THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

WET GRINDING OF SMALL CARBON STEEL COMPRESSION SPRINGS

by

M.R. Southward, B.Sc

Report No. 341

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SUMMARY

A recent investigation into the crash grinding of compression springs compared the two processes of wet and dry grinding. The conclusion of the investigation was that wet grinding was a more economical process than dry grinding due to the increased production rates and elimination of the dressing operation. The wet grinding process used more wheel than dry grinding to remove the same quantity of metal but the results did indicate that the wheel wear could be reduced without having any detrimental effect on the cutting performance by using a harder grade of wheel thus making the process even more economical.

This investigation performs the same grinding trials as in the previous investigation but employs wet wheels two grades harder than the previous wheels.

Using the harder wheels production rates were achieved which were some 3½ times greater than the fastest dry grinding rates.

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1. INTRODUCTION

The process of crash grinding compression springs is continually being investigated by the Association, and until recently previous reports have determined the optimum combination of production rate and wheel composition for dry grinding of a particular spring design. The last report published on end grinding (No. 327) concerned the conversion of a dry grinding machine to a wet grinding machine and the performance of grinding trials to compare the two processes. The conclusions of that investigation were that wet grinding was a more economical process than dry grinding due to the increased production rate and elimination of the wheel dressing operation. However, the life expectancy of the wet grinding wheels was lower than for the dry grinding wheels and analysis of the wheel performance data indicated that a harder grade of wet wheel would increase the life expectancy without having any detrimental effect upon the cutting performance. Thus indicating that even greater savings could be achieved.

This investigation concerns the performance of wet grinding when using wheels two grades harder than those employed in the previous investigation. The results are compared with information extracted from previous reports on wet and dry grinding.

2. SPRING DESIGN

The spring design selected for this investigation is the same as that used in previous investigations and is as follows:-

Wire Diameter (mm)	2.03
Mean Coil Diameter (mm)	12.7
Active Coils	4.0
Total Coils	6.0
Free Length after grinding (mm)	20.32
Weight of unground springs (gm)	5.14

3. PROCEDURE

The parameters controlling the decision for cessation of grinding are the same as used in previous investigations. Grinding was stopped when spreading of the end coils exceeded 0.15 mm on spring diameter or when approximately one quarter of the end coil is discoloured. If neither of these parameters were exceeded then grinding was stopped at 5000 springs.

The type of wheel selected for this work was WA 40 ND which was 2 grades harder than the type used on previous wet grinding trials. These wheels were placed on the grinding machine and dressed level. The machine was then left running for 1 hour with the coolant switched on for the first 30 minutes. After this period the machine was switched off, and as soon as the wheels stopped rotating they were removed from the grinding machine and weighed. Prior to the replacement of the wheels on the grinding machine they were placed cutting face up on a surface plate and a dial gauge traversed radially across the wheel face to check profile and thickness of wheel.

The grinding machine and coolant were switched on and left running for 30 minutes to achieve an even working environment. The grinding rate was set at 70 springs/minute and the gap between the wheels adjusted so as to produce a spring of the required dimensions meeting the BS 1726 class B tolerance for end squareness. Next, 500 springs were weighed and then ground, the last 10 of every 200 were collected. On completion of grinding the coolant was switched off but the grinding machine left running for 30 minutes in order to remove excess water from the wheels prior to weighing. After weighing, the wheels were placed cutting face up on a surface plate. A dial gauge was then traversed along three equally spaced radii of the wheel. Measurements of wheel thickness were recorded at 6 mm intervals along each radius. Subsequently the wheels were replaced and the grinding machine switched on, to attain an even working environment. The grinding procedure was then repeated in 500 spring batches until 5000 springs had been ground.

The whole procedure was repeated for table speeds of 90 and 110 springs/min.

4. RESULTS

As this report is a continuation of the comparison between the processes of wet and dry grinding, information from previous investigations has been listed in the tables of this report; including the previous results using the softer wheel.

The amount of grit removed from the wheels for each batch of springs is expressed as grammes per spring and shown in Table I. Using the results for loss of weight for each batch of springs, the ratio of metal removed/wheel wear has been calculated and recorded in table II. An analysis of grinding time and total amount of wheel used for both wheels, is shown in Table III, which also includes the costing based on the grinding of 5000 springs.

