OPERATIONS MANUAL
FOR THE AUTOMATIC OPERATION
OF THE VERTICAL WORKSTATION

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AMRF

National Institute of Standards and Technology
formerly

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DISCLAIMER

Certain commercial equipment, instruments, or materials are identified in this paper in order to specify adequately the operating procedures. Such identification does not imply recommendation or endorsement by the National Institute of Standards & Technology nor does it imply that the materials or equipment are necessarily the best available for the purpose.

CONTENTS

I. INTRODUCTION TO THIS MANUAL

The Vertical Workstation is located in the Automated Manufacturing
Research Facility at the National Institute of Standards and Technology.
This manual is for those individuals who wish to use the Vertical
Workstation (VWS) equipment and control it from the workstation
controller. Anyone possessing the ability to flip a switch, press a
button, turn a valve, and operate a personal computer can follow these
steps and place the VWS under command of the workstation controller.

The purpose of presenting only the steps required to configure the VWS for
automatic operation is that there are potential users who do not care
about the hardware details. These details are contained in the VWS
Operator's Manual.

With one exception, you cannot damage any equipment by following these
steps. The one exception is moving the robot to the "SAFE" location if it
is not already near to the SAFE location. It is always possible to move
the robot safely with a vertical translation AWAY from fixtures, trays,
etc. However, lateral movements of the robot may cause the robot to
strike fixtures, trays, etc. If you have doubts, contact a member of the
VWS staff at extension 6533.

This document is for "hands-on" operation of the VWS equipment. Figure 1
is a layout of the equipment locations at the VWS. After a few minutes of
following these steps on site at the VWS, the user will realize that all
steps can be accomplished in 3 to 5 minutes. The first section describes
the "cold start" configuration of the VWS and the equipment state when use
is not expected for several hours. The next two sections describe,
respectively, the step-by-step instructions to start up the VWS for
automated manufacturing and to shut down the VWS upon completion of
automated manufacturing. The shut down procedure places the VWS in the
"cold start" configuration. The final section presents the step-by-step
instructions for reinitializing the VWS if a communication failure between
the workstation controller and the equipment controller occurs. Four
appendices are included that describe procedures for configuring the
workstation to the "cold start" condition following power outages or other
disabling conditions that might occur.

Please note that, if you cut metal at the VWS, you are responsible for
cleaning up the equipment. We have a VERY POWERFUL VACUUM CLEANER for
this purpose. It is the big green machine to the right of the Monarch
machining center (see Fig. 1). Push the START button to turn it on and
the STOP button to turn it off.

Remember, safety glasses are required on the floor of the AMRF and NEVER
enter the work volume if the robot arm power is on.

VERTICAL
WORKSTATION

Work Bench

Transformer

Fixture
Hydraulics

Hydraulics

Vacuum
Cleaner

VMC-75

Changing
Stations

Controller

ROBOT

Fixture
Computer

Roller
Tables

Computer

VWS
Electronics Rack

Robot
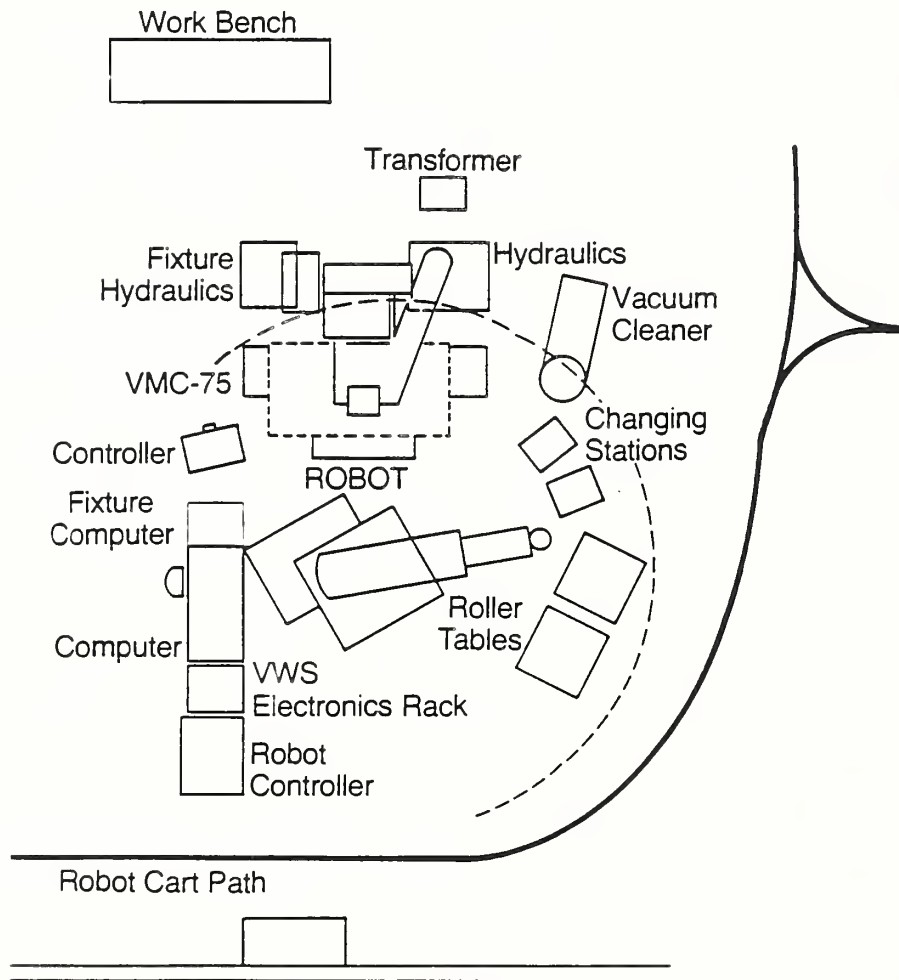Controller

Robot Cart Path

Figure 1   Equipment Layout of the Vertical Workstation of the AMRF

II. COLD START CONFIGURATION

The following steps assume that the VWS is in a "cold start" configuration. You may determine this status by observing the following four conditions:

1. Robot & Robot Console

   Robot arm power is off. This condition is true if the red warning light is off and the robot is not making any noise.

   The red stop button on the console is up and the green power light is on.

2. Equipment Controller and Hydraulics Controller

   The monitor screens of the HP9000 and the HP9836 computers are blank.

3. Power Supplies and Instrumentation

   No lights are lit on the equipment rack located between the HP9000 and the robot console.

4. Monarch VMC-75

   The green "on" button at the lower right hand side of the controller console is on and the flashing message CONTROL EMERGENCY STOP appears when the MSG key is pressed.

If the above conditions are not evident refer to the appendices for directions to configure the VWS to the "cold start" conditions. The contents of the appendices are as follows: A) Rebooting the Robot, B) Rebooting the VMC, C) Manual Operations of Robot, and D) Subsystem Testing.

