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SURFACE PREPARATION AND COATINGS  
DESIGN/PRODUCTION INTEGRATION  
HUMAN RESOURCE INNOVATION  
MARINE INDUSTRY STANDARDS  
WELDING  
INDUSTRIAL ENGINEERING  
EDUCATION AND TRAINING

# **THE NATIONAL SHIPBUILDING RESEARCH PROGRAM**

## **Ultra Portable Power Supply/Wire Feeder**

U.S. DEPARTMENT OF THE NAVY  
CARDEROCK DIVISION,  
NAVAL SURFACE WARFARE CENTER

in cooperation with  
Peterson Builders, Inc.

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July 1996

Dear Shipbuilder,

Subject:   SNAME Panel SP - 7 Project: 7-94-5 "ULTRA PORTABLE POWER  
SUPPLY/WIRE FEEDER."

The enclosed report is the product of the National Shipbuilding Research Program  
(NSRP). NEWPORT NEWS SHIPBUILDING developed this information under the  
auspices of the Society of Naval Architects and Marine Engineers Ship Production  
Committee's Welding Panel SP - 7.

The ULTRA PORTABLE POWER SUPPLY/WIRE FEEDER objective was: "Develop  
and evaluate an ultra portable inverter type power supply and wirefeeder combination  
that is capable of Gas Metal Arc (GMAW) and Shielded Metal Arc (SMAW) Welding."

After reviewing the enclosed report, please take time to complete and return the  
reader response card.

Sincerely,

John Meacham  
Industrial Processes Program Manager

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# **FINAL REPORT**

PETERSON BUILDERS PURCHASE ORDER 9757-0037

PROJECT NO. 7-94-5

## **"ULTRA-PORTABLE POWER SUPPLY/WIRE FEEDER"**

A PROJECT OF

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

FOR

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

SHIP PRODUCTION COMMITTEE

SP-7 WELDING PANEL

PREPARED BY

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JUNE 1996

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## **1.0 ABSTRACT**

This report marks the realization of a welding package conceptual idea, generated by the author in early 1993. The development of a prototype ultra-portable (less than 50 lbs.) welding power supply/wire feeder combination within one enclosure has been successfully designed, prototype developed, welding laboratory tested, and utilized/evaluated in a shipyard production environment. The unit even in its prototype enclosure design (sheet metal verses fiberglass or injection plastic molded) weighs under 50 pounds and has a operating range of up to 300 amperes DC at 60% duty cycle while performing SMAW (shielded metal arc welding), FCAW (flux cored arc welding), and GMAW (gas metal arc welding, spray and short circuit) processes. The prototype's design offers the operator four process options along with mobility and simplicity of set up.

## **2.0 OBJECTIVE**

Develop and evaluate a welding equipment prototype that has the potential to significantly enhance welding productivity due to its unique design, portability, physical size and process selection options. The design should incorporate a welding power supply and wire feeder combined within the same enclosure and allow selection of multiple welding processes. The unit should maintain the application diversity, simplicity and portability of the simplest process, shielded manual metal arc welding (SMAW), while offering it and higher productivity welding processes such as gas metal arc welding (GMAW) and flux cored arc welding (FCAW).

To meet these aggressive objectives a plan was developed with significant milestones divided into five major task areas, spanning a sixteen month period. These tasks and the events within each one are shown in Appendix (A), Gantt Chart of Major Tasks and Performance Periods.

## **3.0 BACKGROUND**

Welding in the shipbuilding industry is performed utilizing any one of five basic and widely used processes: SMAW - shielded metal arc welding; GTAW - gas tungsten arc welding; GMAW - gas metal arc welding (pulse, spray and short circuit); FCAW - flux cored arc welding; SAW - submerged arc welding.

SMAW, the simplest most basic process and the backbone of most heavy steel fabrication facilities, requires the least monetary investment and is the easiest to relocate from one welding area to another. It requires only a power source, ground cable to work and electrode line that can be extended up to several hundred feet to the weld site. Other than GTAW, which is primarily used for sheet metal, thin materials and some pipe, it's productivity (man-hours spent per pounds of weld metal deposited) is the lowest of the five basic processes discussed earlier. When it is feasible and there is an economical advantage, higher productivity processes are used.

In comparison, a higher productivity process such as GMAW would require a similar size power supply and the same ground cable and electrode lead; in addition to gas and control cables for the wire feeder. When these larger bundles of cables are routed through the construction areas, relocation is difficult, additional personnel are often required and many times the lines because of their routing create a safety concern. Many power suppliers (SMAW & GMAW) lack remote control capability and require several trips, by the welder, from the job site to the power source for parameter adjustment prior to and while performing production welding. As a result, some of the man hour savings realized by higher welding deposition rates through utilizing the more efficient processes are eroded by the relocation and set-up labor. For portability and expediency, SMAW is often a more economical option.

*The physical configuration and design of conventional transformer-type multi-purpose/process welding power supplies and wire feeders restrict their mobility and require valuable space at the work/construction site. The power supply itself is normally located at some central location and the wire feeder is moved to the various welding sites within a given radius, dependent upon the length of interconnecting cables. These factors combined with the ones listed below restrict wide spread mobility and decrease utilization in shipyard environments of higher productivity semi-automatic wire processes.*

- New multi-process welding power supplies with outputs in the 300 ampere range still weigh 85 to 150 lbs.
- Wire feeders weigh from 28 to 50 lbs. without wire.
- The weight of the interconnecting cable assembly itself, will average almost 2 lbs per foot.
- Support labor and equipment (forklift/crane) is required for set-up and relocation whenever ship erection sequences, schedules or maintenance necessitates.



When considering the optimum type of equipment to purchase and use in a shipbuilding construction environment many factors such as application diversity, portability and productivity are reviewed for return on investment.

#### **4.0 APPROACH**

Newport News Shipbuilding (NNS) initially conducted marketplace searches to benchmark present technology. This was accomplished through phone conversations, correspondence and meetings with representatives of the major welding equipment manufacturers. An extensive review of similar product type availability and present technology was conducted. The result of our efforts was identification of major welding equipment manufacturers that were not only interested in the project but several had contemplated/performed some related research. Examples of similar existing product lines include Lincoln's "SP-100/130", Hobart's "Handler 120", Miller's "Milleromatic 130" and L-Tee's "Mig 130". All of which operate from 115 or 230 VAC, are designed for light/thin materials and have very low duty cycles at amperages up to 130. These units do not incorporate inverter technology, are heavy ( 57 - 73 lbs.) and exceed our weight requirements even at these lower outputs.

Based on the information obtained during the marketplace search, equipment specifications, preliminary development timetables and construction schedules were compiled into a purchase order solicitation.

A list was generated of welding equipment manufacturers interested and capable of participating in the development of an ultra-portable GMAW welding power supply and wire feeder combination within one enclosure. Most manufacturers that were contacted felt that the project was very worthwhile but felt that the weight restrictions eliminated most of their on-the-shelf components and the developmental time period which would require some modules to be developed from scratch was much too short. After extensive discussions with interested welding equipment manufactures who felt that they could undertake such a project, the list was narrowed to five potential suppliers.

The undertaking of such a project in the limited twelve month time frame left a minimal developmental period. To most effectively convey the urgency of the project, a very simple and straight-forward purchase order was developed for submittal to interested welding equipment manufacturers. Major highlights of the purchase order were as follows:

- 1 Develop and construct an ultra-portable inverter-type GMAW power supply/Wire feeder combination within one enclosure. It will also have the capabilities and output connector for switching to SMAW. The completed unit should be capable of performing GMAW-short circuit, GMAW-spray and FCAW while meeting the following specifications and operating characteristics:
  - A. Welding output approximately 12 - 38 volts DC and 50 - 300 amperes DC at 60% duty cycle.
  - B. Welding torch length GMAW/FCAW - 15 ft., SMAW - 25 ft. with both having quick disconnects.
  - C. Process controls should include: contactor, weld current and voltage control, shielding gas purge, wire feed speed control, cold wire inch, anti-stick/burn back, pre/post flow gas capabilities, GMAW/SMAW switch, voltage and amperage meters, etc. and will be contained within the power supply/wire feeder enclosure and readily accessible to the operator.
  - D. The wire feed motor and wire spindle assembly for a standard 10 lb./8 inch spool will be contained within the enclosure but -be readily accessible to the operator without him being exposed to the unit's circuitry.
  - E. Wire feeder minimum capabilities shall be .023 through .045 inch hard and soft wires, .035 through 1/16 inch flux core and have wire feed speed ranges of approximately 50 - 650 IPM.
  - F. Optimum input voltage/phase will be single phase 115 VAC with an input current of 20 amperes at rated load. An optional input voltage/phase would be single or three phase 230/460 VAC.
  - G. Unit weight should be approximately 50 pounds, exclusive of detachable items such as GMAW torch, SMAW cable, ground cable and wire spool. It must be configured such that it is capable of being re-located by one person.

The solicitation packages were sent to the top five equipment manufacturers who had expressed interest in the project. The selection of a manufacturer was based on their ability to meet the stated specification criteria and accomplish the project within the planned schedule.

## 5.0 DEVELOPMENT

M. T. Gilliland, Inc. was selected to develop the power supply/wire feeder combination. His response to our solicitation included a proposal to revise the timetables and sequence of the original milestone/payment schedule without affecting the overall time frame. This change better served all parties involved by devoting more of their resources and time to the critical developmental stage of the product. This change was approved by the NSRP Program Manager and the Gantt Chart outlining the various TASKS and their major activities was revised to reflect the changes.

### 5.1 DEVELOPMENT - PHASE ONE

NNS issued a purchase order to M. T. Gilliland, Inc. on March 14, 1995 for the development and manufacture of subject unit. An initial meeting was held on 4/07/95 with D. M. Wheeler, NNS Project Supervisor, and M. T. Gilliland at his manufacturing facility. Also in attendance were the individuals responsible for the Project's development and subsequent manufacture (Kenneth Gilliland & Brent Hughes). The items below are the highlights of this meeting.

- 1 Discussions centered around application advantages, conceptual make-up/layout of the unit, their experiences with various hi-tech/state of the art electronic devices, the technical approach which they plan to pursue and the project milestones.
- 1 Primary input voltage was discussed and the group consensus was to use 460 volts, three phase. Outlined below are the highlights of this discussion:
  - (1) Each voltage (115, 230, or 460 VAC) has certain advantages and disadvantages.
  - (2) The proposed 115 volt single phase model will require more power than the 20 ampere suggested circuit can supply.
  - (3) New ships under construction and those in service normally would have 460 VAC available.
  - (4) Single phase operation would require adding smoothing capacitance, thereby increasing the weight.
  - (5) The primary current draw on 460 VAC would be the least of the three, thereby requiring a lighter and smaller gauge input cable.

- Their progress at this point included receipt of a special lightweight transformer core material, actual winding of the transformer itself and mounting it to a mock-up heat sink for testing purposes. Numerous other electronic devices had been ordered for preliminary component evaluation including electrical outputs and temperature range/variations.
- A wide range of wire feeding methods were discussed. We shared our prior experiences with the various devices available.

The conclusion of this meeting marked the completion of the project's TASK I requirements.

## 5.2 DEVELOPMENT-PHASE TWO

This phase, approximately twenty-one weeks after purchase order placement, was designed to evaluate the manufacture's developmental progress, review the conceptual welding machine package and witness operation of a breadboard "concept" unit.

The NNS Project Supervisor visited the manufacturer's plant on August 9, 1995. The purpose was to evaluate their progress to date, review the conceptual package, witness its operation and determine if the purchase order requirements for Task II had been fulfilled. Outlined below are the highlights of this trip.

- Prior to this visit, preliminary enclosure design and configuration proposals were compiled based on input solicited from Newport News Shipbuilding welding production, equipment maintenance and welding technical personnel. Based on their combined input, a design sketch and the rationale for physical locations of various components was developed and forwarded to the manufacturer.
- A meeting was held with M. T. Gilliland, President, and the persons in charge of the project. During this meeting discussions centered around developmental experiences, various component characteristics, operational testing/results and the challenges of encapsulating all the components into one enclosure.
- The major portion of this visit was spent reviewing and welding with the breadboard unit. The

electrical modules and circuitry were laid out on three different workbenches. Each workbench's contents were as follows: wire feeding mechanism and controller on one; the second included the main transformer, method of rectification with heat sink and cooling fans; and the third consisted of the inverter control/logic breadboarded circuit board.

- The welding processes performed were:

SMAW: 1/8" & 5/32" dia. 7018 electrodes, 130-185 A  
FCAW: .052" dia. 71T-1 wire, CO<sub>2</sub> gas, 225 A/23.5 V  
GMAW(spray): .045" dia. 70S-3 wire, 95/5 gas,  
215 Amps/ 24 Volts  
GMAW (short circuit): .035" dia., 70S-3 wire, 75/25  
gas, 115 amperes/15.5 volts.

- The welding characteristics (arc starting and welding) of SMAW and GMAW (spray) required some fine tuning within the inverter's electronic circuitry. Some component values, length of time/current and slope/ramp up values, and other minor adjustments were made during our testing. The ability to quickly make these changes during development is one the significant advantages of inverter technology and its electronic circuitry.
- Total weight of the unit was a primary design factor and specification of the purchase order. During discussions we reviewed the various components that will make up the complete package, not including the enclosure and determined their total weight to be approximately 39 lbs.
- The final production model enclosure may not be configured the same as the prototype. The prototype was hand constructed/welded instead of fabricated from molded plastic/fiberglass type materials and may be somewhat heavier. The vendor still projected the completed unit to be under the 50 lbs. weight specification.

The meeting was very productive and the operational testing of the-breadboard unit was highly successful. A conceptual package design was agreed upon, and over the next four weeks the parts and pieces were installed into a completed prototype unit. All requirements of TASK 11 had been accomplished at this time.

