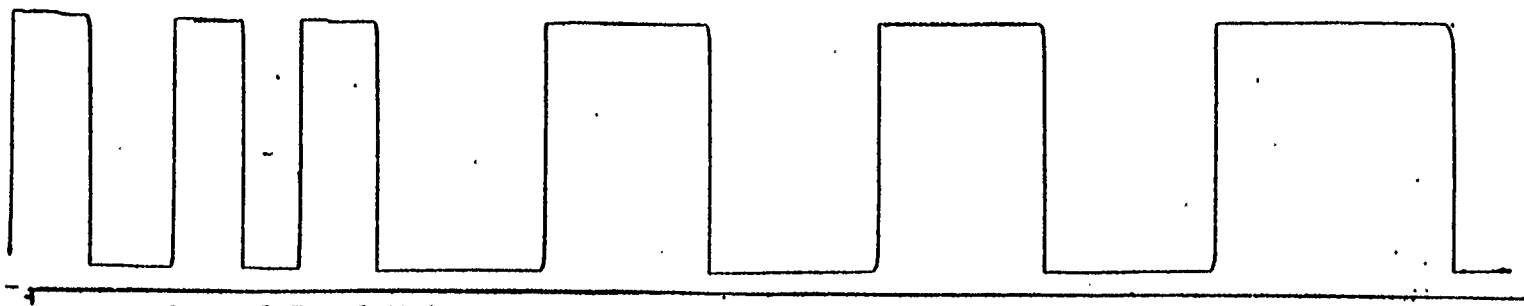
Weld/inch toggle switch: Weld [V]
Inch/pre-purge push button: Pre-Purge [—]
Wire feed speed control potentiometer [=]

Tractor Travel: Break-delay [V] motion [ ]
Tractor Travel: Left [ ] Right [V]
Tractor Travel Speed Control: [2.40] to 4.28

Oscillation: normal [ ] delay [V]
Oscillation stroke: long [V] short [ ]
Oscillation speed control [.37]
Stroke amplitude [OPEN] Outside dwell control [.10 / .30] Inside dwell control [.10 / .30]

FIGURE 6

CONSTANT AMPLITUDE, TRAVEL SPEED & FREQUENCY BUT
INCREASED DWELL: LEFT TO RIGHT



Control Panel Mode:
Power on - [✓]

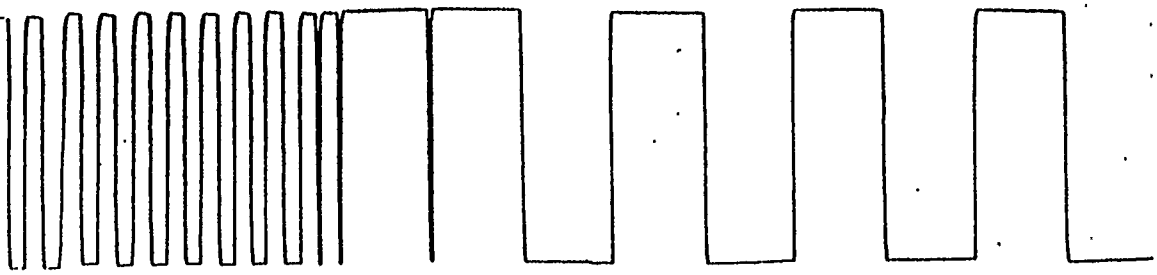
Weld/inch toggle switch: Weld [—]
Inch/pre-purge push button: Pre-Purge [—]
Wire feed speed control potentiometer [—]

Tractor Travel: Break-delay [✓] motion [ ]
Tractor Travel: Left [ ] Right [✓]
Tractor Travel Speed Control: [2.40]

Oscillation: normal [ ] delay [✓]
Oscillation stroke: long [✓] short [ ]
Oscillation speed control [.30]
Stroke amplitude [OPEN] Outside dwell control [.10 / .30] Inside dwell control [.10 / .30]

FIGURE 7

CONSTANT AMPLITUDE, WEAVING SPEED; BUT INSIDE & OUTSIDE
DWELL INCREASED GRADUALLY LEFT TO RIGHT



ntrol Panel Mode:
Power on - [√]

Weld/inch toggle switch: Weld [—]
Inch/pre-purge push button: Pre-Purge [—]
Wire feed speed control potentiometer [—]

Tractor Travel: Break-delay [√] motion [ ]
Tractor Travel: Left [ ] Right [√]
Tractor Travel Speed Control: [2.40]

Oscillation: normal [ ] delay [√]
Oscillation stroke: long [√] short [ ]
Oscillation speed control [.30]
Stroke amplitude [OPEN] Outside dwell control [0] Inside dwell control [0]
.30 .30

FIGURE 8

ONSTANT AMPLITUDE, WEAVING SPEED, BUT OUTSIDE DWELL INCREASED ONLY 2 CYCLES
HEN SUBSEQUENTLY INCREASED INSIDE DWELL TO SAME MAGNITUDE AS OUTSIDE DWELL

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W., P.O. Box 3806, Seattle, Washington 98124 • 623-1635 (206)

DESCRIPTION					
WELDER QUALIF.	MIL-STD-248C		PROCEDURE QUALIF. STD.	MIL-STD-248C NAVSHIPS 0900-000-1001	
BASE METALS	HY-80 - MIL-S-16216		PROCESS	GMAW	
SPEC./TYPE FILLER METAL	MIL-100S-1/MIL-E-23765/2		POWER SOURCE; MODEL/TYPE		
			POLARITY	DCRP	
POSITION OF WELD	FLAT		GAS: FLOW RATE/TYPE	30 CFH 98% ARGON/2% OXYGEN	
JOINT PREPARATION & SIDE NUMBER	45° INCLUDED ANGLE			TORCH TYPE	
				CUP SIZE 5/8"	
INTERPASS CLEANING	WIRE BRUSH				
REPAIRS	NONE				
PREHEAT TEMPERATURE	60°F	INTERPASS TEMPERATURE	300°F MAX.		
WELD TECHNIQUE	STRINGER BEAD - TEMPER BEAD APPLIED				

ACTUAL TRAVEL SPEED (I.P.M.)	FILLER METAL DIAMETER	AMPERAGE RANGE	ARC VOLTAGE RANGE	WELDING POSITION	NOTES:
11-20	1/16	320-380	27-30	FLAT	

Control Panel Mode:

Power on - [X]

Weld/inch toggle switch: Weld [X]
Inch/pre-purge push button: Pre-Purge [X]
Wire feed speed control potentiometer [405]

Tractor Travel: Break-delay [ ] motion [X]
Tractor Travel: Left [ ] Right [X]
Tractor Travel Speed Control: [284]

Oscillation: normal [X] delay [ ]
Oscillation stroke: long [ ] short [ ]
Oscillation speed control [ ]
Stroke amplitude [ ] Outside dwell control [ ] Inside dwell control [ ]

WELDING ENGINEER Approval _____ DATE _____

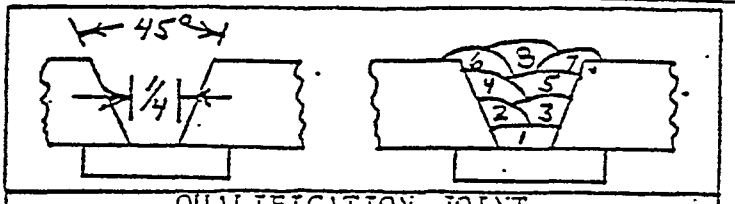
GILLILAND MACHINE SETTINGS

FIGURE 9

TODD SHIPYARDS CORPORATION
Seattle Division

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

Test Series No. 1504-1
Procedure No. TWPS 976-15
Process GMAW
Contract N00024-76-C
Date June 13, 19



QUALIFICATION JOINT

MATERIALS:
Base Spec. MIL-S-16216, HY-80
Base Thkns. 1/2 inch
Filler Spec. MIL-E-23765/2, Type MIL 100S-1 (Linde 95)
Filler Dia. 1/16 inch
Shielding Gas 98% Argon 2% Oxygen
Flux and Size N/A

EQUIPMENT:
Power Supply Gilliland 600 Amp (CP)
Torch or Holder Type Gilliland 400 Amp.
Cup Type & Size 5/8" dia.
Electrode Type & Size N/A

OPERATING PARAMETERS:
Welding Pos. Flat No. Passes 8
Preheat 60°F Min. Interpass Temp 300°F Ma
Current Charac. D.C.R.P. (Spray Transfer)
Current Range 320-380 Amps
Voltage Range 27-30 Volts
Wire Feed IPM N/A
Shield Flow 30 CFH
Travel Speed 11-20 IPM
Max. Heat Input J/in 47,127 Joules
Heat Treat None
Other Temper Bead Applied
Repairs: HAZ ground to remove defects loca by MT.

NDT Tests:

[X] Vis. [ ] PT [ ] UT [A] RT [A] MT

DT TESTS: Plate or Spec. Ser. No.

[X]	RST	Sat. Report #E13494 Attached.
[ ]	HRDNS	
[ ]	CHARPY	
[ ]	SIDE BEND	
[X]	ROOT BEND	Sat. Report #E13494 Attached.
[X]	FACE BEND	Sat. Report #E12394 Attached.
[ ]	FILLET BEND	
[ ]	FILLET BREAK	
[ ]	TRANS. SHEAR	
[ ]	LONG SHEAR	
[ ]	EXPL. BULGE	
[ ]	OTHER	

RESULTS
Vis: No Visible Defects
RT: Acc., Report # 4831 Attached
MT: Acc., Report # 737 Attached

REMARKS: Electrode Control per TWPS 976-4003

L. Johnston		W. Feller	1/8 to 1 inch
WELD OPR.	CLOCK NO.	TEST BY	QUAL. RANGE

This certifies that the data herein is complete and accurate to best possibl knowledge and that testing and evaluation was conducted in accordance with the requirements listed below.

