ENGINEERING RESEARCH INSTITUTE
THE UNIVERSITY OF MICHIGAN
ANN ARBOR

A MACHINABILITY EVALUATION OF GROUPS XII—XVI OILS ON THE MULTIPLE-SPINDLE AUTOMATIC SCREW MACHINE

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Project 2080

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CONCLUSIONS

1. The levels of 175 microinches for turning and 200 microinches for forming appear to be satisfactory in adjudging the tool life (number of pieces per tool grind) when evaluating cutting fluids on the multiple-spindle, automatic screw machine. In some cases, however, visual inspection of the samples was used to supplement the graphical data, as was explained in the "Test Results."

2. In the machining of various steels on a multiple-spindle, automatic screw machine, the 4316 oil shows better characteristics in heat transfer, and the resulting improvement in tool life (indicated by surface roughness as a criterion), than do the other oils, with oils L589 and 4332 running a close second in all-around performance.

3. Feeds of 0.0031 inch/revolution for turning and 0.001 inch/revolution for forming seem to give reasonable tool life on the various steels that are included in this study. The feed of 0.004 inch/revolution which was used on the second forming operation was definitely too heavy and resulted in short tool life in all cases. A cutting speed of 117.5 feet per minute is reasonable on the AISI 1141 and 4145 materials, but should be reduced for production on the 8620 steel to insure a larger number of parts per tool grind.

AN EVALUATION OF OILS NO. L581, L589, 4332, AND 4316 AS APPLIED TO THE OPERATION OF A NEW BRITAIN-GRIDLEY, 6-SPINDLE, AUTOMATIC SCREW MACHINE IN THE MACHINING OF AISI 1141, 4145, AND 8620 STEELS

Operating Conditions

Machine

A New Britain-Gridley Model 60, 6-spindle, automatic screw machine was used in the testing of three steels and four oils for this series of tests.

Oils

Oils No. L581, L589, 4332, and 4316 as received from the company were used in the above machine. Test samples of each of the first two oils were sent to the laboratory for verification of condition.

Steels

The certification of analysis of each material from the supplier and the Brinell Hardness Number (BHN) are listed as follows:

Steel	C	Mn	P	S	Si	Cr	Mo	Ni	BHN 3000-kg load
1141	.41	1.37	.025	.090	.10				223
4145	.44	1.04	.021	.021	.28	1.05	.13		223
8620	.21	.86	.019	.023	.31	.49	.17	.50	217

The 4145 and 8620 steels were prepared in an annealed and cold-drawn condition and the 1141 in a cold-finished state. All materials were 13/16 inch outside diameter and from 10 to 12 feet in length.

Cutting Tools

Turning.—The turning tools were M-3-D High-Speed Steel (Universal Cyclops) of 6% Mo, 4% Cr, 2.4% V, and 6% W. The tools were ground to the following signatures:

Oil	1st turn	2nd turn
L581	17,2,8,8,6,0,1/64	17,2,8,8,6,0,1/64
L589	17,2,8,8,6,0,1/64	17,2,8,8,6,0.1/64
4332	17,2,8,8,6,0,1/64	8,15,8,8,6,0,1/64
4316	17,2,8,8,6,0,1/64	8,15,8,8,6,0,1/64

The signature was held constant on the first turning tool for all tests. However, the tool signature was varied on the second turning tool to observe any improvement in number of pieces produced before failure of the tool.

Forming.—The form tools were purchased as 18-4-1 High-Speed Steel (18% W, 4% Cr, 1% V). The following back-rake angles were ground on the tools:

Oil	1st form	2nd form
L581	15°	8°
L589	15°	0°
4332	15°	15°
4316	15°	15°

The back-rake angle on the first forming tool was held constant for all tests while the back rake on the second-form tool was varied to observe any improvement in number of pieces produced before failure of the tool and to determine if the feed rate of 0.004 inch per revolution was a deterrent to good performance.

Test Method

The AISI 1141 steel was machined under the first machine setup at 117.5 feet per minutes (556 rpm) and feeds of 0.0031 inch/revolution on the turning tools, 0.001 inch/revolution on the first form, and 0.004 inch/revolution on the second form, using the L589 oil. All machine spindles were checked for accuracy and variations in surface finish on the machined parts.

The No. 2 spindle was chosen as representative of the average of all six, and the work pieces that were retained for subsequent examination and surface-roughness inspections were taken from this same spindle at intervals of approximately thirty pieces throughout the life of the test. The three steels and four oils were tested under the above conditions.

Test Criteria

It was determined that values of surface roughness (microinches, rms) would be obtained from the first and second turn and the first- and second-form surfaces by averaging the values of three readings on each surface as measured by a micrometrical profilometer. These values were plotted as ordinate vs number of pieces as abscissa for each of the roughness inspections throughout the life of the test.

The drills that were used in producing 5/16-inch-diameter holes did not show consistent evidence of tool wear and thus were not included in the evaluation of the test data. In running tests on oils 4332 and 4316, the drilling operation was eliminated altogether.

Test Results

After all data had been plotted, it was observed that a value of 175 microinches, rms, was representative of average tool life for the turning tools and 200 microinches, rms, for the form tools. These values are shown on each of the Figs. 1 through 28 to indicate the number of pieces produced prior to tool failure (inability to produce desirable surface finish).

Figs. 1-6 show the results obtained in testing the L581 and L589 oils in turning 1141, 4145, and 8620 steel. Solid lines were used to show the trend of the first-turning operation while dashed or broken lines were used for the second turn.

Figs. 7-12 show the results obtained in testing the L581 and L589 oils in forming 1141, 4145, and 8620 steel. Solid lines were used to show the trend of the first-forming operation while dashed or broken lines were used for the second form.

Figs. 13-16 show the results obtained in testing the 4332 and 4316 oils in turning 1141 and 4145 steel. Solid lines were used to show the trend of

the first-turning operation while dashed or broken lines were used for the second turn. In most cases, two sets of turning tools failed prior to the failure of one set of form tools.

Figs. 17-20 show the results obtained in testing the 4332 and 4316 oils in forming 1141 and 4145 steel. Solid lines were again used to show the trend of the first-forming operation while dashed or broken lines were used for the second form.

Figs. 21-24 show the results obtained in any one turning operation, using one steel, for the four different oils, i.e., Fig. 22, first-turning operation on 4145 steel, using oils L581, L589, 4332, and 4316.

Figs. 25-28 show the results obtained in any one forming operation, using one steel, for the four different types of oil, i.e., Fig. 26, first-forming operation on 4145 steel, using oils L581, L589, 4332, and 4316.

The following is a quick reference chart to assist in finding the graph for any one operation with any combination of oil and steel. The numbers on the chart represent the corresponding figure numbers on the graphs.

GRAPH REFERENCE CHART		Oil			
	Steel	L581	L589	4332	4316
1st turn	1141	--	2,21	13,21	14,21
	4145	3,22	4,22	15,22	16,22
	8620	--	6	--	--
2nd turn	1141	1,23	2,23	13,23	14,23
	4145	3,24	4,24	15,24	16,24
	8620	5	6	--	--
1st form	1141	7,25	8,25	17,25	18,25
	4145	9,26	10,26	19,26	20,26
	8620	11	12	--	--
2nd form	1141	7,27	8,27	17,27	18,27
	4145	9,28	10,28	19,28	20,28
	8620	11	12	--	--

The following Table I shows the values of the number of pieces obtained prior to tool failure as defined by 175 microinches for turning and 200 microinches for forming. These values were found in the majority of cases by direct interpolation from the various graphs, in some cases, visual inspection superseded the graphical data. This was due to the

tendency of the built-up edge on the tool to produce a rough surface (profilometer readings above the average in microinches, rms) for a few samples and then a return to normal after the built-up edge had changed. On the other hand, a tool which had failed sometimes showed a tendency to produce a burnished or torn surface, resulting in a good profilometer reading (below the average in microinches, rms), but an unsatisfactory finish as shown by visual inspection. Therefore, direct interpolation alone, in some cases, does not give clear and accurate results.

In Table I the machining of AISI 1141 steel with the 4316 oil shows the most improvement in the number of pieces produced before tool failure in both the turning and forming operations. The 4332 and L589 oils show very little difference in the turning operation, but the forming cuts favor the 4332 oil over the L589 and indicate a similarity in performance with the 4316 oil. The worst performance is shown by the L581 oil in both the turning and forming operations.

In the machining of AISI 4145 steel, oils L581 and L589 show the best performance of the four in the turning operation, with slight differences in the number of pieces produced before tool failure. Oil L589, however, is definitely superior to the others in the forming operation. Oil 4316 rates second to the L589 in the forming operation, and oils L581 and 4332 third and fourth, respectively.

In the machining of AISI 8620 steel, oil L589 shows ability to aid in producing more pieces per tool grind than the L581 oil in each of the cases shown. This steel was not tested with the 4332 and 4316 oils at the request of Mr. Ford Teeter.

TABLE I

NUMBER OF PIECES OBTAINED PRIOR TO LOSS IN SURFACE FINISH

Steel	Oil	1st Turn 0.0031 feed 175 microinches	2nd Turn 0.0031 feed 175 microinches	1st Form 0.001 feed 200 microinches	2nd Form 0.004 feed 200 microinches
1141	L581	*	180	800+	88
1141	L589	555	335	900+	245
1141	4332	520	420	1080	525
1141	4316	660	660	1400+	750
4145	L581	405	485	440	80
4145	L589	380	135	850+	115 (Tool Failure)
4145	4332	190	230	230	75
4145	4316	220	220	525	65
8620	L581	*	125	0**	0**
8620	L589	180	190+	65	0**

*No test results. **Roughness over 200 microinches, rms, at start.

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SURFACE FINISH Vs. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .0031
Parts Per Hour: 171
Cutting Fluid: Sinclair L-581
Material Cut: AISI - 1141 Steel
Tool Material: M-3-D H.S.S.
Tool Type: Box, 2nd Turn
Tool Signature: 17, 2 , 8, 8, 6, 0, 1/64

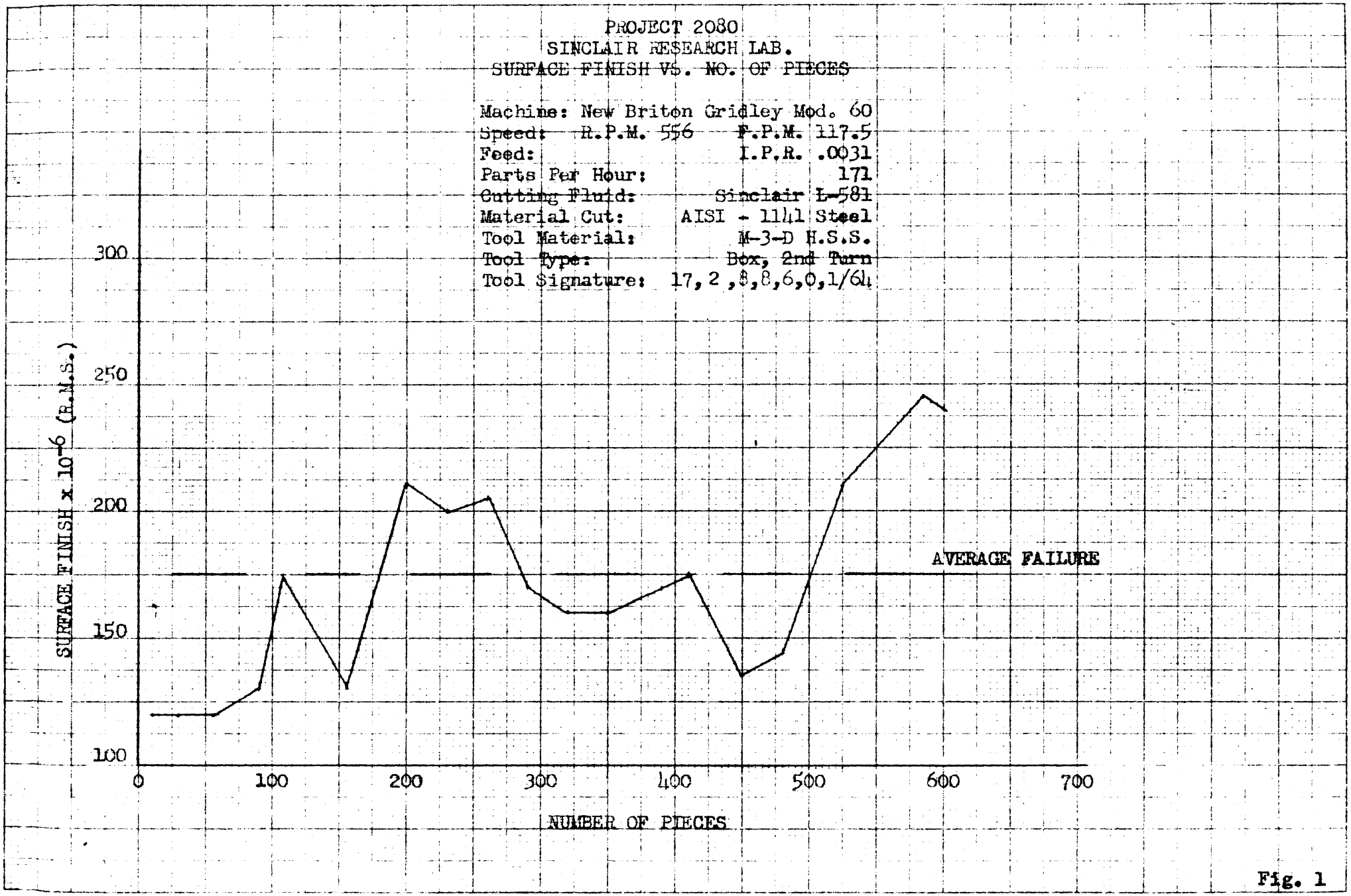

Fig. 1

PROJECT 2080
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SURFACE FINISH VS. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .0031
Parts Per Hour: 171
Cutting Fluid: Sinclair L-589
Material Cut: AISI - 1141 Steel
Tool Material: M-3-D H.S.S.
Tool Type: Box, 1st Turn & 2nd Turn
Tool Signature: 17, 2, 8, 8, 6, 0, 1/64

