SURFACE FINISHING IN THE ANALYSIS OF ALUMINIUM ALLOYS BY X-RAY FLUORESCENCE SPECTROMETRY

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A DISSERTATION

in

CHEMISTRY

Presented in Partial Fulfillment of the Requirements
for the Degree of Master of Science at
Sir George Williams University
Montreal, Canada

August, 1970

ACKNOWLEDGMENTS

I wish to express my gratitude and appreciation to Professor J.G.Dick for his enlightening discussion and for his continuing interest, generous advice, assistance and encouragement during the progress of this work.

I would also like to express my thanks to the Aluminium Company of Canada Limited for providing the standard samples, as well as to Air Canada for permitting the use of their Surfmeter tester.

ABSTRACT

The determination of the surface finishes of maximum roughness permissible for solid aluminium alloy specimens intended to be analyzed for silicon, iron, copper, magnesium, zinc, manganese, titanium, chromium and nickel by X-ray fluorescence on the Picker Nuclear Spectrodiffractometer.

The determination of the value of "K" for the optical geometry associated with the above instrument.

The determination of the applicability of engine lathe machining as a method of surface finishing allowing the determination quantitatively of the elements above, while meeting the requirements as to speed of finishing demanded by industrial analytical processes.

T A B L E O F C O N T E N T S

1. INTRODUCTION AND THEORY

Solid aluminium alloy samples, secured by methods similar to those used in the sampling of molten aluminium alloys for chemical analysis by emission spectrography, can be analyzed both qualitatively and quantitatively by X-ray fluorescence spectrometry. The method is, of course, subject to the usual limitations as to quantity and element commonly associated with this technique of analysis. For example, elements of atomic number lower than sodium are not determinable with any worthwhile degree of accuracy using equipment that is standard in industrial applications.

The technique has, over recent years, been used as both a substitute for and an adjunct to the analysis of metallic materials by emission spectrography and, because of:

a) less complicated elemental spectra than the comparable emission spectra,

b) less restrictions as to the range of quantity determinable,

c) a generally improved relative error situation

has provided for, in many instances, an improved pattern of qualitative and quantitative results.

In brief, the technique as applied to aluminium alloys involves the irradiation of a properly prepared aluminium alloy solid sample surface with x-rays. The source of these x-rays is an x-ray tube, the anode of which is usually tungsten for the detection of elements of atomic number higher than scandium, or chromium in the case of elements of atomic number lower than titanium, although other tube anode materials are quite commonly encountered.

The primary beam from the anode causes the emission of secondary x-ray radiation by the sample, the pattern of emitted radiation representing a combination resulting from the elements present in the sample matrix. The collimated secondary beam is passed to a diffraction crystal, the nature of which will depend on the wavelengths for the impimging radiation. Subsequently the diffracted radiation is detected and measured, by either a scintillation counter or a proportional flow counter, at a 2-theta angle appropriate to the radiation wavelength involved and the diffraction crystal used. Figure 1 represents the general arrangement.

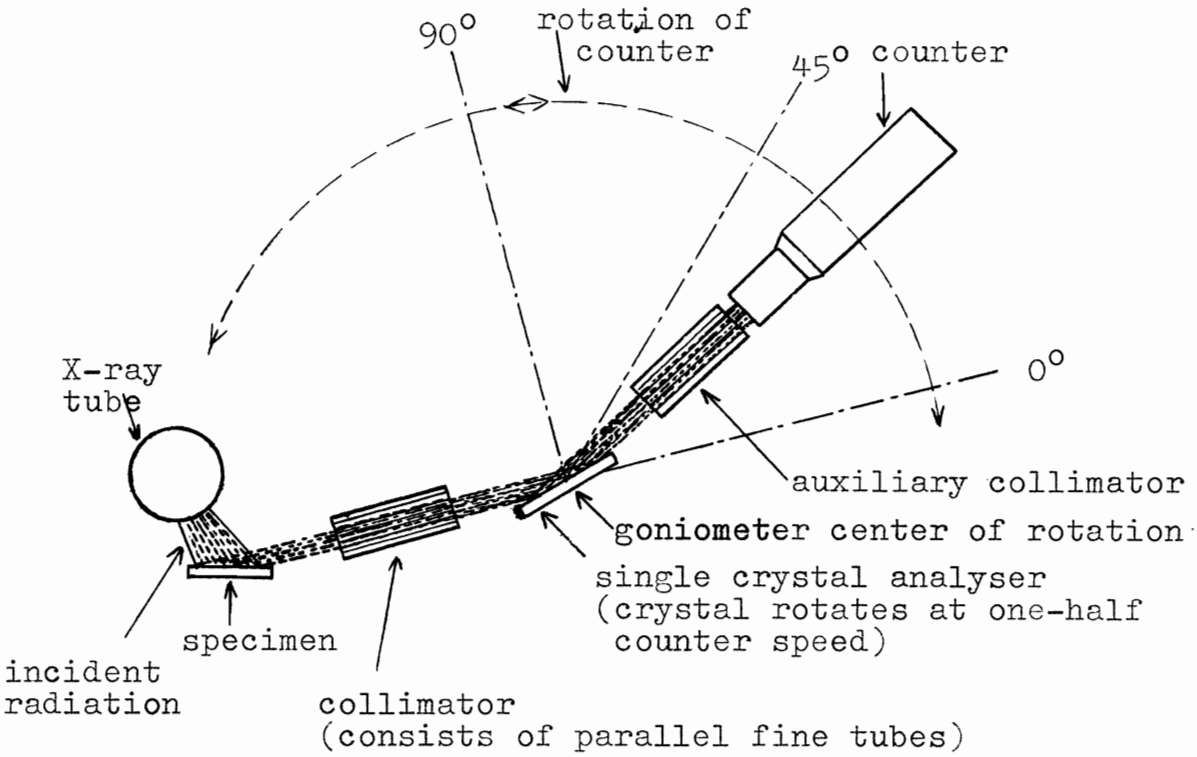

Figure 1.

Basic geometry of X-ray emission spectrograph.

Detection of diffracted radiation at specific 2-theta angles serves to identify the matrix elements involved; the intensity of the radiation measured at each angle by the counter permits quantitative estimation.

2. PURPOSE

The importance of the method of preparation of the surface of solid samples to be analyzed by x-ray fluorescence (XRF) has been stressed by several authors, notably Michaelis and Kilday (1), Flikkema and Schablaske (2), Gidley (3), Bills (4) and (5), Kilday and Michaelis (6), Lihl and Fischhuber (7) and Jenkins and Hurley (8). Basically two aspects relative to surface finish and preparation are of importance. These are:-

a) the separation distance between the sample surface and the x-ray tube anode

b) the shielding effect of the surface maxima arising out of the general surface finish.

An elaboration of these factors follows.

a) SEPARATION DISTANCE

This represents the distance separating the

anode of the X-ray tube and the surface of the sample under examination. The effect of increasing separation will be, of course, to lower the intensity of the primary beam at the sample surface and, consequently, the intensity of any secondary radiation emitted by the sample. In X-ray fluorescence spectrometers the sample is located at a fixed distance from the anode. Surface irregularities produced by the method of surface preparation do, however, result in a difference between the distance of separation of the peaks and valleys of these irregularities from the anode. An investigation by Jenkins and Hurley (8) indicated that, using several selected wavelengths of secondary emission, no significant change in emitted intensity took place until an increase in separation distance of 50 μ (1 $\mu = 10^{-6}$ meters) was achieved. At a separation distance of 500 μ the decrease in intensity amounted to about 3 percent, and thereafter the decrease in intensity amounted to about 1 percent for each additional 90 μ increase in separation distance. Generally speaking, the effects observed were independent of the emitted wavelength, but were strongly dependent on instrumental geometry, decreasing with

increasing fixed distance from sample surface to anode and increasing with decreasing take-off angle from the sample surface.

Since the surface is unlikely to be worse than an average of 50 μ distance from peak to valley of the irregularities as a commercial practice this effect, for a given instrument, will be relatively unimportant.

b) SHIELDING EFFECT

This effect has been described by Gunn (9). Figure 2 shows the effective depth of penetration of the sample surface by primary x-rays as the dotted lines, while the sample surface is shown as the solid line. A primary beam entering the sample at an angle of ψ_1 , penetrates to the effective depth, so that the cross-hatched area of the sample does not contribute in any way to the intensity of the secondary radiation emitted. The effective depth of penetration can be estimated from the take-off angle ψ_2 of the spectrometer, and the value of "x", the path length of the emitted radiation to be measured. The value of "x" can be calculated from the standard expression for absorption:-

$$I = I_o e^{-(u_m dx)} \qquad (1)$$

where u_m is the mass absorption coefficient of the

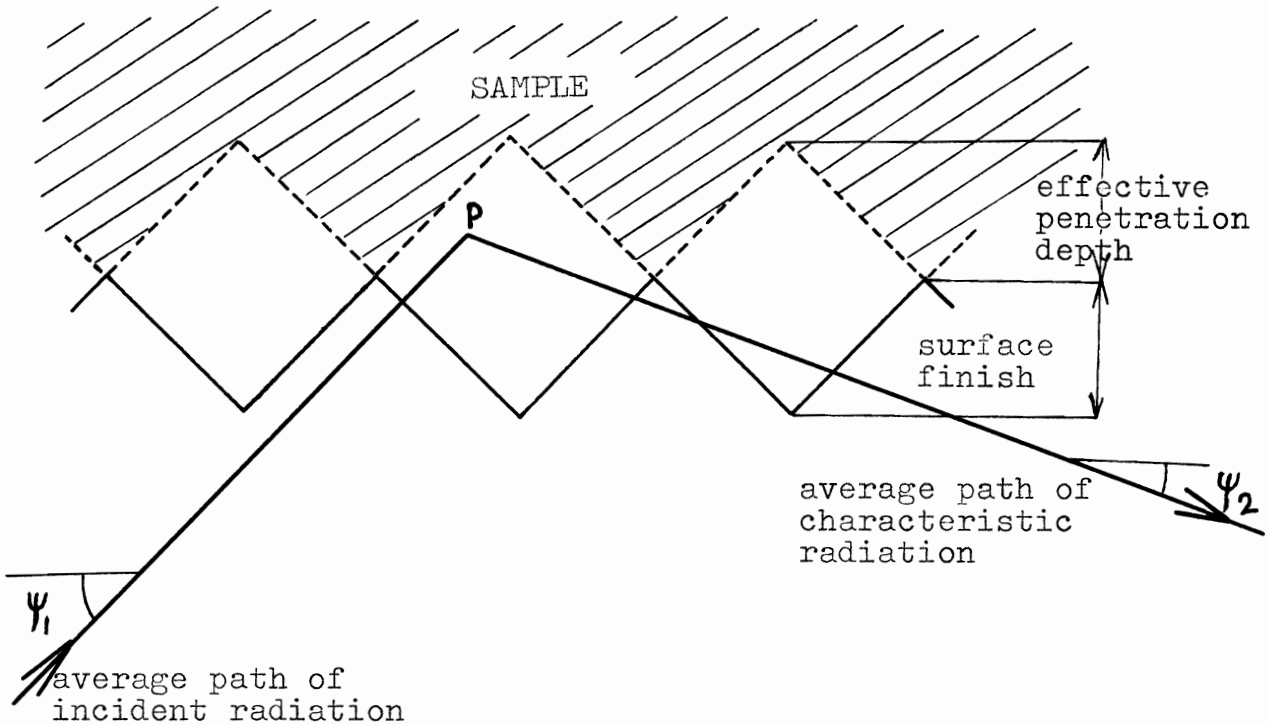

Figure 2.

Effect of shielding due to surface finish.

matrix for the wavelength of the measured radiation, and "d" is the density of the matrix. For a value of 99 percent absorbance we have:-

$$0.01 = e^{-(u_m dx)}$$

and:-

$$x = \frac{4.6052}{u_m d} \quad \text{in cm}$$

$$= \frac{46052}{u_m d} \quad \text{in microns } (\mu)$$

Any radiation arising at the point P, although it lies within the effective depth of penetration, will not be measurable, because of the additional interposed path length of the surface maximum involved.

Obviously, the more severe the surface maxima (rougher surfaces) the greater will be this effect in reducing the measurable intensity of emitted radiation. Just as obviously, the greater the take-off angle, the less this effect for comparable surface maxima. Again, the effect will be somewhat reduced with shorter emitted wavelengths (i.e. longer path lengths).

