

THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

A COMPARISON OF WET AND DRY END GRINDING
OF STAINLESS STEEL COMPRESSION SPRINGS

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by

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SUMMARY

Previous investigations on the wet and dry grinding of carbon steel compression springs has shown that wet grinding is by far the most economical of the two processes. This is due to the elimination of the dressing operation and increased production speeds. This investigation performs the same grinding trials as employed in previous investigations except that the springs have been manufactured from stainless steel wire, in order to ascertain whether the benefits of wet grinding carbon steel springs can be achieved by wet grinding stainless steel springs. In fact the work indicates that these benefits can be achieved, resulting in production rates 2.8 times the overall dry grinding production. This improvement is not necessarily the best that can be achieved as the fastest wet grinding rate was not ascertained.

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1. INTRODUCTION

The Association has investigated the process of crash grinding carbon steel compression springs and issued reports on the optimum combination of production rate and wheel composition for dry grinding and similarly for wet grinding of the same design of spring. A comparison (Report 327) of the two processes concluded that wet grinding is a far more economical process than dry grinding due to the elimination of the dressing operation and production rates some $3\frac{1}{2}$ times the rate for dry grinding.

Springs manufactured from stainless steel wire normally cause a bottleneck at the grinding operation due to the necessity of low production rates in order to grind satisfactorily. Consequently this investigation was initiated to ascertain whether the benefits of wet grinding carbon steel could also be achieved with the wet grinding of stainless steel. The project was performed along the same guidelines as those used in previous investigations except that the grade of grinding wheel was constant for both wet and dry grinding trials.

Additional to the grinding trials a de-watering attachment was developed so that a complete wet grinding system capable of replacing the dry system was now available.

2. SPRING DESIGN

The spring design selected for this investigation is the same as that used in previous investigations apart from the material now being stainless steel.

The design 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)	5.16

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 was exceeded then grinding was stopped at 5000 springs.

The type of wheel selected for this work was CA24 LB as being the most suitable wheel for dry grinding stainless steel springs. In fact this grade of wheel was also the most suitable wheel for wet grinding of stainless steel springs. The grinding trials were divided into two parts.

3.1 Dry Grinding

Once the wheels were attached in position, they were dressed level and weighed. The gap between the wheels was then adjusted so as to produce a spring of the required dimensions meeting the BS 1726 class B tolerance for end squareness.

The table speed was selected at 20 springs/min.

A batch of 500 springs of known weight was ground and the grinding machine adjusted when necessary to maintain the required free length of the spring. In addition, springs were checked for spreading of the end coils and discolouration. On completion of grinding 500 springs they were

reweighed and the amount of metal removed determined. Similarly the wheels were removed, weighed and their profiles measured. The latter was performed by traversing a dial gauge along the radius of the wheel and recording the readings at 6 mm intervals. The average readings obtained from three radii on each wheel were calculated and the wheel profiles constructed. The wheels were then replaced in position and the next batch of springs ground. This procedure was repeated until cessation of grinding when the wheels were then measured and redressed square. This procedure was performed for two further grinding rates of 30 and 40 springs/min.

3.2 Wet Grinding

The 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.

The grinding machine and coolant were switched on and left running for 30 minutes to achieve an even working environment. The procedure was then performed as for dry grinding except that the wheels were always spun dry for 30 minutes prior to weighing and measurement of wheel profile.

Similarly prior to grinding of each batch of springs the machine was allowed to achieve an even working environment. The procedure was performed for grinding rates of 30 and 70 springs/min.

4. RESULTS

The amount of grit removed from the wheels for each batch of springs is expressed as grammes per spring and is 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 I. 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 at each grinding rate, and typical graphs for dry and wet grinding are shown in Figs.1 & 2. 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 a previous report, consequently the figures are not exact and should only be used for comparative purposes.

5. DISCUSSION

The dressing operation at all three dry grinding production rates was necessary where as it was not required for either of the wet grinding production rates.

