THE SPRING RESEARCH ASSOCIATION

THE INSTRUMENTATION OF A TORRINGTON 115A AUTOCOILING MACHINE

by

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Report No. 216

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SUMMARY

This report describes how a Torrington 115 A autocoiling machine was fitted with load cells and a synchro resolver to measure coiling forces and pitch variations respectively. The results obtained during coiling indicated that there was a relationship between the coefficient of friction and the pitch variation.

The report includes the coefficient of friction for the two types of wire coiled and concludes that these values could be used as references for future measurement of wire coilability.

This method of assessing coiling performance provided an immediate analysis of the process and was able to show the improvement produced by the effect of wire lubrication.

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1. INTRODUCTION

The instrumentation described in this report relates the friction forces of coiling to the pitch variation of the spring produced and in this way a better understanding and assessment of the behaviour of the autocoiling process can be achieved.

Wire coilability is assessed by the care and accuracy with which it can be coiled. Normally this involves spring free length measurement to determine the free length variability. This method is time consuming and requires calculation. Therefore a means has been devised whereby the coiling properties of wire can be quickly assessed without recourse to spring measurement.

2. APPARATUS

The slide containing the coiling point was fitted with piezo-electric load cells as illustrated in Figs. 1 and 2. From these the electric signals, representing the normal and friction forces, were amplified by Kistler charge amplifiers.

Pitch error detection was by a synchro-resolver fitted with a pivoting probe. The probe was spring loaded so that it would be in contact with the innermost coil adjacant to the pitching tool. An adjustment stop was provided to keep the probe in an appropriate position during spring cut-off. The electrical signal from the resolver was amplified by an SE 905 transducer converter. The amplified signals from the load cells and resolver were recorded simultaneously on an SE 2000 Ultraviolet recorder.

3. PROCEDURE

3.1 Spring Design

The coiling machine was set to produce a spring 0.432 in outside diameter from 0.048 in dia wire. The length of spring was set to a maximum (3.5 inches, 20 coils, open end coils) such that no oscillation or vibration of the spring occurred when it was coiled. Had oscillation of the spring occurred it would have been recorded by the pitch transducer and reproduced in the form of a sine wave superimposed on the pitch variation trace. This would impair the accuracy of pitch variation detection.

3.2 Instrumentation

Figs. 1 and 2 show the positioning of the load cells for the measurement of the friction forces. One load cell, which measured the normal force, was positioned between the coiling point slide and the slide adjustment screw. The other cell was positioned between the pivoted coiling point holder and the upper adjustment screw. The screw was adjusted just so that light pressure was exerted on the load cell.

A magnetic base was secured to the machine above the cut-off tool to support the pitch transducer. The support clamps were adjusted so that the probe of the transducer could fit between the generated spring coils. The probe adjusting screw was set to maintain the approximate position of the spring loaded probe after the cut off unit had operated. In this way the phasing of the pitches of a newly coiled spring did not foul the probe.

3.3 Calibration

The transducers were connected via the amplifiers into the U.V. recorder as shown in Fig. 2. A spring balance was attached to the tip of the coiling point and in turn to the coiling point clamp and loaded. The load cells were calibrated by observing the amplitude of the signals produced in the recorder by the respective balance loads. Once the calibration of the load cells had been established the load sensitivity could be varied to suit the forces being measured by adjustment of the amplifier gain switch.

The pitch transducer was adjusted to a set amplification of 400 times.

3.4 Coiling

Coiling trials were undertaken using patented cold drawn steel wire (B.S. 1408C), coiled without a lubricant, and stainless steel (En 58A) coiled both with and without a chlorinated mineral oil. The lubrication method was by wire immersion in an oil bath immediately adjacent to and preceding the wire guides.

The very nature of the load cells (piezo-electric) necessitated that they be grounded or 'earthed' simultaneously at some point during the coiling cycle. This was done, using a grounding button on the amplifiers, immediately after the cut-off shear had operated. The subsequent normal and friction force traces were then directly related to zero forces coincident to the pause in the coiling cycle before the spring was generated.

