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THE USE OF COMPUTER TECHNIQUES IN SURFACECTEXTURE ASSESSMENT

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ABSTRACT

The work represents a successful attempt of using a computer technique in surface texture assessment for metallic surfaces. A computer - Talysurf system composed of a PDP-8/L computer in connection with Talysurf 4 was employed in the analysis of surface profiles.

The performance of the Computer-Talysurf system was checked by looking into the consistency of the output reading compared with the expected values according to the loading computer program.

A loading program to the PDP-8/L computer was used to instruct the computer to register of the surface ordinates from an arbitrary datum line at certain sampling interval. A facility for changing the sampling interval and the number of registered ordinate heights was made.

A I904 code Algol processing computer program was constructed and used for analyzing the characteristics of the measured surface profiles.

For ground surfaces, by using a sampling interval of I.2I9 micron and a number of ordinates equals 3000, it was found that the computed value of the surface center line average equals to yhat given by the Talysurf, and the cumulative distributions of the surface peaks and ordinates were gaussian as expected.

Finally, a picture of a surface profile obtained from the computer output compared with the surface profile obtained from the Talysurf is presented.

The operating procedure of the Computer-Talysurf system and the computer program are not included for space limitations.

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INTRODUCTION

All engineering and medical , or every day application associated with sliding or rolling elements are of tribological importance. Properties of the surfaces of such components have considerable influence on their performance efficiency.

The significance of advanced research is becomming apparent where surface systems play an important role affecting the behaviour of a physical process. In the identification and optimization of reliable systems involving surfaces, texture is the firist prerequisite for a successful accomplishment of the task in this age of automation and space flight.

We may perhaps agree that the problems in design, such as, wear, lubrication, friction, stiffness of joints, strength of parts, fatigue, paintability, accuracy of dimensional chains and kinematic trains, dynamic of machine tools, heat transfer, real contact assessment, elastohydrodynamics,.... etc, can not be satisfactorily approached without information about the surface configuration.

In manufacturing, surface quality control was limited to surface roughness as the only important feature , but now, there are many surface properties being taken into consideration.

A general approach for specifying and measuring surface quality for every day purpose is needed. The texture of a part's surface often strongly influence tha ability of that part to do its job. This is true, not only when two bodies slide over each other where clearly the texture can influence the friction and wear but also in such situations as thermal contact, electrical contact, and hermitic sealing. It then becomes very important to be able to measure and describe the surface shape. The Computer-Talysurf system used in this work provides a very reliable technique in measuring and describing surface shapes.

EXPERIMENTAL EQUIPMENT, PROCEDURE AND TECHNIQUES.

The Talysurf 4

The stylus instrument used for measuring surfaces in this work is the model 4 Talysurf surface measuring instrument produced by " RANK TAYLOR HOBSON " shown in fig. I. The Talysurf provides vertical magnifications of 500 - I0000 times and horizontal magnifications of 20 and I00. A horizontal magnification of 500 can be obtained by using an additional motor , fig. 2.

The manufacturer's specfications provides for a pick up

with a diamond stylus of a nominal tip radius of 0.0025 mm., and the stylus static force is of the order of 0.I gm., and that is just sufficient to ensure continuous contact between the stylus and the surface being measured without causing significant damage to the surface.

The Talysurf stylus is a capacitance type one. While the stylus traverses over the surface, the capacitance changes according to the surface geometery and an electric signal is given to the PDP-8/L computer accordingly.

The PDP-8/L Computer - Talysurf System.

A PDP-8/L Computer - Talysurf system shown in fig. I., was employed in the analysis of surface profiles. It is a straightforward matter to feed the output of the Talysurf through a suitable analogue to digital conversion and sampling unit into the digital computer. The stylus and the electromechanical transducer produce the voltage analogue of the surface. The pen recorder draws the profile and at the same time a data conversion unit samples this voltage and punches it on a paper tape. The signal from the Talysurf system is averaged over intervals which can be decided upon, using units of 800 microseconds each. The signal averaged by the digital analogue converter connected to the output of the Talysurf amplifier is then stored in the core memory. The signal is varied between ± I volts and is divided into a I000 equal intervals, thus the digital output of the system varies between 000 , 999. The corresponding value of each interval depends on the vertical magnification chosen. The loading program is designed in such a way that a number of samples less than 3499 can be obtained.

Checking The Performance Of The PDP-8/L Computer.

The operating procedure was followed for the following cases:

I- The Talysurf was connected with the computer while the pen of the pen recorder was at position I fig. 3.

2- The Talysurf was connected with the computer , the pen was at position 4 fig. 3. , the Talysurf vertical magnification was constant 2000 and number of digitized values was 2000. Output values were obtained for each of the sampling intervals I,2,5,I0,20,50,I00,I50,200,and 250 units,(I unit = 800 microseconds.). The results are tabulated in table I.

3- The Talysurf was connected with the computer , digitized values were obtained at constant sampling interval of one unit and a number of digitized values of 2000 when the pen of the recorder was at position 4 fig. 3, for each of the vertical magnifications 500,I000,2000,5000, I0000,20000,and 5000. The results are shown in table 2.