Table I contains the data collected during grinding and shows that the rate of wheel wear to vary considerably for different grinding rates independent of wet or dry grinding. However the wheel wear for both processes is similar. The ratio of metal removed to wheel wear is much greater for dry grinding than wet grinding. However dry grinding requires the dressing operation and the amount of wheel removed during dressing should be included in the ratio. Thus the corrected figures are listed at the base of the table.

These figures show little difference between wet and dry grinding, indicating that the same amount of wheel is lost in order to remove a fixed quantity of material whether the process is wet or dry grinding.

Consider the analysis of grinding time for dry grinding where the grinding rate is the output of the grinding machine. Since the machine is stopped to perform the dressing operation an overall production rate can be calculated to include the lost dressing time. The new values are included in the table and show that an increase in grinding rate does not cause a similar increase in overall production rate. As a dressing operation is not necessary for wet grinding the grinding rates and overall production rates are the same. The breakdown of grinding costs indicates whether grinding time or wheel cost has the most influence on the total cost figure. These results are used to plot curves on Fig. 6. The cost curve for dry grinding shows an optimum grinding rate of 30 springs/min. whilst the wet grinding curve indicates an optimum grinding rate of 70 springs/min. or possibly faster still. These show that wet grinding is the more economical process and is performed at a higher grinding rate, in fact 2.3 times the dry grinding rate or 2.8 times the overall dry grinding production rate. These improvements are not necessarily the maximum because the fastest wet grinding rate was not achieved.

6. CONCLUSIONS

1. The production rate is higher for wet than for dry grinding.
2. Wet grinding is more efficient as a process than dry grinding as it eliminates the non-productive operation of wheel dressing.
3. Comparing the two processes on an economical basis shows wet grinding to reduce costs by at least 54% of dry grinding costs.

7. ACKNOWLEDGEMENTS

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Abrasive Products Limited.

TABLE I GRINDING DATA

	DRY			WET	
Grinding Rate (springs/min)	20	30	40	30	70
No. of springs ground	2885	1811	1000	4000	5000
Dressing operation	Yes	Yes	Yes	No	No
Rate of wheel wear (gm/spring)	.26	.34	.53	.57	.36
Ratio of metal removal to wheel wear	1.3	1.0	0.7	0.4	0.3
Ratio including loss of wheel during dressing	0.5	-	0.4	0.4	0.3

TABLE II ANALYSIS OF GRINDING TIME AND BREAKDOWN OF GRINDING COSTS

	DRY			WET	
Grinding Rate (springs/min)	20	30	40	30	70
No. of dressing operations	1.73	2.76	5	0	0
Dressing time (hrs)	0.43	0.69	1.25	0	0
Overall Production Rate (springs/min)	18	24	25	30	70
Grinding time (hrs)	4.17	2.78	2.08	2.78	1.19
Total time (hrs)	4.6	3.47	3.33	2.78	1.19
Cost of total time (£)	14.86	11.21	10.76	8.98	3.84
Depth of wheel used (mm)	8.76	13.33	23.88	13.65	10.13
Cost of wheel used (£)	2.72	4.13	7.40	4.23	3.14
Total Cost (£)	17.58	15.34	18.16	13.21	6.98

