THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

A COMPARISON OF WET AND DRY END GRINDING OF COMPRESSION SPRINGS

by

M.R. Southward, B.Sc

Report No. 327

MAY 1980

THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

Report No. 327

A COMPARISON OF WET AND DRY END GRINDING OF COMPRESSION SPRINGS

SUMMARY

With increasing concern regarding dust control regulations, changes may have to be made in the air filtering techniques used in the dry grinding process. One method of eliminating dust problems is to use wet grinding for springs, a process not new to the spring industry but normally only employed on heavy springs.

In this investigation, the application of the wet grinding process to light springs has been studied. Since there were no wet grinding machines available upon which to undertake this research a Bennett SG1-14 grinding machine was converted to enable wet grinding. This type of machine had been used for the previous investigations on dry grinding and so a direct comparison between the two processes was possible. To enable this comparison of grinding performance to be made, data on dry grinding from a previous investigation (1) is included in this report.

Springs of the same design as used previously were wet ground with one type of wheel and at three grinding rates. Measurements were taken on the springs and on the wheels in order to produce data on metal removal/grit removal ratios. From this data the cost of the grinding operation was calculated and a comparison was made between the costs for wet and for dry grinding.

MAY 1980

CONTENTS

THE SPRING RESEARCH & MANUFACTURERS' ASSOCIATION

Report No. 327

A COMPARISON OF WET AND DRY END GRINDING OF COMPRESSION SPRINGS

by

M.R. Southward B.Sc

1. INTRODUCTION

The traditional practice when end grinding springs is to grind small springs dry and to grind heavy springs wet. Thus the method of grinding springs wet is not new but rarely encountered in the small spring side of the industry. In the near future the Government proposes to introduce stricter legislation regarding the re-circulation of extracted air from grinding machines and several possible solutions exist to meet the demands of the new legislation. One approach is to use much more efficient dust extractors; these however tend to be very expensive to purchase and run. A second approach is to exhaust the air to the outside of the building; this however is very wasteful since the air is heated in the building. A third solution is to use wet grinding techniques. The final alternative is investigated by this report and compared with identical dry grinding trials previously performed by the Association (Report No. 262).

Due to lack of demand for wet grinders operating on small springs it was not possible to locate a suitable machine on which to perform the wet grinding tests. Consequently it was decided to modify a Bennett SG1-14 dry grinder, a model we have used in previous investigations. On completion of the modifications to the grinding machine, trials were undertaken to ensure that the machine was running satisfactorily before grinding trials commenced. The programme of work followed the same lines as the previous investigations and used the same design of spring. The results were analysed separately, and compared with dry grinding data, enabling a comparison to be made between the two processes.

2. CONVERSION OF GRINDING MACHINE

The conversion of the machine required the manufacture of special parts and a certain amount of dismantling to facilitate the fitting of guards and seals. The basic changes to the machine are listed below:-

i) The drive spindle for the top wheel required a hole down the centre in order to feed grinding fluid to the grinding wheels. This item was fitted to the machine by the manufacturer prior to delivery.

ii) The top guide plate on the input side was replaced by one of the same physical dimensions but manufactured in two parts joined horizontally. The lower part which comes into contact with the spring was of hardened steel whilst the top part had grooves milled along the bottom surface (Fig. 1). This modification was carried out for two reasons- the first was to direct grinding fluid onto the rotating table and flood it, the second was to spray the spring as it enters and traverses between the grinding wheels.

iii) The attachment of a collecting tank for the grinding fluid (Fig. 2). This necessitated the extension of the shaft to align the lower hand wheel with the work table adjustment hand wheel. Also a re-design of the mounting bracket for the input guides was required. In order to fit the tank the wheel backing plates and the guard had to be removed.

iv) Designing and fitting of labyrinth seals (Fig. 3) to the grinding wheel back plates to prevent grinding fluid from reaching the main shaft bearings.

v) The sealing of apertures around the machine guards and collecting tank to prevent spray from escaping to the atmosphere around the machine.

vi) A pump and external reservoir was sited next to the spring end grinder. This pump delivered a standard water based coolant containing an inhibitor at a flow rate of 6.8 litre/min.

3. SPRING DESIGN

In order to enable a comparison to be made with previous work the same spring design has been selected. This spring can be ground in one pass by the SG1-14 machine and details of the design are given below:

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 spring (gm)	5.14

4. EXPERIMENTAL PROCEDURE

The parameters controlling the decision for cessation of grinding are the same as used in previous investigations. This is an allowable spreading of end coils up to 0.15 mm on spring diameter or when approximately one quarter of the end coil is discoloured. If neither of these parameters is exceeded then grinding will stop at 5000 springs.

The grinding wheels type WA40LB, were recommended by the wheel manufacturer as possibly being the most suitable for this investigation.

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 50 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 and 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 was 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 70 and 90 springs/min.

5. RESULTS

To enable a comparison to be made between wet grinding and dry grinding, information from a previous investigation into dry grinding has been included in this report. This information is based on what proved to be the most economical wheel (grade N) and grinding rate (30 springs/minute), and is listed beside each table constructed for the wet grinding results.