## 5.3 DEVELOPMENT - PHASE THREE

This phase completed the project's developmental work and a demonstration of the prototype's abilities to NNS production welding and maintenance representatives was conducted at the manufacturer's facility. This visit was to evaluate/test the final version of the prototype prior to it being shipped to NNS for the Welding Laboratory and Production Evaluation. The major areas of concern included:

- Welding output capabilities/arc characteristics by process (SMAW, GMAW, FCAW)
- Wire feeding performance/consistency within specified ranges and wire types
- Operational/location of process controls/switches
- Electrical circuitry operation including component layout for maintenance/repair
- User/operator friendliness
- Overall weight (under 50 lbs) and portability
- Compliance with purchase order specifications

An initial meeting was held in their Welding Lab with M. T. Gilliland, President, and the persons in charge of the project. We discussed the various aspects of the developmental project and the features of the prototype so everyone would be acquainted with the machine. Below is information by welding process and our conclusion at the completion of the testing.

- 1 The operational characteristics (arc stability) of the SMAW process (electrodes: 5/32" dia. 11018 & 7018; 1/8" dia. 70/30 CU/N & 309-15) was very erratic and had excessive spatter. After several adjustments it was determined that an additional resistance (inductance) was needed in the output circuit. An inductance was connected externally in the secondary output circuit and after evaluating several value ranges, the optimum was determined based on arc performance over the weldable range of the above electrode types and sizes.
- 1 GMAW (short circuit) was evaluated in the flat, vertical up and down positions using Type 70S-3, .035" wire and 75A/25CO<sub>2</sub> gas. It performed very well with excellent arc starting and good arc maneuverability. Parameters ranged from 95 amps @ 16.5 volts to 195 amps @ 20 volts.
- GMAW (spray) was evaluated with Type 70S-3, .045" wire and 95A/5CO<sub>2</sub> gas. Parameters ranged from 200 amps @ 24.5 volts up to 255 amps @ 28 volts. The

arc was very stable with a good distinctive cone shape. The unit's internal current limiting device prematurely shut the unit down as we approached the upper amperage value (300 amps). Gilliland representatives explained that the overload device was set too low and would require adjustment to allow maximum output. This change had to be made on the unit's internal circuit board.

- FCAW with .045" wire Type 71T-1 wire using 75AR/25C0<sub>2</sub> gas was demonstrated for fillet welding in the vertical position, both upward and downward progression. A butt was also welded vertically with ceramic backing tape (3/16" opening) with as-welded acceptable backside reinforcement.
- The unit's cooling fans functioned very well. The heat sink temperature was monitored and never exceeded 112° F even when the current limiting device shut the unit down. When welding was stopped for three to four minutes, the fans would bring the heat sink temperature back to ambient.
- Total weight of the unit was a primary design factor and specification of the purchase order. The prototype is 20" L X 12" W X 14" H and weighs 49 pounds. The enclosure was fabricated from sheet aluminum. Production units would be constructed from molded plastic/fiberglass which should further reduce the overall weight.

The following items were discussed and the vendor agreed that the changes would be completed before shipping to NNS for the Welding Lab and Production Evaluations.

- 1) Install a resistor for inductance in the SMAW output circuit.
- 2) The outer case of the enclosure was secured with small sheet metal screws. Because the unit might be lifted overhead with a crane and possibility by the handles, the group concurred that bolts with nuts and lock washers would be used where the case attaches to the main structure of the unit.
- 3) A center handle was needed to allow incremental movement by the operator with one hand.
- 4) Pre/post purge gas delay and wire anti-stick features were not available and would need to be incorporated into the circuitry.

- 5) The gas purge switch could be accidentally cut on and continue to purge gas through the torch when not welding. We requested a spring loaded momentary contact switch be used since the unit would be used internally shipboard.
- 6) The output current limiting circuit required adjustment to allow full usage of the unit's entire welding current/voltage ranges in all processes.

The project team was very pleased with the overall testing and performance of this innovative enhancement to welding technology and equipment ingenuity. All parties concerned felt that the identified changes/improvements were minor in nature and would be completed prior to the scheduled shipment date to Newport News Shipbuilding.

## **6.0 EVALUATION-NNS WELDING LABORATORY**

During this evaluation period several significant events occurred that resulted in a request and subsequent approval for a four-month extension to the job order's performance period with no additional cost to the project. This changed the project completion date from February 1, 1996 to June 1, 1996. The extension was needed to resolve performance problems discovered during the initial Welding Lab evaluation of the prototype unit (Task IV). We considered the additional time requested to be warranted based on the uncertainty of the corrective actions to be taken at that time, availability of necessary components, and retesting necessary before undertaking another Welding Lab evaluation.

### **6.1 EVALUATION - NNS WELDING LABORATORY PHASE ONE**

The vendor prototype unit was initially received at Newport News Shipbuilding on October 2, 1995. Its receipt completed the requirements of Task III. Several photographs were taken to illustrate its portability to NNS's production welding trade management personnel (see Appendix B).

During NNS'S initial Welding Lab evaluation (first step of Task IV) excessive spatter/erratic arc characteristics in SMAW mode, insufficient pinch effect on the wire during droplet transfer in the GMAW short arc mode and intermittent loss of wire feed speed control (attributed to external



transient voltages/frequencies) were observed. These problems were significant enough to terminate the evaluation and the unit returned (10/13/95) to the manufacturer. Additional information relating to these findings are located in the Welding Laboratory Report, Appendix C.

Following discussions with Malcolm Gilliland, problems in the SMAW mode were attributed to the unit's low open circuit voltage. A similar problem identified during testing at Gilliland's plant was thought to be corrected by adding an inductance resistor. To alter the open circuit voltage, complete disassembly and main transformer rewinding was required. To accomplished this, there was a risk of not being able to achieve the required lower level of welding/arc voltage. The other identified problems were electronically controlled and required component changes/enhancements.

During the forthcoming weeks NNS worked very closely with the vendor to resolve the identified issues and expedite project completion. Significant progress was made and extensive testing was performed at their plant. Upon attaining satisfactory performance, arrangements were made for the vendor to return the unit to NNS and conduct a performance demonstration at NNS. This was accomplished on November 21, 1995. The unit performed excellent in all processes with only one problem being identified. This problem was in the length of time that the "hot start" remained - energized during arc initiation while in both the SMAW and GMAW short circuit mode. The vendor took the unit back to his plant so that components could be ordered and modifications completed.

## **6.2 EVALUATION - NNS WELDING LABORATORY PHASE TWO**

The prototype unit with all modifications complete was returned to NNS in mid - December, 1995. Resumption of Task IV and Phase Two of the Laboratory Evaluation began January '96.

The evaluation investigated the unit's welding characteristics and performance for SMAW, FCAW, and GMAW (short circuit and spray transfer) processes. The evaluation was accomplished by welding 3/4" groove joints and "T" joints. The groove joints were visually (VT) and radiographically (RT) inspected. Macro samples were taken from both the groove and Tj1 joints. Additional details can be found in Appendix C, Welding Laboratory Report. Appendices D through G include Laboratory Data Sheets by welding processes with photographs of the joint macro. Several improvements were recommended by the Welding Engineer and technician for incorporation into the

final unit. The suggested improvements were non-critical and not detrimental to its operation or ability to produce quality welds. The Welding Laboratory conclusion stated that the Gilliland Ultra-Portable Power Supply/Wire Feeder performance evaluation was satisfactory and the unit was suitable for a production evaluation in its current configuration.

## **7.0 EVALUATION - NNS PRODUCTION**

The production evaluation began in the latter part of January '96 and lasted through April '96. Areas of usage include a Sheet Metal Shop, structural welding aboard an aircraft carrier during overhaul and sheet metal/foundation welding during outfitting aboard a Sealift Conversion Ship.

The production evaluation was temporarily terminated in February for about seven weeks. Problems were encountered with fuses being blown in the 460 VAC primary circuit supplying power to the unit. This problem occurred while being used on a Sealift Conversion Ship. Initial investigation revealed an electrical short circuit within the unit when it was powered up. Grinding dust and metal powder were found inside the unit but this is expected for equipment of this type after being used in a shop or shipboard environment for any length of time. No apparent cause for the electrical short circuit could be visually detected by NNS Maintenance personnel. The manufacturer was contacted concerning the problem and a decision was made to return the unit.

The manufacturer's investigation revealed an electrical short circuit occurred in the inverter section of the power supply requiring replacement of one of the electrical components. His investigation revealed that the grinding dust had penetrated the insulation isolating an electrical component. Because of the state-of-the-art technology being applied this component was not readily available. During the delay time waiting for part replacement, the manufacturer incorporated several changes that had been identified during the Laboratory Evaluation. Upon receipt of the needed part the unit was tested and returned to NNS for continuation of the Production Evaluation.

Although there was one incidence of equipment failure and the unit was returned to the manufacturer for repair, the production evaluation was considered successful. Section 8.0 RECOMMENDATIONS contains the comments received from production users and welding laboratory personnel. Outlined in the following statements are specifics relative to the evaluation.

- Typical welding processes and electrode types used during the production evaluation include:  
FCAW: MIL-71T-1/.045" & .035" dia., 75AR/25CO<sub>2</sub> gas  
GMAW: (spray): MIL-70S-3/.045" dia., 95AR/5CO<sub>2</sub> gas  
GMAW: (short circuit): MIL-70S-3/.035" dia., 75AR/25CO<sub>2</sub> gas  
SMAW: MIL-11018-M & MIL-7018, dia. 5/32"/1/8"
- Electrode consumption during the production evaluation was estimated to be 475 lbs. GMAW/FCAW wire and 30 lbs. SMAW electrodes.
- The evaluation included approximately 46 production work days (5 Shop/41 shipboard) over a 60 day period.
- Typical environmental conditions included temperatures ranging from 45 to 60° F indoors to shipboard operation where temperatures varied from 25 to 80° F and the humidity levels reached upwards to 100% (rain & snow).
- During this time frame the unit was still in its early prototype stages (minimum insulation was applied to electrical components to facilitate replacement if required). Based on recommendations, by the vendor, extra care was taken to ensure that it did not get wet. When not being used (off-shifts) it was kept in an office and issued out daily.

## **7.1 SHEET METAL SHOP (Indoors)**

The initial evaluation in the Sheet Metal Shop included welds on 16 gauge to 1/4" material where lap, corner, butt and fillet welds were produced. The unit functioned satisfactory and the users were very impressed with the GMAW (short circuit) capabilities, but they would only be interested if they were buying new equipment and were looking for portability. Their existing equipment remains stationary most of the time. While in this location, the Department Manager set up an in-house demonstration for both Shop and Shipboard welding management personnel. These people were impressed with the units capabilities for its physical size and very interested in participating in a shipboard evaluation. The size of existing welding equipment and its availability limit their usage of GMAW/FCAW. This results in most of their welding being done with the SMAW process.

## **7.2 SHIPBOARD - SEALIFT CONVERSION CONTRACT**

On this type of ship, during outfitting, ventilation encompasses a large portion of the sheet metal work. The welders used the unit on fillet and butt welds in areas that ranged from the lower levels of the ship to performing welding in the smoke stack enclosure. They were able to utilize GMAW on work that, if this unit was not available, would have been done with SMAW. Using the SMAW process requires an excessive amount of labor due to thinness/types (some were galvanized) of material, fit up and opening in joints.

## **7.3 SHIPBOARD - AIRCRAFT CARRIER (CVN) OVERHAUL**

Structural welding management personnel witnessed a demonstration of the unit's performance and capabilities while it was being evaluated in the Welding Laboratory. Their particular type of work entails a variety of materials, joint types and diversity of applications. A large portion of these are small jobs requiring between two and six hours of actual arc time. Currently the time to set-up GMAW/FCAW equipment and extend the wire feeder to the work site is often longer than the time required to weld the job. This is due to the welding equipment's size and configuration, physical restrictions of re-locating equipment aboard ship and the support labor required to assist in the move. For this reason SMAW is often used in lieu of a more efficient process.

## **7.4 PRODUCTION EVALUATION COMMENTS**

Outlined below are comments from welding operators and their supervisors involved in utilizing the machine to perform production welding operations/work.

- "I completed three job assignments in one day that would otherwise have taken a minimum of two to three days with our standard equipment. I would have had to disconnect and wrap up all the secondary cables on the standard machine, get on the waiting list for a forklift operator to move my equipment, find deck space to set it up and then extended the secondary cables to my assigned job. With this unit, I just disconnected it, carried it to the next job and hooked it back up"
- "Several jobs I worked required that a bead of SMAW be applied prior to FCAW. With this unit only one piece of equipment was required instead of two".

- "I used the unit on several job assignments for FCAW that would otherwise have been completed with SMAW. The volume of weld to be performed would not justify the time it usually requires to obtain our standard FCAW equipment and get it hooked Up".
- "The attribute of welding up to 300 amperes, welding process selection feature, portability and ability of a single operator/welder to physically relocate and hook-up the machine himself without additional support, opens up the potential to apply wire welding processes that otherwise would have been completed with SMAW".
- "By having the welding controls right at the welding site, I tend to adjust the welding parameters more for job situations/conditions and produce better weld results than with other types of equipment that required leaving the job site to make adjustments".
- "My people's comments have been very favorable, especially the arc characteristics, weight and physical size in relationship to welding output".
- "We could use twenty-five to thirty units right now on just sheet metal type welding applications. When you take this unit back, I want to-k-know when another one is available".

## 8.0 RECOMMENDATIONS

During both the Welding Laboratory Evaluation and the Production Evaluation, numerous suggestions were expressed to enhance the performance of this particular piece of equipment so it would be more user friendly for the operator. Under our contract with the manufacturer, he is only obligated to meet the requirements as stated in the purchase order issued to him. Therefore many of the comments have been passed verbally to the manufacturer for his consideration when he decides to develop production units.