III. START UP SEQUENCE

Purpose: To Configure VWS for Automatic Operation

STEP 1 of 12: INITIALIZE MATERIAL HANDLING SYSTEM (MHS) TRAYS

Location - controller under Tray #2.

a) Flip the power switch up (the light goes on).

b) Flip the REMOTE switch to the "remote" position.

c) Flip the two solenoid switches to "auto" position.

STEP 2 of 12: PRESSURIZE GRIPPER PNEUMATIC SYSTEM

Location - rear of robot base.

a) Turn the yellow valve handle 90° counterclockwise so that it is in line with the red pigtail air hose.

STEP 3 of 12: POWER ON THE HP9000 EXTERNAL MEMORY

Location - to the left of the HP9000 when viewed from the rear of the robot.

a) Flip the A/C POWER switch to the ON position.

STEP 4 of 12: POWER ON THE PRINTER FOR THE HP9836

Location - on top of the HP9836 to the right of the HP9000 when viewed from the rear of the robot.

a) Flip LINE (Power) switch to ON position.

STEP 5 of 12: INITIALIZE UNIMATE 4070 ROBOT

Location - robot control console.

a) Open the doors in the console cabinet.

b) Push the white switch located on the fifth card from left on the card rack; close and latch the doors again.

c) Type N and press return key in response to each of the two queries to load VAL II and to initialize memory.

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III. START UP SEQUENCE

   Purpose: To Configure VWS for Automatic Operation

         d)   Turn the MODE switch to HOLD.

         e)   Turn the ARM POWER switch to ON.

         f)   Turn the MODE switch to RUN.

         g)   Type DO MOVE SAFE and press the return key. The robot
              will then move. SEE WARNING BELOW.

         h)   Type EN NETWORK, SUPERVISOR and press return key.

THE UNIMATE 4070 IS NOW CONFIGURED TO OPERATE VIA EXTERNAL COMMAND. THE
KEYBOARD IS LOCKED OUT.

_____

WARNING: Before issuing this command, make certain that the robot is
           approximately at the "SAFE" position. If you have doubts, call
           a member of the VWS staff at extension 6533. See Appendix C,
           Figure C-1.

_____

STEP 6 of 12:   TURN ON POWER SUPPLIES, DIGITAL VOLTMETER, AND DATA
                ACQUISITION UNITS

         Location - equipment rack to right of HP9000 computer.

         Note: The sequence (a) through (e) below is not important;
         however, all steps must be completed.

         a)   Flip the switch on the hydraulics power supply (on top
              of the equipment rack).

         b)   Flip three switches labeled PWR-1, PWR-2, and LW/PWR
              (these are power supplies for pneumatic solenoids,
              proximity sensors, and load washers).

         c)   Press and release the LINE power button of the HP3455A
              Digital Voltmeter.

III.   START UP SEQUENCE

   Purpose: To Configure VWS for Automatic Operation

        d)   Press and release the LINE power button of <u>both</u>
             HP3497A Data Acquisition and Control Units.

        e)   Flip the LINE (power) switch on the HP6002A DC Power
             Supply (located to the left of the equipment rack on
             top of the HP9000 external memory).

NOTE: All toggle switches are ON in the up position and OFF in
   the down position. Indicator lamps are lit when the units are on.

STEP 7 of 12: LOAD HP9000 CONTROL PROGRAM
               (This is the Equipment Controller for the VWS.)

        a)   Turn on the HP9000 computer (the red switch is located
             on the right hand side between the monitor and the
             computer).

        b)   Wait until the message Basic Ready For Use appears.

        c)   Type LOAD "VWS_CONTROL:CS80,7,0" and press the EXECUTE
             key. (quotation marks are required)

STEP 8 of 12: LOAD HP9836 CONTROL PROGRAM
               (This is the controller for the hydraulics system for
               clamps located on the Monarch Table).

        a)   Obtain the System Floppy Disks from the bottom desk
             drawer under the HP9836. The Disks are labeled:

             VWS HYD CONTRLR 1/2
             VWS HYD CONTRLR 2/2

        b)   Place Disk VWS HYD CONTRLR 1/2 in the right hand disk
             drive of the HP9836 and close the drive door.

        c)   Turn on the HP9836 Computer by Pressing the switch
             located below the numeric keypad on front of the
             computer base. Wait until the message Basic Ready
             2.0 appears.

III. START UP SEQUENCE

Purpose: To Configure VWS for Automatic Operation

d)   Remove Disk VWS HYD CONTRLR 1/2 from the right hand disk drive and return it to its envelope.

e)   Place Disk VWS HYD CONTRLR 2/2 in the right hand disk drive and close the drive door.

f)   Type LOAD BIN "AP2_1" (quotation marks are required) and press the EXECUTE key. Wait until a soft-key label block appears on the monitor screen and the message BASIC Ext. AP2.1 appears.

g)   Type LOAD "PALL_CLAMP" (quotation marks are required) and press execute key.

h)   Leave disk VWS HYD CONTRLR 2/2 in the right hand disk drive.

STEP 9 of 12:   INITIALIZE MONARCH VMC-75

Location - Monarch control console on a stand to the left of the VMC-75.

a)   Check that the green ON button is lit.

b)   Press MSG key below screen (message 6201 should be active; CONTROL EMERGENCY STOP is flashing).

c)   Follow the instructions displayed under Message 6201.

1)   Release the emergency stop button by twisting it clockwise. This is a big red button to the lower left of the monitor screen.

2)   Press and release the green ON button. Message 6201 should be automatically cleared from screen. Ignore any other messages.

d)   Press the MDI button to the left of the monitor screen.

e)   Type X0.5Y19.5

f)   Press the CYCLE START BUTTON located to the left of the "Emergency Stop" Button. The Monarch Table will move to its "Park Position" - be certain that no personnel are near the table.

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III. START UP SEQUENCE

Purpose: To Configure VWS for Automatic Operation

g) Press the POSN key below the monitor screen. The
following readings should be observed:

X + 0.5000
Y + 19.5000
Z + 0.0000

h) Press the TERM key located below the monitor screen.

i) Press and hold the CTRL key on the left of the space
bar on the keyboard.

j) Key in the letters ADC (a space and return is not
required). The message DNC STATUS: DIALOG and a
flashing cursor should appear on screen.

k) Press the POSN key to display:

X + 0.5000
Y + 19.5000
Z + 0.0000

l) Press the AUTO button located to the left of the
monitor screen (this button may not light up as it
seems to burn out bulbs very quickly).

THE MONARCH VMC-75 IS NOW CONFIGURED TO COMMUNICATE WITH THE VWS EQUIPMENT
CONTROLLER.