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 the 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. 4 to 6. Fig. 7 shows the wheel profile for dry grinding.

To enable comparison of wet and dry grinding to be made on an economical basis cost curves for both processes have been plotted on Fig. 8. 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.

6. DISCUSSION

Grinding of 5000 springs was possible for all three production rates without discolouration or excessive spreading of the end coils. Neither was there any sign that a dressing operation would be necessary.

The rate of wheel wear recorded in Table I is expressed as grammes/spring and shows this loss to be independant of grinding rate for wet grinding. Comparison of these figures with those obtained when dry grinding, indicates a much larger loss of wheel for wet grinding.

The ratio of metal removed/wheel wear is listed in Table II and again appears independant of grinding rate. On comparison of these figures with those obtained for dry grinding it can be seen that more metal is removed per unit of wheel for dry than wet grinding. This is due to the large wheel wear discussed earlier. The average figures listed in the table are for the grinding of 5000 springs wet but only 3000 dry. Thus, if we calculate the ratio for grinding of 5000 springs dry, we will include the amount of wheel removed during the dressing operation. The reason for this being that although the grit is not removed during the grinding operation it does have to be removed in order to maintain the wheel in a fit condition to grind 5000 springs satisfactorily. This new figure has been placed at the base of the table and is only slightly greater than for wet grinding. Thus showing that wet grinding removes 20% less metal than dry grinding for one unit of wheel or to remove the same amount of material wet grinding uses 30% more wheel.

A visual indication of what has just been discussed can be seen by comparing the wheel profiles for both processes. The profiles for wet grinding show a uniform loss of wheel right across the cutting face. This means that the cutting surface is continuously and uniformly dressed by the grinding operation thus eliminating the need for a separate dressing operation. The profile for dry grinding indicates that most of the wheel loss occurs at the edge of the wheel and for grinding of 3000 springs the actual loss is less than for wet grinding but the wheel does then need dressing; a non-productive operation.

Analysis of grinding time and a breakdown of costs has been performed for wet grinding and recorded in Table III enabling cost curves to be plotted on Fig. 8 along with the dry grinding results. This graph shows that wet grinding operates at a faster rate than dry and with the elimination of dressing operations the time cost is reduced. Due to the increased wheel wear during wet grinding the wheel cost curve is higher than for dry grinding at its most economical rate. This increase in wheel cost is however overshadowed by the decrease in time cost resulting in a much lower total cost curve for wet grinding.

An overall comparison of the two methods shows wet grinding to be a more efficient process as it eliminates the dressing operation but there is a larger wheel wear. From the data so far collected on wet grinding the loss of wheel might be reduced if a harder wheel were employed but only further grinding trials will supply such information. From an economical viewpoint, wet grinding presents a large improvement on dry grinding, though it must be emphasized that the costing is only for the actual processes and manufacturers would need to calculate their own operating costs and machine conversion costs to determine if they can afford the benefits of wet grinding.

7. CONCLUSIONS

1. The production rate is higher for wet than for dry grinding.
2. The wheel wear is greater with wet grinding by about 30% when compared with the most economical dry grinding operation for this particular design. Though this might be improved by using a harder wheel.

3. Wet grinding is more efficient as a process than dry grinding as it eliminates the non-productive operation of wheel dressing.
4. Comparing the two processes on an economical basis shows wet grinding to be an improvement on dry grinding.

8. REFERENCES

1. Southward M.R. "End grinding of Springs: Progress Report No. 2". SRAMA Report No. 262. May 1976.

9. ACKNOWLEDGEMENTS

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

Abrasive Products Limited
Bennett Tools Limited.

TABLE I RATE OF WHEEL WEAR (g/spring)

No. of springs ground	Wet Grinding			Dry
	Grinding Rate (springs/min)			
	50	70	90	30
1- 500	.48	.43	.71	.33
501-1000	.32	.18	.42	.13
1001-1500	.27	.24	.21	.10
1501-2000	.26	.27	.21	.15
2001-2500	.27	.26	.32	.03
2501-3000	.20	.21	.31	.06
3001-3500	.30	.19	.13	
3501-4000	.15	.26	.3	
4001-4500	.18	.19	.18	
4501-5000	.19	.19	.26	
Average	.26	.24	.30	.13

TABLE II RATIO OF METAL REMOVAL/WHEEL WEAR

No. of springs ground	Wet Grinding			Dry
	Grinding rate (springs/min)			
	50	70	90	30
1- 500	.38	.15	.28	1.1
501-5000	.57	.56	.37	2.8
1001-1500	.52	.41	.72	3.9
1501-2000	.55	.72	.67	2.4
2001-2500	.61	.61	.54	10.9
2501-3000	.90	.68	.59	6.2
3001-3500	.60	.72	.97	
3501-4000	.73	.44	.52	
4001-4500	1.07	.52	.72	
4501-5000	.72	.86	.56	
Average	.61	.61	.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

