The only official copy of this file is the one on-line on the Superconducting Magnet Division website. Before using a printed copy, verify that this is the most current version by checking the document issue date on the website.

SMD Operations Procedures Manual

8.1.1.34 2M Direct Wiring Machine

Text Pages 1 through 15
Attachment(s) 1, 2, 3, 4

Hand Processed Changes

HPC No.	Date	Page Nos.	Initials

Revision No. 02 Approved:

Signature on File 5/15/2013

Division Head Date

Preparer(s): J. Escallier

The only official copy of this file is the one on-line on the Superconducting Magnet Division website. Before using a printed copy, verify that this is the most current version by checking the document issue date on the website.

8.1.1.34 2M Direct Wiring Machine

1.0 Purpose and Scope

1.1 This procedure provides instruction in the operation of the 2M Direct Wiring Machine, located in Building 902.

1.2 This procedure establishes the minimum qualification for any person who will operate the Wiring Machine.

2.0 Responsibilities

2.1 Authorized operators of the Wiring Machine will perform the tasks described here.

2.2 The operator shall complete the following documentation:

2.2.1 Log Book. Entries shall include notes of any irregularities regarding operation of the Machine.

2.2.2 Interlock Test Form. The form shall be completed when the safety interlocks are tested. A copy of the form shall be posted near the Wiring Machine.

2.2.3 Wiring run sheet. Documents repairs from factory and repairs made by wiring tech.

3.0 Prerequisites

3.1 Training

3.1.1 Operator shall be hands-on instructed by the cognizant Technical Supervisor before operating the Wiring Machine.

3.1.2 Operator shall be trained as an “affected employee” as defined by SBMS Subject Area: Lockout/Tagout (LOTO)

The only official copy of this file is the one on-line on the Superconducting Magnet Division website. Before using a printed copy, verify that this is the most current version by checking the document issue date on the website.

3.2 Initial State of Wiring Machine

3.2.1 Operator controls shall be set to their "initial" settings (see paragraph 5.3) before activating power to the Wiring Machine.

4.0 Precautions

This procedure involves working near moving machinery.

4.1 Entanglement with rotating machinery can occur, if loose fitting clothing or hanging jewelry is worn or if long hair is not tied up.

4.2 All guards and covers should be in place.

4.3 Injury is possible if hands are not kept from pinch points when the machine is in motion.

4.4 Do not use if a test of interlocks was not performed within the last six months and the dated Interlock Test Form is not posted near the Wiring Machine.

4.5 Verify machine is clear of any foreign objects which could damage equipment or be thrown from the machine.

5.0 Procedure

5.1 Overview

The 2M Direct Wiring Machine provides a means of feeding wire in a tightly controlled pattern into a layer of epoxy pre-impregnated fiberglass cloth.

The machine consists of a rotary head for turning the magnet tube, with a movable gantry to position the wiring head along the axis of the tube. On the gantry are two additional linear axis, one to raise and lower the wiring head, and the second to horizontally position the wiring stylus within the slot on the tube. Three rotary axis are on the head, theta is for rotating the head the full 360^0, while two axis are used for positioning the wire feed mechanism and one axis is used for paying out the wire.

The machine is computer controlled, with a keyboard for operator input and a monitor for display of menu driven operating instructions and Machine status.

The only official copy of this file is the one on-line on the Superconducting Magnet Division website. Before using a printed copy, verify that this is the most current version by checking the document issue date on the website.

5.2 Operator Controls

5.2.1 System Controls (Attachment 1)

A. Item 1 - 120 volt input disconnect switch. Disconnects all power to the machine.

B. Item 2 - CRASH red mushroom-head push buttons (qty 5) and a **RED CRASH** cord. Deactivates power to the servos; causes all machine motion to stop; requires that the machine be reset before power can be re-activated.

C. Item 3 - ON green push button. Activates power to the servos after the RESET button is depressed.

D. Item 4 - OFF black push button. De-activates power to the servos; the machine does not have to be reset before re-activating power to the servos.

E. Item 5 - CONTROL POWER ON red indicator light. Illuminates when power to the servos is activated.

Item 6 - Joystick control.

Item 7 B AC on orange lamp. Illuminates when AC connected.