From the readings of wheel thickness the wheel profiles have been constructed after each batch of springs for each grinding rate, and are shown in Figs. 1. to 5.

To enable a comparison of wet and dry grinding to be made on an economical basis, cost curves for both processes have been plotted on Fig. 6. The costing has been based on the figures from the previous report. Consequently the figures are not exact and should only be used for comparative purposes.

5. DISCUSSION

Grinding of 5000 springs was possible for all three production rates without discolouration or excessive spreading of the end coils.

The rate of wheel wear is recorded in Table I and expressed as grammes/spring. This loss of wheel has been considerably reduced from the previous wet grinding results by the use of harder grinding wheels. Also this improved figure is now approaching the dry grinding result.

The ratio of metal removed/wheel wear is listed in Table II and shows a marked improvement on the previous wet grinding result using a softer wheel. Also, the ratio is much better than that for dry grinding when the wheel removed during dressing is accounted for. This overall figure for dry grinding is listed at the base of the table and is calculated using the amount of grit removed during dressing in order to level the cutting face of the wheel. Comparing this figure with the present wet grinding results shows that the harder wheel used in this investigation removed more metal per unit wheel than is achieved when dry grinding.

The wheel profiles depicted in Figs. 1 to 3 show how there is a continual loss of wheel right across the cutting face which results in the elimination of the dressing operation. Comparison of these profiles with the dry wheels and the softer grade wet wheel indicates that the profile for the hard wet wheel is approaching the profile for the dry wheel. Thus even harder wet wheels may require a dressing operation.

Analysis of grinding time and a breakdown of costs has been performed for wet grinding with the hard wheel and recorded in Table III enabling cost curves to be plotted on Fig. 6 along with the soft wet wheel and the dry wheel results. The time cost curves are the same for both types of wet wheel but the wheel cost curve for the harder wheel is lower than the curve for the soft wheel which results in a lower total cost curve for the harder grade of wheel.

The values shown on Fig. 6 for grinding rate, relate to the table speed and are the number of springs passed between the wheels every minute. However, when dry grinding, production must stop to perform the wheel dressing operation and allowance of this non productive time reduces a grinding rate of 50 to an overall production rate of 30 springs/min. Since wet grinding does not require a dressing operation the overall production rate is the same as the grinding rate. Consequently wet grinding can be performed 3½ times greater than the fastest overall production rate for dry grinding.

During the grinding trials, springs were collected and hardness tests performed along the ground surface of the end coils. These results indicated no significant difference in hardness with changes in either production rate or the number of springs ground.

6. CONCLUSIONS

1. The wet grinding process increases production rate by approximately 3½ in comparison with dry grinding.

2. The wheel wear for the harder grade of wet wheel is considerably less than the wear upon the softer grade of wet wheel thus making the process even more economic.

3. Comparing the process on an economical basis shows wet grinding with the harder wheel to be an improvement on the previous wet grinding operation and a large improvement on dry grinding.

4. End coil hardness is not affected by wet grinding.

7. REFERENCES

1. Southward M.R. "A Comparison of Wet and Dry End Grinding of Compression Springs" SRA,A Report No. 327.

8. ACKNOWLEDGEMENTS

The Association would like to thank the following member company for their invaluable assistance in the project.

Abrasive Products Ltd.

TABLE I RATE OF WHEEL WEAR (g/spring)

Grinding Rate (springs/min.)	WET GRINDING Hard Wheels (present work)			WET GRINDING Soft Wheels (previous work)	Dry Grinding
	70	90	110	90	30
No. of springs ground					
1 - 500	.37	.4	.41	.71	.33
501 - 1000	.16	.24	.12	.42	.13
1001 - 1500	.15	.47	.24	.21	.10
1501 - 2000	.17	.09	.05	.21	.15
2001 - 2500	.08	.13	.11	.32	.03
2501 - 3000	.09	.08	.11	.31	.06
3001 - 3500	.09	.13	.16	.13	
3501 - 4000	.04	.16	.22	.3	
4001 - 4500	.09	.13	.15	.18	
4501 - 5000	.14	.09	.20	.26	
Average	.14	.19	.18	.30	.13