Determination Of The Appropriate Sampling Interval.

Three series of tests were undertaken:

I- Profile measurements were taken at constant sampling interval of I.22 micrometer for 500,I000,2000,3000, and 3499 ordinates.

2- At a constant sampling length of 3.66 mm., tests were undertaken at sampling intervals of I.22,I.42,I.63, and 2 micrometers.

3- For a number of ordinates of 3000, tests were carried out at sampling intervals of 0.4,0.8I, I.02,I.22,I.42, and I.63 micrometers. The computed results are shown in fig.4 and in fig. 5.

The Effect Of The Talysurf Stylus Traversing Speed On Parameter Values Of The Measured Surface Profiles At Constant Number Of Traverses.

Three surface profiles were measured at stylus traversing speeds of 76.2, I5.24, and 3.05 mm./min. which correspond to Talysurf horizontal magnifications of 4,20, and I00 respectively. One profile was measured per traversing speed.

The values of appropriate surface parameters after I0 traverses are compared with those of the corresponding original surface profiles. The results are shown in table 3, and fig. 6.

The Effect Of The Number Of Traverses On The Parameter Values Of The Measured Surface Profiles At Constant Traversing Speed.

At a constant traversing speed of 3.05 mm./min., a surface profile was measured after leveling the Talysurf external datum relative to it and its characteristics were taken as those of the original profile. Then the characterestics of the profile were determined after 5,I0,20,30, and 50 traverses. Results are shown in fig. 7, and fig. 8.

DISCUSSION

The System Performance.

All the digitized numbers were zreo when the Talysurf was connected with the computer and the pen of the recorder was at position I as in fig. 3. This is exactly what was expected because the loading program was designed to give zero reading when pen becomes at position I , 250 at position 2 , 500 at position 3, 750 at position 4, and 999 at position 5.

The results shown in table I, and table 2, indicate that

the digitized values when the recorder pen was at position 4 fig. 3, are close to the expected value 750. The results also reveal that changing the sampling interval and the vertical magnification of the Talysurf has no effect on the digitized values relative to the pen position.

In addition, several surface profiles were measured and the computed values of the arithmetic mean deviation found to be almost equal to the values taken directly from the Talysurf. Therefore the results indicate the suitability of the PDP-8/L Computer-Talysurf system used.

The external datum should be parallel to the general direction of the profile before taking measurements. The procedure for doing this, requires the stylus to be traversed a few times across the surface at the highest traversing speed of the stylus (76.2 mm./min.). Since the number of surface profiles to be measured in surface studies is quite large , it was found necessary to investigate this matter.

Stylus Traversing Speed

It is shown in table 3, and fig. 6, that the surface traversing speed withen the practical range of speeds has no significant effect on the surface parameter values and so on the cumulative distribution of the profile ordinate heights.

Stylus Number Of Traverses.

Although the manufacturer declare that the stylus force is only sufficient to ensure continous contact between the stylus tip and the surface, it was found from fig. 7, that σ, Ra, and R_t decrease slightly with the increase of number of traverses of the stylus , while S , and ρ increase slightly.

The results are in agreement with what one would expect. Because the force acting on the asperities due the stylus force , a very small amount of deformation may occure which in turn may cause a slight reduction in R_t , R_a , and σ. Such deformation is accompanied with rounding off the asperities and some peaks may well be squashed and in turn ρ , and S may also be increased. The results also reveal that ρ and σ are most sensitive to deformation effects of these kinds.

Experience has shown that leveling the datum unit of the Talysurf to the surface profile to be measured rarely requires more than 10 stylus traverses across the profile. Fig. 7, shows that for 10 stylus traverses , the change in the surface parameter values is withen $\pm$ 3% , which is quite negligible. Fig. 8, shows that the cumulative distribution

of ordinate heights of the measured surface is not significantly affected by the stylus traversing.

The Appropriate Sampling Interval.

Fig. 4, shows that the change in most of the surface parameter values at a number of ordinates greater than or equal to 2000 is negligible. It is worthy to say that at constant sampling interval , the larger the digitized number of ordinate heights , the bigger the length of the studied surface profile, the closer the computed parameter values to the actual values of the surface.

Fig. 5, shows that the graphs of the parameter values of the measured surface profile with the change in the sampling interval at constant sampling length intersect with their corresponding ones at constant number of ordinates 3000 at sampling intervals ranging from I.I to I.35 micron of which I.22 micron is an average value.

The above technique was used for computing the R_a and R_t of a test specimen using 3000 ordinates and I.22 micron as sampling interval , results were very close to those stated by the national laboratry in the U.K.

Fig. 9, shows that the reproduced profile trace by the system is quite satisfactory representation of the profile produced by the Talysurf.

CONCLUSION

I- The PDP-8/L Computer-Talysurf system is reliable for metallic surfaces studies.
2- A number of ordinates equals to 3000 and a sampling interval of I.22 micron are suitable for surface texture assessments.
3- The Talysurf stylus traversing speed has no significant effect on surface characterestics.
4- For practical applications, the stylus traversing has no significant effect on the characterestics of the measured profiles.

