



SPECIFICATION No. 415

***Model 415
Automated Welding Power Supply and Control System***

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1.0 SCOPE

This specification is intended to describe, in detail, the functions and parameter ranges of the Model 415 (M-415) Power Supply.

The M-415 is intended for normal use in conjunction with Arc Machines, Inc. (AMI) automatic orbital welding heads or automated welding fixtures and as such, the M-415 is plug-compatible with all present and future standard weld head products.

Descriptions of welding heads or fixtures are only used in this specification where necessary for M-415 clarification. For details about AMI weld heads, please consult the individual specification for that weld head model.

2.0 APPLICATIONS

The M-415 Power Supply can be used to weld all alloys which are weldable with the "Gas Tungsten Arc Welding" (GTAW) DC process. Although the system is designed primarily for use as an automated orbital pipe welding (filler addition) system, it is also practical for orbital fusion (no filler addition) applications. The M-415 is also suited for tube-to-tubesheet applications, specialized fixture welding (orbital and non-orbital) applications and manufacturing work cell applications.

3.0 FEATURES

1. Solid State, precision, pulsed, air cooled GTAW Power Source
2. Operates all AMI Weld Heads.
3. Complete welding operations at weld head location up to 200 feet from power supply
4. Complete welding operation remotely (at power supply) from weld head up to 200 feet.
5. Graphical User Interface (GUI) display of all weld information.
6. Color VGA Display with "Touch Screen" for ease of operation.
7. Programmable memory for storage of all weld schedule information and function values.
8. 4 standard Closed Loop Motor Servos, 4 optional Closed Loop Motor Servos.
9. 8 Optional Open Loop Motor drives for positioning and jog functions.
10. Create Weld Schedules at the Power Supply or download from a PC or Main Frame.

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4.0 GENERAL DESCRIPTION

1. DIMENSIONS (basic Power Supply):

Height: 39 inches (990.6 mm)
Width: 26 inches (660.4 mm)
Depth: 36 inches (914.4 mm)

2. WEIGHT: Less than 700 lb. (317.5 kg) depending on configuration.

3. SYSTEM BASIC COMPONENTS

1. Basic Power Supply consisting of:

1. Input Power Section with Power Cable
2. Weld Head Connect Panel
3. Display Section
4. I/O Interface Section
5. Power Supply Section
6. Computer Section
7. Servo Control Section
8. Torch Cooling Unit Section
9. Gas Control Section
10. Base with semi-pneumatic wheels
11. Main chassis with lifting eyes.

2. Standard 40 foot (12.2 m) Pipe Weld Head Adapter Cable (service and control)

3. Operators Pendant with 10 foot ((3 m) Cable and built-in Heads Up Display

4. Operators Pendant extension Cable, 40 foot (12.2 m).

5. Ground Cable with Clamp, 50 foot (15.2 m).

6. Input Gas Hose with fittings, 25 foot (7.6 m).

4. STANDARDS - The M-415 is designed and maintained to meet all applicable IEC and ISO standards as well as all applicable EC Directives.

5.0 SYSTEM PERFORMANCE and SPECIFICATIONS

1. RATED CONDITIONS - The system will meet or exceed the functional ranges and tolerances stated, provided that the following conditions exist:

1. Input Power does not deviate greater than +/- 10%.
2. Ambient operating temperature range is between 0 degrees C (32 F) and 40.5 C (105 F)
3. Arc voltage at the power supply terminals is between 5 and 30 volts.
4. All electrical performance is based on maximum weld head distance of 200 feet (61 m) from the M-415

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5.0 SYSTEM PERFORMANCE and SPECIFICATIONS

2. INPUT POWER (all voltages are +/- 10%)

200 VAC	- 3 phase	- 50/60 Hz	- 60 Ampere Service
240 VAC	- 3 phase	- 50/60 Hz	- 60 Ampere Service
400 VAC	- 3 phase	- 50/60 Hz	- 40 Ampere Service
440 VAC	- 3 phase	- 50/60 Hz	- 40 Ampere Service
480 VAC	- 3 phase	- 50/60 Hz	- 40 Ampere Service
575 VAC	- 3 phase	- 50/60 Hz	- 40 Ampere Service

1. Breaker - 3 phase Auto-Trip
2. Emergency Stop - On Power Supply, on Pendant and external hardware command.
3. Power Cable - 25 foot (7.6 m)

3. CURRENT OUTPUT

NOTE

The following specifications will, in many cases, reference "User Defined" . User defined means that the user can set up the actual programmable ranges and functionality of any given function. For specification purposes this means that no actual function range can be given. Where applicable only an absolute maximum or minimum are given.