TABLE II RATIO OF METAL REMOVAL/WHEEL WEAR

	WET GRINDING				
	Hard Wheels (present work)			Soft Wheels (previous work)	Dry Grinding
Grinding Rate (springs/min.)	70	90	110	90	30
No. of springs ground					
1 - 500	0.66	0.58	0.31	0.28	1.1
501 - 1000	0.97	0.96	1.24	.37	2.8
1001 - 1500	0.43	0.46	0.61	.72	3.9
1501 - 2000	0.69	2.85	2.8	.67	2.4
2001 - 2500	1.60	1.69	1.25	.54	10.9
2501 - 3000	2.37	2.53	1.61	.59	6.2
3001 - 3500	0.86	1.44	1.38	.97	
3501 - 4000	3.4	1.04	1.06	.52	
4001 - 4500	1.59	0.91	0.87	.72	
4501 - 5000	1.02	1.73	1.17	.56	
Average	1.03	1.03	0.96	.60	3.1
The overall figure including loss of wheel during dressing operation					0.8

TABLE III ANALYSIS OF GRINDING TIME AND BREAKDOWN OF GRINDING COSTS

	Grinding Rate (springs/min.)		
	70	90	110
Grinding time (h)	1.19	0.93	0.76
No. of dressing operations	0	0	0
Total Time (h)	1.19	0.93	0.76
Cost of grinding time (£)	3.84	3.00	2.45
Depth of wheel used (mm)	4.42	5.33	5.61
Cost of wheel used (£)	1.58	1.90	2.00
Total cost (£)	5.42	4.90	4.45