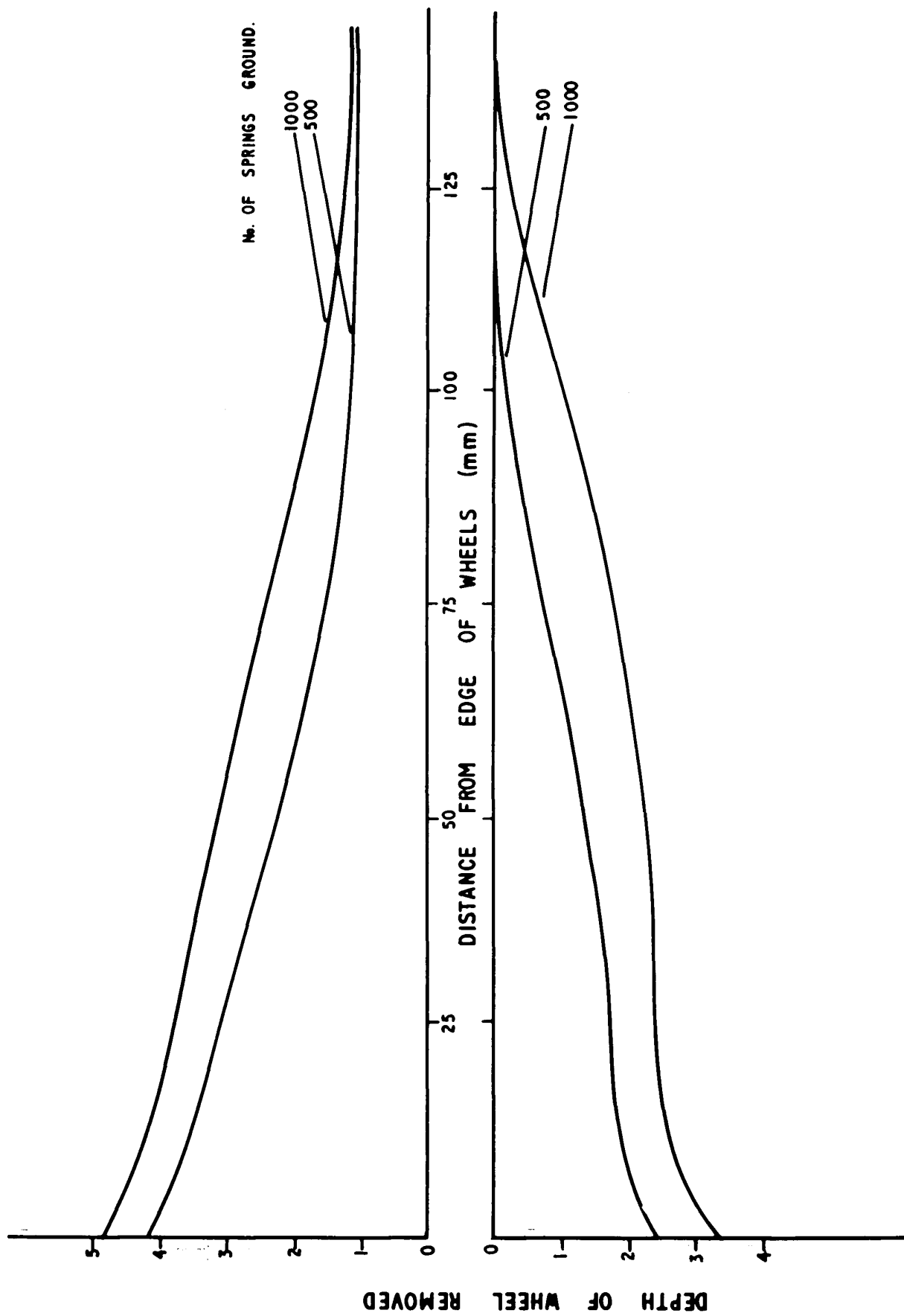


FIG.1. WHEEL PROFILES FOR DRY GRINDING AT 40 SPRINGS/ MIN.