Traces taken from the recorder usually covered two or three coiling cycles.

4. RESULTS

Table I shows the derivation of the coefficient of friction for the various coiling trials and also shows the associated pitch variation. The pitch variation was measured over the entire length of the spring with the exception of the last one and a half coils which did not pass the probe. Table I gives the difference between the largest and smallest pitch. This was found by measuring the amplitude of the trace for each spring. The data presented in Table I is an average of at least two traces for each of the coiling trials.

Figure 3 shows the approximate relationship between the coefficient of friction and the pitch variation.

5. DISCUSSION

This technique of instrumentation not only provided valuable information about the relationship between the coefficient of friction and the pitch in the coiling process but also gave some reference values of the coefficient of friction to be expected for different spring materials and the effect of varying the coiling conditions on these. This technique could be used to investigate the influence of wire diameter, spring index and coiling conditions on pitch variation.

This method of assessing coiling performance provided an immediate analysis of the coiling process and was able to show the improvement gained by, and the beneficial effects of, lubrication on previously unlubricated stainless steel coiling.

6. CONCLUSIONS

1. The instrumentation of the coiling machine enabled an accurate assessment of coiling forces and associated pitch variations for different samples of wire and coiling conditions.

2. An approximate relationship between coefficient of friction and pitch variation for different coiling conditions has been established.

3. Small increases in coefficient of friction produced relatively large increases in pitch variation.

4. This technique of instrumentation provides a very quick and reliable assessment of the coilability of wire and its associated coiling conditions.

TABLE I

RESULTS OF COILING TRIALS

Material and Coiling Condition	Average Trace Displacement (cm)		Sensitivity (mV/Pb)	Load Cell Calibration		Load (lbf)		Coef-ficient of friction (μ)	Pitch Variation (in)
	Horizontal	Vertical		Horizontal lb/cm	Vertical lb/cm	Horizontal	Vertical		
Unlubricated Stainless Steel En 58A	6.16	1.90	2	10.4	17.85	64.06	33.91	0.529	> 0.013
Lubricated Stainless Steel En 58A	3.40	0.65	2	10.4	17.85	35.36	11.60	0.328	0.010
	6.50	1.37	5	4.16	7.14	28.08	9.82	0.350	0.011
Unlubricated Patented Cold Drawn Steel B.S. 1408C	4.70	0.87	5	4.16	7.14	19.55	6.247	0.319	0.005

