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MANUFACTURING METHODS AND TECHNOLOGY ENGINEERING FOR NEODYMIUM --ETC(U)
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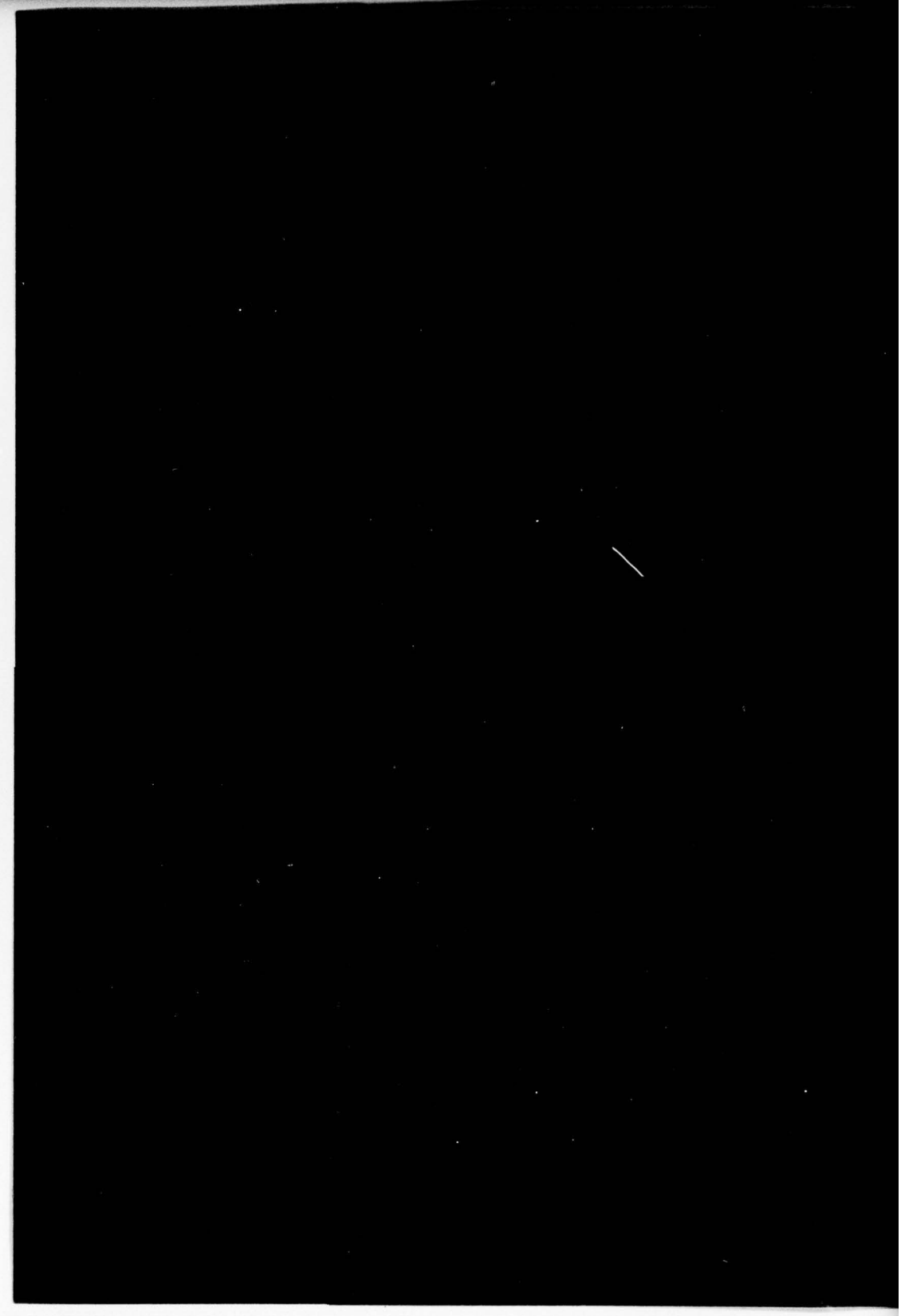

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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Manufacturing Methods and Technology
Engineering for Neodymium Doped YAG Laser Rods

D. Dentz

Second Quarterly Progress Report
June 1, 1977 to August 31, 1977

Contract No. DAAB07-77-C-0375

The objective of this program is to develop the production engineering techniques for multiple rod fabrication of Nd:YAG laser materials to a set of specifications typical of a system rod.

