INVENTORY OF EQUIPMENT IN THE INSPECTION WORKSTATION

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By:
Jay H. Zimmerman
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I. **INTRODUCTION**

1. **WHAT THIS MANUAL IS ABOUT**

This manual serves as a comprehensive inventory guide to electronic and mechanical equipment and instruments used by the Inspection Workstation (IWS). It furnishes some technical specifications that may be useful in reaching decisions regarding product and system requirements.

2. **AUDIENCE**

This manual is intended for use by inspection personnel, quality control engineers, advanced metrologists, and plant managers.

3. **OVERVIEW**

The IWS is a prototype inspection facility with four computer systems and six essential components. The computer systems of the IWS include:

(a) Main Workstation Controller (WSC),
(b) Inspection Robot Controller (IRC),
(c) Coordinate Measuring Machine Controller (CMMC), and
(d) Surface Roughness Instrument Controller (SRIC).

Principal commercial mechanical and electronic equipment and instruments of the IWS include:

(a) Horizontal Arm Coordinate Measuring Machine,
(b) Automatic Dial Indicator,
(c) Inspection Robot,
(d) Mechanical (NBS-designed) Robot Gripper,
(e) Electronic Safety Fence, and
(f) Optical Surface Roughness Instrument.

Chapters II and III describe the four computer systems and the six components, respectively.

The appendices consist of useful information. Appendix A lists the entire IWS documentation set. Equipment manufacturers specific to the IWS are listed in Appendix B. Appendix C contains a glossary of terms used in this document.

Completing the document is a reader/comment form. The reader is encouraged to write down comments and mail the attached form to the address specified.
II. COMPUTER SYSTEMS OF THE INSPECTION WORKSTATION

The IWS has four computer systems all of which are physically located at the AMRF Inspection Workstation (at NBS), Building 304, Room 148. These computer systems are functionally interdependent based on the AMRF hierarchical control architecture. Notably, each system performs its own unique set of tasks (i.e., main computer system controller, commercial equipment controller, instrument controller, etc.).

All four computer systems are manufactured by Hewlett-Packard (HP) and use the Motorola 16.0 MHz 68000 microprocessor. These computers feature a minimum Random Access Memory (RAM) capacity of approximately 750 kilobytes which is considered necessary and adequate for most current software applications at the IWS.

1. WORKSTATION CONTROLLER COMPUTER SYSTEM

The workstation controller (WSC) computer system uses equipment manufactured by Hewlett-Packard (HP). The components of this system include:

(a) HP 9000 Series 200 Microcomputer (Model No. 9920U),
(b) 12-inch Monochromatic Monitor (Model No. 82913A),
(c) HP-HIL Nimitz Keyboard (Model No. 98203B),
(d) 16.7-Megabyte (Mbyte) CS/80 Winchester Disc (Model No. 7908P),
(e) 286.72-Kilobyte (Kbyte) AMIGO Dual 3-1/2 Inch Flexible Disc (Model No. 9121D),
(f) Three 256-Kbyte RAM Cards (Product No. 98256A),
(g) Keyboard/HP-IB Interface Card (Product No. 9920A),
(h) Composite Video Interface Card (Product No. 98204A),
(i) HP-IB Interface Card (Product No. 98624A),
(j) RS-232 Serial Interface Card (Product No. 98626A),
(k) General Purpose I/O (GPIO) Interface Card (Product No. 98622A),
(l) Data Communication Interface (adds DCE (female, direct-connect) RS-232 cable) (Product No. 98628A Option 002), and
(m) Pascal 3.0 Language System (Product No. 98615A Option 630).