The work of Jenkins and Hurley (8) showed that it was possible, from data secured relative to surface roughness and emitted intensity of secondary radiation, to correlate path length and surface finish, and to

determine an expression for the estimation of the maximum allowable surface roughness (peak-to-valley distance) for the characteristic wavelength emitted by a given element in a given metallic matrix. Their work, where it covered aluminium alloys, reported only S_{max} (surface roughness maximum) values for aluminium, silicon, iron, copper. This, together with data accumulated on other metallic matrices, permitted the formulation:

$$S_{max} = K \cdot \left(\frac{46052}{\mu_m d}\right)^{1/3} \text{ microns } (\mu) \quad (2)$$

where: S_{max} is the surface finish in terms of the average peak-to-valley separation in microns.
K is a factor dependent on the instrumental geometry.(For a take-off angle of 35^{o}, K was found to be 30).

It will be noted that S_{max} varies as the one-third power of "x" the path length of the emitted radiation to be measured.

Mention should be made of a third factor of some considerable importance in sample surface preparation. This is the property of certain elements, notably silicon and lead, of producing surface smearing effects under standard lathe turning or abrasive

methods of surface finishing. Such surface layers result from the detachment of softer particles of these elements from the matrix, and the smearing of the particles over the surface. While this effect can be minimized by carefully controlled techniques of surface finishing, where it occurs it can cause either or both:

a) enhancement of the intensity of the emitted radiation for the smeared element,

b) decrease by absorption of the intensity of emitted radiation for certain lower atomic number matrix elements.

The available methods of surface preparation for aluminium alloys commonly applied are:

a) lathe turning,

b) abrasive finishing.

Although many XRF operations are based on the reduction of the sample surface by abrasive finishing, care must be taken to avoid final finishing operations with abrasive papers, cloths or powders involving silicon carbide or aluminium oxide, since these two substances may permit erratic results, particularly in the determination of aluminium (for Al_2O_3 finishes) or silicon (for SiC finishes) in the matrix. Where

final abrasive finishes are involved, a last step with fine diamond abrasive is required to eliminate the possibility of such effects.

The method of abrasive finishing usually involves the use of successively finer grits, culminating with a final operation using 20 micron diamond paste. The method, while excellent, is time-consuming and, in industrial applications where many samples must be handled rapidly, time is usually an extremely important factor. Methods involving lathe turning, if applicable, would provide a much more rapid means of securing the desired surface finish. Care must be taken relative to machine tool shape and sharpness in order to avoid the problems associated with surface smearing.

The purpose of this investigation is therefore to investigate further in depth the work of Jenkins and Hurley (8) relative to:

a) extending the number of elements in the aluminium alloy matrix for which S_{max} is determined,

b) since the optical geometry of the Picker Nuclear Instrument differs from that of the Philips equipment used by Jenkins and Hurley (45^{o} take-off instead of 35^{o}, for example), determination of the

value of "K" in equation (2) was required for future reference,

c) determination of the applicability of the method of lathe turning as a rapid means of surface finishing aluminium alloy samples for XRF analysis.

3. METHODS OF DATA AQUISITION

a) Matrix elements to be investigated

The most common elements determined in the aluminium alloy matrix are:

Silicon
Iron
Copper
Magnesium
Manganese
Zinc
Titanium
Chromium
Nickel

It is understood that, for metallurgical reasons, the determination of silicon by XRF is usually restricted to those aluminium alloys where the

silicon content is about 10 % or less. Problems with respect to segregation and resultant lack of compositional homogenity prevent the obtaining of accurate results where the silicon content much exceeds this level.

b) Selection of standard samples for investigation

A selection of standard analyzed samples was made available by the Aluminium Company of Canada. Of these, several were selected relative to the investigation of various matrix elements, and the relationship between surface finish and their emitted radiation intensities. Table 1 shows the selection, compositions and elements investigated.

c) The method of preparing the surface

The Alcan standards were available in discs of the proper diameter to fit the Picker Nuclear sample holder. Only two discs of each alloy were available, but the discs were of a thickness adequate to permit successive surface finishing operations to be carried out.

With only two discs of each alloy available, it was not feasible to cross-section each disc after each surface finishing procedure and X-ray emission intensity measurements in order to determine by measurement the actual surface roughness as an average peak-to-valley value. A series of discs was therefore cut from standard aluminium alloy bar stock, and one of these was subjected to each surface finishing operation. These extra discs were then cross-sectioned and used to determine the surface given by each finishing operation. It was assumed that, in any such comparison, the surface finish or profiles determined for these extra or control discs would hold for the experimental discs.

Each experimental disc, with the control disc for that set, was turned down on a high speed engine lathe at the depths of cut and traverse speeds given in Table 2. The descriptive number under the column headed "SET" is intended to identify each turning operation by the anticipated peak-to-valley value in inches. The lathe tool used had a 60° profile at the carballoy tip and was re-sharpened after each individual set series.

In addition to and after the series of surface finishes produced by lathe turning, each experimental disc was subjected finally to a series of abrasive finishing operations involving successively 180, 240, 320, 400 and 600 grit silicon carbide abrasive cloths. The final finish for each disc was given with a wet polishing wheel using 6 micron diamond paste.

d) Method of determining the surface finish

All of the lathe turned control discs were cross-sectioned at right angles to the finished surface. The cross-sectioned surface was then reduced successively using 180, 240, 320, 400 and 600 grit silicon carbide abrasive cloths. The final finish was given with a wet polishing wheel using 1 micron diamond paste. These cross-sections were then examined at 1000 magnifications under a metallurgical microscope. The projection screen of the microscope was capable of the following measurement limits:-

1 division = 0.010 mm (10 μ)

with an uncertainty of:-

± 0.2 division = ± 0.002 mm (2 μ)

Each control disc was examined at 10 locations, and

the corresponding peak-tovalley values secured. Tables 3 to 12 inclusive show the values obtained.

The diamond finished control disc was examined in 10 locations by a Surfmeter tester, and Table 13 shows the results secured.

Table 14 shows the final values of surface finish in microns peak-to-valley separation involved. The optimum value of surface finish for graphing purposes is also shown.

As a matter of interest, the average surface finish produced by various abrasive grit polishes was determined by Surfmeter measurement.

Table 15 shows the associated values in microns. It will be noted that even a finish by 80 grit silicon carbide provides for a surface of lesser roughness than the best lathe turning operation applied in this investigation.

e) Method of securing emission intensity data

The instrumental operating parameters required for the detection of emitted radiation from the matrix elements to be investigated had previously been determined for aluminium alloys by Professor

Dick in association with Mr. A. Fraser and Mr. G. Green. These parameters are shown in table 16. The intensity of emission for each element involved the following wavelengths.

Element	Radiation	λ(Å)
Silicon	K_α	7.13
Iron	K_α	1.94
Copper	K_α	1.54
Magnesium	K_α	9.89
Manganese	K_α	2.10
Zinc	K_α	1.44
Titanium	K_α	2.75
Chromium	K_α	2.29
Nickel	K_α	1.66

In order to ensure that the counting level for each series of counts involving the different surface finishes was referred to the same basis, an emission intensity counting standard for each element was used. These counting standards were aluminium alloy discs of fixed and measured surface finish. For each set of surface fihishes for the experimental discs, the counting standard appropriate to the element involved was counted, and a correction factor was subsequently used

to correct the counting intensity for a given element to the same basis for each surface finish. The counting standards used were:

Counting Standard	Element
143-AA	Iron
CA-6195-AA-D	Silicon
6561-CABS	Zinc
143-AA	Copper
143-AA	Chromium
6046-CABS	Titanium
340-AA-D	Magnesium
143-AA	Manganese
6046-CABS	Nickel

The emission intensity for each element, associated with each surface finish, was first corrected for dead time wherever the count rate on the scintillation counter exceeded 30,000 cps. No counts taken on the proportional flow counter exceeded the dead time correction minimum, so that proportional flow counter counting required no dead time corrections. The formulation for dead time correction on the scintillation counter was derived by Professor Dick as:

$$N = \frac{n}{1.02437 - (0.79681 \times 10^{-6} \times n)} \qquad (3)$$

where:- N = corrected count in cps

n = measured count in cps

Subsequent to the dead time correction, the count intensity was corrected for the average background count. Finally, this latter corrected count was multiplied by the counting standard correction factor. Tables 17 to 25 inclusive summarize the data secured for each element and each finishing operation. The final column in each case gives the 3s (3 times standard deviation) counting error in cps for the counting level involved. The second to the last column shows the difference between the counts in cps for each surface finish and the finish immediately rougher. It was taken that any difference equal or less than the 3s counting error represented the achievement of a constant counting rate and a finished surface finer than which would yield no further change in the intensity of emission.

Figures 3 to 11 show the data from Tables 17 to 25 expressed in graphic form. The straight line

section representing a steady intensity of emission was extrapolated in each case, and the departure point of the curve corresponding to magnitude of difference equal to $3s$ was taken as the point of critical surface finish or S_{max}. This point is indicated on the extrapolated line by the cut-off "] " position. The following S_{max} values were secured in this way:

Element	S_{max} (μ)
Silicon	75
Iron	265
Copper	235
Magnesium	115
Manganese	200
Zinc	250
Titanium	145
Chromium	135
Nickel	195

f) Calculation of mass absorption coeffcients for the various alloy matrices

In order to determine the value of "K" in equation (2)

$$S_{max} = K \cdot \left(\frac{46052}{\mu_m \, d}\right)^{1/3} \text{ microns}$$

it is necessary to determine the alloy densities, and the mass absorption coefficients for the various elements relative to the alloy matrices.

The density values were determined by the usual displacement - weight technique. These were found to be sufficiently similar for the alloys involved to allow use of a general density value of 2.7 g/cm^3.

Table 26 shows the calculation of the mass absorption coefficient for the relevant elements in the various alloy matrices.

These can be summarized as:

Element	Alloy	μ_m
Silicon	CA-6195-AA-D	2840
Iron	CA-6195-AA-D	86
Copper	CA-6195-AA-D	50
Magnesium	CA-79-S-AE	770
Manganese	CA-6195-AA-D	119
Zinc	CA-79-S-AE	43
Titanium	6449-AA	269
Chromium	CA-79-S-AE	152
Nickel	162-AZ	62

g) Calculation of the value "K"

Using the values of μ_m and density as determined, the value of "K" for equation (2) was calculated relative to each elemental S_{max} value secured from the curves of intensity versus surface finish. The following "K" values were obtained:

Element	"K" (Equation (2))
Silicon	41
Iron	44
Copper	34
Magnesium	41
Manganese	38
Zinc	34
Titanium	36
Chromium	28
Nickel	30
Average value	36 ± 5

It is difficult to explain the unusually low values for chromium and nickel. One could assume, for chromium, that the straight line section, representing the constant intensity zone, depends for its location only three points which themselves are in rather poor agreement.

The value of "K" at 36 is, as anticipated, higher than the value of 30 found by Jenkins and

Hurley (8), this on the basis of the difference in instrumental geometry. A comparison of the values for S_{max} calculated using $K = 36$ with those from the graphs yields the following, and allows some estimation of the accuracy of expressing S_{max}.

Element	S_{max} Calculated	S_{max} Graph
Silicon	60 (6 x 10)	75
Iron	210 (21 x 10)	265
Copper	250 (25 x 10)	235
Magnesium	100 (10 x 10)	115
Manganese	190 (19 x 10)	200
Zinc	260 (26 x 10)	250
Titanium	140 (14 x 10)	145
Chromium	170 (17 x 10)	135
Nickel	230 (23 x 10)	195

Thus the use of equation (2) with $K = 36 \pm 5$ in the calculation of S_{max} for elements other than listed here should be quite feasible.

If one considers that silicon is the critical element to be determined, relative to its sensivity

to surface finish, and if one considers that a surface finish of 25 μ would be satisfactory for all of the elements investigated, it is possible to secure an adequate surface finish by lathe turning at a final cut of 0.001 inch and a traverse speed of 0.001 inch/revolution. It is understood that the tool profile should be 60° under these conditions.

4. CONCLUSIONS

a) The investigation indicates the determination of S_{max} for nine elements commonly determined quantitatively. The maximum allowable surface roughness for each element is indicated so that, where only certain elements must be determined, the optimum lathe settings to secure this final finish most rapidly could be ascertained.

b) The value of "K" is established for the Picker Nuclear Spectrodiffractometer. While this value is not established with high accuracy, because of both the graphic method used and the low values obtained for "K" for chromium and nickel, it allows calculation of S_{max} for other metallic matrices with a sufficient level of accuracy. This is particularly so since ordinarly the S_{max} calculated for any element would suggest an approach to a surface finish twice as fine (e.g. S_{max} = 200 : lathe turn for S_{max} = 100).

c) The method of lathe turning is shown to be capable of the preparation rapidly, and with a satisfactory surface finish, of aluminium alloy samples for analysis by XRF. It should be pointed out that, in its proper application, an initial cut should be taken on the lathe, followed by a final cut at the proper depth and traverse settings.