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NOMENCLATURE

h	Height from datum line.	micron.
l	Sampling interval.	micron.
p	Percentage of ordinates	
R_a	Arithmetic mean deviation.	micron.
R_t	Maximum peak to valley height.	micron.
S	Average spacing of asperities.	micron.
ρ		
σ		
$\Delta+$		
$\Delta-$		

Table I. The influence of sampling interval on the output punched values at constant no of ordinates and vertical magnification.

Sampling interval (units)	punched value	Sampling interval (units)	Punched value	Sampling interval (units)	Punched value
I	754	20	756	I50	755
2	770	50	770	200	769
5	756	I00	753	250	758
I0	775				

Vertical magnification=2000
No.of digitized values=2000
Tests were carried out three times, the results were of the same order as shown.

Table 2. The influence of changing the vertical magnification on the output values at constant no.of samples and sampling interval

Vertical magnification	Average of digitized values
500	759
I000	744
2000	744
5000	76I
I0000	757
20000	755
50000	76I

No.of digitized values = 2000
Sampling interval = I unit (800 microseconds).
Talysurf stylus was at position 4 Fig. 3.
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Talysurf stylus was at position 4 Fig. 3.
Tests were carried out 3 times, results were of the same order.

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Table 3. The effect of the Talysurf stylus traversing speed on surface parameter values.

Traversing speed / Parameter	76.2 mm./min. D%	152.4 mm./min. D%	3.05 mm./min. D%
Max peak to valley height.	0.39	0.44	I.88
Average spacing of asperities.	-0.97	2.89	-I.69
Arithmetic mean deviation.	-0.09	2.I7	I.03
Standard deviation of peak heights.	3.6	7.87	0.03
Average radius of peak curvatures.	-9.I7	0.82	I.49
Mean positive slope at mean line.	3.38	0.42	4.59
Mean negative slope at mean line.	I0.46	-7.33	-0.4

D% = Deviation percentage from original profile parameter values.
Vertical magnification = 5000.

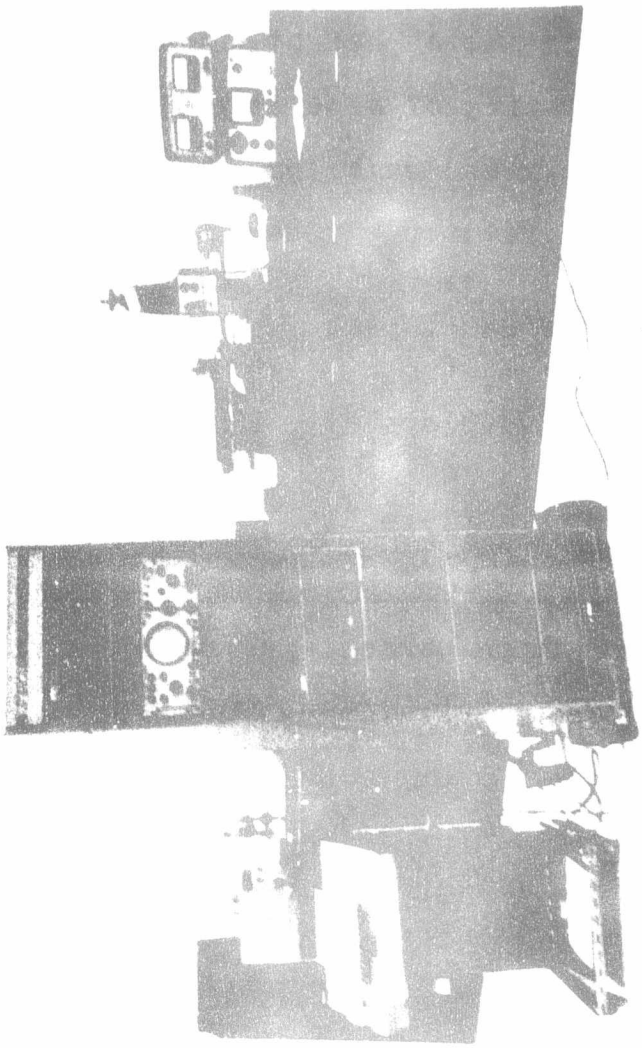
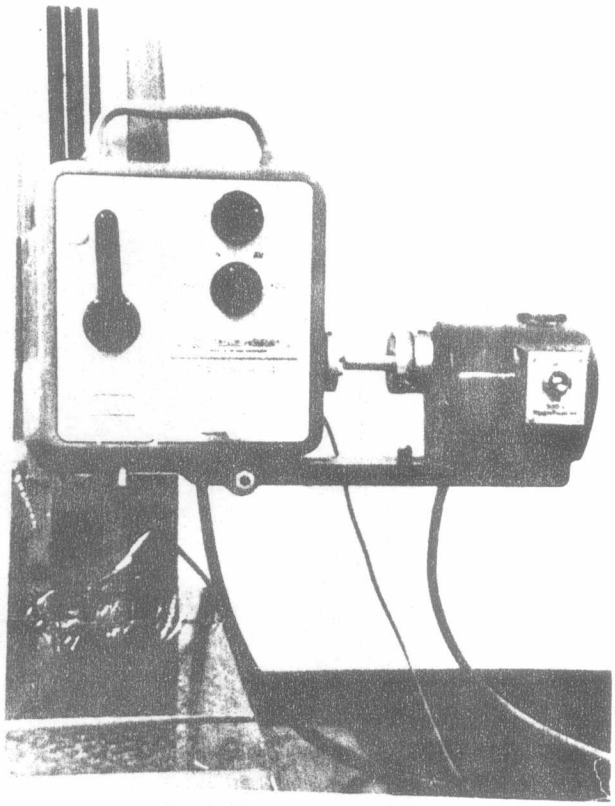
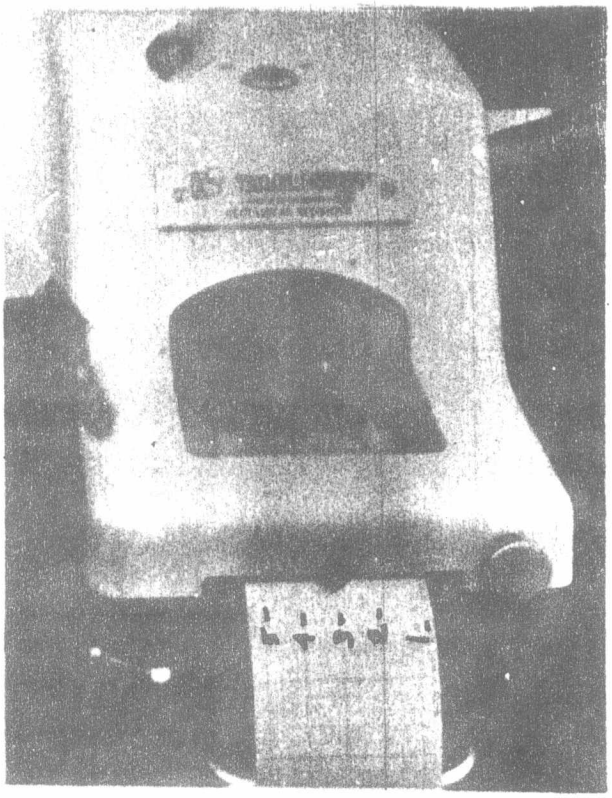