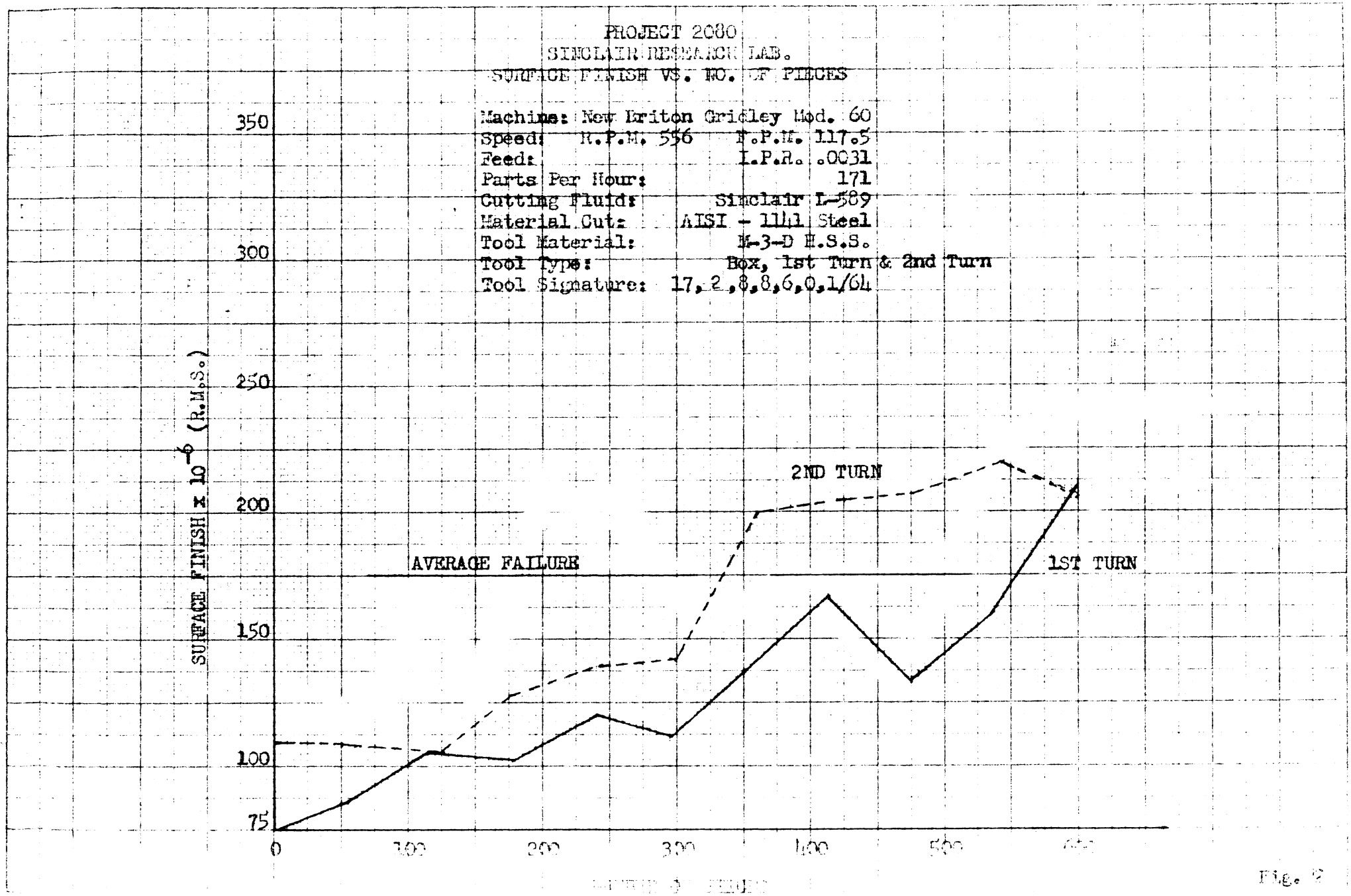

Fig. 2

PROJECT 2080
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SURFACE FINISH VS. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .0031
Parts Per Hour: 171
Cutting Fluid: Sinclair L-581
Material Cut: AISI - 4145 Steel
Tool Material: M-3-D H.S.S.
Tool Type: Box, 1st Turn & 2nd Turn
Tool Signature: 17, 2, 8, 8, 6, 0, 1/64

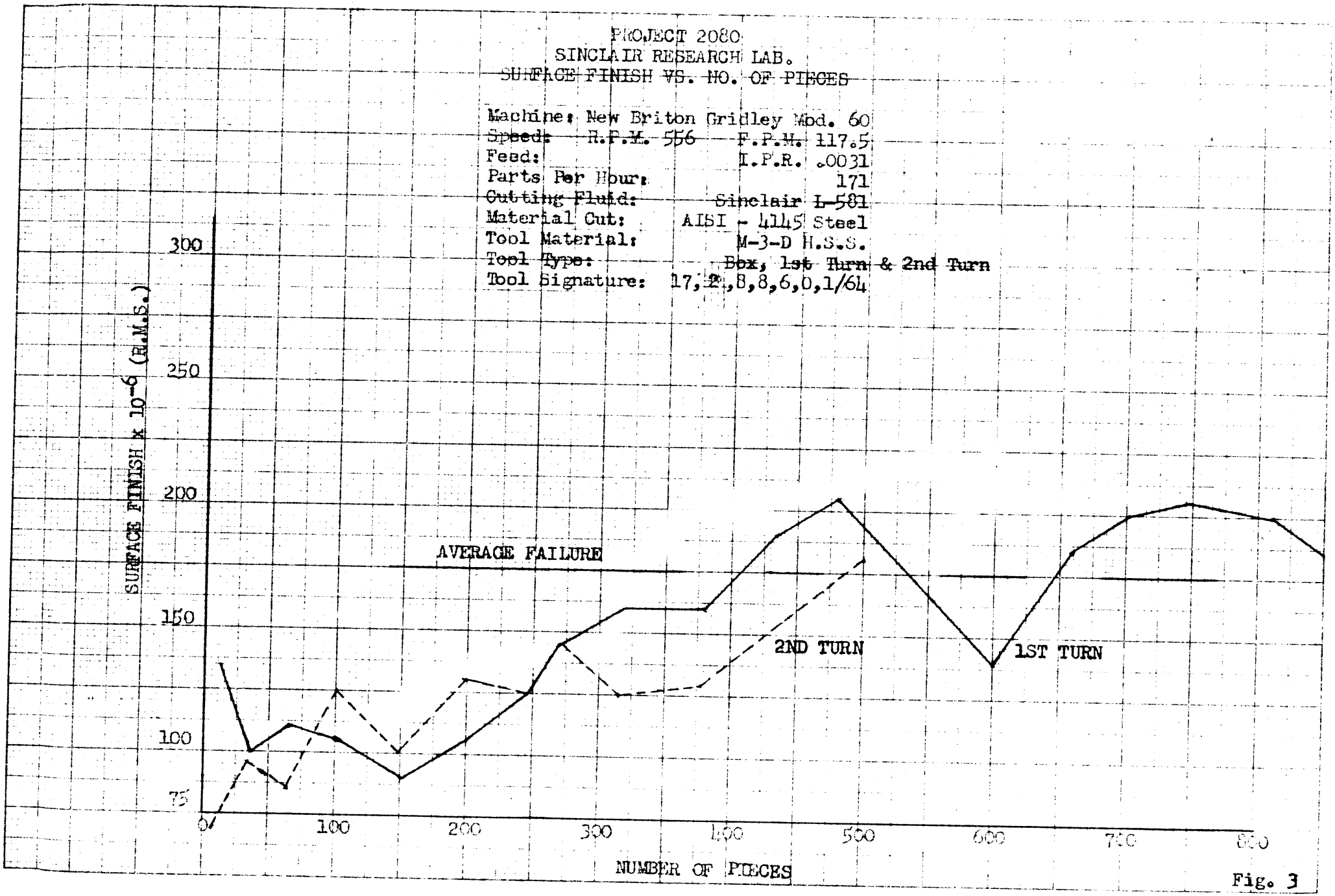

Fig. 3

PROJECT 2080
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SURFACE FINISH VS. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .0031
Parts Per Hour: 171
Cutting Fluid: Sinclair L-589
Material Cut: AISI - 4145 Steel
Tool Material: M-3-D H.S.S.
Tool Type: Box, 1st Turn & 2nd Turn
Tool Signature: 17, 2 ,8,8,6,0,1/64

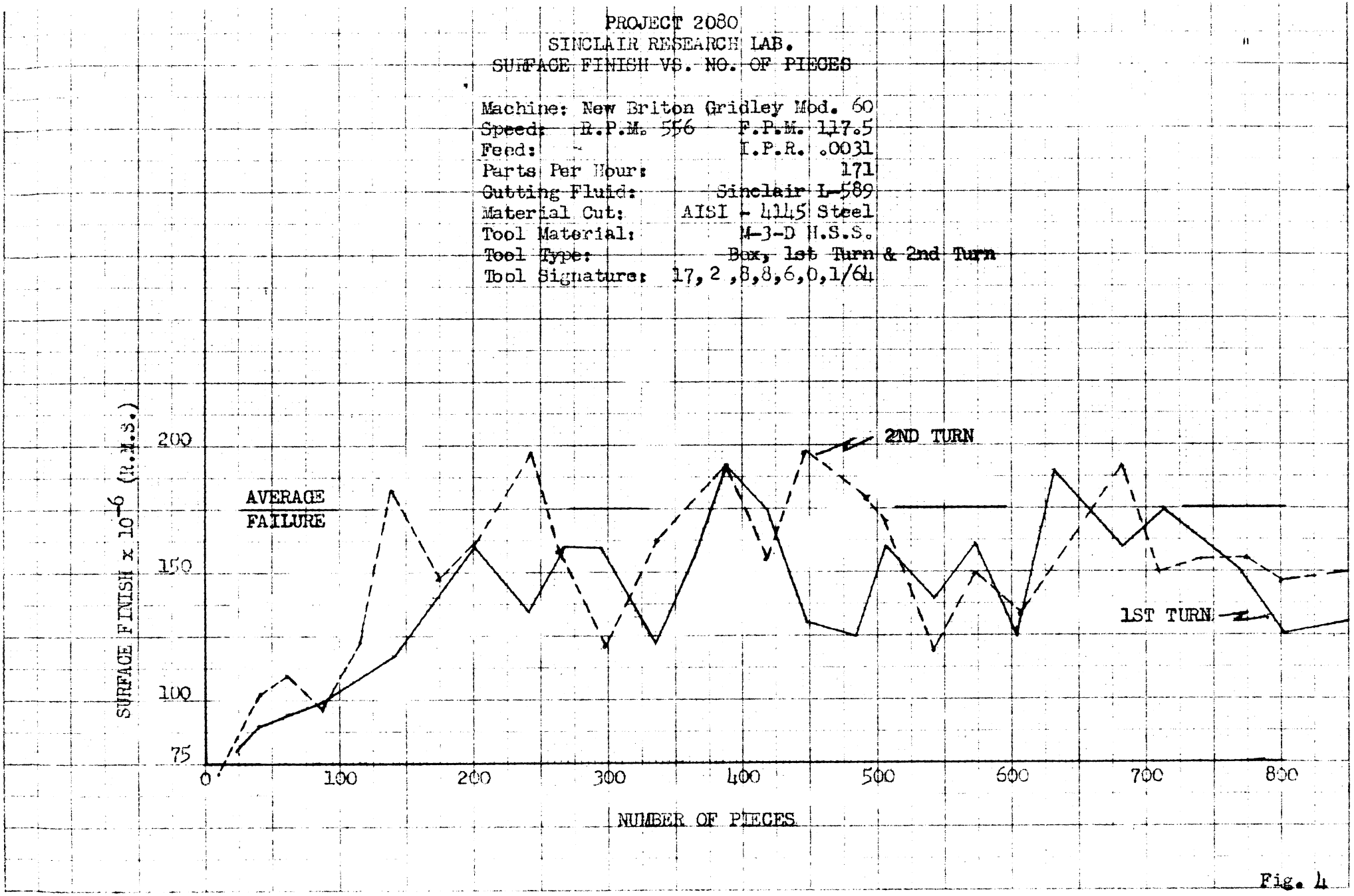

Fig. 4

PROJECT 2080
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SURFACE FINISH VS. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .0031
Parts Per Hour: 171
Cutting Fluid: Sinclair L-581
Material Cut: AISI - 8620 Steel
Tool Material: M-3-D H.S.S.
Tool Type: Box, 2nd Turn
Tool Signature: 17, 2, 8, 8, 6, 0, 1/64

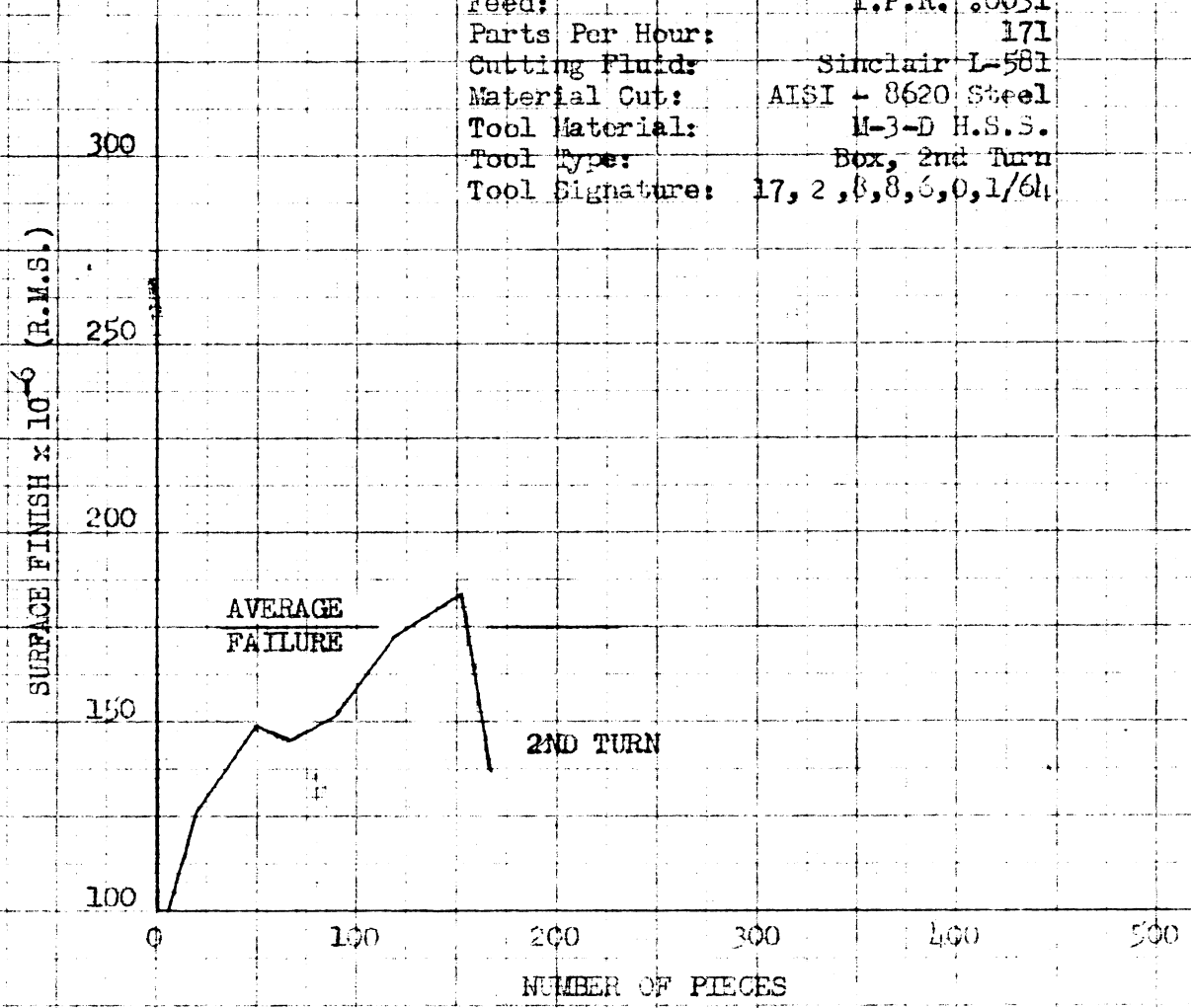

Fig. 5

PROJECT 2080
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SURFACE FINISH VS. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .0031
Parts Per Hour: 171
Cutting Fluid: Sinclair L-589
Material Cut: AISI - 8620 Steel
Tool Material: M-3-D H.S.S.
Tool Type: Box, 1st Turn
Tool Signature: 17, 2 ,8,8,6,0,1/64