Outlined below are the recommendations/suggestions that were submitted to the manufacturer at the conclusion of the evaluations so they could be considered for incorporation into the final prototype version. These suggestions are to enhance/fulfill the original development specifications.

- Increase the torque of the wire feeder motor. Occasions of arc fluttering and instability in the wire processes was attributed to lack of wire feed motor torque. If the max end of the wire feed range is reduced to accomplished this, it should not be lower than 450 1PM.
- The Hot Start time in the GMAW spray and short arc modes is still too long when used out of position and where openings in the joint are encountered. Reduce the time by at least one-half.
- The handles used to lift the unit are too small for a person to put his hands through while wearing gloves. Please increase their physical size to accommodate use of welding gloves.
- During the Welding Laboratory evaluation, a restriction in the wire feed path resulted in a blown wire feed motor fuse. The fuse was not readily accessible and required considerable disassembly to replace. Replace with an accessible fuse assembly or circuit breaker.
- Users were a little confused by the Process Mode Switch. Define clearer by having a position for major welding processes.
- Completely insulate the electrical components within the enclosure to facilitate production usage within a shipyard environment. This environment is subjected to high humidity, moisture, dirt, grit and grinding dust. This was the reason for the electrical short circuit and subsequent interruption of the production evaluation. It should be understood that when conducting prototype equipment evaluations, insulating techniques and thicknesses must facilitate some component replacement. For this reason, insulating practices are not as extensive during an initial evaluation as those on final prototypes or production units.

## 9.0 CONCLUSIONS

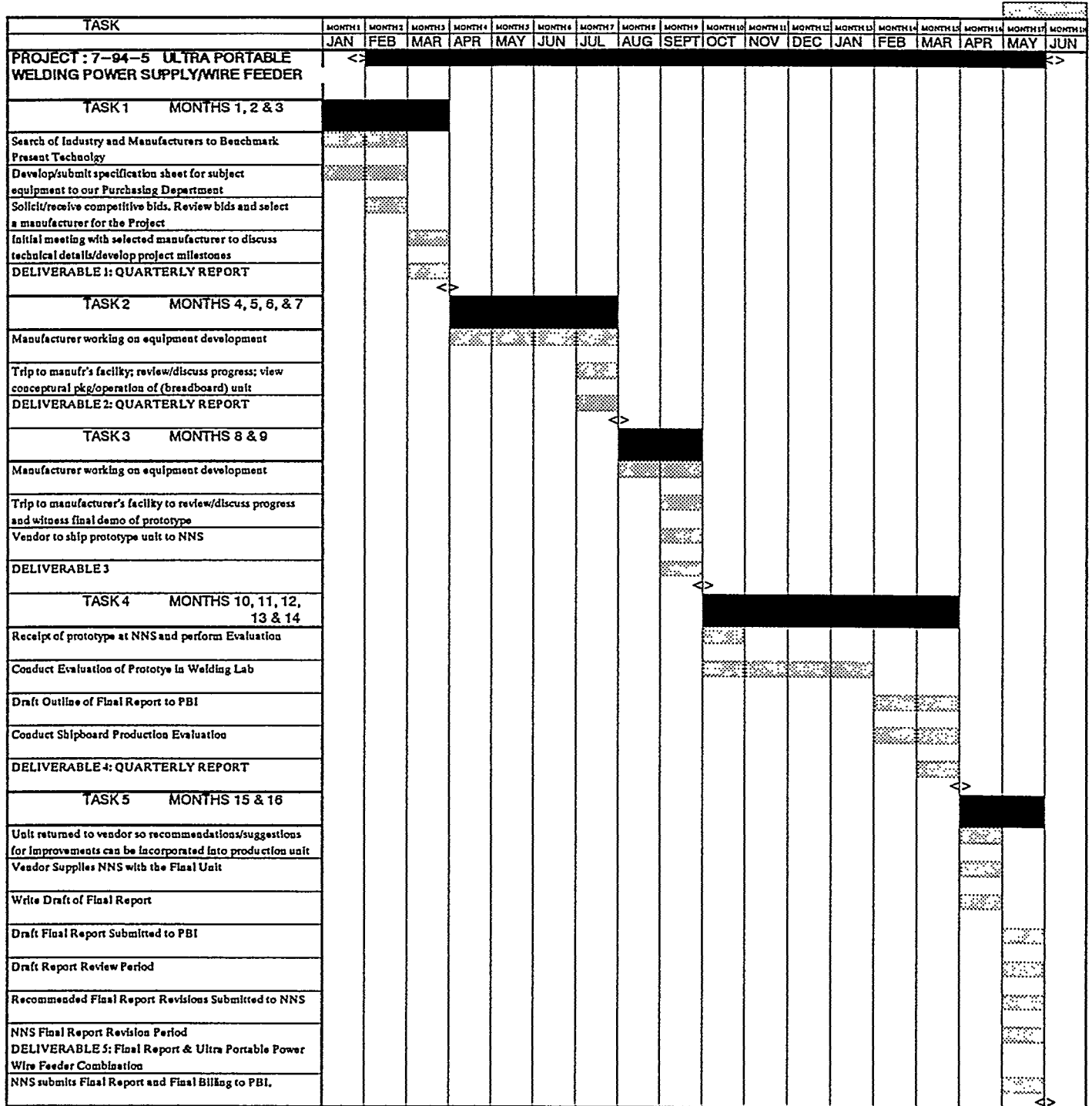
The objective to develop a prototype welding power supply/wire feeder combination within one enclosure, that has the potential to significantly enhance welding productivity through its unique design of portability, physical size and process selection options, has been accomplished.

Operating and welding characteristics were evaluated in Newport News Shipbuilding's Welding Laboratory and during a sixty-day Production Evaluation period where it was used performing normal work in a production environment. The evaluation concluded that the prototype welder in its current configuration, would produce satisfactory welds with each of the process options and based on the comments from the persons using it, was a viable tool to increase welding productivity. The durability of the electrical components and circuitry can only be attested to based on our limited evaluation period and as described in this report. Prior to it becoming a marketable welding apparatus, Newport News Shipbuilding recommends that additional production welding arc hours be performed to ensure its reliability.

This Project has experienced its share of developmental and production evaluation setbacks as outlined in the respective sections of this report. This is not unusual for a task of this magnitude and type. Appreciation and gratitude are extended to Malcolm T. Gilliland, Kenneth A. Gilliland and Brent S. Hughes for their relentless efforts and dedication to the realization of this project's objective.

# NEWPORT NEWS SHIPBUILDING'S PROJECT PERFORMANCE PERIOD

KEY



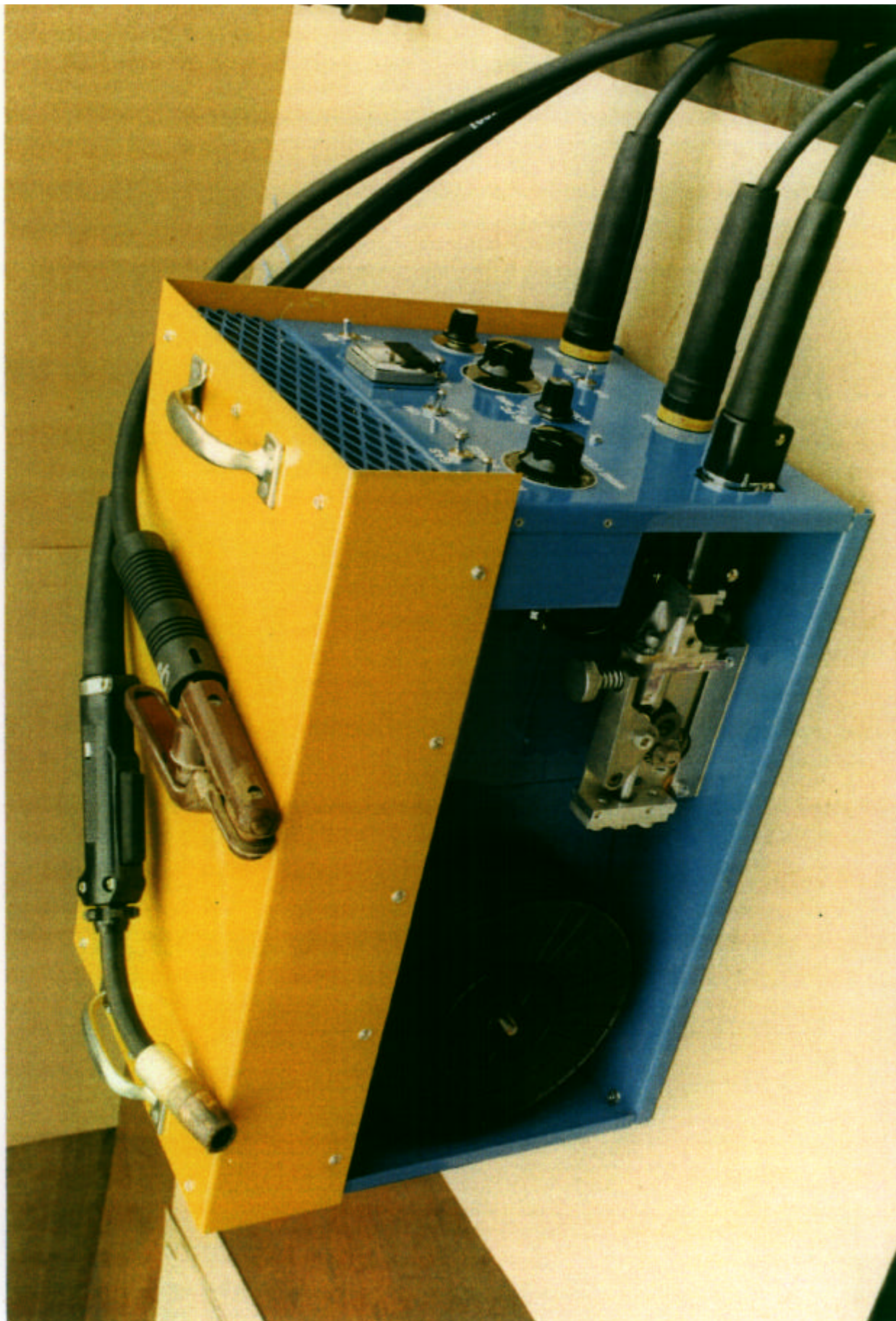
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## APPENDIX (A) - GANTT CHART MAJOR TASKS AND PERFORMANCE PERIOD









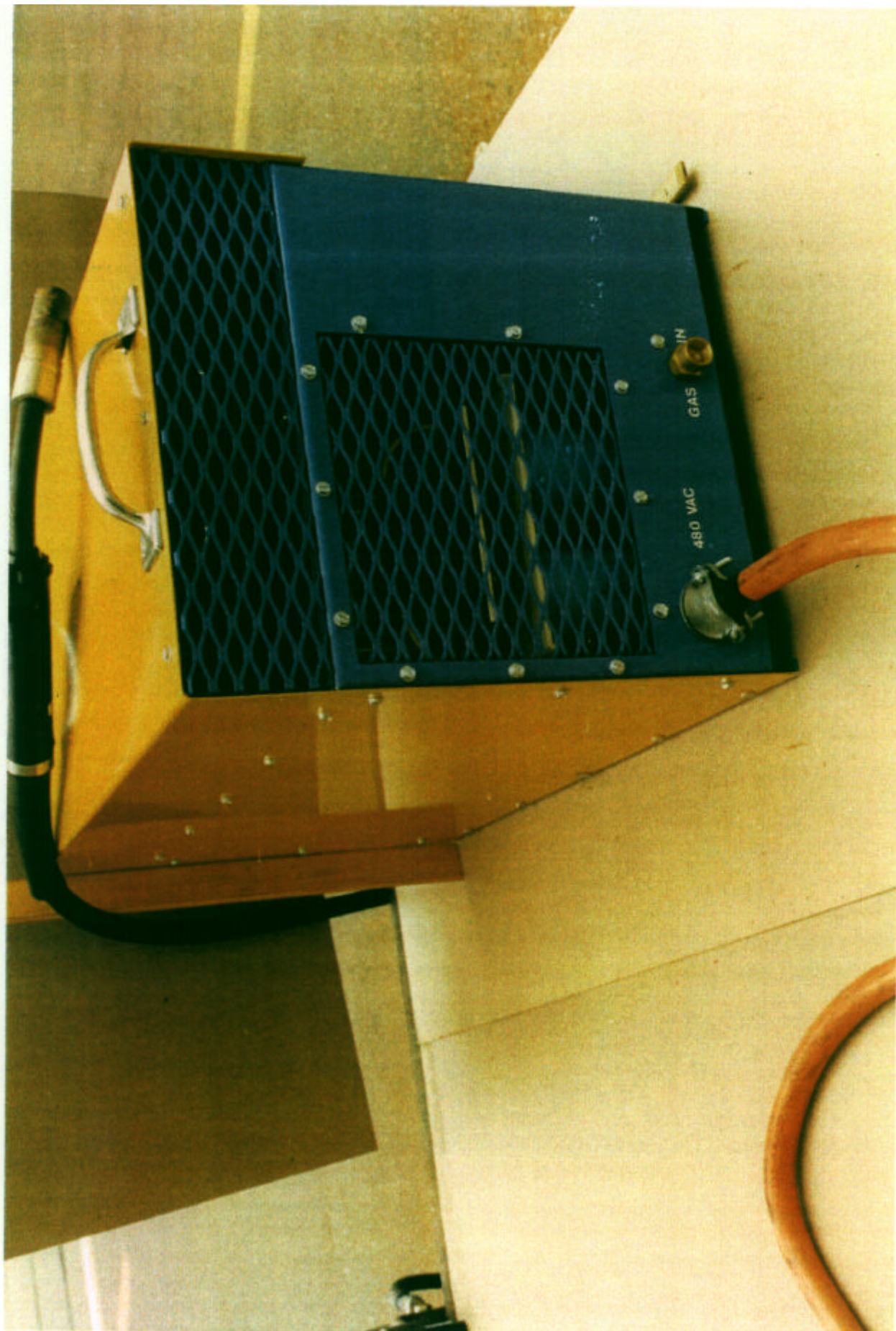
APPENDIX (B) - PHOTOGRAPH (2)  
PROTOTYPE POWER SUPPLY/WIRE FEEDER





APPENDIX (B) - PHOTOGRAPH (3)  
PROTOTYPE POWER SUPPLY/WIRE FEEDER





APPENDIX (B) - PHOTOGRAPH (4)  
PROTOTYPE POWER SUPPLY/WIRE FEEDER

# **WELDING LABORATORY REPORT**

## **Purpose/Background**

The purpose of this project was to evaluate the welding characteristics and operational performance of the Gilliland Ultra-Portable Power Supply/Wire feeder. This machine was developed by M. T. Gilliland, Inc. under a task funded by the National Shipbuilding Research Program (NSRP) SP-7 Panel. This power supply is an ultra-portable inverter type with the wire feeder packaged within one enclosure, all weighing less than 50 pounds. It is capable of SMAW, GMAW (spray and short circuit transfer), and FCAW, with an output up to 300 amperes (60% duty cycle) from 460 VAC primary power.