5.2.2 Air Flow and Pressure Controls (Attachment 1)

A. Item 8 - Main air feed shutoff valve. This valve is mounted on the wall behind the machine.

B. Item 11 - Air regulator and gauge. Regulates cooling air onto the stylus mounted on the back right table pedestal.

5.2.3 Ultrasonic Controls

Ultrasonic Generator (Attachment 2)

A. Item 1 - ON/OFF toggle switch. Activates power to the U/S generator.

The only official copy of this file is the one on-line on the Superconducting Magnet Division website. Before using a printed copy, verify that this is the most current version by checking the document issue date on the website.

B. Item 2 - NULL/NORM toggle switch. Calibration use; set to the NORM position during operation.

C. Item 3 - Three position selector switch (labeled "1", "2", "3"). Calibration use; set to the "2 or 3" position during operation.

D. Item 4 - DC mA meter. Indicates the power output of the Generator. Used for power output verification.

Ultrasonic Generator Power Supply (Attachment 2)

A. Item 11 - Test jacks. Allow the output of the power supply to be monitored by connecting a voltmeter to the test jacks. The voltage across the jacks is 4.7 volts per 1 amp output.

B. Item 12 - CURRENT ADJUST Potentiometer. Adjusts current output of the supply; calibration use; not used during operation.

Wattmeter (BNL) (Attachment 3)

A. ON/OFF toggle switch. Activates power to the Wattmeter located on back of unit.

B. Item 2 - Indicator lights (3). Illuminate when power is activated.

C. Item 3 - Potentiometer with readout. Not functional when MAN/SWEEP/NULL selector switch (item 4) is set to null (as it is during operation).

D. Item 4 - MAN/SWEEP/NULL three position selector switch. Calibration use; set to NULL during operation.

E. Item 5 - SINE WAVE/SQUARE WAVE toggle switch. Selects the control output waveform sent to the U/S generator. Calibration use; set to SINE WAVE during operation.

F. Item 6 - Potentiometer. Adjusts the output amplitude; calibration use; set to the OFF position during operation.

The only official copy of this file is the one on-line on the Superconducting Magnet Division website. Before using a printed copy, verify that this is the most current version by checking the document issue date on the website.

G. Item 7 - IDLE/RUN/NULL three position toggle switch. Calibration use; set to the RUN position during operation.

H. Item 8 - WATT/AMP/VOLT selector switch. In the WATT position, the digital display (Item 9) indicates the power (in watts) delivered to the ultrasonic stylus; In the AMP position, indicates the DC biasing current delivered to the drive coil; in the volts position, shows the peak to peak voltage delivered to the drive coil.

I. Item 9 - Digital display. Displays the parameter selected by the WATT/AMP/VOLT selector switch (Item 8).

J. Item 10 - Toggle, Constant Voltage/Constant Power (CV/CP).

K. TEST POINTS K, D, H, B, A, F, V, I. Calibration use.

5.3 Initial Control Settings (Assumes norm operation stylus in calibration)

5.3.1 U/S Gen. ON/OFF toggle switch (Item 1, Attachment 2) set to off.

5.3.2 U/S Gen. Selector switch (Item 3, Attachment 2) set to position 2.

5.3.3 Wattmeter MAN/SWEEP/NULL three position selector switch (Item 4, Attachment 3) set to NULL.

5.3.4 Wattmeter SINE WAVE/SQUARE WAVE toggle switch (Item 5, Attachment 3) set to SINE WAVE.

5.3.5 Wattmeter Potentiometer (Item 6, Attachment 3) set to OFF.

5.3.6 Wattmeter IDLE/RUN/NULL three position switch (Item 7, Attachment 3) set to RUN.

5.3.7 Wattmeter WATT/AMP/VOLT selector switch (Item 8, Attachment 3) set to WATT.

5.3.8 Wattmeter ON/OFF toggle switch (back of unit) set to ON (UP).

5.3.9 Wattmeter CV/CP toggle switch (Item 10, Attachment 3) set to CP.

5.4 Starting Up the Machine

5.4.1 Refer to the applicable Magnet Assembly Procedure for instructions on setting up the substrate within the slot of the magnet tube.

5.4.2 Verify that the controls are set to their initial settings (5.3). Verify that the 120 volt disconnect switch is in the OFF (DOWN) position.

