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Semiconductor Measurement Technology:

A Manual Wafer Probe Station for an Integrated Circuit Test System

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Table of Contents

List of Figures

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A Manual Wafer Probe Station for an Integrated Circuit Test System

by

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This report describes the design of a manual wafer probe station for wafer-level testing of integrated circuits, test structures, and test patterns. The station includes a translatable vacuum chuck, a probe assembly which can be used for probe cards or individual micropositioner-mounted probes, and a microscope holder. Except for a few components which are commercially available, construction details are provided for all parts.

Key words: Integrated circuit test methods; microelectronic test structure; probe station; semiconductor process control; test pattern; test structure; wafer chuck; wafer probe station.

1. Introduction

Wafer-level testing can be a critical ingredient in a comprehensive test program to assure integrated circuit functionality in microelectronic devices and materials research and development. In production facilities wafer testing is usually automated. However, manual probing is frequently required to supplement automated testing, especially in research and development environments.

On the wafer, measurements can be made using specially designed microelectronic test structures [1,2] or using the product circuit itself. The devices are electrically addressed by probes which are brought into contact with metallized areas, called probe pads, on the wafer. The mechanism which includes devices to hold and position the wafer and to bring the probes into contact with the probe pads on the wafer is usually referred to as a wafer probe station. Since certain electrical tests must be performed in darkness, and sometimes in an inert atmosphere, it is frequently desirable that the wafer probe station is mounted in a suitable enclosure.

The manual wafer probe station and associated enclosure described in this paper are both versatile and convenient to use. They can be constructed from inexpensive, readily available materials. Specifications and mechanical drawings are provided for each of the probe station parts.

2. Description

The manual wafer probe station, including the light-tight enclosure, is shown in figures 1 through 5. An outline drawing of the mechanism is shown in figure 6. This drawing also shows the location of the parts which are iden-

tified by number in table 1. In the following description, the various parts are referred to by their part number.

Wafers are held in place on a vacuum chuck (17) which can be moved forward rapidly by a lever (22) for accessibility for mounting a wafer on the chuck. The vacuum chuck is positioned in two directions by an x-y movement translation stage. The probes are brought into contact with the wafer by lowering the probe-mounting plate (6) with a handle (13) and adjusting screw (9). The probes can be on a probe card or they can be individual micropositioner-mounted probes. The parts required to hold a probe card are shown in figure 6. However, the probe-card plate (8) can be replaced with other plates suitable for a variety of micropositioners. One type of probe plate (7) is shown in the detailed mechanical drawings; however, it is easy to design other probe plates for different types of probes. If the probe station is to be used with both probe cards and micropositioners, it is advisable to fabricate additional mounting plates (6) so that the probes can be changed simply by replacing the entire probe assembly using the mounting plate screw (14).

3. Parts Specifications

All of the parts identified by number are specified in the detailed mechanical drawings shown in figures 7 through 10.

In addition to the numbered parts, there are other components which must be obtained. They include the microscope pod, microscope mounting bracket, probe card holder, translation stages, micrometer heads for the translation stages, cables and connectors for the probe-pad holder, probe cards or probes, a "V" ways and roller set, and an enclosure.

The microscope shown in figures 1 through 3 is a Bausch and Lomb Stereo Zoom 7 power pod with coaxial illuminator.* The microscope fits into a mounting bracket called an E arm by the manufacturer. It is necessary to modify the E arm to make room for the motion of the probe assembly. The modification involves separating the ring that supports the microscope pod from the rack and pinion gear, cutting off the protrusion at the bottom of the ring where it adjoins the rack, rotating the bracket containing the gears so that it is upside down and protrudes upward, and remounting the ring at the bottom of the rack. In figure 6, the E ring is at top left. The concentric circles represent the knob which is used to adjust the height of the microscope. The extension above the knob is the bracket which contains the gears. The ring support, extending to the left, can be moved downward without interfering with the probe assembly.

The probe card holder, shown in the pictures and identified in figure 6, can accommodate probe cards with up to 48 pins. Cables are soldered to the terminals at the end of the holder. The miniature coaxial cables and BNC-type connectors can be seen in figure 2.

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* The microscope is identified because the modifications to the mounting bracket are specific to the microscope used. The use of another microscope would require different mechanical modifications.

The wafer chuck translation stages are visible in figures 1 through 3. The dimensions of parts 17 through 21 were chosen to accommodate the specific translation stages specified in figure 6. While these units are not unique, substitution of other manufacturer's stages may require adjustment of certain dimensions of parts for the wafer chuck. The lower stage is mounted as received. The upper stage is modified by moving the micrometer head to the opposite side of the stage. This permits both stages to be operated with the least amount of hand movement. The micrometer heads for the translation stages are adjustable from 0 to 50 mm. Since they are not actually used for measurement in this application, the specific type of micrometer head is unimportant.

The "V" ways and roller set precisely controls the vertical travel. The adjusting screw (9) and lock screw (10) are used to set the height to which the probe assembly is lowered by the handle (13).

Fine angular adjustment of the wafer is accomplished by rotating the vacuum chuck (17) with the adjusting lever (21). By operating levers (21) and (22) in conjunction, the wafer may be aligned quickly with the probe array.

The aluminum enclosure also shown in the pictures was designed and built for the probe station. It has the feature that when the lid is closed, a push-button switch turns off the microscope illuminator. The box containing the switch can be seen at the top left in figure 3. By examining the photographs of the enclosure, the input/output feedthrough connector layout, the lid handle and the safety catch arrangement should be clear. The purpose of the double lip which is visible on the edge of the lower portion of the enclosure (figs. 1 to 3) is to prevent light leaks when the box is closed. The lid also has a double lip; because lights are usually above the probe station, if only one edge has a double lip, it should be the edge of the lid. Not visible in the photographs is the vacuum line feedthrough which is at the rear. The vacuum line valves and the vacuum release valve are visible on the left side of the enclosure.

