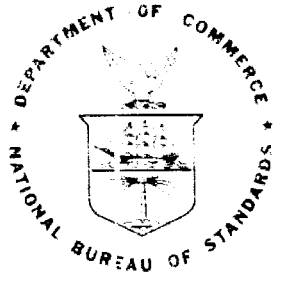
NBSIR 73-232

A Survey of the Stability of Optical Flats

Charles P. Reeve
Ralph C. Veale

Institute for Basic Standards
National Bureau of Standards
Washington, D. C. 20234

June 25, 1973



U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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U. S. DEPARTMENT OF COMMERCE, Frederick B. Dent, Secretary
NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director

A Survey of the Stability of Optical Flats

by

Charles P. Reeve and Ralph C. Veale

1. Introduction

The National Bureau of Standards has occasionally been asked how often optical flats should be calibrated. The motivation for this question seems to be a concern on the part of the optical flat owner about the expected long range stability of his flat. It would be futile to try to answer this question directly because optical flats are used in many different situations and different levels of accuracy are required in each case. Perhaps the best way to approach this problem is to study the case histories of several flats which have been regularly calibrated over a number of years. The frequency of use for all of them is not known, but is believed to range from virtually no use to almost daily use.

2. Method of Sampling

The most commonly calibrated flats for which records exist between 1959 and 1972 are those of ten inches in diameter. Five of these flats were calibrated at least three times during that period and are included in this survey. Also included, are the most frequently calibrated four, six, and eight inch flats. The four inch flat was coated and the coating was noted to be wearing. The only flat which belongs to NBS is the ten inch master flat #1-3. The frequency of calibration of these flats was once every two to four years.

3. Graphical Display

In order to enhance the interpretation of the optical flat profiles, the profiles are presented as graphs instead of numbers in figures 1 through 19. Each line represents the profile of the flat along the given diameter. Measurements were made at the positions where a vertical slash (|) appears, and then a smooth curve composed of weighted parabolas was fitted to the measured values. This curve is believed to give a good estimate of the actual surface profile.

The variations in the profiles can be attributed to three main sources:

(1) random and systematic error in a single calibration

(2) a between time component of error due to variation in the setup procedures

(3) a long-term physical change in the surface profile of the flat (instability).

The current method of calibration for a typical flat has a three standard deviation limit for random error of measurement of about 0.10 microinch. The limit for master error is estimated not to exceed 0.25 microinch giving a total uncertainty of 0.35 attributable to the first source. Methods for separating errors from the second and third sources have not been devised. It is believed, however, that errors from the second source do not exceed the random component of error in the measurement process.

4. Conclusions

In all cases except figures 10 and 11, it is apparent that the long term variation in profile of an optical flat is quite small. (Figures 10

and 11 give a strong indication that either the flat was refinished between calibrations or that a possible mistake in sign was made in reducing the data.) This does not necessarily mean that optical flats should be calibrated only once. Repeated calibrations serve as checks on previous calibrations and also give an indication of the total variability of the optical flat.

It is up to the user to weigh the above factors as he examines his own particular needs and then conclude how frequently he should have his optical flat calibrated.

TABLE I

Years of Calibration for Selected Optical Flats

Optical Flat Identification	Diameter	Years of Calibration	Figure No.
NBS #1-3	10"	50 54 64 68	1
#Q-0513	10"	68 69 71	2-5
#EPP-1	10"	61 66 67 69	6-7
#ACL82414	10"	63 64 66	8-9
#852	10"	60 62 66	10-11
#TI	8"	59 61 62 64 65 66 67 69	12-13
#VK6224	6"	64 65 69 71	14-17
#VK4505	4"	64 65 66 67 68	18-19

Bibliography

1. Dew, G. D., The Measurement of Optical Flatness, Journal of Scientific Instruments, Vol 43, pp 409-415, 1966.
2. Emerson, Walter B., Determination of Planeness and Bending of Optical Flats, Journal of Research of the National Bureau of Standards, Vol 49, No. 4, pp 241-7, October 1952.
3. Reeve, Charles P., The Calibration of an Optical Flat by Interferometric Comparison to a Master Optical Flat (in preparation).

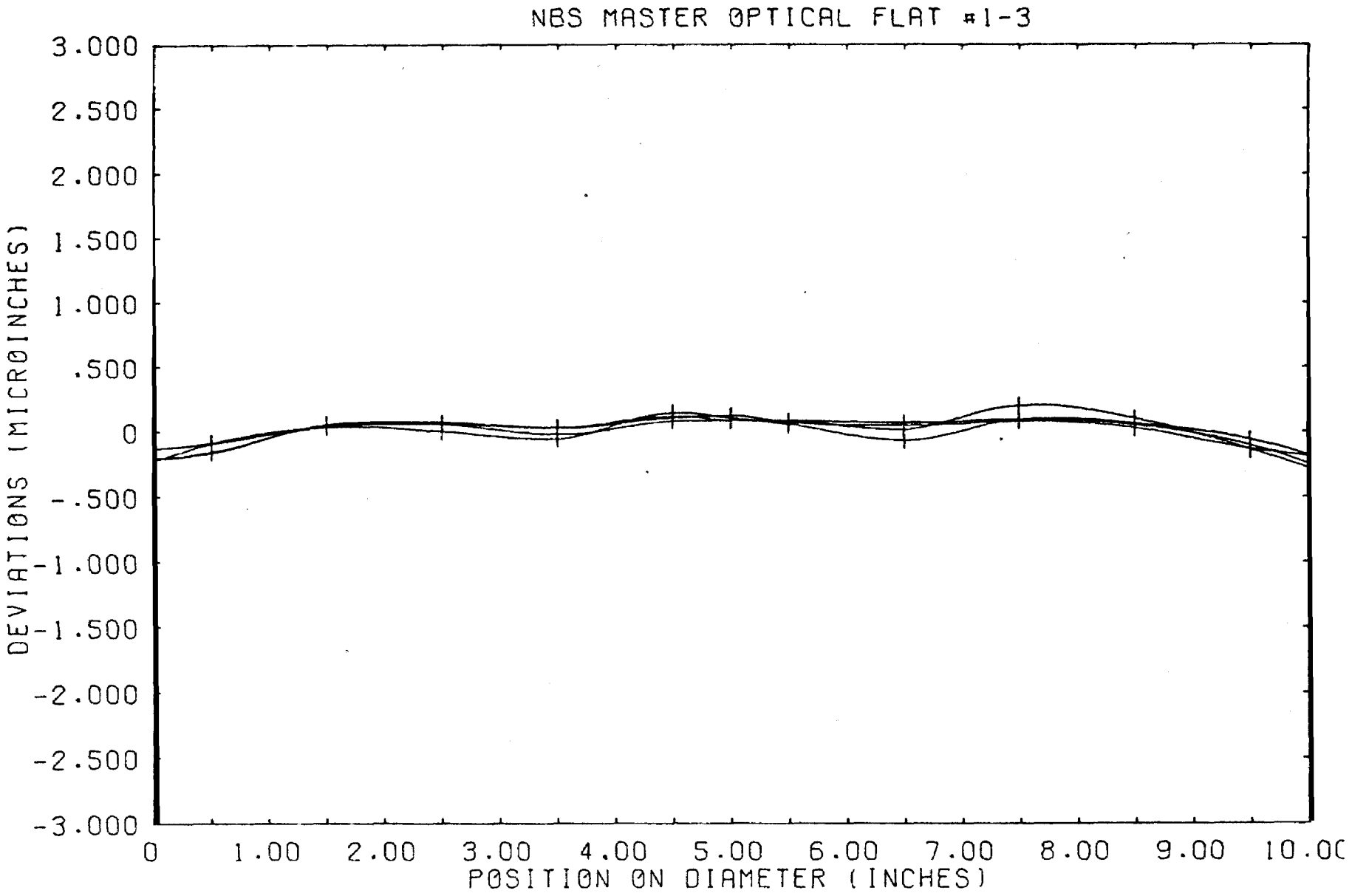

NBS MASTER OPTICAL FLAT #1-3
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 1