	Wet Grinding			Dry
	Grinding Rate (springs/min)			
	50	70	90	30
Grinding time (h)	1.67	1.19	0.93	2.78
No. of dressing operations	0	0	0	1.67
Total time (h)	1.67	1.19	0.93	3.20
Cost of Grinding time (£)	5.39	3.84	3.00	10.34
Depth of wheel used (mm)	9.93	8.23	8.51	6.5
Cost of wheel used (£)	3.08	2.55	2.64	2.01
Total Cost (£)	8.47	6.39	5.64	12.35

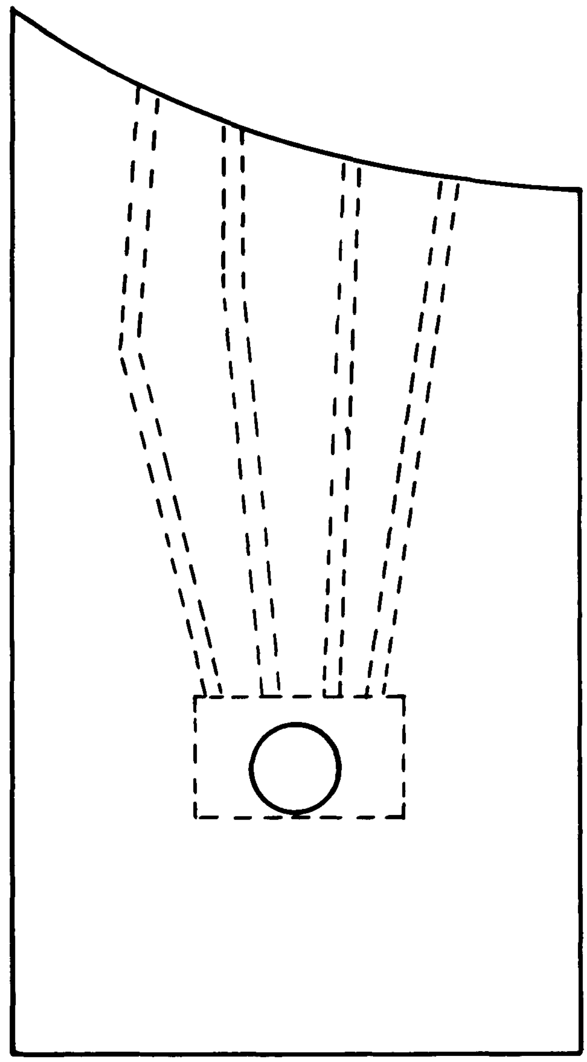

FIG. 1. MODIFIED TOP GUIDE.