Acknowledgments

The authors gratefully acknowledge the contributions of others who have provided insights and suggestions during the evolution of the design of the manual wafer prober. In particular, useful improvements were due to Leonard Smith, Martin Buehler, Mel Doggett, and Rich Koyama.

References

1. Carver, G. P., Linholm, L. W., and Russell, T. J., Use of Microelectronic Test Structures to Characterize IC Materials, Processes, and Processing Equipment, *Solid State Technology* 23 (9), 85-92 (September 1980).

2. Buehler, M. G., Comprehensive Test Patterns with Modular Test Structures: The 2 by N Probe-Pad Array Approach, *Solid State Technology* 22 (10), 89-94 (October 1979).

Table 1. Manual Wafer Prober Station Part Numbers.

1	Column	13	Handle
2	Base	14	Mounting plate screw
3	Spacer	15	Sliding base
4	Roller set holder	16	Track
5	Face plate	17	Vacuum chuck
6	Mounting plate	18	Cam plate
7	Probe plate	19	Lock ring
8	Probe card plate	20	Chuck base
9	Adjusting screw	21	Adjusting lever
10	Lock screw	22	Lever
11	Adjusting screw block	23	Link
12	Stop	24	Sector

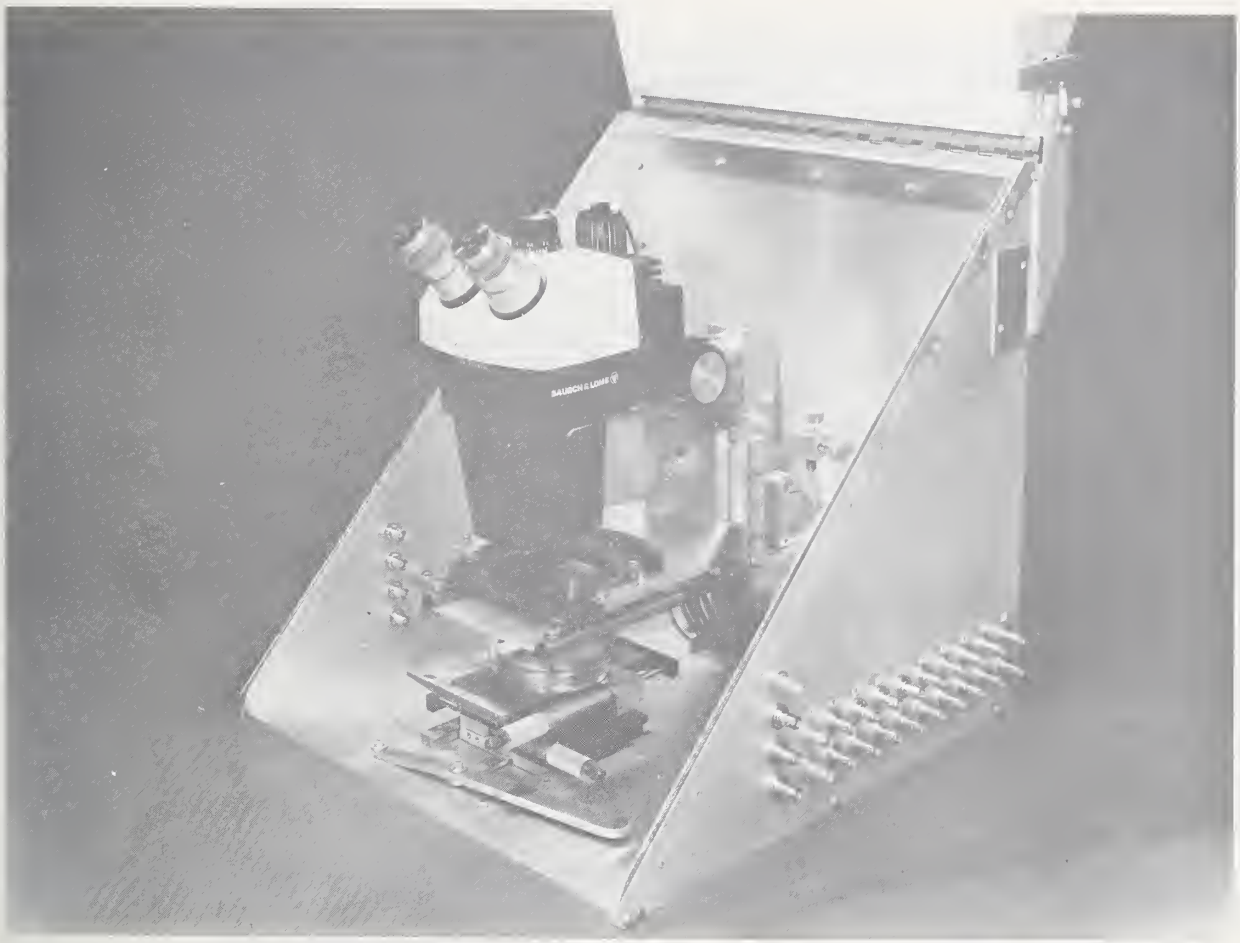

Figure 1. Right-side view of the wafer probe station. The electrical feedthrough connectors are visible on the right side of the lower part of the aluminum enclosure. A probe card is in place in the probe card holder.