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6. APPENDIX

T A B L E S AND F I G U R E S.

TABLE 1

SELECTION OF STANDARD SAMPLES FOR INVESTIGATION

Sample No	COMPOSITION Si	Fe	Cu	Mg	Mn	Zn	Ti	Cr	Ni	Bi	Pb	Al	Element Investigated
CA-6195-AA-D	9.50	0.70	3.42	1.09	0.42	0.90						83.70	Silicon Copper Manganese Iron
CA-6195-AC	identical values												
CA-79-S-AE		0.29	0.65	3.34	0.22	4.70		0.20				90.20	Zinc Chromium Magnesium
6449-AA	0.65	0.25	0.32	0.89	0.15		0.08			0.46	0.46	96.50	Titanium
162-AZ	12.10	0.41	0.79	1.09					2.50			82.90	Nickel

Where no values are shown for elemental composition, these were low enough to be considered insignificant.

Analysis results as reported by Alcan Laboratories

Table no: 2

LATHE SETTING FOR VARIOUS SURFACE FINISHES

Set	Depth of Cut (ins.)	Traverse Speed (in. per rev.)
0.028	0.028	0.032
0.024	0.024	0.028
0.020	0.020	0.023
0.016	0.016	0.018
0.012	0.012	0.014
0.008	0.008	0.009
0.006	0.006	0.007
0.004	0.004	0.005
0.002	0.002	0.002
0.001	0.001	0.001

Table no: 3

DETERMINATION OF SURFACE FINISH - SET 0.028

Measurement	Scale (div.)	mm	d	d^2
1	65.4	0.654	0.050	0.002500
2	68.6	0.686	0.018	0.000324
3	74.8	0.748	0.044	0.001936
4	71.4	0.714	0.010	0.000100
5	70.4	0.704	0.000	0.000000
6	72.8	0.728	0.024	0.000576
7	69.9	0.699	0.005	0.000025
8	69.3	0.693	0.011	0.000121
9	72.8	0.728	0.024	0.000576
10	68.2	0.682	0.022	0.000484

Average mm = 0.704

Standard deviation (s) = 0.027

Table no: 4

DETERMINATION OF SURFACE FINISH - SET 0.024

Measurement	Scale (div.)	mm	d	d^2
1	64.3	0.643	0.050	0.002500
2	62.8	0.628	0.035	0.001225
3	57.4	0.574	0.019	0.000361
4	57.5	0.575	0.018	0.000342
5	56.9	0.569	0.024	0.000576
6	57.4	0.574	0.019	0.000361
7	60.2	0.602	0.009	0.000081
8	59.7	0.597	0.004	0.000016
9	56.9	0.569	0.024	0.000576
10	59.5	0.595	0.003	0.000009

Average mm = 0.593

Standard deviation (s) = 0.026

Table no: 5

DETERMINATION OF SURFACE FINISH - SET 0.020

Measurement	Scale (div.)	mm	d	d^2
1	52.9	0.529	0.039	0.001521
2	46.8	0.468	0.022	0.000484
3	47.7	0.477	0.013	0.000169
4	48.8	0.488	0.002	0.000004
5	50.4	0.504	0.014	0.000196
6	46.7	0.467	0.023	0.000529
7	49.8	0.498	0.008	0.000064
8	51.0	0.510	0.020	0.000400
9	48.8	0.488	0.002	0.000004
10	46.6	0.466	0.024	0.000576

Average mm = 0.490

Standard deviation (s) = 0.021

Table no: 6

DETERMINATION OF SURFACE FINISH - SET 0.016

Measurement	Scale (div.)	mm	d	d^2
1	38.9	0.389	0.009	0.000081
2	38.8	0.388	0.008	0.000064
3	39.5	0.395	0.015	0.000225
4	38.9	0.389	0.009	0.000081
5	40.6	0.406	0.026	0.000676
6	38.0	0.380	0.000	0.000000
7	39.4	0.394	0.014	0.000196
8	39.9	0.399	0.019	0.000361
9	37.7	0.377	0.003	0.000009
10	38.5	0.385	0.005	0.000025

Average mm = 0.380

Standard deviation (s) = 0.014

Table no: 7

DETERMINATION OF SURFACE FINISH - SET 0.012

Measurement	Scale (div.)	mm	d	d^2
1	31.2	0.312	0.024	0.000576
2	28.4	0.284	0.004	0.000016
3	29.2	0.292	0.004	0.000016
4	28.8	0.288	0.000	0.000000
5	27.5	0.275	0.013	0.000169
6	28.4	0.284	0.004	0.000016
7	29.8	0.298	0.010	0.000100
8	30.0	0.300	0.012	0.000144
9	27.8	0.278	0.010	0.000100
10	26.9	0.269	0.019	0.000361

Average mm = 0.288

Standard deviation (s) = 0.013

Table no: 8

DETERMINATION OF SURFACE FINISH - SET 0.008

Measurement	Scale (div.)	mm	d	d^2
1	20.8	0.208	0.014	0.000196
2	19.1	0.191	0.003	0.000009
3	18.9	0.189	0.005	0.000025
4	19.5	0.195	0.001	0.000001
5	19.9	0.199	0.005	0.000025
6	19.0	0.190	0.004	0.000016
7	18.7	0.187	0.007	0.000049
8	20.1	0.201	0.007	0.000049
9	18.5	0.185	0.009	0.000081
10	19.2	0.192	0.002	0.000004

Average mm = 0.194

Standard deviation (s) = 0.007

Table no: 9

DETERMINATION OF SURFACE FINISH - SET 0.006

Measurement	Scale (div.)	mm	d	d^2
1	15.9	0.159	0.013	0.000169
2	16.1	0.161	0.015	0.000225
3	14.0	0.140	0.006	0.000036
4	14.1	0.141	0.005	0.000025
5	14.0	0.140	0.006	0.000036
6	13.8	0.138	0.008	0.000064
7	14.9	0.149	0.003	0.000009
8	15.0	0.150	0.004	0.000016
9	14.2	0.142	0.004	0.000016
10	14.0	0.140	0.006	0.000036

Average mm = 0.146

Standard deviation (s) = 0.008

Table no: 10

DETERMINATION OF SURFACE FINISH - SET 0.004

Measurement	Scale (div.)	mm	d	d^2
1	10.9	0.109	0.014	0.000196
2	10.1	0.101	0.006	0.000036
3	8.9	0.089	0.006	0.000036
4	8.7	0.087	0.008	0.000064
5	9.4	0.094	0.001	0.000001
6	9.8	0.098	0.003	0.000009
7	9.2	0.092	0.003	0.000009
8	9.6	0.096	0.001	0.000001
9	8.9	0.089	0.006	0.000036
10	9.3	0.093	0.002	0.000004

Average mm = 0.095

Standard deviation (s) = 0.007

Table no: 11

DETERMINATION OF SURFACE FINISH - SET 0.002

Measurement	Scale (div.)	mm	d	d^2
1	5.9	0.059	0.011	0.000121
2	6.1	0.061	0.013	0.000169
3	4.0	0.040	0.008	0.000064
4	3.9	0.039	0.009	0.000081
5	4.5	0.045	0.003	0.000009
6	4.8	0.048	0.000	0.000000
7	4.4	0.044	0.004	0.000016
8	4.6	0.046	0.002	0.000004
9	4.8	0.048	0.000	0.000000
10	4.9	0.049	0.001	0.000001

Average mm = 0.048

Standard deviation (s) = 0.007

Table no: 12

DETERMINATION OF SURFACE FINISH - SET 0.001

Measurement	Scale (div.)	mm	d	d^2
1	2.9	0.029	0.004	0.000016
2	3.1	0.031	0.006	0.000036
3	2.4	0.024	0.001	0.000001
4	2.1	0.021	0.004	0.000016
5	2.0	0.020	0.005	0.000025
6	2.6	0.026	0.001	0.000001
7	2.4	0.024	0.001	0.000001
8	2.8	0.028	0.003	0.000009
9	2.1	0.021	0.004	0.000016
10	2.5	0.025	0.000	0.000000

Average mm = 0.025

Standard deviation (s) = 0.004

Table no: 13

DETERMINATION OF SURFACE FINISH - SET 6 μ

Measurement	Surfmeter reading (μ ins.)	μ	d	d^2
1	7	0.178	0.025	0.000625
2	7	0.178	0.025	0.000625
3	8	0.203	0.000	0.000000
4	8	0.203	0.000	0.000000
5	8	0.203	0.000	0.000000
6	9	0.229	0.026	0.000676
7	9	0.229	0.026	0.000676
8	8	0.203	0.000	0.000000
9	8	0.203	0.000	0.000000
10	7	0.178	0.025	0.000625

Average $\mu = 0.203$

Standard deviation $(s) = 0.018$

Table no: 14

SURFACE FINISH IN MICRONS FOR EACH TEST SET

Set	mm	μ	Value for graphing
0.028	0.70 ± 0.03	(70 ± 3)x10	700
0.024	0.59 ± 0.03	(59 ± 3)x10	600
0.020	0.49 ± 0.02	(49 ± 2)x10	500
0.016	0.38 ± 0.01	(38 ± 1)x10	400
0.012	0.29 ± 0.01	(29 ± 1)x10	300
0.008	0.194 ± 0.007	194 ± 7	200
0.006	0.146 ± 0.008	146 ± 8	150
0.004	0.095 ± 0.007	95 ± 7	100
0.002	0.048 ± 0.007	48 ± 7	50
0.001	0.025 ± 0.004	25 ± 4	25
Diamond paste 6 μ	-	0.20 ± 0.02	0

Table no: 15

SILICON CARBIDE ABRASIVE PAPER SURFACE FINISHES

(measured with Surfmeter)

Grit class	Microinches μ (10^{-6}in.)	Microns μ (10^{-6} m)
80	85	2.1
120	50	1.3
240	40	1.0
320	28	0.7
400	20	0.5
600	8	0.2
Diamond paste 6 μ	8	0.2

TABLE 16

X-RAY SPECTROMETER PARAMETERS FOR SURFACE FINISH STUDY

	Cu	Cr	Fe	Mn	Ni	Ti	Zn	Mg	Si
Target	W	W	W	W	W	W	W	Cr	Cr
Kv	40	44	40	40	40	40	40	50	50
mA	20	26	36	20	24	30	18	32	30
Crystal	LiF	LiF	LiF	LiF	LiF	LiF	LiF	ADP	PET
w angle	+ 0.19	+ 0.19	+ 0.19	+ 0.19	+ 0.19	+ 0.19	+ 0.19	- 0.44	- 0.47
Collimator	fine	coarse	fine	coarse	fine	coarse	fine	coarse	coarse
Counter	SC	SC	SC	SC	SC	PFC	SC	PFC	PFC
He flow	1.5 cfh for all examinations								
P-10 flow	-	-	-	-	-	0.5 cfh	-	0.5 cfh	0.5 cfh
Gain	5	5	5	5	5	5	5	5	5
Counter HV	832	892	832	880	832	1520	832	1530	1534
Lower level kev	0.50	0.50	0.50	0.50	0.50	3.72	0.50	0.50	0.86
Upper level kev	zero	zero	zero	zero	zero	5.00	zero	2.00	2.62
Mode	Int	Int	Int	Int	Int	100 %	Int	100 %	100 %
Counting Secs	10	10	10	10	10	10	10	10	10
2 theta peak	45.02	69.34	57.52	62.94	48.66	86.12	41.78	136.69	109.21
Background 1	44.30	68.00	56.52	61.50	47.50	84.40	41.20	135.40	107.00
Background 2	45.80	70.50	58.52	64.50	49.50	88.00	42.50	138.50	111.50
Sample rotation	All samples rotated								