STEP 10 of 12: PRESSURIZE HYDRAULIC SYSTEM FOR PALLET CLAMPS

Location - the hydraulic power unit behind the Monarch
console to the left of VMC-75.

a) On the aluminum switch-box flip all 12 toggle switches
up to COMP position. (This setting places the
hydraulic solenoids under control of the HP9836
computer.)

b) Turn the four-lobe handle on top of the power unit
clockwise until it stops turning. (This closes the
return drain line to the hydraulic reservoir.)

c) Press and release the power-on switch for the pump

III. START UP SEQUENCE

   Purpose: To Configure VWS for Automatic Operation

               motor on left hand side of the power unit.

          d)   The Hydraulic system will pressurize to 2600 lb/in^2 as
               indicated on the pressure gage.

STEP 11 of 12: EXECUTE VWS_CONTROL PROGRAM

          Location - HP9000 Keyboard.

          a)   Press the RUN key located on the upper left center of
               keyboard.

          b)   WAIT for the screen to fill up with a display
               indicating the VWS status. This takes approximately 30
               seconds.

STEP 12 of 12: EXECUTE PALL_CLAMP PROGRAM

          Location - HP9836 Keyboard.

          a)   Press the RUN key located between the keyboard and the
               numeric pad.

          b)   A "?" will appear on the screen. Type N and press the
               ENTER key.

The status of the hydraulics controller will be printed out on the HP9836
printer and the first four lamps will light across the switch box located
on the end of the hydraulic power unit.

 THE VWS IS NOW READY FOR AUTOMATED MANUFACTURING

IV. SHUT DOWN SEQUENCE

     Purpose: To configure the VWS to the "Cold Start Condition"
                  following automatic operation.

STEP 1 of 10: STOP EXECUTION OF HYDRAULICS CONTROLLER

         location - keyboard of the HP9836 computer.

         a)   Press and hold down the SHIFT key.

         b)   Press the CLR/IO key (above the numeric pad).

         c)   Release the SHIFT key.

         d)   Press the CLR/IO key.

STEP 2 of 10: STOP EXECUTION OF EQUIPMENT CONTROLLER

         location - keyboard of the HP9000 computer.

         a)   Press and hold down the SHIFT key.

         b)   Press the STOP key (upper left center of the
              keyboard). Release the SHIFT and STOP keys.

         c)   Press the SCRATCH key (upper left of the numeric pad).

         d)   Type A.

         e)   Press the EXECUTE key (between the keyboard & the
              numeric pad).

STEP 3 of 10: POWER DOWN HP9836 & PRINTER

         location - HP9836 Terminal.

         a)   Switch off the power to the printer. The switch is
              located on the upper right hand side of the rear of
              the printer when facing the front of the printer.

         b)   Remove the disk from the right hand drive unit of the
              HP9836 and return it to envelope in the bottom left
              hand drawer of the desk.

         c)   Switch off the power to the HP9836. The switch is on
              the front of terminal below the numeric pad.

IV. SHUT DOWN SEQUENCE

Purpose: To configure the VWS to the "Cold Start Condition"
following automatic operation.

STEP 4 of 10: POWER DOWN HP9000 & EXTERNAL MEMORY

Location - HP9000 Terminal.

a) Switch off power to the terminal. Switch is on the
right hand side between the monitor and the keyboard.

b) Switch off power to the external memory. The Switch is
on lower left hand side on the rear of the external
memory next to the HP9000 Terminal.

STEP 5 of 10: POWER DOWN MONARCH VMC-75

Location - Monarch Control Console.

a) Press in the Red Control Emergency Stop button
(located to the left of the keyboard).

STEP 6 of 10: DEPRESSURIZE HYDRAULIC SYSTEM

Location - Hydraulic Power Unit behind Monarch Control
Console to left of VMC-75.

a) Press the red stop button on the power switch on the
left hand side of the unit.

b) Turn the four-lobe valve counterclockwise until the
system is depressurized (watch the pressure gage).

STEP 7 of 10: POWER DOWN POWER SUPPLIES, DIGITAL VOLTMETER, AND DATA
ACQUISITION AND CONTROL UNITS

Location - Electronics rack between HP9000 and robot
control console.

a) Flip toggle switches down on the following:

1) HP6002A DC Power Supply

2) Hydraulic Power Supply

3) PWR-1, PWR-2, and LW/PWR

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IV.   SHUT DOWN SEQUENCE

    Purpose: To configure the VWS to the "Cold Start Condition"
               following automatic operation.

        b)   Press and release the power switches on the HP3455A
              Digital Voltmeter and the two HP3497A Data Acquisition
              & Control Units.

STEP 8 of 10:   POWER DOWN UNIMATE 4070 ROBOT

    Location - robot control console.

    a)   Turn the mode switch to HOLD.

    b)   Turn the ARM POWER SWITCH to OFF.

STEP 9 of 10:   DEPRESSURIZE GRIPPER PNEUMATIC SYSTEM

    Location - rear of robot base.

    a)   Turn the yellow handle on the airline (red pigtail
          hose) 90° clockwise.

STEP 10 of 10: CLEAN UP YOUR MESS

If you have machined something, then YOU are responsible for cleaning up
your mess. The vacuum cleaner is conveniently located for this purpose.
However, it is preferable that you allow cooling fluid to drain back into
the VMC-75 reservoir before using the vacuum cleaner. To speed up the
draining process, you may brush chips and coolant into the chip removal
trough along the front of the VMC-75 table.

V. REINITIALIZATION SEQUENCE

Purpose: To reinitialize the VWS for automatic operation following a communication between the Equipment Controller and the Workstation Controller.

STEP 1 of 6:   STOP EXECUTION OF HYDRAULICS CONTROLLER

Location - keyboard of HP9836 computer.

a)   Press and hold down the SHIFT key.

b)   Press the CLR/IO key (above the numeric pad).

c)   Release the SHIFT key.

d)   Press the CLR/IO key.

STEP 2 of 6:   STOP EXECUTION OF EQUIPMENT CONTROLLER

Location - keyboard of HP9000 computer.

a)   Press and hold down the SHIFT key.

b)   Press the STOP key (upper left center of the keyboard). Release the SHIFT and STOP keys.

c)   Press the SCRATCH key (upper left of the numeric pad).

d)   Type A.

e)   Press the EXECUTE key (between the keyboard & the numeric pad).

STEP 3 of 6:   Load HP9000 Control Program

Location - keyboard of HP9000 computer.

a)   Type LOAD "VWS_CONTROL:CS80,7,0" and press EXECUTE key. (quotation marks are required)

STEP 4 of 6:   REINITIALIZE UNIMATE 4070 ROBOT

Location - robot control console.

a)   Open the doors in the console cabinet.

b)   Push the white switch located on the fifth card from

V.   REINITIALIZATION SEQUENCE

Purpose: To reinitialize the VWS for automatic operation following a
communication between the Equipment Controller and the
Workstation Controller.

left on the card rack.

c)   Close and latch the doors.

d)   Type N and press the return key in response to queries
to load VAL II and to initialize robot memory.

e)   If the robot is <u>not</u> at its SAFE position, return the
robot to the SAFE position.