5.4.3 Turn on the air supply by turning the valve on the air line next to the machine. Verify that the regulator settings are as per the log book for the machine.

5.4.4 Mount the wire spool and thread the wire through the wiring head.

NOTE ***Wire mounting may also be done after the AC power is disabled with the crash buttons.***

5.4.5 Place the 120 VOLTS disconnect switch, located on the rack cabinet, in the ON position. The AC **ON** amber lamp illuminates on the Control Box.

5.4.6 Turn on the computer by operating the rocker switch on the front panel of the computer case. Wait until the Main Menu of the control software is displayed on the monitor.

5.4.7 From windows, enter the helical winder program.

5.4.8 Depress the ON green push button on the Control Box. Verify that the CONTROL POWER ON red indicator light illuminates.

5.4.9 Activate power to the Ultrasonic Generator by placing the ON/OFF toggle switch in the ON position.

5.4.10 Verify power to the Ultrasonic Wattmeter is ON.

5.4.11 Choose an action from the menu of action choices on the computer monitor (Refer to the next section for a description of the operator choices available from the software menu).

5.5 Computer Software Menu

5.5.1 Main Menu choice “Files”

5.5.1.1 This is the only choice available at startup of the winder. Select the coil to be wound within the menu system.

5.5.2 Main Menu choice “home axis”

5.5.2.1 This function allows the machine to home, and uses the file selection to locate the home information for the type of tube used.

5.5.2.2 The first axis which homes is the Z axis. The z axis homes in the up direction, and homing z first forces the stylus tip to its farthest travel location from the tube. If the z axis does not move up initially, and is not close to the upper travel limit, immediately hit a crash button to prevent collision with the tube.

5.5.3 Main Menu choice “joystick”

5.5.3.1 Select the axis to be moved. Once selected, click on “select”. This enables joystick control of the selected axis.

5.5.3.2 When finished with an axis, click on “finished”. At this time, a different axis can be selected, or the operator can exit the joystick routine.

5.5.4 Main Menu choice “Zero check”

5.5.4.1 This selection places the Z axis at 5 inches above zero height, and then moves all other axis= to zero location. Once the move is complete, the joystick window will appear.

5.5.4.2 In joystick mode, move the z axis down to engage the zero hole in the magnet tube. Select appropriate axis= to verify the accuracy of the zero location. When the zero location is confirmed as accurate, select “done”, and then “no” at the “save zero screen”. If zero has changed, choose “yes”, and enter the new z height in the zero height screen. Typically, after zero has been re-located, move the z axis up to 5 inches, and then save the

z height as 5 inches. This also serves to raise the tip of the stylus out of harms way.

5.5.5 Main Menu choice "run"

NOTE ***In the event of incorrect machine travel, use the crash buttons or wire to halt machine travel.***

5.5.5.1 Once selected, the software will prompt for confirmation of run mode.

5.5.5.2 When confirmed, the machine will proceed with the run sequence. The run sequence is designed to allow the operator to verify correct slot, and to check the accuracy of positioning of the stylus within the slot. Failure of the machine to position accurately can be spotted at this time, to prevent damage of the stylus mechanism.

5.5.5.3 The first action is a z move to 5 inches above the center of the tube. Watch the machine to verify that the z axis move stops at about 5 inch height.

5.5.5.4 Once at the 5 inch height, the machine will proceed to the correct x and phi co-ordinates for the beginning of the coil chosen. The machine will then drop to a position at the bottom center of the slot. At this point, a prompt will appear, asking if the stylus is at the center of the slot selected.

5.5.5.5 At this point, an answer of yes will cause the stylus to move sideways to the start location. Watch carefully the movement during this time and, if the travel is not as expected, the only way to stop the machine is to push any one of the crash buttons or wires. An answer of "no" will cause the program to stop the run sequence.

5.5.5.6 Once the stylus is at the bottom of the slot in the start location, it will ask "it is ok to engage the stylus pressure?" Again, an answer of "no" will terminate the run sequence.

5.5.5.7 If "yes" is selected, the stylus down force will engage. The program will then as "Ready to run?" A "no" will end the run sequence. A "yes" will begin the wiring in the slot.