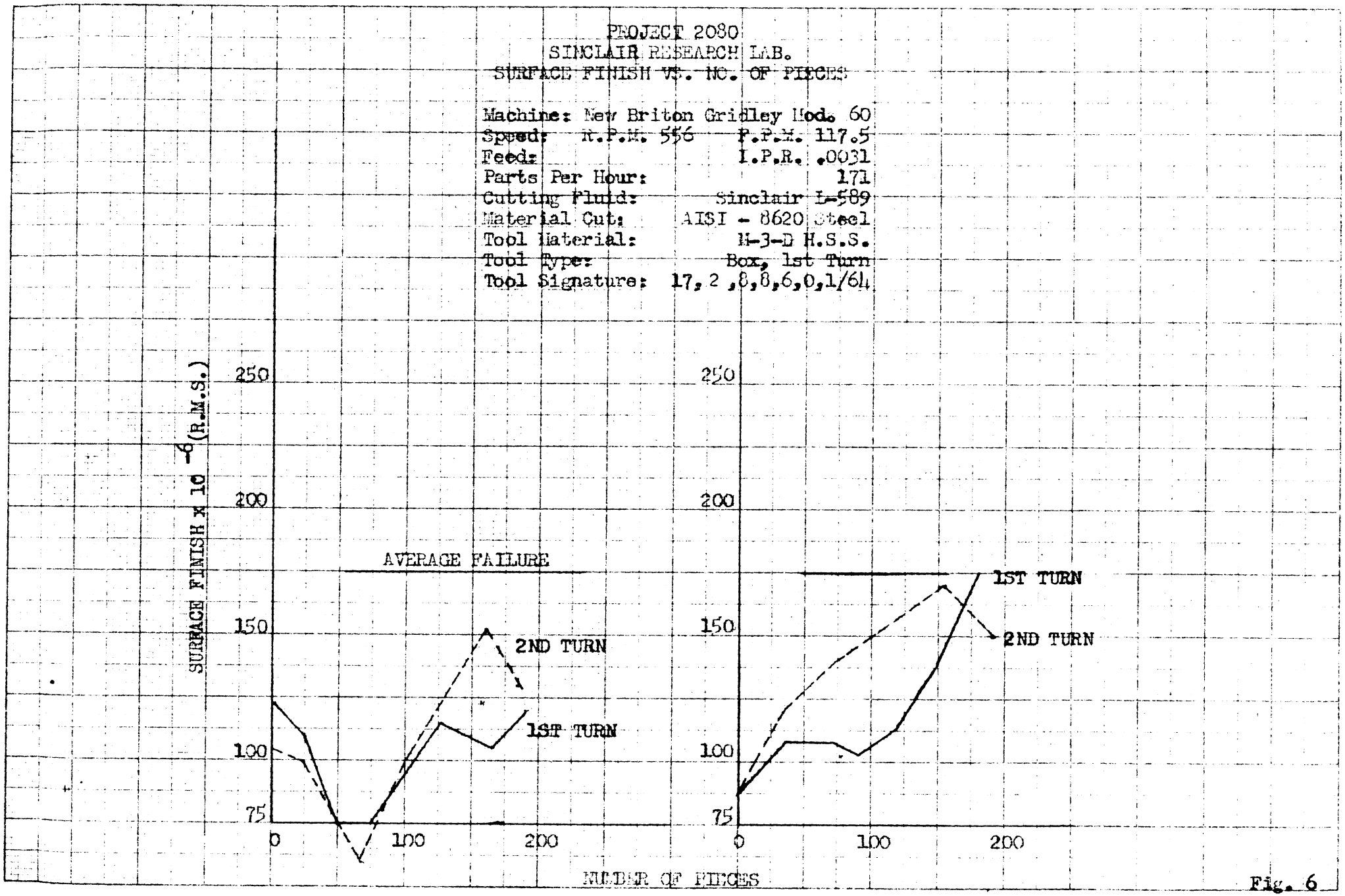

Fig. 6

PROJECT 2080
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SURFACE FINISH VS. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .001
Parts Per Hour: 171
Cutting Fluid: Sinclair L-581
Material Cut: AISI - 1141 Steel
Tool Material: 18-4-1 H.S.S.
Tool Type: 1st & 2nd Form
Tool Signature: 5° Relief, 15° Rake

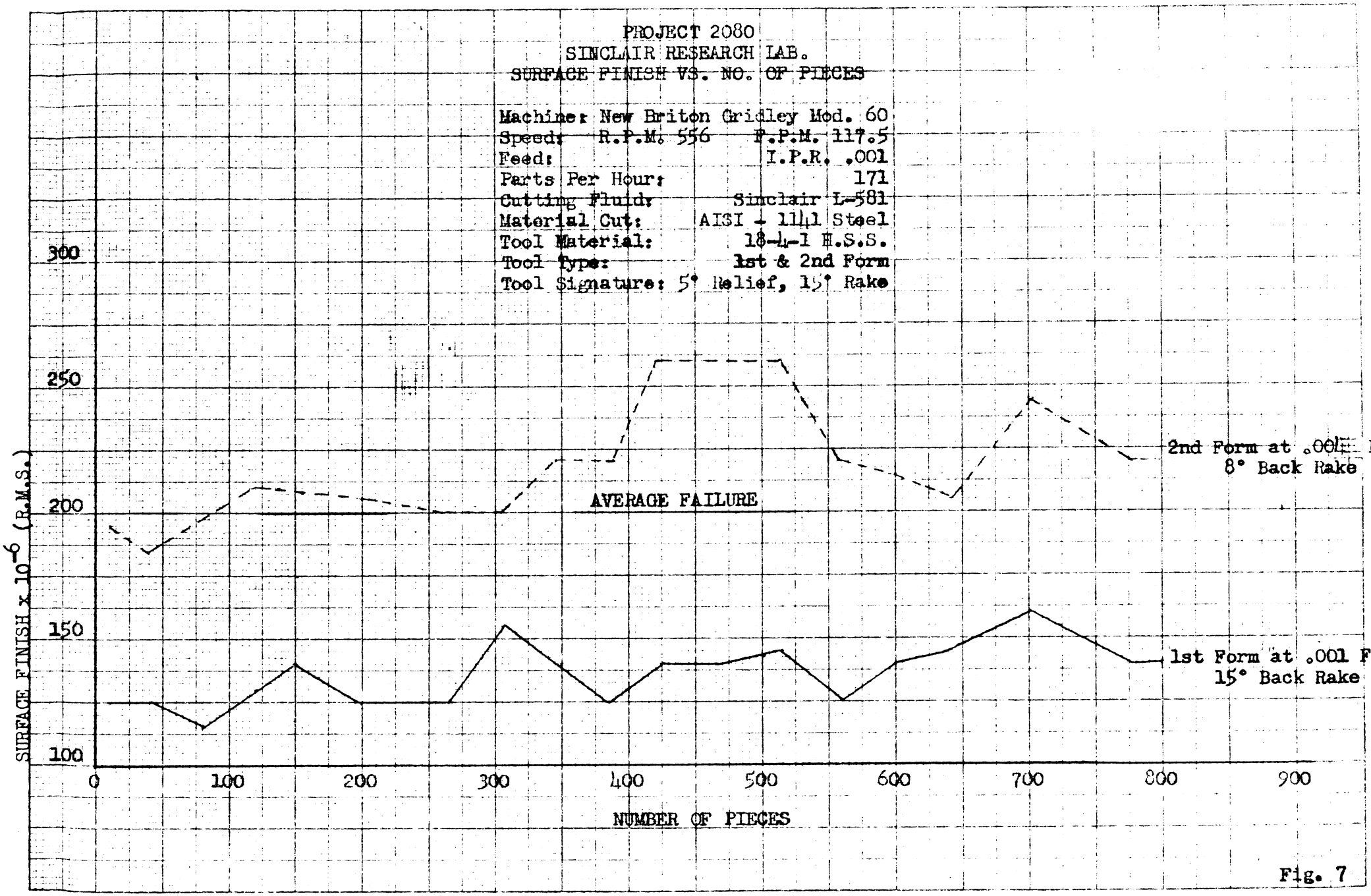

Fig. 7

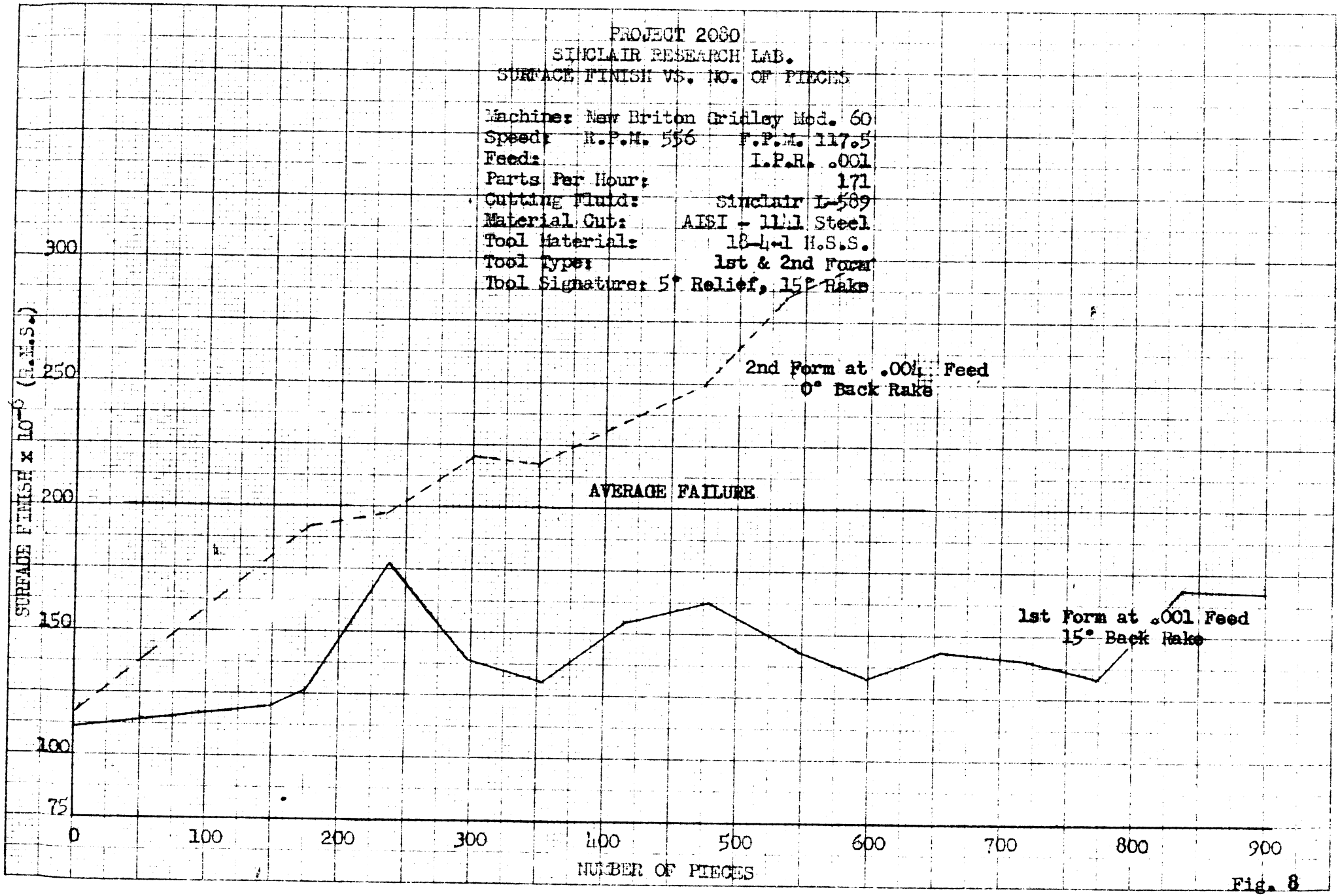
PROJECT 2080
SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES
Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .001
Parts Per Hour: 171
Cutting Fluid: Sinclair L-589
Material Cut: AISI - 1141 Steel
Tool Material: 18-4-1 H.S.S.
Tool Type: 1st & 2nd Form
Tool Signature: 5° Relief, 15° Rake
2nd Form at .001 Feed
0° Back Rake
AVERAGE FAILURE
1st Form at .001 Feed
15° Back Rake
SURFACE FINISH x 10⁻⁶ (R.M.S.)
300
250
200
150
100
75
0
100
200
300
400
500
600
700
800
900
NUMBER OF PIECES

Fig. 8

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SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. F.P.M. 117.5
Feed: I.P.R. .001
Parts Per Hour: 171
Cutting Fluid: Sinclair L-581
Material Cut: AISI - 4145 Steel
Tool Material: 18-4-1 H.S.S.
Tool Type: 1st & 2nd Form
Tool Signature: 5° Relief, 15° Rake

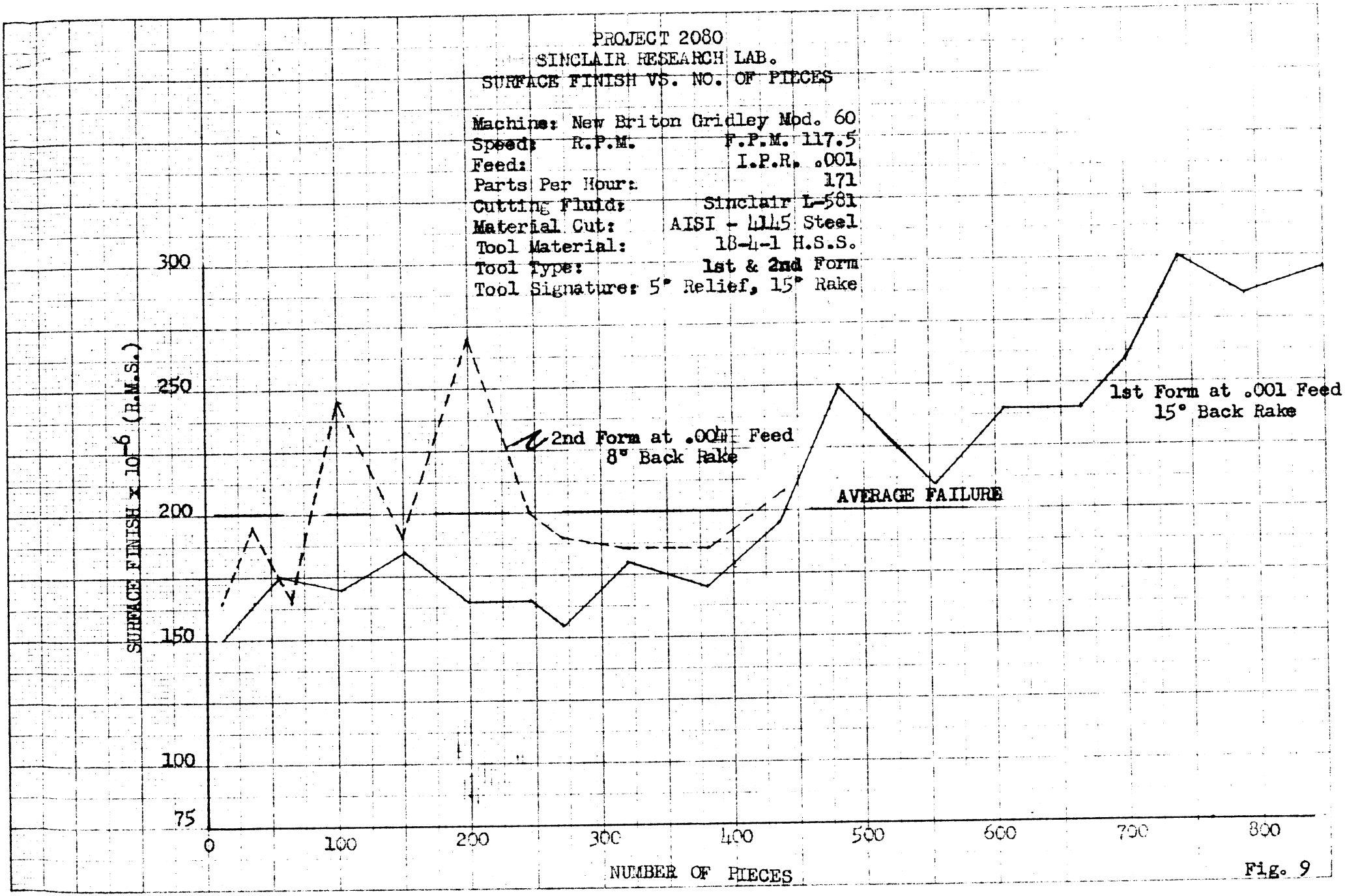

Fig. 9

PROJECT 2080
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SURFACE FINISH VS. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .001
Parts Per Hour: 171
Cutting Fluid: Sinclair L-589
Material Cut: AISI - 4145 Steel
Tool Material: 18-4-1 H.S.S.
Tool Type: 1st Form
Tool Signature: 5° Relief, 15° Rake