MIL-STD 248C
NAVSHIPS 0900-000-1001
NAVSHIPS 0900-003-8000
NAVSHIPS 0900-003-9000

M.T. Nakata 6-14-78
Welding Engineer date

FIGURE 10

NORTHWEST LABORATORIES

of Seattle, Incorporated

Technical Services for: Industry, Commerce, Legal Profession & Insurance Industry

Forensic Science & Administrative Offices: 423 SMITH TOWER BLDG. – SEATTLE, WASHINGTON 98104 – Telephone: (206) 622-0680
Laboratories: 200 JAMES STREET – SEATTLE, WASHINGTON 98104 – Telephone: (206) 622-6944

Report to: Todd Shipyards Corporation Date: May 18, 1978

Report on: Welds, P.O. PS16738 Lab. No. E13494

IDENTIFICATION:

WPS 976-1504 Series 1504-1
Base Material - MIL-S-16216H (Ship) HY-80; 1/2" Thick
Welding Process - GMAW; Welding Position - Flat
Welding Electrode - 1/16" Dia., Type MIL 100S-1 (MIL-E-23765/2A)
Shielding Gas - 98% Argon, 2% Oxygen

TRANSVERSE TENSILE TEST:

			Specified
Number	T-1	T-2	
Measurements	1.505 x .510	1.505 x .514	
Area Sq. Inches	.768	.773	
Yield Strength, Lbs. Actual	73,760	73,830	
Yield Strength, PSI	96,040	95,510	80,000 to 100,000
Ultimate Load, Lbs.	87,540	87,870	
Tensile Strength, PSI	113,980	113,670	Information Only
Elongation in 2 Inches	.49	.45	
Elongation, %	24.5	22.5	Information Only
Location of Fracture	Base Metal	Base Metal	

BEND TESTS:

Number	Type of Bend	Location, Nature & Size of Cracks & Tears
F-1	Face	No Flaws - Satisfactory
F-2	Face	2 Cracks 1/16", 1 Crack 1/32" - Satisfactory
R-1	Root	No Flaws - Satisfactory
R-2	Root	No Flaws - Satisfactory

This is to certify that the above weld procedure qualification test specimens have been tested and found to be acceptable per requirements of MIL-STD-248C and MIL-STD-418C.

Albert O. Wahto, P.E.
Chief Testing Engineer
License No. 3004

MECHANIZED PROPERTIES
FCAW HY 80-HY 80

FIGURE 11

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W., P.O. Box 3806, Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 4831
DATE 4-26-79

RADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. N00024-76-C-2101 HULL NA

JOB NAME WELDING PROCEDURE QUALIFICATION- GMAW JOB NO. 6561 ITEM NO. 821.16 PAGE 1 of 1

DESCRIPTION PROCEDURE #1504 MAT'L FE HY-80 QUANTITY 1

RSS NO. FFG-5-5-1 QUALITY LEVEL: 2-2T ☐ 2-4T ☒ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

FILM TYPE(S)	SFD(INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION (INCOMPLETE FUSION)	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION: JOINT	DISPOSITION: ACCEPT	DISPOSITION: REJECT	REMARKS
#00	24	1/2	1	0-1	0	1					1			X		SURFACE WITHIN SPEC

MIL-STD-271-E ☒
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A ☐ CLASS B ☐
OTHER:

CODE
1. ACCEPTABLE
2. BORDERLINE
3. EXCESSIVE

SINGLE FILM ☒
MULTIFILM ☐
BOTH ☐

RADIATION SOURCE:
X-RAY: KV _____ mA _____
IR-192: CURIES 25

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10	7×17	
1			1	

RADIOGRAPHER(S) R. Bacon / T. Moore

PREPARED BY R. Bacon

APPROVED BY R. Bacon

ACCEPTED BY _____

QA-RT-2

FIGURE 12

TODD SHIPYARD CORP. SEATTLE DIVISION
MAGNETIC PARTICLE TEST REPORT

SHEET 1 OF 1

DATE 4/27/78

NAVY SPEC NO. _____
PARAGRAPH NO. _____
REPORT NO. 737

NAME OF JOB FFG-10 JOB NO. 6561 ITEM NO. 821.24

EQUIPMENT USED [X] PARKER CONTOUR PROBE YOKE TODD NO. 3427
[ ] MACHINE AND MODEL NO. _____

TOTAL CABLE LENGTH _____ FT. MAGNETIZING CURRENT: A.C. [ ] D.C. HALF WAVE [ ] D.C. PULSE [ ]

CIRCULAR FIELD: PRODS [ ] CENTRAL CONDUCTOR [ ] HEAD [ ] PROD SPACING 6 IN.
MAGNETIZING CURRENT _____ AMPS

LONGITUDINAL FIELD: MAGNETIZING CURRENT _____ AMPS X _____ TURNS = _____ AMPERE TURNS

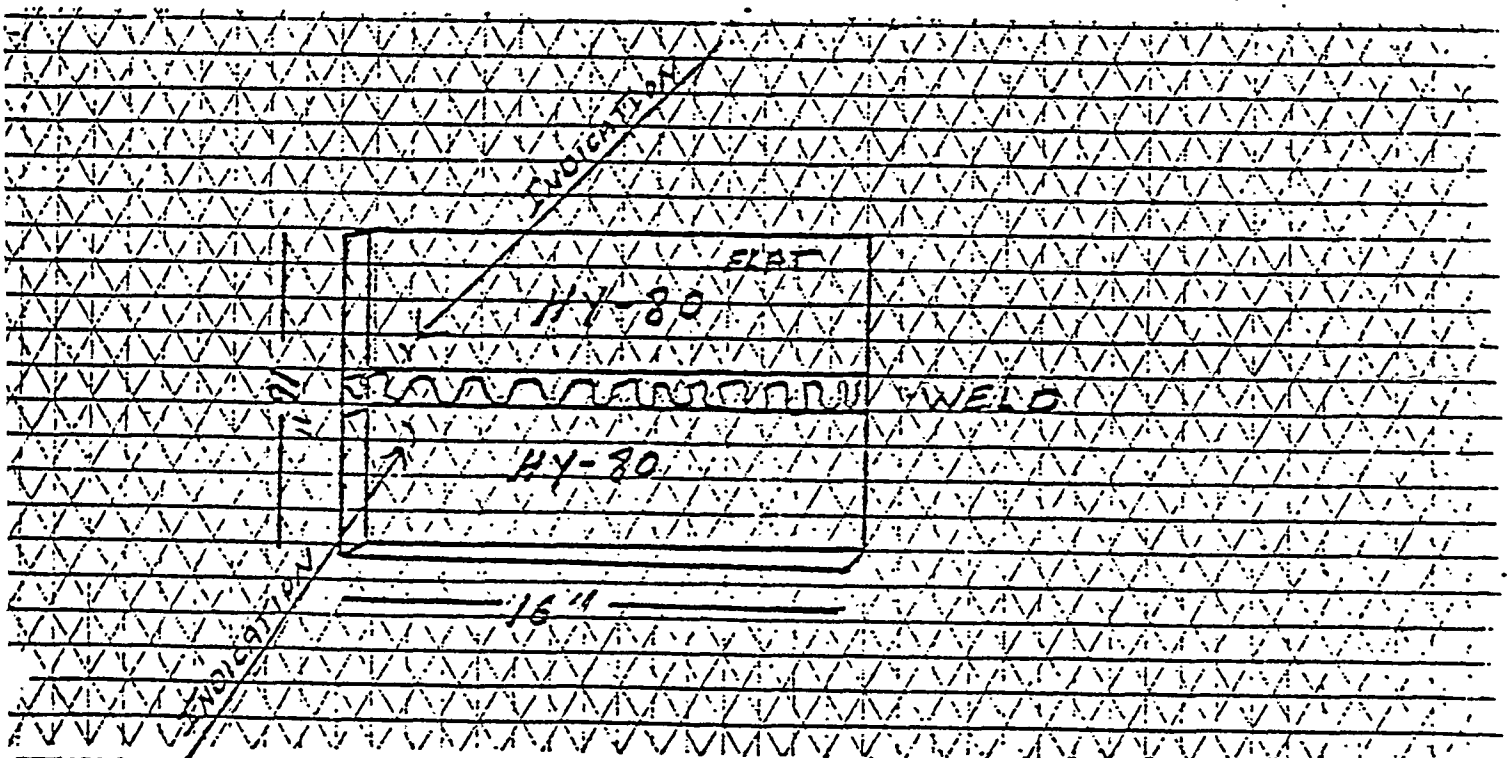
FERROMAGNETIC PARTICLES USED: DRY [X] WET [ ] FLOURESCENT [ ] BATCH NO. 7M009

SPECIFICATION: NAVY MIL SPEC NO. 271 [X] NAVSHIP 0900-003-8000 [ ] A.B.S. [ ]
OTHER _____

OBJECT TESTED/LOCATION: TEST PLATE HY-80 TO HY-80 FLAT

IDENTIFICATION MARKS OR SERIAL NO. GMAW-S

DESCRIPTION OF OBJECT/LOCATION AND TEST RESULTS Performed NDT inspection using the magnetic particle method on one test plate HY-80 to HY-80 flat setting up a magnetic field in two directions parallel and to the right angle of the weld and 1 in. of the heat affected zone. Indications that were found were removed by grinding re-inspected and found acceptable. See sketch below.