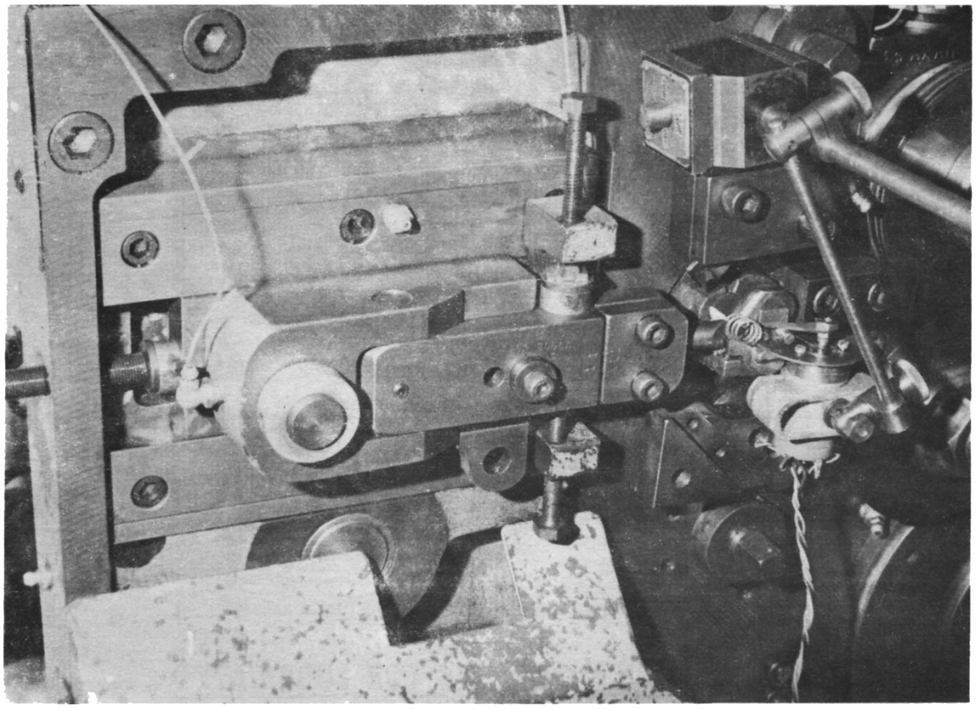

FIG. I ARRANGEMENT OF TRANSDUCERS ON COILING MACHINE

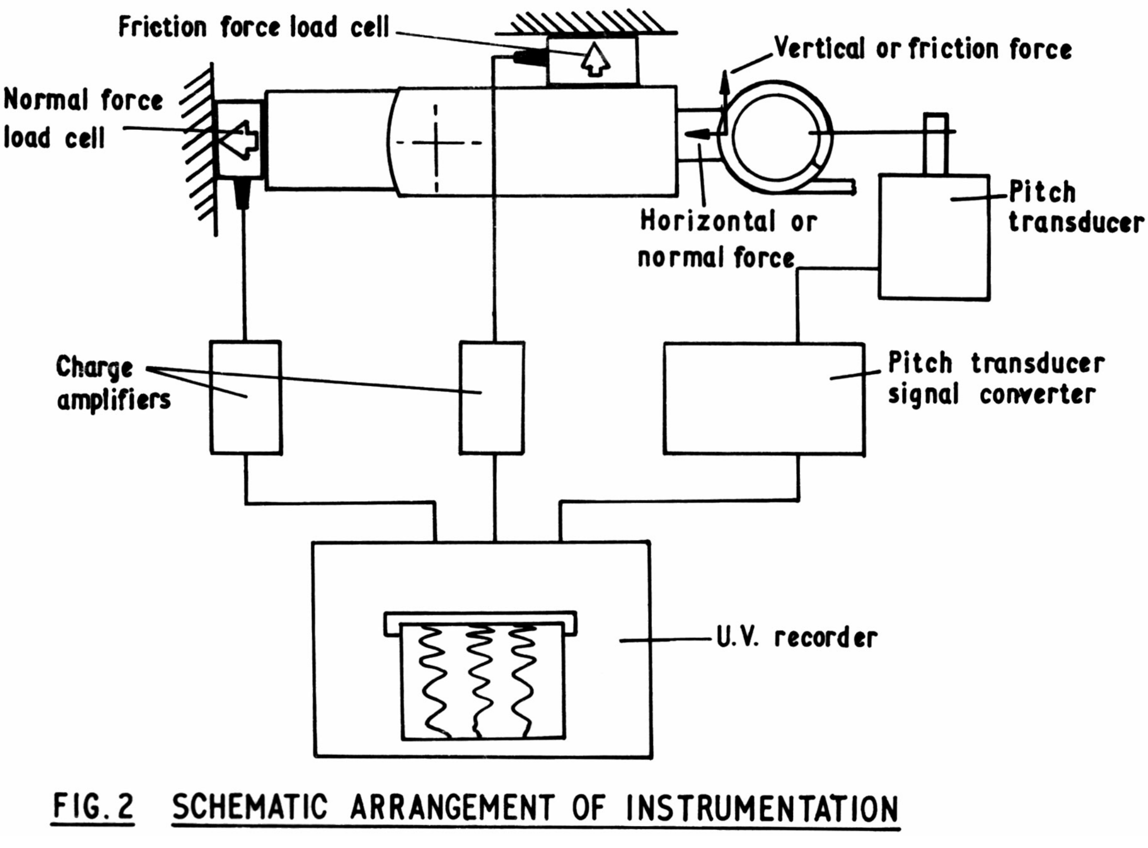