The computer system contains a Random Access Memory capacity of approximately 786 kilobytes. It functions as the main workstation controller.
2. COORDINATE MEASURING MACHINE CONTROLLER
COMPUTER SYSTEM

The coordinate measuring machine controller (CMMC) computer system uses HP-manufactured equipment. The components of this system include:

(a) HP 9000 Series 200 Microcomputer (Model No. 9836),
(b) 65.6-Mbyte CS/80 Winchester Disc (Model No. 7912P),
(c) Line Printer (Model No. 2631B),
(d) 1.0-Mbyte RAM Card (Product No. 98257A),
(e) Three 256-Kbyte RAM Cards (Product No. 98256A),
(f) General Purpose I/O (GPIO) Interface Card (Product No. 98622A),
(g) Data Communication Interface (adds DCE (female, direct-connect) RS-232 cable) (Product No. 98628 Option 002), and
(h) Pascal 3.0 Language System (Product No. 98615A Option 630).

The computer system contains a Random Access Memory capacity of approximately 1,901 kilobytes. It functions as the coordinate measuring machine controller.

3. INSPECTION ROBOT CONTROLLER COMPUTER SYSTEM

The robot controller (IRC) computer system uses HP-manufactured equipment. The components of this system include:

(a) HP 9000 Series 200 Microcomputer (Model No. 9920U),
(b) 12-inch Monochromatic Monitor (Model No. 82913A),
(c) HP-HIL Nimitz Keyboard (Model No. 98203B),
(d) 28.7-Mbyte CS/80 Winchester Disc (Model No. 7911P),
(e) 286.72-Kbyte AMIGO Dual 3-1/2 Inch Flexible Disc (Model No. 9121D),
(f) Four 256-Kbyte RAM Cards (Product No. 98256A),
(g) Keyboard/HP-IB Interface Card (Product No. 9920A),
(h) Composite Video Interface Card (Product No. 98204A),
(i) HP-IB Interface Card (Product No. 98624A),
(j) RS-232 Serial Interface Card (Product No. 98626A),
(k) General Purpose I/O (GPIO) Interface Card (Product No. 98622A),
(l) Data Communication Interface (adds DCE (female, direct-connect) RS-232 cable) (Product No. 98628A Option 002), and
(m) Pascal 3.0 Language System (Product No. 98615A Option 630).

The computer system contains a Random Access Memory capacity of
approximately 1,048 kilobytes. It functions as the robot controller.

4. SURFACE ROUGHNESS INSTRUMENT CONTROLLER
COMPUTER SYSTEM

The surface roughness instrument controller (SRIC) computer system uses HP-manufactured equipment. The components of this system include:

(a) HP 9000 Series 200 Microcomputer (Model No. 9920U),
(b) 12-inch Monochromatic Monitor (Model No. 82913A),
(c) HP-HIL Nimitz Keyboard (Model No. 98203B),
(d) 16.7-Mbyte CS/80 Winchester Disc (Model No. 7908P),
(e) 286.72-Kbyte AMIGO Dual 3-1/2 Inch Flexible Disc
   (Model No. 9121D),
(f) 1.0-Mbyte RAM Card (Product No. 98257A),
(g) Four 256-Kbyte RAM Cards (Product No. 98256A),
(h) Keyboard/HP-IB Interface Card (Product No. 9920A),
(i) Composite Video Interface Card (Product No. 98204A),
(j) HP-IB Interface Card (Product No. 98624A),
(k) RS-232 Serial Interface Card (Product No. 98626A),
(l) General Purpose I/O (GPIO) Interface Card (Product
   No. 98622A),
(m) Data Communication Interface (adds DCE (female,
   direct-connect) RS-232 cable) (Product No. 98628A
   Option 002), and
(n) Pascal 3.0 Language System (Product No. 98615A Option
   630).

The computer system contains a Random Access Memory capacity of approximately 2,228 kilobytes. It functions as the surface roughness instrument controller.
III. INSPECTION WORKSTATION EQUIPMENT

1. COORDINATE MEASURING MACHINE

The coordinate measuring machine (CMM) is a Sheffield 2000 Series horizontal arm type (Model No. 2015) coordinate measuring machine manufactured by the Sheffield Measurement Division of Warner and Swasey Company of Dayton, Ohio formerly known as the Automated and Measurement Division of the Bendix Corporation. This measuring machine has direct computer control (DCC) capability and thus meets IWS application requirements for operating in either automatic (computer-assisted) or manual mode. The CMM is equipped with an air-lifted rotary table and a motorized two-axis, three dimensional Renishaw PH9 probe.