1. Range - 5 to 400 Amperes programmable. Programmable increments can be user defined in units of 1 or 0.1 amperes.
2. Type - Continuous or pulsed output DC Straight Polarity for GTAW (TIG) welding only.
3. Regulation - Constant Current closed loop servo using second generation high frequency (60 KHz) series switching regulation.
4. Regulation Response - Response time for correction of current deviation is less than 500 microseconds. Pulsed mode rise time from background current to primary is 1.2 ampere per microseconds.
5. Regulation Tolerance - +/- 0.5% of programmed setting or +/- 1.0 ampere whichever is greater.

4. ARC VOLTAGE and ARC VOLTAGE CONTROLLER

1. Open Circuit Output Voltage - 61 VDC
2. Maximum Output Voltage under load - 30 volts (measured at power supply, not at torch)
3. Arc Voltage Controller Range - (measured at the torch)
Minimum - 5 VDC
Maximum - 25 VDC
Actual programmable range is user defined.
4. AVC Motor Output Current Limit - User defined by weld head type in increments of 0.1 Amperes up to a maximum motor drive current limit of 4.0 Amperes.
5. AVC Motor Output Voltage Limit - 35 VDC
6. Regulation - Closed Loop position servo using arc voltage measured at the torch. Intended for DC permanent magnet type motors only.
7. Regulation Tolerance - +/- 1% of program value or 0.1 VDC, whichever is greater. Based on primary current only with no current pulsation. Measurable accuracy with the current pulsing can be affected by the puddle growth and shrinkage.
8. Regulation Response - Variable and programmable.
9. Jogs - Motor servo provides for UP and DOWN motor jogs. Jog speeds are adjustable.

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5.0 SYSTEM PERFORMANCE and SPECIFICATIONS

5. TRAVEL (torch rotation)

1. Range - Programmable range is User defined by weld head type. Unit of measure (IPM or RPM) and increments is user defined by weld head type.
2. Regulation - Closed loop velocity servo using, as standard, analog tachometer feedback of 0 to 5 VDC. Can be set up to regulate using digital tachometer or digital encoder feedback. Intended for DC permanent magnet type motors only.
3. Motor Output Current Limit - User defined by weld head type in increments of 0.1 Amperes up to a maximum motor drive current limit of 4.0 Amperes.
4. Motor Output Voltage Limit - 35 VDC
5. Regulation Tolerance - +/- 1% of program value or +/- 0.1 IPM or RPM whichever is greater. Based on maximum range being at least 10 IPM or RPM.
6. Jogs - Motor servo provides bi-directional (CW and CCW) motor jogs. Jog speeds are adjustable.

6. WIRE FEED

1. Range - Programmable range is User defined by weld head type. Unit of measure (IPM or mpm) also user defined by weld head type.
2. Regulation - Closed loop velocity servo using, as standard, analog tachometer feedback of 0 to 5 VDC. Can be set up to regulate using digital tachometer or digital encoder feedback. Intended for DC permanent magnet type motors only.
3. Motor Output Current Limit - User defined by weld head type in increments of 0.1 Amperes up to a maximum motor drive current limit of 4.0 Amperes.
4. Motor Output Voltage Limit - 35 VDC
5. Regulation Tolerance - +/- 2% of program value or +/- 1 inch, whichever is greater. Based on maximum range being at least 100 IPM.
6. Jogs - Motor servo provides bi-directional (FEED and RETRACT) motor jogs. Jog speeds are adjustable.

7. TORCH OSCILLATION and CROSS-SEAM STEERING

1. Range - User Defined by weld head type as to maximum programmable amplitude.
2. Regulation - Closed loop position servo.. Feedback device varies with weld head model. Intended for DC permanent magnet type motors only.
3. Motor Output Current Limit - User defined by weld head type in increments of 0.1 Amperes up to a maximum motor drive current limit of 4.0 Amperes.
4. Motor Output Voltage Limit - 35 VDC
5. Regulation Tolerance - +/- 1% of program value or 0.010 inches, whichever is greater. Based solely on M-415 servo specification. Actual response speed and tolerance performance can vary depending on the dynamic loads on the weld head. Consult the weld head specification for each weld head tolerance.
6. Jogs - No jogs are provided. Oscillator is continually seeking desired position. Position is based on input (steering) commands from steering devices (on Pendant and Display).