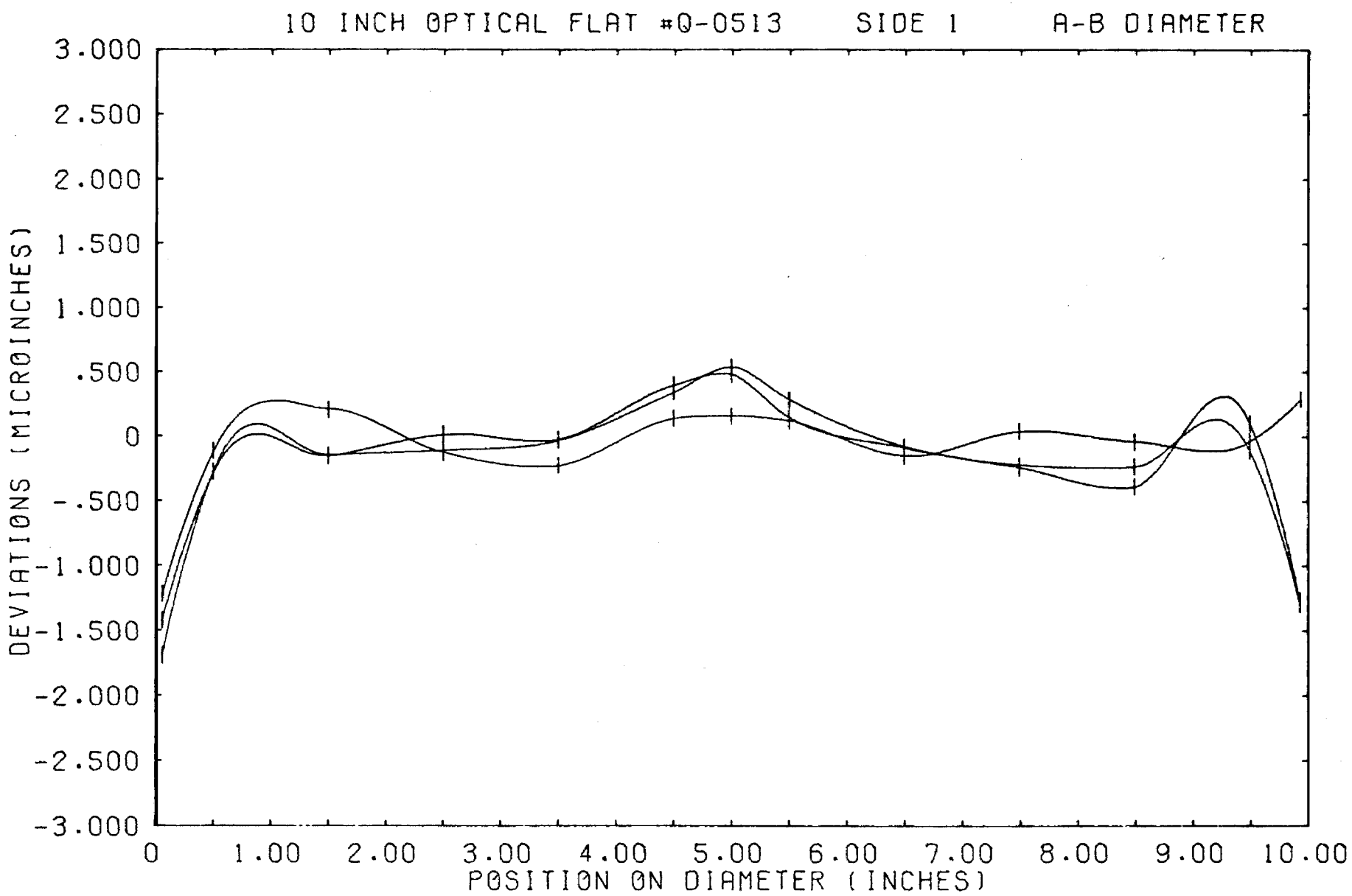

10 INCH OPTICAL FLAT #Q-0513 SIDE 1 A-B DIAMETER
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 2

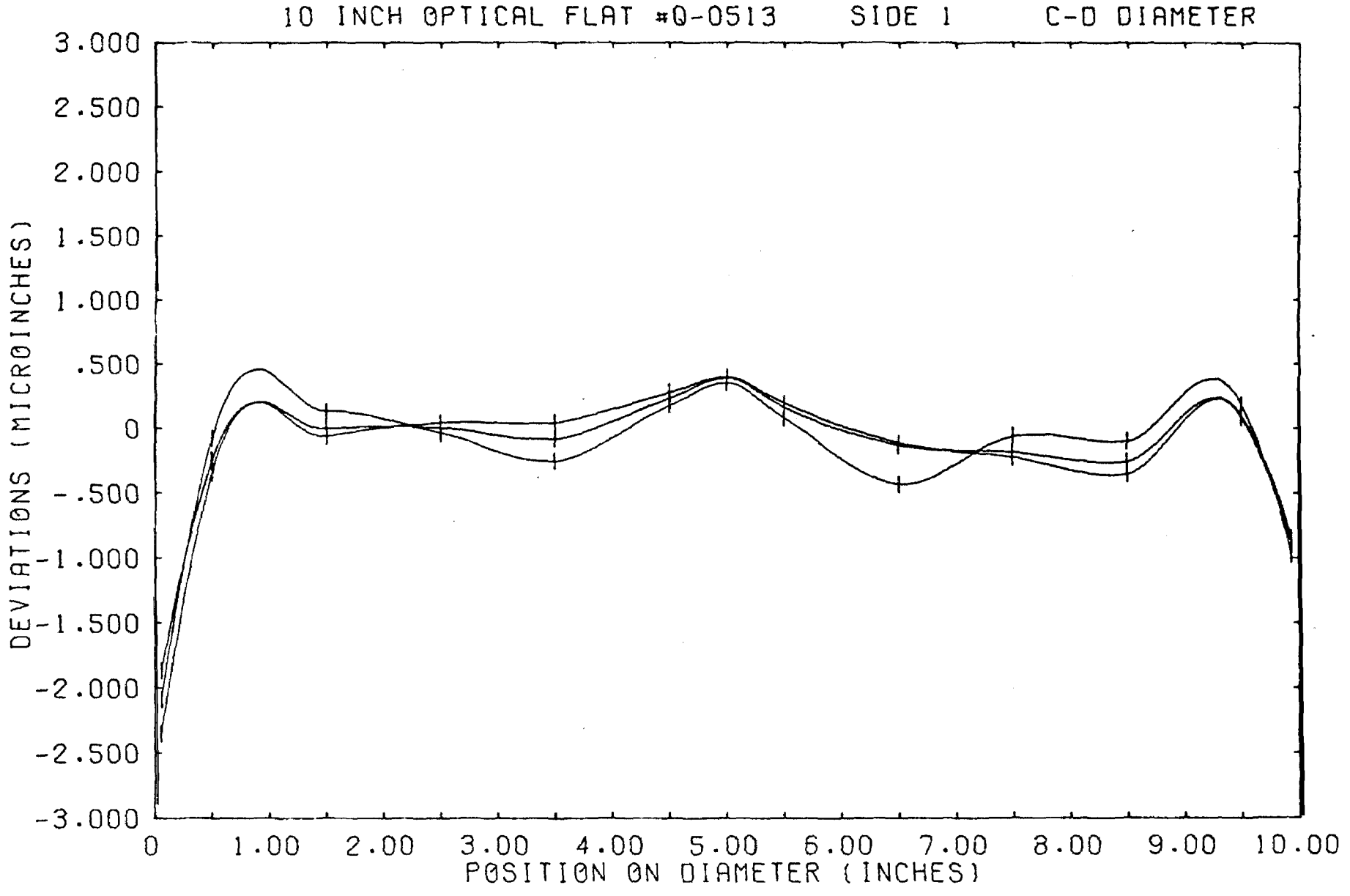

10 INCH OPTICAL FLAT #Q-0513 SIDE 1 C-D DIAMETER
DEVIATIONS (MICROINCHES)
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 3

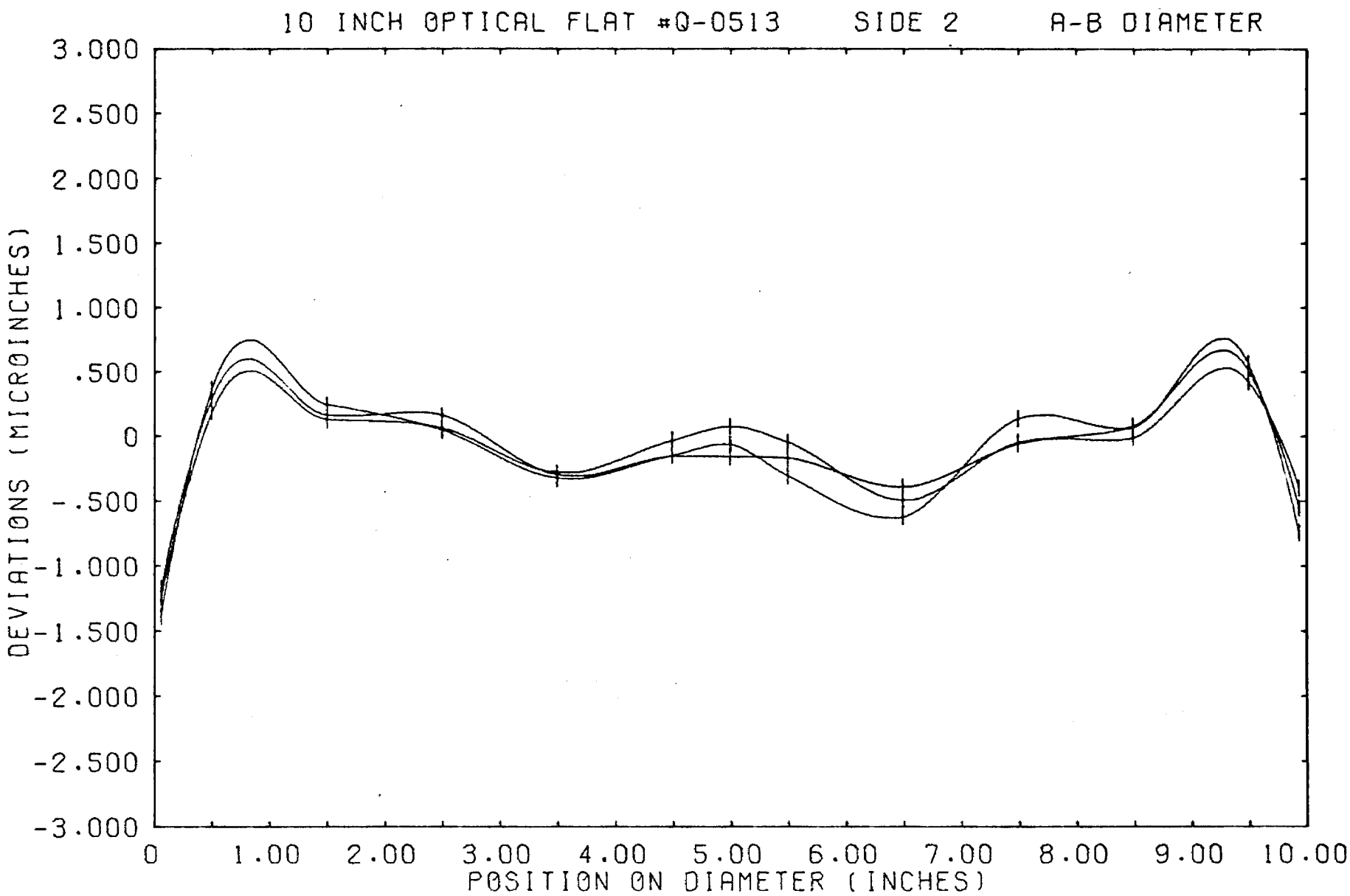
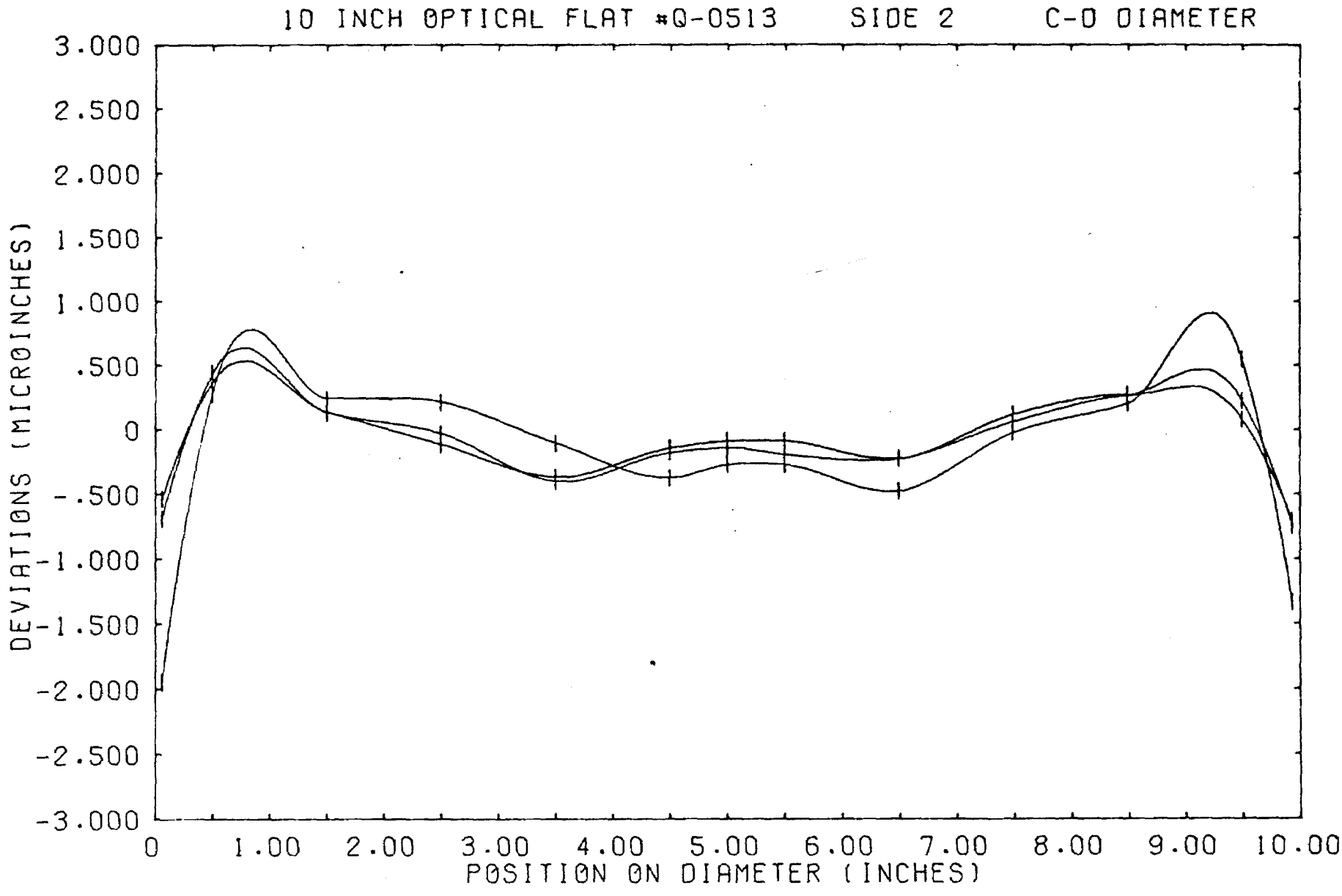