FIG. 2 SCHEMATIC ARRANGEMENT OF INSTRUMENTATION

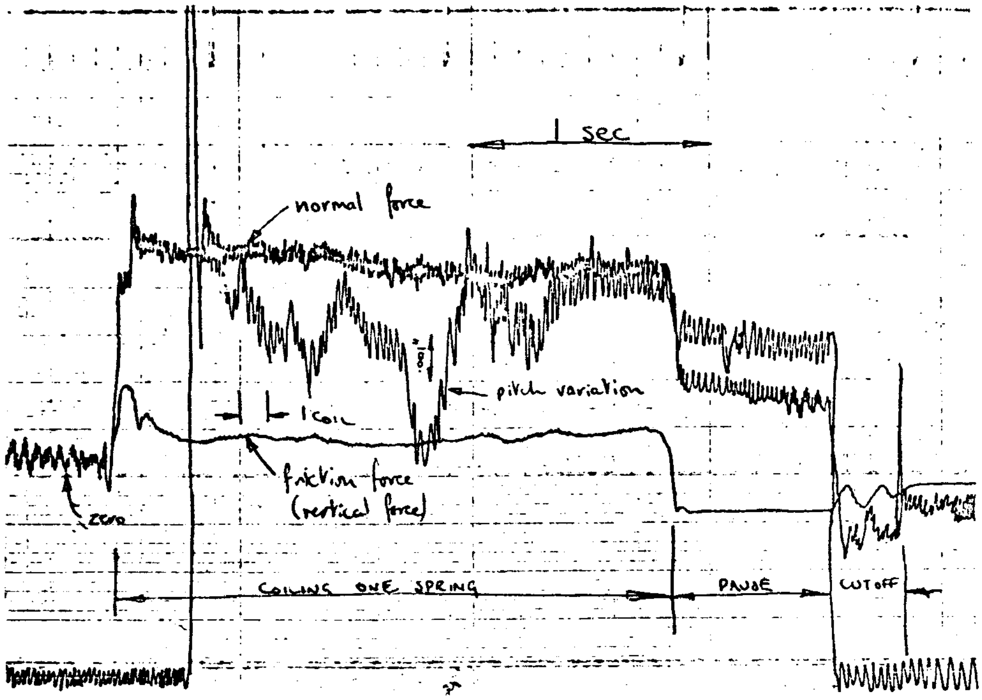

FIG. 3 TYPICAL TRACES FOR B.S. 1408 C (UNLUBRICATED)