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5.0 SYSTEM PERFORMANCE and SPECIFICATIONS

8. TIMING FUNCTIONS

1. Purge Time Range (pre and post) -
000 to 1000 seconds. User can define minimum programmable time.
2. Start Delay Time Range (Travel, Wire, AVC) -
00.0 to 100 seconds in increments of 0.1 seconds.
3. Stop Delay Time Range (Travel, Wire, AVC) -
00 to 100 seconds.
4. Upslope Time Range -
00.0 to 100 seconds. User can define minimum programmable time
5. Downslope Time Range -
00 to 100 seconds. In increments of 1 second
6. Weld Level Time Range (up to 99 levels) -
0000 to 10000 seconds.
7. Pulse Timing Range (Primary/Background) -
0.00 to 100 seconds in increments of 0.01 seconds.
8. Oscillator Timing Range (Dwells and Excursion) -
0.00 to 100 seconds in increments of 0.01 seconds.
9. Primary WF pulse delay -
0.01 to 100 seconds in increments of 0.01 seconds.
10. Timing Resolution -
+/- 0.01 seconds (all timing functions)

9. ARC STARTING

1. Starting Methods - Touch or RF (radio frequency). Starting Frequency is approximately 10 MHz and will vary with components and cables.
2. Touch Start provides a smooth, consistent and tungsten inclusion free start with any weld head that has an AVC. Touch and Retract speeds are user defined. User can set up for single start attempt or multiple start attempt.
3. RF Starting provides a method of arc starting without touching the weld. System is designed for best performance under the following conditions:
 1. Minimum first level primary current - 5 Amperes (in Argon)
 2. Gases - Argon, 95/5 Argon/Hydrogen, Helium or Helium/Argon Mixes.
 3. 1 atmosphere pressure. Consult factory for operation in pressure chambers.
 4. Maximum arc gap - 0.156 inch (4 mm)
 5. Cerriated or Thoriated Electrodes with conventional grinds.
 6. Cable lengths up to 200 feet.
 7. Multiple arc strike attempts.

10. TORCH COOLING UNIT - Liquid cooled, forced air heat exchanger with coolant reservoir.

1. Reservoir Capacity - 2.5 Gallons (9.46 liters)
2. Maximum Pressure - 60 PSI
3. Flow - 0.3 GPM for 400 Ampere Torches.
0.2 GPM for 300 or less Ampere Torches
4. Head - Up to 100 feet with 200 feet of cable.
5. Duty Cycle - 100 %
6. Distilled Water, anti-freeze and algacide required (not supplied)
7. Filters - 3 cleanable strainer devices throughout system.
8. Internal Pump Pressure relief and coolant system shut down for loss of flow.

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5.0 SYSTEM PERFORMANCE and SPECIFICATIONS

11. GAS DISTRIBUTION SYSTEM

1. Control - Electrical Solenoid valve.
2. Pressure - Maximum 50 PSI
3. Flow - 5 to 100 CFH

12. SENSORS and FAULTS

1. **Torch Gas Flow** - An analog flow sensor provides a signal equal to the Flow rate (CFH) and the M-415 displays this flow rate and compares it against a program value and creates an Sequence Stop condition if it is not correct during a weld and prevents sequence if not correct during Pre-purge. Function is calibratable for Argon Torch gas only.
2. **Coolant Flow Sensors** - Monitor coolant flow rate and creates a Sequence Stop if below 0.2 GPM. Fault can be disabled by weld head type.
3. **Coolant Level Sensor** - Senses if coolant level in reservoir is low and displays to the operator that the level is low. No fault is created.
4. **Over Temperature Sensors** - Located on critical assemblies will create ALL STOP conditions if certain assemblies get too hot.
5. **Ground Fault** - Prevents Sequence Start or creates an ALL STOP condition if ground is lost during welding.
6. **AVC Mechanical Limit** - Creates a Sequence Stop if a weld head attempts to exceeds its AVC stroke. User can disable function by weld head type.
7. **OSC Mechanical Limit** - Creates a Sequence Stop if a weld head attempts to exceed its Oscillator stroke. User can disable function by weld head type.
8. **STUB OUT Detect** - Creates an ALL STOP if arc voltage goes below 5 VDC. Can be disabled by Weld head type.
9. **Over Voltage protection** - Creates an ALL STOP if power supply output voltage during a weld sequence exceeds 30 VDC.
10. **External Fault** - Allows the user to input up to 2 outside signals that will, when actuated from an external signal, create either an ALL STOP, Sequence Stop or WARNING as defined by the user.
11. **Power Supply Air Flow Fault** - Detects a loss of forced air cooling through the Power Source and creates an ALL STOP condition.