5.5.6 Main Menu Choice "Pause"

NOTE ***A "pause" will halt all controlled motion, but does <u>NOT</u> de-energize the motor circuits. If access within the motion enevelope is required, disable the machine using the crash string. Verify power is OFF by inspecting the red power on indicator (Attachment 1, Item 5).***

This function is used to stop the wiring machine and still retain the wiring run. It smoothly stops the machine anywhere along the wiring path and allows operator intervention should any difficulties arise. Typically, this function is used to allow placement of the substrate between layers and to check or fix the wire or wire placement. When the pause is activated, access to all the wiring and layer parameters for this particular coil block is allowed.

5.5.6.1 This option is only available while the machine is actively wiring. By selecting this option, the machine will slow down to a stop along the wiring path and will turn off the gate force and the ultrasonic power. When this mode has engaged, the pause button will be replaced with a continue button. This button will start the machine along the correct wiring path.

5.5.7 Main Menu Choice "End"

5.5.7.1 This choice is for ending the program.

5.6 <u>Shutting Down the Machine</u>

5.6.1 Return the wiring head to the load position.

5.6.2 Depress the OFF black push button on the control box to de-activate servo power.

5.6.3 Exit from the control software.

5.6.4 Turn off the computer.

5.6.5 Place the 120 volts disconnect switch in the OFF position.

5.6.6 Turn off the air.

5.7 Testing the Safety Interlocks

5.7.1 Set all the controls to their initial settings (section 5.3).

5.7.2 Place the 120 volts disconnect switch, located on the rack, in the ON position.

5.7.3 Turn on the computer. Start the Motion Engineering (MEI) software program.

5.7.4 Depress the ON green push button on the control box. Verify that the CONTROL POWER ON red indicator light illuminates.

5.7.5 Depress a CRASH mushroom push button. The CONTROL POWER ON red indicator light and the RESET green lighted push button should extinguish.

5.7.6 Check the appropriate box on the Interlock Test Form (Attachment 5).

5.7.7 Test all seven CRASH push buttons and both crash cords. To re-energize the Machine after each crash, depress the ON green push button.

5.7.8 After the last CRASH push button has been tested, re-start the Machine

5.7.9 Using the MEI software, move the head gantry (X axis) towards the positive limit of travel.

5.7.10 Before the end of the track is reached, the positive optical limit switch should trip. Motion should stop. The servos remain on.

5.7.11 Within the MEI software, disable the positive limit switch for the X axis.

5.7.12 Continue moving the gantry in the positive direction.

5.7.13 Before the end of the track is reached, a mechanical limit switch should trip. Motion should stop and the servos should shut off.

NOTE ***The power to the servo's cannot be activated as long as the crash switch is depressed. Once the gantry has been moved off the switch, the operator will be able to re-energize the servo power with the "on" button.***

5.7.14 To re-start the machine, it will be necessary to hand move the gantry back off the mechanical crash switch. This is done by rotating the lead screw.

5.7.15 Depress **ON** green push button.

5.7.16 Repeat the test in the negative X axis direction..

5.7.17 Check the appropriate boxes on the Interlock Test Form.

5.7.18 Repeat Steps 5.7.9 through 5.7.10 for the Y and Z axis.

5.7.19 Initial and date the Form and post it near the Wiring Machine.

5.7.20 If an interlock fails, stop work, write "fail" on the form, and immediately notify the Cognizant Engineer and the ES&H Coordinator.

5.8 Aligning the Stylus

5.8.1 Verify that the controls are set to their "initial" settings (5.3).

5.8.2 Mount the wire spool (do not thread the wire through the wiring guide yet).

5.8.3 Place the 120 volts disconnect switch, located on the rack, in the ON position.

5.8.4 Turn on the computer by operating the rocker switch on the computer front panel. Wait until the Main Menu of the control software is displayed on the monitor.

5.8.5 Depress the ON green pushbutton on the Control Box. Verify that the CONTROL POWER ON red indicator light illuminates.

5.8.6 Home the wiring machine.

5.8.7 Run Zero check.

5.8.8 Insert a 200 mil shim under the stylus voice coil.

5.8.9 Using the joystick on Z axis, lower the stylus to a point 50 mils above the home hole adapter in the tube.

5.8.10 Verify the stylus drops into the adapter hole.

5.8.10.1 If the stylus does not drop into the hole, loosen the bottom assembly screws, and re-position the stylus holding mechanism to allow a clean drop into the hole.