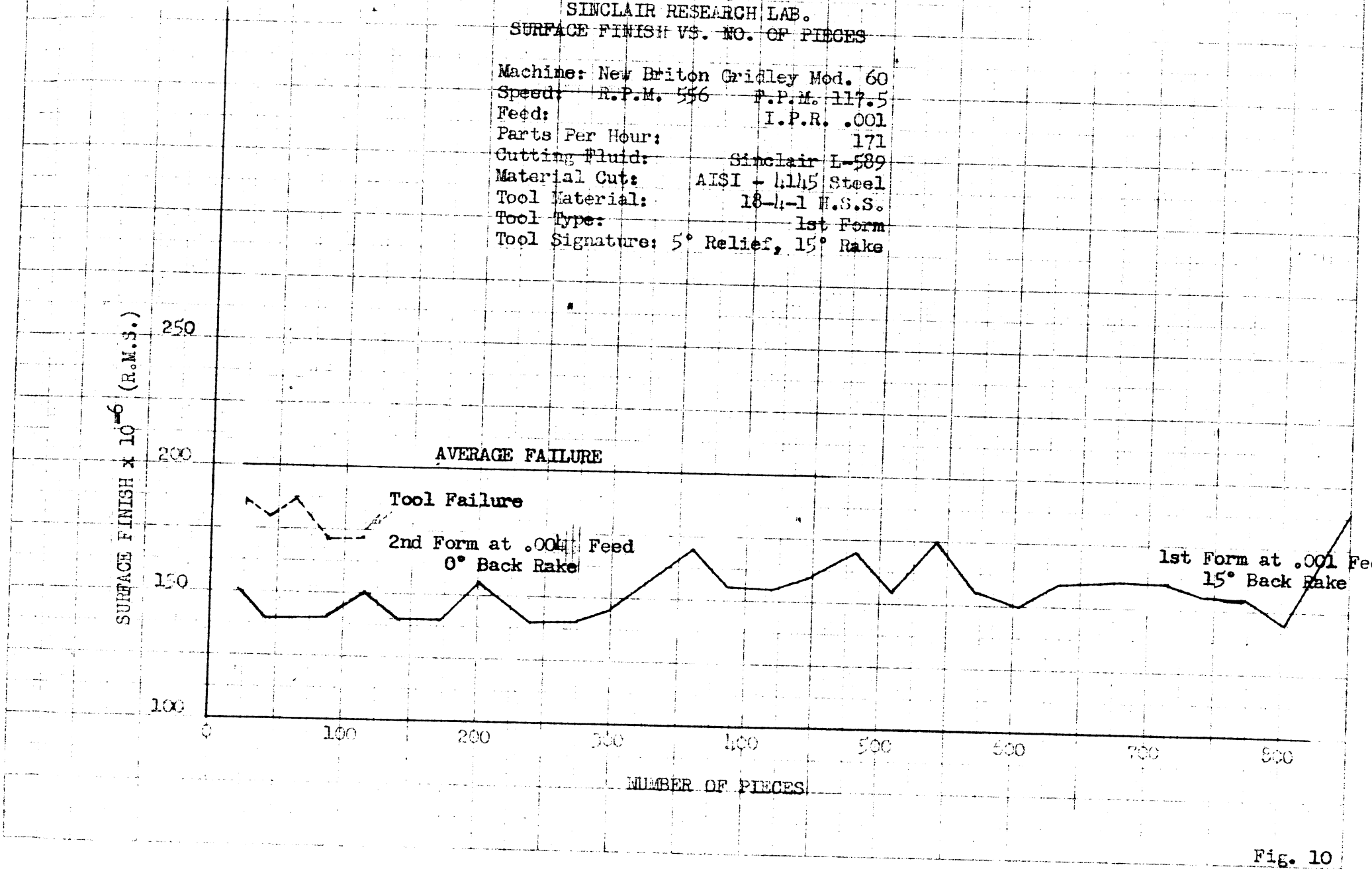

Fig. 10

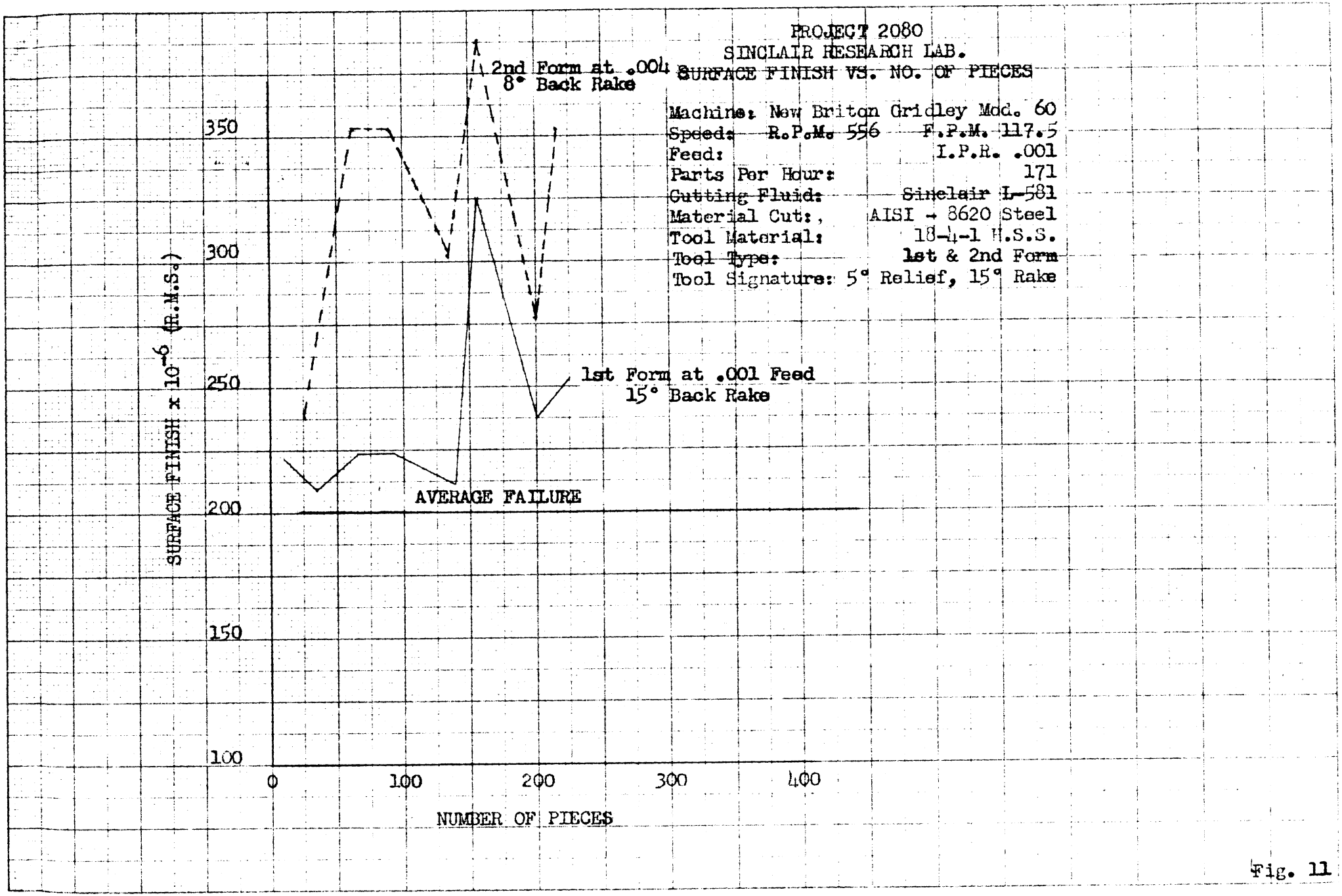
PROJECT 2080
SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES
Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .001
Parts Per Hour: 171
Cutting Fluid: Sinclair L-581
Material Cut:, AISI - 8620 Steel
Tool Material: 18-4-1 H.S.S.
Tool Type: 1st & 2nd Form
Tool Signature: 5° Relief, 15° Rake
2nd Form at .004
8° Back Rake
1st Form at .001 Feed
15° Back Rake
AVERAGE FAILURE
SURFACE FINISH x 10⁻⁶ (R.M.S.)
350
300
250
200
150
100
0
100
200
300
400
NUMBER OF PIECES

Fig. 11

PROJECT 2080
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SURFACE FINISH VS. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .001
Parts Per Hour: 171
Cutting Fluid: Sinclair L-589
Material Cut: AISI - 8620 Steel
Tool Material: 18-4-1 H.S.S.
Tool Type: 1st Form
Tool Signature: 5° Relief, 15° Rake

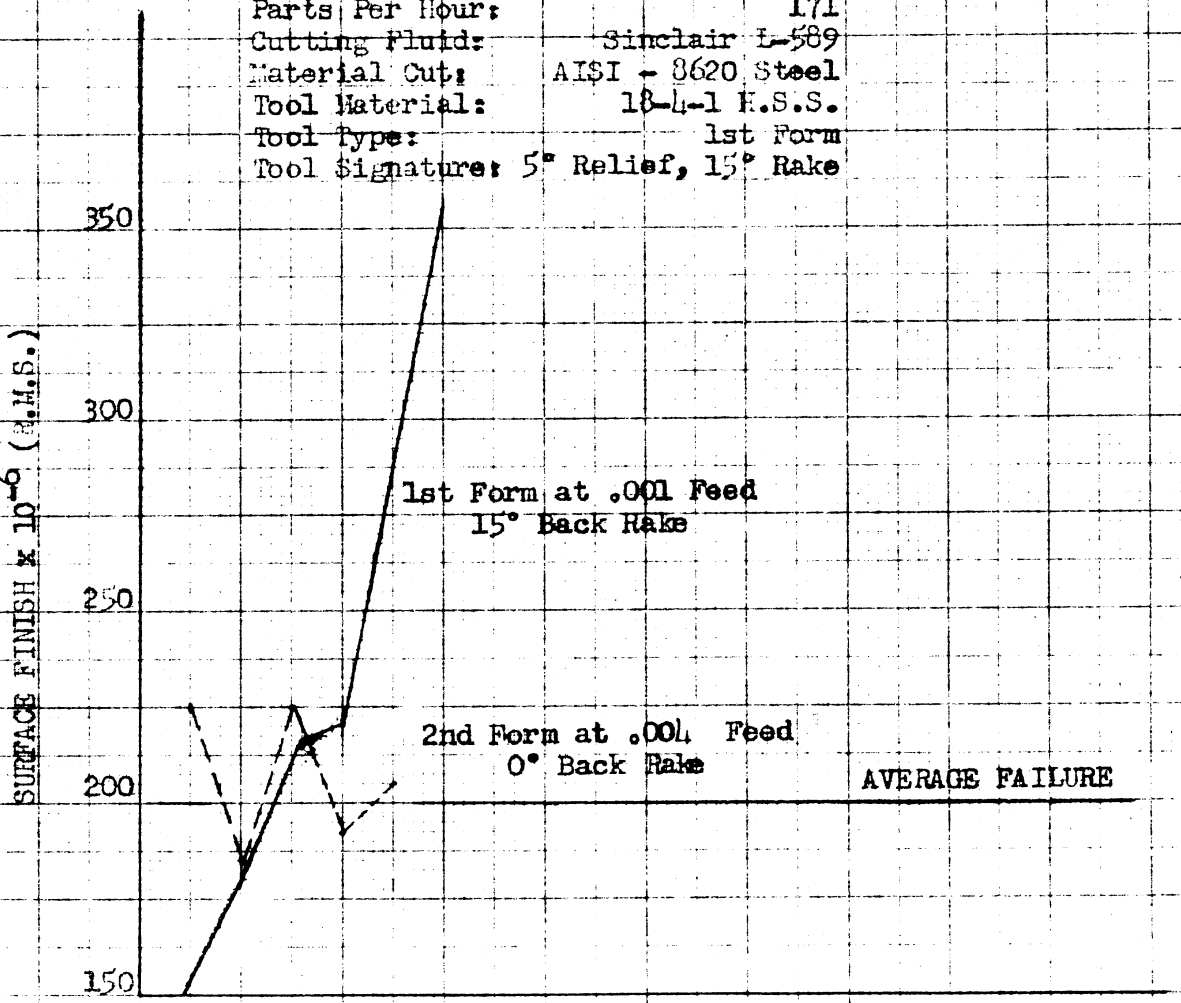

Fig. 12

PROJECT 2080
SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .0031
Parts Per Hour: 171
Cutting Fluid: 4332
Material Cut: AISI - 1141 Steel
Tool Material: M-3-D H.S.S.
Tool Type: Box, 1st& 2nd Turn