## **Initial Evaluation**

An initial evaluation was performed by welding with each process and mode on practice fillet and groove joints. Many items needing correction were identified during this time, and it was established that the unit needed to be returned to the manufacturer. The following is a description of the problems observed.

### **SMAW:**

While welding with this process, it was noticed that the arc was sometimes erratic and not very smooth. Large globs of spatter were produced ahead of the puddle when welding in the vertical position. Also, the arc would cut off during welding and require restarting. These problems were attributed to the unit's low open circuit voltage, and it was recommended that the unit's open circuit voltage be increased in the SMAW mode.

### **GMAW - Spray :**

The arc was fairly smooth in this mode. There were still times when the arc was erratic for about the first three seconds after arc initiation, but then it smoothed out.

### **GMAW-Short Circuit :**

This welding mode was evaluated using .045" diameter, Type 70S - 3 wire and 75A/25C<sub>2</sub> gas. It was later determined that this machine was not programmed to weld .045" diameter wire in this mode. Arc transfer was between short circuit and globular and produced lots of very fine spatter.

**FCAW :**

The unit welded flux cored wire (Type 71T-1 HYM, .045" dia., 75A/25C<sub>2</sub> gas) very well, having a smooth stable arc and a fluid weld puddle that was very controllable. Spatter was minimal and nice smooth beads were welded in the vertical (3G) position.

**General Observations:**

When welding with the wire processes, there were times of intermittent loss of wire feed control. The wire feed accelerated and decelerated significantly, and no adjustment from the wire feed speed dial helped. It was noted that when the unit was lifted off the grounded table and placed on a wooden pallet, this problem went away. The problem was thought to be caused by external transient voltage/frequencies. Based on this problem and those identified in the SMAW and GMAW spray transfer modes, it was decided that this unit should be returned to the manufacturer, M. T. Gilliland, Inc., for modification.

**Second Evaluation:**

The manufacturer, M. T. Gilliland, returned with the unit for a demonstration/evaluation of the changes requested in the initial evaluation. The unit performed well in all processes with only one problem, the duration the "hot start" remained energized during initial arc initiation while in both the SMAW and GMAW mode. This caused a hot, unstable arc for about 2 to 4 seconds before stabilizing at the desired parameters. Excessive spatter was observed at this time. The manufacturer took the unit back to his plant so components could be ordered and modifications completed.

**Final Evaluation:**

The unit was returned for final lab evaluation after all recommended modifications were made. The evaluation included welding, with each process, a carbon steel, 6" long by 3/4" thick, single-vee butt joint with a backing strap (B2V.1 joint design) and a 12" long fillet weld T-joint. A T-joint using 16 gauge sheet metal was the only joint welded in the GMAW-short circuit process mode.

The wire feed drive system seemed a little weak. It could be stopped by grabbing the wire using moderate force as it exited the torch. Other wire feeders used in the yard continue to feed wire, balling it up in your hand. The underpowered wire feed system could be a factor contributing to arc fluttering and instability noticed when welding with the wire processes.

The butt joints were radiographically inspected (RT), and all joints were macro-etched. The following is a description of the evaluation done by process.

**SMAW :**

All SMAW welding was done using MIL-7018M electrode. The butt joint was welded with 1/8" diameter electrode in the vertical (3G) position. One side of the T-joint was welded with 1/8" diameter electrode and the other side with 5/32" electrode. The T-joint was welded in the horizontal (2F) position.

The machine worked very well in this mode. The butt joint passed RT, and the macros looked good. Appendix D, Figure (1) shows the lab data sheet, and Appendix D, Figures 1A and 1B are photos of the macros. The white squiggly line at the right of the weld in Figure 1A is attributed to a fiber of some type on the macro during photography.

**FCAW :**

All FCAW was done using MIL-71T-1-HYM electrode and 75% Ar 25% CO<sub>2</sub> shielding gas. The first three passes were welded with .045" diameter wire, and the rest of the joint was welded with 1/16" diameter electrode. One side of the T joint was welded with .045" diameter wire, and the other side with 1/16" diameter wire. The butt joint was welded in the vertical (3G) position, and T-joint welded in the horizontal (2F) position.

The machine welded favorably in the FCAW mode. There was some arc fluttering during welding, but it is suspected this was caused by the wire feed system and not the power supply. The butt joint passed RT and the macros look good. Appendix E, Figure (2) shows the lab data sheet, and Figures 2A and 2B are photos of the macros. Figure 2B shows some trapped slag in the root of one of the fillet welds, this is attributed to poor bead placement and improper torch angle rather than the power supply.

**GMAW - Spray :**

All GMAW-spray arc welding was done using .045" diameter MIL-70S-3 wire with 95% Ar 5% CO<sub>2</sub> shielding gas. The butt joint was welded in the flat (1G) position, and the T joint was welded in the horizontal (2G) position. The machine welded OK in this mode, but it seemed to have a sensitive arc. The arc became erratic with any change of stick-out and took 1 to 2 seconds to stabilize again.

The butt joint passed RT, and the macros looked good. Appendix F, Figure (3) shows the lab data sheet, and Figures 3A and 3B are photos of the macros.

### **GMAW Short Circuit :**

All GMAW short circuit welding was done using .035" diameter MIL-70S-3 wire with 75% Ar 25% CO<sub>2</sub> shielding gas. The T-joint, made from 16 gauge (1/16" thick) mild steel, was welded in the horizontal (2F) position. The machine welded well at low parameters, enabling the welding of sheet metal. However, it does exhibit a hot start that can cause burn through in thin materials before the machine adjusts to its running parameters. Appendix G, Figure (4) shows the lab data sheet, and Figure (4A) is a photo of the T joint macro. The macro shows lack of fusion on the web leg on one of the fillets. This was caused by poor welding technique such as focusing the arc more on the flange and using excessive travel speed. The other fillet weld looks very good, showing good penetration into both the flange and web of the joint.

### **Conclusions:**

The Gilliland Ultra-Portable Power Supply/Wire feeder is recommended for field evaluation. Overall, it has good arc characteristics and is easy to use. The underpowered wire feed system should be improved and also evaluated to determine if it was a contributing factor causing the arc fluttering and instability in the wire processes. Also, if possible, the hot start should be shortened to provide quicker arc stabilization in the GMAW spray and GMAW short circuit modes.



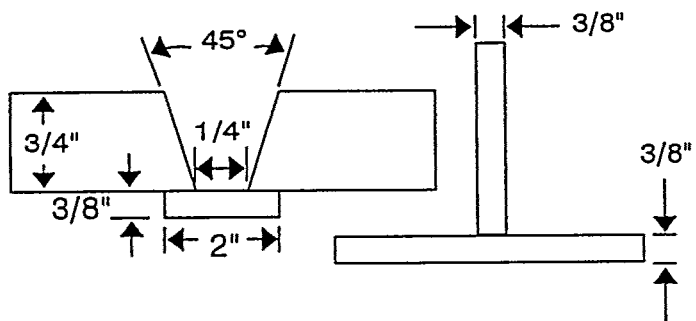
## Laboratory Data Sheet

## FIGURE 1

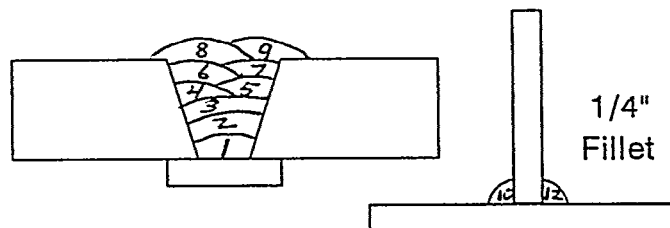
Newport News Shipbuilding

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<b>Equipment</b> Power Supply/Model <u>Gilliland Prototype</u> Torch/Gas Cup/Wire Feeder <u>NA</u> <u>NA</u> <u>NA</u> Current <input type="checkbox"/> AC <input checked="" type="checkbox"/> DCEP <input type="checkbox"/> DCEN <input type="checkbox"/> AC <input type="checkbox"/> DCEP <input type="checkbox"/> DCEN		<b>Filler Material</b> A <u>1/8" Alloy Rods MIL-7018M</u> Size/Brand/Type <u>NA</u> <u>62481</u> <u>2F415CO</u> PO/Heat/Lot <u>MIL-E-0022200/10A</u> Specification <u>MIL-E-0022200/10A</u>	
<b>Base Material</b> Type/Dimensions <u>CS / 3/4" X 6" X 11"</u> PO/Heat/Lot <u>NA</u> Specification <u>MIL-S-22698</u>		<b>Fillet Weld</b> Type <u>CS / 3/8" X 5" X 12"</u> PO/Heat/Lot <u>NA</u> Specification <u>MIL-S-22698</u>	
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<b>Shielding Method</b> Gas Mix <u>CFH</u> Flux <u>CFH</u> PO/Heat/Lot <u>CFH</u>		<b>Joint</b> Type <u>B2V.1 / PT2S.1</u> Avg Bead Lgth <u>7 / 12</u> <b>Torch Angle</b> Lead/Lag <u>CFH</u> Tilt <u>CFH</u>	