WARNING: If you do not have a 4070 jockey license, do not
do this - call a member of the VWS staff at
extension 6533, or read Appendix C.

f)   Type EN NETWORK, SUPERVISOR and press the return key.

STEP 5 of 6:   EXECUTE EQUIPMENT CONTROLLER PROGRAM

Location - keyboard of HP9000.

a)   Press the RUN key (location - upper left center of the
keyboard). Wait approximately 30 seconds for the VWS-
CONTROL program to initialize the workstation and
report the VWS status.

STEP 6 of 6:   EXECUTE HYDRAULIC CONTROLLER PROGRAM

Location - keyboard of HP9836.

a)   Press the RUN key (location - between keyboard and
numeric pad).

b)   A ? will appear on the monitor screen. Key in N and
press the ENTER key

THE VWS HAS NOW BEEN REINITIALIZED FOR AUTOMATIC OPERATION.

APPENDIX A.   REBOOTING UNIMATE 4070 CONTROLLER

Occasionally, it will be necessary to reboot the Unimate 4070 controller.
The reason for this may be a sudden power surge or power failure, or it
may happen that the control emergency stop button (big red button on
console) has been pressed. All steps are performed at the robot control
console.

STEP 1 of 3:   POWER ON THE 4070 ROBOT

        a)   Press in and pull out the control emergency stop
            button.

        b)   Press in the green power button located on the upper
            left corner of the console.

STEP 2 of 3:   LOAD OPERATING SYSTEM (VAL II)

        a)   Open the cabinet doors.

        b)   Reach an arm in behind the disk drive and toggle the
            two switches down and then up.

        c)   Locate the floppy disk identified as:

            VAL II.4k6
            NBS ver 2.0A
            10/15/85

            in the disk storage file in bottom of the cabinet.

        d)   Place the disk in the disk drive and close the latch.

        e)   In response to the query "LOAD VAL II FROM FLOPPY
            (Y/N)?" type Y and press the return key; Uppercase is
            not required. Type 3952 in response to the subsequent
            query for the serial number.

        f)   In approximately 2 to 3 minutes, VAL II will be loaded
            and the query "INITIALIZE SYSTEM (Y/N)? will appear.

        g)   Remove the disk from disk drive and return it to the
            envelope in the file box before performing the next
            step.

        h)   Type Y and press the return key to obtain the query
            ARE YOU SURE (Y/N)? Type Y again and press the return
            key; Uppercase is not required. The result is a small
            period with a flashing underline cursor on the screen.

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VAL II has now been loaded; however, there are <u>no</u> work volume locations in the robot memory.

STEP 3 of 3:   LOAD WORK VOLUME POINTS

a)   Locate the disk identified as DENVER'S DEMO DISK in the disk storage file in bottom of cabinet.

b)   Place the disk in the disk drive and close the latch.

c)   Type in FLIST (for <u>F</u>ile <u>LIST</u> - upper case characters are not required) and press return. This displays the files on the disk. These files comprise utility programs and TAUGHT points or work volume locations.

d)   Type in LOAD CDL030387.V2 and press return. This loads the latest set of utility programs and work volume locations (as of this report date). Once again, upper case characters are not required.

e)   If you desire to list the work volume locations, type in LLIST and press return. The locations are listed on the screen.

f)   Remove the disk from the disk drive and return it to its envelope in the disk storage file.

g)   Close and latch the cabinet doors.

WARNING: IF THE ROBOT CART IS OPERATING, BE CERTAIN THAT THE CABINET DOORS ARE POSITIONED SO THAT THE CART CANNOT STRIKE THE DOORS WHEN THEY ARE OPEN.

THE UNIMATE 4070 CONTROLLER IS NOW REBOOTED AND THE WORK VOLUME POINTS HAVE BEEN RESTORED IN MEMORY.

APPENDIX B.   REBOOTING THE MONARCH VMC-75

If the monitor screen on the Monarch Control Console is blank and the red
OFF button is lit, it will be necessary to reboot the VMC-75. A power
surge or power failure is the cause. Never press the OFF button.

STEP 1 of 5:   TURN OFF MONARCH POWER AND RESET THE CONTROLLER

    a)   Walk to the rear of the VMC-75 and locate the master
       power switch (black knob) on upper left-hand side of
       the cabinet doors.

    b)   Turn the knob counterclockwise until you hear a loud
       click and the transformer "hum" stops.

    c)   Open the cabinet doors and locate the CONTROL RESET
       button in the lower left of the electronics rack.

    d)   Press the CONTROL RESET button.

    e)   Close and latch the cabinet doors.

STEP 2 of 5:   TURN ON MONARCH POWER

    a)   After the cabinet doors have been latched, turn the
       master power switch (black knob) clockwise until you
       hear a loud click and the transformer hum is audible.

    b)   Return to the Monarch Control Console and press the
       green POWER ON button. The button will light and the
       Monarch will begin its power-up diagnostics and
       rebooting. This takes approximately 2 to 3 minutes.

STEP 3 of 5:   REFERENCE AXES ENCODERS

    a)   Press the FREE SPINDLE button.

    b)   Walk to the front of the Monarch and turn the large
       black hand-wheel at the right of the spindle to lower
       the spindle approximately 5 cm from its initial
       position.

    c)   Press the FREE SPINDLE button.

    d)   Twist the Control Emergency Stop button clockwise and
       press the green ON button.

    e)   Press the REF ZERO button.

f)   Press the MSG button.

g)   The message UNREFERENCED X, Y, Z, W AXES appears on the message page.

h)   Press either the X LEFT or X RIGHT button and the Monarch Table will begin to slowly move. When the encoder reference is detected, the message status will be updated to indicate which of the axes remain unreferenced. (See Note below.)

i)   Proceed as in step g above, individually, for the Y, Z, and W axes. If an encoder reference is not detected, simply push the button for the axis again. You may press any of the buttons individually (i.e., Y IN or Y OUT, Z UP or Z DOWN, W UP or W DOWN).

j)   When the message page indicates that all axes are referenced (i.e., there is no message on screen), you may proceed to the next step.

Note: If you think the tool in the spindle will strike a fixture, press W UP or W DOWN first and then reference X, Y, and Z.

STEP 4 of 5:   RESET USER PRIVILEGE LEVEL

In order to select, delete, load, and edit part programs, it is necessary to reset the USER PRIVILEGE LEVEL.

a)   Press the TERM key (below the monitor screen).

b)   Press the Page < key to select the COMMAND PAGE.

c)   Press the ↓ key to select the Change Privilege option.

d)   Press the SELECT key.

e)   In response to the query ENTER NEW PRIVILEGE LEVEL: type 2 and press the RETURN key.

f)   In response to the query ENTER NEW PASSWORD type in USER and press the RETURN key. Note: The password will not appear on the screen.

g)   Press the RETURN key.