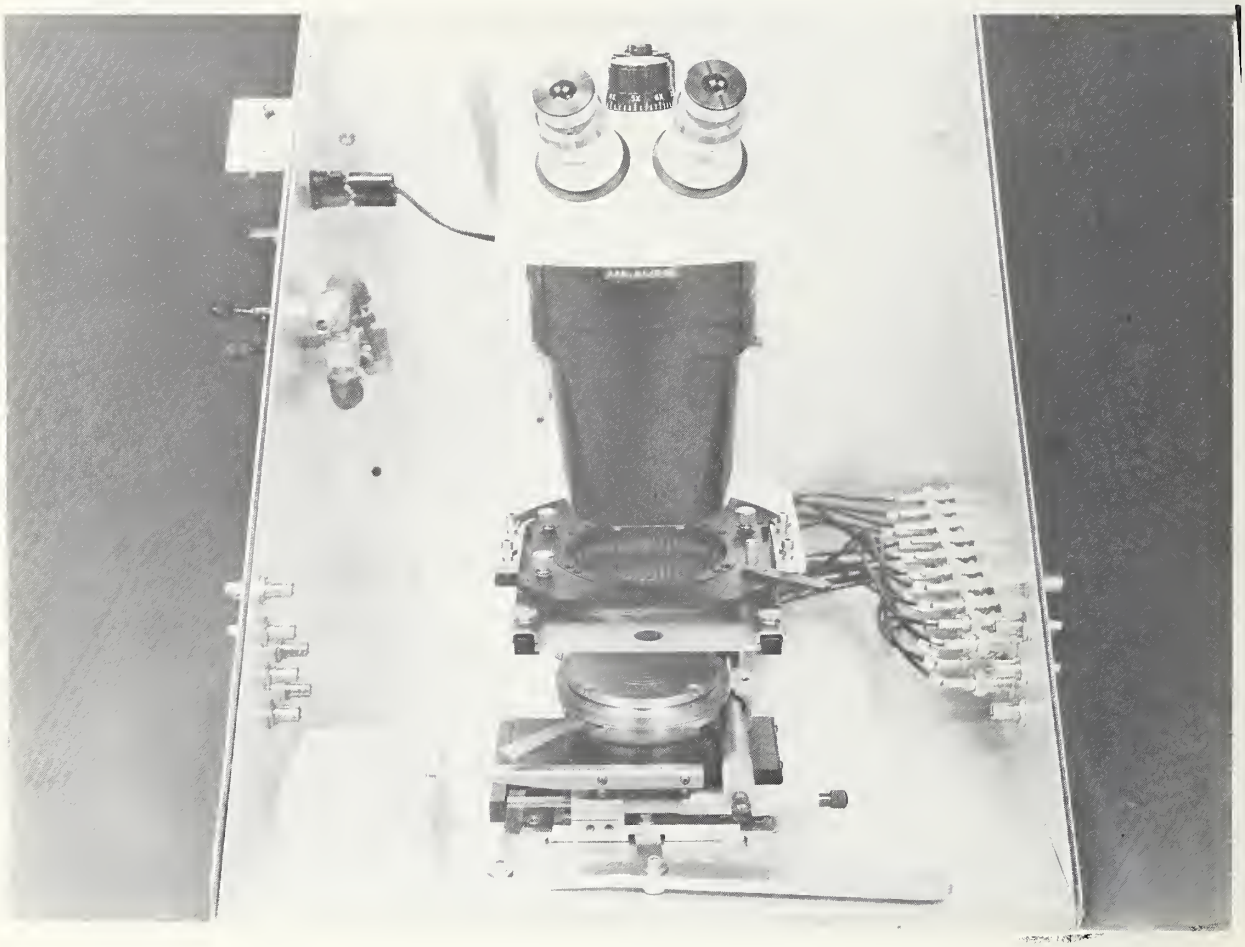

Figure 2. Center view of the wafer probe station. The vacuum line valves, electrical connection to the microscope illuminator, and additional electrical feedthroughs are visible on the left side of the enclosure. The pointer and block at left bottom are used to indicate the number of the chip under test.