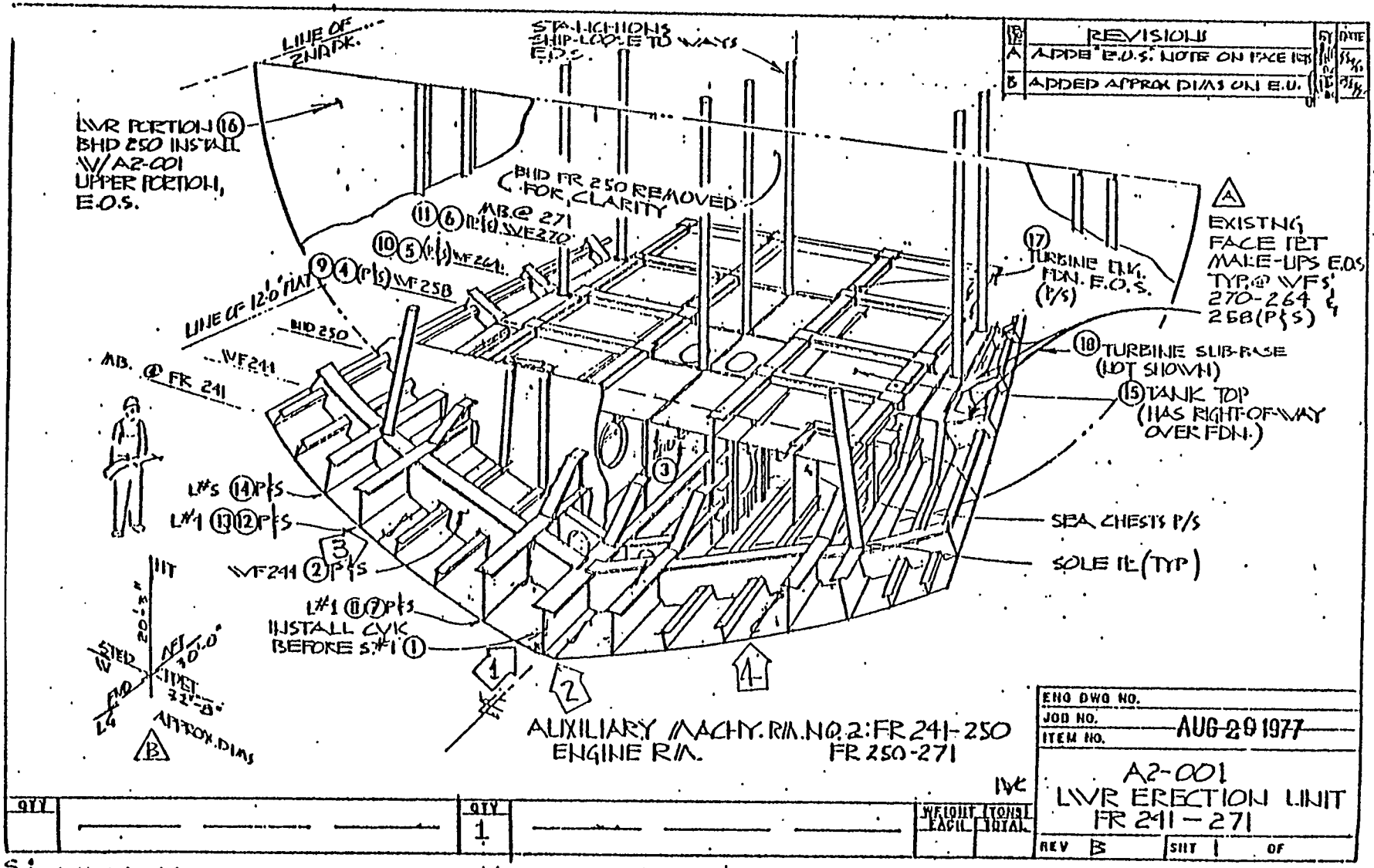
REPORTS TO: BILL POTTS, BOB GRAY, BOB BELL, JIM JOHNSTON, 3 to Electric Shop (09)

OPERATOR _____

EXAMINER E. T. Thomas

FIGURE 13

RM*77-1



NOTES:

1 THRU 4 = SEAM WELDS USING GILLILAND SYSTEM.

FIGURE 14
SKETCH-LOWER ERECTION UNIT
FFG-FR. 241-271

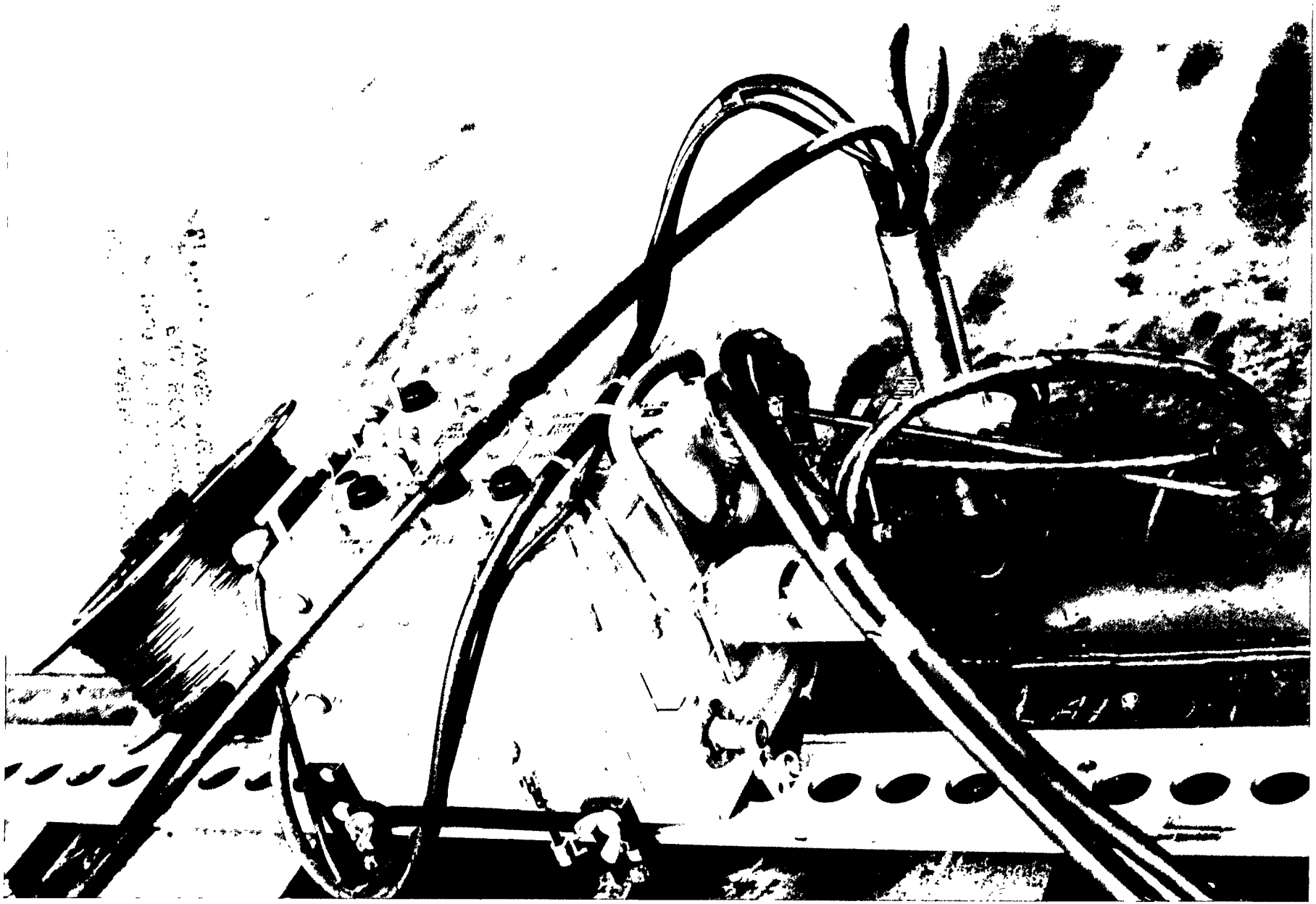


FIGURE 15 - GILLILAND TRACTOR, TORCH AND CONTROL WITH 25 POUND FLUX CORED WIRE (LINDE 727) MOUNTED ON GILLILAND RAILS.