10 INCH OPTICAL FLAT #Q-0513 SIDE 2 A-B DIAMETER
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 4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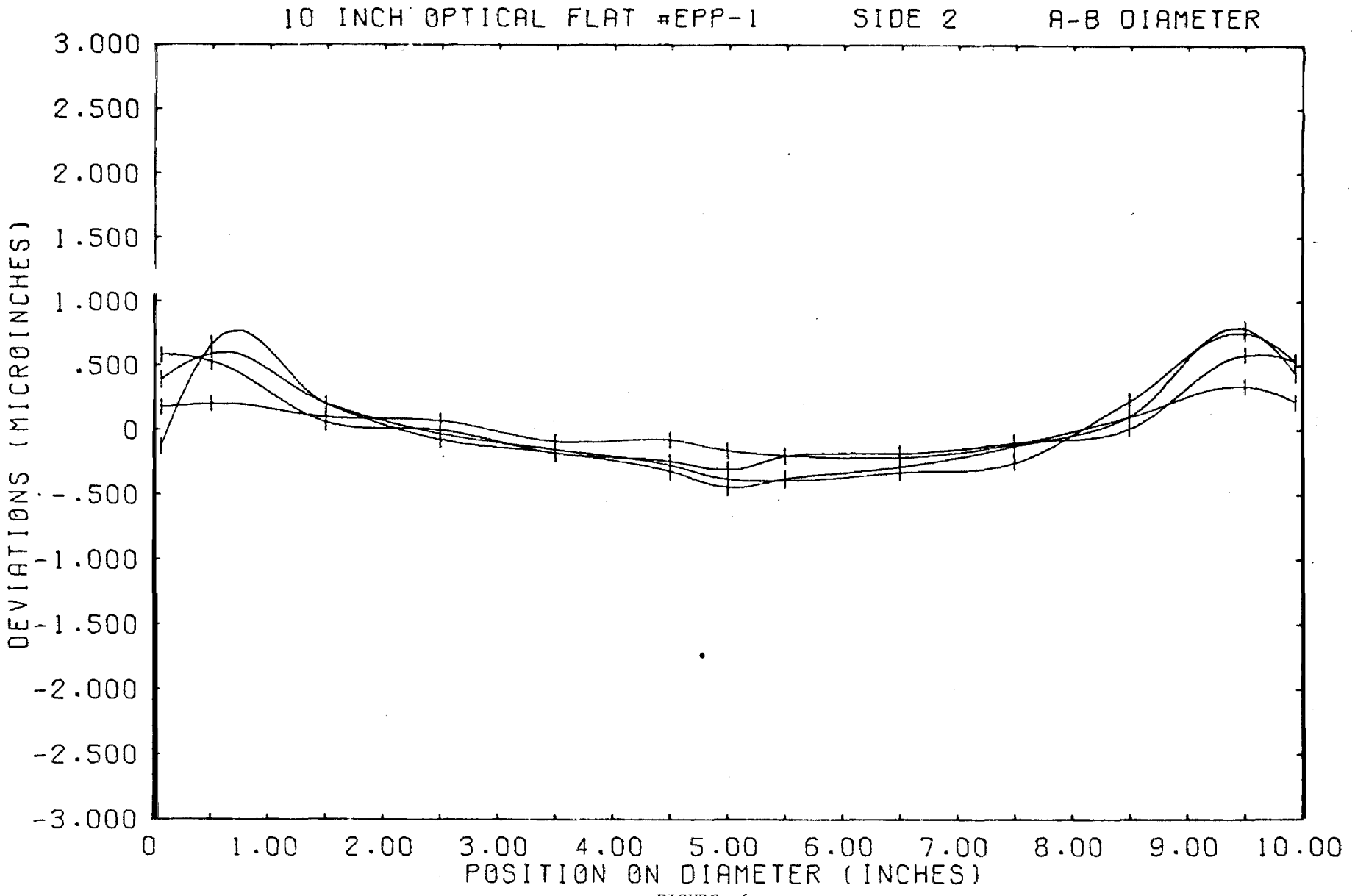
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 5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3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 6