SILICON — INTENSITY OF EMISSION VERSUS SURFACE FINISH

Counting standard:- CA-6195-AA-D Standard count taken for set 0.024 = 1567 cps

Test sample:- CA-6195-AC

Set	Set count cps	Average cps	Correction Factor	Peak cps	Bkg 1 cps	Bkg 2 cps	Average peak	Average bkg	Corrections to Average Peak: Dead time	av. bkg.	Factor	Diff	3s
0.024	1590,1557, 1555	1567	1.0000	962,957, 959	16, 14,15	7,8, 7	959	11	-	948	948	+ 95	28
0.020	1580,1549, 1552	1560	1.0045	1052,1062, 1043	17, 17,16	9,8, 9	1052	13	-	1039	1043	+ 88	31
0.016	1581,1547, 1545	1558	1.0058	1144,1136, 1134	18, 17,17	9,9, 8	1138	13	-	1125	1131	+ 92	34
0.012	same as 0.016	1558	1.0058	1234,1222, 1231	18, 18,18	9,9, 9	1229	13	-	1216	1223	+137	37
0.008	1575,1562, 1559	1565	1.0013	1372,1356, 1358	18, 19,19	10,9, 9	1362	14	-	1348	1350	+ 48	32
0.006	same as 0.008	1565	1.0013	1430,1411, 1402	19, 19,18	10,10, 10	1414	14	-	1400	1402	+ 74	35
0.004	1598,1575, 1569	1581	0.9911	1529,1491, 1490	19, 18,20	10,11, 9	1503	14	-	1489	1476	+ 53	36
0.002	same as 0.004	1581	0.9911	1568,1547, 1555	19, 20,19	10,11, 10	1557	14	-	1543	1529	+ 12	38
0.001	1531,1532, 1563	1542	1.0162	1540,1501, 1556	21, 20,22	10,11, 10	1532	15	-	1517	1541	- 6	39
6 u	same as 0.001	1542	1.0162	1540,1522, 1518	22, 21,20	10,12, 12	1527	16	-	1511	1535		38

TABLE 18

IRON — INTENSITY OF EMISSION VERSUS SURFACE FINISH

Counting standard:- 143-AA Standard count taken for set 0.016 = 4014 cps

Test sample:- CA-6195-AC

Set	Set count cps	Average cps	Correction Factor	Peak cps	Bkg 1 cps	Bkg 2 cps	Average peak	Average bkg	Corrections to Average Peak: Dead time	av. bkg.	Factor	Diff	3s
0.028	4062,4028, 3988	4026	0.9970	4708,4681, 4686	358, 350,361	109,107, 106	4692	231	-	4461	4448		67
0.024	4010,3992, 3985	3996	1.0045	5288,5250, 5238	362, 357,363	112,107, 114	5259	236	-	5023	5046	+598	66
0.020	same as 0.024	3996	1.0045	5864,5923, 5838	368, 364,371	116,112, 117	5875	242	-	5633	5658	+612	70
0.016	3974,4046, 4021	4014	1.0000	6498,6479, 6489	376, 372,378	118,115, 119	6487	246	-	6241	6241	+583	77
0.012	same as 0.016	4014	1.0000	6849,6815, 6828	378, 372,381	120,118, 118	6830	248	-	6582	6582	+341	75
0.008	4271,4307, 4324	4301	0.9333	7431,7490, 7406	453, 450,456	122,129, 129	7442	290	-	7152	6675	+93	76
0.006	same as 0.008	4301	0.9333	7539,7476, 7453	461, 452,455	128,124, 121	7489	290	-	7199	6719	+44	77
0.004	4015,3998, 4009	4007	1.0017	7036,6980, 6966	468, 472,470	118,120, 124	6994	296	-	6698	6709	-10	76
0.002	same as 0.004	4007	1.0017	7072,7000, 6964	480, 474,476	118,116, 114	7012	297	-	6715	6726	+17	77
0.001	4013,3993, 3978	3995	1.0048	7043,7000, 6978	474, 472,471	116,118, 118	7007	295	-	6712	6744	+18	77
6 u	same as 0.001	3995	1.0048	7043,6880, 7056	470, 477,472	116,116, 119	6993	295	-	6698	6730	-14	77

COPPER

INTENSITY OF EMISSION VERSUS SURFACE FINISH

Counting standard:- 143-AA Standard count taken for set 0.016 = 28407 cps

Test sample:- CA-6195-AC

Set	Set count cps	Average cps	Correction) Factor	Peak cps	Bkg 1 cps	Bkg 2 cps	Average peak	Average bkg	Corrections to Average Peak: Dead time	Av. Bkg.	Factor	Diff	3s
0.028	28580,28430 28451	28487	0.9972	25210,25058 25086	248, 252,240	209,212, 207	25118	228	-	24890	24821		149
												+1447	
0.024	28489,28352 28401	28414	1.0000	26623,26514 26390	255 261,249	230,225 224	26509	241	-	26268	26268		157
												+1430	
0.020	same as 0.024	28414	1.0000	27999,27848 28001	270 255,262	241,238 237	27949	251	-	27698	27698		166
												+1408	
0.016	28353,28407 28460	28407	1.0000	29430,29366 29276	268 264,277	235,232, 230	29357	251	-	29106	29106		157
												+1283	
0.012	same as 0.016	28407	1.0000	30695,30503 30713	270 266,260	230,228 233	30637	248	-	30389	30389		164
												+793	
0.008	27127,27002 26964	27031	1.0509	29995,29913 29941	306 316,312	248,243 237	29949	277	-	29672	31182		168
												-133	
0.006	same as 0.008	27031	1.0509	29994,29764 29726	310 324,309	260,250 242	29828	283	-	29545	31049		167
												+79	
0.004	28280,28396 28204	28293	1.0040	31303,31208 31314	301 304,298	241,239 247	31275	271	-	31004	31128		168
												+31	
0.002	same as 0.004	28293	1.0040	31372,31202 31362	315 310,303	248,245 241	31312	277	-	31035	31159		168
												+85	
0.001	28273,28310 28206	28263	1.0051	31429,31303 31351	315 310,306	242,239 242	31361	276	-	31085	31244		169
												-102	
6 u	same as 0.001	28253	1.0051	31308,31128 31279	304 294,290	245,246 242	31238	270	-	30984	31142		168

MAGNESIUM INTENSITY OF EMISSION VERSUS SURFACE FINISH

Counting standard:- 340-AA-D Standard count taken for set 0.016 = 533 cps

Test sample:- CA-79-S-AE

Set	Set count cps	Average cps	Correction Factor	Peak cps	Bkg 1 cps	Bkg 2 cps	Average peak	Average bkg	Corrections to Average Peak Dead time	Av. Bkg.	Factor	Diff	3s
0.024	584,571,568	574	0.9286	71,59,62	20,17,19	10,9,11	64	15	-	49	45		6
0.020	same as 0.024	574	0.9286	87,80,80	18,19,19	9,9,9	82	14	-	68	64	+19	6
0.016	565,528,505	533	1.0000	107,99,102	19,18,16	9,9,8	102	13	-	89	89	+25	8
0.012	same as 0.016	533	1.0000	136,127, 125	17,19,19	11,9,12	129	14	-	115	115	+26	10
0.008	506,519,502	509	1.0471	139,139, 139	18,19,15	10,7,9	139	11	-	128	134	+19	11
0.006	same as 0.008	509	1.0471	165,155, 158	19,20,15	8,10,9	159	13	-	146	152	+18	11
0.004	508,490,506	501	1.0658	167,165, 158	14,15,16	8,8,7	163	12	-	151	161	+9	11
0.002	same as 0.004	501	1.0658	168,174, 168	15,16,14	9,9,8	170	12	-	158	168	+7	11
0.001	510,485,509	489	1.0702	169,168, 158	14,13,15	8,7,7	165	10	-	155	166	-2	11
6 u	same as 0.001	489	1.0702	167,160, 171	14,16,13	8,7,9	166	11	-	155	165	-1	11

MANGANESE INTENSITY OF EMISSION VERSUS SURFACE FINISH

Counting standard:- 143-AA Standard count taken for set 0.016 = 2403 cps

Test sample:- CA-6195-AC

Set	Set count cps	Average cps	Correction Factor	Peak cps	Bkg 1 cps	Bkg 2 cps	Average peak	Average bkg	Corrections to Average Peak: Dead time	Av. Bkg.	Factor	Diff	3s
0.028	2401,2392, 2418	2404	1.0000	2529,2540, 2540	161,158, 154	129,131, 130	2536	144	-	2392	2392		45
												+197	
0.024	2420,2418, 2401	2413	0.9959	2765,2733, 2741	164,160, 159	133,130, 129	2746	146	-	2600	2589		49
												+239	
0.020	same as 0.024	2413	0.9959	3038,2978, 2961	170,174, 168	136,130, 134	2992	171	-	2840	2828		48
												+172	
0.016	2387,2416, 2406	2403	1.0000	3194,3125, 3147	170,177, 170	138,138, 139	3155	155	-	3000	3000		51
												+207	
0.012	same as 0.016	2403	1.0000	3403,3323, 3351	174,170, 170	137,136, 139	3361	154	-	3207	3207		54
												+135	
0.008	2514,2512, 2513	2513	0.9563	3703,3629, 3647	175,183, 181	155,148, 148	3660	165	-	3495	3342		56
												+31	
0.006	same as 0.008	2513	0.9563	3712,3685, 3685	181,178, 184	153,149, 156	3694	167	-	3527	3373		57
												+35	
0.004	2356,2348, 2360	2355	1.0204	3498,3482, 3503	175,170, 169	138,140, 135	3494	154	-	3340	3408		58
												+24	
0.002	same as 0.004	2355	1.0204	3537,3503, 3511	174,169, 170	135,140, 136	3517	154	-	3363	3432		58
												-23	
0.001	2348,2364, 2348	2353	1.0212	3499,3470, 3504	169,174, 169	138,134, 133	3491	153	-	3338	3409		58
												+16	
6 u	same as 0.001	2353	1.0212	3520,3511, 3492	171,170, 166	136,141, 139	3508	154	-	3354	3425		58

ZINC — INTENSITY OF EMISSION VERSUS SURFACE FINISH

Counting standard:- 6561-CABS — Standard count taken for set 0.016 = 24108 cps

Test sample:- CA-79-S-AE

Set	Set count cps	Average cps	Correction Factor	Peak cps	Bkg 1 cps	Bkg 2 cps	Average peak	Average bkg	Corrections to Average Peak: Dead time	Av. Bkg.	Factor	Diff	3s
0.028	23845,23781, 23772	23799	1.0130	35876,35799, 35719	362 350,344	336,350, 316	35798	340	35845	35505	35963		187
0.024	same as 0.028	23799	1.0130	37552,37448, 37423	426 401,398	372,361, 346	37474	384	37680	37296	37780	+1817	185
0.020	24285,24345, 24039	24223	0.9953	41594,41474, 41536	369 375,379	323,323 338	41534	351	41899	41548	41351	+3571	203
0.016	24153,24098, 24074	24108	1.0000	43725,43621, 43660	382 385,395	341,336 343	43669	364	44129	43765	43765	+2414	215
0.012	same as 0.016	24108	1.0000	46152,46052 46972	414 412,403	359,358 346	46059	382	46634	46252	46252	+2487	194
0.008	24369,24212, 24287	24289	0.9926	46652,46739 46633	636 635,650	403,401 410	46675	524	47281	46757	46409	+157	195
0.006	same as 0.008	24289	0.9926	47025,46940 46987	643 641,650	418,404 403	46984	527	47606	47079	46728	+319	196
0.004	24632,24600, 24614	24615	0.9794	47486,47419 47411	449 438,435	385,371 370	47439	408	48085	47677	46695	-33	196
0.002	same as 0.004	24615	0.9794	47608,47512 47538	482 469,472	398,402 400	47553	437	48204	47767	46783	+88	197
0.001	24534,24633, 24601	24589	0.9804	47618,47520 47567	462 448,438	400,385 378	47568	419	48409	47990	47051	+268	198
6 u	same as 0.001	24589	0.9804	47563,47482 47588	471 475,470	375,370 378	47544	423	48195	47772	46838	-213	194

