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PANTOGRAPH POSITIONING SYSTEM
FOR INSPECTING MICROCIRCUITS

June 1973

Bendix Corporation
Kansas City, Missouri

MASTER

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PANTOGRAPH POSITIONING SYSTEM
FOR INSPECTING MICROCIRCUITS

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Topical Report
PDO 6984522

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PANTOGRAPH POSITIONING SYSTEM FOR INSPECTING MICROCIRCUITS

A pantograph positioning system was developed to facilitate locating the areas on hybrid microcircuits which require visual inspection under high power microscopes. The system significantly increases the speed and reliability offered by manual positioning methods.

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SUMMARY

As part of a project to increase the speed and reliability of visual inspection of complex parts at Bendix Kansas City, a Pantograph X-Y positioning system (PPS) was developed to facilitate the positioning of hybrid microcircuits (HMC) under high power microscopes. To date, the only inexpensive positioning method has been a manual operation involving microscope micrometer stages or gliding stages with no uniform scanning procedure. This method is slow and unreliable. A preliminary comparison of the PPS with the manual positioning method indicated that the PPS reduced positioning time by a factor of four. Equally significant, the error rate was reduced from 4.5 percent to essentially zero.

As a result of this development it was concluded that the PPS significantly improved current techniques, while remaining low in cost. Although developed for use with high power microscopes, the PPS is also recommended for low magnification applications, such as inspection of printed circuit assemblies where it is necessary to direct an inspector's attention to a specific location.

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DISCUSSION

SCOPE AND PURPOSE

The visual inspection of a hybrid microcircuit (HMC) requires locating and inspecting through 100X microscopes as many as 20 to 80 different locations on the circuit. Accurately positioning these locations under the microscope is an extremely difficult task because the high power and small field of view of the microscope prohibits the inspector from realizing which area of the circuit is being viewed. An automatic system, such as a computer-controlled or tape-controlled positioning stage, solves this problem but is expensive (\$8,000 to \$10,000).

Development was initiated under PDO 6984522, Rapid Visual Scanning, to develop a low-cost device to improve the speed and reliability of the positioning process. The most promising concept was based on the Pantograph principle (Figure 1) which mechanically links two points in space and causes them to

Figure 1. Pantograph Principle of Operation (A Reproduces on a Reduced Scale the Movement of B)

move in identical paths except for a scale factor. By attaching an X-Y stage to Point A, its small movements can be accurately controlled by moving Point B through a similar, but larger movement.

ACTIVITY

Description of Pantograph Positioning System

The PPS in operation is shown in Figure 2. The operator positions the X-Y stage containing the HMC under the microscope by manually moving a stylus along a track on an adjacent 10:1 master template. The track has detents which automatically stop the stylus at positions corresponding to locations on the HMC which must be inspected. This procedure allows rapid positioning from one inspection scene to the next and ensures that no inspection locations are overlooked.

Interchangeable master templates (Figure 3) make possible the inspection of any HMC. Its effectiveness is limited only when the number of different inspection locations becomes so dense that they cannot be conveniently connected by the guiding track. Templates having as many as 75 locations are being constructed for future evaluation. The PPS, excluding the microscope, is \$1,000 to \$1,500, and the templates are about \$100 each.

Evaluation of Pantograph Positioning System

In a preliminary evaluation, the PPS was compared with the currently used procedure of manually positioning the stage by only direct, visual alignment. Six members of the Advanced Inspection Department (not experienced inspectors) were test subjects in the evaluation. Since actual HMC's were not available for evaluation purposes, they were simulated with thin pieces of 1 by 1-inch (25.4 by 25.4 mm) white cardboard. Either a small black, blue, or green dot was placed on the cardboard at each location shown in the scale drawing (Figure 4). Four simulated circuits were made: one had all 12 components represented by dots, the other three had from one to three dots omitted to represent missing components. The test subjects were given the drawing shown in Figure 4 and asked to use the PPS and then the unaided technique to inspect each circuit under a 100X microscope and to report the color of each dot present or report as missing those not present. Each inspector was allowed to use the first circuit for learning purposes. The results of the three remaining circuits inspected are shown in Table 1 which includes the inspection time and the errors made in each circuit inspection by each of the two techniques and for each of the six inspectors. An error consisted of either overlooking or incorrectly identifying a component, or of not detecting a missing component.

Figure 2. Pantograph Positioning Systems With HMC Positioned Under Microscope

Figure 3. An Interchangeable Master Template

Figure 4. Relative Locations of the 12 Components on the Test HMC

Table 1. Comparison of HMC Inspection Positioning Methods

		Circuits Inspected Time per Circuit (sec)/Errors per Circuit			
Inspector	Method*	First	Second	Third	Total
1	U	145/0	120/0	85/0	350/0
	P	45/0	40/0	30/0	115/0
2	U	105/0	90/0	85/0	280/0
	P	45/0	35/0	20/0	100/0
3	U	180/0	230/2	180/0	590/2
	P	45/0	40/0	48/0	133/0
4	U	140/0	120/3	180/3	440/6
	P	60/0	30/0	20/0	110/0
5	U	300/1	285/0	270/0	855/1
	P	58/0	38/0	50/0	146/0
6	U	80/0	135/0	125/1	340/1
	P	50/0	45/0	35/0	130/0
*U = Unaided Positioning Method P = Pantograph Positioning System					

Further analysis of Table 1 (based on the overall data of six inspectors checking three circuits each at 12 component locations (216 sample points) indicates that the average time required to move through position-inspection sequence to the next location was 13.2 seconds for the unaided method compared with 3.3 seconds for the PPS. The average error rate per position was 4.6 percent, or 10 errors in 216 points, for the unaided method compared with no errors for the PPS.

ACCOMPLISHMENTS

The PPS reduced the time required for positioning the components under the microscope by a factor of 4. In non-HMC inspections, similar advantages exist. For example, printed circuit assemblies and intricate plastic parts sometimes require inspection in many locations which are similar in appearance. Though little, if any, magnification is required for these assemblies, the PPS would efficiently direct the inspector's attention to each location in sequence, with the assurance that no location will be overlooked.

FUTURE WORK

A PPS has been provided to the hybrid microcircuit inspection department. No further PPS development is anticipated, unless a modification of the current PPS concept is indicated for improvement of function.