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13. MULTI-LEVEL FUNCTIONS and MODES

Most M-415 functions have the ability to be programmed to change during a weld sequence. This change of parameters are contained with in LEVELS. The M-415 provides up to 100 levels for the following functions and modes.

1. **Primary Current** - Sets the value of current in each level during the primary pulse time.
2. **Background Current** - Sets the value of Current in each level during the background time.
3. **Primary Pulse Time** - Sets the length (time) for Primary pulse functions.
4. **Background Pulse Time** - Sets the length (time) for Primary pulse functions.
- * 5. **Pulse Mode**
 - Off** - Provides continuous functions only, no pulsing (no background functions).
 - On** - Pulses from primary to background based on the Pulse Time settings.
 - Sync** - Synchronizes the pulsing to the OSC movement. Dwell times are primary
 - Excursion time is background
 - Ext** - Will pulse from primary to background based on an external timing signal.
6. **Level Mode**
 - Auto** - Uses Level time to determine when to switch to next level.
 - Manual** - Levels switch only from Pendant command manually made by operator.
 - Advance by position** - Allows levels to advance based on weld head position in degrees or inches.
 - Ext** - Allows levels to advance based on an external input signal.
7. **Level Time** - Sets the time each level will be used before advancing to the next level, if the Level Mode is set to Auto.
8. **Level Position** - Sets the position in degrees or inches that will determine when the levels will change, if the Level Mode is set to Position.
9. **Primary Travel Speed**
10. **Background Travel Speed**
- * 11. **Travel Step Mode**
12. **Primary Wire Feed Speed**
13. **Background Wire Feed Speed**
- * 14. **Wire Pulse Mode**
 - Off** - Wire Feed is continuously the Primary value regardless of pulse mode.
 - On** - Wire Feed will pulse from Primary to Background based on the pulse mode time.
15. **Primary AVC** (arc voltage)
16. **Background AVC**
- * 17. **AVC Mode**
 - Continuous** - Regulates the Arc Voltage to the Primary AVC during primary and regulates the arc voltage to the Background AVC during the background pulse.
 - Sample on the Primary** - Regulates the arc voltage servo to the Primary AVC value during Primary pulse and turns the AVC servo OFF during the Background.
 - Sample on the Background** - Regulates the arc voltage servo to the Background AVC value during the Background pulse and turns the AVC servo OFF during the Primary pulse.
 - OFF** - Turns the AVC servo OFF and does not attempt to regulate the Arc Voltage.

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13. MULTI-LEVEL FUNCTIONS and MODES

- * 18. **AVC Response** - Sets a value that determines how fast the AVC responds to errors in the arc voltage value versus the programmed AVC value (primary and/or background).
- 19. **Osc IN Dwell Time** - Sets the time that the Oscillator will be in the IN Dwell position
- 20. **Osc OUT Dwell Time** - Sets the time that the Oscillator will be in the OUT Dwell position
- 21. **Osc EXCURSION Time** - Sets the time that the Oscillator will take to move from the IN to the OUT and the OUT to the IN.
- 22. **Osc Amplitude** - Set the distance that the Oscillator moves from OUT to IN and IN to OUT. User defines by weld head type the amplitude range.
- * 23. **Osc Mode** -
On- Allows the Oscillator to move at the Dwell/Excursion rate and Amplitude distance.
Off - The Osc servo is only used for steering and does not move during sequence.
- * 24. **Osc Slew To** - Sets the desired torch cross-seam position at the beginning of a Level.