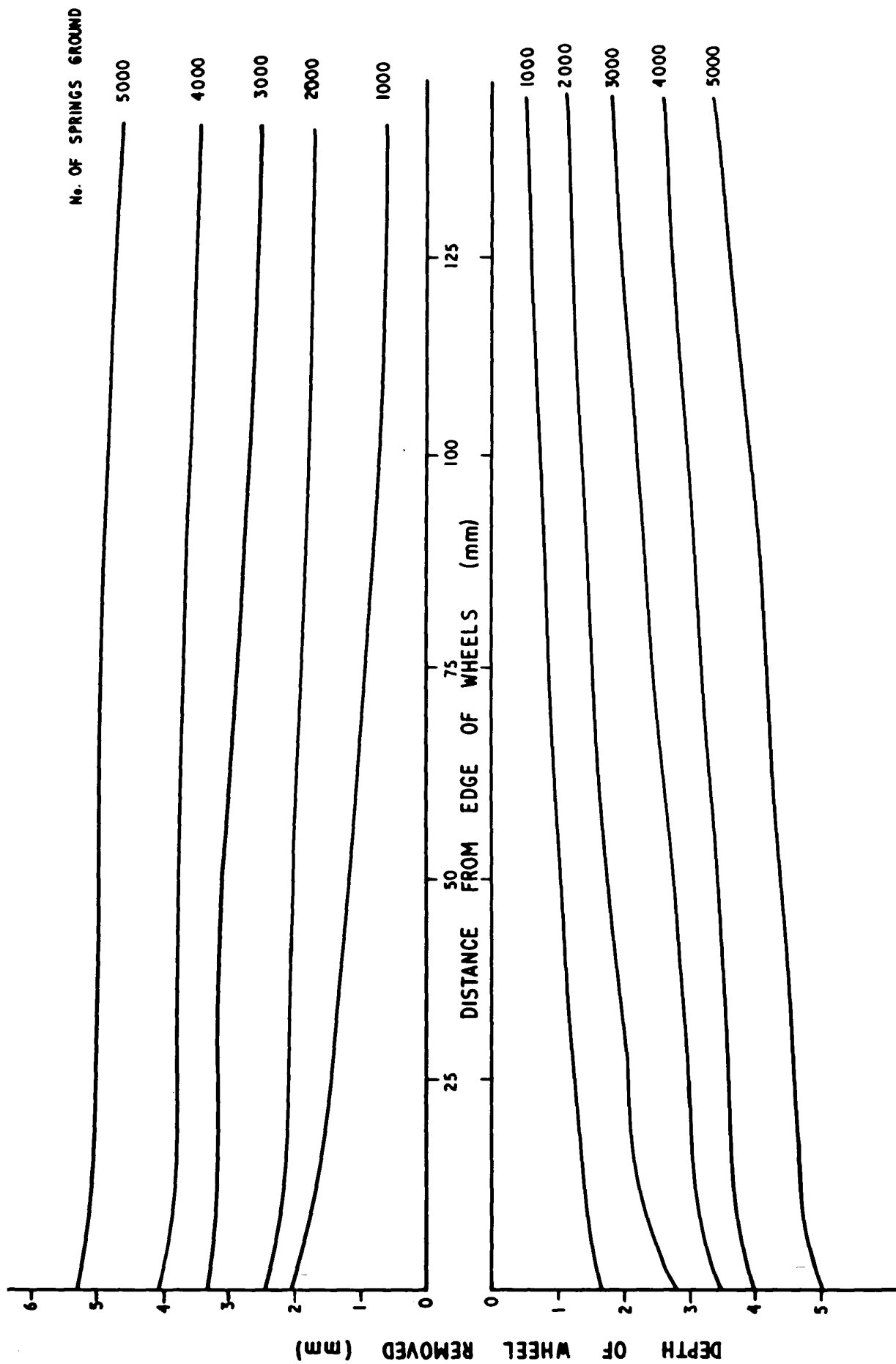


FIG. 2. WHEEL PROFILES FOR WET GRINDING AT 70 SPRINGS / MIN.