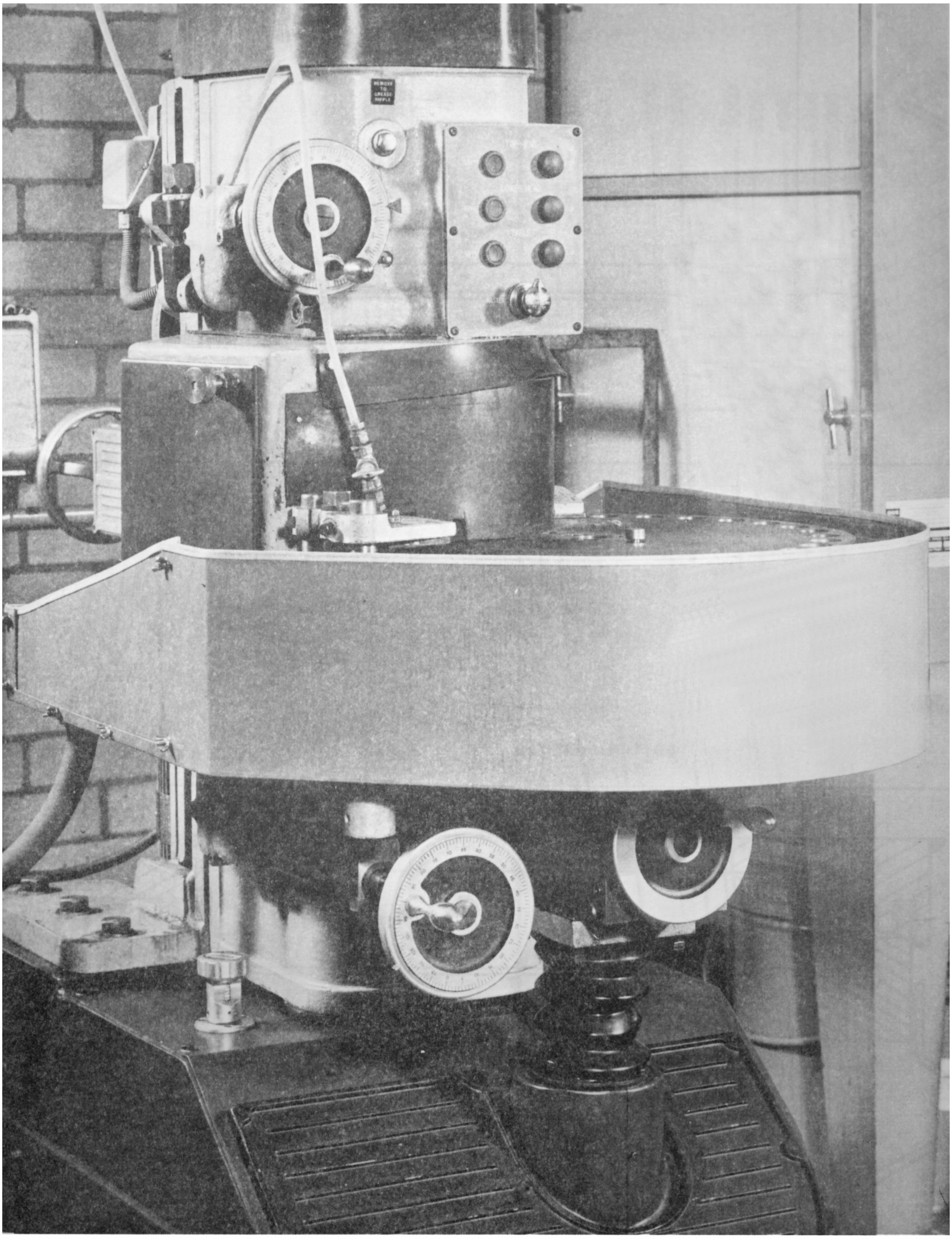

FIG. 2 PHOTOGRAPH OF MODIFIED MACHINE SHOWING COLLECTING TANK

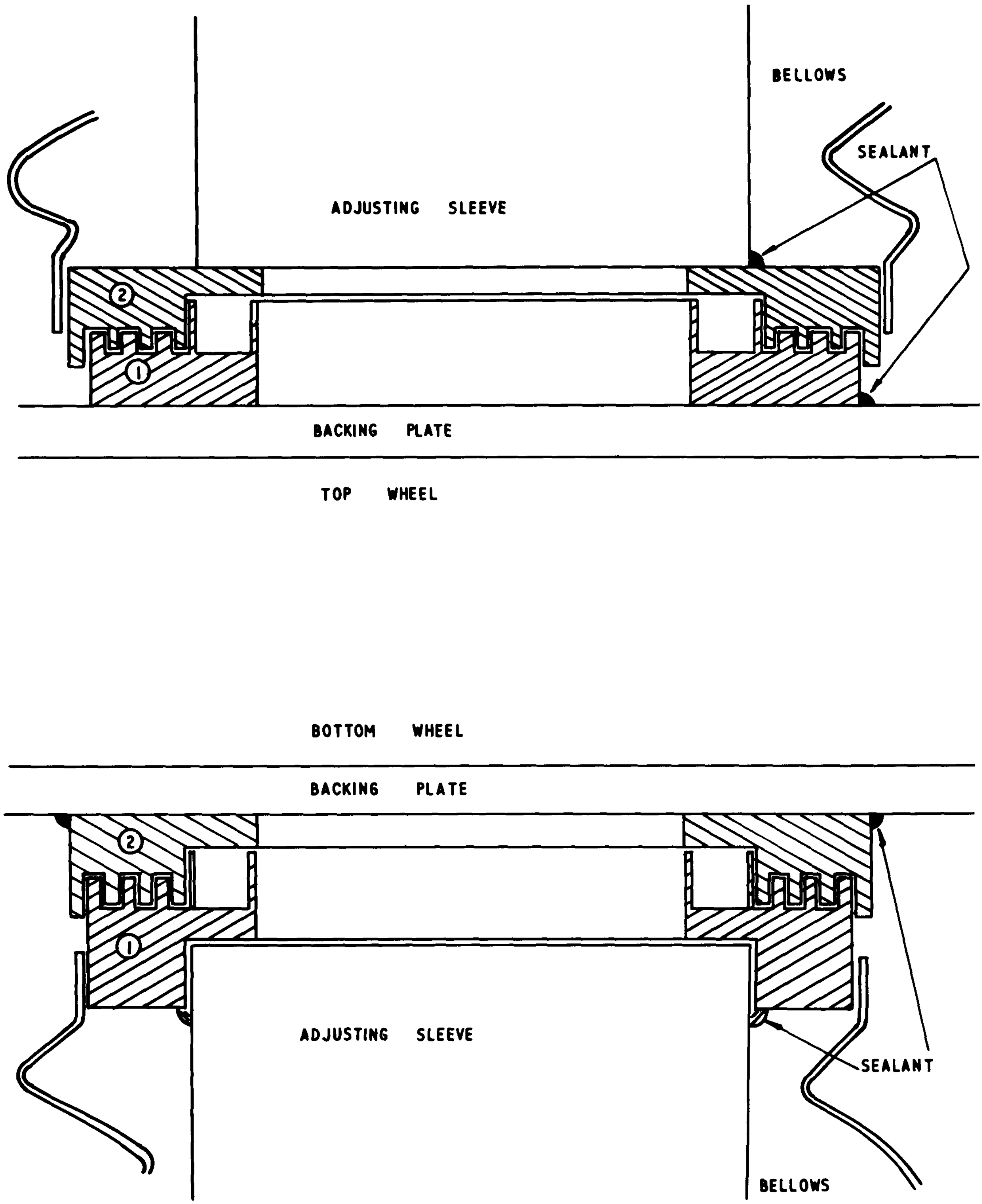

FIG. 3. CROSS SECTIONAL VIEW OF SEALS WHEN FITTED.