TABLE 23

TITANIUM — INTENSITY OF EMISSION VERSUS SURFACE FINISH

Counting standard:- 6046-CABS Standard count taken for set 0.016 = 259 cps

Test sample:- 6449-AA

Set	Set count cps	Average cps	Correction Factor	Peak cps	Bkg 1 cps	Bkg 2 cps	Average peak	Average bkg	Corrections to Average Peak: Dead time	Av. Bkg.	Factor	Diff	3s
0.028	258,269,256	261	0.992	105,109,107	1,1,2	1,2,1	107	1	-	106	105	+17	10
0.024	255,262,260	259	1.000	126,121,126	2,2,1	2,1,1	124	2	-	122	122	+21	11
0.020	same as 0.024	259	1.000	149,146,141	2,2,2	2,2,1	145	2	-	143	143	+25	11
0.016	256,264,256	259	1.000	178,170,167	2,2,1	1,2,2	170	2	-	168	168	+23	12
0.012	same as 0.016	259	1.000	195,196,188,	2,2,1	1,2,2	193	2	-	191	191	+19	14
0.008	261,269,259	263	0.985	212,219,213	3,3,2	2,3,2	215	2	-	213	210	+23	15
0.006	same as 0.008	263	0.985	240,239,238	3,3,2	2,2,3	239	2	-	237	233	+9	16
0.004	268,275,270	271	0.956	259,252,254	2,2,3	3,3,2	255	2	-	253	242	+9	17
0.002	same as 0.004	271	0.956	270,264,272	3,3,3	3,3,2	265	3	-	262	251	-2	17
0.001	272,264,278	271	0.956	268,260,264	3,3,2	3,3,3	264	3	-	261	249	+6	17
6 u	same as 0.001	271	0.956	272,264,272	3,3,2	3,2,2	269	2	-	267	255		17

TABLE 24

CHROMIUM — INTENSITY OF EMISSION VERSUS SURFACE FINISH

Counting standard:- 143-AA Standard count taken for set 0.016 = 686 cps

Test sample:- CA-79-S-AE

Set	Set count cps	Average cps	Correction Factor	Peak cps	Bkg 1 cps	Bkg 2 cps	Average peak	Average bkg	Corrections to Average Peak: Dead time	Av. Bkg.	Factor	Diff	3s
0.028	705,691,680	692	0.9913	1347,1331, 1336	191,190, 187	175,171, 169	1338	181	-	1157	1147	+150	34
0.024	700,689,675	688	0.9971	1494,1478, 1488	196,194, 189	180,179, 177	1487	186	-	1301	1297	+141	32
0.020	same as 0.024	688	0.9971	1639,1618, 1624	194,189, 181	177,185, 181	1627	185	-	1442	1438	+134	36
0.016	680,702,677	686	1.0000	1744,1742, 1785	194,194, 192	177,175, 177	1757	185	-	1572	1572	+135	39
0.012	same as 0.016	686	1.0000	1925,1881, 1894	201,204, 207	180,187, 180	1900	193	-	1707	1707	+135	43
0.008	707,720,704	710	0.9662	2109,2118, 2097	215,214, 211	194,194, 184	2108	202	-	1906	1842	+129	39
0.006	same as 0.008	710	0.9662	2245,2231, 2241	210,212, 213	181,192, 185	2239	199	-	2040	1971	+30	41
0.004	714,710,705	710	0.9662	2272,2275, 2286	205,206, 200	190,193, 191	2278	198	-	2080	2001	+32	42
0.002	same as 0.004	710	0.9662	2291,2306, 2295	205,200, 197	190,179, 182	2297	193	-	2104	2033	-14	43
0.001	680,688,678	682	1.0060	2198,2190, 2206	198,200, 196	188,187, 178	2198	191	-	2007	2019	+17	43
6 u	same as 0.001	682	1.0060	2217,2219, 2212	210,199, 200	189,181, 176	2216	192	-	2024	2036		43

NICKEL

INTENSITY OF EMISSION VERSUS SURFACE FINISH

Counting standard:- 6046-CABS Standard count taken on set 0.016 = 27426 cps

Test sample:- 162-AZ

Set	Set count cps	Average cps	Correction Factor	Peak cps	Bkg 1 cps	Bkg 2 cps	Average Peak	Average Bkg	Corrections to Average Peak: Dead time	Av. Bkg.	Factor	Diff	3s
0.028	27460,27492, 27431	27461	0.9987	26068,25964 25953	143,140, 144	231,225, 224	25995	184	-	25811	25778		139
0.024	27500,27410, 27430	27447	0.9992	27621,27541 27616	148,144, 141	229,236, 233	27593	189	-	27404	27382	+1604	148
0.020	same as 0.024	27447	0.9992	29301,29189 29248	149,151, 146	214,208, 218	29246	182	-	29064	29041	+1659	157
0.016	27455,27384, 27438	27426	1.0000	30986,30907, 30896	150,150, 149	216,222, 221	30924	185	30932	30747	30747	+1706	166
0.012	same as 0.016	27426	1.0000	32581,32511 32467	165,171, 172	249,250, 254	32520	210	32570	32360	32360	+1613	174
0.008	27366,27403, 27419	27396	1.0011	33588,33639 33654	206,207, 194	249,258, 254	33627	227	33708	33481	33518	+1158	174
0.006	same as 0.008	27396	1.0011	33856,33831 33726	196,194, 184	254,246, 245	33804	220	33891	33671	33708	+190	175
0.004	27790,27684, 27664	27713	0.9896	34438,34362, 34356	199,201, 200	261,259, 255	34385	229	34476	34247	33891	+183	176
0.002	same as 0.004	27713	0.9896	34198,34141 34153	200,204, 199	258,249, 255	34164	228	34254	34026	33672	-219	175
0.001	27782,27696, 27665	27714	0.9896	34438,34362 34398	192,198, 203	261,258, 255	34399	228	34491	34263	33907	+235	176
6 u	same as 0.001	27714	0.9896	34341,34282 34286	200,201, 204	268,260, 262	34303	233	34390	34157	33802	-105	176