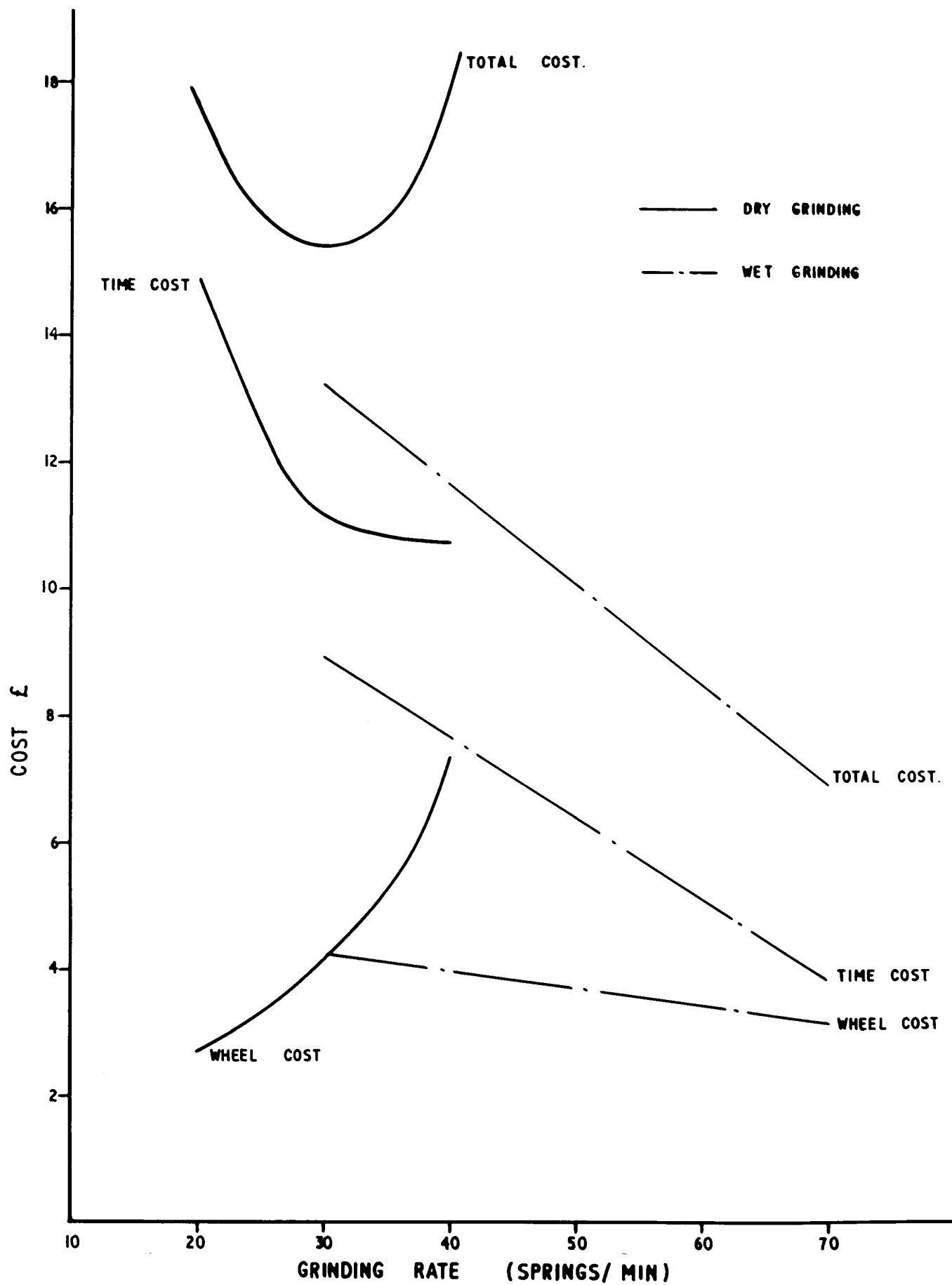


FIG. 3. COST CURVES.