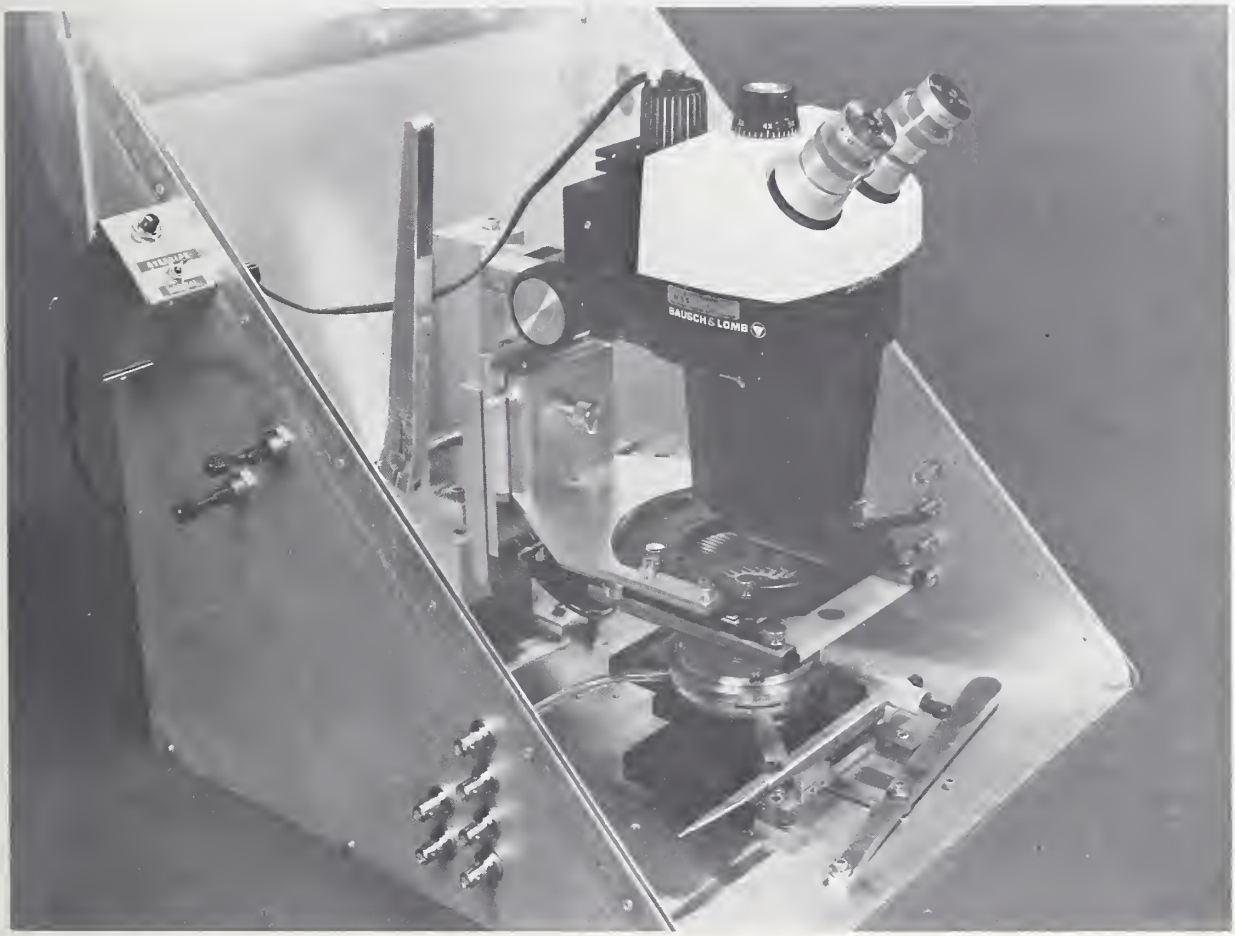

Figure 3. Left-side view of the wafer probe station. The small box at upper left houses the pushbutton switch which turns off the microscope illuminator when the enclosure lid is closed.

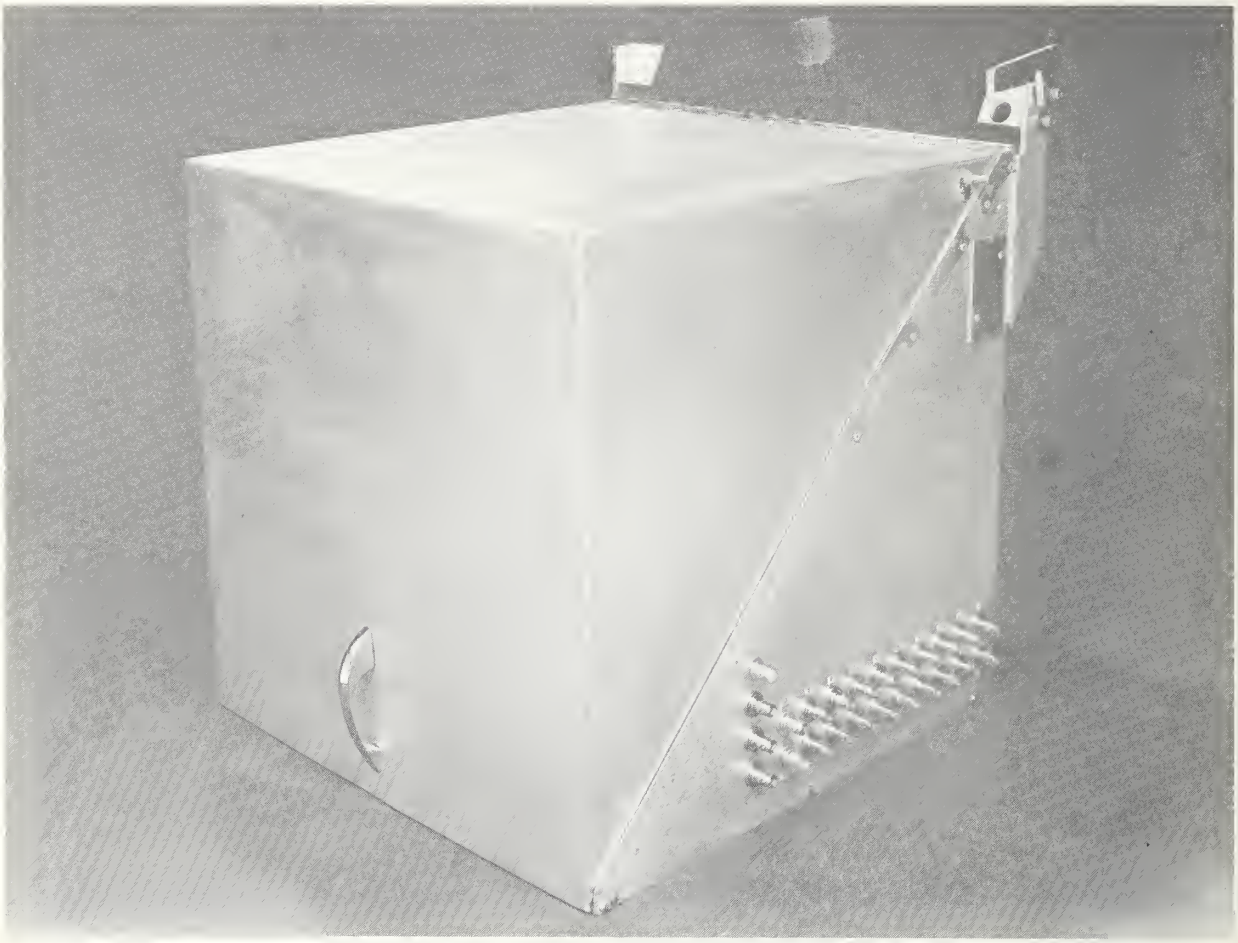

Figure 4. Right-side view of the probe station enclosure with the lid closed. The mechanism at upper right holds the lid open.