Table no: 26

CALCULATION OF MASS ABSORPTION COEFFICIENT

FOR ALLOY MATRIX

Alloy: CA-6195-AA-D

SILICON K_{α} = 7.13 Å

Si-Si

$\mu Si(Si) \times cSi = 315 \times 0.095 = 30$

Si-Fe

$\mu Si(Fe) \times cFe = 2040 \times 0.007 = 14$

Si-Cu

$\mu Si(Cu) \times cCu = 2415 \times 0.0342 = 83$

Si-Mg

$\mu Si(Mg) \times cMg = 2660 \times 0.0109 = 29$

Si-Mn

$\mu Si(Mn) \times cMn = 1920 \times 0.0042 = 8$

Si-Zn

$\mu Si(Zn) \times cZn = 2510 \times 0.009 = 23$

Si-Al

$\mu Si(Al) \times cAl = 3170 \times 0.837 = 2653$

2840

Other elements are low order

μ matrix = 2840

MANGANESE K_{α} = 2.10 Å

Mn-Mn

$\mu Mn(Mn) \times cMn = 80 \times 0.0042 = 0.3$

Mn-Fe

$\mu Mn(Fe) \times cFe = 91 \times 0.007 = 0.6$

Mn-Cu

$\mu Mn(Cu) \times cCu = 123 \times 0.0342 = 4.2$

Mn-Mg

$\mu Mn(Mg) \times cMg = 95 \times 0.0109 = 1$

Mn-Si

$\mu Mn(Si) \times c\ Si = 146 \times 0.095 = 14$

Mn-Zn

$\mu Mn(Zn) \times cZn = 135 \times 0.009 = 1.2$

Mn-Al

$\mu Mn(Al) \times cAl = 117 \times 0.837 = 98$

119

Other elements are low order

μ matrix = 119

COPPER K_α = 1.54 Å

Cu-Cu

$\mu Cu(Cu) \times cCu = 55 \times 0.0342 = 2$

Cu-Fe

$\mu Cu(Fe) \times cFe = 316 \times 0.007 = 2$

Cu-Mg

$\mu Cu(Mg) \times cMg = 40 \times 0.0109 = 0.4$

Cu-Mn

$\mu Cu(Mn) \times cMn = 287 \times 0.0042 = 1.2$

Cu-Si

$\mu Cu(Si) \times cSi = 63 \times 0.095 = 6$

Cu-Zn

$\mu Cu(Zn) \times cZn = 60 \times 0.009 = 0.5$

Cu-Al

$\mu Cu(Al) \times cAl = 45 \times 0.837 = 37.7$

50

Other elements are low order

μ matrix = 50

IRON K_α = 1.94 Å

Fe-Fe

$\mu Fe(Fe) \times cFe = 71 \times 0.007 = 0.5$

Fe-Cu

$\mu Fe(Cu) \times cCu = 96 \times 0.0342 = 3.3$

Fe-Mg

$\mu Fe(Mg) \times cMg = 77 \times 0.0109 = 0.8$

Fe-Mn

$\mu Fe(Mn) \times cMn = 64 \times 0.0042 = 0.3$

Fe-Si

$\mu Fe(Si) \times cSi = 116 \times 0.095 = 1.1$

Fe-Zn

$\mu Fe(Zn) \times cZn = 110 \times 0.009 = 1$

Fe-Al

$\mu Fe(Al) \times cAl = 94 \times 0.837 = 79$

86

Other elements are low order

μ matrix = 86

Alloy: CA-79-S-AE

ZINC K_{α} = 1.44 Å

Zn-Zn

$\mu Zn(Zn) \times cZn = 49 \times 0.047 =$ 2.3

Zn-Cu

$\mu Zn(Cu) \times cCu = 45 \times 0.0065 =$ 0.3

Zn-Fe

$\mu Zn(Fe) \times cFe = 261 \times 0.0029 =$ 0.8

Zn-Mg

$\mu Zn(Mg) \times cMg = 35 \times 0.0334 =$ 1.2

Zn-Mn

$\mu Zn(Mn) \times cMn = 238 \times 0.0022 =$ 0.5

Zn-Cr

$\mu Zn(Cr) \times cCr = 200 \times 0.002 =$ 0.4

Zn-Al

$\mu Zn(Al) \times cAl = 41 \times 0.902 =$ 37

43

Other elements are low order

μ matrix = 43

CHROMIUM K_α = 2.29 Å

Cr-Cr

$\mu Cr(Cr) \times cCr = 90 \times 0.002 = 0.2$

Cr-Cu

$\mu Cr(Cu) \times cCu = 159 \times 0.0065 = 1$

Cr-Fe

$\mu Cr(Fe) \times cFe = 115 \times 0.0029 = 0.3$

Cr-Mg

$\mu Cr(Mg) \times cMg = 122 \times 0.0334 = 4$

Cr-Mn

$\mu Cr(Mn) \times cMn = 101 \times 0.0022 = 0.2$

Cr-Zn

$\mu Cr(Zn) \times cZn = 174 \times 0.047 = 8.2$

Cr-Si

$\mu Cr(Si) \times cSi = 193 \times 0.0018 = 0.3$

Cr-Al

$\mu Cr(Al) \times cAl = 153 \times 0.902 = 138$

152

Other elements are low order

μ matrix = 152

MAGNESIUM K_α = 9.89 Å

Mg-Mg

$\mu Mg(Mg) \times cMg = 350 \times 0.034 =$ 12

Mg-Si

$\mu Mg(Si) \times cSi = 740 \times 0.0018 =$ 1

Mg-Cu

$\mu Mg(Cu) \times cCu = 5035 \times 0.0065 =$ 33

Mg-Fe

$\mu Mg(Fe) \times cFe = 4100 \times 0.0029 =$ 12

Mg-Mn

$\mu Mg(Mn) \times cMn = 3790 \times 0.0022 =$ 8

Mg-Zn

$\mu Mg(Zn) \times cZn = 5235 \times 0.047 =$ 246

Mg-Cr

$\mu Mg(Cr) \times cCr = 3510 \times 0.002 =$ 7

Mg-Al

$\mu Mg(Al) \times cAl = 500 \times 0.902 =$ 451

770

Other elements are low order

μ matrix = 770

Alloy: 6449-AA

TITANIUM K_{α} = 2.75 Å

Ti-Ti

$\mu Ti(Ti) \times cTi = 114 \times 0.0008 = 0.1$

Ti-Cu

$\mu Ti(Cu) \times cCu = 262 \times 0.0032 = 0.8$

Ti-Fe

$\mu Ti(Fe) \times cFe = 193 \times 0.0025 = 0.5$

Ti-Mg

$\mu Ti(Mg) \times cMg = 212 \times 0.0089 = 2$

Ti-Mn

$\mu Ti(Mn) \times cMn = 171 \times 0.0015 = 0.3$

Ti-Si

$\mu Ti(Si) \times cSi = 328 \times 0.0065 = 2$

Ti-Bi

$\mu Ti(Bi) \times cBi = 970 \times 0.0046 = 4.5$

Ti-Pb

$\mu Ti(Pb) \times cPb = 935 \times 0.0046 = 4.3$

Ti-Al

$\mu Ti(Al) \times cAl = 263 \times 0.965 = 254$

269

Other elements are low order

μ matrix = 269

Alloy: 162-AZ

NICKEL K_{α} = 1.66 Å

Ni-Ni

$\mu Ni(Ni) \times cNi = 61 \times 0.025 = 2$

Ni-Cu

$\mu Ni(Cu) \times cCu = 65 \times 0.0079 = 0.5$

Ni-Fe

$\mu Ni(Fe) \times cFe = 397 \times 0.0041 = 2$

Ni-Mg

$\mu Ni(Mg) \times cMg = 48 \times 0.0109 = 0.5$

Ni- Si

$\mu Ni(Si) \times cSi = 76 \times 0.121 = 9$

Ni-Al

$\mu Ni(Al) \times cAl = 58 \times 0.829 = 48$

62

Other elements are low order

μ matrix = 62

Figure no: 3

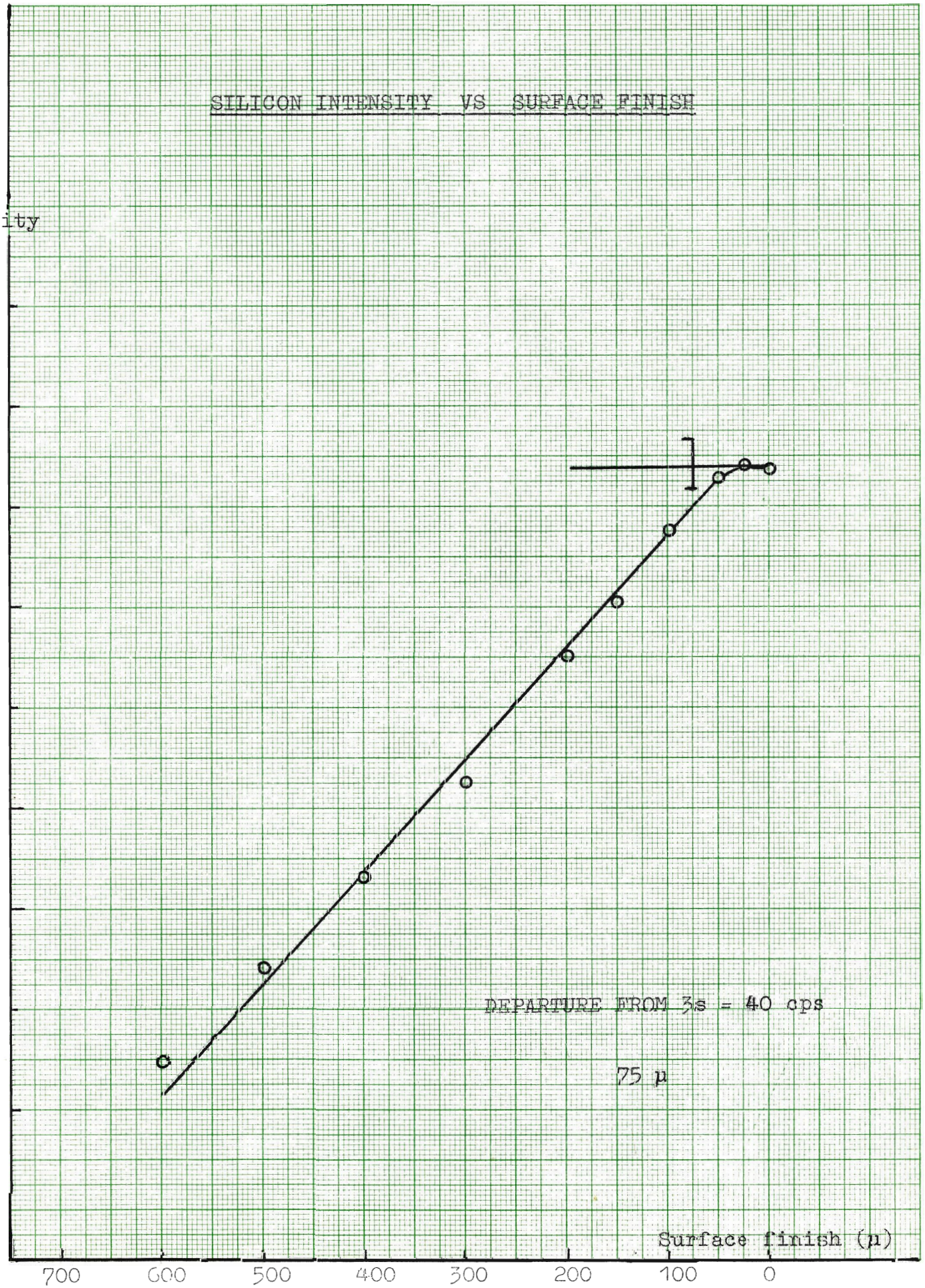

SILICON INTENSITY VS SURFACE FINISH
tensity
cps
1700
1600
1500
1400
1300
1200
1100
1000
900
DEPARTURE FROM 3s = 40 cps
75 µ
Surface finish (µ)
700
600
500
400
300
200
100
0

Figure no: 4

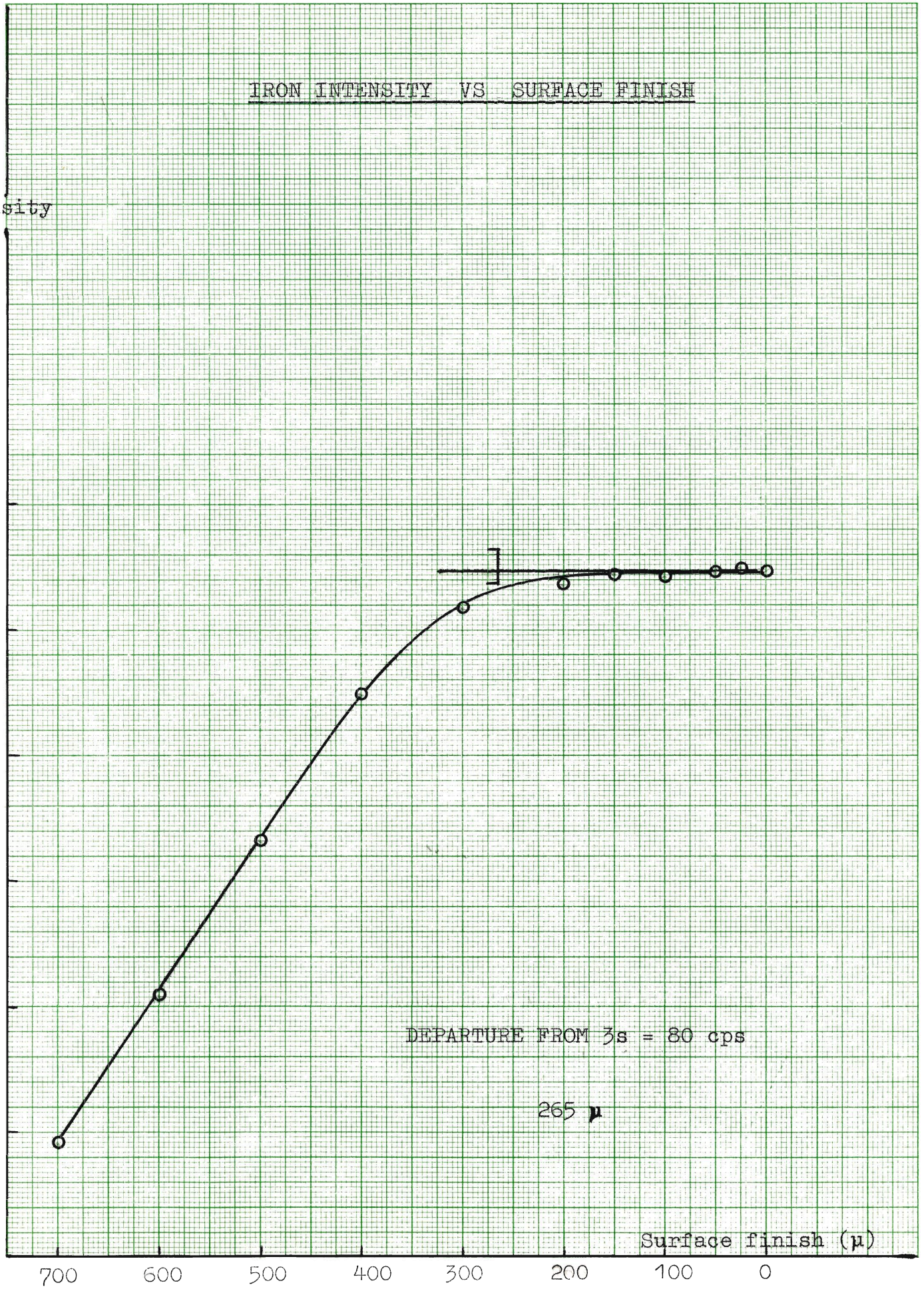

IRON INTENSITY VS SURFACE FINISH
ntensity
cps
7000
6500
6000
5500
5000
4500
4000
DEPARTURE FROM 3s = 80 cps
265 µ
Surface finish (µ)
700
600
500
400
300
200
100
0

Figure no: 5

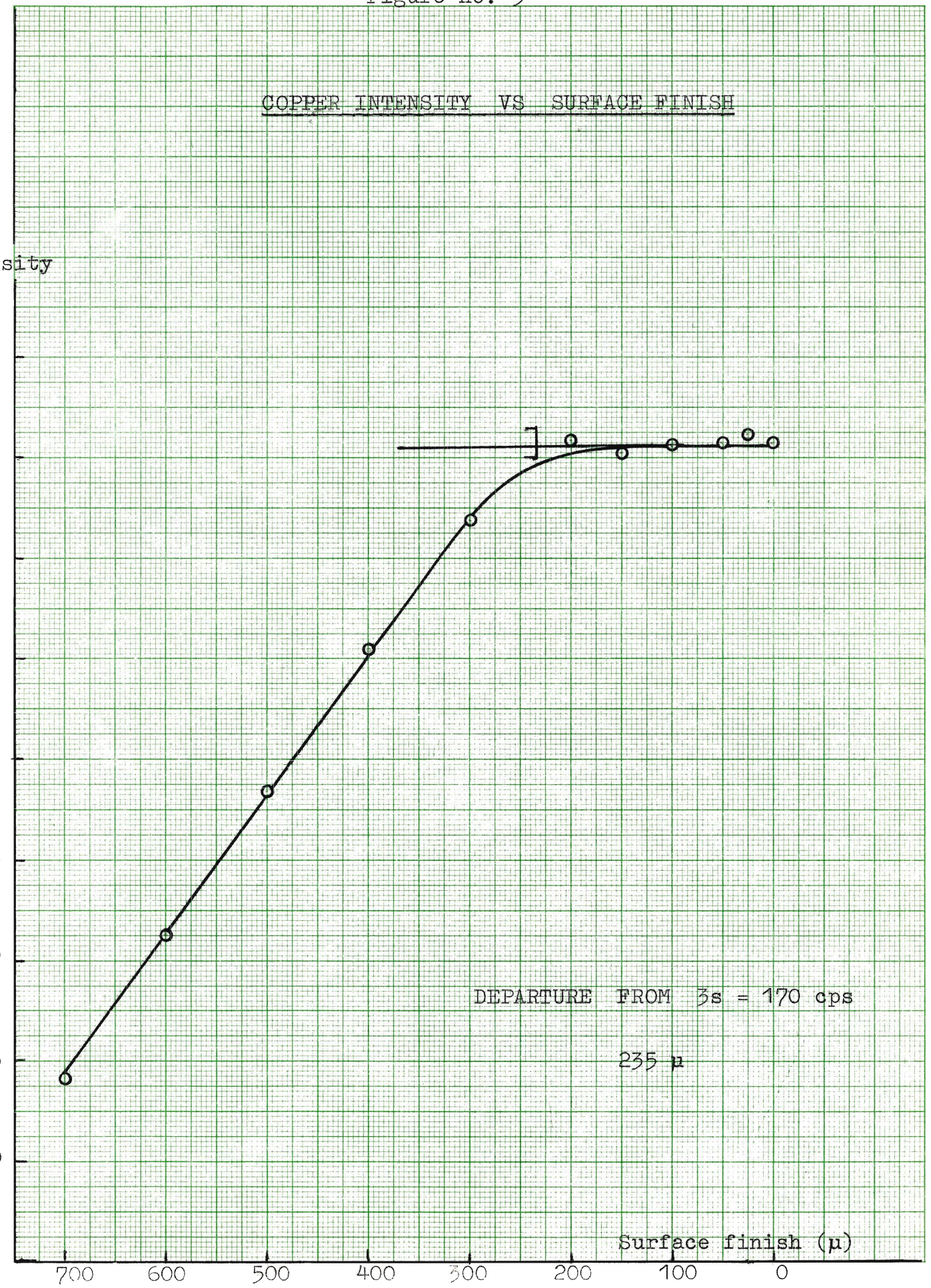

COPPER INTENSITY VS SURFACE FINISH
ntensity
cps
2000
1000
0000
9000
8000
7000
6000
5000
000
DEPARTURE FROM 3s = 170 cps
235 µ
Surface finish (µ)
700
600
500
400
300
200
100
0