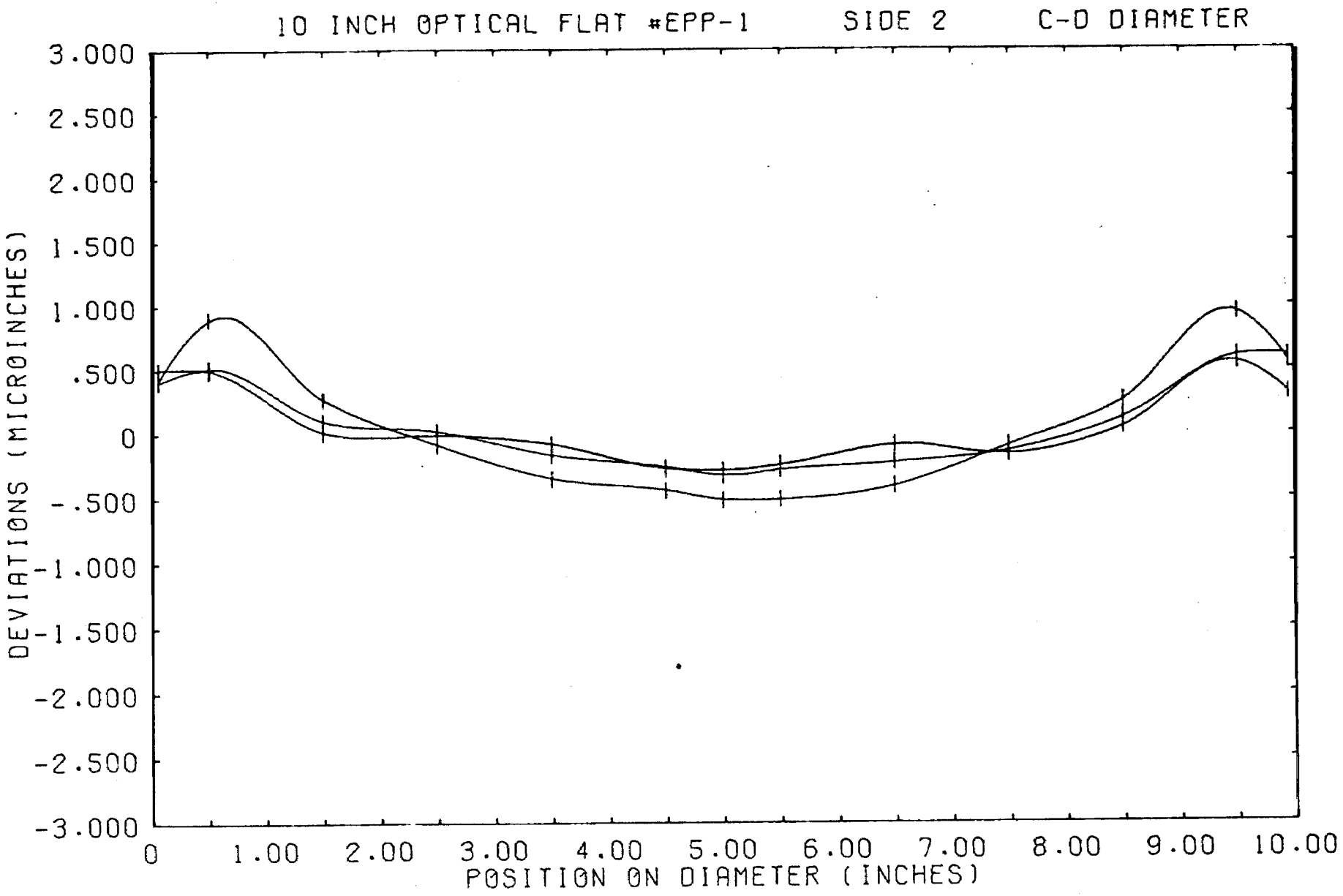

10 INCH OPTICAL FLAT #EPP-1 SIDE 2 C-D DIAMETER
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 7

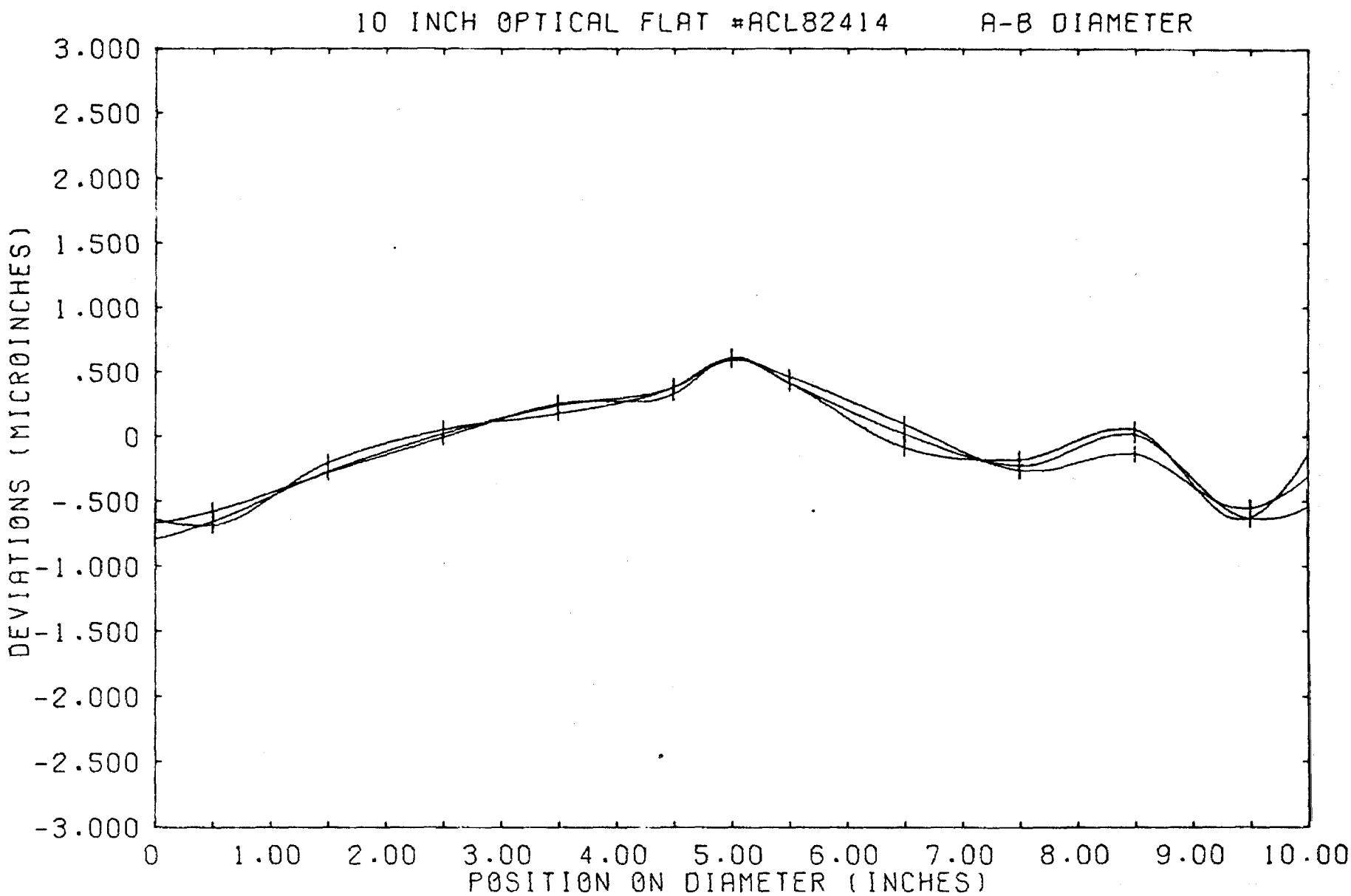

10 INCH OPTICAL FLAT #ACL82414 A-B DIAMETER
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 8

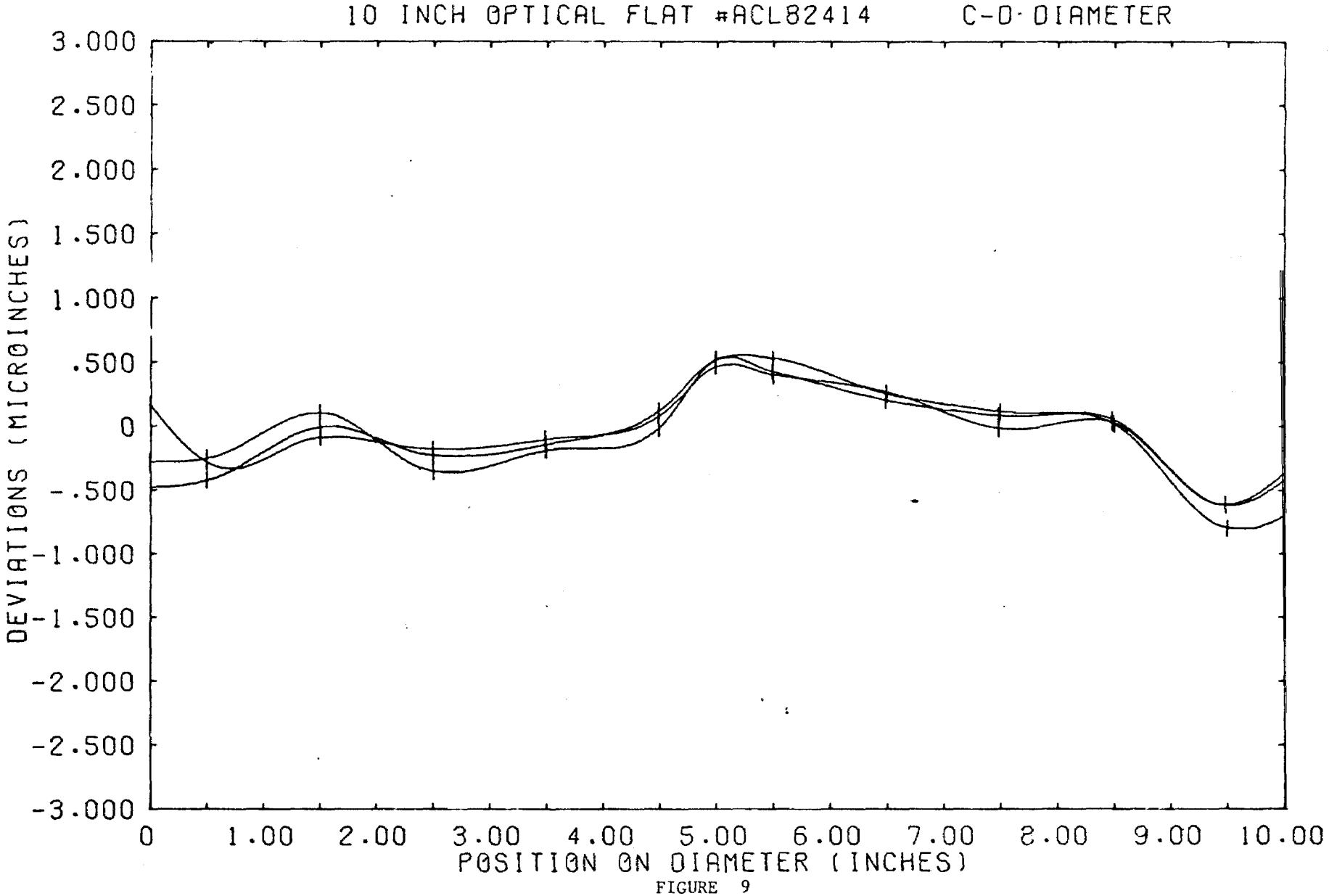
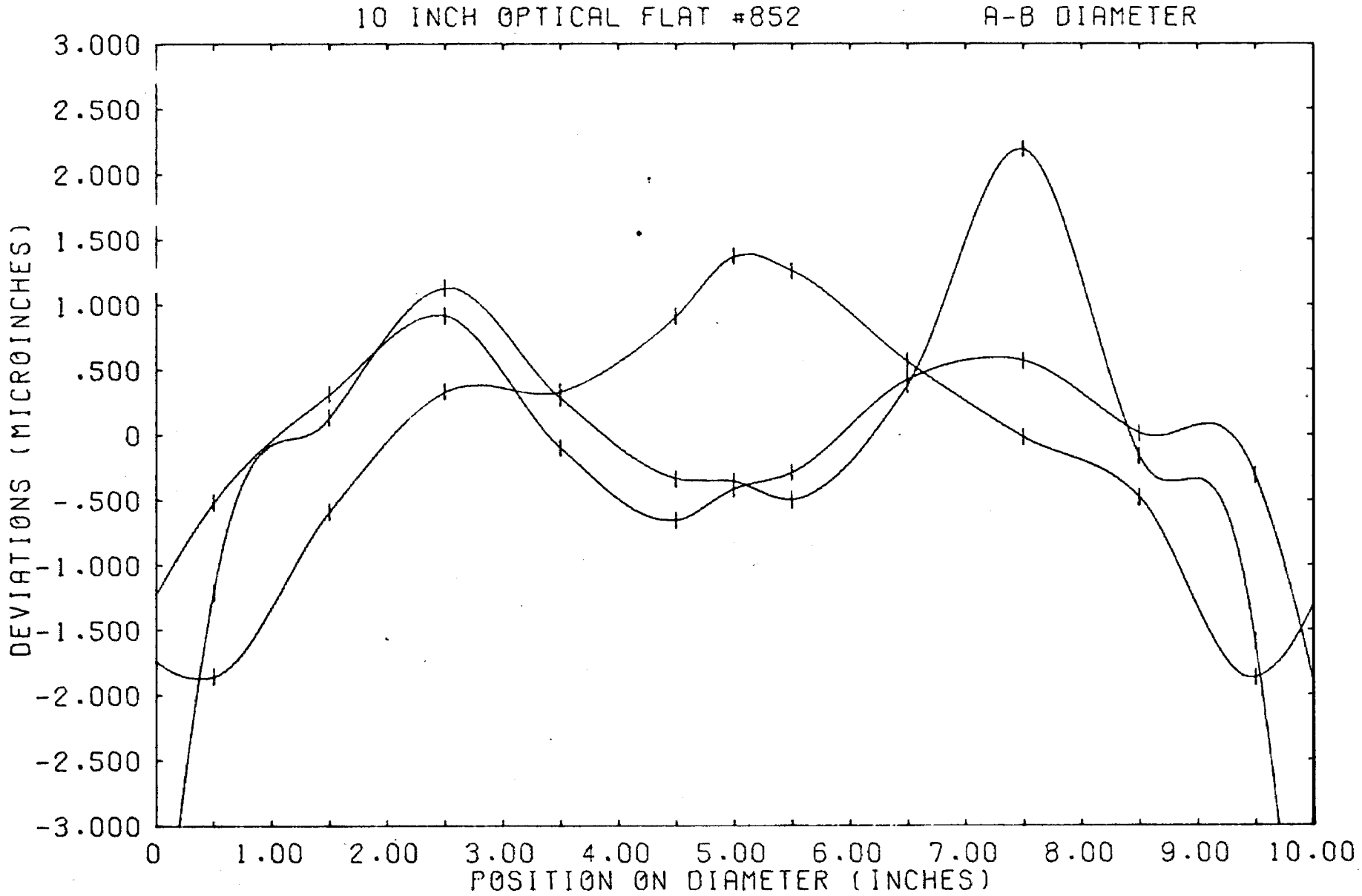