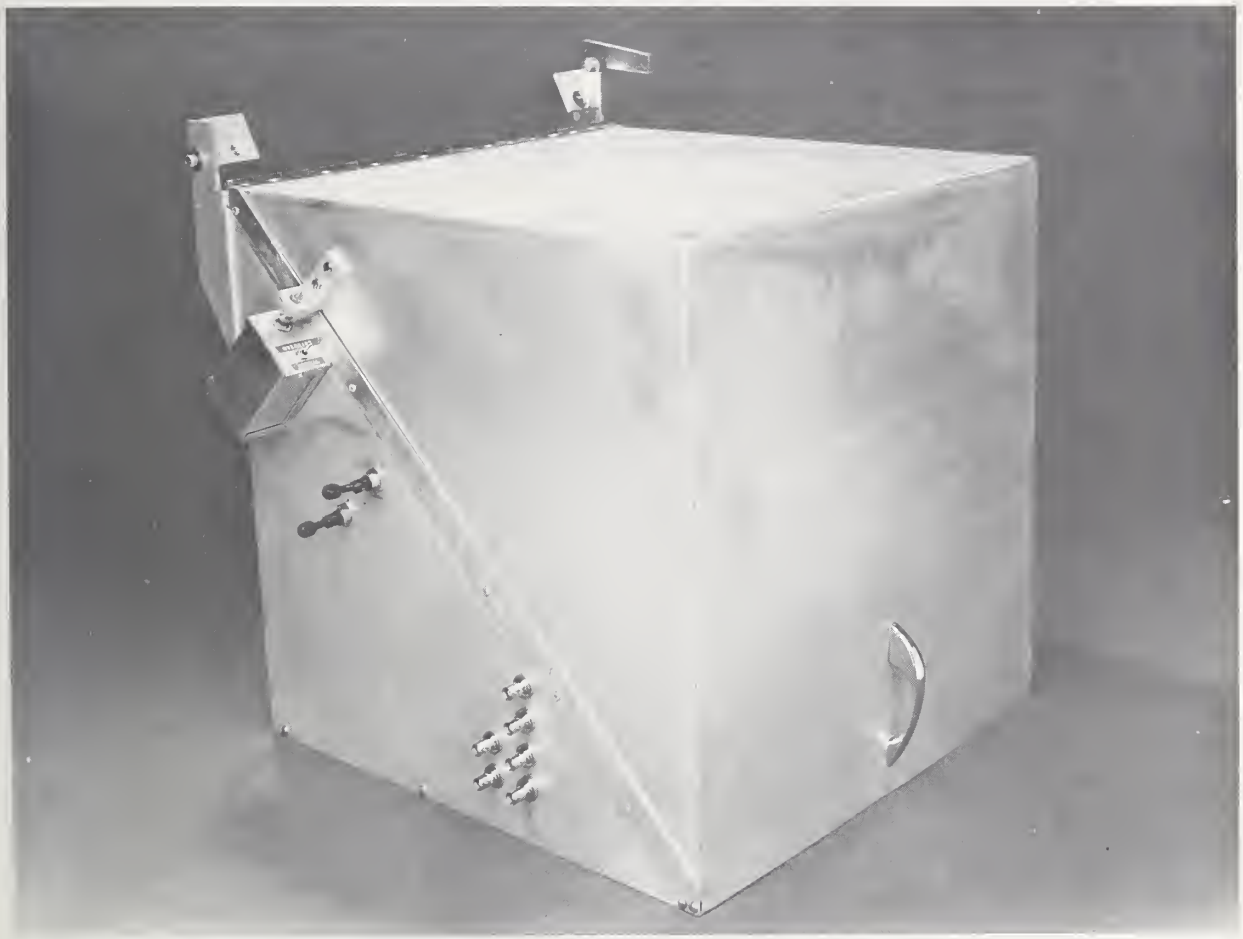

Figure 5. Left-side view of the probe station enclosure with the lid closed.