ABSTRACT

The polishing fixture designed to hold sixteen rods during fabrication was received during this quarter. Using this fixture several lots of rods were processed to evaluate the proposed polishing process. Process data, times and yields were obtained. Rods were measured for adherence to specifications and data collected as a function of rod position within the block.

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PURPOSE

The purpose of this production engineering program is to develop the mechanical and optical processes for multiple rod fabrication of neodymium doped YAG laser material. Control of quality is to be obtained through test procedures designed to meet the specifications of a typical system rod.

1.0 INTORDUCTION

The object of this MM & TE program is to attain a polishing rate for Nd:YAG laser rods of twelve rods per eight hours. To attain this rate a polishing fixture was designed and constructed to hold sixteen rods such that both ends could be polished without remounting of rods. This fixture is to be used in conjunction with a polishing process similar to that used for processing single rods. The first experimental runs using this fixture were made during this quarter. Particular attention was made to the ability of the fixture and process to produce rods meeting the required specifications. In the following sections more detailed information on the fixture, process and the results obtained will be presented.

2.0 FIXTURING AND TOOLING

The polishing fixture to be used in the program was designed to hold sixteen rods during the grinding and polishing operations. The design of the fixture was reported in the First Quarterly Report. A photograph of the fixture is shown in Figure 1.

The two critical laser rod parameters which can be effected by the fixture design are rod end face perpendicularity and parallelism. If the rod mounting holes are not sufficiently perpendicular to the block face and parallel to one another perpendicularity would be effected. If the mounting holes are not straight then the rod could be stressed in mounting and thus yield poor parallelism.

One of the objects of the polishing runs made during this quarter was to verify that the required specification could be achieved. The results of the first runs indicate that the fixture will be capable

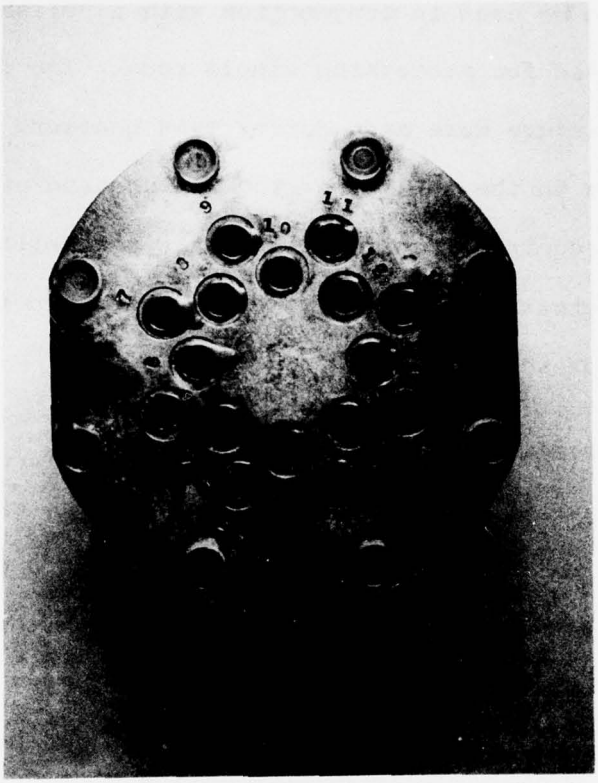

Figure 1. Polishing Fixture

of achieving the required specifications. All of the rods processed met the required perpendicularity, and all but one the required parallelism. A more complete discussion of the results is given in Section 4.0.

3.0 MANUFACTURING PROCESS

Rods are coredrilled, centerless ground and sized in preparation for mounting in the polishing fixture. The block is then heated with the rods in position and the rods are wax mounted. The assembly is cooled and the rod ends ground with a grinding wheel. At this point the rods are prepared for the final grinding and polishing operations.

The final grinding and polishing is composed of three grinding and two polishing steps for each of the two ends. The slurry composition, lap rotation rates and approximate material removals achieved are shown in Table I. Glass laps were used throughout the processing. In each case the slurry is prepared on the lap. If the slurry becomes too thick during the course of processing additional water is added as required.

The proper lap rotation rate is established prior to placing the block of rods on the lap. In processing, the block of rods is moved in a circular or figure eight pattern across the lap. The block is rotated by 90° after an approximately equal number of strokes in each direction. During first end processing frequent dimensional measurements are taken to assure that the surfaces are being worked evenly and proper perpendicularity achieved. Final perpendicularity is assured through use of an autocollimator.