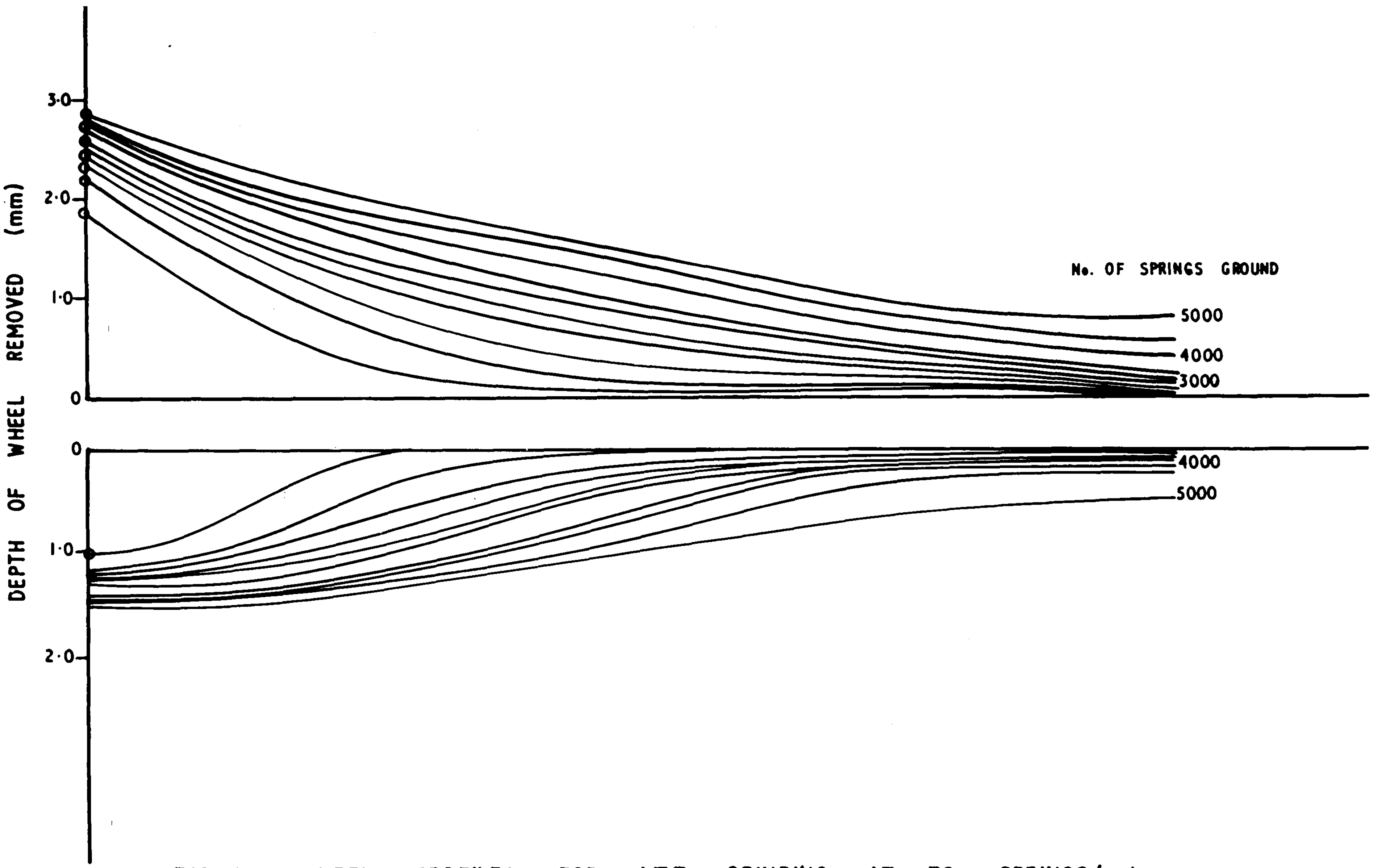

FIG. 1. WHEEL PROFILES FOR WET GRINDING AT 70 SPRINGS/min.