14. SINGLE LEVEL FUNCTIONS and MODES

- 1. **Prepurge** - Sets the time that gas flows to the torch after Sequence Start and before arc start.
- 2. **Start Mode** - Can be set to **RF** Start or **Touch** Start.
- * 3. **Travel Mode** - Determines which direction Clockwise or Counter Clockwise or OFF the Travel Servo will drive the motor when the Travel Servo is enabled.
- 4. **Upslope** - Sets the time that the Current and the Oscillator will take to rise to Level I maximum values after arc start.
- 5. **Travel Start Delay** - Sets the time from Arc Start until the Travel Servo is enabled.
- 6. **Wire Feed Start Delay** - Sets the time from Arc Start until the Wire Feed Servo is enabled.
- * 7. **Primary Wire Feed Pulse Delay** - Sets the amount of time the Wire Feed can be delayed from changing to the Primary value from the Background value.
- 8. **AVC Start Delay** - Sets the time from Arc Start until the AVC Servo is enabled.
- 9. **Downslope** - Sets the time that the Current and Oscillator will take to fall to minimum programmable values before the arc goes out and Postpurge begins.
- 10. **Travel Stop Delay** - Sets the time the Travel Servo remains enabled after the beginning of Downslope.
- 11. **Wire Feed Stop Delay** - Sets the time the Wire Feed Servo remains enabled after the beginning of Downslope.
- 12. **AVC Stop Delay** - Sets the time the AVC Servo remains enabled after the beginning of Downslope.
- 13. **Postpurge** - Sets the time that gas continues to flow to the torch after the end of Downslope and the arc has gone out.
- 14. **Wire Feed Select** - CW or CCW

NOTE

Multi-Level and Single Level Functions marked with an * can be user defined to be single or multi-level. They are listed here according to how they are set at the factory.

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15. MISCELLANEOUS NON-PROGRAMMABLE FUNCTIONS

1. **Return to Home** - System can be set up, by weld head type, to automatically at the end of Post Purge, jog the Travel Servo and move the torch to the mount/dismount position or starting position for next pass.
2. **Autowrap function** - System can be set up, by weld head type to allow the operator to engage the autowrap function and wrap the cables prior to the start of weld sequence.
3. **Wire Slope** - During the period of Wire Feed Stop Delay the Wire will be sloping toward 0 IPM. When the Wire Feed Stop Delay is complete the Wire will stop running completely.
4. **Set Function** - System can be set up, by weld head type to allow the operator to engage the Set Function which will automatically position the torch (via the AVC servo) to the correct gap for arc starting.
5. **Torch Position Indicator** - Can be set up by Weld head Type to display the position of the torch in relationship to the center of the Oscillator.
6. **Weld Head Position Indicator** - Can be set up by weld head type to display the position of the Torch in relation to Travel movement (can be in inches, mm or degrees).
7. **Override Limits** - User can define how great a change an operator can make to any overridable function.

16. PENDANT CONTROLS

The M-415 comes standard with an Operators Pendant. This Pendant has all the controls necessary to Select Weld Schedules and passes, set up the weld head for operation, start/stop the weld, reset faults and make overrides before and during the weld.

1. LIBRARY (LBRY) - Key is used to access Weld Schedules and passes.
2. CLEAR (CLR) - Used to clear entries and reset faults.
3. ENTER (ENT) - Used to engage an entry.
4. ID# - Used to enter the Weld Identification number.
5. PRE WRAP - Used to engage the Auto Wrap Function
6. SET - Used to engage the Set Function.
7. OSC MAN - Used to engage Oscillator Manual Mode which will, when not in sequence, cause the Oscillator to move at the weld schedule program rate and amplitude.
8. MAN PURGE - Used to engage the Gas Solenoid when not in sequence.
9. WELD TEST - Sets whether system is in TEST Mode or WELD Mode.
10. LAMP - Used to turn the illuminating lamps on and off for torches with vision systems.
11. TVL MODE - Allows operator to change Travel Direction or turn Travel OFF.
12. WIRE ON/OFF - Allows operator to turn Wire Feed On or OFF.
13. SEQ START - Used to Start Weld Sequence.
14. MAN ADV - Used to advance the Sequence from one level to the next level.
15. STEERING - Thumb Wheel is used to steer or set the Torch Oscillator Position.
16. SEQ STOP - Used to Stop the Weld Sequence and engage Downslope
17. ALL STOP - Used in welding emergency to stop the weld sequence and engage Postpurge.
18. ARROW UP/DOWN - Used for changing values during overrides.
19. AMPS - Used for overriding Current.
20. AVC - Used for overriding AVC setting.
21. EXC - Used to override Osc Excursion time and/or Osc Amplitude
22. DWL - Used to override Osc IN and/or OUT Dwell time.
23. TVL - Used to override Travel Speed.
24. WIRE - Used to override Wire Feed Speed.