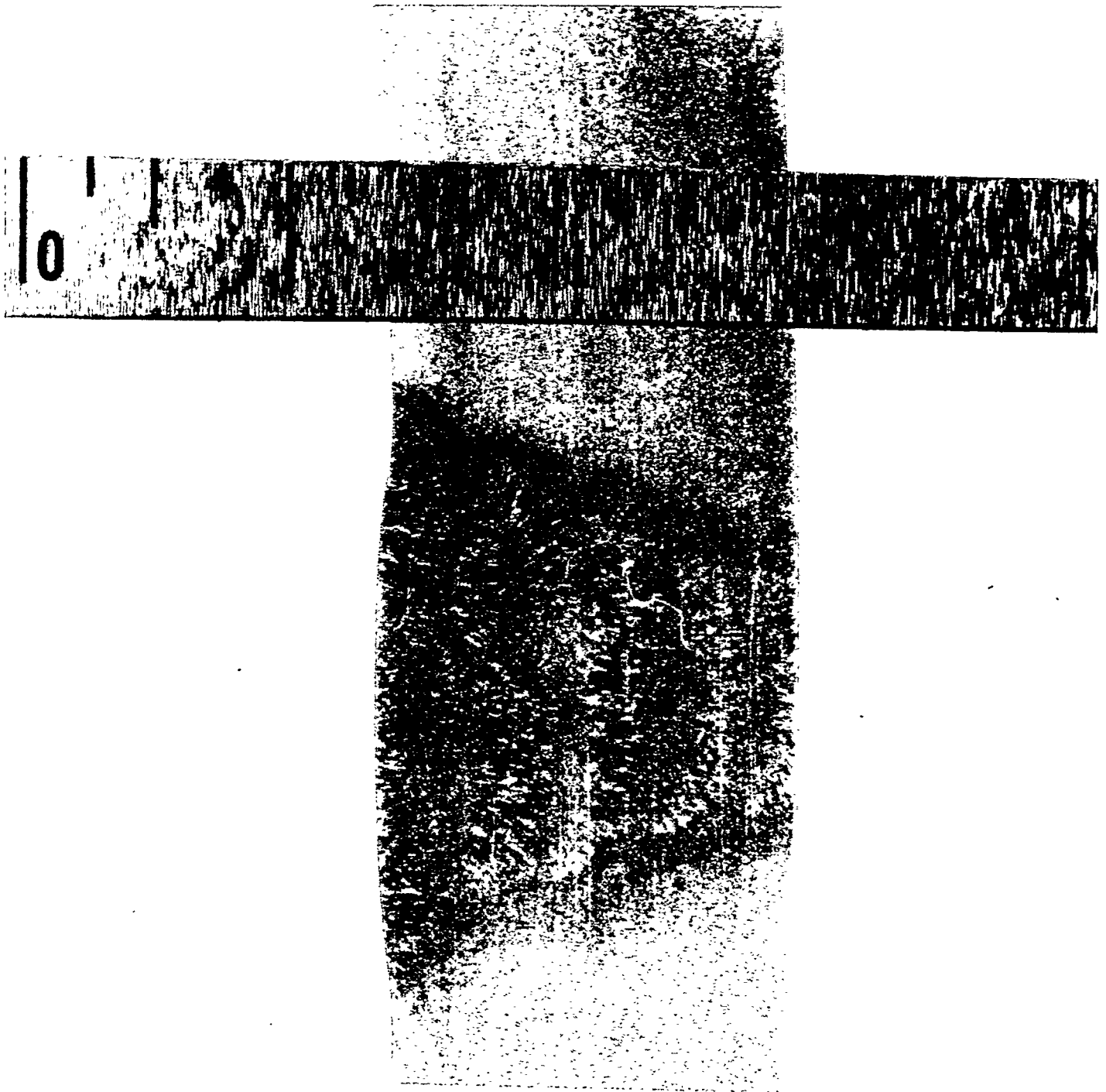
Joint Sketch



Bead Placement

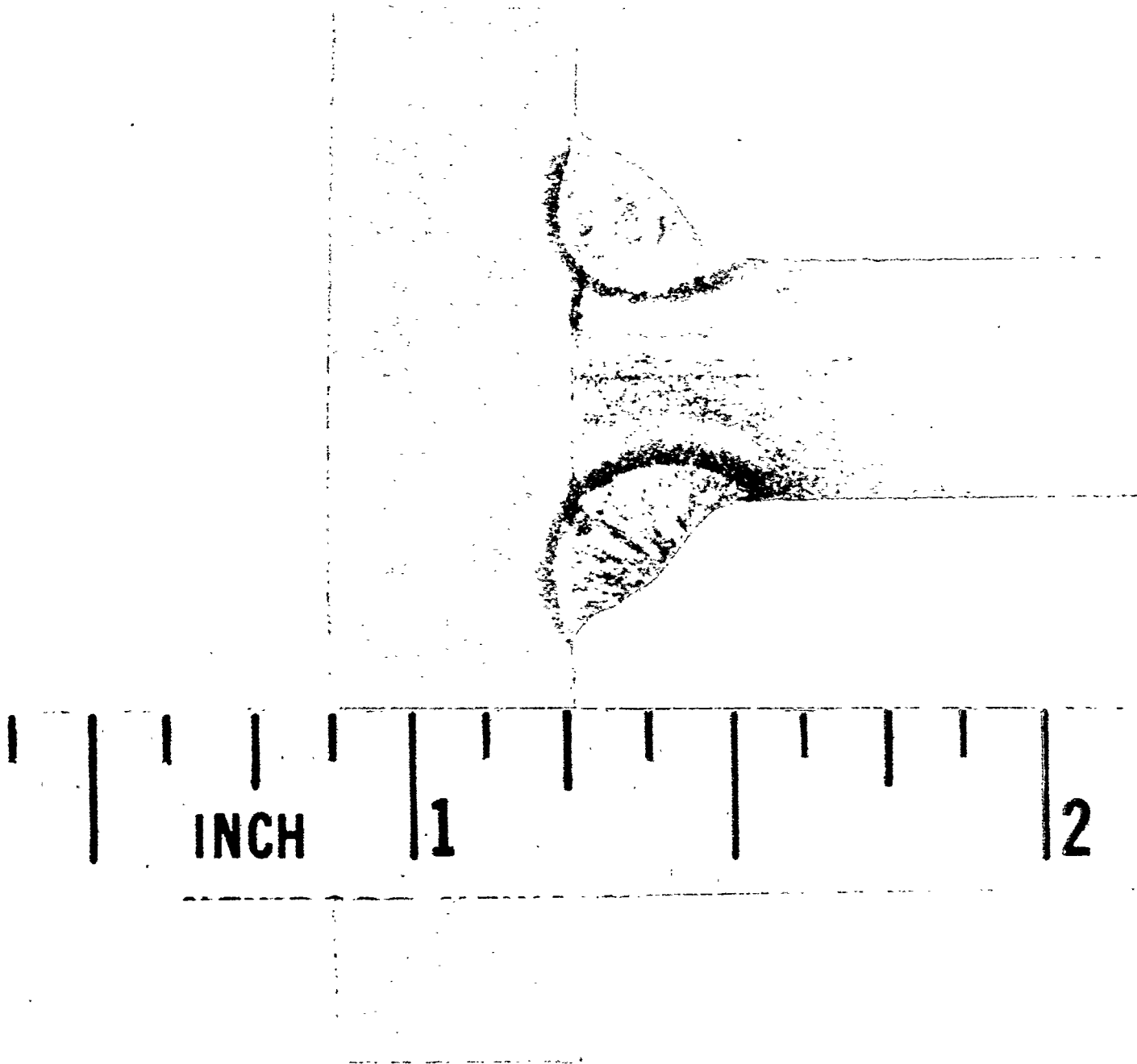


Pass No	Volts P.S.   Arc	Amps	Filler Mat'l	Electrode Stickout	Travel Speed	Wire Feed Speed	NOTES
1-9	21.7-25.	126-130	A	NA	1.3 - 3	NA	Welding of the groove joint.
10	22.9	128	A	NA	10	NA	Fillet weld using 1/8" diameter rod.
12	23.3	180	B	NA	11	NA	Fillet weld using 5/32" diameter rod.
Technician <u>S. N. Jamison</u> Charge <u>2511-T</u> Date <u>1/02/96</u> Joint No <u>95-48-01</u>							



10-8h-5b

75-48-017



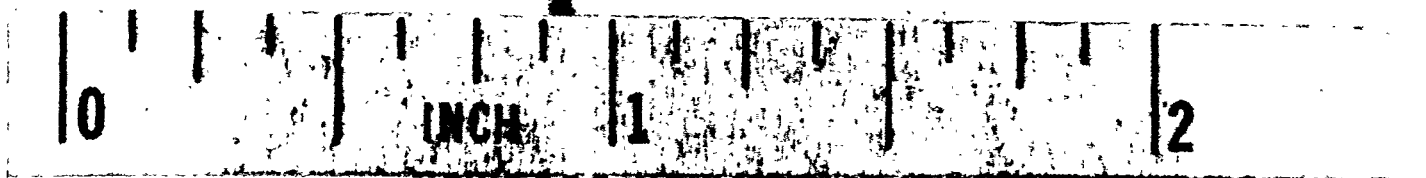
## Laboratory Data Sheet

## FIGURE 2

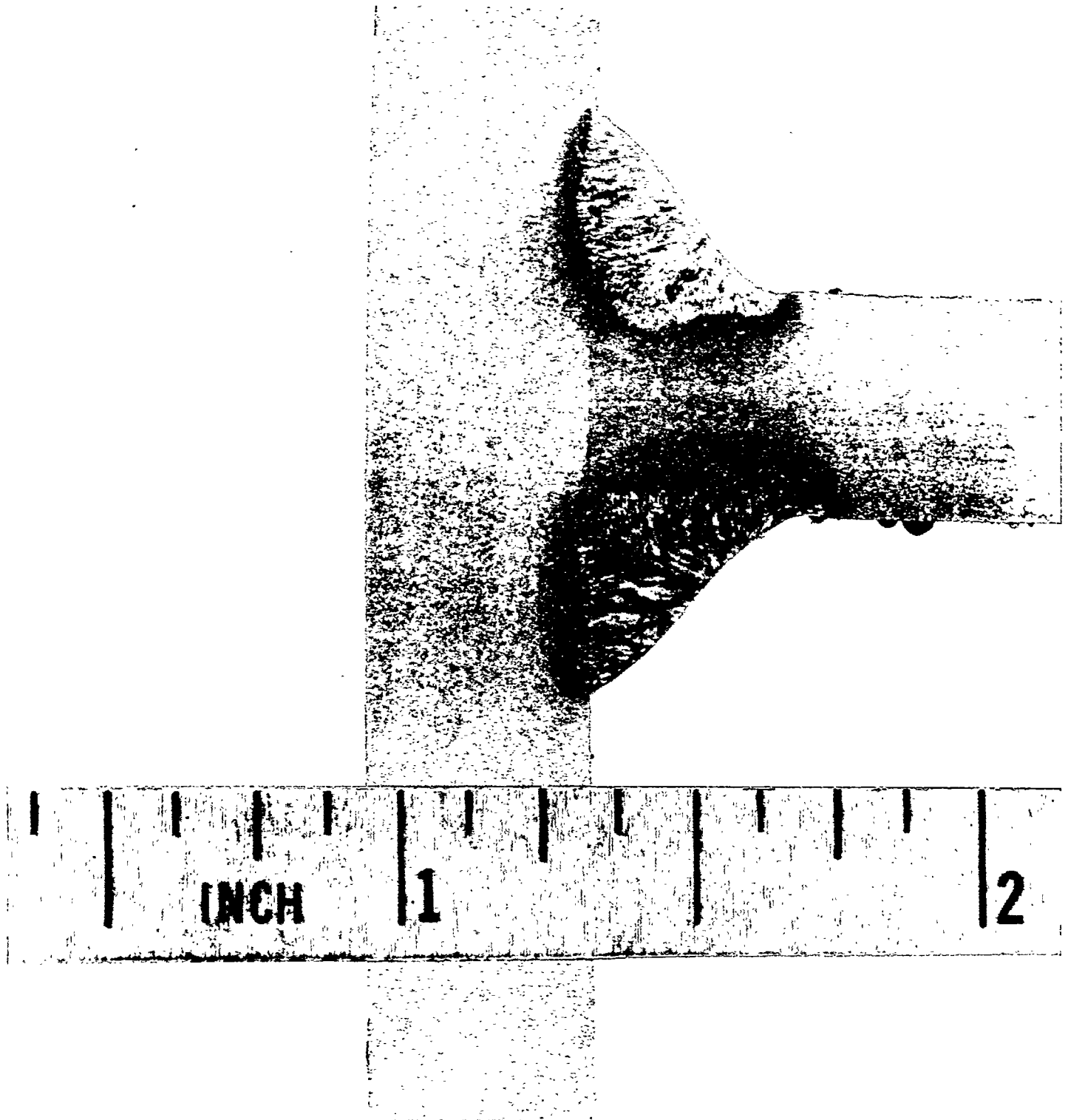
Newport News Shipbuilding

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<b>Equipment</b> Power Supply/Model <u>Gilliland Prototype</u> Torch/Gas Cup/Wire Feeder <u>MTG 4001 #8 MTG</u> Current <u>AC</u> <input checked="" type="checkbox"/> DCEP <input type="checkbox"/> DCEN <u>AC</u> <input type="checkbox"/> DCEP <input type="checkbox"/> DCEN				<div style="border: 1px solid black; height: 100px; width: 100%; position: relative;"> <div style="position: absolute; top: 0; right: 0; width: 50px; height: 50px; background: linear-gradient(to top right, transparent 49%, black 49%, black 51%, transparent 51%);"></div> </div>			
<b>Filler Material</b> A <u>.045 Alloy Rods MIL-71T-1-HYM</u> Size/Brand/Type <u>NA</u> <u>NA</u> <u>44869</u> PO/Heat/Lot <u>MIL-E-24403/1D</u> Specification <u>MIL-E-24403/1D</u>		B <u>1/16" Alloy Rods MIL-71T-1-HYM</u> Size/Brand/Type <u>NA</u> <u>NA</u> <u>44125</u> PO/Heat/Lot <u>MIL-E-24403/1D</u> Specification <u>MIL-E-24403/1D</u>					
<b>Base Material</b> Type/Dimensions <u>CS / 3/4" X 6" X 11"</u> PO/Heat/Lot <u>NA</u> Specification <u>MIL-S-22698</u>		Fillet Weld Type/Dimensions <u>CS / 3/8" X 5" X 12"</u> PO/Heat/Lot <u>NA</u> Specification <u>MIL-S-22698</u>					
<b>Backside Prep/NDT</b> <input checked="" type="checkbox"/> Ground <input checked="" type="checkbox"/> MT <input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> Gouged <input type="checkbox"/> PT <input type="checkbox"/> Unsatisfactory Procedure <u>N-22/122</u> Initial <u>SNJ</u>		<b>Visual Inspection</b> <input checked="" type="checkbox"/> Ground <input type="checkbox"/> Satisfactory <input type="checkbox"/> As welded <input type="checkbox"/> Unsatisfactory Procedure <u>QAI 612.1</u> Initial <u>SNJ</u>					
<b>Final NDT</b> <input checked="" type="checkbox"/> MT <input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> PT <input type="checkbox"/> Unsatisfactory Procedure <u>N-22/122</u> Initial <u>SNJ</u>				<b>RT</b> <input checked="" type="checkbox"/> Accept <input type="checkbox"/> Reject Radiograph to <u>N-41/141 271D</u> Interpret to <u>0900-003-9000 CL1</u>			
<b>Shielding Method</b> Gas Mix <u>75% Ar - 25% Co2</u> <u>45 CFH</u> Flux <u>NA</u> PO/Heat/Lot <u>NA</u>				<b>UT</b> <input type="checkbox"/> Accept <input type="checkbox"/> Reject Ultrasonic to <u>NA</u> Interpret to <u>NA</u>			
<b>Joint Sketch</b> 				<b>Bead Placement</b> 			
Pass No	Volts P.S. Arc	Amps	Filler Mat'l	Electrode Stickout	Travel Speed	Wire Feed Speed	NOTES
1-3	23.3	211-225	A	1/2" - 3/4"	5 ipm	NA	Welding of the groove joint with .045" wire
4 - 8	23.1	240 - 263	B	1/2" - 3/4"	5.1 ipm	NA	Welding of the groove joint with 1/16" wire
9	23.9	254	A	1/2" - 3/4"	9 ipm	NA	Fillet weld using .045" diameter wire.
10	25.7	261	B	1/2" - 3/4"	10 ipm	NA	Fillet weld using 1/16" diameter wire.
Technician <u>S. N. Jamison</u> Charge <u>2511-T</u> Date <u>1/02/96</u> Joint No <u>95-48-02</u>							