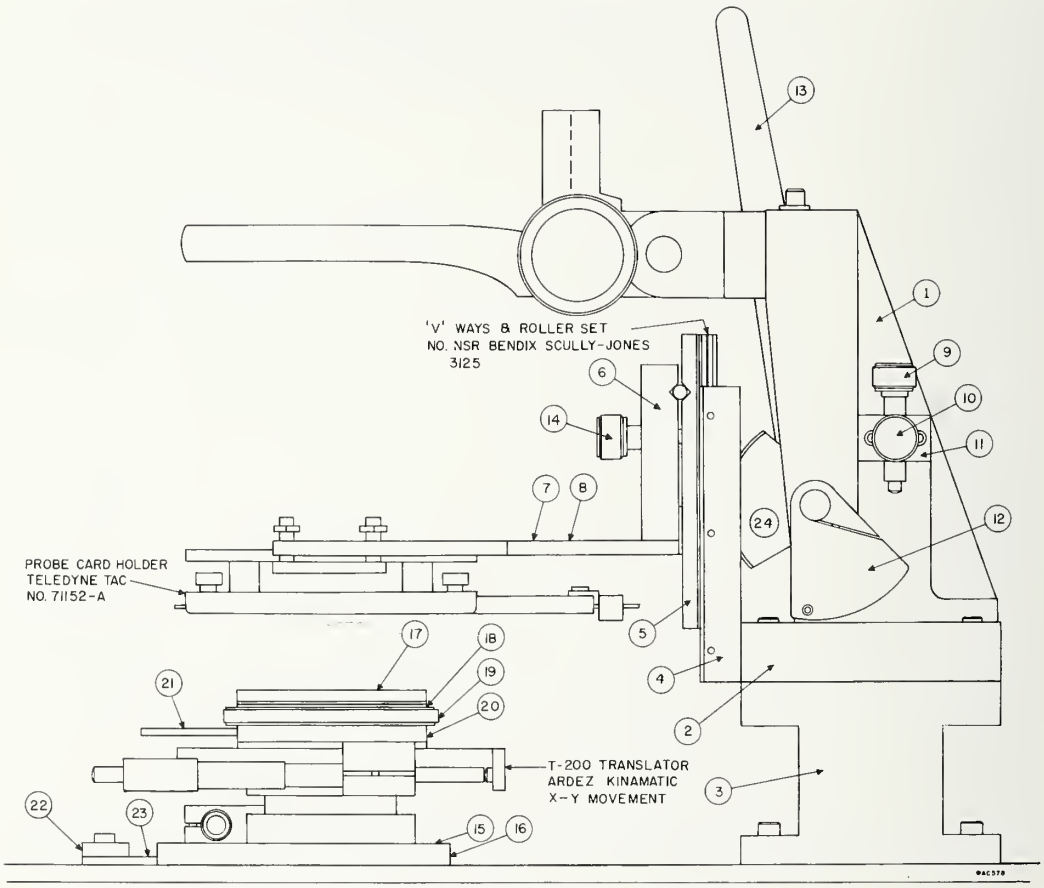

Figure 6. Outline drawing of the side view of the wafer probe station with each part identified numerically or by manufacturer or model number. See table 1 for the number key to the parts.

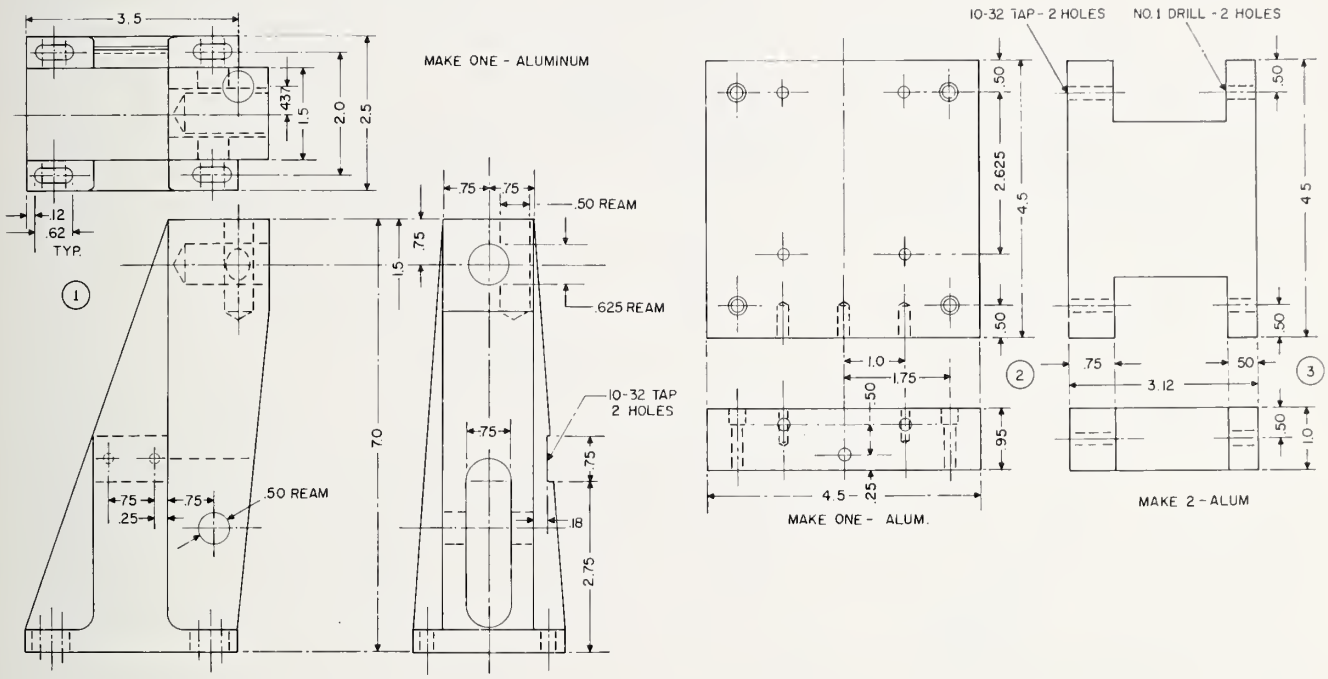

Figure 7. Mechanical drawings for the support parts for the wafer probe station. The column (part No. 1), base (2), and spacers (3) provide structural support for the probe assembly and microscope mounting bracket. The height of the spacers can be increased or decreased from the specified values to accommodate increased or decreased clearance required for probe card holders or x-y translators other than the particular ones identified in figure 6.