The rotary table furnished with the CMM features continuous rotational positioning operated by precision worm with low pitch angle resulting in high-resolution positioning of 0.001 degree. This rotary table is electronically and mechanically interfaced with the CMM for compliance with IWS CAD/CAM application requirements.

The special option probe features adjustable force sensitivity and transmits a latch signal to the processor upon touching an object or part. Normal IWS operation requires the force sensitivity to be set to five grams. This enables most parts to be automatically inspected by the CMM unmounted, or unsecured, to the measuring machine. Small parts, however, must be secured by some sort of fixture (i.e., magnetic device, or vacuum chuck, etc.).

The PH9 probe has a built-in microprocessor that is programmable for up to sixty-four probe tip positions, or orientations. The probe is powered by the interface to the CMM. When power to the interface is disconnected, the probe orientations may be retained in the memory of the PH9 microprocessor for several hours using the microprocessor's internal battery.

2. AUTOMATIC DIAL INDICATOR

The automatic dial indicator (ADI) is a digital dial gauge (Model No. 8X-0047) manufactured by Brown and Sharpe Manufacturing Company of North Kingstown, Rhode Island. This instrument is used for sensing and measuring distance variations. The mechanism of the indicator converts the axial displacement of the measuring spindle into rotational movement which is then amplified by mechanical means and finally displayed by digital readout. This indicator has a RS-232 output for providing direct communication of measurement readings to the SRI controller computer system.
3. INSPECTION ROBOT

The inspection robot is a six-axis robot (Model Merlin) manufactured by American Robot Corporation of Pittsburgh, Pennsylvania. This robot is mounted on an overhead gantry for easy access to the work environment of the IWS workstation. It is equipped with a CNC controller and a robot gripper discussed in the next section.

4. ROBOT GRIPPER

The robot gripper is an NBS-designed and manufactured mechanical-transporting device operated with the Merlin robot of the IWS. It has one set of fingers and is pneumatically actuated, exerting forces up to fifty pounds. For most IWS applications, the gripper fingers are adjusted to exert a force of fifty pounds to handle the tasks of transporting and relocating inspection parts.

5. SAFETY FENCE

The safety fence employed at the IWS is an electronic sensing device (Model No. SS IV-18-R) manufactured by Dolan-Jenner Industries, Incorporated of Woodburn, Massachusetts. This safety fence monitors personnel infiltration into restricted areas of the IWS, particularly during intervals of on-going inspection operations. It has data communications output for providing direct communication with the robot computer system.

6. SURFACE ROUGHNESS INSTRUMENT

The surface roughness instrument (SRI) is an optical instrument (Model No. RM 400) manufactured by Rodenstock Precision Optics, Incorporated of Rockford, Illinois. This instrument examines surface roughness by measuring the angular distribution of scattered light. It employs a beam from a helium-neon laser illuminating the surface at an angle of incidence which may be varied. The scattered light distribution is detected by an array of twenty optical detectors.

This portable, hand-held, commercial device satisfies the requirements of the IWS for non-contact, real-time surface finish inspection. The current instrument system contains the control unit (Rodenstock (Model No. RM 400 C)) and a sensor device (Rodenstock (Model No. RM 400 S)) with a type 40, straight-design measuring head having a measuring spot diameter of 1.8 millimeters and 20-degree optics. The sensor device contains a detector array to collect the angular distribution, which is then processed by the control unit software. The control unit has a RS-232 output for providing direct communication of measurement readings to the SRIC computer system. The SRIC evaluates measurement data.
and sends information to the inspection robot controller (IRC) computer. This information represents essential data concerning the proper alignment of the surface of a part with respect to the sensor device.