95-48-02



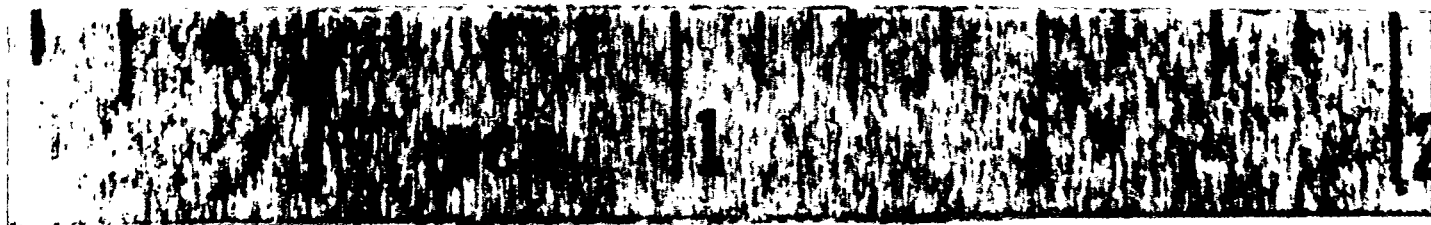
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## Newport News Shipbuilding

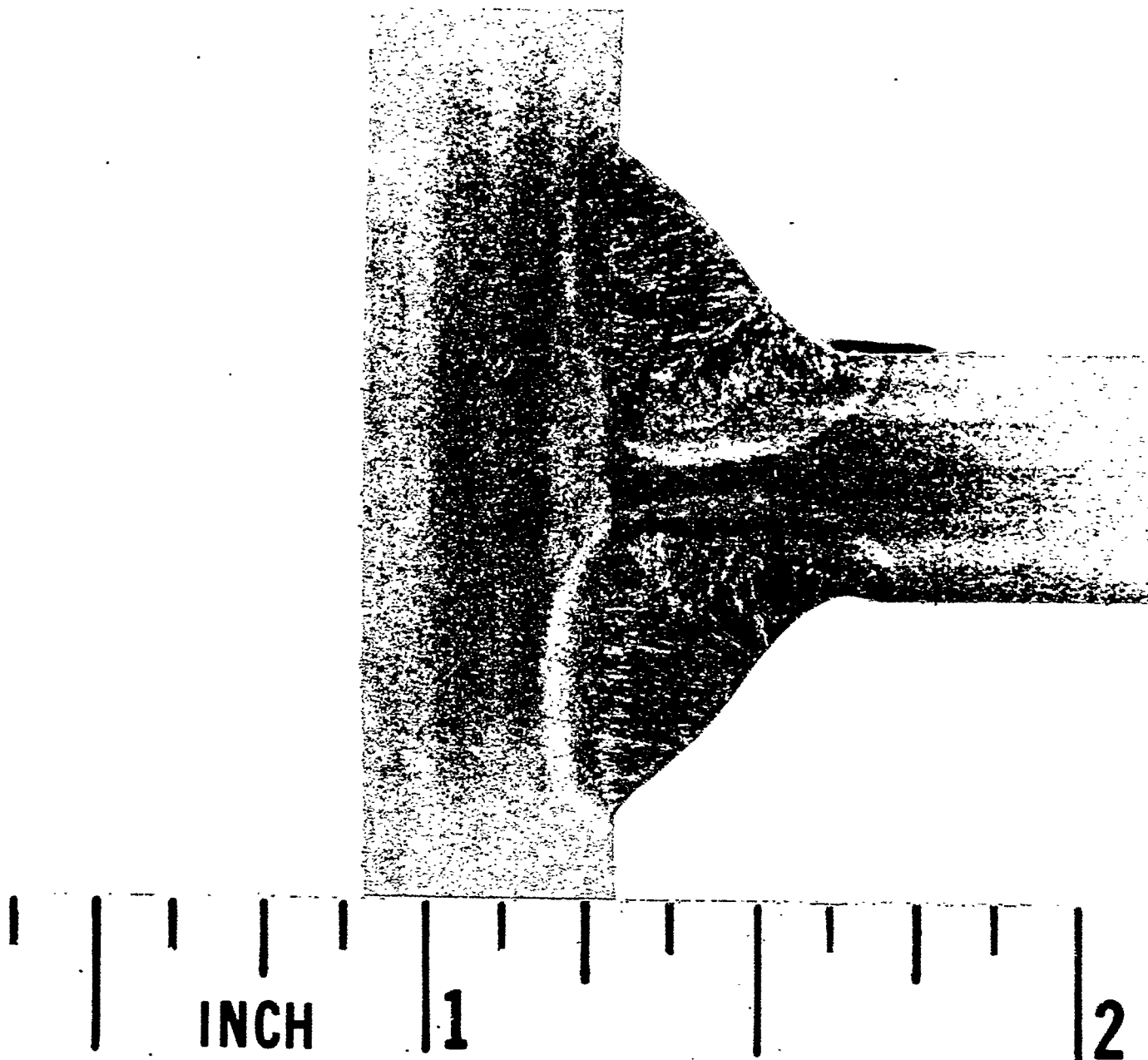
APPENDIX F - FIGURE (3) GMAW LAB DATA SHEET (Page 1)

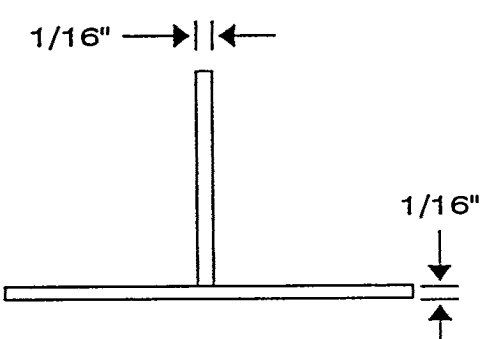
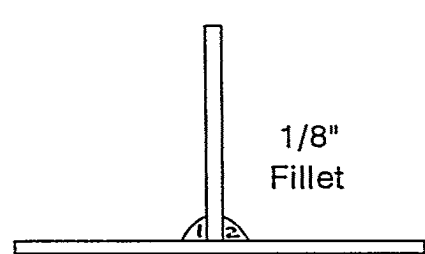
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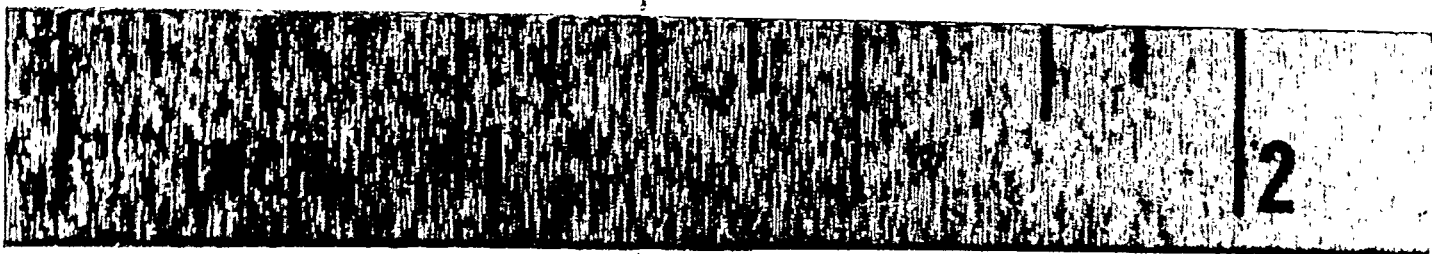
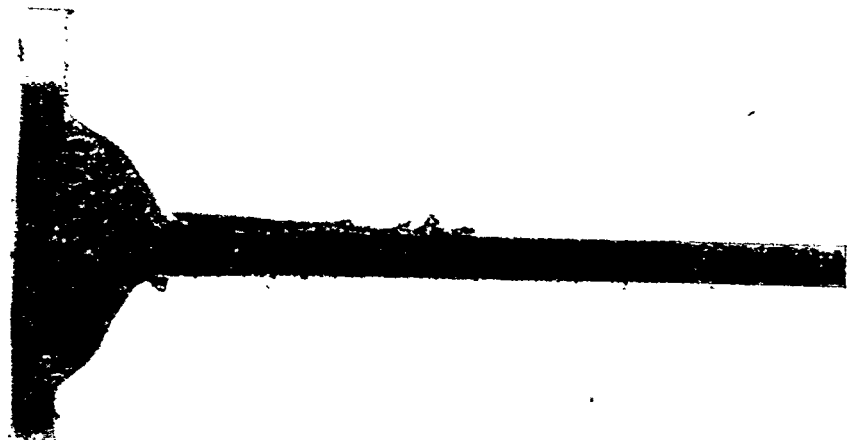


95-44-03-7



<b>Process</b> <input type="checkbox"/> SMAW <input checked="" type="checkbox"/> GMAW <input type="checkbox"/> SAW <input type="checkbox"/> Manual <input type="checkbox"/> 1 <input type="checkbox"/> 3 <input type="checkbox"/> 5 <input type="checkbox"/> G <input checked="" type="checkbox"/> Plate <input type="checkbox"/> GTAW <input type="checkbox"/> FCAW <input type="checkbox"/> OTHER <input checked="" type="checkbox"/> Semi-auto <input checked="" type="checkbox"/> 2 <input type="checkbox"/> 4 <input type="checkbox"/> 6 <input checked="" type="checkbox"/> F <input type="checkbox"/> Pipe				Preheat (min) <u>60 F</u> Method <u>Ambient</u> Interpass (max) <u>NA</u> Measured by <u>NA</u> Maximum interpass reached? Yes <input checked="" type="checkbox"/> No							
<b>Equipment</b> Power Supply/Model <u>Gilliland Prototype</u> Torch/Gas Cup/Wire Feeder <u>MTG 4001 #8 MTG</u> Current <u>AC</u> <input checked="" type="checkbox"/> DCEP <u>DCEN</u> <u>AC</u> <input type="checkbox"/> DCEP <input type="checkbox"/> DCEN				<b>Filler Material</b> A <u>.035 Lincoln MIL-70S-3</u> Size/Brand/Type <u>NA NA 319F</u> PO/Heat/Lot <u>MIL-E-23765/1E</u> Specification <u>MIL-E-23765/1E</u>				<b>Joint</b> Type <u>PT2S.1</u> Avg Bead Lgth <u>8</u> <b>Torch Angle</b> Lead/Lag <u>0 - 5°</u> Tilt <u>45°</u>			
<b>Base Material</b> Type/Dimensions <u>CS / 1/16" x 8" x 5</u> PO/Heat/Lot <u>NA</u> Specification <u>MIL-S-22698</u>				<b>Shielding Method</b> Gas Mix <u>75% Ar - 25% Co2</u> <u>45 CFH</u> Flux <u>NA</u> PO/Heat/Lot <u>NA</u>							
<b>Backside Prep/NDT</b> <input type="checkbox"/> Ground <input type="checkbox"/> MT <input type="checkbox"/> Satisfactory <input type="checkbox"/> Gouged <input type="checkbox"/> PT <input type="checkbox"/> Unsatisfactory Procedure <u>Initial</u>				<b>Visual Inspection</b> <input type="checkbox"/> Ground <input type="checkbox"/> Satisfactory <input type="checkbox"/> As welded <input type="checkbox"/> Unsatisfactory Procedure <u>Initial</u>							
<b>Final NDT</b> <input type="checkbox"/> MT <input type="checkbox"/> Satisfactory <input type="checkbox"/> PT <input type="checkbox"/> Unsatisfactory Procedure <u>Initial</u>				<b>RT</b> <input type="checkbox"/> Accept <input type="checkbox"/> Reject Radiograph to <u>Interpret to</u>							
<b>UT</b> <input type="checkbox"/> Accept <input type="checkbox"/> Reject Ultrasonic to <u>Interpret to</u>											
<b>Joint Sketch</b> 				<b>Bead Placement</b> 							
Pass No	Volts P.S.	Amps Arc	Filler Mat'l	Electrode Stickout	Travel Speed	Wire Feed Speed	NOTES				
1	16.7	55	A	1/8" - 1/4"	NA	NA	GMAW short circuit transfer welding.				
2	16.6	56	A	1/8" - 1/4"	NA	NA					
Technician <u>S. N. Jamison</u>			Charge <u>2511-T</u>			Date <u>1/02/96</u>					
						Joint No <u>95-48-04</u>					

95-48-04-7



2

# Ultra Portable Welding Power Supply/ Wire Feeder

Preliminary Manual

June 24, 1996



# Inverter Safety Precautions

**CAUTION** — Never attempt to operate the machine with the stick electrode holder and the wire feed torch BOTH attached at the same time. Doing so would cause both to be energized simultaneously.

**CAUTION** — Never open the machine without first disconnecting the supply cable. Then allow a minimum of 10 minutes for the capacitors to discharge completely before attempting to remove the cover. Failure to do so could prove **FATAL !**

**CAUTION** — Keep the machine in a dry location. This is a prototype machine and is not completely hardened against exposure to moisture. Exposure to moisture could be catastrophic.

**WARNING** — Never attempt to service the machine. If a problem occurs, contact Malcolm T. Gilliland, Inc., immediately at 770-487-7942 for assistance. This is a prototype machine and as a result all problems need to be thoroughly analyzed by the engineering department at Gilliland to correctly ascertain the cause of the problem and develop an appropriate solution. Currently, the machine is NOT user serviceable.

**CAUTION** — Never stand or sit on the machine. It is an intricate piece of welding equipment – not a step stool. The machine could be seriously damaged by standing or sitting on it.

In addition to these machine specific precautions, be sure to observe all of the normal welding precautions.

## Inverter Specifications

output: 300A at 60% Duty cycle Max.  
38VDC Max.

Wire Feed: 55-550 Inches per Minute  
.035-.045 Hard and Soft Wires  
.035-1/16 Flux cored Wire

Input: 480V, 3 Phase, 60 Hertz  
Disconnect Shall Be Fused at 20A.

## Inverter Operation Controls

**A:** Power Switch

Main power switch for turning machine off and on.