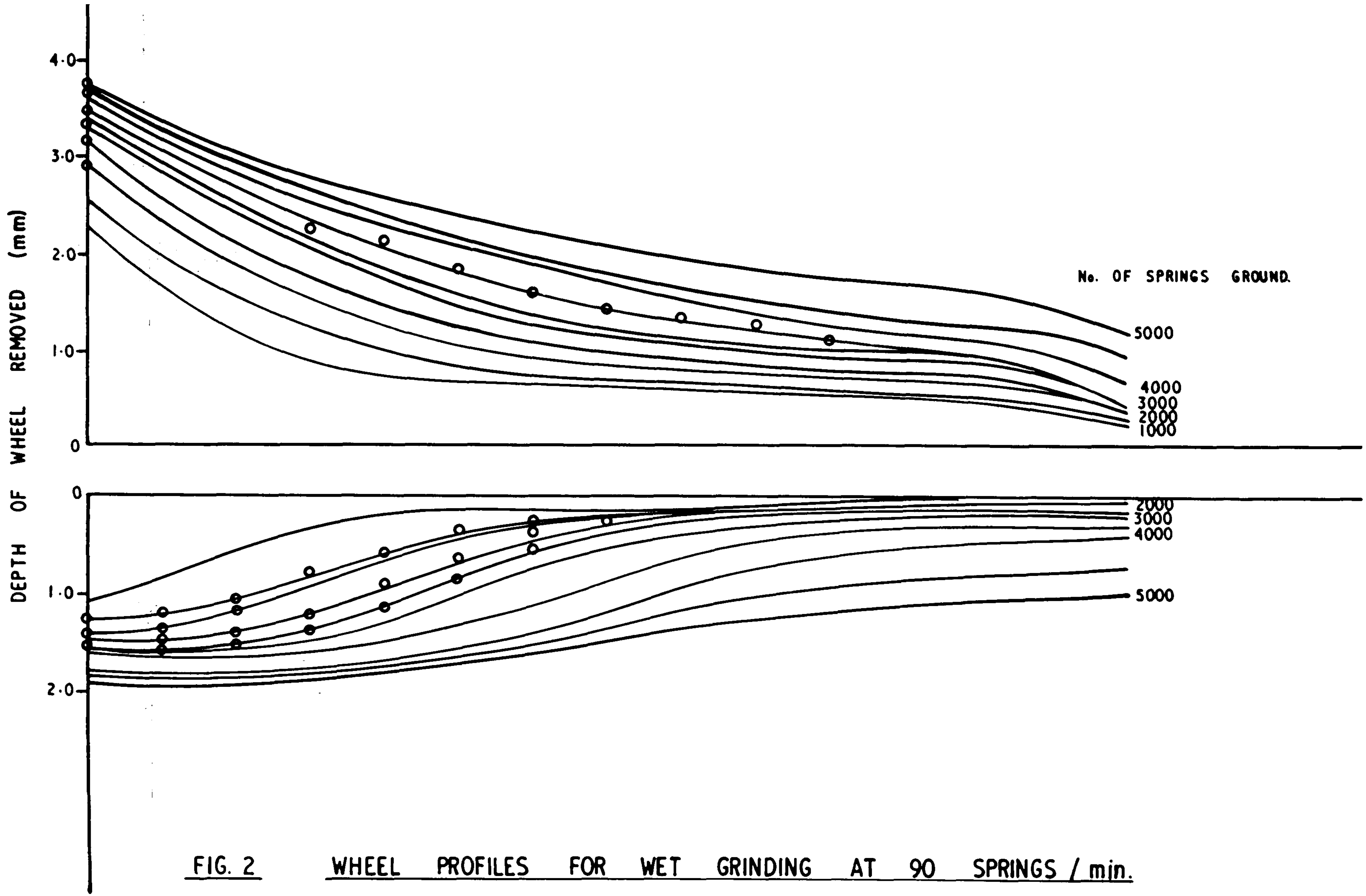

FIG. 2 WHEEL PROFILES FOR WET GRINDING AT 90 SPRINGS / min.