Fig. [illegible] RCA RDF-8/L Computer - [illegible]



THE ADDITIONAL DRIVE MOTOR CONNECTED TO THE TALYSURF GEAR-BOX

Fig. 2. The Additional Drive Motor [illegible]



THE RECORDER OF THE TALYSURF

FIG. 3. The Recorder Of The Talysurf.

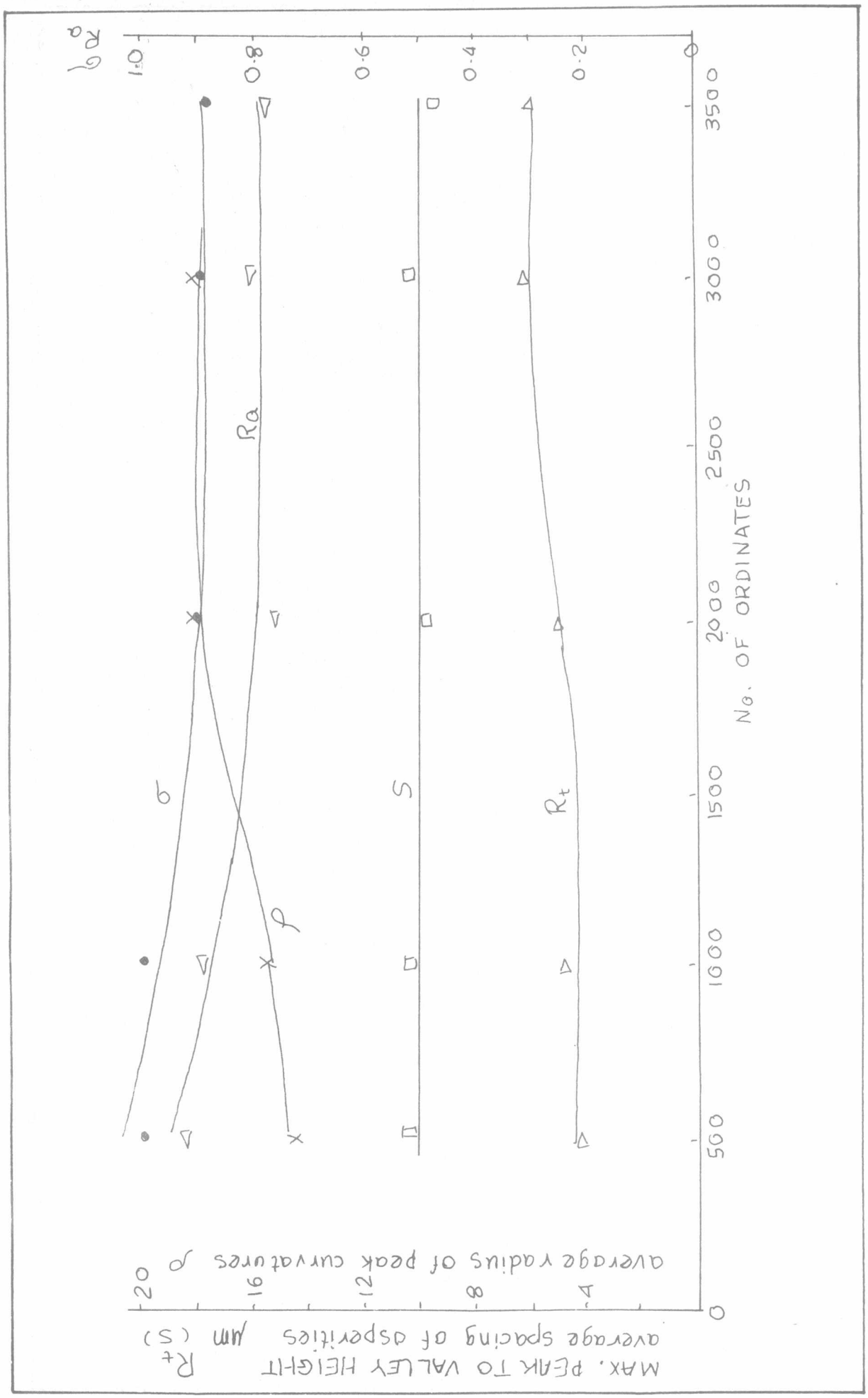


Fig. 4, THE CHANGE IN SOME SURFACE PARAMETER VALUES WITH THE CHANGE IN THE NUMBER

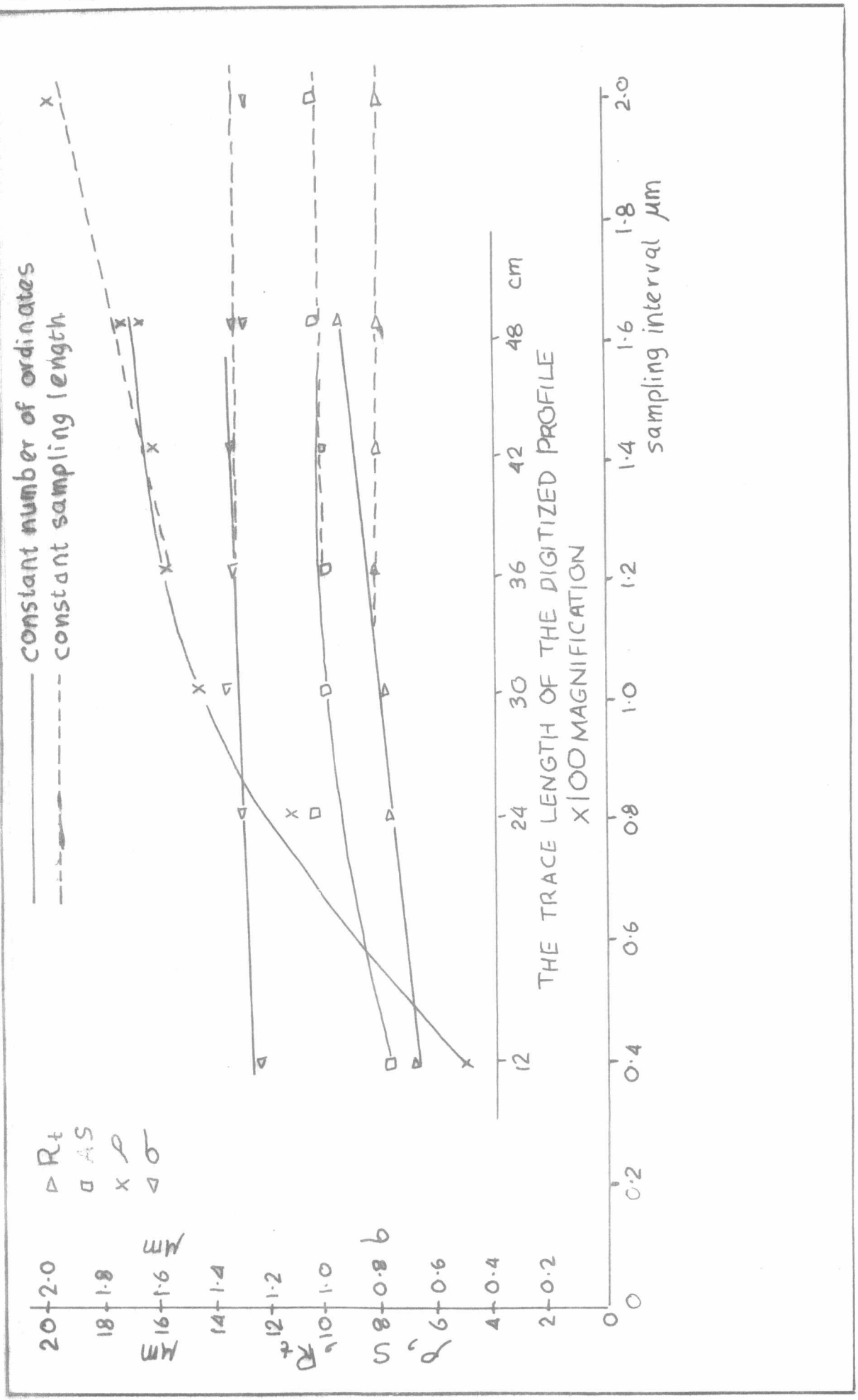


Fig. 5. THE CHANGE IN SOME SURFACE PARAMETER VALUES WITH THE CHANGE IN THE SAMPLING INTERVAL.