**B:** A/V Switch

Selects whether the panel meter displays welding current (A) or welding voltage (V). When A is selected, the output current is the meter reading times 10.

**C:** OUTPUT Control

Controls output current when the constant current stick mode is selected. controls output voltage when one of the two constant voltage modes (SA and FC/SPRY) is selected.

**B** IND control

controls the "inductance" or "arc force" in all modes.

**E:** SA/STD Switch

SA – Short Arc welding

STD – Standard position for all other processes

**F: Mode Switch**

M S – Stick Electrode Mode

FC/SPRY – Flux Core and Spray Arc Mode

SA – Short Arc Mode

**G: CONT Switch**

Turns on the output terminals or "contactor" for use when stick welding.

**H: GAS/PURGE Switch**

Momentary switch which opens the gas valve and purges welding gas while held down in the purge position.

**I: WELD/TNCH Switch**

Momentary switch which performs a cold welding wire inch at the speed selected by the WIRE FEED control while the switch is held down in the inch position.

**J WIRE FEED Control**

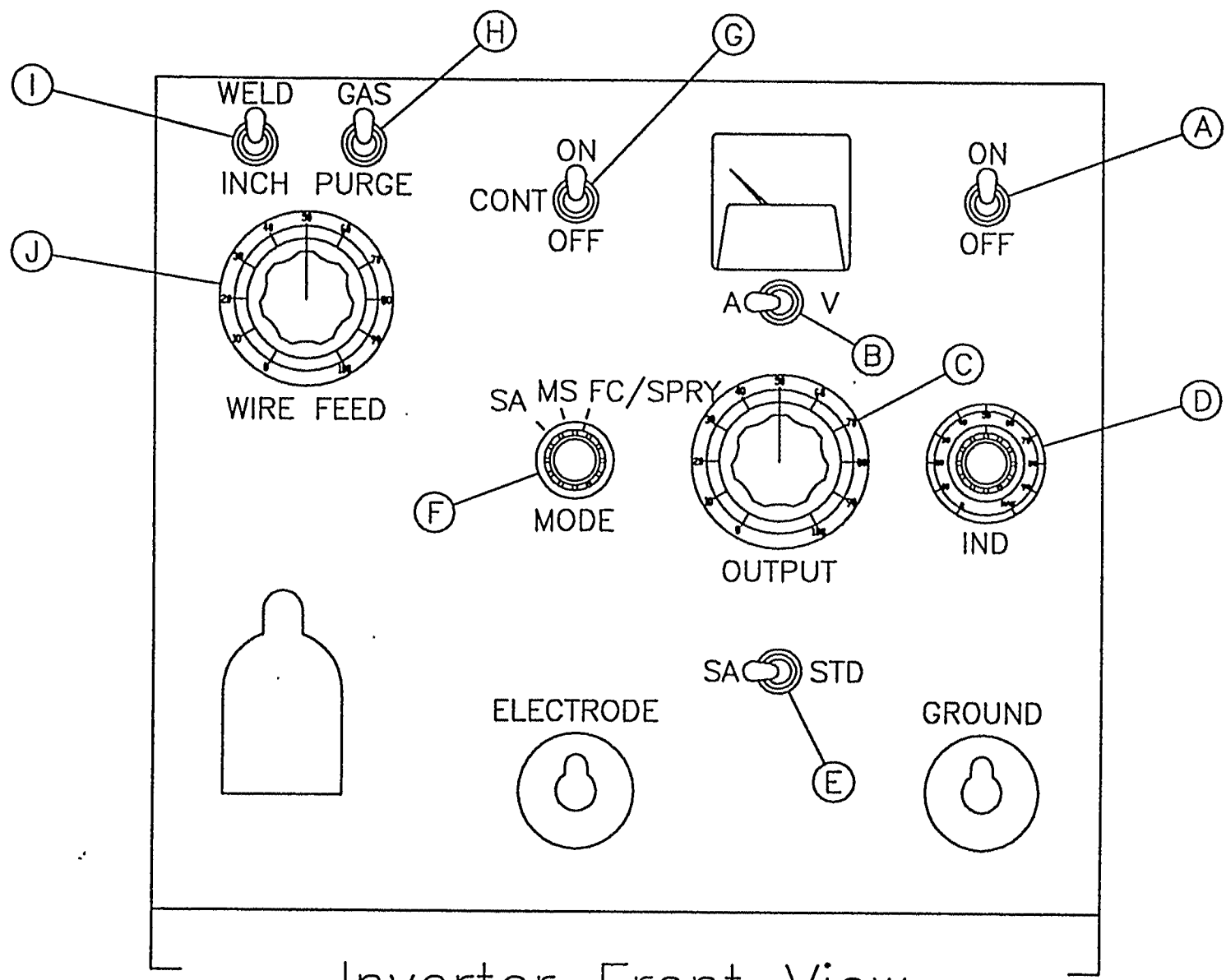
Controls the wire feed speed.

**K: Wire Feed Breaker**

Resettable breaker for wire drive motor.

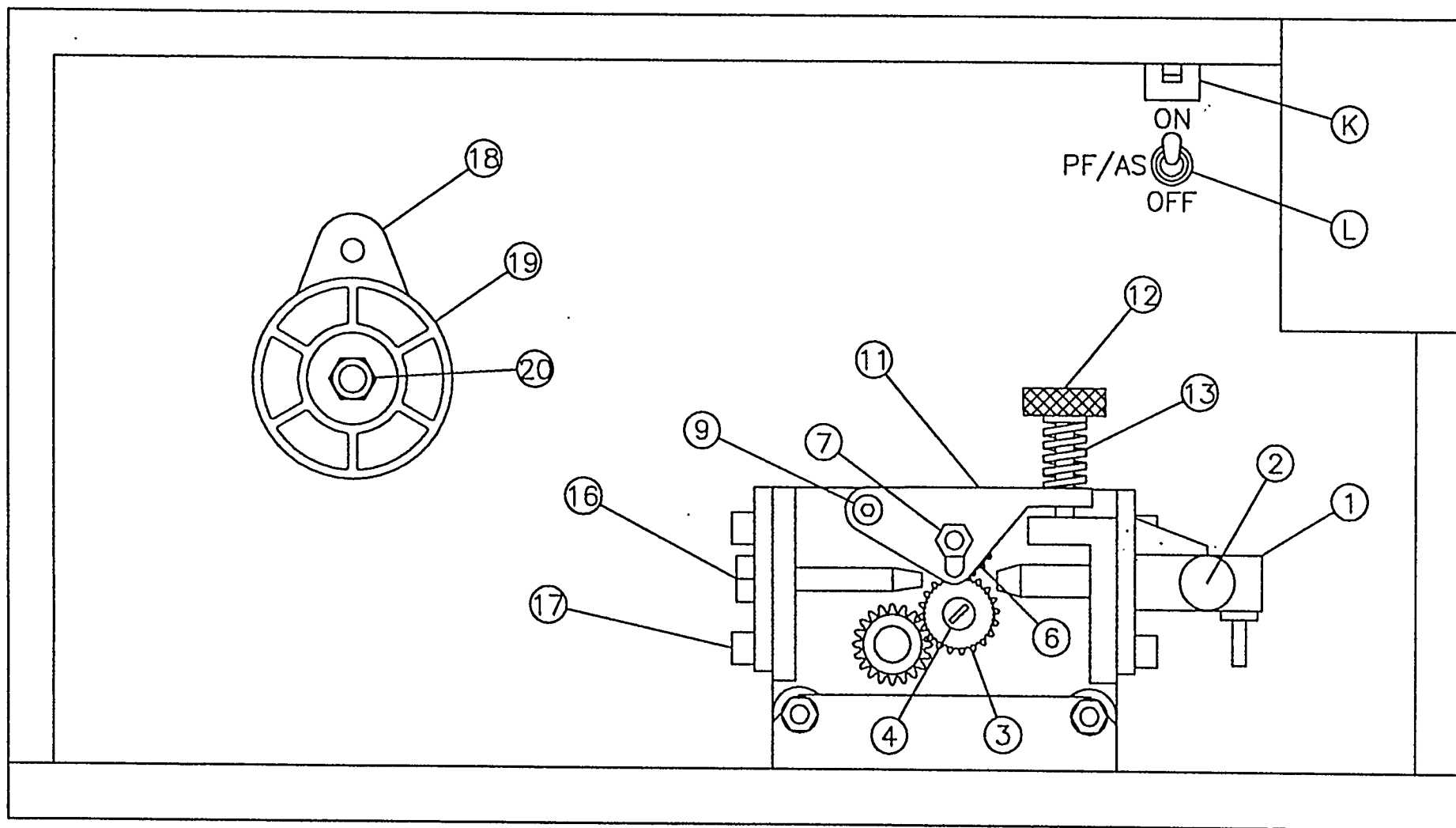
**L PF/AS Switch (Located in the feeder compartment)**

Turns on and off the "Pre-Flow" and "Anti-Stick" features, both of fixed duration. The post-flow is always active.



Inverter Front View





Inverter Side View

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 Information Above This Line Must Be Given When Ordering Parts
 

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<u>item No.</u>	<u>Part No.</u>	<u>Description</u>	<u>Reqd.L</u>
1	MTG-300I-1-X-1	Quick Connect Torch Adapter	1
2	MTG-300I-1-X-2	Thumb Screw	1
3	MTG-300I-1-X-3	Drive Roll (Knurled Carbide)	1
4	MTG-300I-1-X-4	Idler Roll /Drive Roll Mounting Bolt	2
5	MTG-300I-1-X-5	Drive Roll Spacer (Not Shown)	1
6	MTG-300I-1-X-6	Idler Roll (V Groove)	1
7	MTG-300L1-X-7	1/4 - 28 Hex Nut	1
8	MTG-300I-1-X-8	Idler Roll Spacer (Not Shown)	2
9	MTG-300I-1-X-9	Tension Bracket Mounting Screw	1
10	MTG-300I-1-X-10	Tension Bracket Mounting Nut (Not Shown)	1
11	MTG-300I-1-X-11	Tension Bracket	1
12	MTG-300I-1-X-12	Tension Screw	1
13	MTG-300I-1-X-13	Tension Spring	1
14	MTG-300I-1-X-14	Tension Spring Washer (Not Shown)	1
15	MTG-300I-1-X-15	Tension Screw Keeper (Not Shown)	1
16	MTG-300I-1-X-16	Inlet Guide	1
17	MTG-300I-1-X-17	5/16" - 24 X 518" Socket Head Cap Screw	4
18	MTG-300I-1-X-18	Spool Holder	1
19	MTG-300I-1-X-19	Spool Holder Nut	1
20	MTG-300I-1-X-20	3/8" -- 16 Self-Locking Hex Jam Nut	1
21	MTG-300I-1-X-21	Spring (Not Shown)	1
22	MTG-300I-1-X-22	3/8" Flat Washer (Not Shown)	1
23	MTG-300I-1-X-23	Fiber Washer (Not Shown)	4

MTG-PLB-1-X

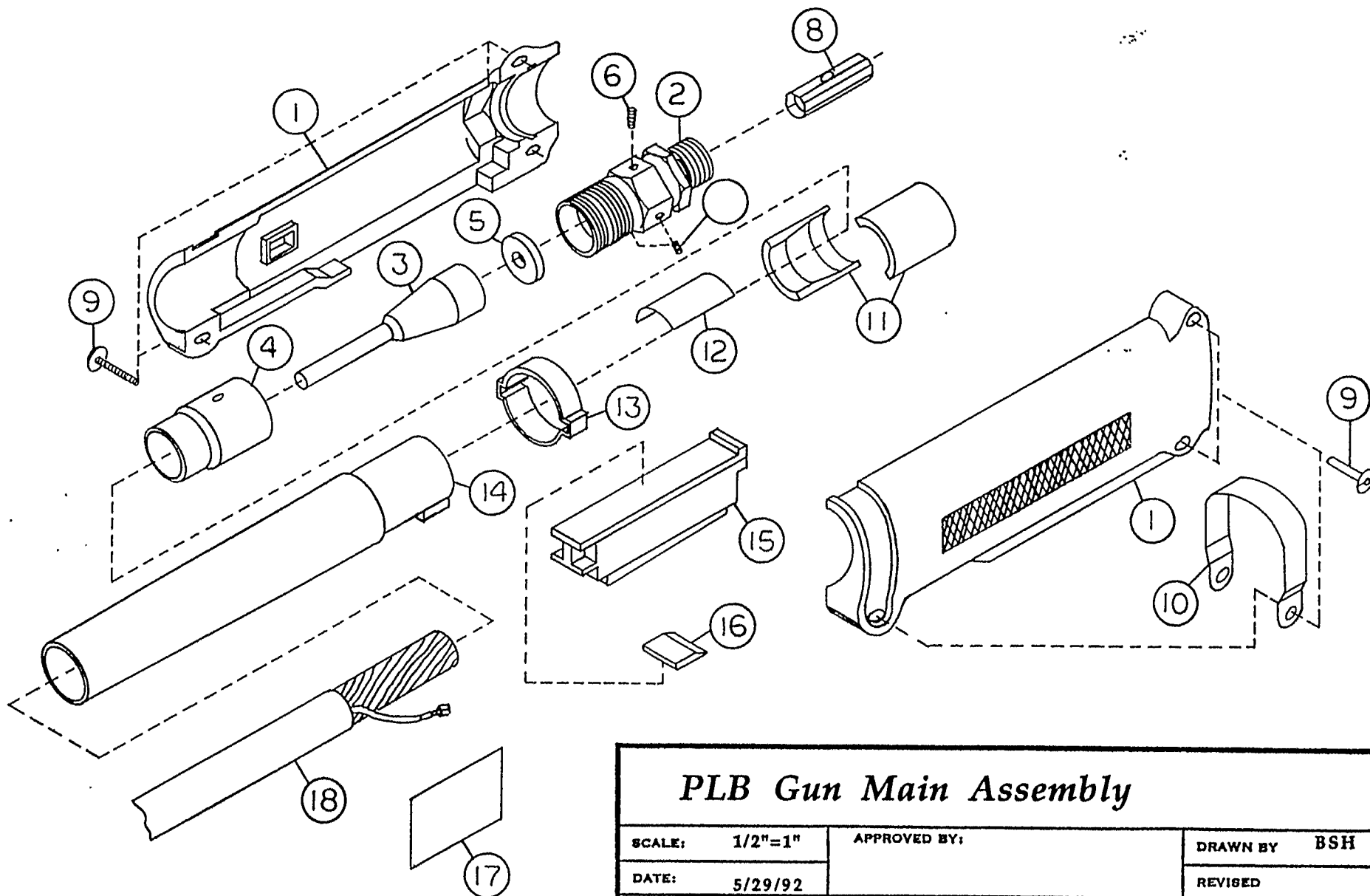
PLB Gun Main Assembly

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Information Above This Line Must Be Given When Ordering Parts