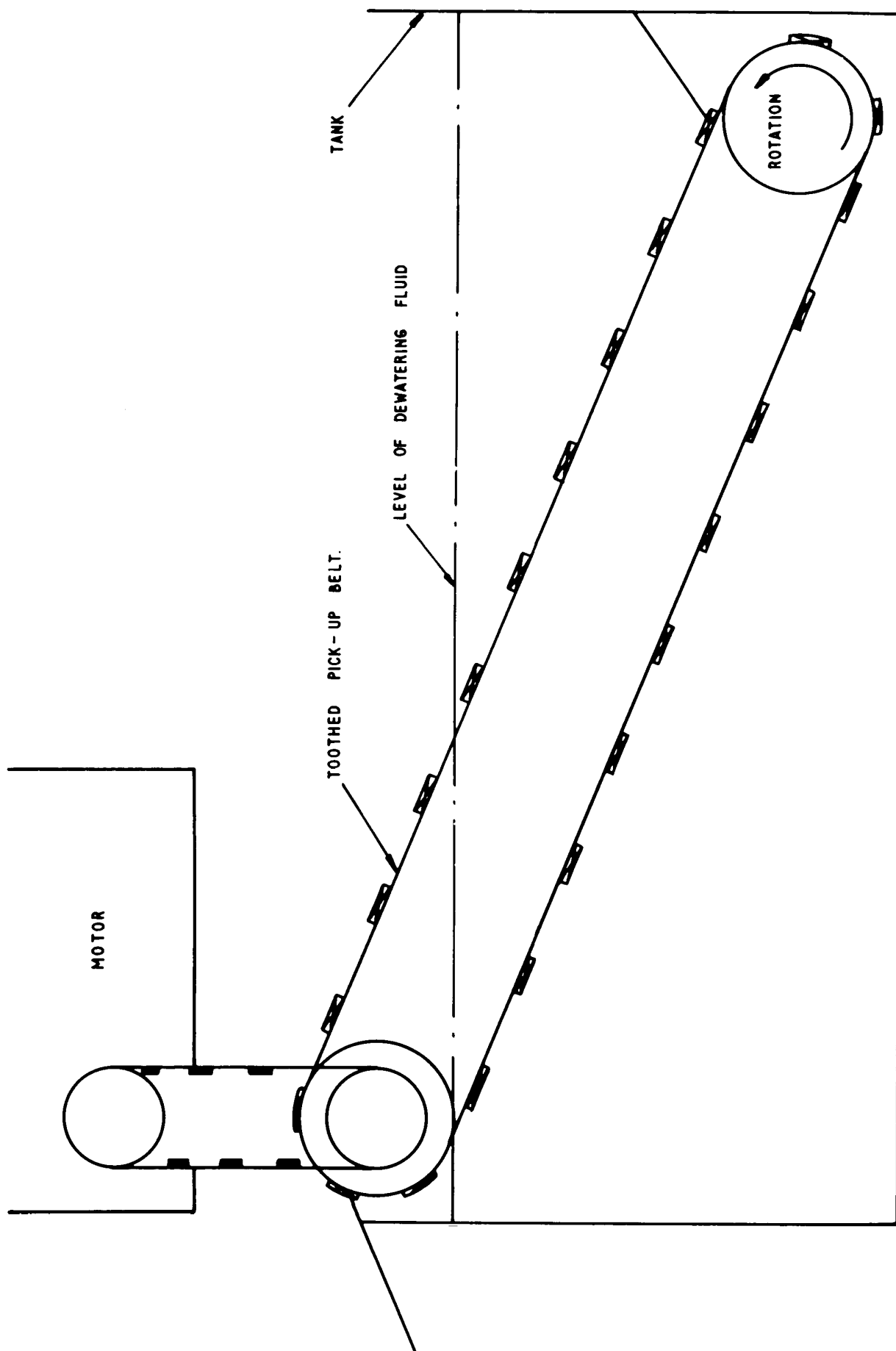


FIG. 4. SCHEMATIC VIEW OF DEWATERING ATTACHMENT.