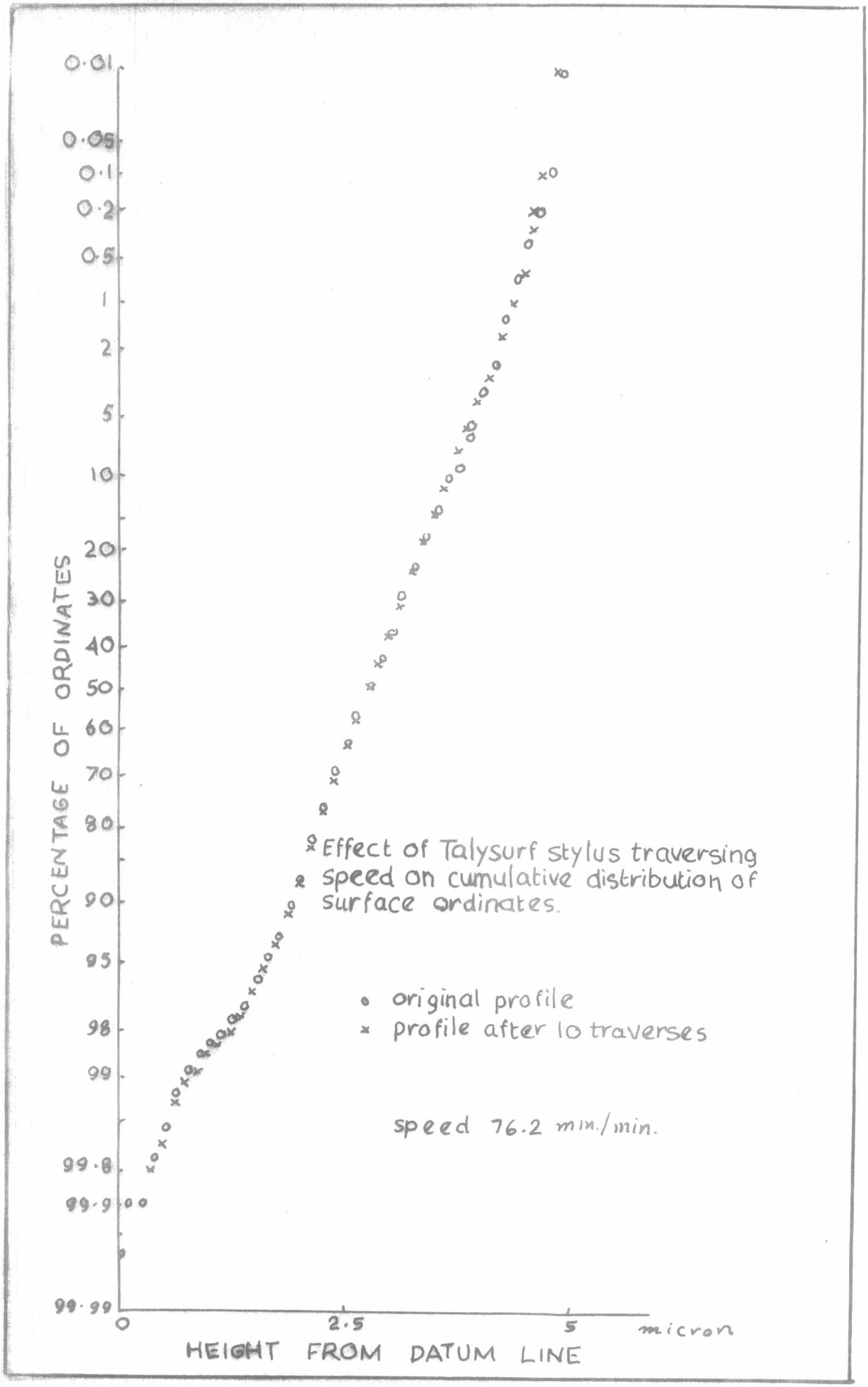


Fig.6. Effect of Talysurf stylus traversing speed on cumulative distribution of

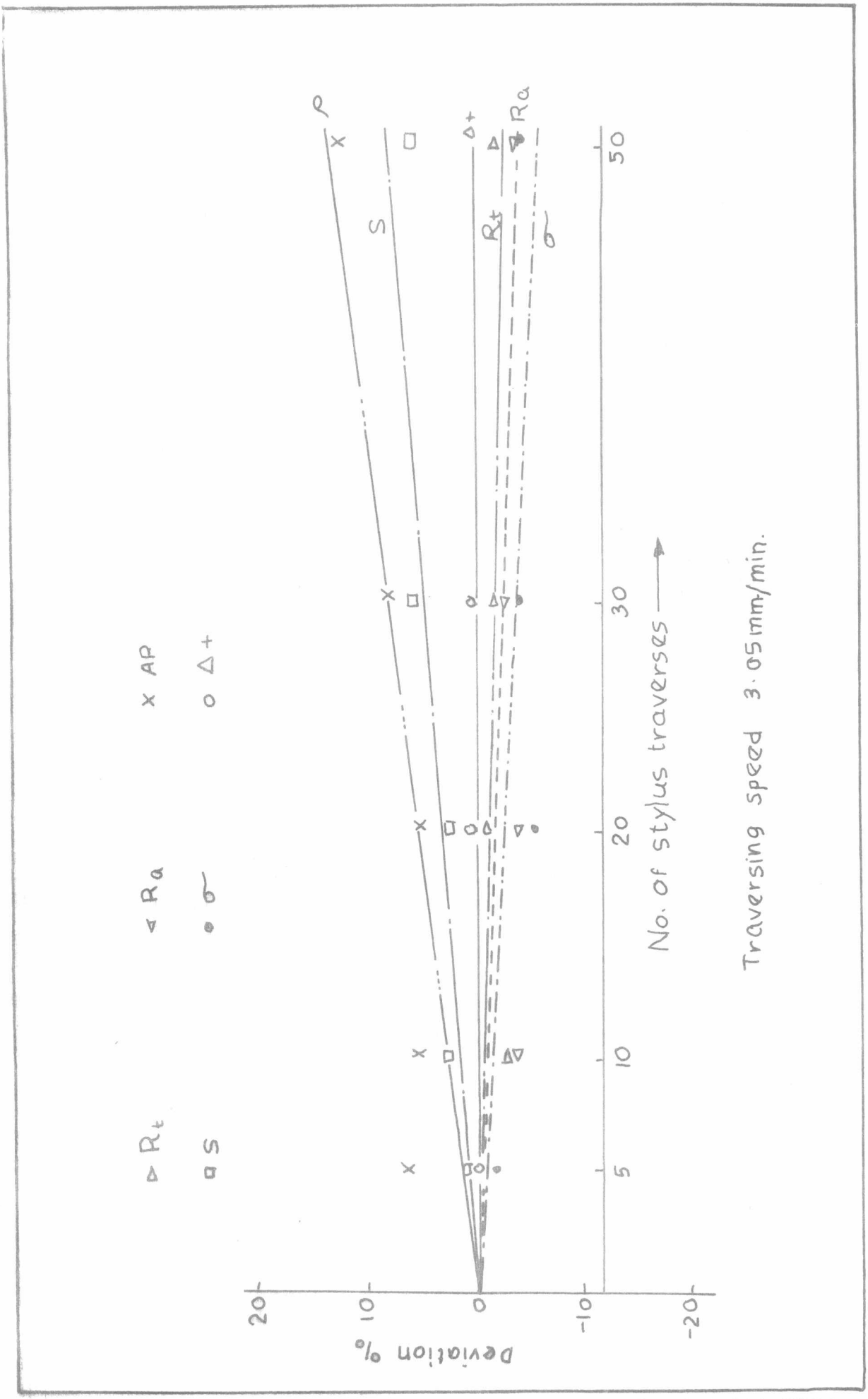


Fig 3. THE EFFECT OF THE TALYSURF STYLUS NUMBER