5.8.11 Re-shim the stylus above the hole. With the joystick set to theta, rotate the stylus and head 180E.

5.8.12 Verify the stylus drops into the hole.

5.8.12.1 If the stylus is now misaligned, use the joystick with both x and y axis to move the stylus ***halfway*** to the hole. Use wrenches to move the stylus the other half of the error.

5.8.13 Re-verify the stylus position with theta=0 and 180. Repeat step 5.8.12.1 until zero is correct.

5.8.14 Exit zero check, and enter the present z height.

5.9 Setting up and Calibrating the Ultrasonic Unit

5.9.1 Equipment Needed to Tune the U/S unit

A. U/S Wattmeter Tuning Module

B. Oscilloscope with differential input (Minimum bandwidth 100 Khz) with 10x probe.

5.9.2 Initial Settings

5.9.2.1 Set the AC power switch on the Wattmeter to “ON.”

5.9.2.2 Connect oscilloscope probe to test point H and test point K (ground) on U/S Wattmeter. (This is to test output of U/S Wattmeter.

5.9.2.3 Set oscilloscope vertical gain to 20mV/div (AC) and sweep rate to 10uS/div.

5.9.2.4 Place U/S Wattmeter switch marked with a sine wave figure and a square wave figure (Attachment 3, Item 5) towards the sine wave figure.

5.9.2.5 Place U/S Wattmeter switch marked IDLE-RUN-NULL (Attachment 3, Item 7) on position NULL.

5.9.2.6 Place U/S Wattmeter switch marked MAN-SWEEP-NULL (Attachment 3, Item 4) on position NULL.

5.9.2.7 Turn amplitude control on U/S Wattmeter (Attachment 3, Item 6) until a signal of 25 Khz and about 100mV p-p is observed on the oscilloscope screen. (Period of about 40 microseconds).

5.9.2.8 On U/S Generator, place “NULL/NORM” switch in “NULL” position (Attachment 2, Item 2).

5.9.2.9 Turn U/S Generator rotary switch to position 2 (Attachment 2, Item 3).

5.9.3 To Adjust Stylus DC Bias Current

5.9.3.1 Set the AC power switch to “ON” on the U/S Generator (Attachment 2, Item 1).

5.9.3.2 Place switch marked WATT-AMP-VOLT on U/S Wattmeter (Attachment 3, Item 8) on AMP position.

5.9.3.3 With a small screwdriver, adjust the potentiometer on the Power Supply labeled CURRENT ADJUST (Attachment 2, Item 15) until the current is 1.1 A +/- .1 A. (This value is read on the digital display on the U/S Wattmeter).

5.9.4 Bridge Calibration

5.9.4.1 Connect oscilloscope probe to test point “F” and test point “K” (ground) on the Wattmeter. Adjust coil “E” on the Generator (Attachment 2, Item 9) for minimum signal as displayed on oscilloscope. Always tune coil “E” through a minimum, until signal increases, then back off again to minimum. This is to ensure that a true minimum is found.

5.9.4.2 Adjust pot. B (Attachment 2, Item 7) to a minimum signal as displayed on the screen.

5.9.4.3 Adjust pot. E again to verify that a minimum has been achieved.

5.9.4.4 Turn the amplitude control on the U/S Wattmeter (Attachment 3, Item 6) to the “OFF” position.

5.9.5 Initial Gain Loop Adjustment

5.9.5.1 Connect oscilloscope probe to test point “B” and the ground lead to test point “K” on the Wattmeter.

5.9.5.2 Set oscilloscope vertical gain to 10V/div. And sweep rate to 10uS/div. Set the input for AC only.

5.9.5.3 Set U/S Generator rotary switch to position 2 (Attachment 2, Item 3).

5.9.5.4 Place “NULL/NORM” switch on Generator on “NORM” (Attachment 2, Item 2). A sine wave (5 to 20 volt p-p) may occur, if no signal, adjust pot 6.