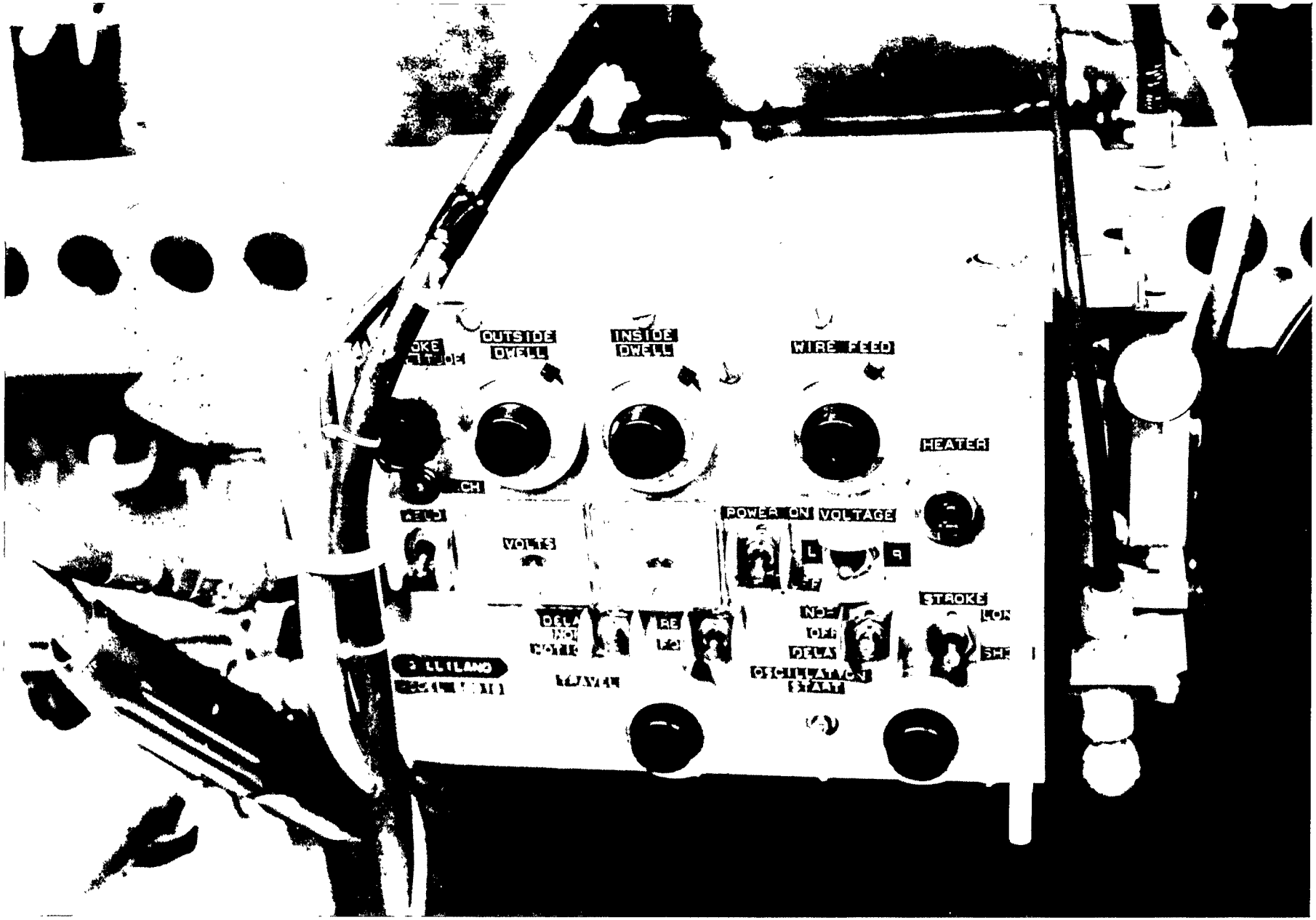


FIGURE 16 - CLOSE-UP VIEW OF GILLILAND TRACTOR UNIT.

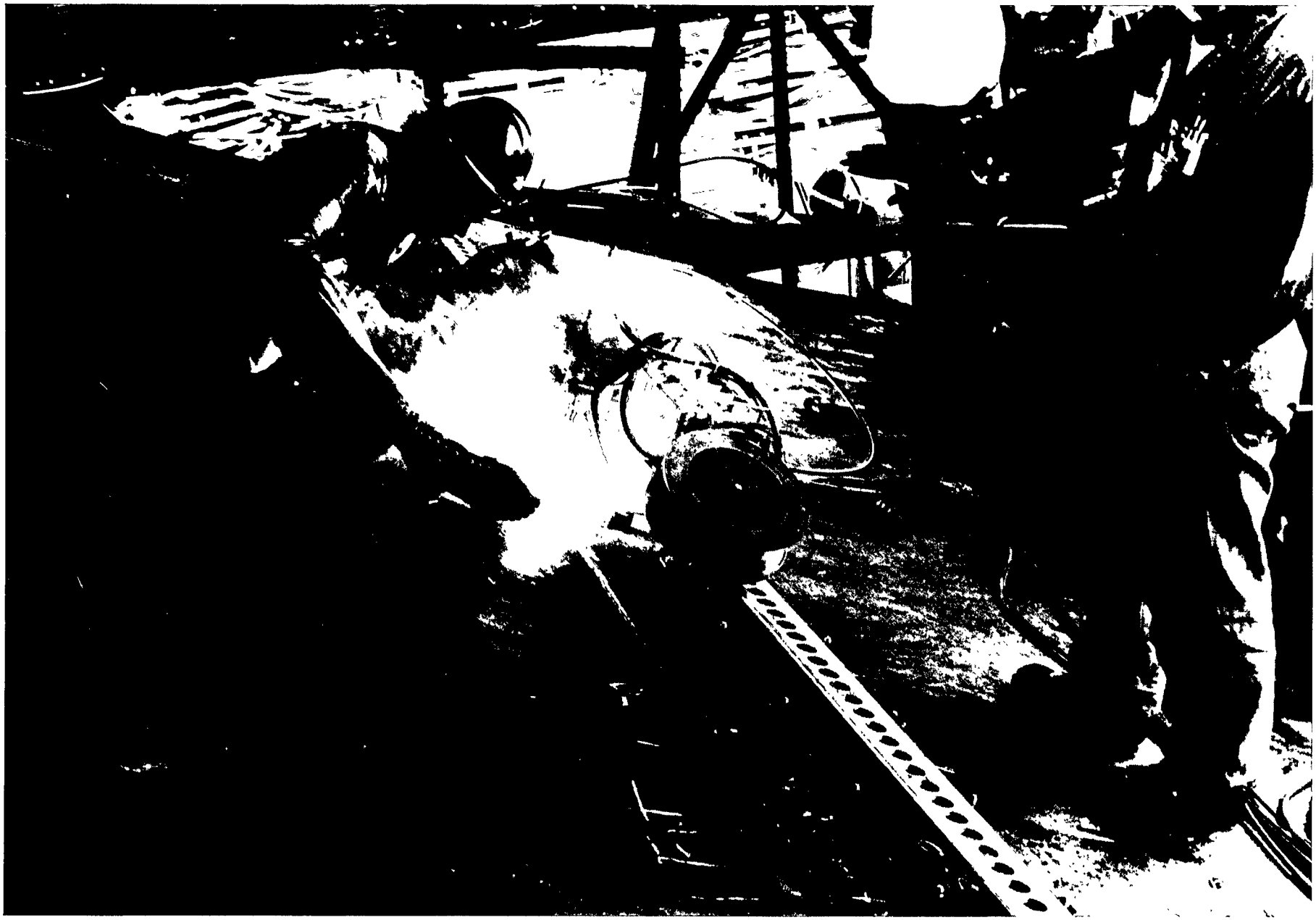


FIGURE 17 - GILLILAND SYSTEM AT WORK.

FIGURE 18 - GILLILAND SYSTEM AT WORK.

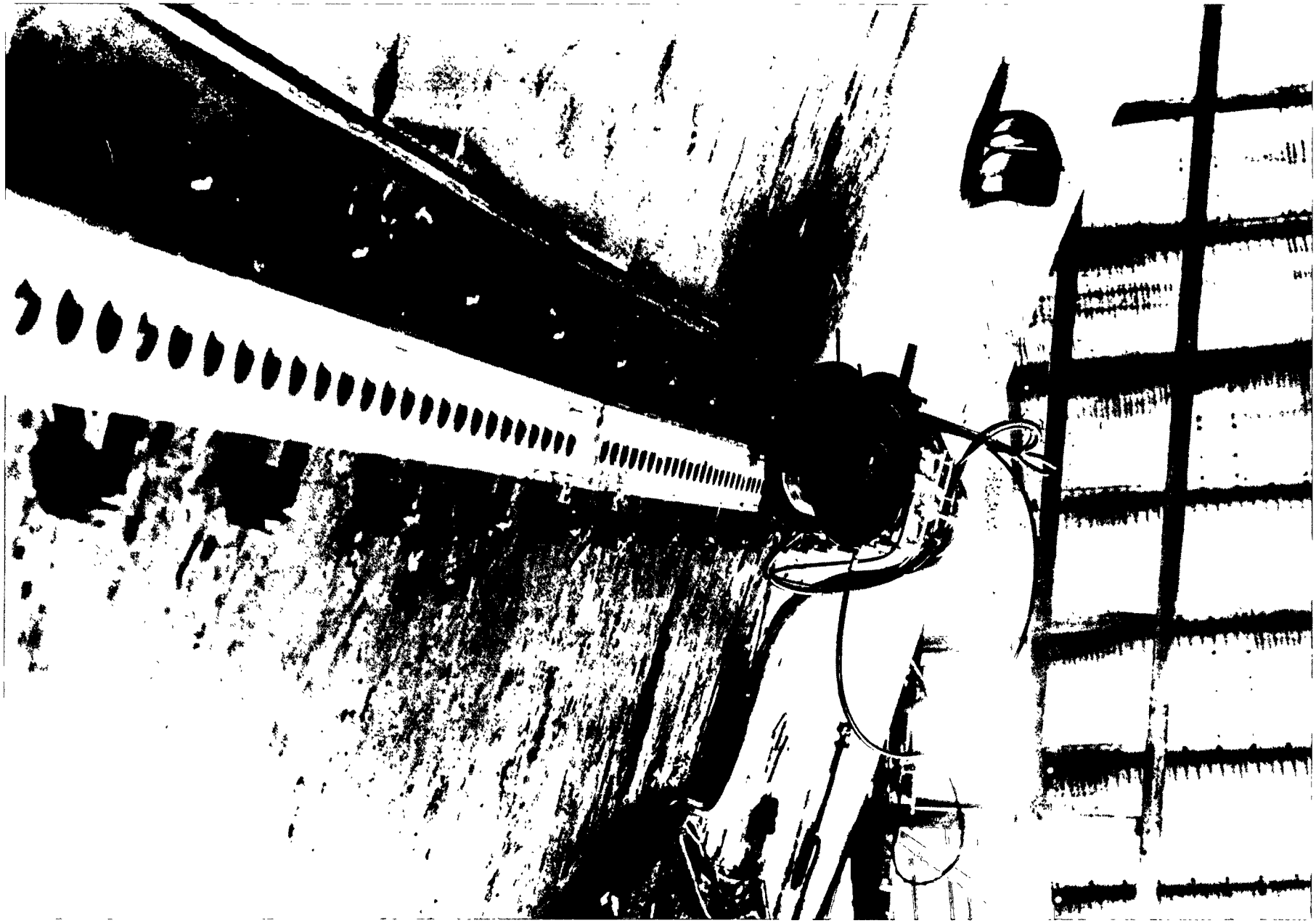


FIGURE 19 - COMPLETED FCAW WELD USING GILLILAND SYSTEM.