As a special note, the product manufacturer of this instrument provides additional sensor types for special applications. At the present time, NBS personnel have found the standard (type 40) sensor with a spot diameter of 1.8 millimeters and 20-degree optics the most versatile for inspecting surface finishes of parts manufactured in the AMRF facility.
A. IWS DOCUMENTATION LIST

1. H. T. Moncarz, Architecture and Principles of the Inspection Workstation, to be published as an NBSIR.


3. H. T. Moncarz and T. H. Hopp, Implementation of the CMM Controller, to be published as an NBSIR.

4. H. T. Moncarz and T. V. Vorburger, Implementation of the SRI Controller, to be published as an NBSIR.


6. S. A. Osella, Implementation of the Workstation Controller, to be published as an NBSIR.


B. IWS EQUIPMENT MANUFACTURERS LIST

1. Coordinate Measuring Machine
   Sheffield Measurement Division
   Warner and Swasey Company
   721 Springfield Street
   Dayton, Ohio 45403
   (513) 254-5377

2. Automatic Dial Indicator
   Brown and Sharpe Manufacturing Company
   Precision Park
   North Kingstown, Rhode Island 02852
   (401) 866-2000

3. Inspection Robot
   American Robot Corporation
   121 Industry Drive
   Pittsburgh, Pennsylvania 15275
   (412) 787-3000

4. Robot Gripper
   United States Department of Commerce
   National Bureau of Standards
   Building 220 Metrology Room A107
   Gaithersburg, Maryland 20899
   Attn: Bruce Borchardt
   (301) 975-3482

5. Safety Fence
   Dolan-Jenner Industries, Incorporated
   Post Office Box 1020-T
   Woodburn, Massachusetts
   (617) 935-7444

6. Surface Roughness Instrument
   Rodenstock Precision Optics, Incorporated
   4845 Colt Road
   Rockford, Illinois 61109
   (815) 874-8300
   Telex 28-9425
C. **GLOSSARY (and abbreviations)**

**ADI** Abbreviation for the Automatic Dial Indicator.

*automatic dial indicator* Instrument used to measure the distance that a spring mounted stem is depressed.

**CMM** Abbreviation for the Coordinate Measuring Machine.

**CMMC** Abbreviation for the Coordinate Measuring Machine Controller.

*controller* Supervises the operation of a mechanism and/or another controller.

*coordinate measuring machine* Machine used to measure the dimensions of a part.

**inspection robot** Robot used in the Inspection Workstation to retrieve and/or relocate a part.

**inspection workstation** AMRF workstation that inspects parts for dimensional tolerance and surface finish.

**IRC** Abbreviation for the Inspection Robot Controller.

**IWS** Abbreviation for the Inspection Workstation.

**Kbyte** Abbreviation for kilobyte (1024 bytes).

**Mbyte** Abbreviation for megabyte (1,048,576 bytes).

**RAM** Abbreviation for Random Access Memory.

**SRI** Abbreviation for the Surface Roughness Instrument.

**SRIC** Abbreviation for the SRI Controller.

*surface roughness instrument* Machine that measures the optical scattering from the surface of a part. The scattering can be correlated with its surface roughness.

**WSC** Abbreviation for the Workstation Controller.
INVENTORY OF EQUIPMENT IN THE INSPECTION WORKSTATION

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Building 220, Room B-111
Gaithersburg, MD 20899
This document is a comprehensive inventory guide to electronic and mechanical equipment and instruments used by the Inspection Workstation (IWS) in the Automated Manufacturing Research Facility (AMRF) at the National Bureau of Standards. The IWS is a prototype inspection facility with four computer systems and six essential components. The computer systems of the IWS include the Main Workstation Controller (WSC), the Inspection Robot Controller (IRC), the Coordinate Measuring Machine Controller (CCMC), and the Surface Roughness Instrument Controller (SRIC). The principal commercial mechanical and electronic equipment and instruments include the horizontal arm coordinate measuring machine (CMM), the automatic dial indicator (ADI), the inspection robot, the mechanical (NBS-designed) robot gripper, the electronic safety fence, and the optical surface roughness instrument (SRI).