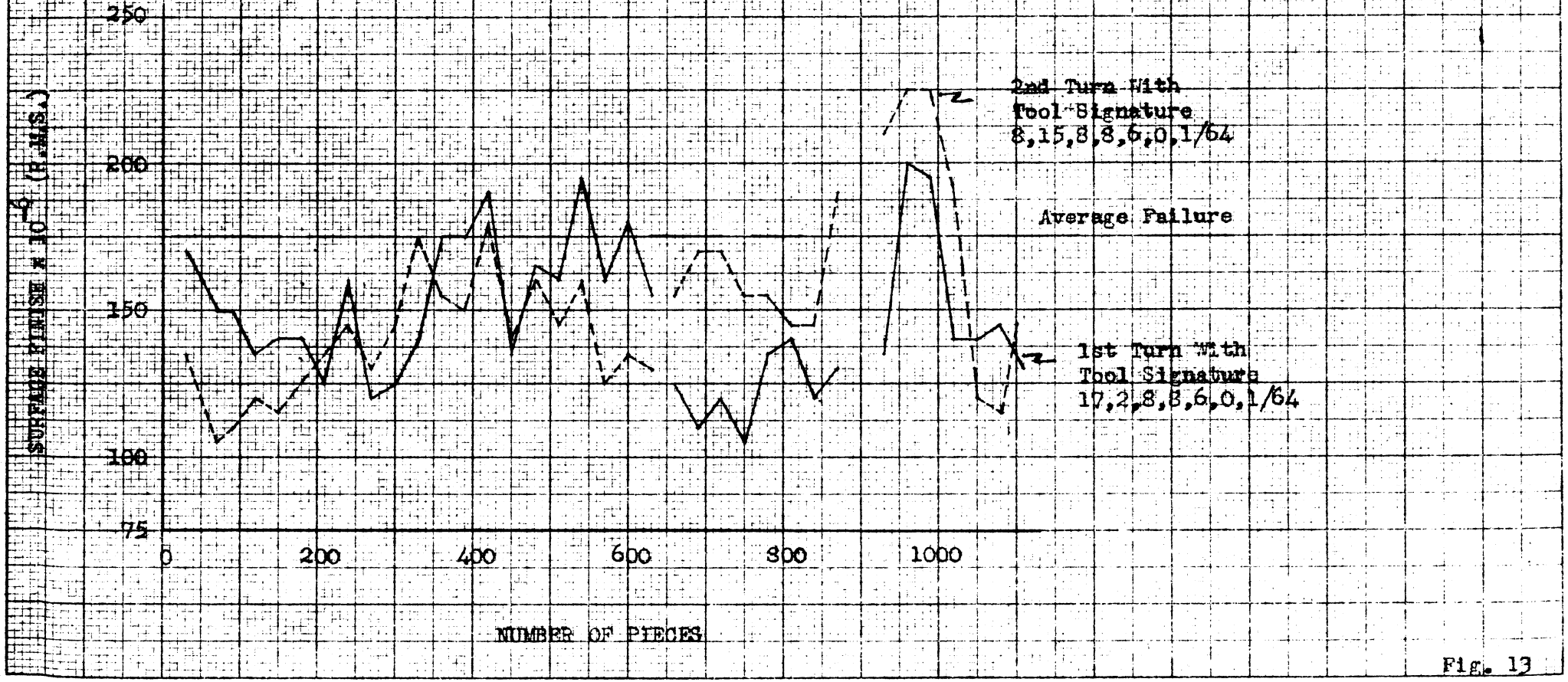

Fig. 13

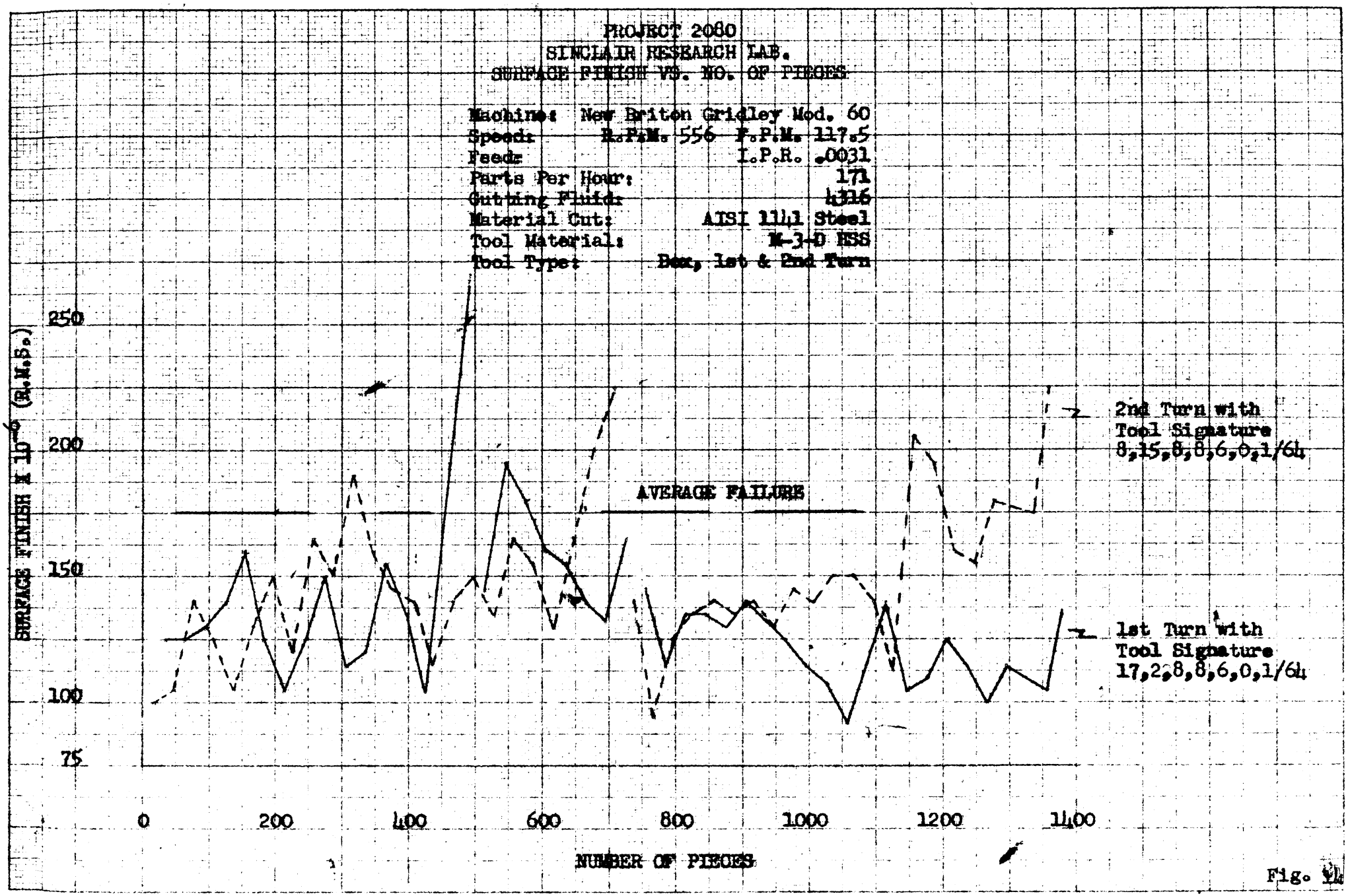

Fig. 14

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SURFACE FINISH VS. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .0031
Parts Per Hour: 171
Cutting Fluid: 4332
Material Cut: AISI - 4145 Steel
Tool Material: M-3 D H.S.S.
Tool Type: Box, 1st & 2nd Turn

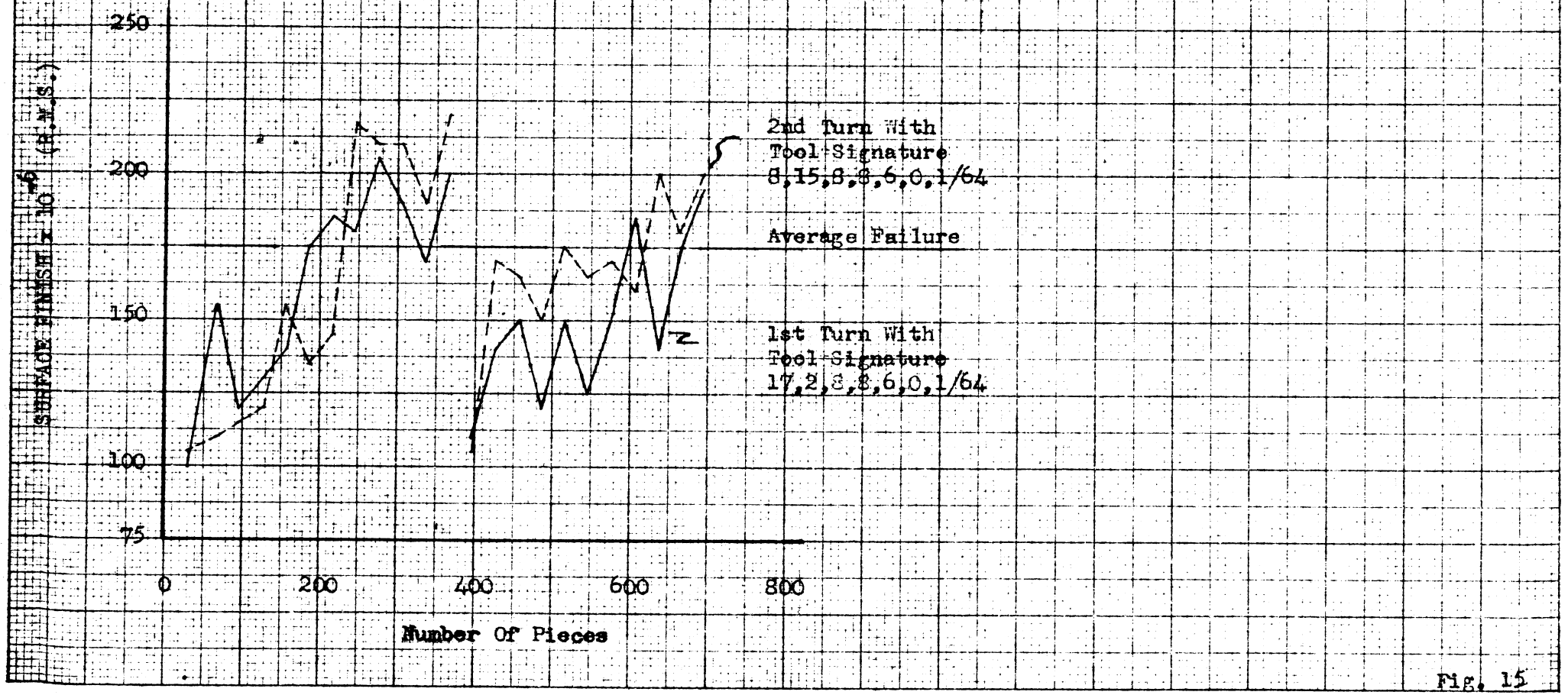

Fig. 15

PROJECT 2080
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SURFACE FINISH VS. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .0031
Parts Per Hour: 171
Cutting Fluid: 4316
Material Cut: AISI - 4145 Steel
Tool Material: M-3-D H.S.S.
Tool Type: Box, 1st & 2nd Turn

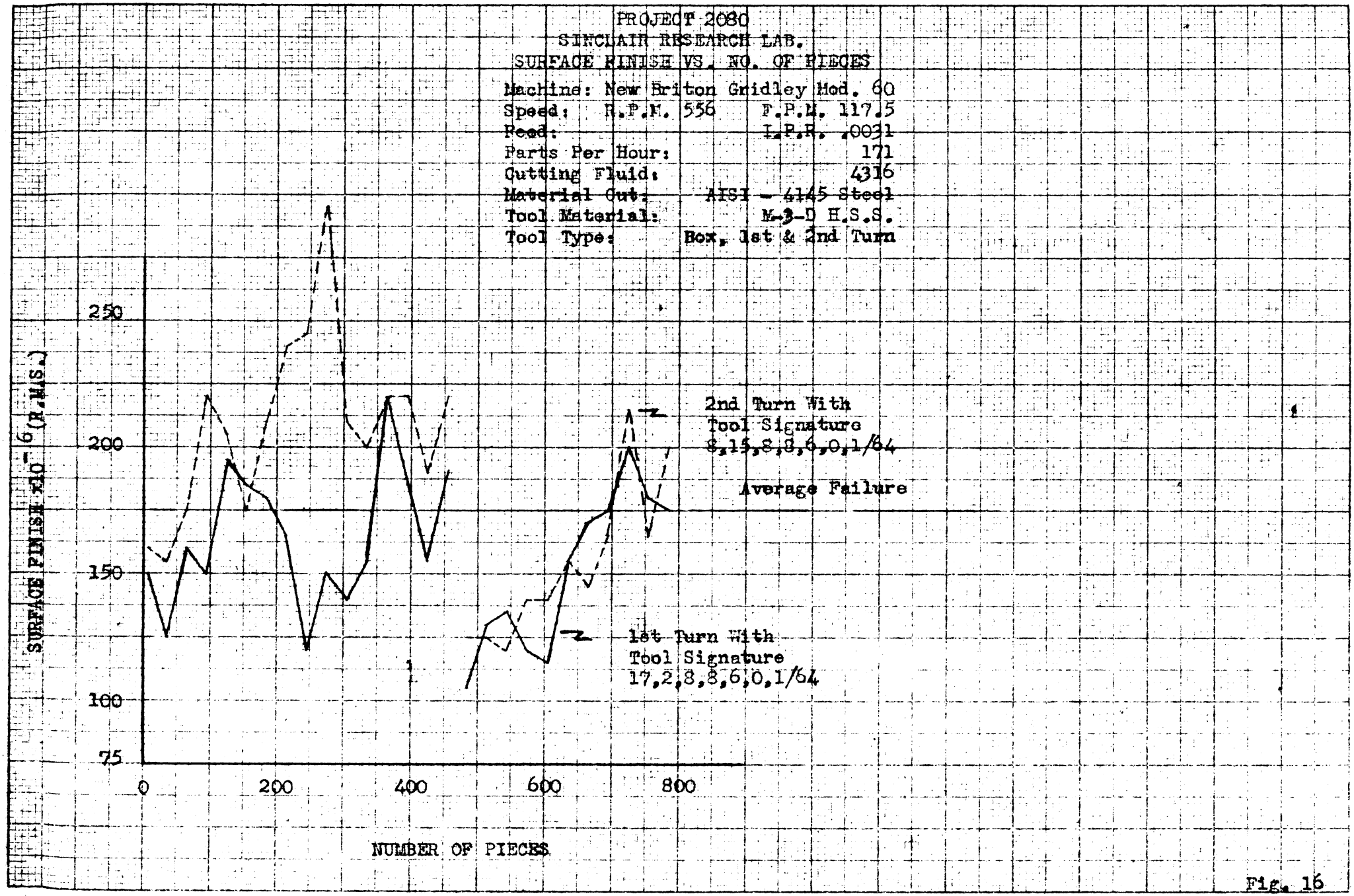

Fig. 16

PROJECT 2080
SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Parts Per Hour: 171
Cutting Fluid: 4332
Material Cut: AISI - 1141 Steel
Tool Material: 18-4-1 HSS Steel
Tool Type: 1st & 2nd Form
Tool Signature: 15° Back Rake