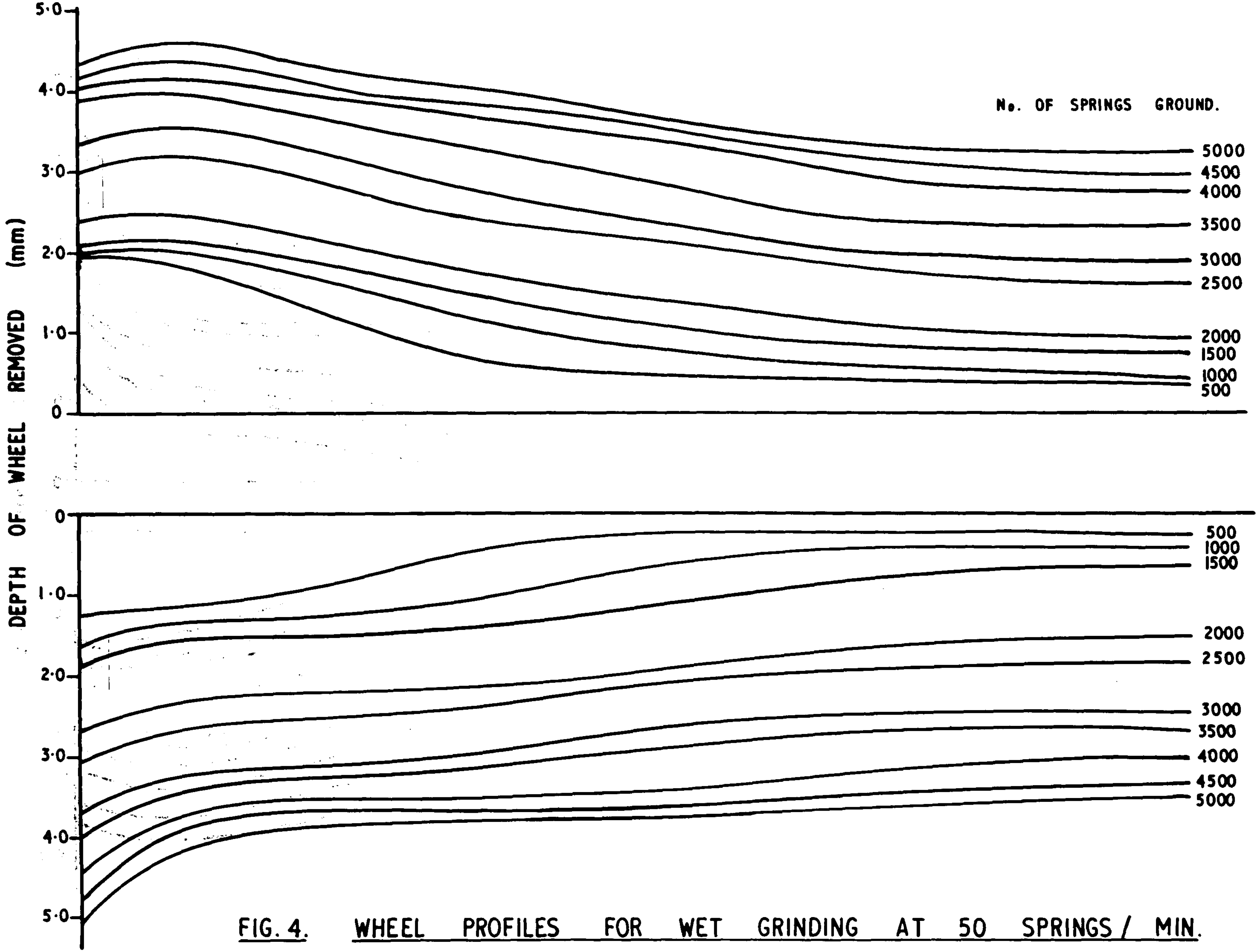

FIG. 4. WHEEL PROFILES FOR WET GRINDING AT 50 SPRINGS / MIN.