10 INCH OPTICAL FLAT #ACL82414 C-O-DIAMETER
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 9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A-B DIAMETER
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 10

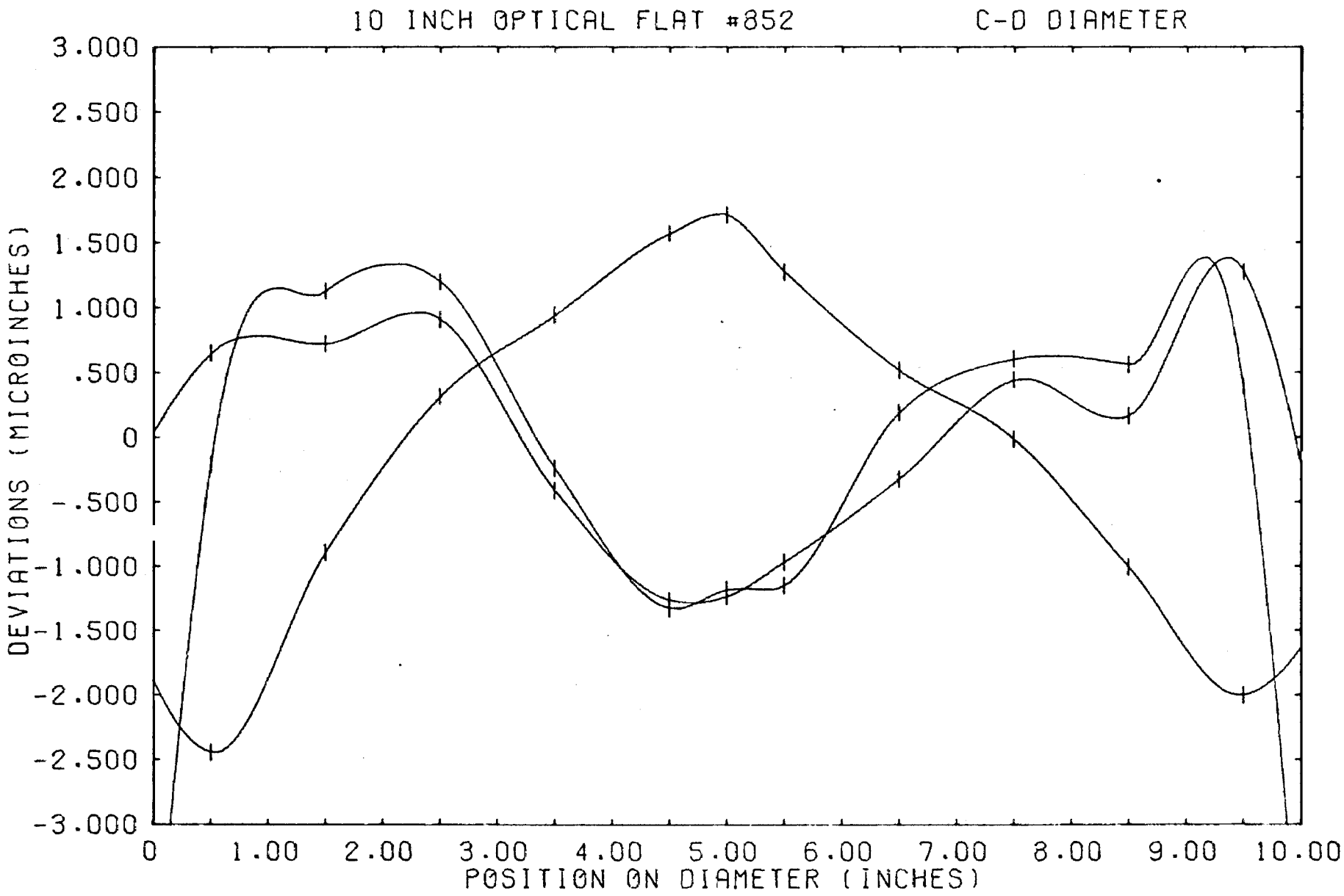
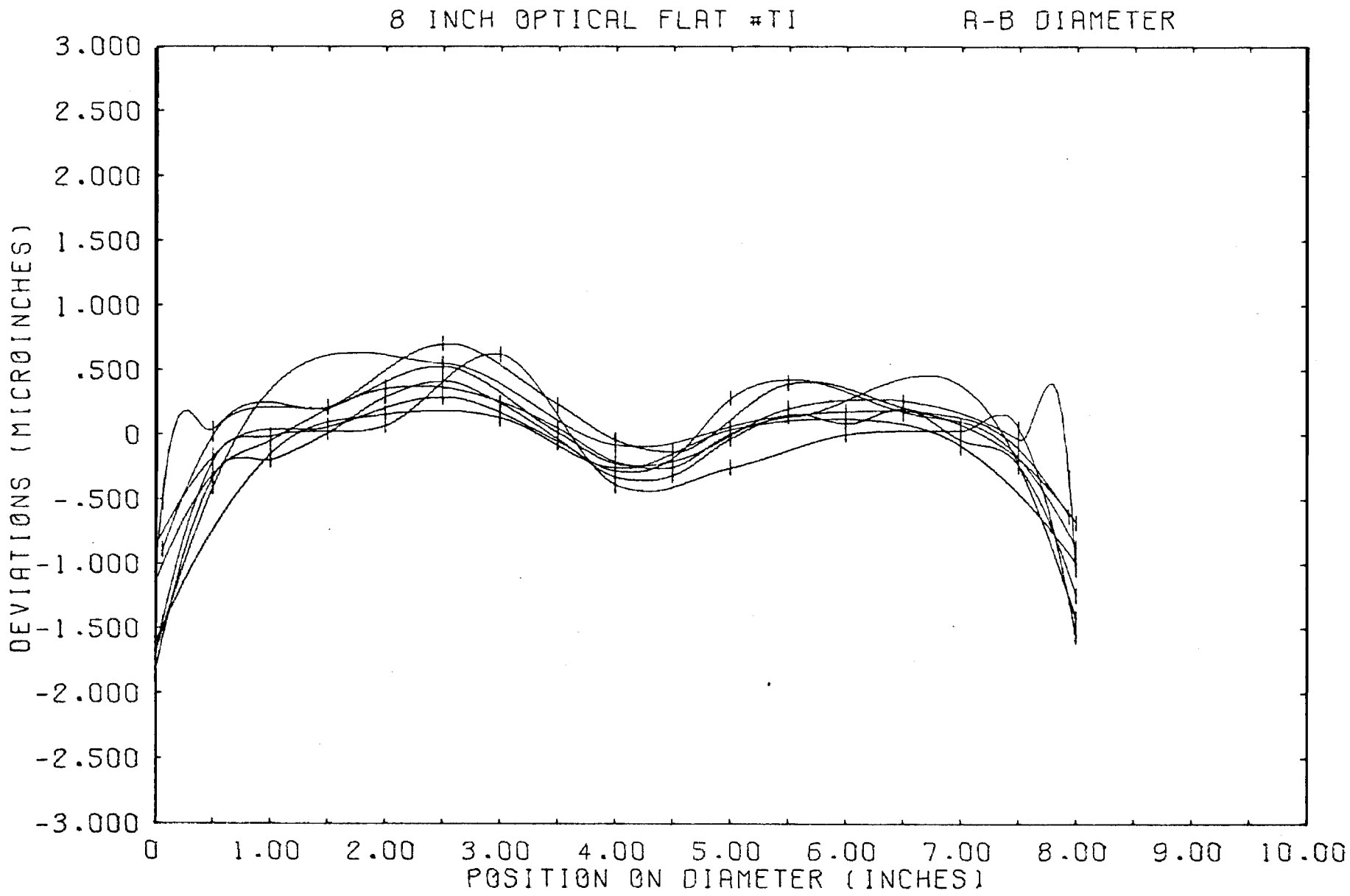