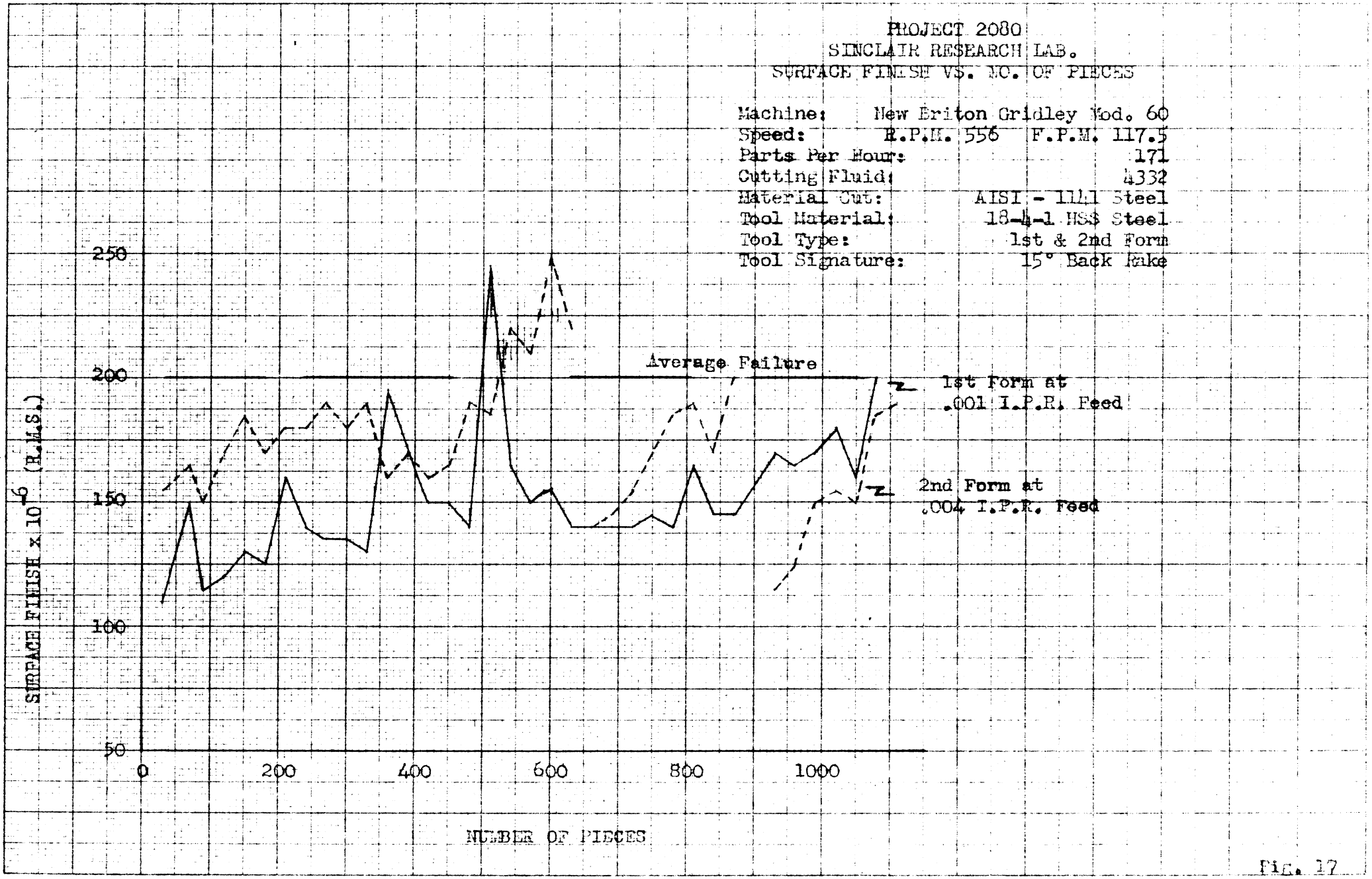

Fig. 17

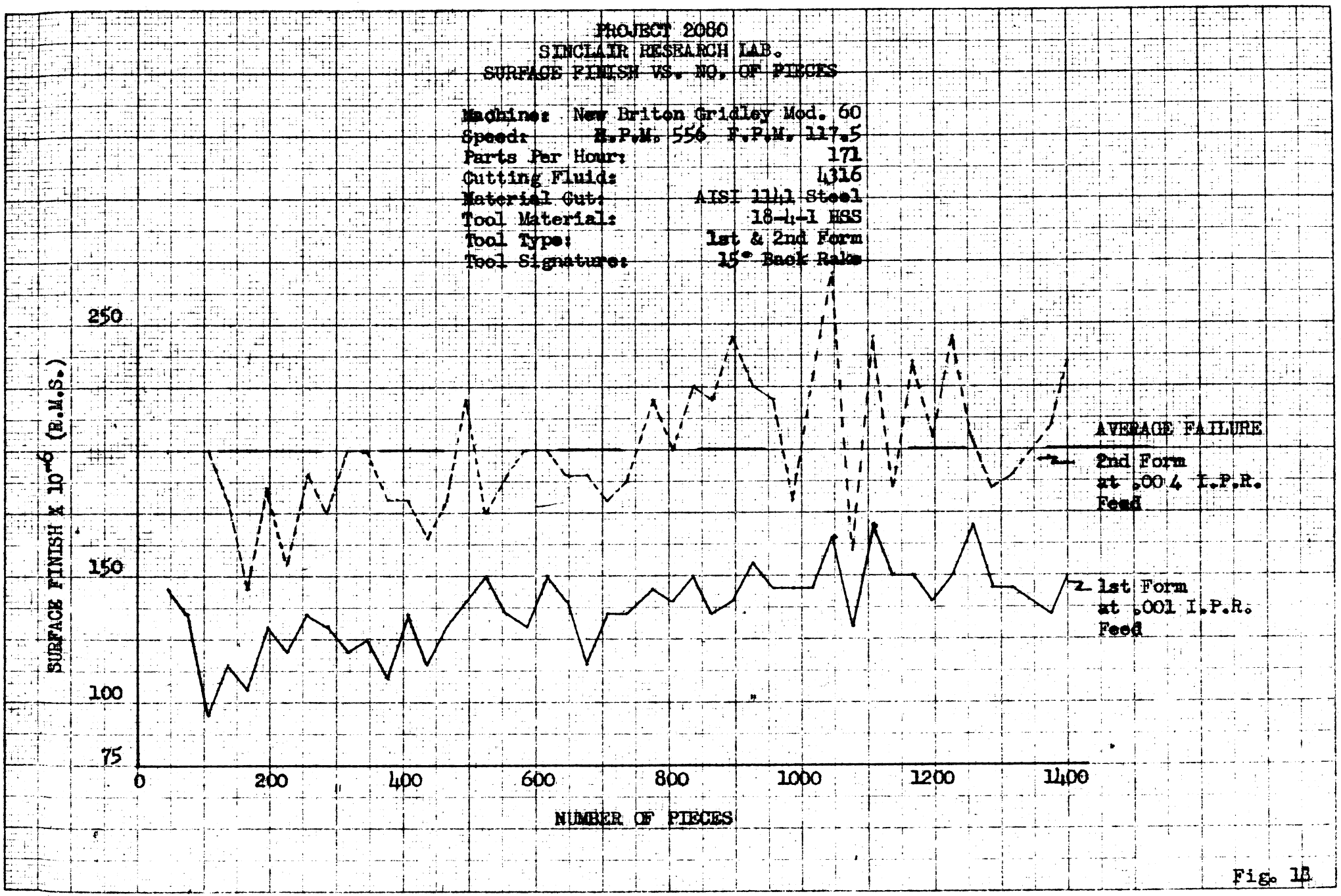
PROJECT 2080
SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES
Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Parts Per Hour: 171
Cutting Fluid: 4316
Material Cut: AISI 1141 Steel
Tool Material: 18-4-1 HSS
Tool Type: 1st & 2nd Form
Tool Signature: 15° Back Rake
SURFACE FINISH X 10⁻⁶ (R.M.S.)
250
150
100
75
0
200
400
600
800
1000
1200
1400
NUMBER OF PIECES
AVERAGE FAILURE
2nd Form
at .004 I.P.R.
Feed
1st Form
at .001 I.P.R.
Feed

Fig. 18

PROJECT 2080
SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Parts Per Hour: 171
Cutting Fluid: 4332
Material Cut: AISI - 4145 Steel
Tool Material: 18-4-1 H.S.S.
Tool Type: 1st & 2nd Form
Tool Signature: 15° Back Rake

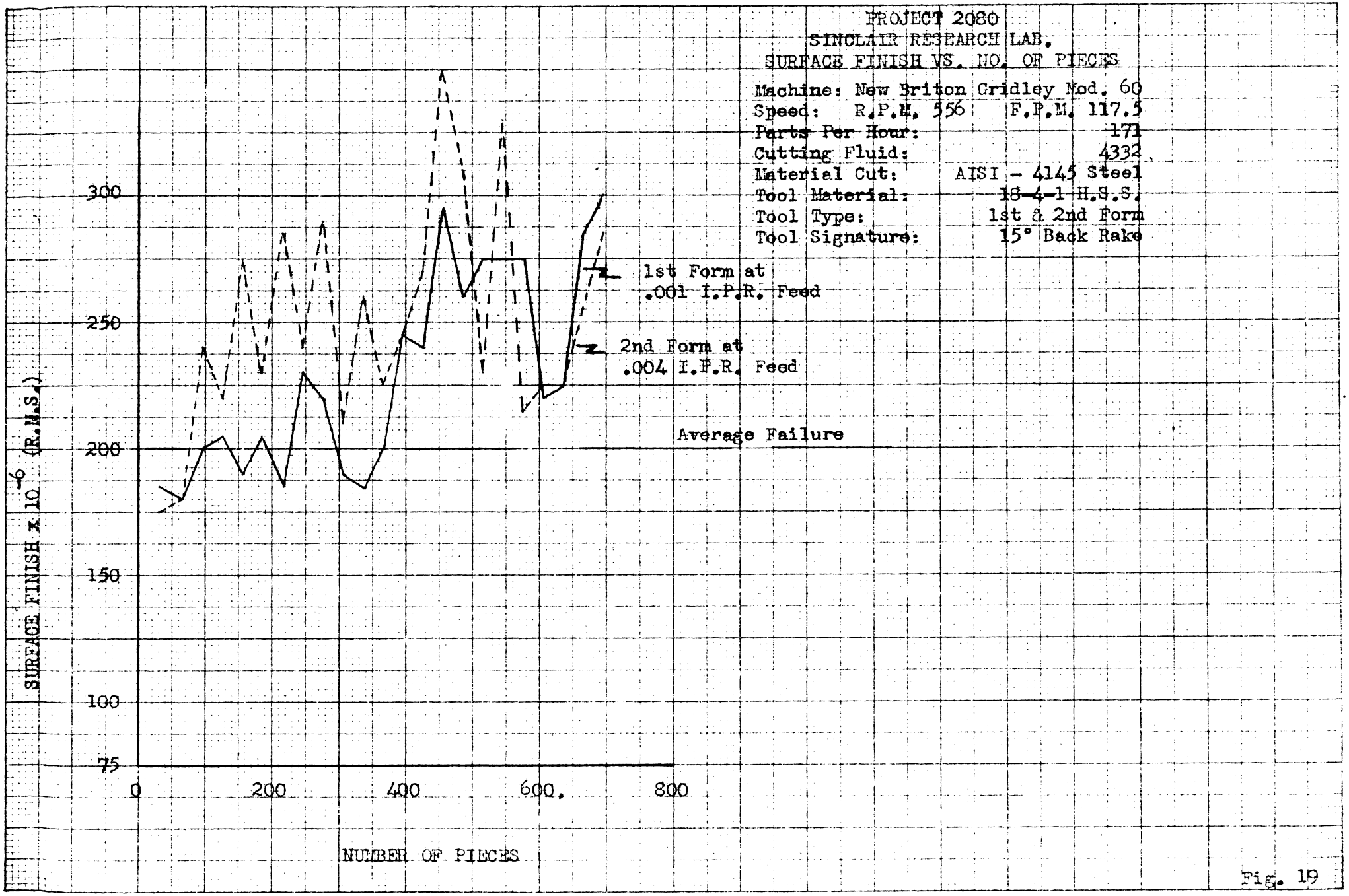

Fig. 19

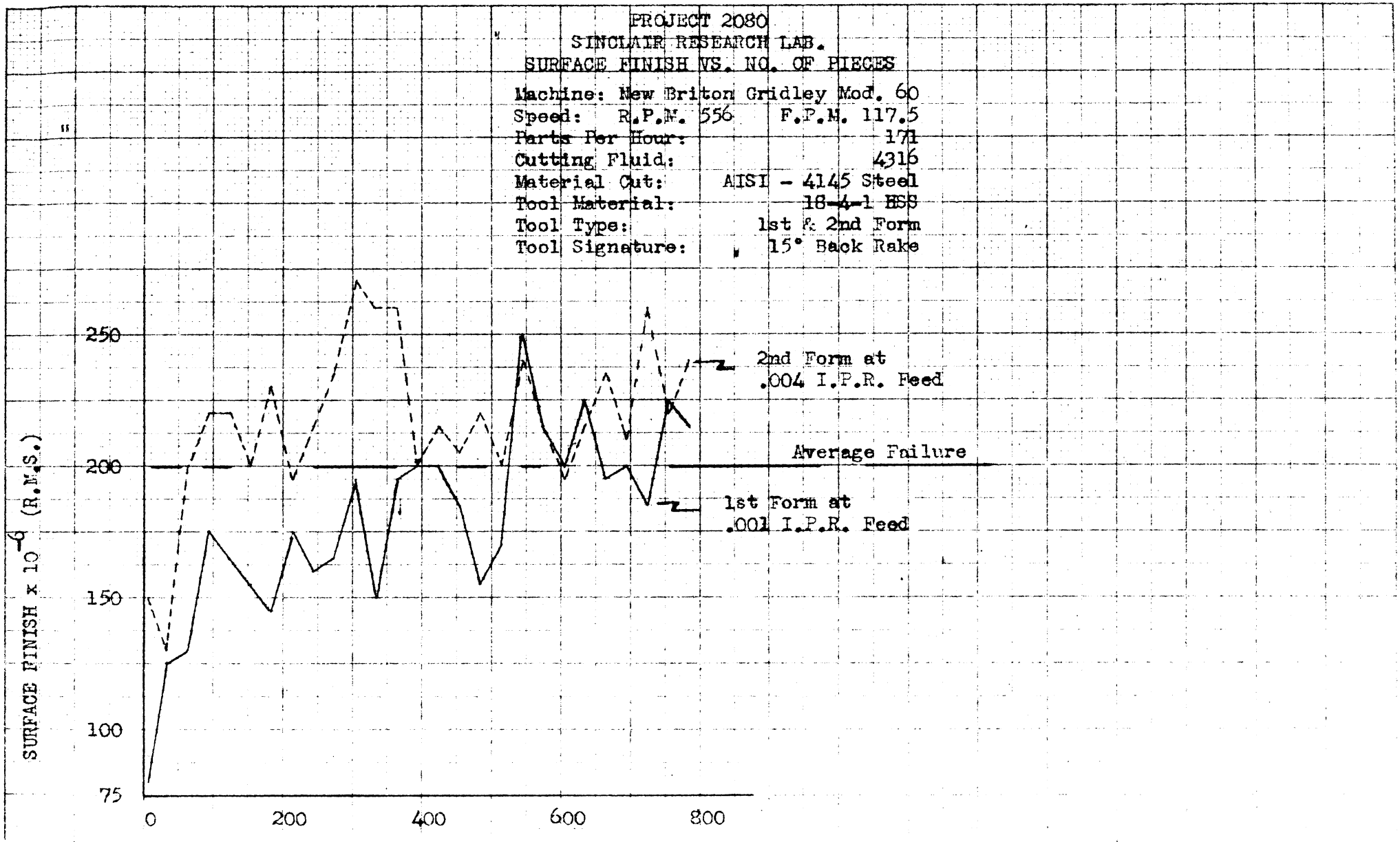
PROJECT 2080
SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES
Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Parts Per Hour: 171
Cutting Fluid: 4316
Material Cut: AISI - 4145 Steel
Tool Material: 18-4-1 HSS
Tool Type: 1st & 2nd Form
Tool Signature: 15° Back Rake
2nd Form at .004 I.P.R. Feed
Average Failure
1st Form at .001 I.P.R. Feed
SURFACE FINISH x 10⁻⁶ (R.M.S.)
250
200
150
100
75
0
200
400
600
800
NUMBER OF PIECES

Fig. 20

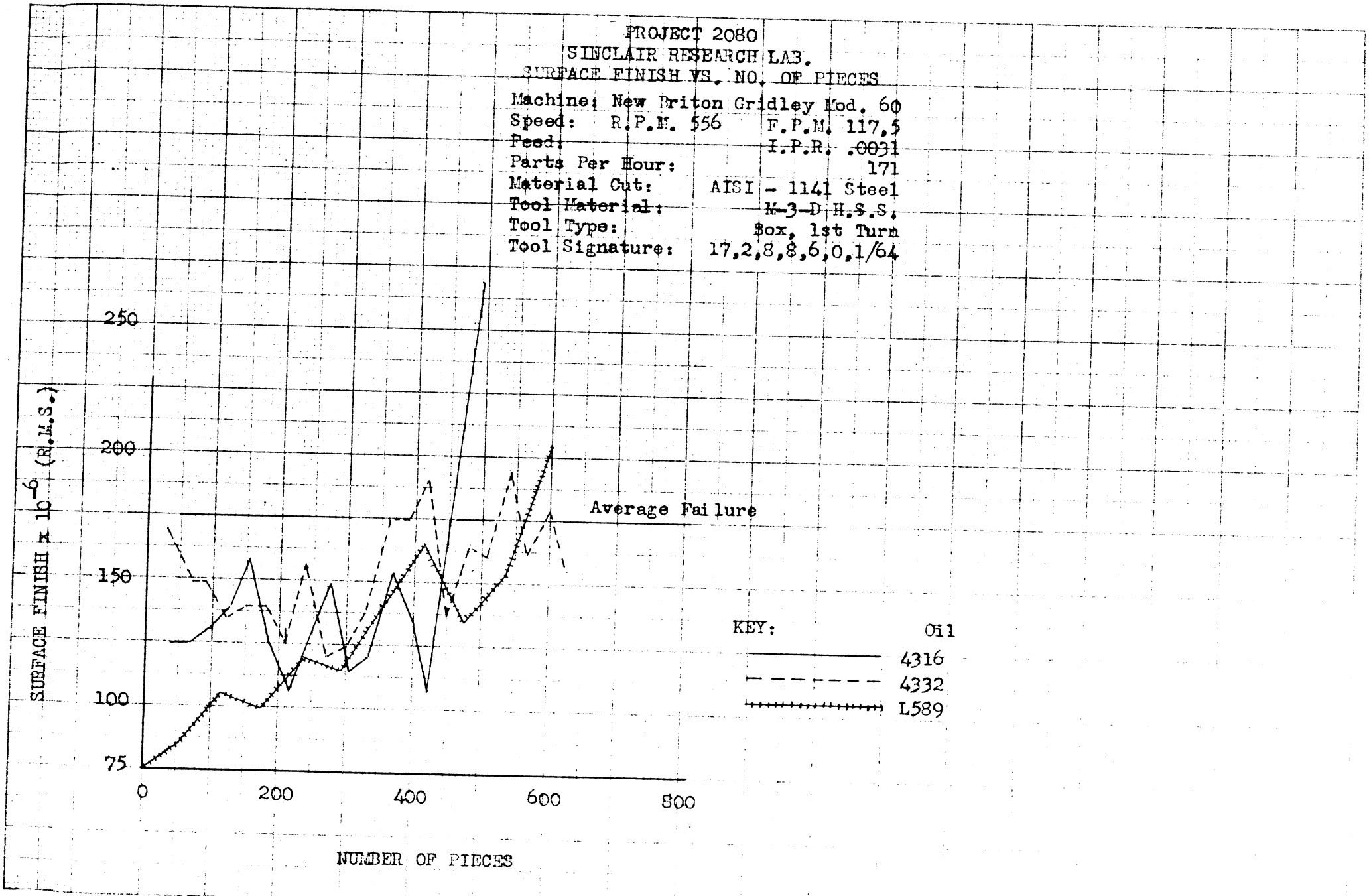
PROJECT 2080
SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES
Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .0031
Parts Per Hour: 171
Material Cut: AISI - 1141 Steel
Tool Material: M-3-D H.S.S.
Tool Type: Box, 1st Turn
Tool Signature: 17,2,8,8,6,0,1/64
SURFACE FINISH x 10⁻⁶ (R.M.S.)
250
200
150
100
75
Average Failure
KEY: Oil
4316
4332
L589
0
200
400
600
800
NUMBER OF PIECES