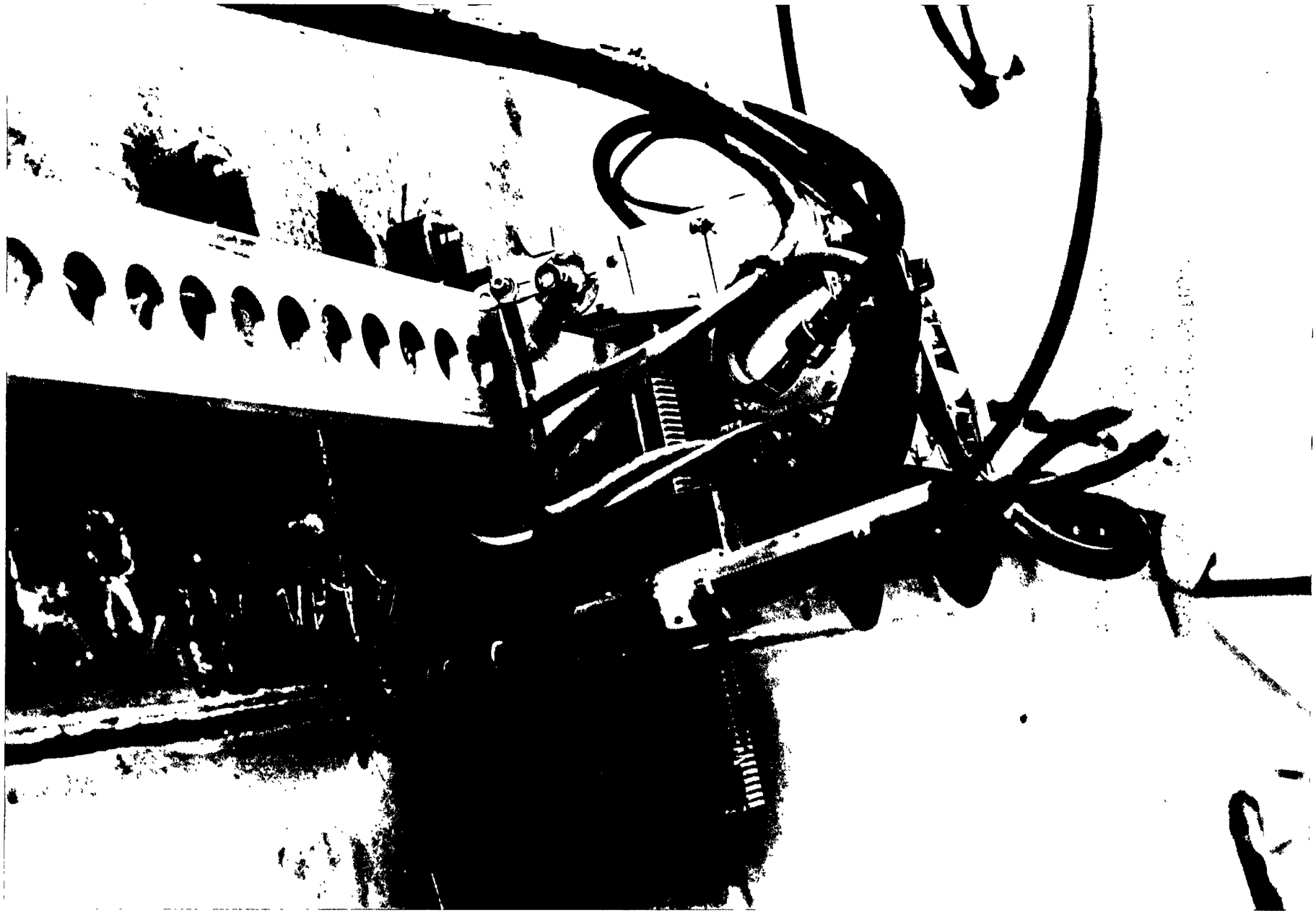


FIGURE 20 - COMPLETED FCAW SEAM USING GILLILAND SYSTEM.

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W., P.O. Box 3806, Seattle, Washington 98124 • 623-1635 (206)

DESCRIPTION	JOINT #1 & #2 SECTION #2101 - DRW.1111-05 SHT.3A - FR 241-271		
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF. STD.	MIL-STD-248C NAVSHIPS 0900-000-1001
BASE METALS	LOW CARBON STEEL	PROCESS	FCAW
SPEC./TYPE FILLER METAL	1/16 Inch Diameter LINDE 727 E70T-G	POWER SOURCE; MODEL/TYPE	GILLILAND CV600
		POLARITY	D.C. R.P.
POSITION OF WELD	FLAT	GAS: FLOW RATE/TYPE	45 C.F.H. 75% ARG/25% CO_2
JOINT PREPARATION & SIDE NUMBER	B2V.1	TORCH TYPE	GILLILAND
		CUP SIZE	5/8" ORIFICE
	SIDE #1		
INTERPASS CLEANING	ALL SLAG AND OUTER FOREIGN DEPOSITS SHALL BE REMOVED BEFORE DEPOSITING SUBSEQUENT BEADS		
REPAIRS	REPAIRS MADE IN ACCORDANCE WITH MIL-STD-248C		
PREHEAT TEMPERATURE	60° MIN.	INTERPASS TEMPERATURE	
WELD TECHNIQUE	WELD TECHNIQUE IN ACCORDANCE WITH T.W.P.S 976-1516		

ACTUAL TRAVEL SPEED (I.P.M.)	FILLER METAL DIAMETER	AMPERAGE RANGE	ARC VOLTAGE RANGE	WELDING POSITION	NOTES:
	1/16	230-25	28	FLAT	ROOT PASS
	1/16	200	30	FLAT	2 ND PASS
	1/16	210-220	31	FLAT	COVER PASS

Control Panel Mode:

Power on - [√]

Weld/inch toggle switch: Weld [√]
Inch/pre-purge push button: Pre-Purge [√]
Wire feed speed control potentiometer [1.65]

Tractor Travel: Break-delay [√] motion [ ]
Tractor Travel: Left [ ] Right [√]
Tractor Travel Speed Control: [2.40-2.80]

Oscillation: normal [ ] delay [√]
Oscillation stroke: long [√] short [ ]
Oscillation speed control [.22]
Stroke amplitude [OPEN] Outside dwell control [30] Inside dwell control [30]

WELDING ENGINEER Approval J. C. Johnston DATE 11/1978

Executive Offices: One State Street Plaza - New York, N.Y. 10004

GILLILAND MACHINE SETTINGS

FIGURE 21

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W., P.O. Box 3806, Seattle, Washington 98124 • 623-1635 (206)

DESCRIPTION	SECTION #2101 - DRW. 1111-05 SHT. 3A - FR241-271		
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF. STD.	MIL-STD-248C NAVSHIPS 0900-000-1001
BASE METALS	LOW CARBON STEEL	PROCESS	FCAW
SPEC./TYPE FILLER METAL	1/16 Inch Diameter LINDE 727 E70T-G	POWER SOURCE; MODEL/TYPE	GILLILAND CV600
		POLARITY	DC RP
POSITION OF WELD	FLAT	GAS: FLOW RATE/TYPE	45 C.F.H. 75% ARGON/25% CO_2
JOINT PREPARATION & SIDE NUMBER	SINGLE BEVEL	TORCH TYPE	GILLILAND
	SIDE #1	CUP SIZE	5/8" ORIFICE
INTERPASS CLEANING			
REPAIRS			
PREHEAT TEMPERATURE	NA	INTERPASS TEMPERATURE	NA
WELD TECHNIQUE	PER TWPS 976-1516		

ACTUAL TRAVEL SPEED (I.P.M.)	FILLER METAL DIAMETER	AMPERAGE RANGE	ARC VOLTAGE RANGE	WELDING POSITION	NOTES:
	1/16	200	30	FLAT	2 ND PASS

Control Panel Mode:

Power on - [√]

Weld/inch toggle switch: Weld [√]
Inch/pre-purge push button: Pre-Purge [√]
Wire feed speed control potentiometer [1.65]

Tractor Travel: Break-delay [√] motion [ ]
Tractor Travel: Left [√] Right [ ]
Tractor Travel Speed Control: [0.24]

Oscillation: normal [ ] delay [√]
Oscillation stroke: long [√] short [ ]
Oscillation speed control [.32]
Stroke amplitude [OPEN] Outside dwell control [.10] Inside dwell control [.10]

WELDING ENGINEER Approval _____ DATE _____

GILLILAND MACHINE SETTINGS

FIGURE 22

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W., P.O. Box 3806, Seattle, Washington 98124 • 623-1635 (206)

DESCRIPTION	SECTION #2101 - DRW. 1111-05 SHT. 3A - FR 241-271		
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF. STD.	MIL-STD-248C NAVSHIPS 0900-000-1001
BASE METALS	LOW CARBON STEEL	PROCESS	FCAW
SPEC./TYPE FILLER METAL	1/16 INCH DIAMETER LINDE 727 E70T-G	POWER SOURCE; MODEL/TYPE	GILLILAND CV600
		POLARITY	DC RP
POSITION OF WELD	FLAT	GAS: FLOW RATE/TYPE	50 C.F.H. 75% ARGON/25% CO,
JOINT PREPARATION & SIDE NUMBER	SINGLE BEVEL	TORCH TYPE	GILLILAND
		CUP SIZE	5/8" ORIFICE
	#1		
INTERPASS CLEANING			
REPAIRS			
PREHEAT TEMPERATURE	NA	INTERPASS TEMPERATURE	NA
WELD TECHNIQUE			