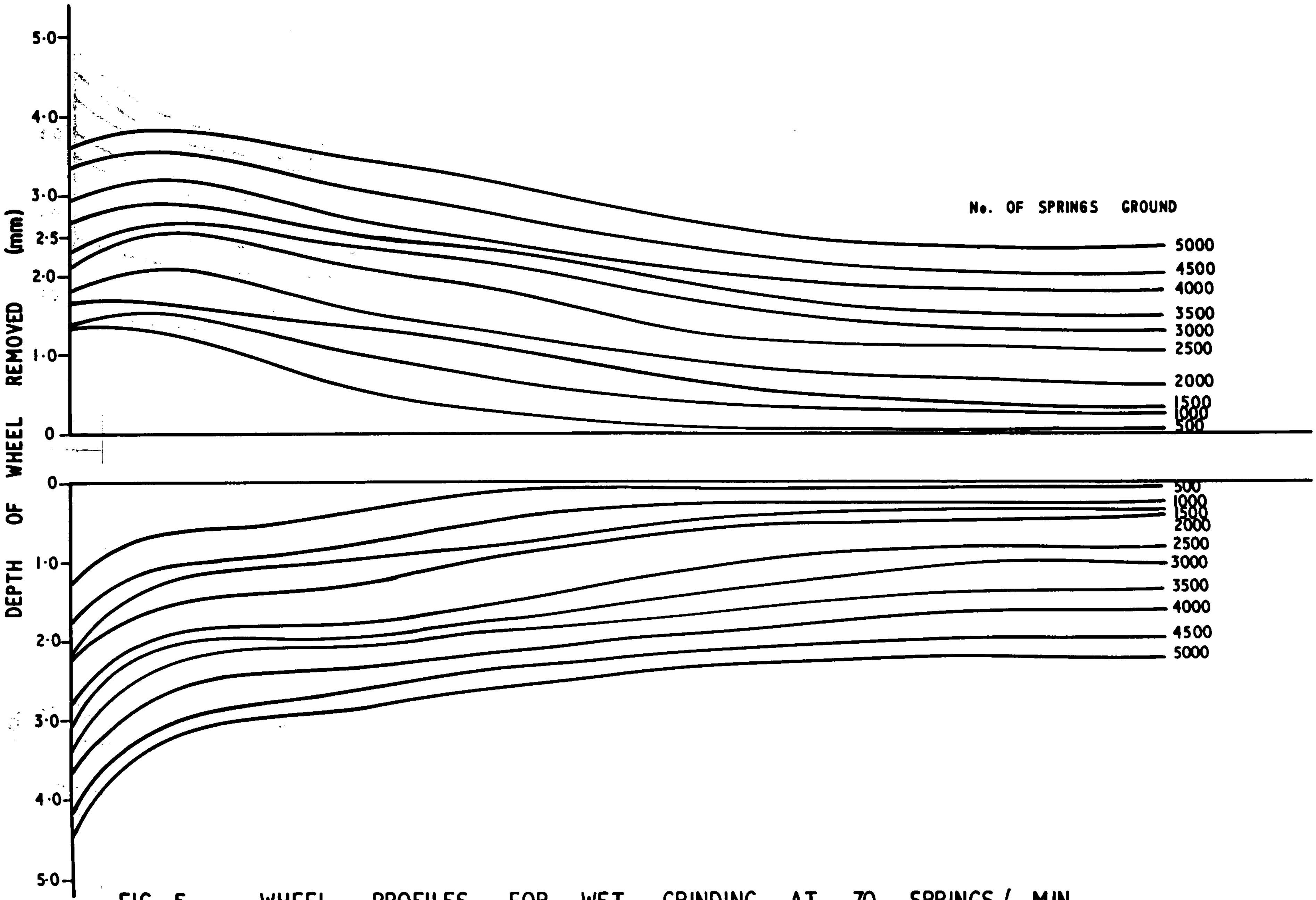

FIG. 5. WHEEL PROFILES FOR WET GRINDING AT 70 SPRINGS / MIN.