Figure no: 6

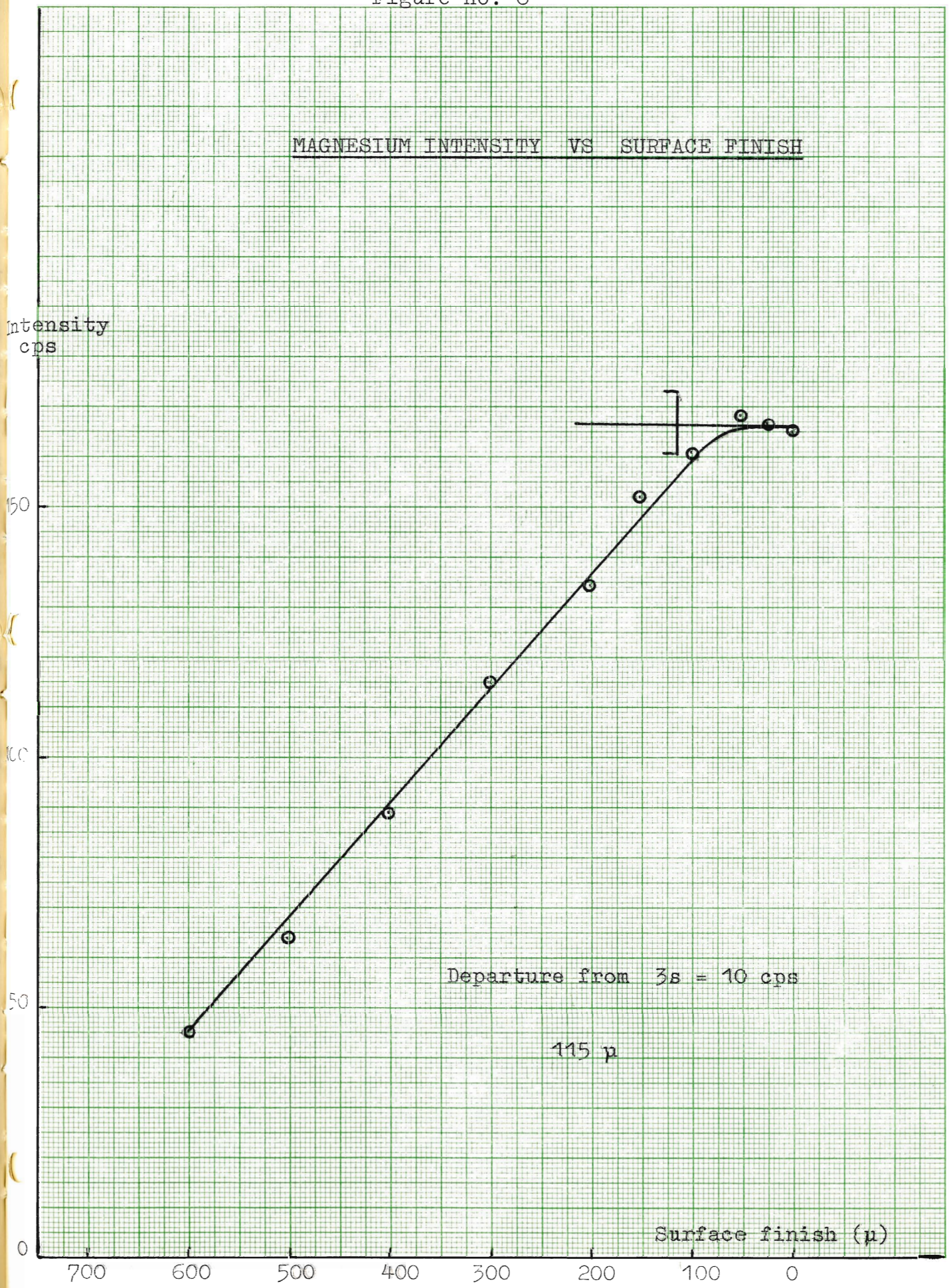
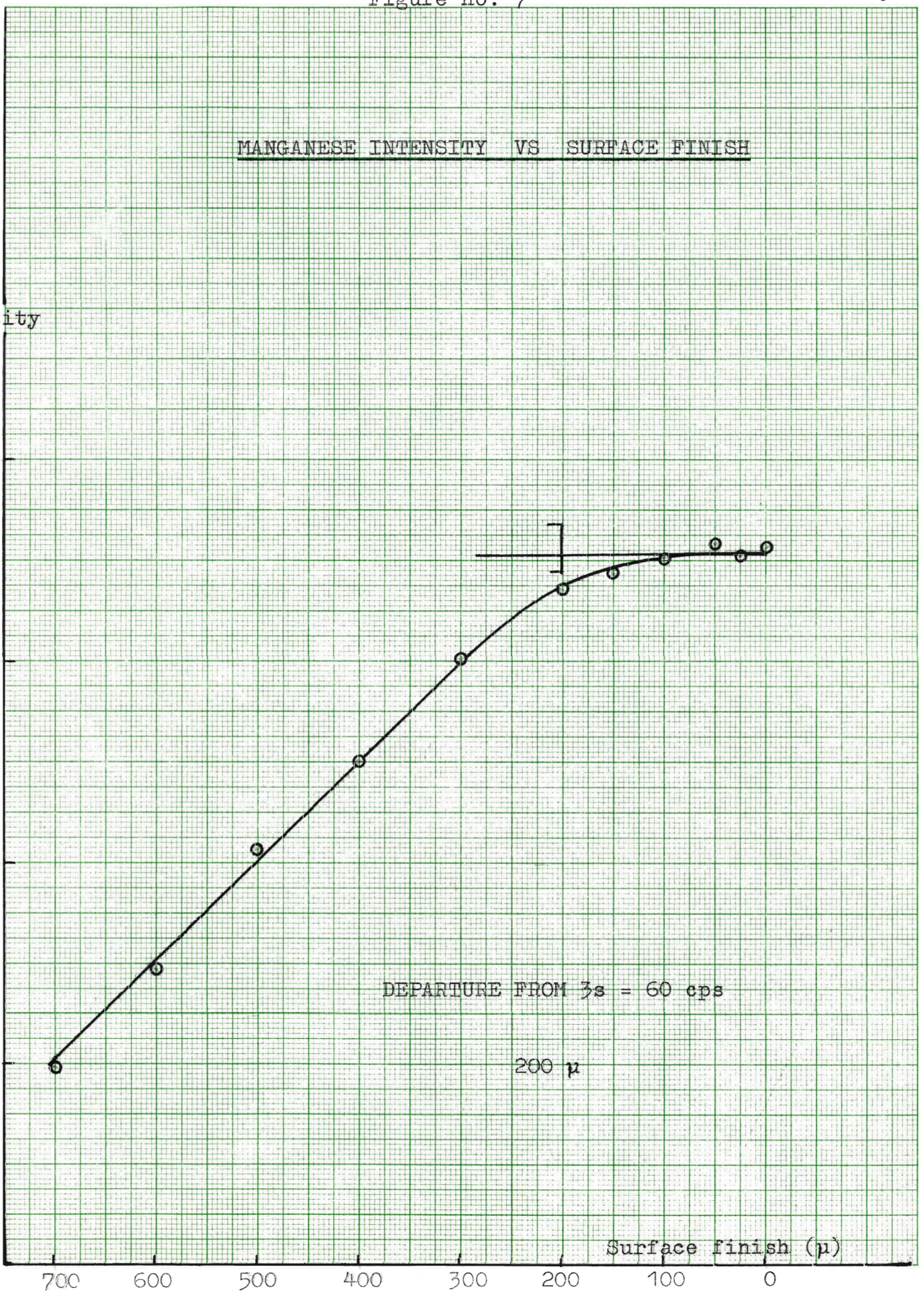
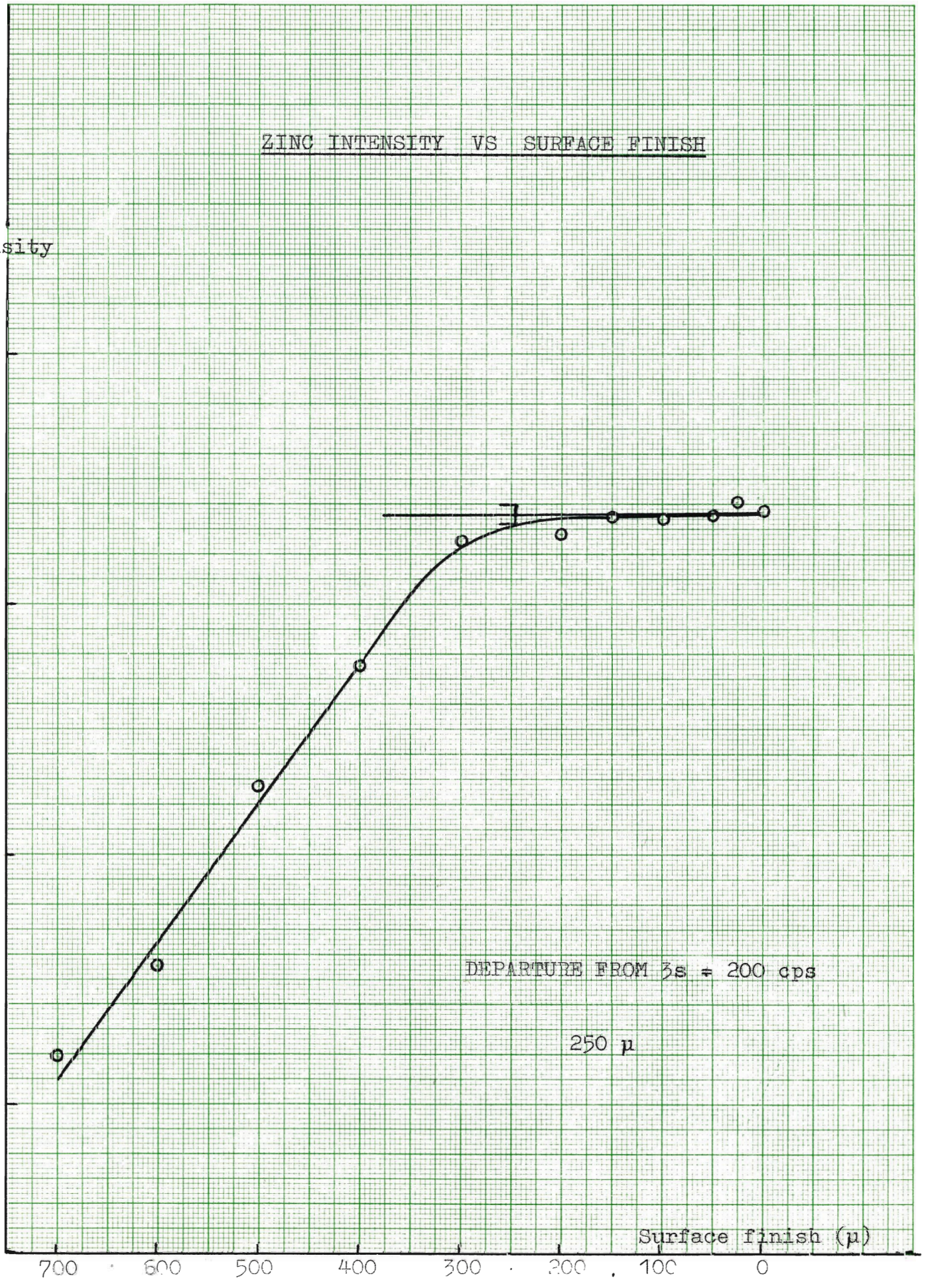
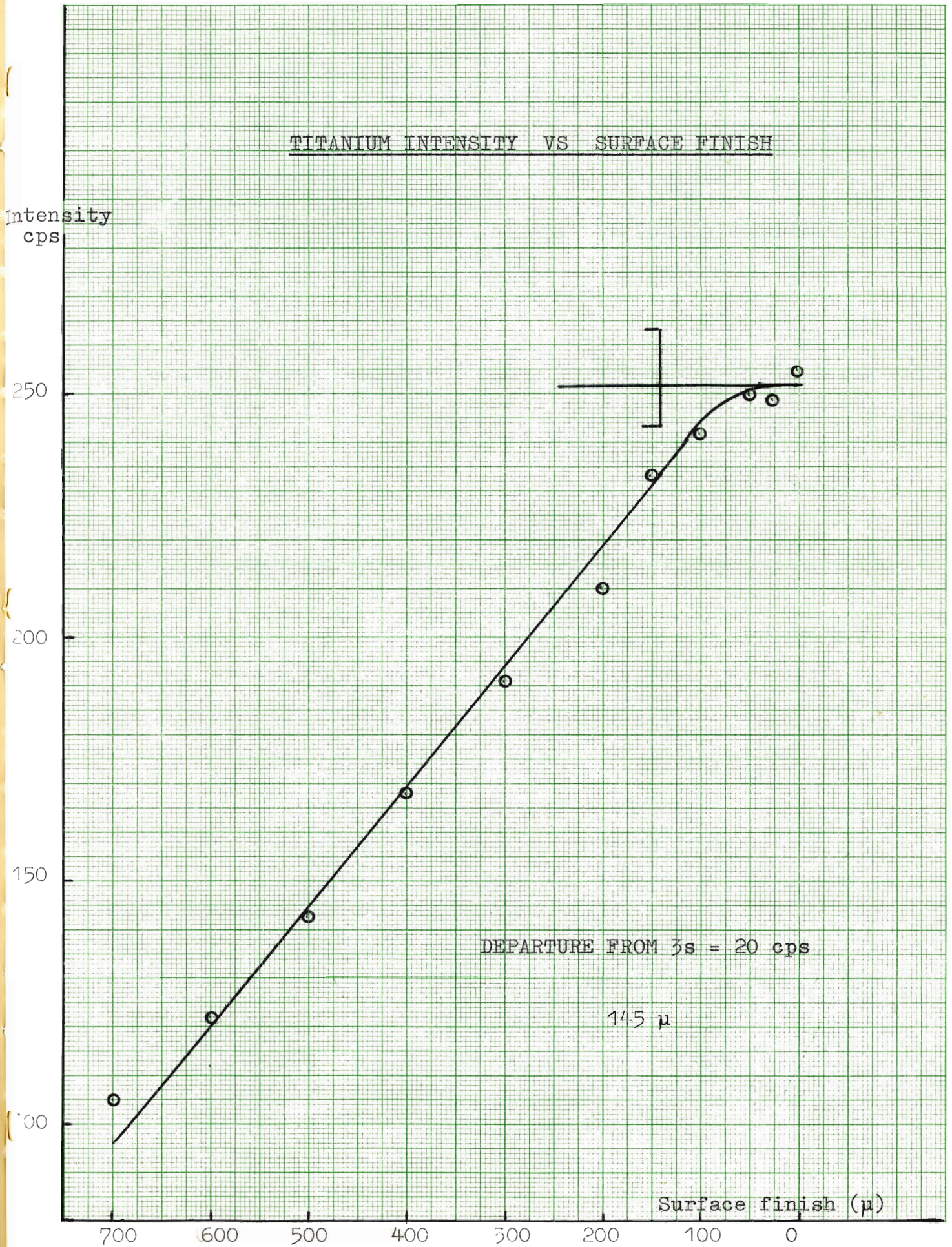