APPENDIX B.   REBOOTING THE MONARCH VMC-75

          h)   Press the Page > key.

THE USER PRIVILEGE LEVEL HAS NOW BEEN RESET.

STEP 5 of 5:   POSITION MONARCH TABLE IN THE PARK POSITION

          The robot may safely load and unload parts from the Monarch
          only if the table is in the PARK POSITION. This position
          is X = 0.5000 inch and Y = 19.5000 inches.

          a)   Press the MDI button.

          b)   Key in the sequence X0.5 Y19.5

Note: The Monarch Table will move rapidly upon pressing the CYCLE START
button. Make certain that all personnel are clear of the table before
pressing the CYCLE START button.

          c)   Press the CYCLE START button.

          d)   Press in the Control Emergency Stop Button if
               immediate use of VMC-75 is not anticipated.

THE MONARCH VMC-75 HAS NOW BEEN REBOOTED TO THE VWS "COLD START"
CONFIGURATION.

APPENDIX C.   MANUAL OPERATION OF ROBOT

C.1 PURPOSE

The purpose of this appendix is to provide the VWS user with a method to maneuver the Unimate 4070 robot under manual control. This procedure would be required only if VWS operation is suspended and the robot is <u>not</u> at the "SAFE" location. The objective is to return the robot to the "SAFE" location (without striking another object) and then restart the VWS.

THE MANEUVERING OF THE ROBOT IS THE ONLY OPERATIONAL PROCEDURE IN THIS MANUAL THAT CAN RESULT IN PHYSICAL DAMAGE TO VWS EQUIPMENT.

C.2 THE "SAFE" LOCATION AND WORK VOLUME POINTS

Figure C-1 is a sketch of the VWS equipment layout illustrating the location of the robot relative to other physical objects and the robot locations utilized for automated manufacturing.

The robot SAFE location is indicated in Figure C-1. When the robot is in the safe location, the arm is aligned with the robot base and elevated approximately 15° from the horizontal. The gripper is in the vertical direction. <u>The SAFE location is the only robot position for which movement can be safely accomplished from any other location</u>. The other locations and the SAFE location also allow for safe movement of the robot when the fingers are in position on the gripper.

The work volume locations are also illustrated in Figure C-1. These locations are denoted as WV1, WV2, etc. The robot may safely move, for example, between tray #2 and the VISE with the movement sequence SAFE, WV7, SAFE, WV1, SAFE. Details of these movements are automatically generated by the process planning system. For example, to pick up a block in tray #2 the robot would be commanded to move from SAFE to WV7, <u>translate down with the gripper open to the tray surface</u>, close the gripper, <u>translate up to WV7</u>, and move to SAFE.

The Unimate 4070 robot drives all joints simultaneously so that the end of arm tooling (i.e., gripper) moves in a "straight line" from the initial location to the commanded location. <u>All pick and place locations for the VWS are at a location below the work volume points</u>. If the robot is commanded to move, for example, between the gripping location on the vise and any work volume point other than WV1, it will most likely strike an object with resulting physical damage. For this reason, all movements between work volume points begin and end at SAFE and all movements between work volume points and pick and place locations are vertical translations.

APPENDIX C.   MANUAL OPERATION OF ROBOT

C.3   THE ROBOT TEACH PENDANT

Figure C-2 is an illustration of the robot teach pendant. The teach
pendant has many uses. The procedure described in this appendix is one
use of the teach pendant restricted solely to placing the robot in a
location "close" to the SAFE location. The term "close" means that the
robot can move safely to the SAFE location from the "close" location.
You, as the VWS operator, place the robot in the "close" location using
the teach pendant.

NEVER ARBITRARILY PUSH BUTTONS ON THE TEACH PENDANT. USE ONLY THE STEPS
DESCRIBED IN THIS APPENDIX. IF YOU THIRST FOR KNOWLEDGE AND WANT TO KNOW
MORE, READ THE UNIMATION MANUALS.

C.4   THE ROBOT JOINT MOVEMENTS

The Unimate 4070 robot may be maneuvered in several different modes using
the teach pendant. The maneuvering procedure described here uses JOINT
MOVEMEMT.

The Unimate 4070 robot utilizes six (6) joint movements to position the
End of Arm (EOA) tooling (i.e., the gripper). These joint motions are
illustrated in Figure C-3. Each joint movement may be in either the
positive (+) or negative (-) direction.

However, as the VWS operator, you are concerned with the end of arm
movement resulting from a joint movement. The end of arm movement for
each joint movement is also illustrated in Figure C-3.

C.5   MANEUVERING THE ROBOT

To configure the Unimate 4070 robot for joint motion using the teach
pendant, use the following steps. (It is assumed that the robot has been
haulted under control of the workstation controller and that the robot is
NOT at the SAFE location.)

STEP 1 of 6:   INITIALIZE THE ROBOT CONTROLLER

                Location - Robot Console.

        a)   On the robot console, place the mode switch in the
              HOLD position.

        b)   Open the console cabinet doors. (Watch for the robot
              cart - do not let the cart strike an open door.)

c)   Push the white switch located on the fifth card from
      the left on the card rack and close and latch the
      cabinet.

d)   Two queries will be displayed on the console monitor
      in sequence. The first query is to load VAL II from
      the floppy disk. Type N and press RETURN. The second
      query is to initialize memory. Type N and press
      RETURN. Uppercase is not required.

e)   On the robot console, place the mode switch in the
      TEACH position.

STEP 2 of 6:   SELECT JOINT MODE ON TEACH PENDANT

a)   Pick up the teach pendant and walk around the <u>outside</u>
      of the work volume (red area on floor) carefully
      placing the teach pendant cable. Place yourself so
      that you can clearly observe the robot gripper.

b)   The small light (#14 in Figure C-2) next to the TEACH
      on the pendant should be on.

c)   Press the button marked JOINT (#11 in Figure C-2).

THE UNIMATE 4070 ROBOT IS NOW CONTROLLED BY THE TEACH PENDANT. EACH JOINT
MAY NOW BE ACTIVATED INDIVIDUALLY TO MANEUVER THE ROBOT.

STEP 3 of 6:   MANEUVER THE ROBOT

The six buttons arranged down the handle of the teach
pendant activate the individual joints as illustrated in
Figure C-2.

Since it is impossible to anticipate the robot location,
the VWS operator must judge the sequence of joint motions
required to maneuver the robot "close" to the SAFE
location.

Most likely, however, the first movement will be to move
the end of arm up and away from a location. In Figure C-3,
this end of arm movement may be realized by moving Joint 2
in the positive direction. By pressing the button marked
2+ and holding the button depressed, Joint 2 will rotate in
the positive direction and the end of arm motion will be an
arch in the vertical direction. Releasing the button will

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stop the motion.

When the arm is elevated approximately 15° from the horizontal, you may stop the motion.