TABLE I

MANUFACTURING PROCESS

Step	Slurry Grit (grams)	Slurry Water (ml)	Lap Rotation Rate (rpm)	Approximate Material removal (in.)
Grind 20μ Al_2O_3	50	50	8	0.002
Grind 12μ Al_2O_3	40	40	8	0.0005
Grind 5μ Al_2O_3	25	40	8	0.0003
Polish 1μ Al_2O_3	10	50	8	0.0004
Polish 0.3μ Al_2O_3	1	50	8	-

During processing surface finishes are frequently examined to assure that the work damage from the previous step is completely removed. When this is achieved the next step is started. The laps used are cleaned with soap and water between each processing step and are reground as necessary.

Upon achieving the specified surface finish and flatness on the first ends, the block is turned and the first ends covered to protect them from any possible contamination. Polishing of the second ends follows the same procedure used on the first ends. During the final steps, however, parallelism rather than perpendicularity is monitored.

When proper parallelism, surface finish and flatness of second ends are achieved, the process is complete and interferograms of each rod are recorded. The rods are then dismounted and submitted for testing. The results obtained applying this process to several groups of rods is discussed in the following section.

4.0 DATA AND ANALYSIS

During the quarter thirty-two rods were processed on one end only for evaluation of perpendicularity and initial process data. Fifteen rods were processed both ends. This run yielded initial parallelism data as well as overall yield.

The results with respect to perpendicularity for all rods processed are shown in Table II. The perpendicularity requirement is five minutes. From the table it can be seen that all rods processed met this specification. The highest value measured was 3.5 minutes. Only one position in the block yielded consistantly high values and that is still well within the required specification.

TABLE II

PERPENDICULARITY

Position	Perpendicularity (min.) Run I	Run II	Run III
1	3.0	3.5	-
2	2.0	2.0	3.0
3	1.0	1.5	0.75
4	2.5	1.5	1.5
5	1.0	1.5	2.0
6	1.0	0.5	0.5
7	0.5	1.5	1.25
8	1.5	3.5	3.0
9	0.75	2.0	1.5
10	0.75	0.5	1.0
11	1.0	0.7	3.0
12	0.5	1.5	2.0
13	2.0	1.5	3.0
14	2.0	0.5	1.0
15	1.5	1.5	3.0
16	0.5	0.5	1.0

TABLE III

ROD DATA

Position No.	Parallelism (sec.)	Flatness (λ)	Surface Finish
1	no	rod	
2	12	.1	0-0
3	<10	.1	0-0
4	<10	.1	0-0
5	<10	.1	0-0
6	16	.1	0-0
7	<10	.1	0-0
8	<10	.1	0-0
9	12	.1	0-0
10	25	.1	0-0
11	12	.1	Scratched & pitted
12	16	.1	0-0
13	<10	.1	0-0
14	<10	.1	0-0
15	16	.1	0-0
16	<10	.1	0-0

The results of the run where both ends were polished are shown in Table III. As can be seen flatness was no problem with all rods meeting the required specifications. On the critical areas of parallelism and surface finish only one rod was out of specification for each parameter. The overall yield was thus 13 of 15 rods processed.

Throughout the processing no major problems were encountered with either the fixture or manufacturing process. The actual time spent in grinding and lapping was minimal. The largest amount of time was spent in monitoring the critical parameters of perpendicularity, parallelism and surface finish.

5.0 CONCLUSIONS

The results of the initial polishing experiments were very promising. The overall process yield of thirteen rods is above the 75% yield (12 rods) required from the block. No difficulties were encountered in achieving the required specifications with respect to critical rod parameters.

No overall process times have been obtained yet. Initial results, however, indicate that actual grinding and polishing times will not be a limiting factor. Future work will address the areas of actual process time and time spent in peripheral areas of monitoring flatness, parallelism, perpendicularity and surface finish. These areas will be significant in the determination of the overall process rate.

6.0 PROGRAM FOR NEXT QUARTER

Polishing experiments using the fixture for processing both rod ends will continue during the next quarter. Additional information on process rates and yields will be obtained. Two critical areas that

will be addressed will be the method of rod mounting and its effect on parallelism and the method of monitoring parallelism during fabrication. Data on critical parameters will be obtained before and after dismounting of rods.

During the quarter assembly of test equipment will continue in preparation for first deliveries.

7.0 IDENTIFICATION OF PERSONNEL

The following is a list of the engineering and manufacturing personnel who contributed to the program during this quarter.

Engineers and Technicians	Hours this Quarter	Cumulative Hours
Dentz, D.	160	280
Turner, S.	40	80
Belt, R.	20	35
Lowe, I.	25	35
O'Neill, J.	40	50
Manufacturing	75	75
TOTALS	360	555

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