ACTUAL TRAVEL SPEED (I.P.M.)	FILLER METAL DIAMETER	AMPERAGE RANGE	ARC VOLTAGE RANGE	WELDING POSITION	NOTES:
	1/16	210-220	31	FLAT	COVER PASS

Control Panel Mode:

Power on - [√]

Weld/inch toggle switch: Weld [√]
Inch/pre-purge push button: Pre-Purge [√]
Wire feed speed control potentiometer [1.85]

Tractor Travel: Break-delay [√] motion [ ]
Tractor Travel: Left [ ] Right [√]
Tractor Travel Speed Control: [3.46]

Oscillation: normal [ ] delay [√]
Oscillation stroke: long [ ] short [√]
Oscillation speed control [.28]
Stroke amplitude [OPEN] Outside dwell control [10] Inside dwell control [.10]

WELDING ENGINEER Approval _____ DATE _____

GILLILAND MACHINE SETTINGS

FIGURE 23

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W., P.O. Box 3806, Seattle, Washington 98124 - 623-1635 (206)

DESCRIPTION

WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF. STD.	MIL-STD-248C NAVSHIPS 0900-000-1001
BASE METALS	LOW CARBON STEEL	PROCESS	F.C.A.W.
SPEC./TYPE FILLER METAL	0.045 inch diameter CHEMETRON 8000 2NI	POWER SOURCE; MODEL/TYPE	Gilliland
		POLARITY	D.C.R.P.
POSITION OF WELD	Vertical-Up	GAS: FLOW RATE/TYPE	35 C.F.H. 75% Argon 25% CO_2
JOINT PREPARATION & SIDE NUMBER	22½° Bevel on eac h plate.	TORCH TYPE	Gilliland
		CUP SIZE	5/8
INTERPASS CLEANING	REMOVE ALL SLAG & WIRE BRUSH EACH PASS		
REPAIRS	NONE		
PREHEAT TEMPERATURE	60°	INTERPASS TEMPERATURE	NA
WELD TECHNIQUE	ROOT OPENING ¼"		

ACTUAL TRAVEL SPEED (I.P.M.)	FILLER METAL DIAMETER	AMPERAGE RANGE	ARC VOLTAGE RANGE	WELDING POSITION	NOTES:
6 I.P.M.	.045	200-240	24 - 26	Vert-Up	Root & 1st Fill Pass
6 I.P.M.	.045	200-240	24 - 26	Vert-Up	2nd & 3rd Fill Pass
6¾ I.P.M.	.045	200-240	24 - 26	Vert-Up	COVER PASS

Control Panel Mode:

Power on - [X]

Weld/inch toggle switch: Weld [X]
Inch/pre-purge push button: Pre-Purge [—]
Wire feed speed control potentiometer [3.66]

Tractor Travel: Break-delay [X] motion [ ]
Tractor Travel: Left [ ] Right [X]
Tractor Travel Speed Control: [4.14]

Oscillation: normal [ ] delay [X]
Oscillation stroke: long [X] short [ ]
Oscillation speed control [.49] Cover pass .31
Stroke amplitude [Y] Outside dwell control [.10] Inside dwell control [.10]

WELDING ENGINEER Approval _____ DATE _____

GILLILAND MACHINE SETTINGS

FIGURE 24

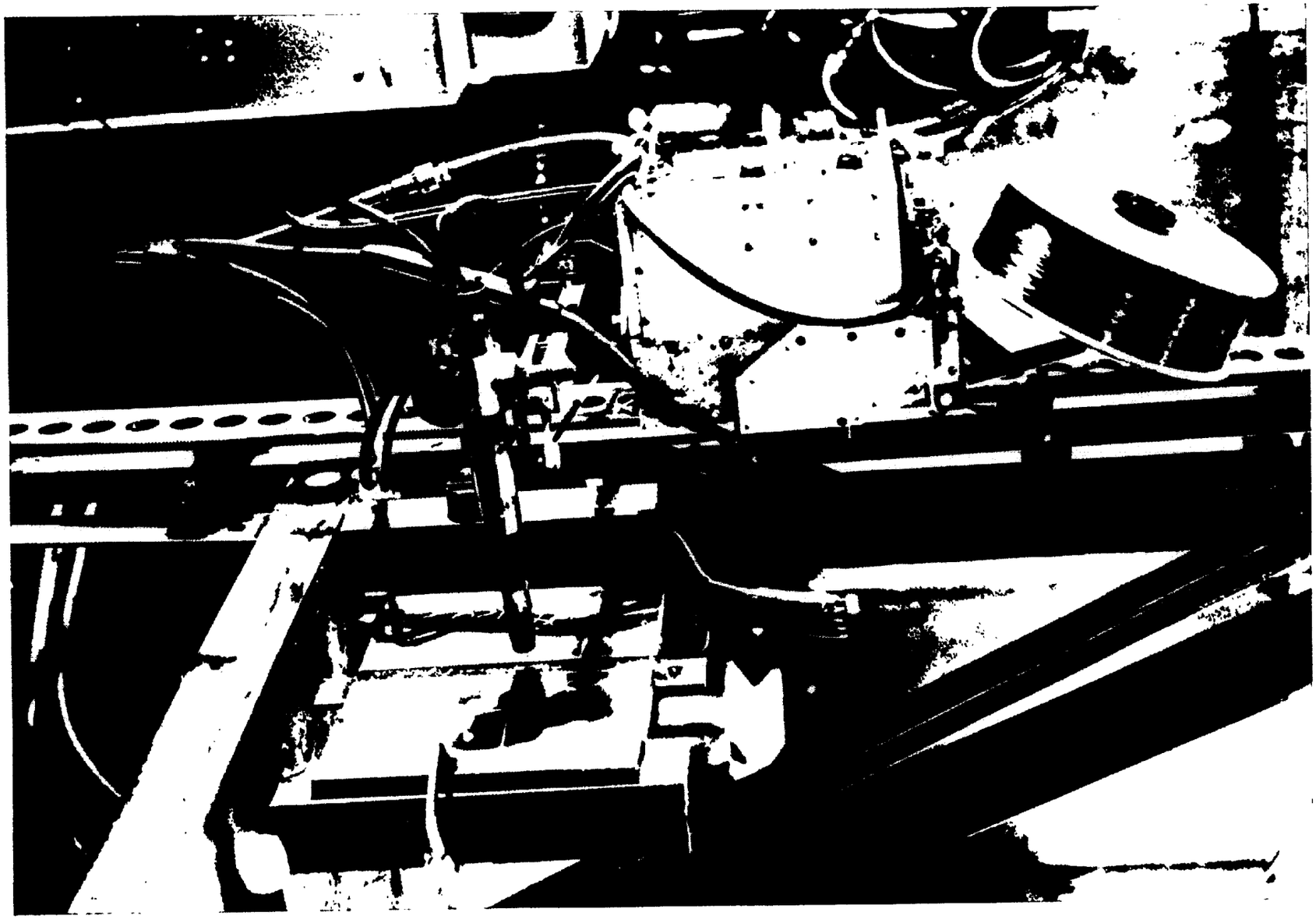


FIGURE 25 - GILLILAND UNIT IN VERTICAL-UP MODE: FCAW WELD TEST SET-UP.

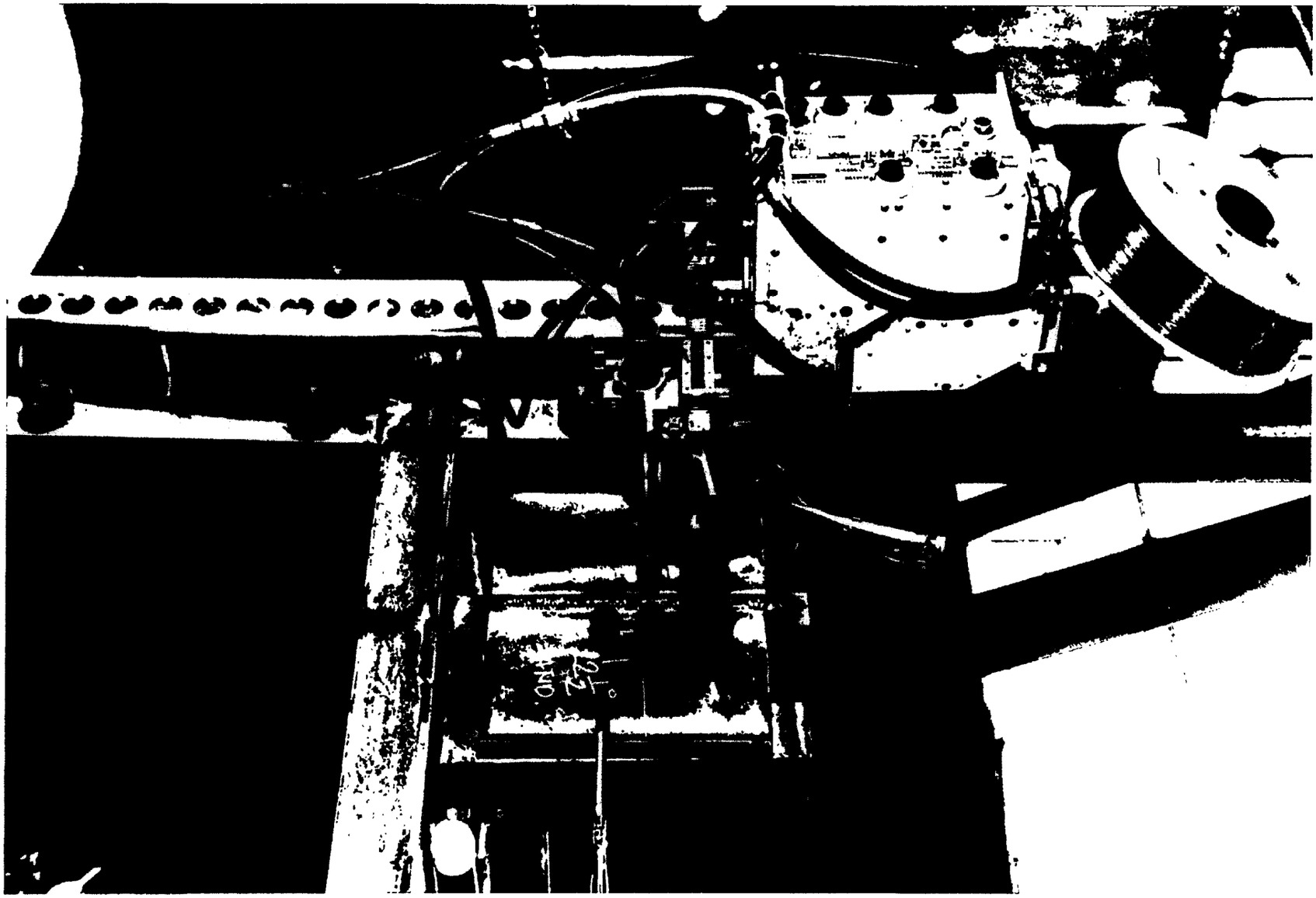


FIGURE 26 - GILLILAND UNIT IN VERTICAL-UP MODE: FCAW WELD TEST SET-UP: FILL PASSES.