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<u>Item No.</u>	<u>Part No.</u>	<u>Description</u>	<u>Reqd.</u>
1	MTG-PLB-1-X-1	Handle Set	1
2	MTG-PLB-1-X-2	Gun Body	1
3	MTG-PLB-1-X-3	Mandrel	1
4	MTG-PLB-1-X-4	Barrel	1
5	MTG-PLB-1-X-5	Spacer Washer (1/16" Copper)	1
6	MTG-PLB-1-X-6	#8-32 X 1/4" Socket Head Set Screw	1
7	MTG-PLB-1-X-7	#8-32 X 3/16" Socket Head Set Screw	2
8	MTG-PLB-1-X-8	Liner Retainer Bushing	1
9	MTG-PLB-1-X-25	PLB Handle Screw Set	3
10	MTG-PLB-1-X-26	Handle Strap	1
11	MTG-PLB-1-X-27	Split Bushing	1
12	MTG-PLB-1-X-28	Curved Aluminum Spacer	1
13	MTG-PLB-1-X-29	Cable Clamp	1
14	MTG-PLB-1-X-31	Strain Relief	1
15	MTG-PLB-1-X-32	Complete Trigger Assembly	1
16	MTG-PLB-1-X-33	Trigger Shim	1
17	MTG-PLB-1-X-34	Switch Wire Insulator	2
18	MTG-PLB-1-X-35	Gun Cable (67K)	1



## PLB Gun Main Assembly

SCALE: 1/2"=1"

APPROVED BY:

DRAWN BY BSH

DATE: 5/29/92

REVISED

MTG-PLB-1

DRAWING NUMBER

MTG - PLB - 2-X

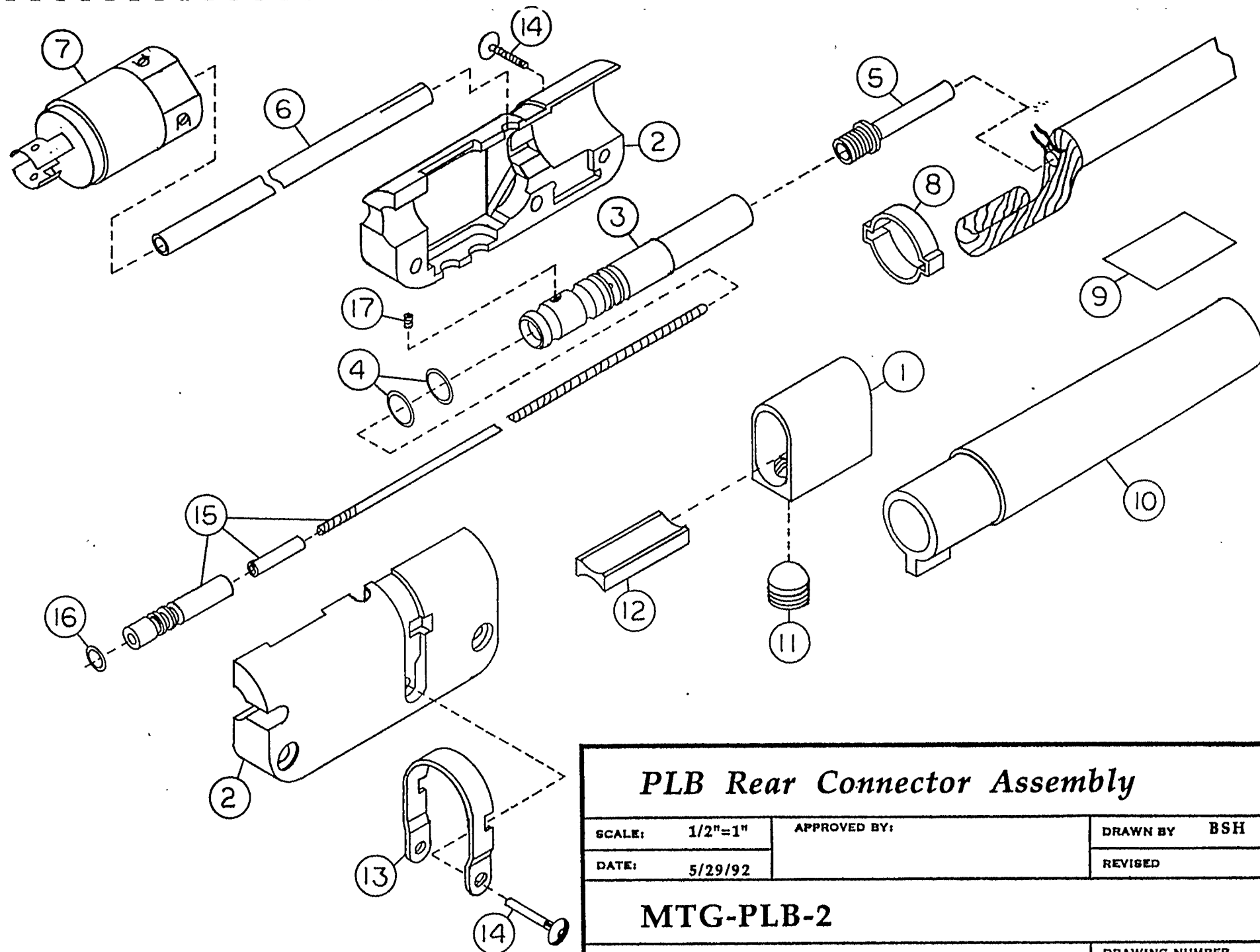
PLB Rear Connector Assembly

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Information Above This Line Must Be Given When Ordering Parts

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<u>Item No.</u>	<u>Part No.</u>	<u>Description</u>	<u>Reqd</u>
1	MTG-PLB-2-X-1	Connector Block	1
2	MTG-PLB-2-X-2	Rear Handle Set	1
3	MTG-PLB-2-X-3	QC Connector	1
4	MTG-PLB-2-X-4	Rubber O-ring	2
5	MTG-PLB-2-X-5	Insert Tube	1
6	MTG-PLB-2-X-21	Switch Wire Sleeve	1
7	MTG-PLB-2-X-22	Switch Plug	1
8	MTG-PLB-2-X-8	Cable Clamp	1
9	MTG-PLB-2-X-9	Switch Wire Insulator	2
10	MTG-PLB-2-X-10	Strain Relief	1
11	MTG-PLB-2-X-11	Ball End Pressure Screw	2
12	MTG-PLB-2-X-12	Separator	1
13	MTG-PLB-2-X-13	Handle Strap	1
14	MTG-PLB-2-X-14	Screw Set	3
15	MTG-PLB-2-X-15-52S	Type BIW Liner for .052-.062 Wire (O-rings Included)	1
16	MTG-PLB-2-X-16	Rubber O-ring	3
17	MTG-PLB-2-X-17	Socket Head Set Screw (#8-32 X 1/8")	1



## PLB Rear Connector Assembly

SCALE: 1/2"=1"

APPROVED BY:

DRAWN BY BSH

DATE: 5/29/92

REVISED

MTG-PLB-2

DRAWING NUMBER

MTG-PLB-3-X

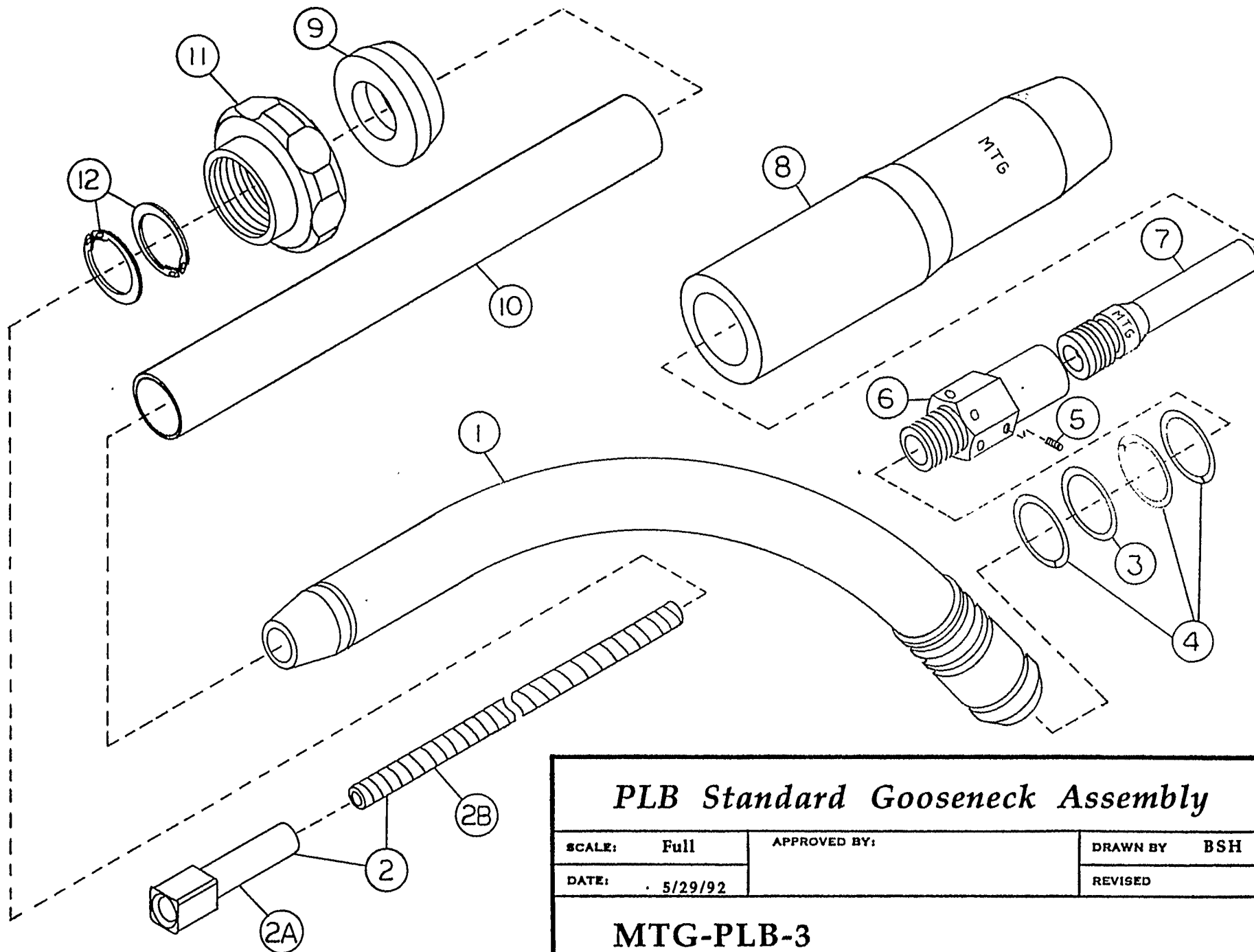
PLB Standard Gooseneck Assembly

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 Information Above This Line Must Be Given When Ordering Parts
 

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<u>Item No.</u>	<u>Part No.</u>	<u>Description</u>	<u>Reqd.</u>
1	MTG-PLB-3-X-9	Gooseneck	1
2	MTG-PLB-1-X-24	Type BI Gooseneck Liner .045-.052 (Keeper Included)	1
2A	MTG-PLB-1-X-24A	Gooseneck Liner Keeper (Type BIW)	1
2B	MTG-PLB-1-X-24B	Gooseneck Liner (No Keeper)	1
3	MTG-PLB-3-X-10	Rubber O-ring (Red)	1
4	MTG-PLB-3-X-11	Nozzle Retainer Ring	3
5	MTG-PLB-3-X-12	#8-32 X 1/8" Socket Head Set Screw	1
6	MTG-PLB-1-X-13	lip Holder (Set Screw Included)	1
7	MTG-PLB-1-X-14-35	.035 LID-A Contact Tip	1
	MTG-PLB-1-X-14-45	.045 LID-A Contact Tip	1
	MTG-PLB-1-X-14-52	.052 LID-A Contact Tip	1
8	MTG-PLB-3-X-17-5/8	Type BI Standard Insulated 5/8" Nozzle	1
	MTG-PLB-3-X-17-LID	5/8" LID Type Nozzle	1
	MTG-PLB-3-X-64	Slide Type Nozzle Body	1
	MTG-PLB-3-X-65	Nozzle Insulator	1
9	MTG-PLB-3-X-20	Gooseneck Insulator Trim	1
10	MTG-PLB-3-X-21	Gooseneck Insulator Tube	1
11	MTG-PLB-3-X-22	Gooseneck Lock Nut	1
12	MTG-PLB-3-X-23	Retainer Ring	2



## PLB Standard Gooseneck Assembly

SCALE: Full

APPROVED BY:

DRAWN BY BSH

DATE: 5/29/92

REVISED

MTG-PLB-3

DRAWING NUMBER



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