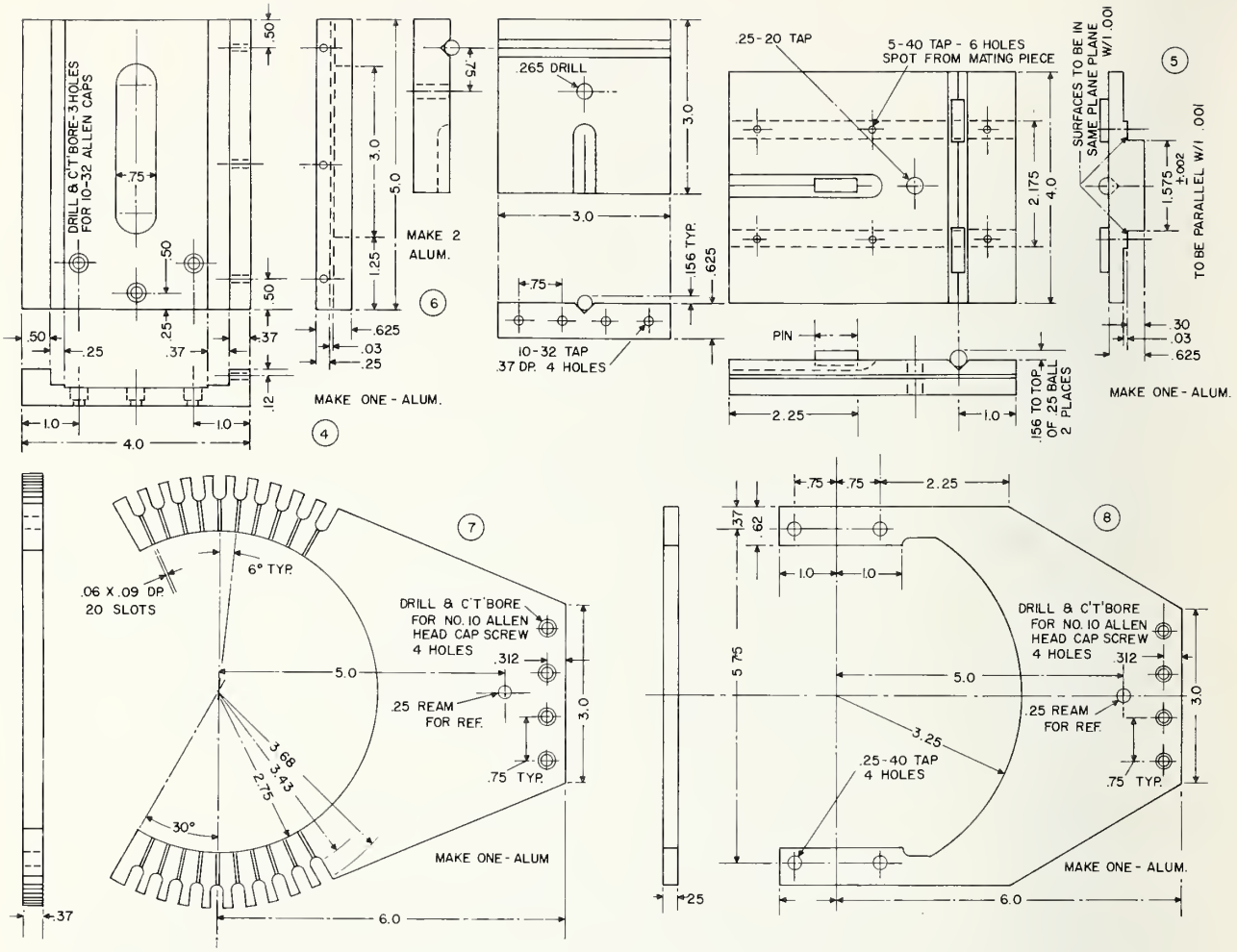

Figure 8. Mechanical drawings for the probe assembly for the wafer probe station. The roller set holder (4) and the face plate (5) may require modification to fit "V" ways and roller sets different from the one identified in figure 6. The probe card plate (8) may also need to be slightly redesigned to adapt to a probe card holder other than the one identified in figure 6. The probe plate (7), which is interchangeable with the probe card plate (8), is designed for types of manual micropositioner-mounted probes which fit into the slots around the outside of the arms. For use with micropositioners having a magnetic base, a circular steel plate can be mounted on the probe card holder (8).