10 INCH OPTICAL FLAT #852
C-D DIAMETER
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 11


8 INCH OPTICAL FLAT #TI
A-B DIAMETER
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
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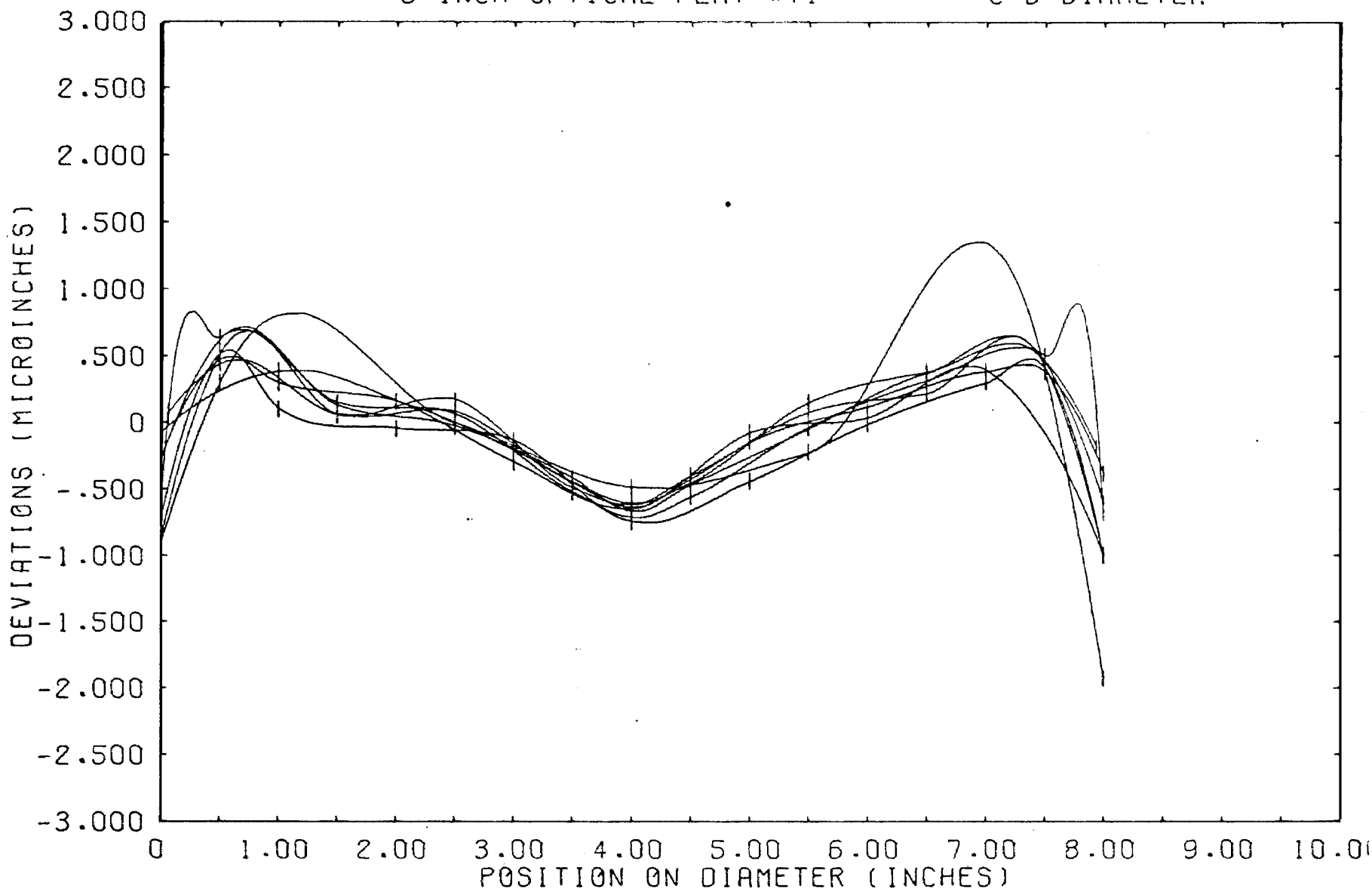
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 12


8 INCH OPTICAL FLAT #TI
C-O DIAMETER
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
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3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.0
POSITION ON DIAMETER (INCHES)

FIGURE 13

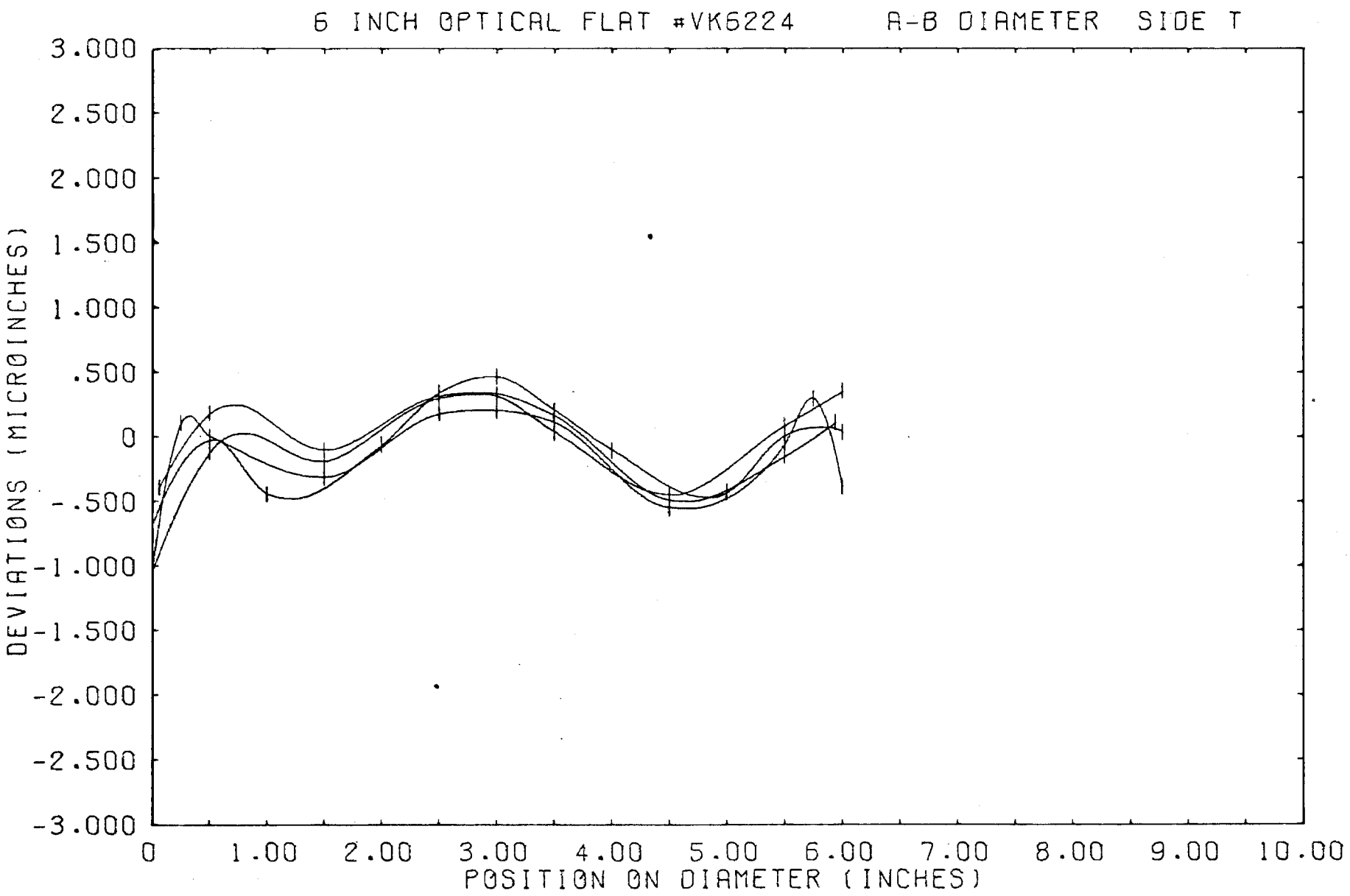
6 INCH OPTICAL FLAT #VK6224 A-B DIAMETER SIDE T
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 14