5.9.5.5 Place switch marked WATT-AMP-VOLT on U/S Wattmeter (Attachment 3, Item 8) on position WATT.

5.9.5.6 Adjust “run” amplitude to 45 V p-p or 25 watts (maximum allowed) by turning pot. **C CCW.**

5.9.6 Idle Voltage Adjustment

5.9.6.1 Set U/S Generator rotary switch (Attachment 2, Item 3) to position 2.Adjust U/S Generator pot. C until “idle voltage” is 8 to 12 v p-p.

5.9.7 Loop Tuning

5.9.7.1 Check that the signal (the “run voltage”) on the oscilloscope is from 40V p-p to 45V p-p. If the signal is too large, adjust pot. D.

5.9.7.2 Check that the signal has a frequency of 25Khz. Tune coil G (Attachment 2, Item 10) until this frequency is obtained.

5.9.7.3 Adjust coil “G” to tune the signal. When the loop is correctly tuned, the waveform will “snap” to the proper frequency, and a “knee” will be apparent on the left side of the positive part of the waveform. (This snapping action is most apparent when tuning from a lower frequency to a higher.)

5.9.8 Final Tuning

5.9.8.1 Verify that the oscilloscope is connected to points K (ground) and B (signal).

5.9.8.2 Set the rotary switch on U/S generator to position 2.

5.9.8.3 Check that the switch marked WATT-AMP-VOLT (Attachment 3, Item 8) on U/S Wattmeter is in position WATT.

5.9.8.4 Carefully adjust coil G while observing the digital display on U/S wattmeter. Coil G should be adjusted through a maximum, or peak wattage, and then back to maximum. Coil G will now be correctly tuned for maximum efficiency. While tuning coil G, care must be taken not to exceed the maximum values of 25 watts or 45 volts p-p. (Best settings are: 40V p-p, 23 watts, 1.1 A).

5.9.8.5 If optimum readings cannot be obtained, repeat the tuning procedures beginning from step 5.9.4.

5.9.8.6 Make final adjustment of power output by adjusting pot for consistently good wire bonding while wiring. Do not exceed 25 Watts output.

The only official copy of this file is the one on-line on the Superconducting Magnet Division website. Before using a printed copy, verify that this is the most current version by checking the document issue date on the website.