Fig. 21

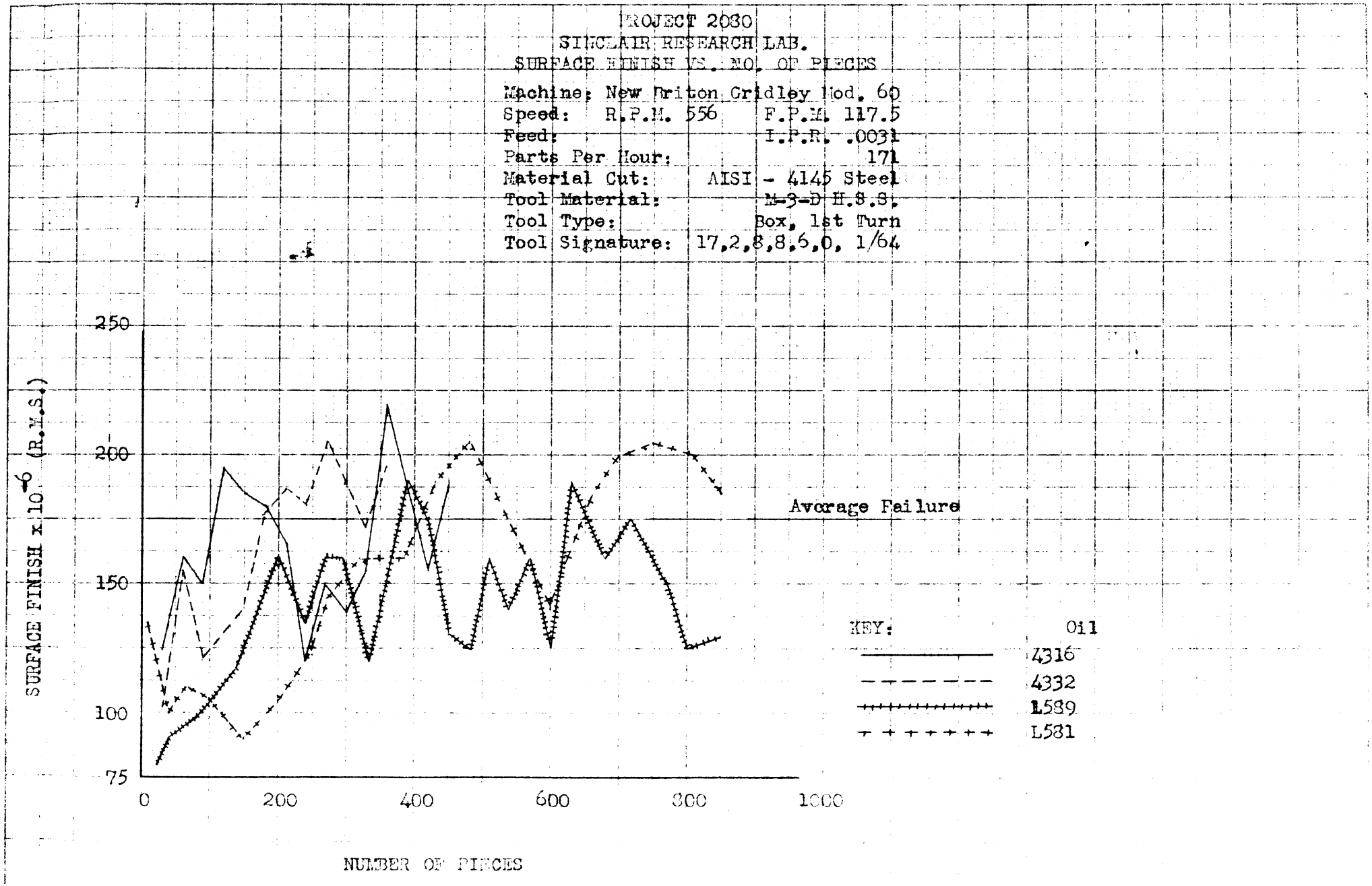
PROJECT 2030
SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES
Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .0031
Parts Per Hour: 171
Material Cut: AISI - 4145 Steel
Tool Material: M-3-D H.S.S.
Tool Type: Box, 1st Turn
Tool Signature: 17,2,8,8,6,0, 1/64
SURFACE FINISH x 10⁻⁶ (R.M.S.)
250
200
150
100
75
0
200
400
600
800
1000
NUMBER OF PIECES
Average Failure
KEY:
Oil
4316
4332
L589
L581

Fig. 22

PROJECT 2080
SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES

Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .0031
Parts Per Hour: 171
Material Cut: AISI - 1141 Steel
Tool Material: M-3-D H.S.S.
Tool Type: Box, 2nd Turn
Tool Signature:
Oils - L581, L589 17,2,8,8,6,0,1/64
Oils - 4332, 4316 8,15,8,8,6,0,1/64

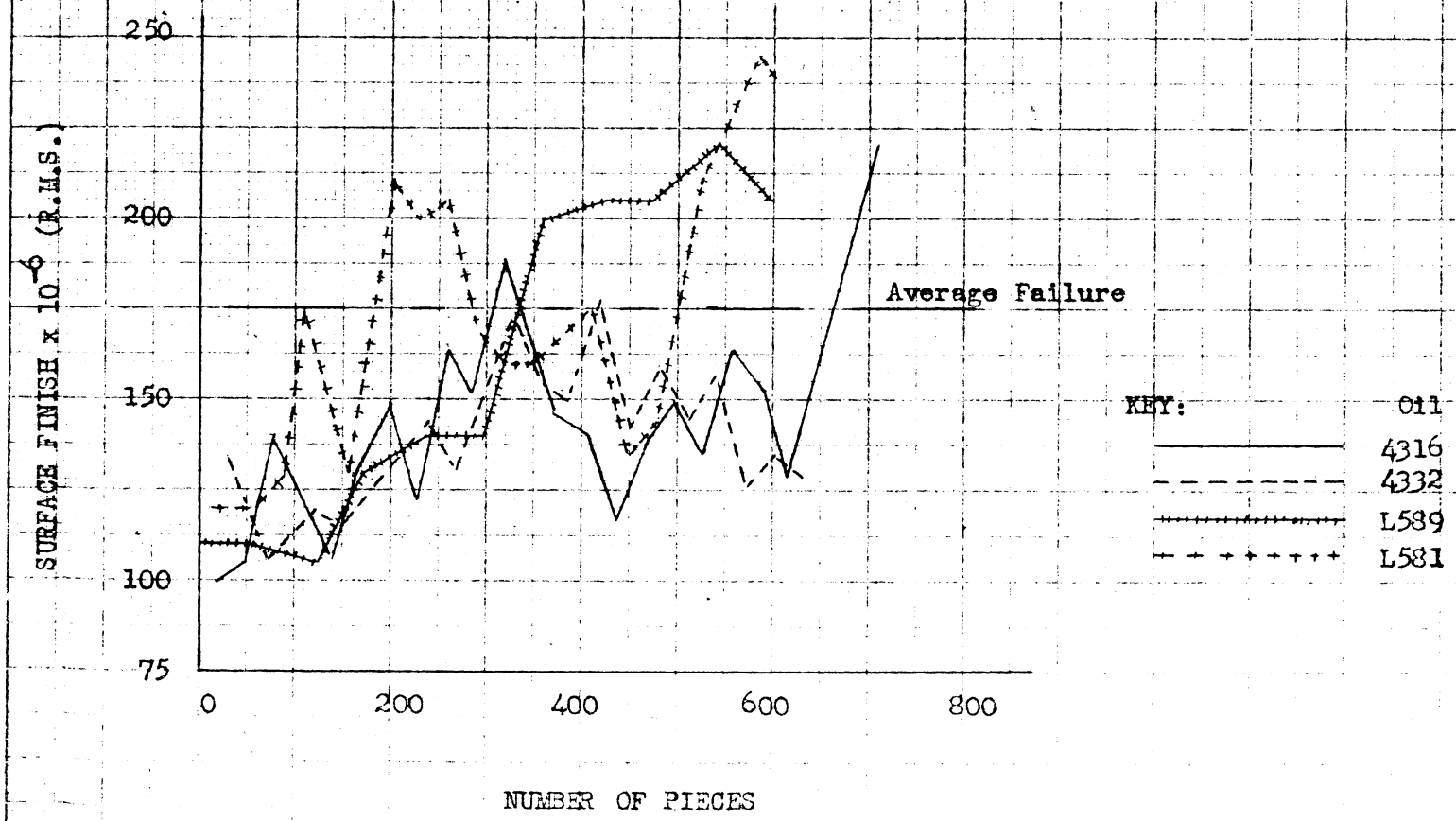

Fig. 23

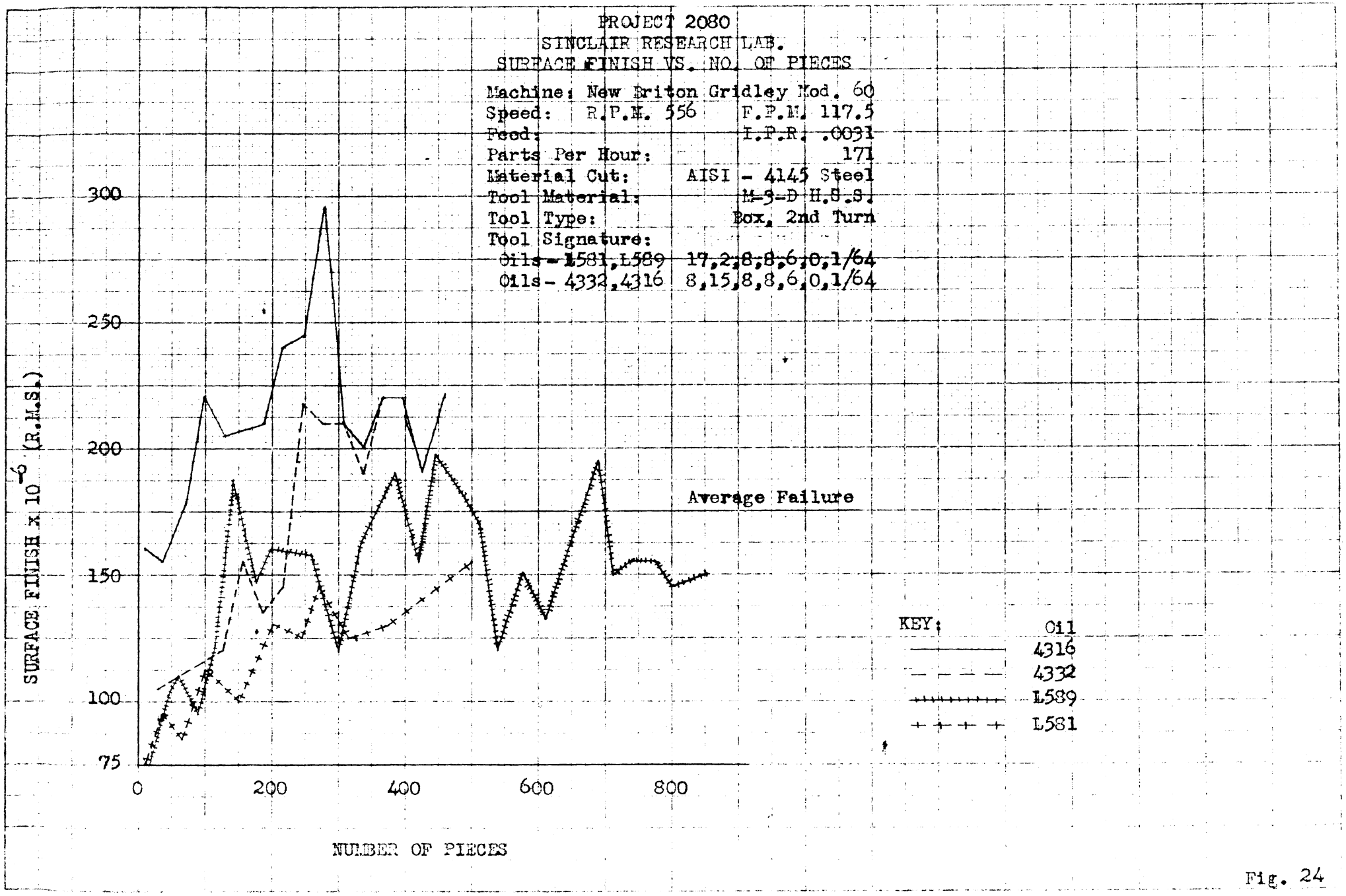
PROJECT 2080
SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES
Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .0031
Parts Per Hour: 171
Material Cut: AISI - 4145 Steel
Tool Material: M-3-D H.S.S.
Tool Type: Box, 2nd Turn
Tool Signature:
Oils - L581, L589 17,2,8,8,6,0,1/64
Oils - 4332, 4316 8,15,8,8,6,0,1/64
Average Failure
SURFACE FINISH x 10⁻⁶ (R.M.S.)
300
250
200
150
100
75
0
200
400
600
800
NUMBER OF PIECES
KEY:
Oil
4316
4332
L589
L581