Check to see that the robot will not strike any object if Joint 1 is activated (see Figure C-3).

Press and hold the button marked 1+ or 1- to rotate the end of arm toward the SAFE location.

When the robot is "close" to the SAFE location, stop the motion by releasing the button.

STEP 4 of 6:   MOVING TO "SAFE"

When the Unimate 4070 robot is "close" to the SAFE location, the arm will be elevated in a vertical plane approximately 15° from the horizontal. This vertical plane bisects the arc centered at the robot base between the end of the Monarch Table and Finger Station #1.

a)   Return the teach pendant to its storage position making certain that the cable is placed off and away from any VWS components and does not represent a tripping hazard.

b)   Go to the robot console and turn the mode switch to the RUN position.

c)   Type in the instruction: SPEED 5 and press the RETURN key. (Uppercase is not required.)

d)   Type in the instruction: DO MOVE SAFE (Uppercase is not required.)

e)   Place one hand on the mode switch in anticipation of quickly switching from RUN to HOLD.

f)   Press the RETURN key.

g)   The robot will now move slowly from the "close" location to the SAFE location. IF IT APPEARS THAT THE ROBOT WILL STRIKE AN OBJECT, QUICKLY TWIST THE MODE SWITCH TO HOLD.

       If you place the robot in HOLD, type in the instruction ABORT and press the RETURN key. Go to

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APPENDIX C.   MANUAL OPERATION OF ROBOT

                STEP 1 and repeat the process.

STEP 5 of 6:   PREPARE ROBOT FOR EXTERNAL CONTROL

        a)   After the robot has reached the SAFE location, the
                monitor screen will display a period with a flashing
                underline cursor. Type in the instruction SPEED 20
                and press the RETURN key.

        b)   Type EN NETWORK, SUPERVISOR and press the RETURN key.
                The robot keyboard is now locked out.

        c)   You have now configured the Unimate 4070 robot for
                external control.

STEP 6 of 6:   INITIALIZE THE VWS CONTROLLERS

                It has been assumed that the VWS was operating under
                external control and something caused the process plan to
                be halted with the robot away from the safe location. The
                above procedure places the robot at the SAFE location and
                initializes the robot controller for command by an external
                or "supervisor" computer.

                It is now necessary to initialize the hydraulics controller
                and the equipment controller so that the VWS can
                reestablish communication with the workstation controller.
                Go to the main text of this report and follow the steps
                described under the heading REINITIALIZATION SEQUENCE.
                However, you may omit Step 4 of that sequence since the
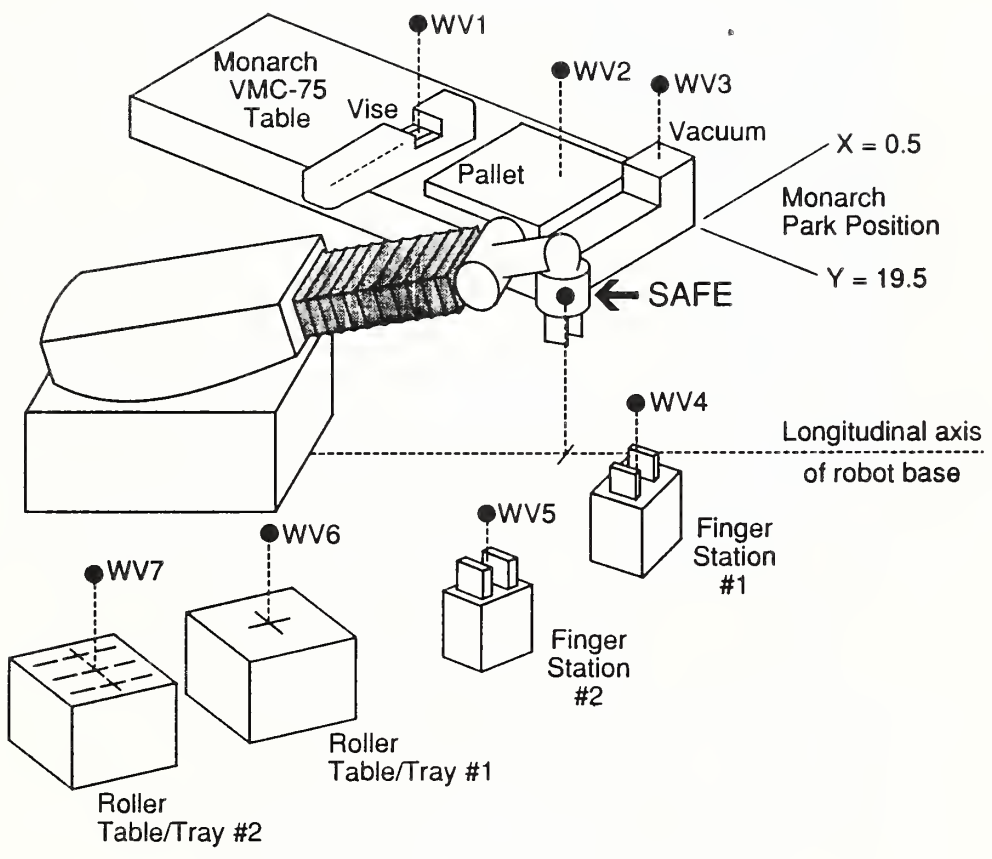   robot has been reinitialized in Step 5, above.