OF TRAVERSES ON THE PARAMETER VALUES OF THE MEASURED SURFACE PROFILE

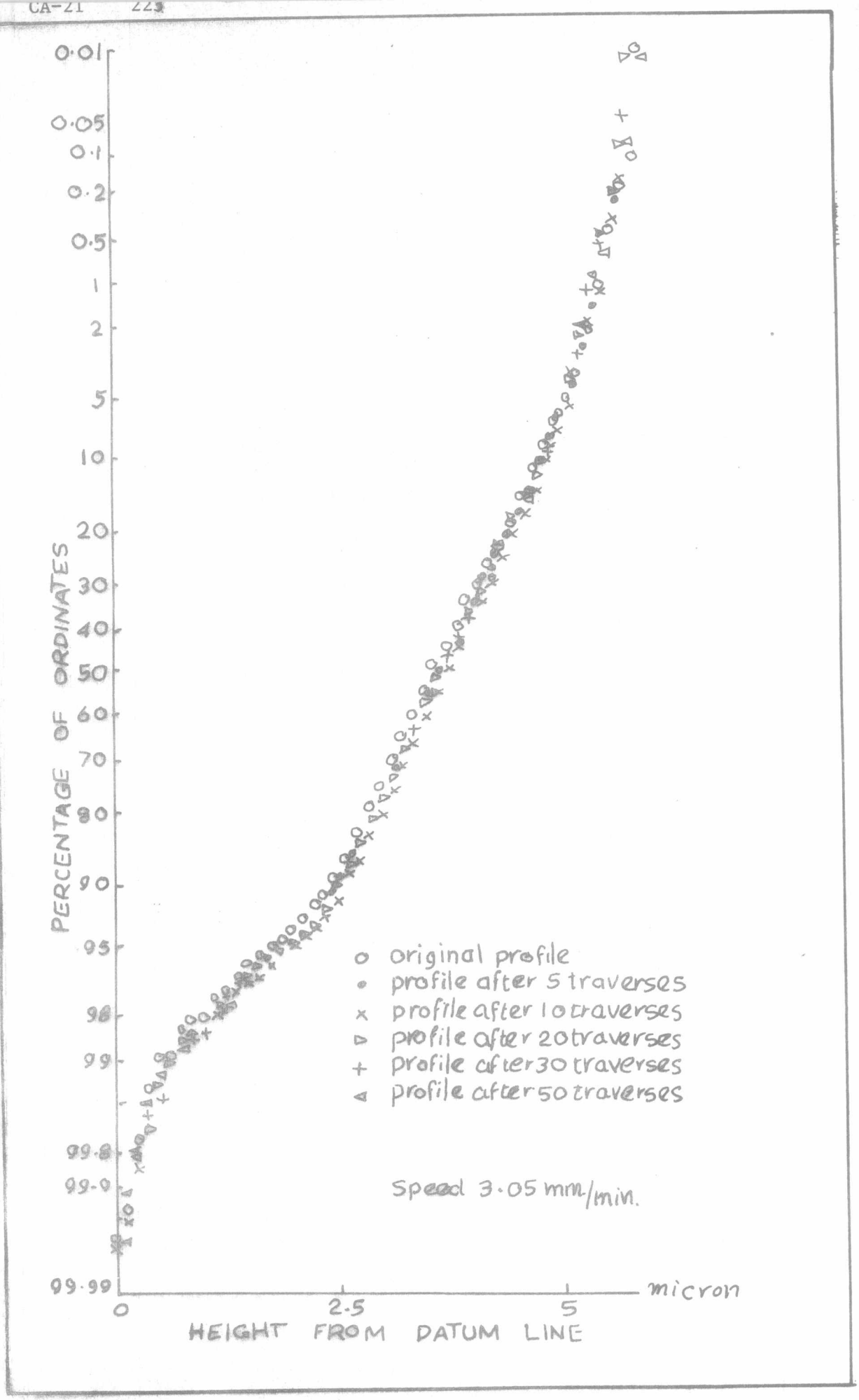


Fig. 8. Effect of Talysurf stylus number of traverses on cumulative distribution of