Fig. 24

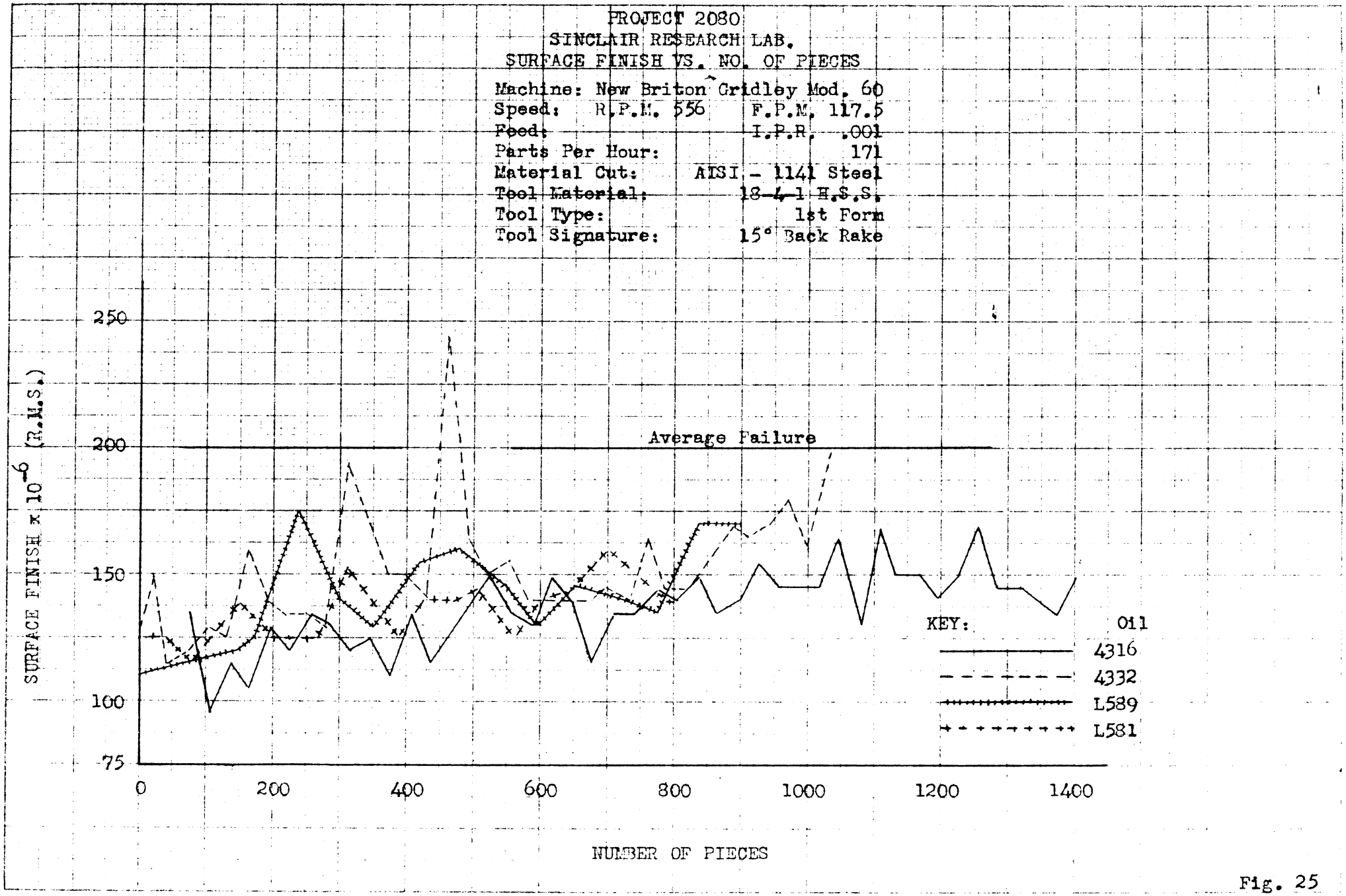
PROJECT 2080
SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES
Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .001
Parts Per Hour: 171
Material Cut: AISI - 1141 Steel
Tool Material: 18-4-1 H.S.S.
Tool Type: 1st Form
Tool Signature: 15° Back Rake
250
200
150
100
75
SURFACE FINISH x 10⁻⁶ (R.M.S.)
Average Failure
KEY:
011
4316
4332
L589
L581
0
200
400
600
800
1000
1200
1400
NUMBER OF PIECES

Fig. 25

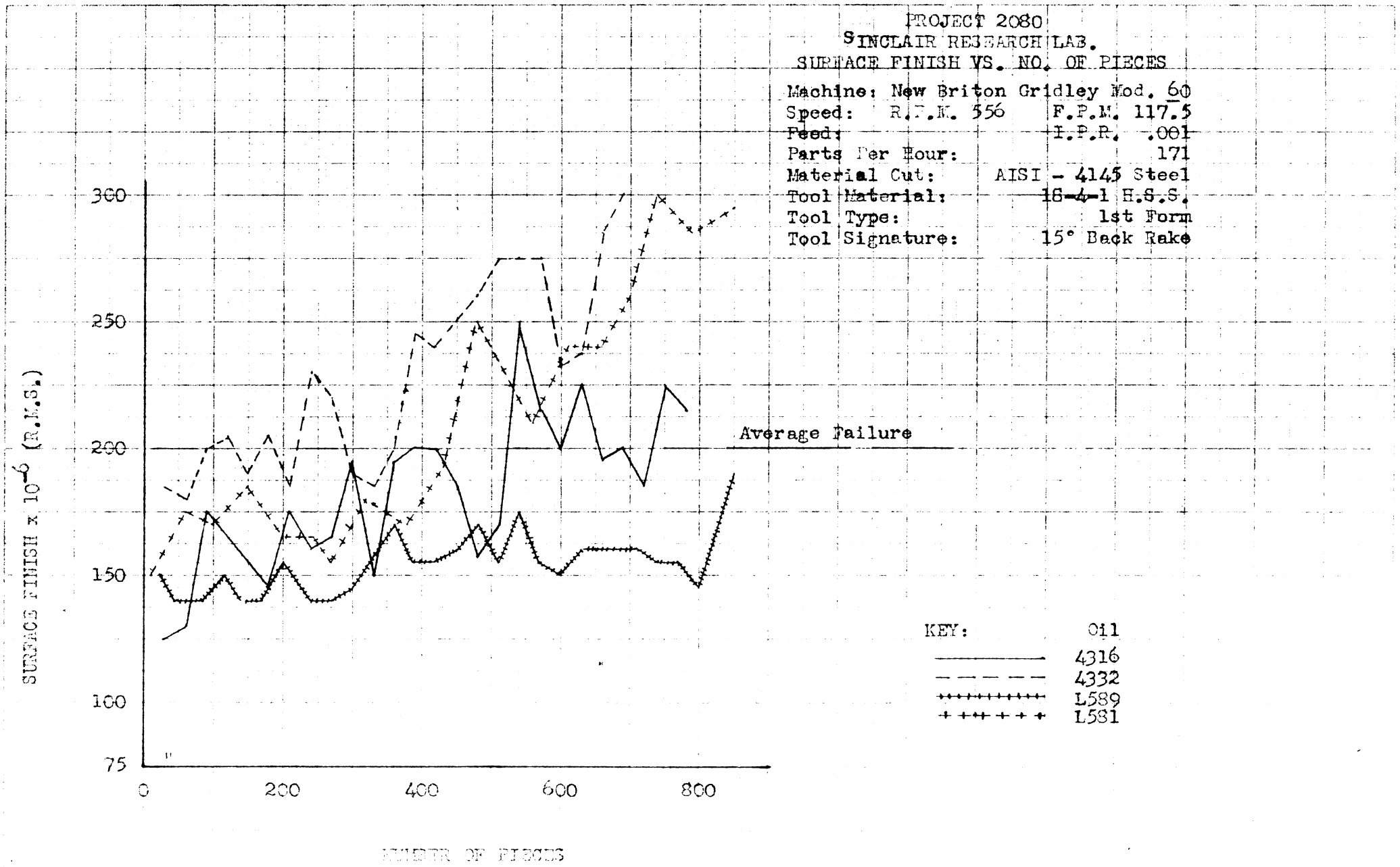
PROJECT 2080
SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES
Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .001
Parts Per Hour: 171
Material Cut: AISI - 4145 Steel
Tool Material: 18-4-1 H.S.S.
Tool Type: 1st Form
Tool Signature: 15° Back Rake
Average Failure
KEY: Oil
4316
4332
L589
L581
SURFACE FINISH x 10⁻⁶ (R.M.S.)
300
250
200
150
100
75
0
200
400
600
800
NUMBER OF PIECES

Fig. 25

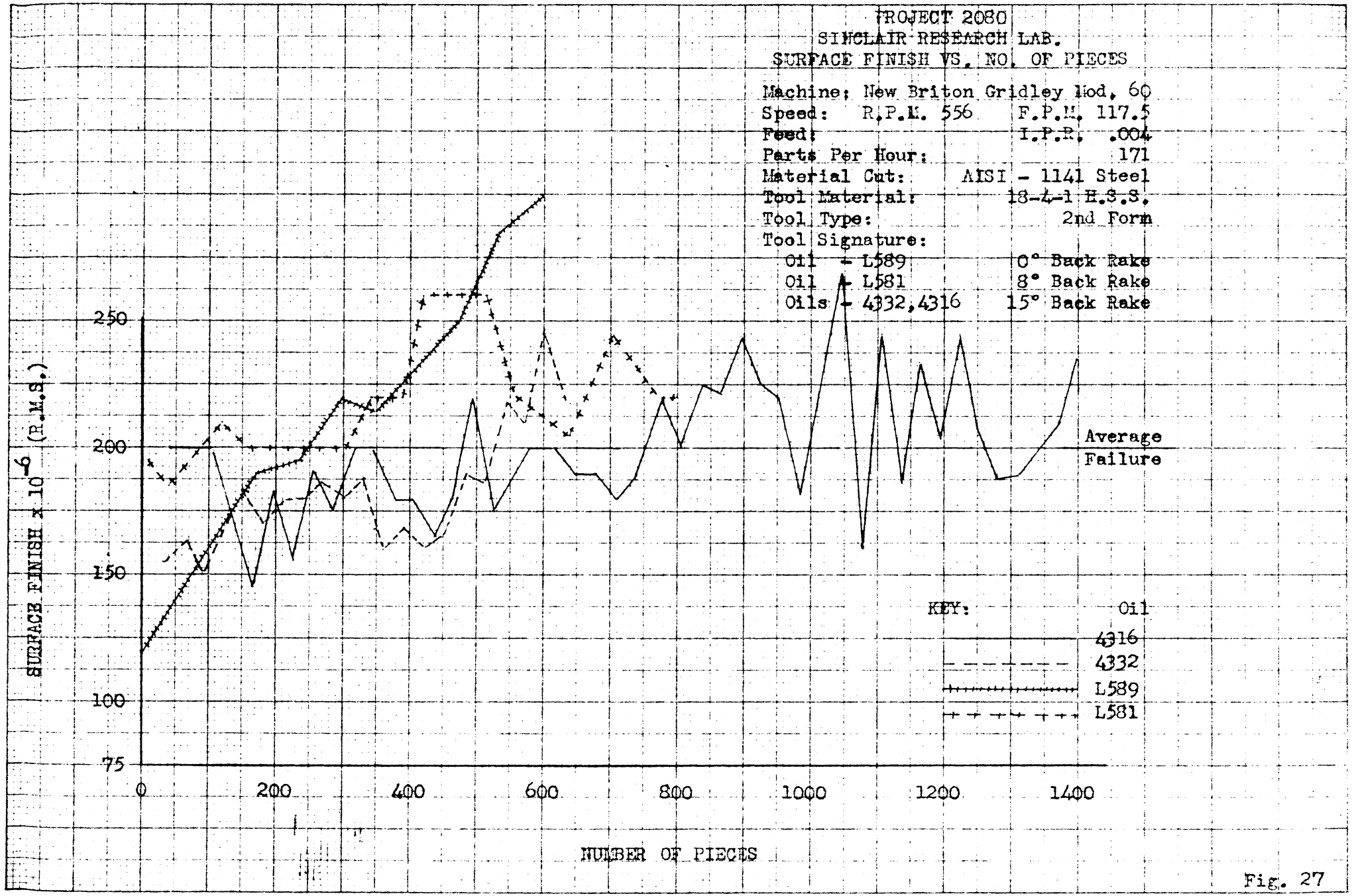
PROJECT 2080
SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES
Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .004
Parts Per Hour: 171
Material Cut: AISI - 1141 Steel
Tool Material: 18-4-1 H.S.S.
Tool Type: 2nd Form
Tool Signature:
Oil - L589 0° Back Rake
Oil - L581 8° Back Rake
Oils - 4332,4316 15° Back Rake
Average Failure
KEY: Oil
4316
4332
L589
L581
SURFACE FINISH x 10⁻⁶ (R.M.S.)
250
200
150
100
75
0
200
400
600
800
1000
1200
1400
NUMBER OF PIECES

Fig. 27

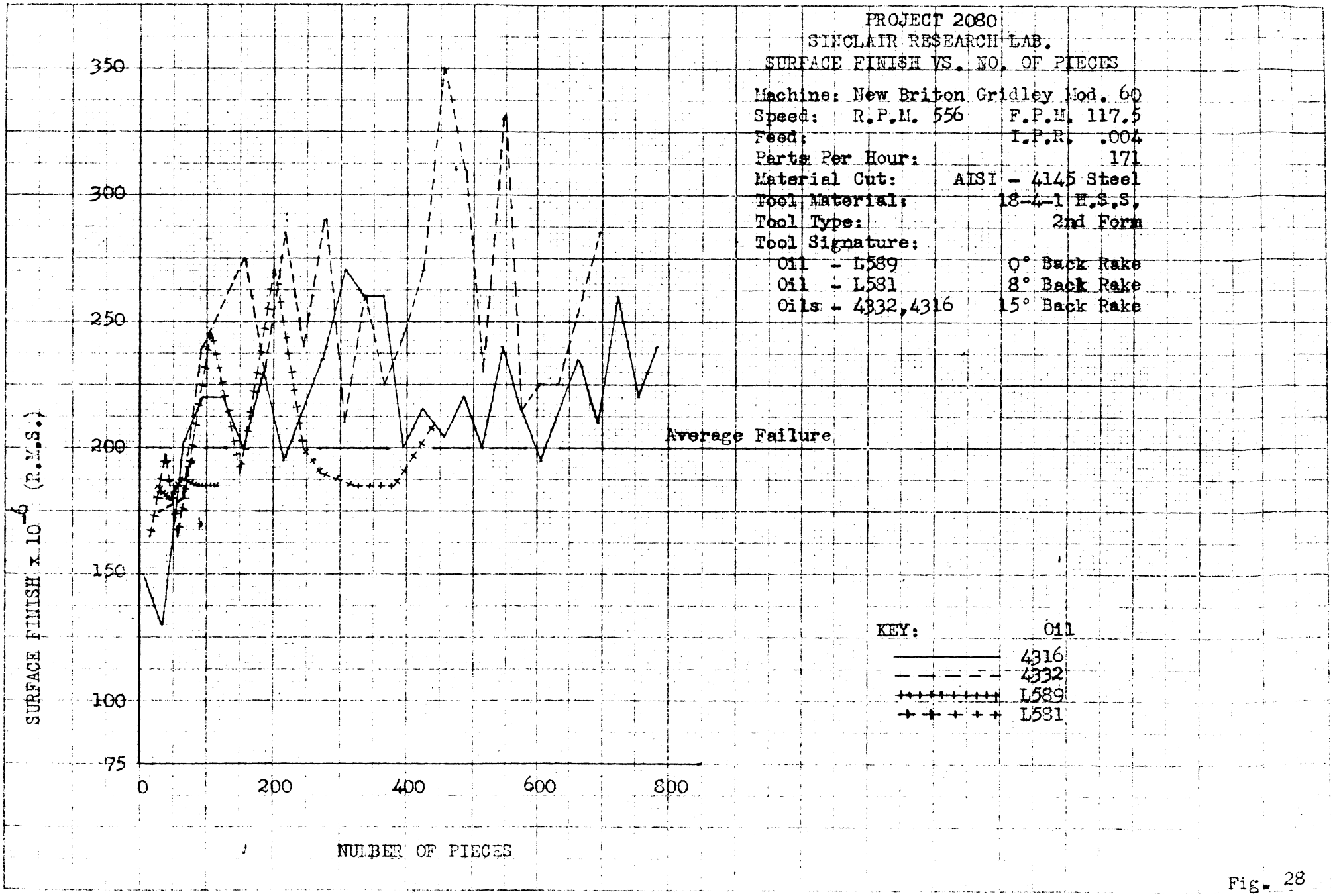
PROJECT 2080
SINCLAIR RESEARCH LAB.
SURFACE FINISH VS. NO. OF PIECES
Machine: New Briton Gridley Mod. 60
Speed: R.P.M. 556 F.P.M. 117.5
Feed: I.P.R. .004
Parts Per Hour: 171
Material Cut: AISI - 4145 Steel
Tool Material: 18-4-1 H.S.S.
Tool Type: 2nd Form
Tool Signature:
Oil - L589 0° Back Rake
Oil - L581 8° Back Rake
Oils - 4332,4316 15° Back Rake
Average Failure
KEY: Oil
4316
4332
L589
L581
SURFACE FINISH x 10⁻⁶ (R.M.S.)
350
300
250
200
150
100
75
0
200
400
600
800
NUMBER OF PIECES

Fig. 28