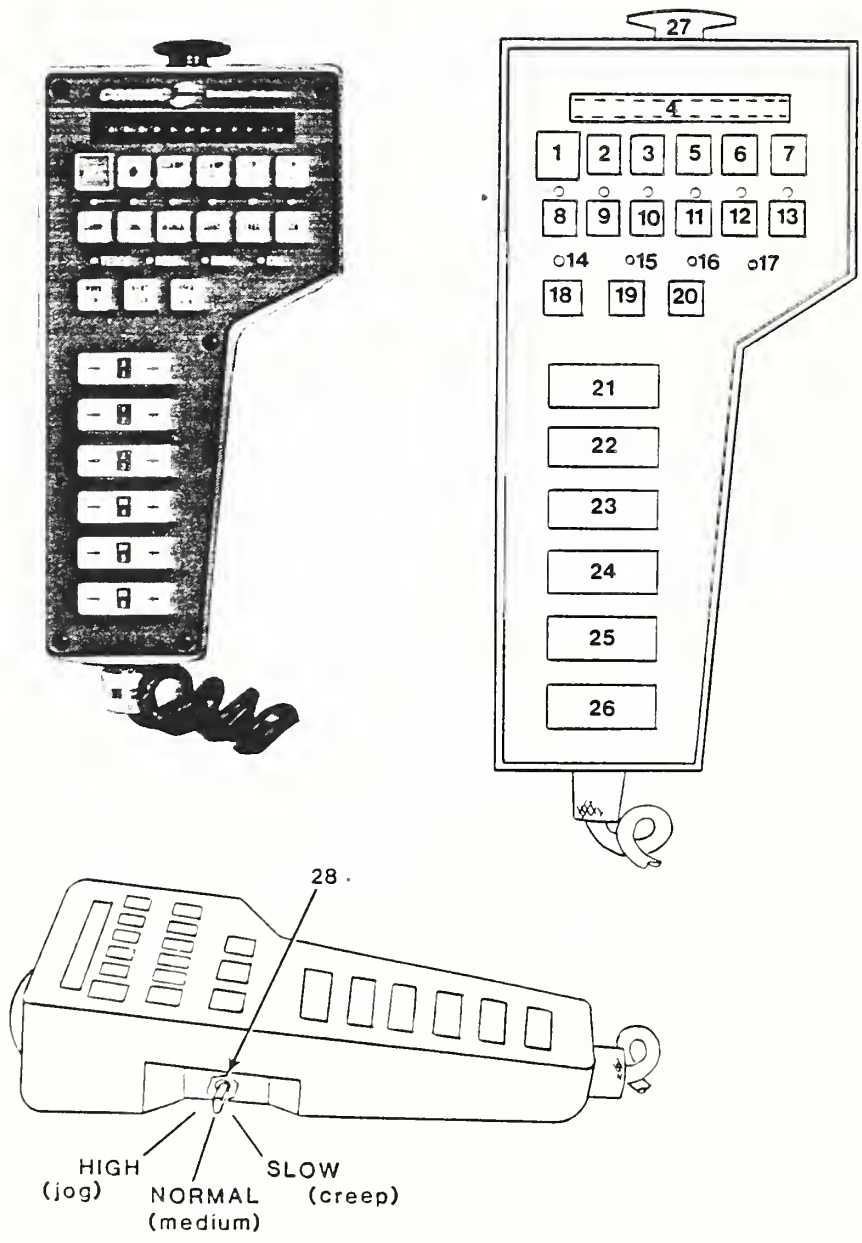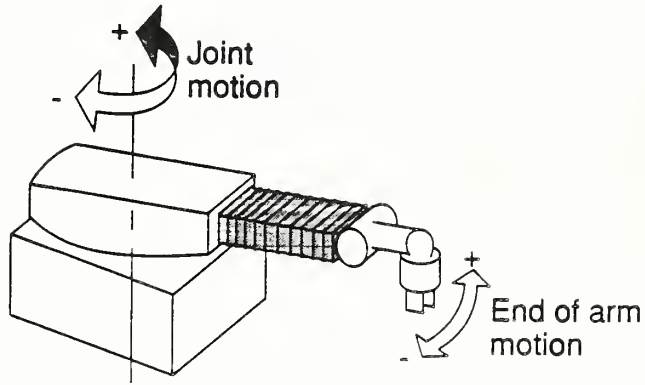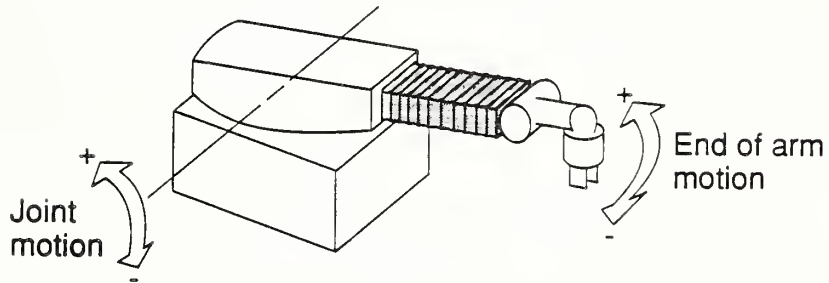Figure C-1 Vertical Workstation: Robot Safe Location and Work Volume Points

Figure C-2   Teach Pendant Controls and Indicators

Joint 1

Joint 2

Joint 3
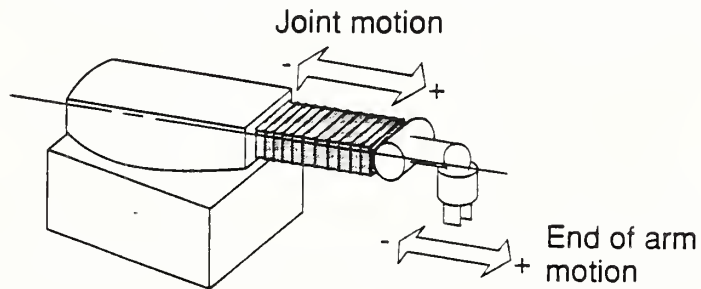
Figure C-3   Unimate 4070 Joint Motions (continued)

Joint 4

End of arm motion

Joint motion

Joint 5

Joint motion

End of arm motion
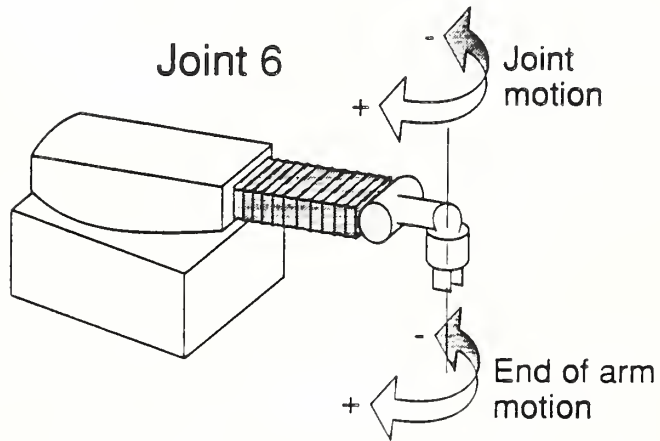
Joint 6

Joint motion

End of arm motion
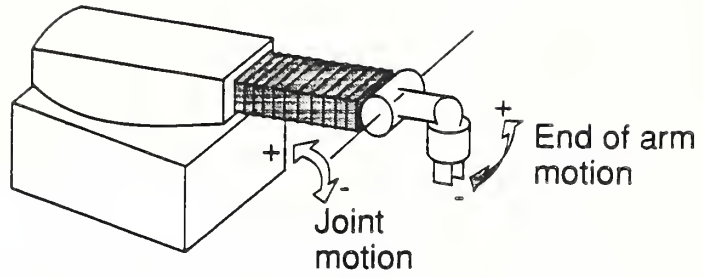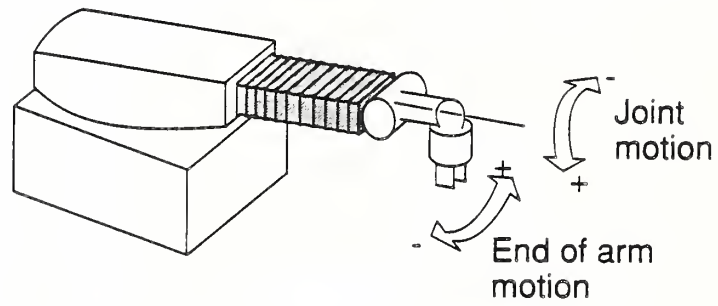
Figure C-3 Unimate 4070 Joint Motions (concluded)

APPENDIX D.   SUBSYSTEM TESTING

From time-to-time, it is necessary to check the various VWS subsystems for proper operation. To perform these tests, a utility program resident in the VWS Equipment Controller is invoked. This program is called SUBSYS_TEST. It allows the VWS operator to exercise, individually, all VWS functions other than robot movements, communication with the Monarch VMC-75, and communication with the workstation controller.