MAGNESIUM INTENSITY VS SURFACE FINISH
Intensity cps
150
100
50
0
Departure from 3s = 10 cps
115 µ
700
600
500
400
300
200
100
0
Surface finish (µ)

Figure no: 7


MANGANESE INTENSITY VS SURFACE FINISH
ntensity
cps
5600
3200
2800
2400
2000
DEPARTURE FROM 3s = 60 cps
200 μ
Surface finish (μ)
700
600
500
400
300
200
100
0


ZINC INTENSITY VS SURFACE FINISH
ntensity
cps
0000
5000
0000
5000
DEPARTURE FROM 3s = 200 cps
250 μ
Surface finish (μ)
700
600
500
400
300
200
100
0


TITANIUM INTENSITY VS SURFACE FINISH
Intensity cps
250
200
150
100
DEPARTURE FROM 3s = 20 cps
145 µ
Surface finish (µ)
700
600
500
400
300
200
100
0

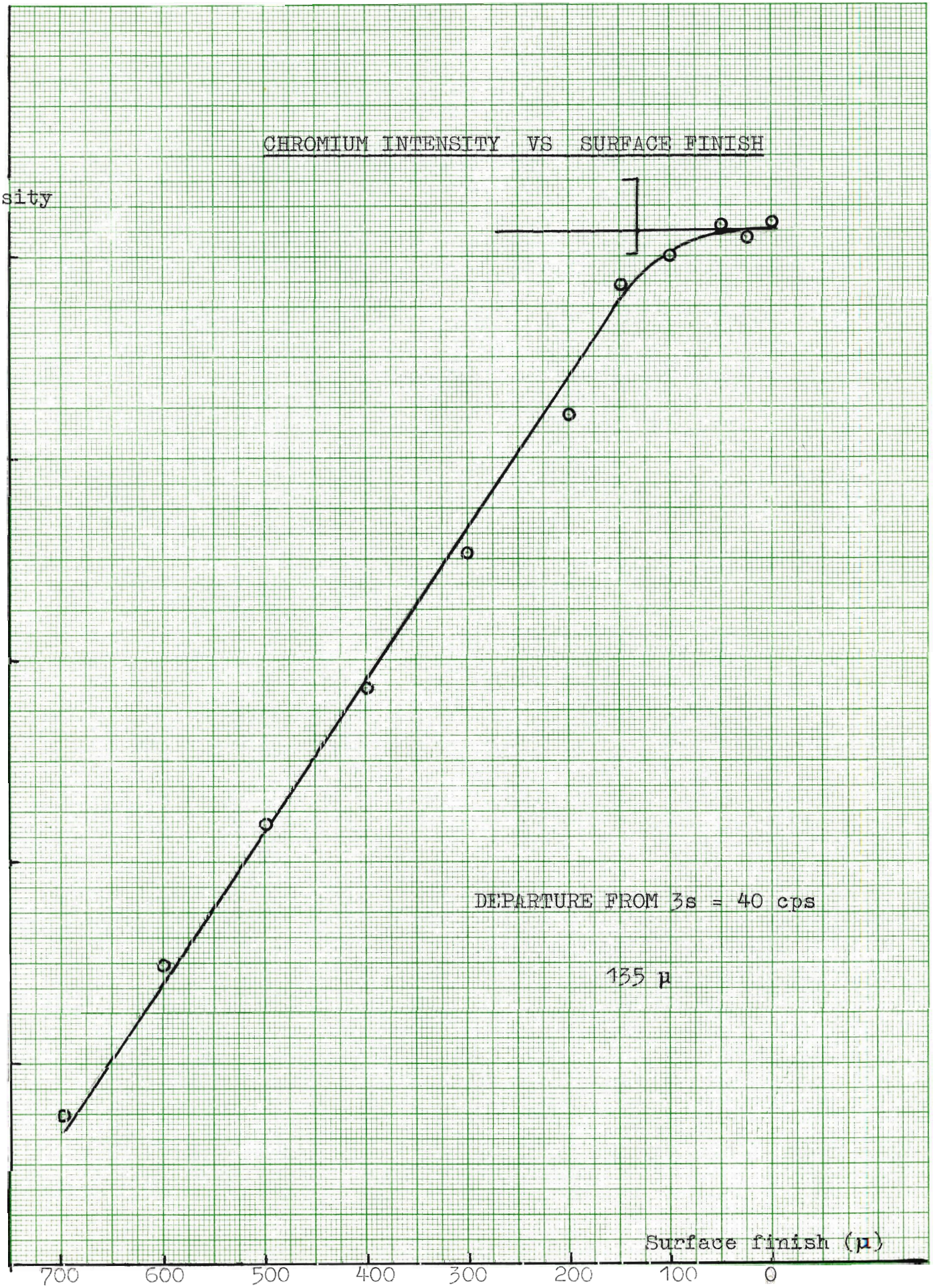
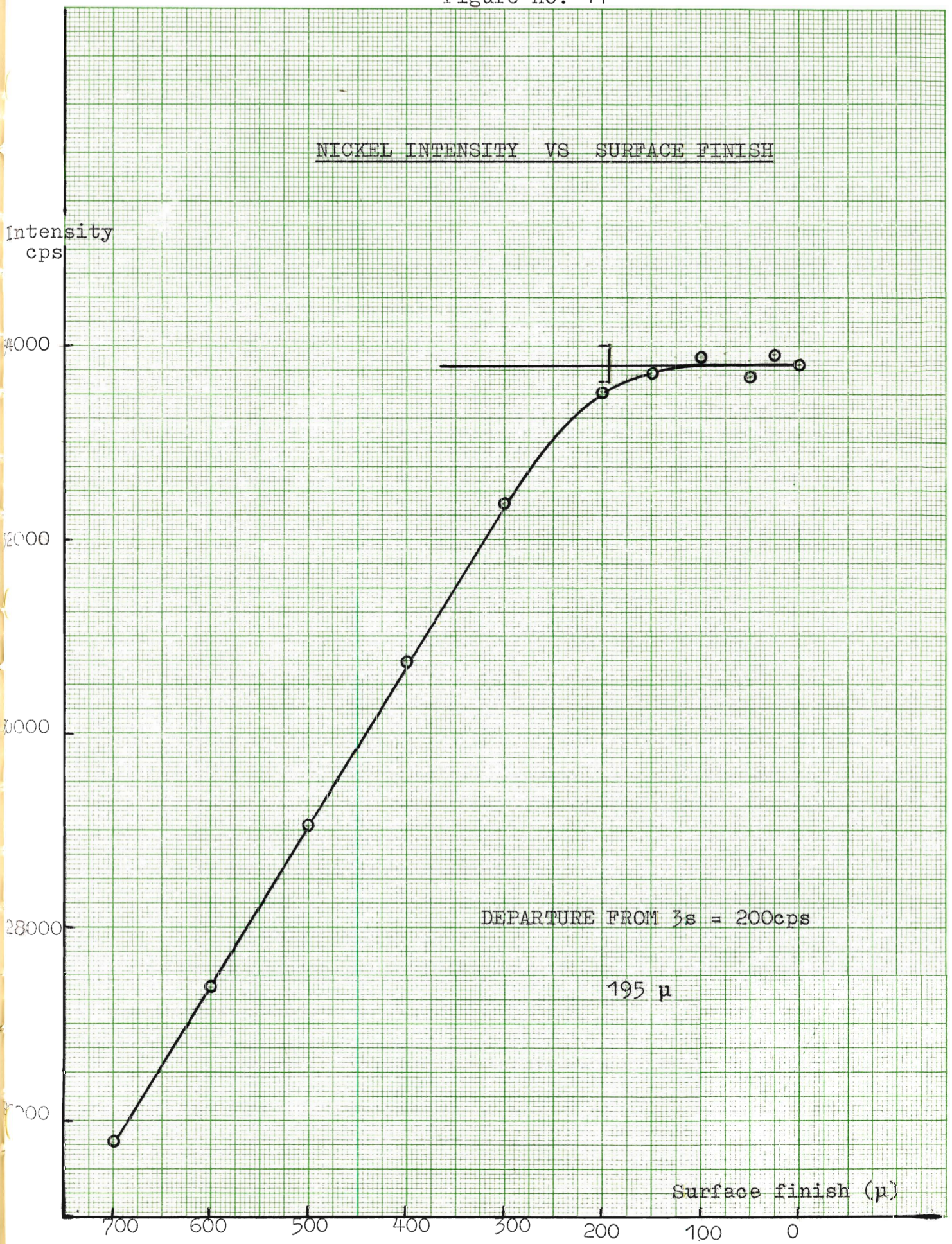

CHROMIUM INTENSITY VS SURFACE FINISH
Intensity cps
2000
1800
1600
1400
1200
1000
DEPARTURE FROM 3s = 40 cps
135 µ
700
600
500
400
300
200
100
0
Surface finish (µ)

Figure no: 11


NICKEL INTENSITY VS SURFACE FINISH
Intensity cps
4000
2000
6000
28000
700
600
500
400
300
200
100
0
Surface finish (μ)
DEPARTURE FROM 3s = 200cps
195 μ