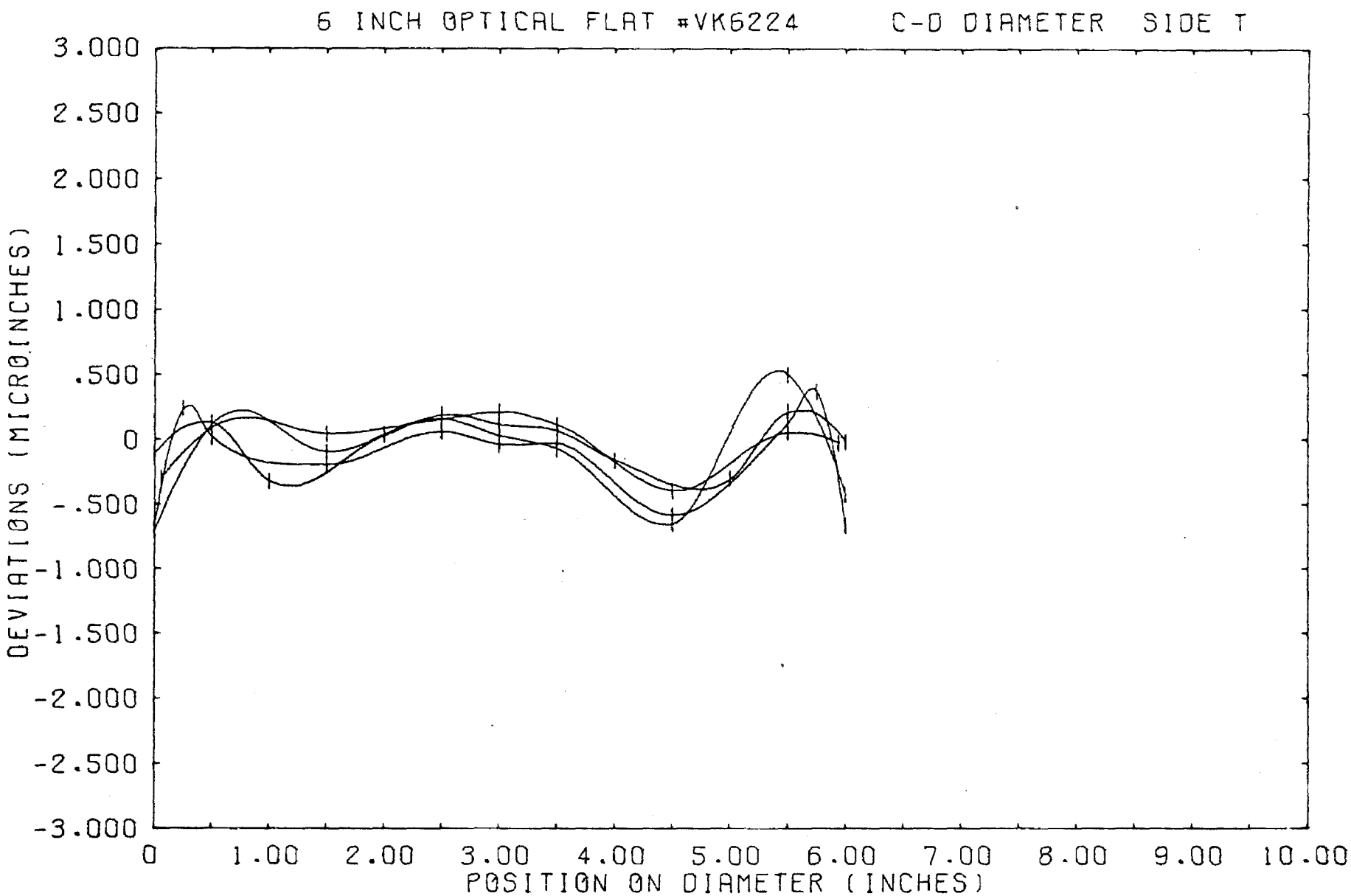
6 INCH OPTICAL FLAT #VK6224 C-O DIAMETER SIDE T
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 15

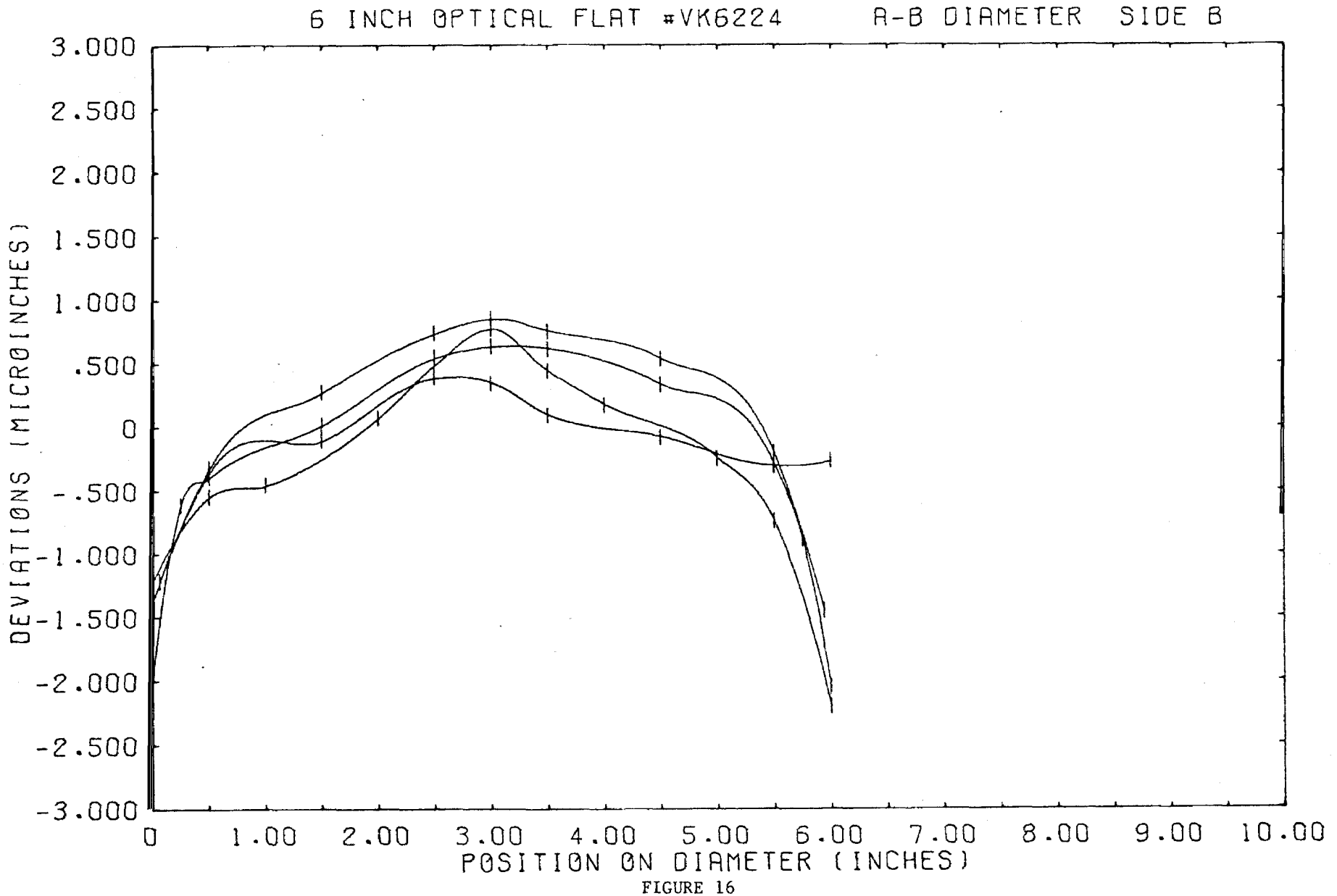
6 INCH OPTICAL FLAT #VK6224 A-B DIAMETER SIDE B
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 16

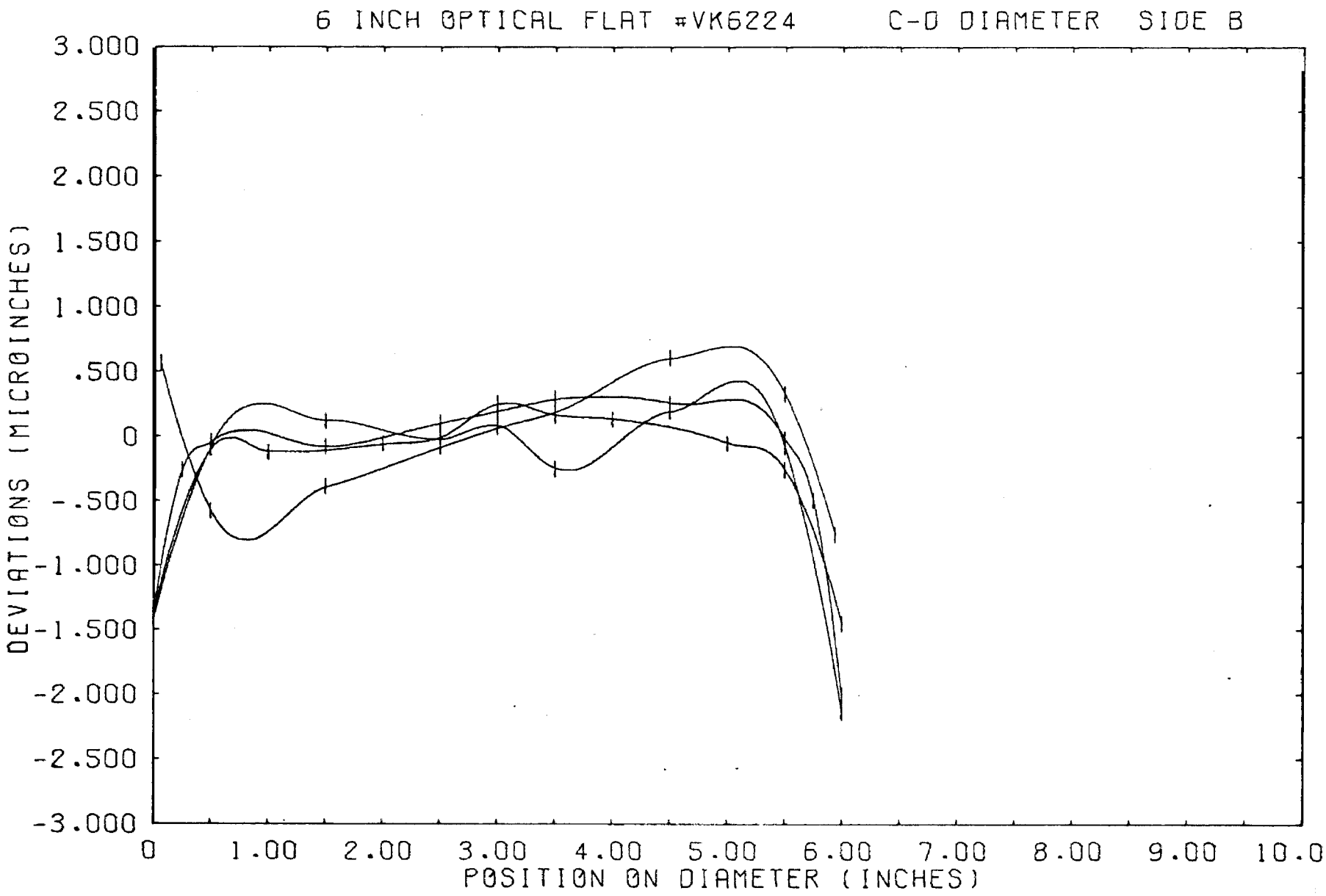
6 INCH OPTICAL FLAT #VK6224 C-O DIAMETER SIDE B
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.0
POSITION ON DIAMETER (INCHES)