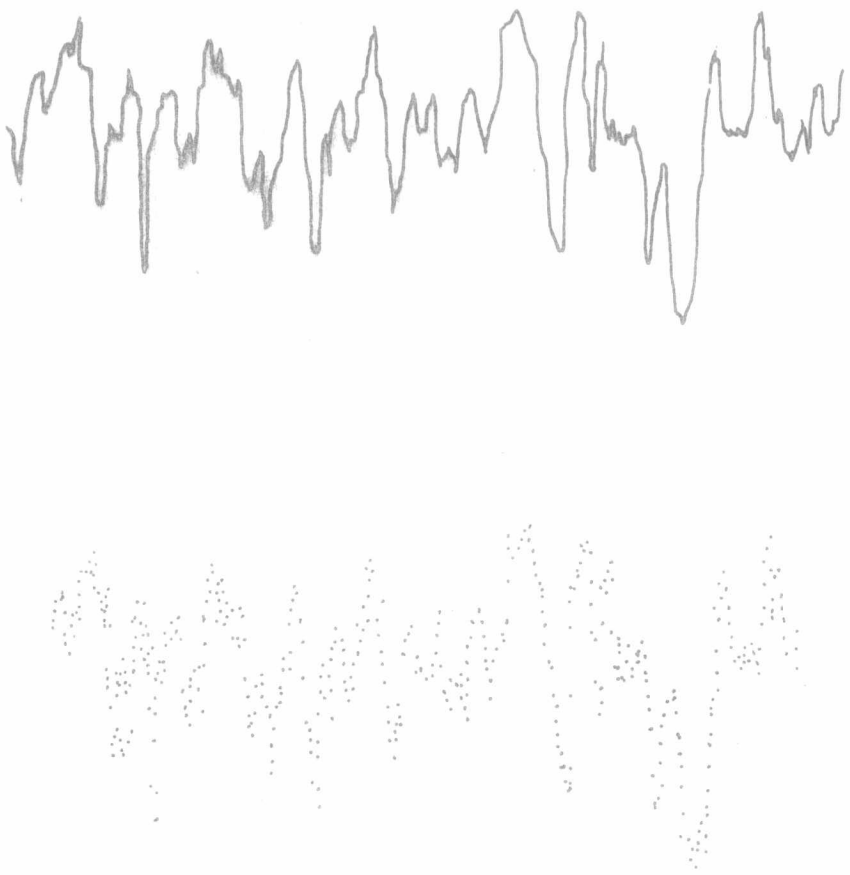


Fig. 9. A COMPARISON BETWEEN A PROFILE TRACE OF A GROUND SURFACE PRODUCED BY THE TALYSURF AND THAT ONE REPRODUCED FROM THE OUTPUT

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