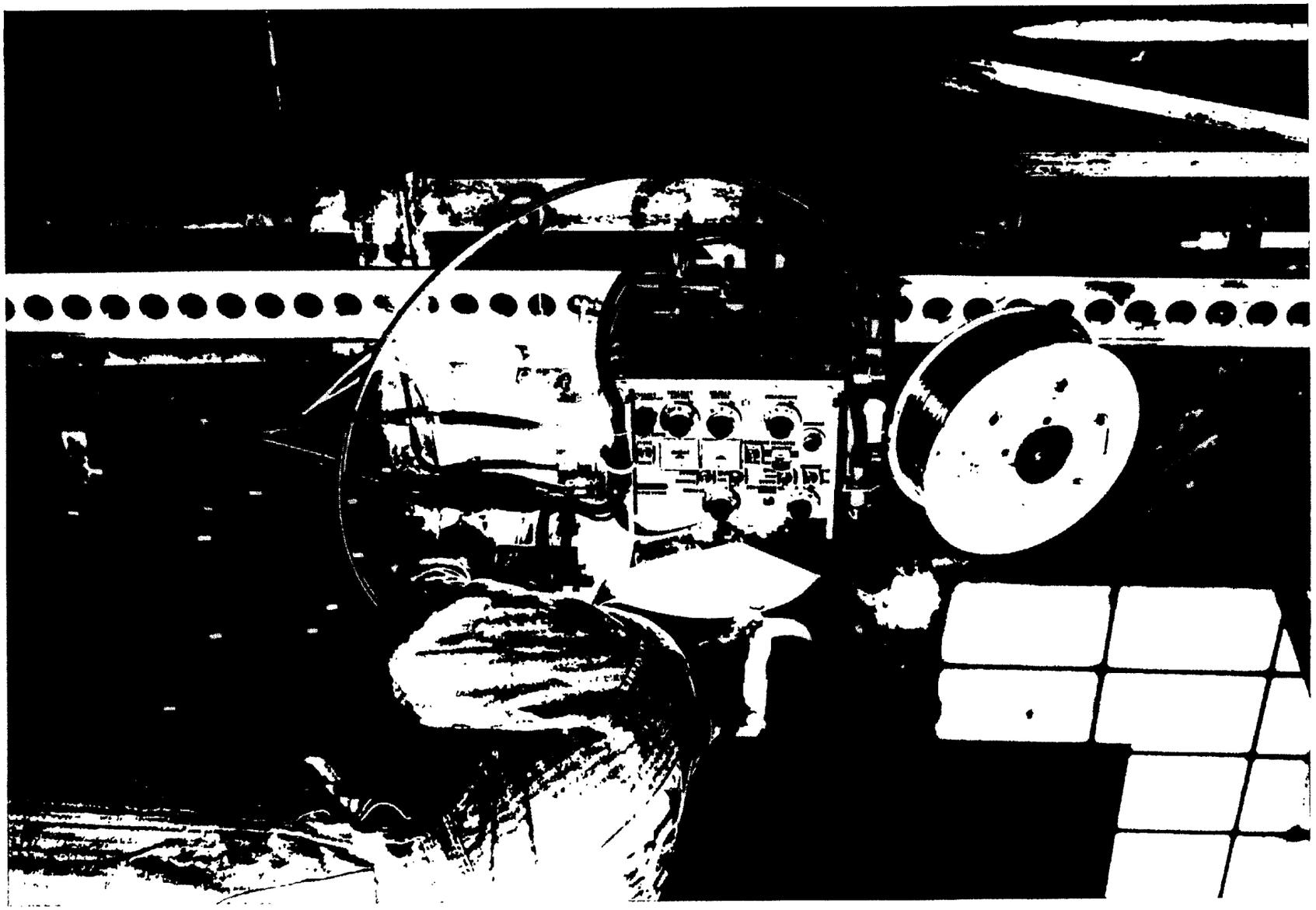


FIGURE 27 - GILLILAND UNIT IN VERTICAL-UP MODE: FCAW CHEMETRON 8000-2NI 0.045 INCH DIAMETER FILLER.

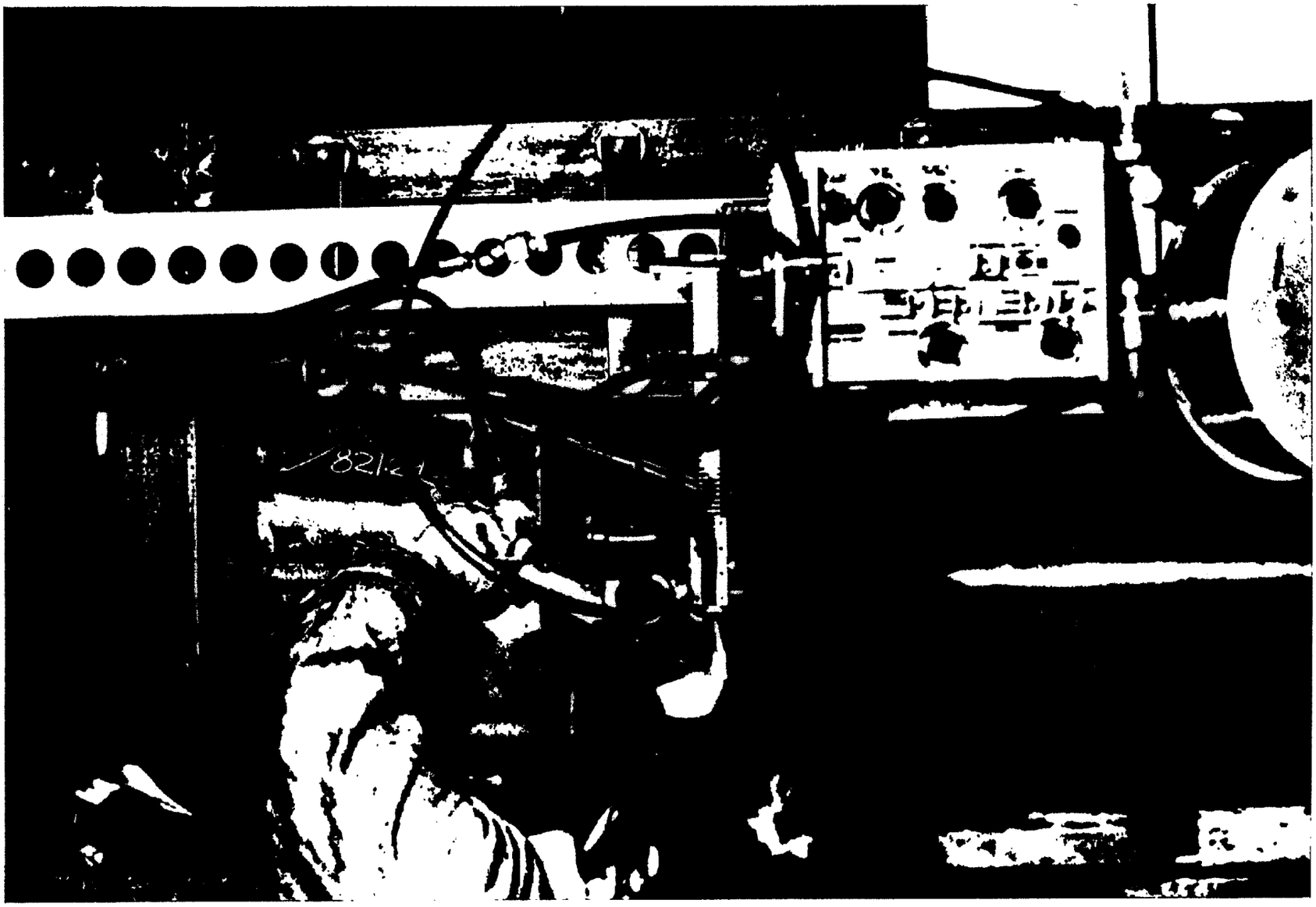


FIGURE 28 - GILLILAND UNIT IN VERTICAL-UP MODE: INTERPASS CLEANING OF WEAVE PASSES.