6.0 Documentation

6.1 Log Book

6.2 Interlock Test Form

7.0 References

7.1 SBMS Subject Area: Lockout/Tagout (LOTO)

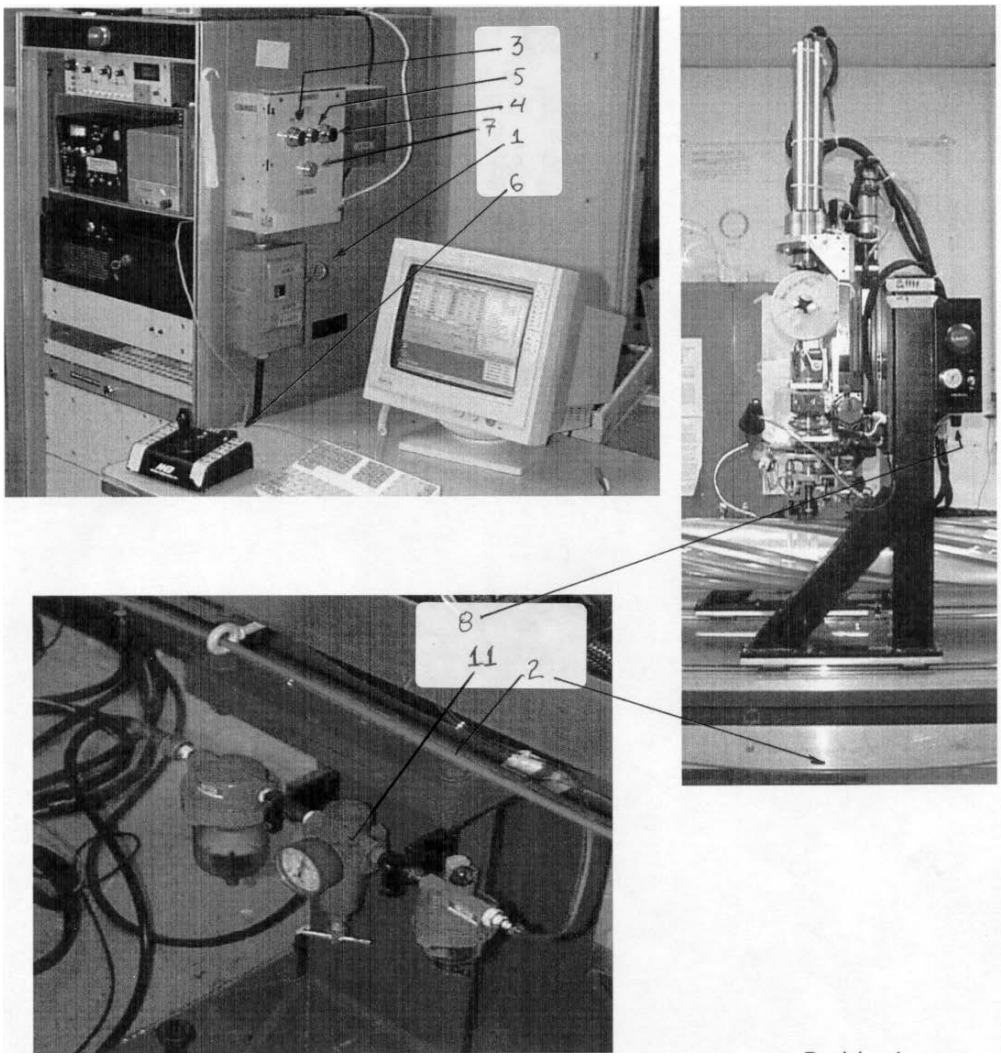
8.0 Attachments

1. Wiring Machine Diagram
2. Ultrasonic Generator and Power Supply
3. Wattmeter
4. Interlock Test Form

The only official copy of this file is the one on-line on the Superconducting Magnet Division website. Before using a printed copy, verify that this is the most current version by checking the document issue date on the website.

Attachment 1

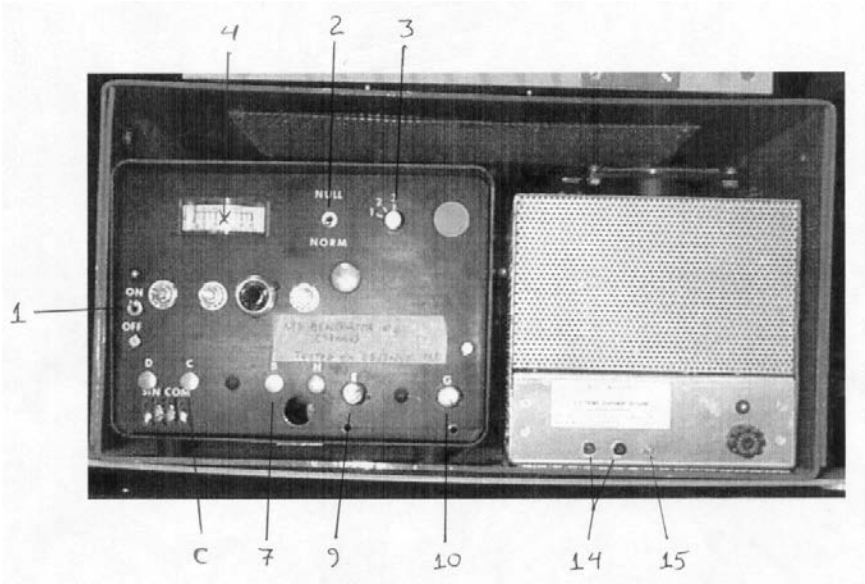
Wiring Machine Diagram



The only official copy of this file is the one on-line on the Superconducting Magnet Division website. Before using a printed copy, verify that this is the most current version by checking the document issue date on the website.

Attachment 2

Ultrasonic Generator and Power Supply



The only official copy of this file is the one on-line on the Superconducting Magnet Division website. Before using a printed copy, verify that this is the most current version by checking the document issue date on the website.

Attachment 3

Wattmeter

The only official copy of this file is the one on-line on the Superconducting Magnet Division website. Before using a printed copy, verify that this is the most current version by checking the document issue date on the website.

Attachment 4

Interlock Test Form

Check if passed

Rack Crash Button	2 Table Crash Buttons	2 Head Crash Buttons	2X Axis Range of Motion End Crash Switches	Table Crash Cord	Operator	Date