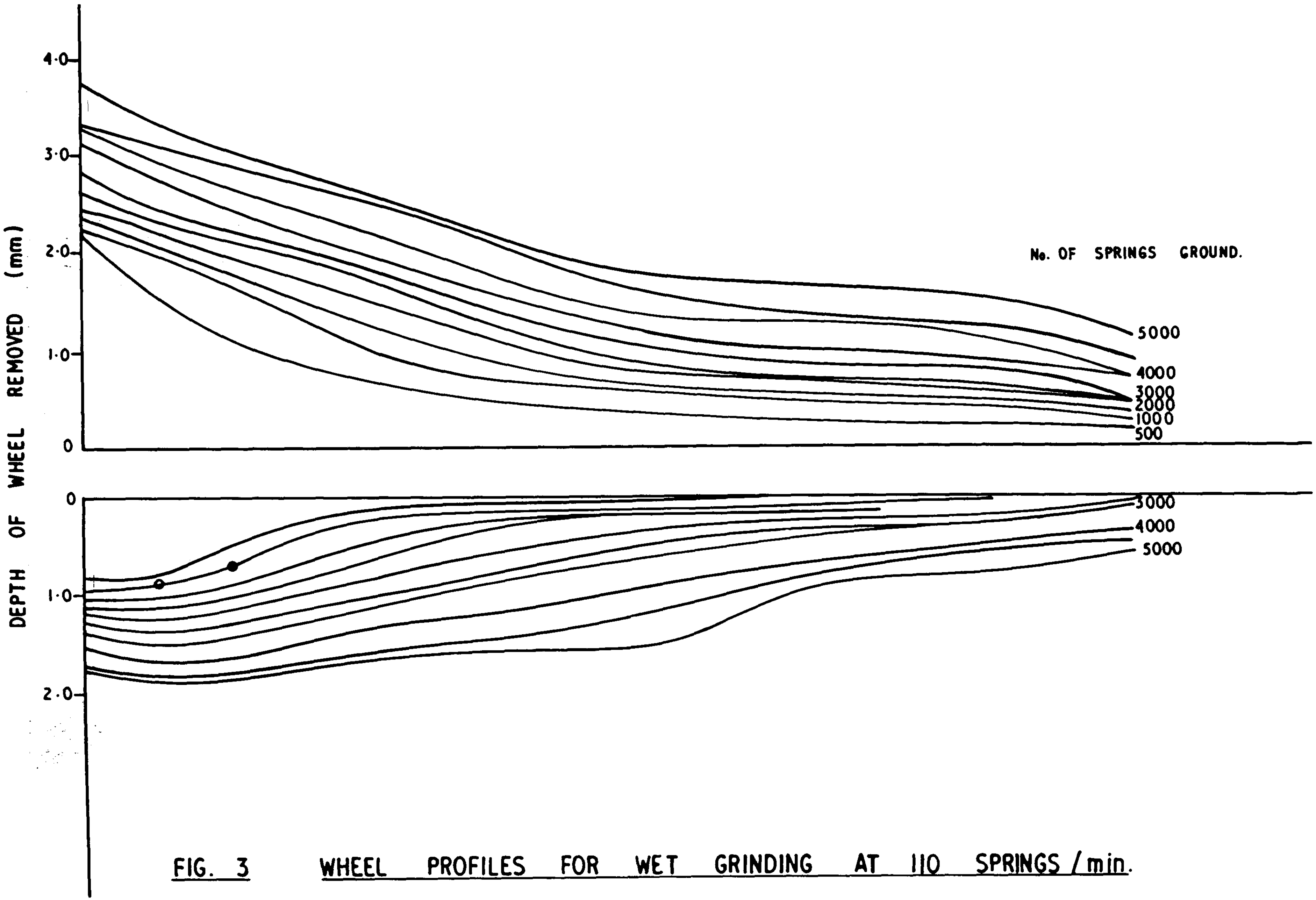

FIG. 3 WHEEL PROFILES FOR WET GRINDING AT 110 SPRINGS / min.