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W., P.O. Box 3806, Seattle, Washington 98124 • 623-1635 (206)

DESCRIPTION			
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF. STD.	MIL-STD-248C NAVSHIPS 0900-000-1001
BASE METALS	LOW CARBON STEEL	PROCESS	GMAW
SPEC./TYPE FILLER METAL	0:045 Inch Diameter Chemetron 8000 2Ni	POWER SOURCE; MODEL/TYPE	Gilliland CU 600
		POLARITY	D. C. R. P.
POSITION OF WELD	OVHD	GAS: FLOW RATE/TYPE	35 C.F.H. 75% Argon 25% CO_2
JOINT PREPARATION & SIDE NUMBER	45° Bevel; 1/8" Land	TORCH TYPE	Gilliland
		CUP SIZE	½
	One Side		
INTERPASS CLEANING	Clean all slag with wire brush		
REPAIRS	Repair any defects before next pass is put in		
PREHEAT TEMPERATURE	60° Min	INTERPASS TEMPERATURE	NA
WELD TECHNIQUE			

ACTUAL TRAVEL SPEED (I.P.M.)	FILLER METAL DIAMETER	AMPERAGE RANGE	ARC VOLTAGE RANGE	WELDING POSITION	NOTES:
10 - 12 IPM	.045	210 - 230	27 - 29	OVHD	
10 - 12 IPM	.045	210 - 230	28 - 30	OVHD	

Control Panel Mode:
Power on - [✓]

Weld/inch toggle switch: Weld [X]
Inch/pre-purge push button: Pre-Purge [—]
Wire feed speed control potentiometer [3.86]

Tractor Travel: Break-delay [—] motion [X]
Tractor Travel: Left [—] Right [X]
Tractor Travel Speed Control: [2.69]

Oscillation: normal [X] delay [—]
Oscillation stroke: long [—] short [—]
Oscillation speed control [—]
Stroke amplitude [—] Outside dwell control [—] Inside dwell control [—]

WELDING ENGINEER Approval J. C. Johnston DATE 4/78

Executive Offices: One State Street Plaza • New York, N. Y. 10004

GILLILAND MACHINE SETTINGS

FIGURE 29

FIGURE 30 - GILLILAND WELDING UNIT IN OVERHEAD WELDING POSITION.

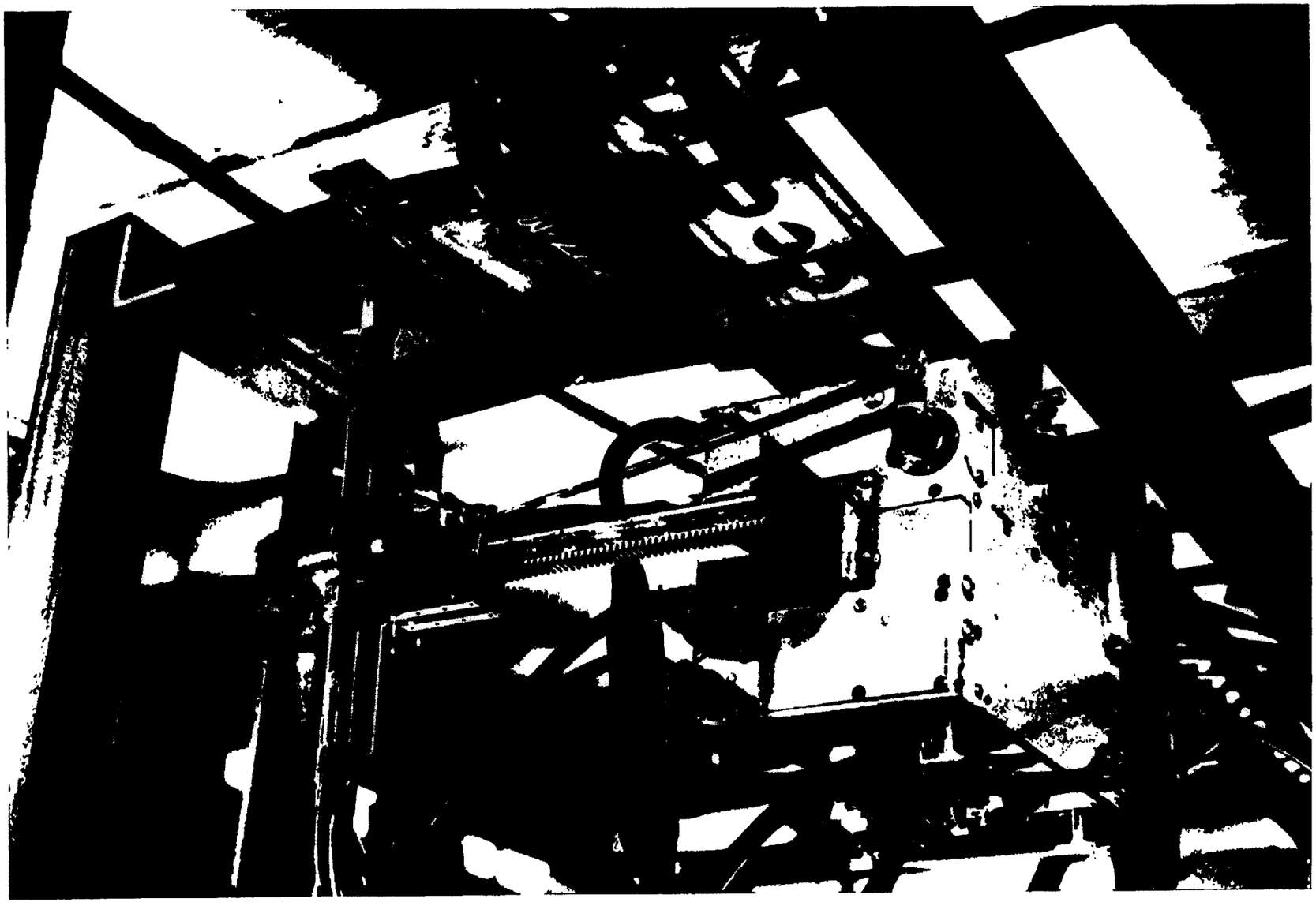


FIGURE 31 - GILLILAND WELDING UNIT IN OVERHEAD WELDING POSITION.

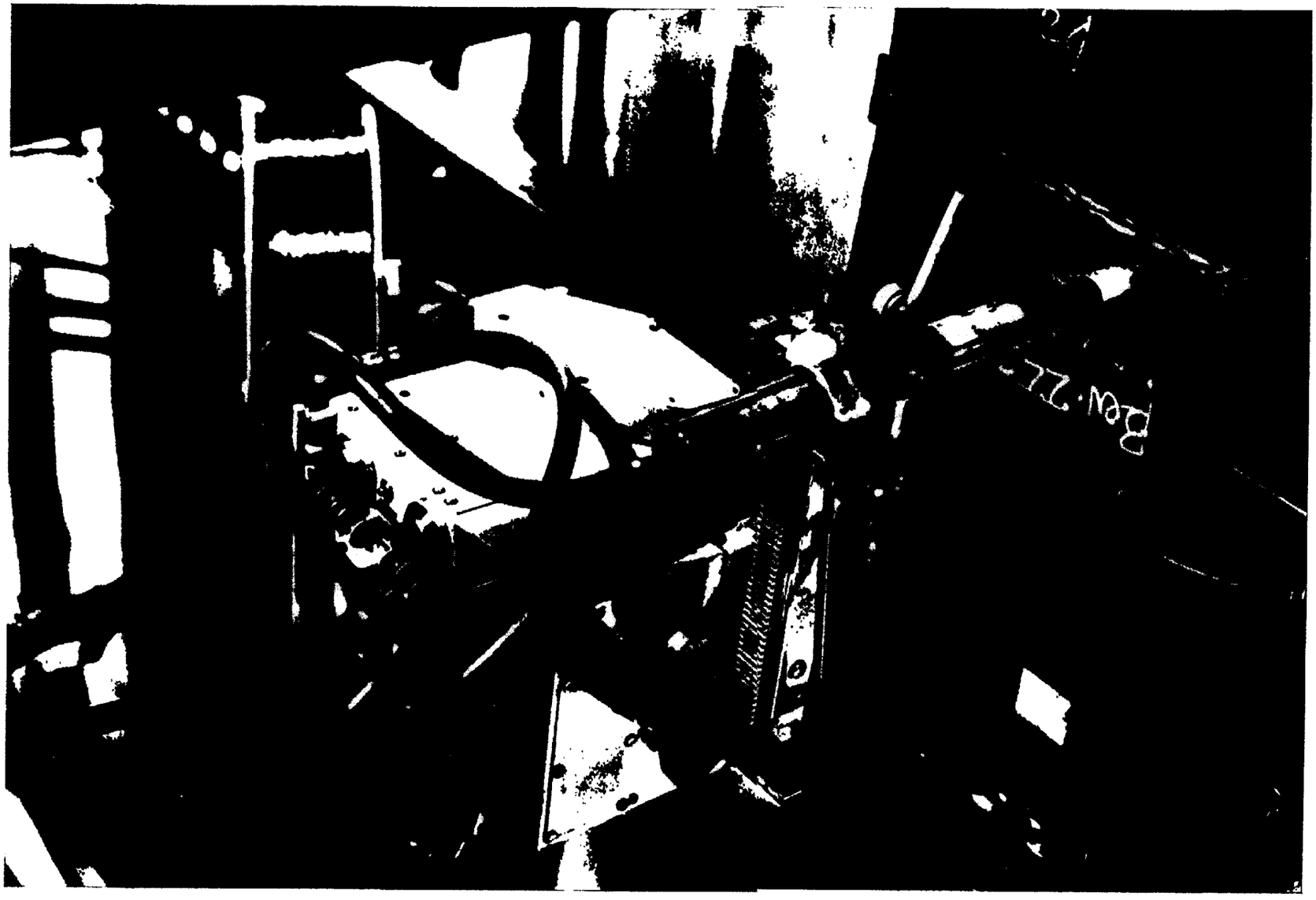


FIGURE 32 - GILLILAND WELDING UNIT IN OVERHEAD WELDING POSITION.