D.1 START UP SEQUENCE

The start up sequence is identical to the VWS start up sequence presented in the main text except that it is not necessary to initialize either the Monarch VMC-75 or the robot controller. The Monarch table should be in the park position, the robot should be at SAFE, and the air supply to the robot pneumatic system should be on.

STEP 1 of 10:   INITIALIZE MHS TRAYS

Location - controller under Tray #2.

a)   Flip the power switch up (the light goes on).

b)   Flip the REMOTE switch to the REMOTE position.

c)   Flip the two solenoid switches to the AUTO position.

STEP 2 of 10:   PRESSURIZE GRIPPER PNEUMATIC SYSTEM

Location - rear of robot base.

a)   Turn the yellow valve handle 90° counterclockwise so that it is in line with the red pigtail air hose.

STEP 3 of 10:   POWER ON THE HP9000 EXTERNAL MEMORY

Location - to the left of the HP9000 when viewed from the rear of the robot.

a)   Flip the AC POWER switch to the ON position.

APPENDIX D.   SUBSYSTEM TESTING

STEP 4 of 10:   POWER ON THE HP9836 PRINTER

Location - on top of the HP9836 to the right of the HP9000
when viewed from the rear of the robot.

a)   Flip the LINE (power) switch to ON position.

STEP 5 of 10:   TURN ON POWER SUPPLIES, DIGITAL VOLTMETER, AND DATA
ACQUISITION UNITS

Location - equipment rack to right of HP9000 computer.

NOTE: All toggle switches are ON in the up position and
OFF in the down position. Indicator lamps are lit when the
units are on.

The sequence of steps described below is not critical.
However, all steps must be completed.

a)   Flip the switch on the hydraulic solenoid power supply
to the ON position. The switch is located on top of
equipment rack.

b)   Flip three switches labeled PWR-1, PWR-2, and LW/PWR
to the ON position.

c)   Press in and release the LINE button (upper left hand
side) of HP3455A Digital Voltmeter.

d)   Press in and release the LINE button on both HP3497A
Data Acquisition and Control Units. The switch is
located to the lower right of the instrument screen
and to left of the keyboard.

e)   Flip the switch on the HP6002A DC power supply.

STEP 6 of 10:   LOAD "SUBSYS_TEST" PROGRAM

a)   Turn on the HP9000 computer. The red switch is
located on the right hand side between the monitor and
the computer.

b)   Wait until the message HP Basic Ready appears.

c)   Type LOAD "SUBSYS_TEST:CS80,7,0" and press the EXECUTE
key (quotation marks are required).

APPENDIX D.   SUBSYSTEM TESTING

STEP 7 of 10:   LOAD THE HP9836 CONTROL PROGRAM

This is the controller for the hydraulics system for pallet clamps located on the Monarch Table.

a)   Obtain the System Floppy Disks from the bottom desk drawer under HP9836.

The Disks are labeled: VWS HYD CONTRLR 1/2
                          VWS HYD CONTRLR 2/2

b)   Place Disk VWS HYD CONTRLR 1/2 in the right hand disk drive of the HP9836 and close the drive door.

c)   Turn on the HP9836 Computer. Press in the switch located below the numeric key pad on the front of the computer base. Wait until the message Basic Ready 2.0 appears.

d)   Remove Disk VWS HYD CONTRLR 1/2 from the right hand disk drive and return it to its envelope.

e)   Place Disk VWS HYD CONTRLR 2/2 in the right hand disk drive and close the door.

f)   Type LOAD BIN "AP2_1" (quotation marks are required) and press the EXECUTE key. Wait until message BASIC EXT. AP2.1 appears.

g)   Type LOAD "PALL_CLAMP" (quotation marks are required) and press the EXECUTE key.

h)   Leave disk VWS HYD CONTRLR 2/2 in the right-hand disk drive.

STEP 8 of 10:   PRESSURIZE HYDRAULICS SYSTEM FOR PALLET CLAMPS

Location - hydraulic power unit behind Monarch Console to left of VMC-75.

a)   On the aluminum switch box, flip all 12 toggle switches up to the COMP position.

b)   Turn the four-lobe handle on top of the power unit clockwise until it stops turning.

c)   Press and release the START switch for the pump motor

on the left hand side of the Power Unit.

d)   The Hydraulic system will pressurize to 2600 lb/in^2
(as indicated on the pressure gage).

STEP 9 of 10:   EXECUTE SUBSYS_TEST PROGRAM

Location - HP9000 keyboard.

a)   Press the RUN key located on the upper left center of
the keyboard.

b)   Wait for the screen to fill up display.

STEP 10 of 10: EXECUTE PALL_CLAMP PROGRAM

Location - HP9836 keyboard.

a)   Press the RUN key located between the keyboard and the
numeric pad.

b)   A ? will appear on screen. Type N and press the ENTER
key.

The subsystem test program is a menu selection process. The menu appears
on the HP9000 monitor with a prompt asking for a selection. Enter your
selection and press the RETURN key. Another prompt will appear that gives
instructions required to operate the particular subsystem. To exit any
subsystem program, press E and the RETURN key. The menu will reappear and
another selection will be made.

The subsystem test program is the most convenient means of manually
operating the vise on the Monarch Table. However, the user must be aware
that the open and close vise commands are simply time delays for switching
the pneumatic solenoid. Hence, several close commands or open commands
may be required to either clamp a block or return the vise to the full
open position (opening is 145.4 mm).

NEVER CLOSE THE VISE UNLESS THERE IS A BLOCK AT LEAST 1.25 INCHES WIDE IN
THE VISE - ALWAYS OPEN THE VISE TO THE FULL OPEN POSITION (145.4 mm).

IF YOU WANT TO CLAMP A PALLET, PLACE A PALLET IN THE CLAMPING AREA BEFORE
ISSUING THE CLAMP COMMAND.

APPENDIX D.   SUBSYSTEM TESTING

D.2 SHUT DOWN SEQUENCE

Follow the shut down sequence described in the main text.

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10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)*

This manual is for those individuals who wish to use the Vertical Workstation (VWS) of the AMRF and control the VWS from the workstation controller. Anyone possessing the ability to flip a switch, press a button, turn a valve, and operate a personal computer can use this manual and place the VWS under that command of the workstation controller.

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

automated manufacturing; operations manual

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