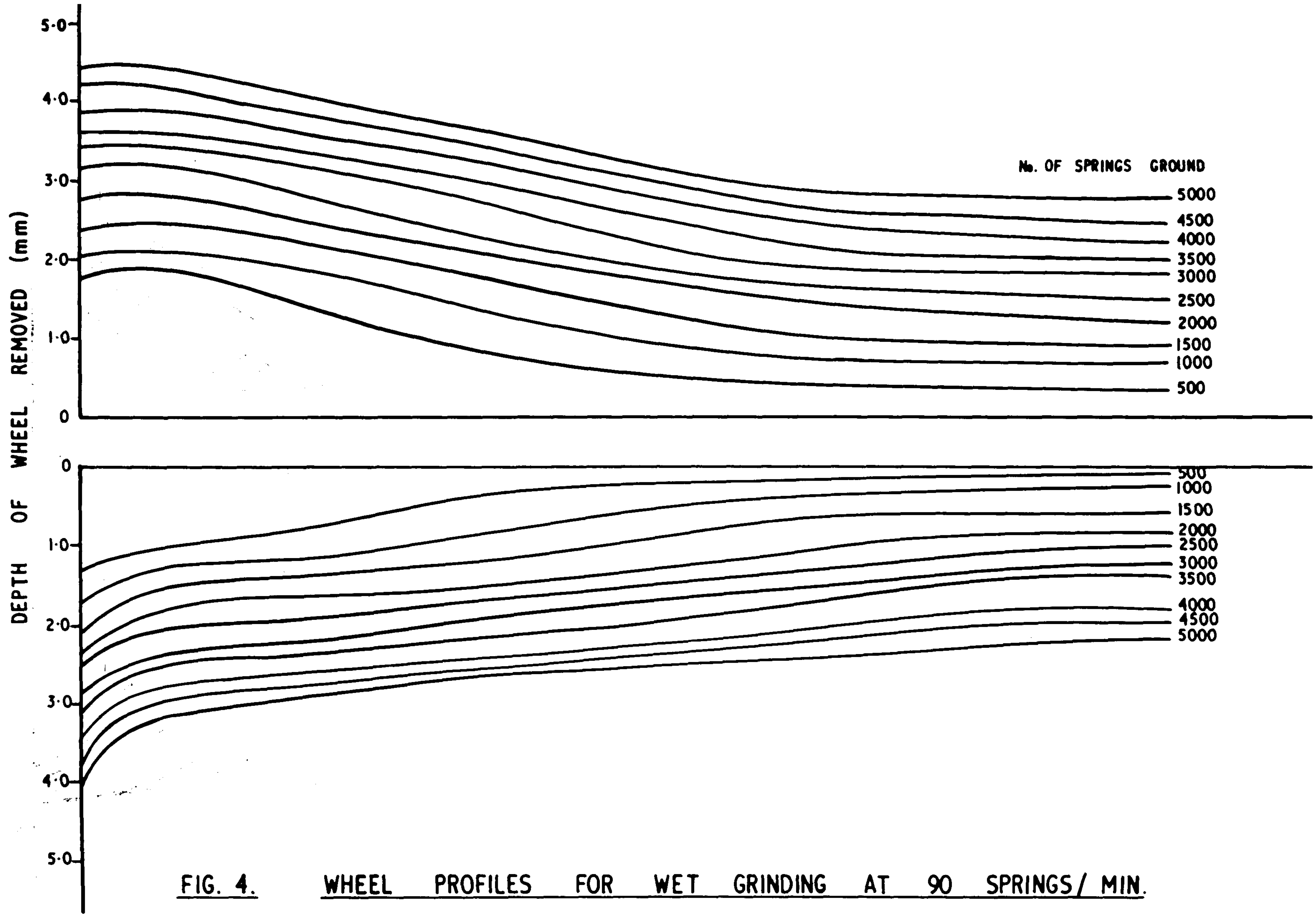

FIG. 4. WHEEL PROFILES FOR WET GRINDING AT 90 SPRINGS/ MIN.