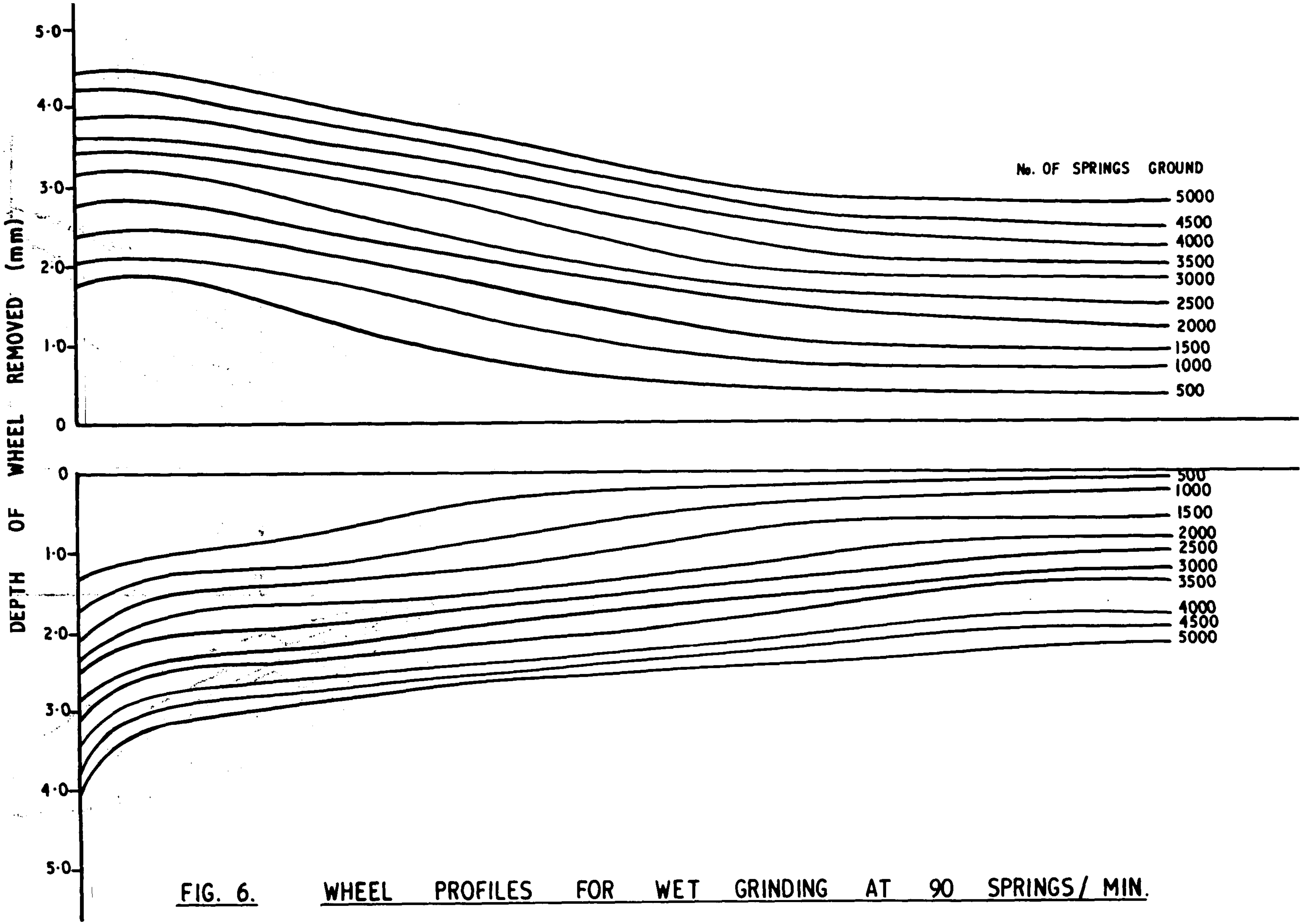

FIG. 6. WHEEL PROFILES FOR WET GRINDING AT 90 SPRINGS/ MIN.