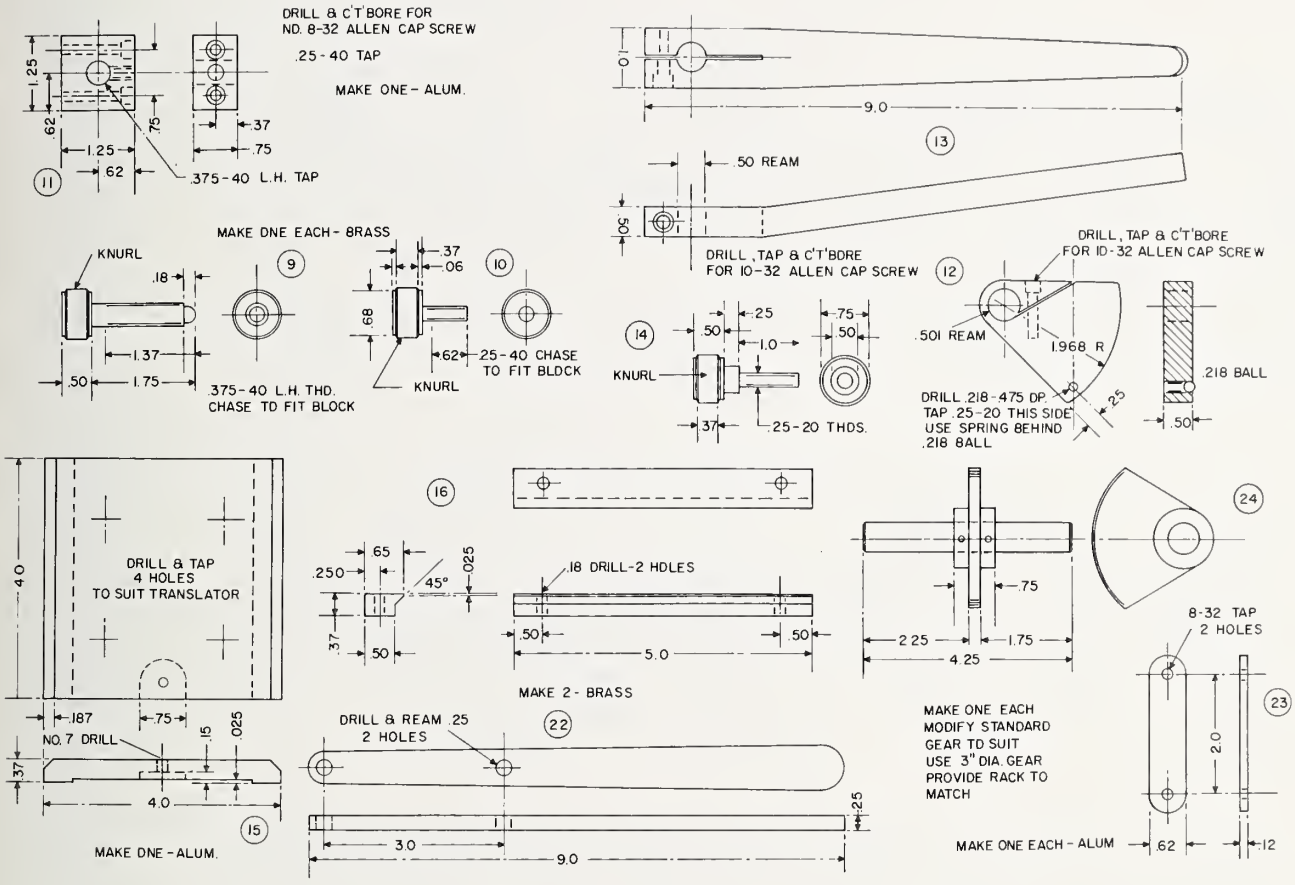

Figure 9. Mechanical drawings for assorted parts for the wafer probe station. The four holes in the sliding base (15) should be located appropriately to match holes in the x-y translator.

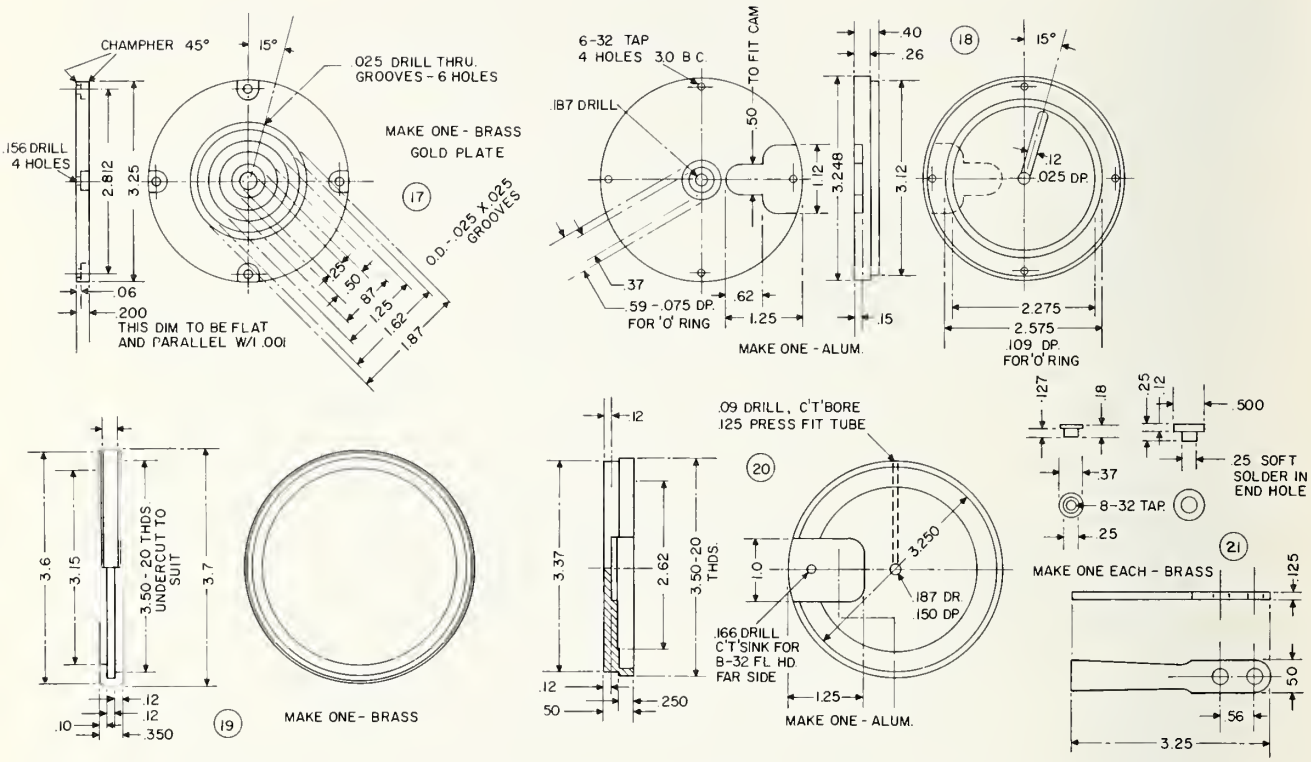

Figure 10. Mechanical drawings for the wafer chuck for the wafer probe station. The wafer chuck is attached to the x-y translator by screws which are inserted into countersunk holes drilled in the chuck base (20). A thin, electrically insulating disc should be mounted beneath the chuck base and the mounting screws should be insulated by nonconducting sleeves and washers. If holes large enough for the mounting screw heads are drilled in the cam plate (18), the wafer chuck can be removed from the translator without being disassembled.

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