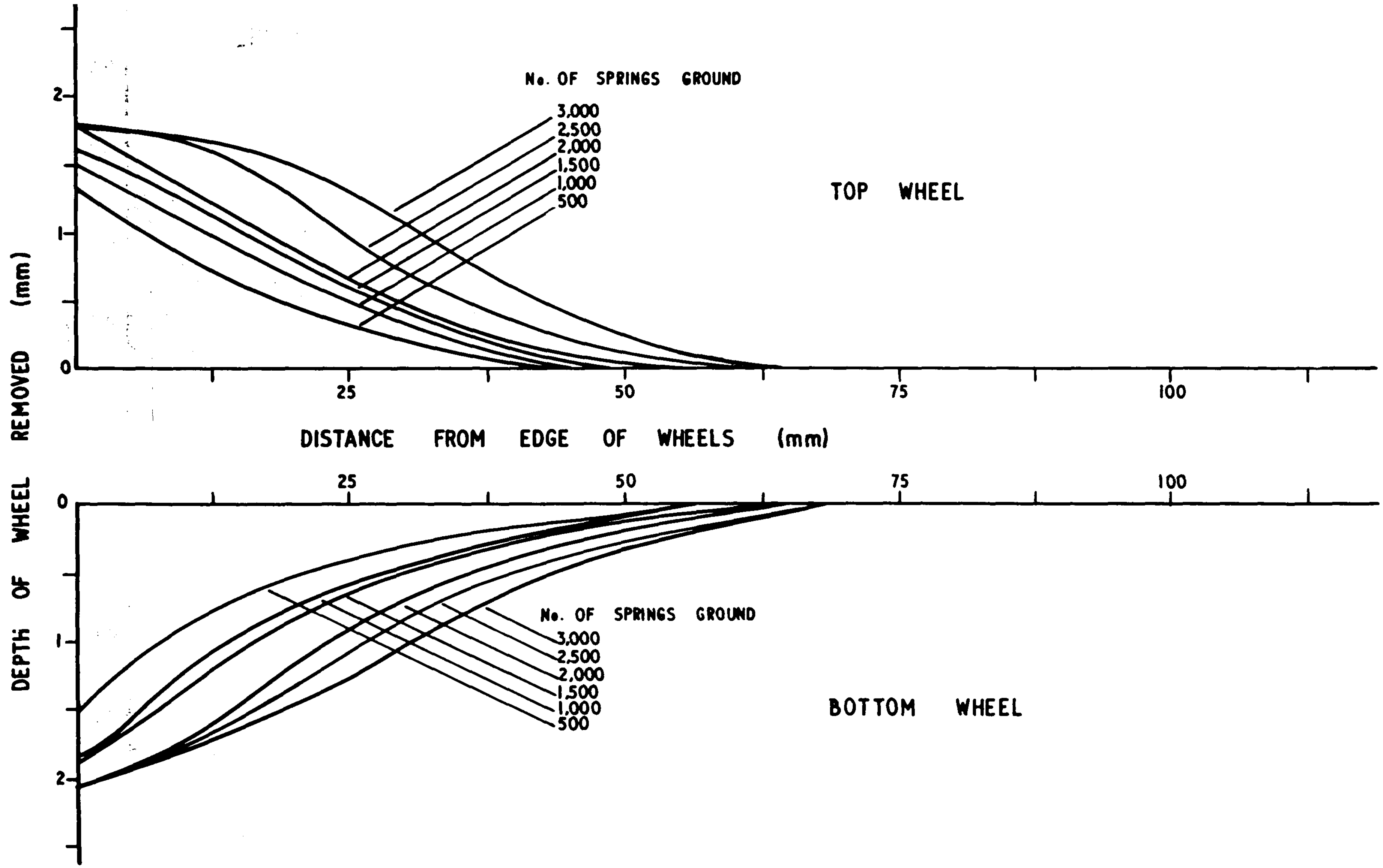

FIG. 5. WHEEL PROFILES FOR DRY GRINDING AT 30 SPRINGS/MIN

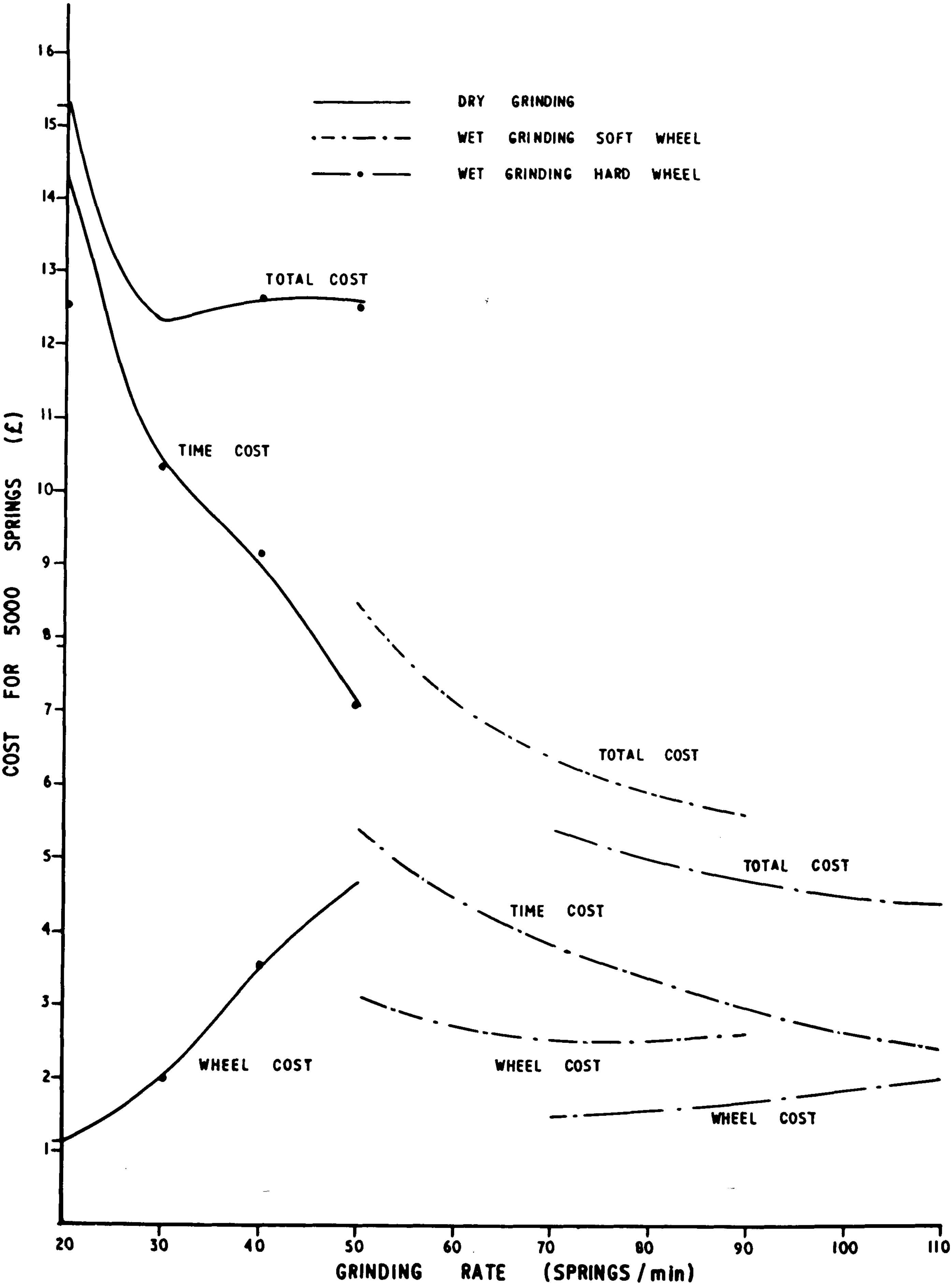

FIG. 6. COST CURVES.