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16. PENDANT CONTROLS

25. AVC RESP - Used to change AVC Response Setting.
26. PLS TIME - Used to override Pulse Times.
27. TVL CW JOG - Used to jog the Travel in the CW direction
28. TVL CCW JOG - Used to jog the Travel in the CCW direction
29. WIRE FEED JOG - Used to manually FEED wire.
30. WIRE RETR JOG - Used to manually RETRACT wire.
31. AVC UP JOG - Used to move the Torch (AVC) UP.
32. AVC DOWN JOG - Used to move the Torch (AVC) DOWN.
33. WIRE MANIPULATOR CONTROL - Used to move Motorized Wire Manipulators.
34. EMERGENCY STOP - Electronically turns the main breaker on the M-415 OFF.

17. OTHER SYSTEM FEATURES

1. PRINTING - The M-415 can be connected to any Windows 95 compatible parallel port printer and hard copies of all weld schedules can be made. An autoprint feature can be set up to allow the system to automatically print a copy of the Weld Parameters used (including overrides) after each sequence.
2. MEMORY MEDIUMS - Built-in 1 GB (or greater) harddrive, built-in 3.5 inch Floppy Drive. 2 Built-in USB ports (units prior to November 2004 have a PCMCIA Memory Card Slot instead of USB ports).
3. DATA BACK UP - All information contained in the system harddrive can be backed up through a variety of methods including Floppy or tape.
4. PASSWORD/SECURITY lockouts - If desired various degrees of security can be set up to control who can change what.
5. SOFTWARE UPGRADES are done via Floppy or PC Option download via MODEM.
6. METRIC/ENGLISH CONVERSIONS - Most functions that have units of measure can be set to be programmable in both English or Metric units.
7. LANGUAGES - The user can set up different language files and translate any or all English text to their language or languages of choice.
8. PROJECT DATA - As standard the M-415 can collect information about a weld including the following:
 1. Weld Identification Number
 2. Welder/Operator Identification name or number
 3. Date, and time of weld pass
 4. Date and time of print out.
 5. Weld Head Model and serial number used.
 6. Power Supply Serial numberThis information can be printed along with the weld parameter after a Weld Sequence.
9. FUNCTION DATA ACQUISITION - As standard the M-415 provides the following Weld Data Collection and/or outputs.
 1. Standard 6 function analog output connector for chart recorders (amps, travel, wirefeed, avc, osc, arc voltage at power supply)
 2. Post Sequence Print capability with Program values/over-ridden values and actual peak/min/average values for that pass.

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10. INPUT/OUTPUTS (I/O) - The M-415 will provides the following input and output signals.
 1. External Sequence Start Input
 2. External Sequence Stop input
 3. External Emergency Stop Input
 4. External Osc Steering Input
 5. Remote Fixture Start output
 6. Remote Fixture Desired Speed analog output
 7. External Hot Wire PS Sequence Start Output
 8. Desired Gas Flow Rate Output

11. SYSTEM and ARC HOURS - System electronically records System ON time and Arc Hours

6.0 OPTIONS

The M-415 is capable of having a great number of options purchased and employed with it. The following is only a brief list and does not contain any specifications as to option function performance.

1. Auxiliary Cooler - For cooling non-torch components such as camera and motor housings.
2. 4 Optional Closed Loop Servos - Can be added to the M-415 and user defined as to function and programming.
3. 8 Optional Open Loop Motor Jog Servos - Can be added for control of open loop motor functions such as wire manipulators and torch tilt mechanics.
4. Laptop or PC computer - Can be connected for remote operation, downloading, bar-coding, etc.
5. Digital Data Acquisition Module - Provides a digital stream of information out of the M-415 that can go to a third party Data Acquisition system or PC program.
6. Manual Torch connection and Manual Welding
7. Manual Foot Controller for Manual Welding.
8. Chart Recorder for Data Acquisition.
9. Remote Welding System (camera, video controllers, cabinetry)

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