FIGURE 17

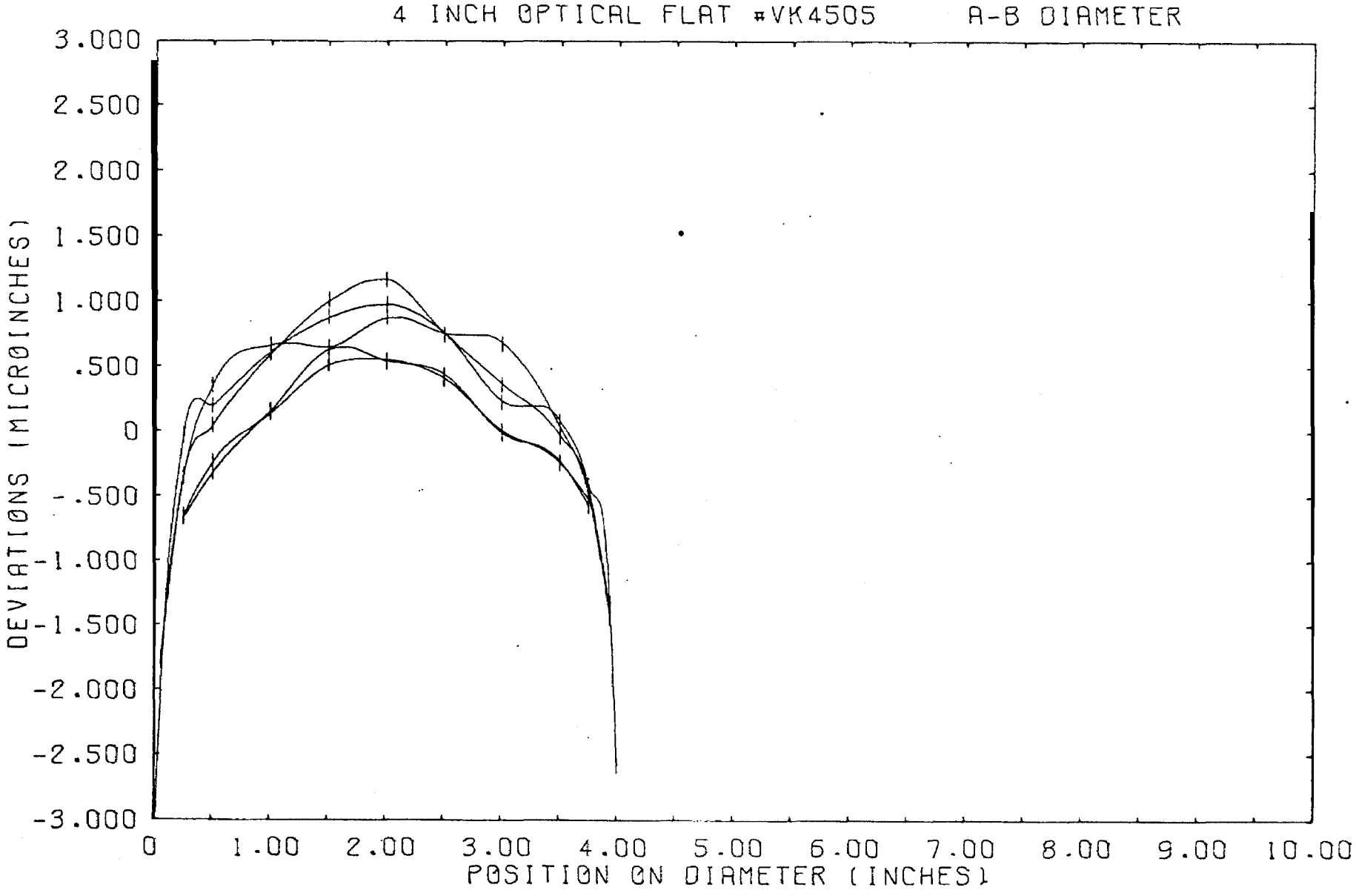
4 INCH OPTICAL FLAT #VK4505 A-B DIAMETER
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
POSITION ON DIAMETER (INCHES)

FIGURE 18

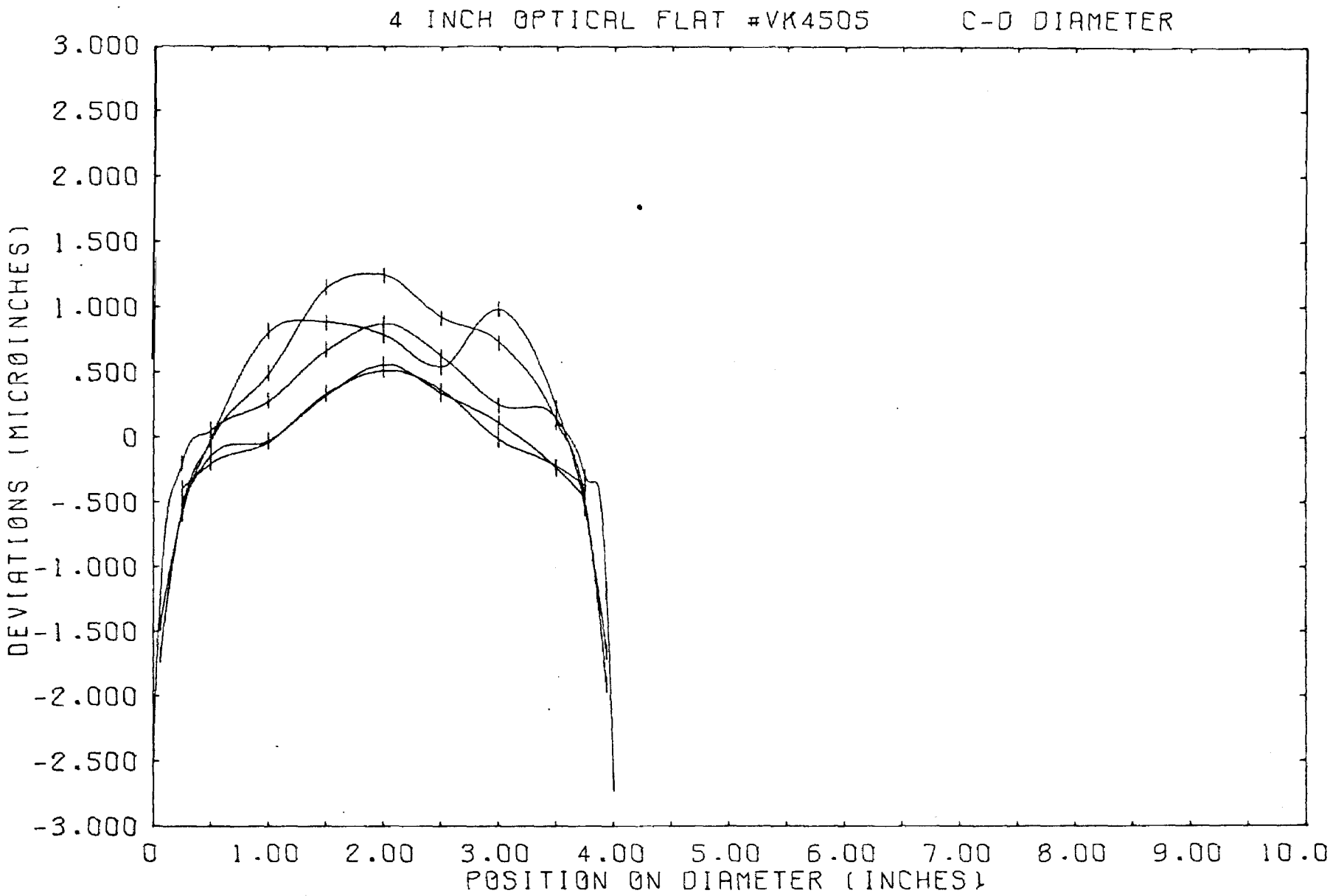
4 INCH OPTICAL FLAT #VK4505 C-O DIAMETER
3.000
2.500
2.000
1.500
1.000
.500
0
-.500
-1.000
-1.500
-2.000
-2.500
-3.000
DEVIATIONS (MICROINCHES)
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.0
POSITION ON DIAMETER (INCHES)

FIGURE 19

FORM NBS-114A (1-71)

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15. SUPPLEMENTARY NOTES

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

Some optical flat owners are concerned about the long term stability of their optical flats. To examine this problem, a survey was made of several optical flats which were calibrated by the National Bureau of Standards at least three times during the period from 1959 to 1972. The measured profiles of these flats are presented graphically so that the different calibrations can be compared. The conclusion of this survey is that optical flats are quite stable over a period of several years, but since the individual requirements for precision may vary greatly, it should be left up to the owner to weigh the appropriate factors in determining how frequently he needs his optical flat calibrated.

17. KEY WORDS (Alphabetical order, separated by semicolons)
Calibration; optical flat, profile; stability; standard deviation.

18. AVAILABILITY STATEMENT

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