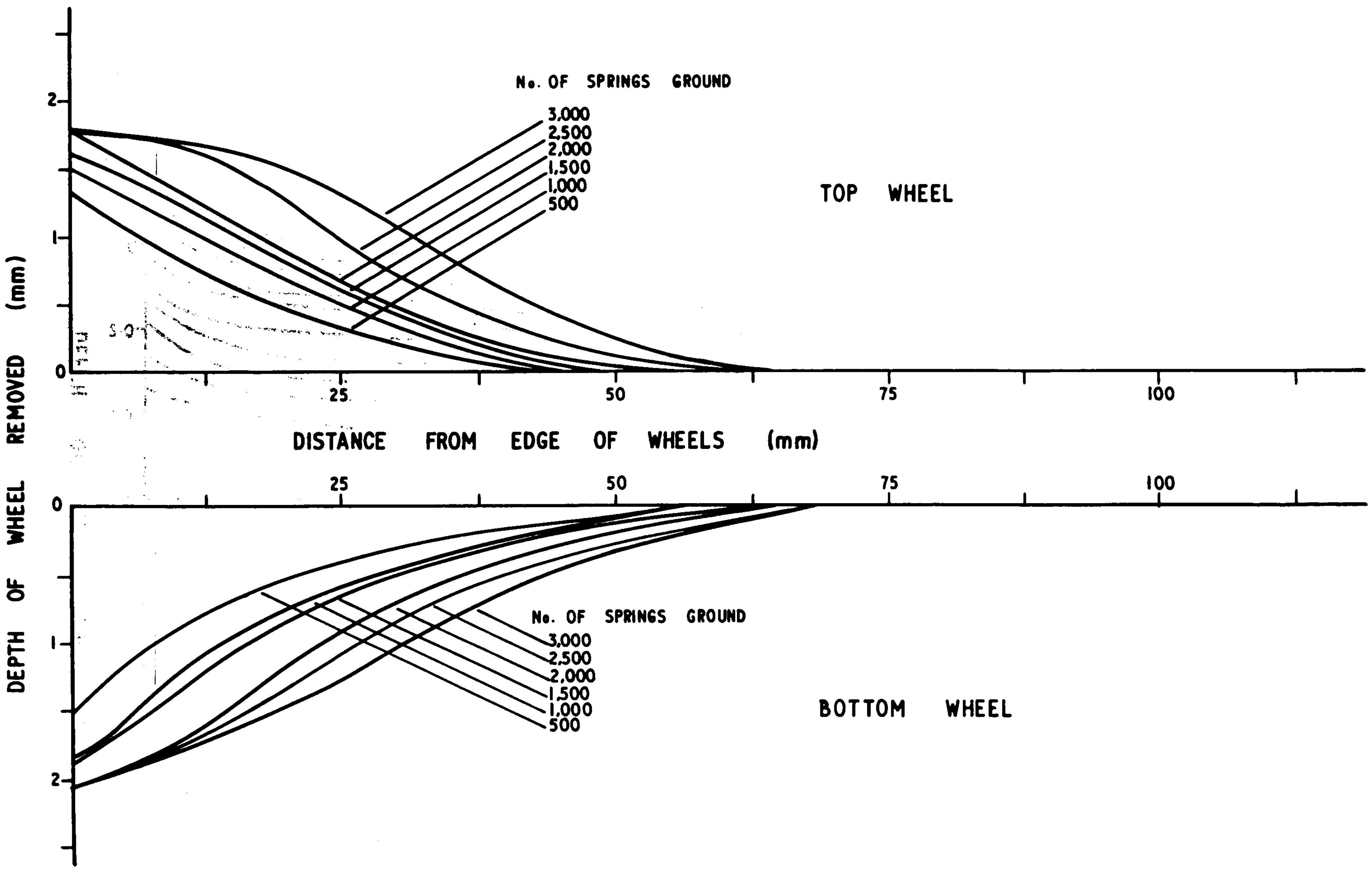

FIG. 7. WHEEL PROFILES FOR DRY GRINDING AT 30 SPRINGS/MIN

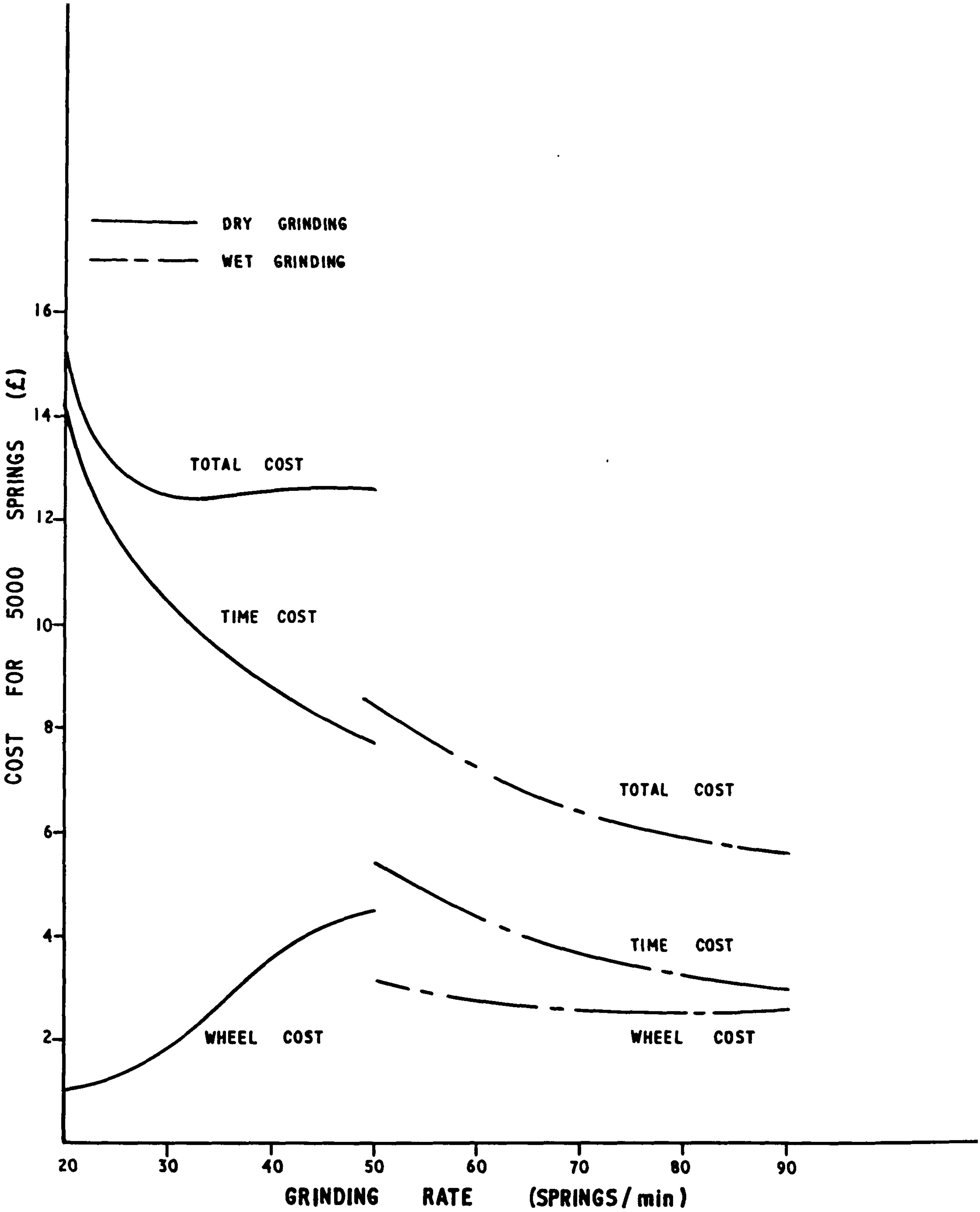

FIG. 8. COST CURVES FOR BOTH METHODS OF GRINDING.