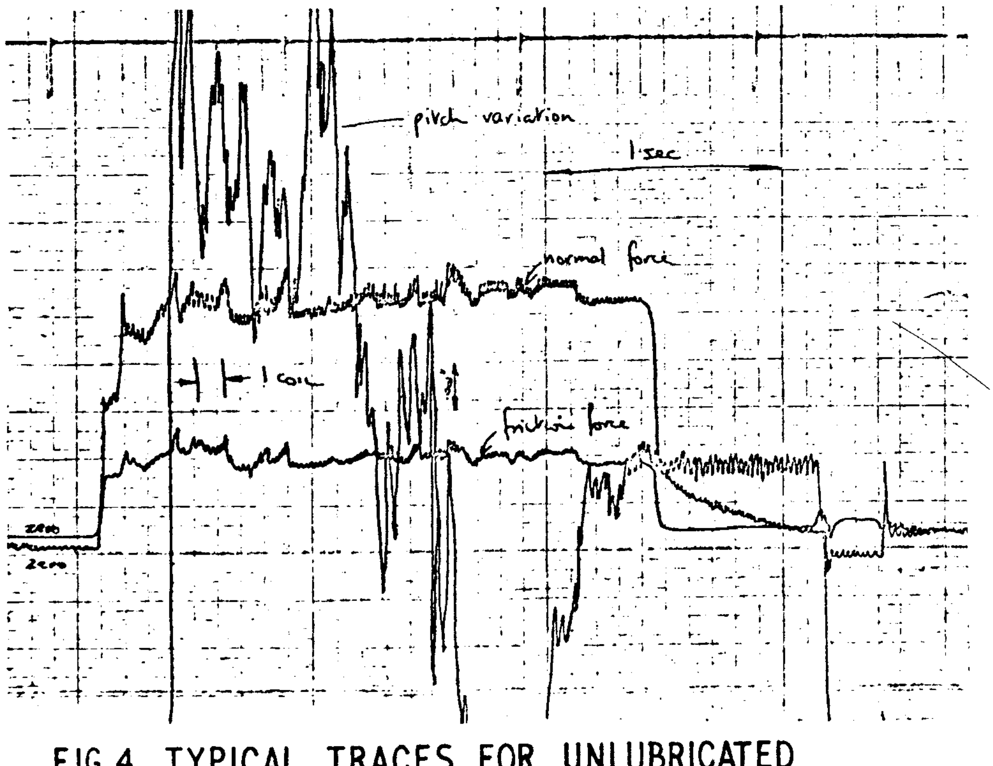

FIG. 4 TYPICAL TRACES FOR UNLUBRICATED STAINLESS STEEL

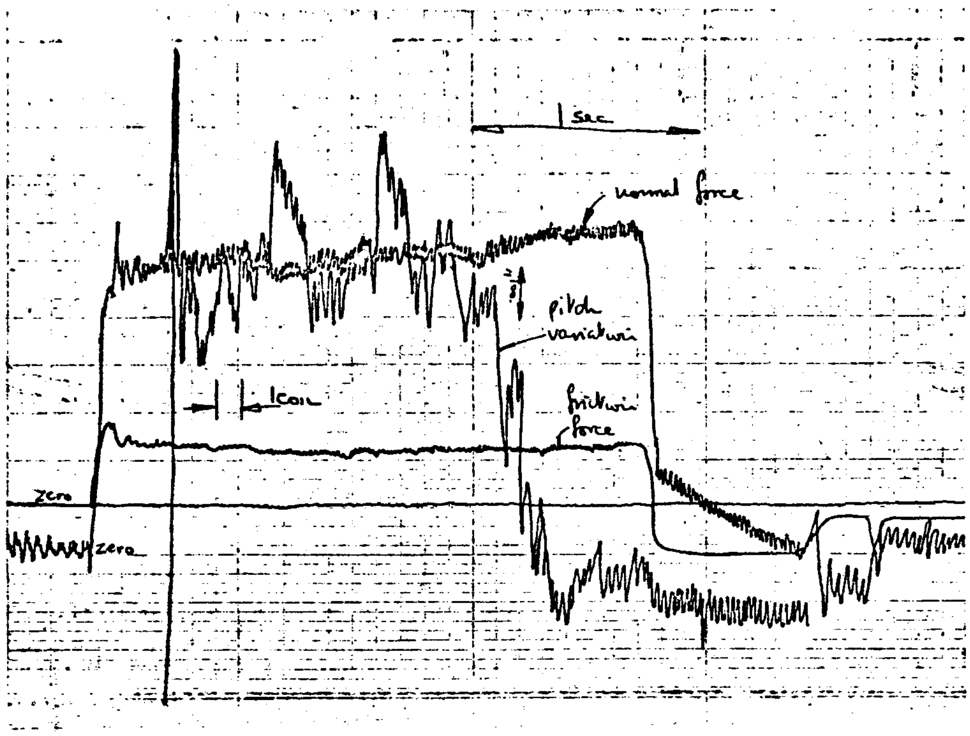

FIG. 5 TYPICAL TRACES FOR LUBRICATED STAINLESS STEEL

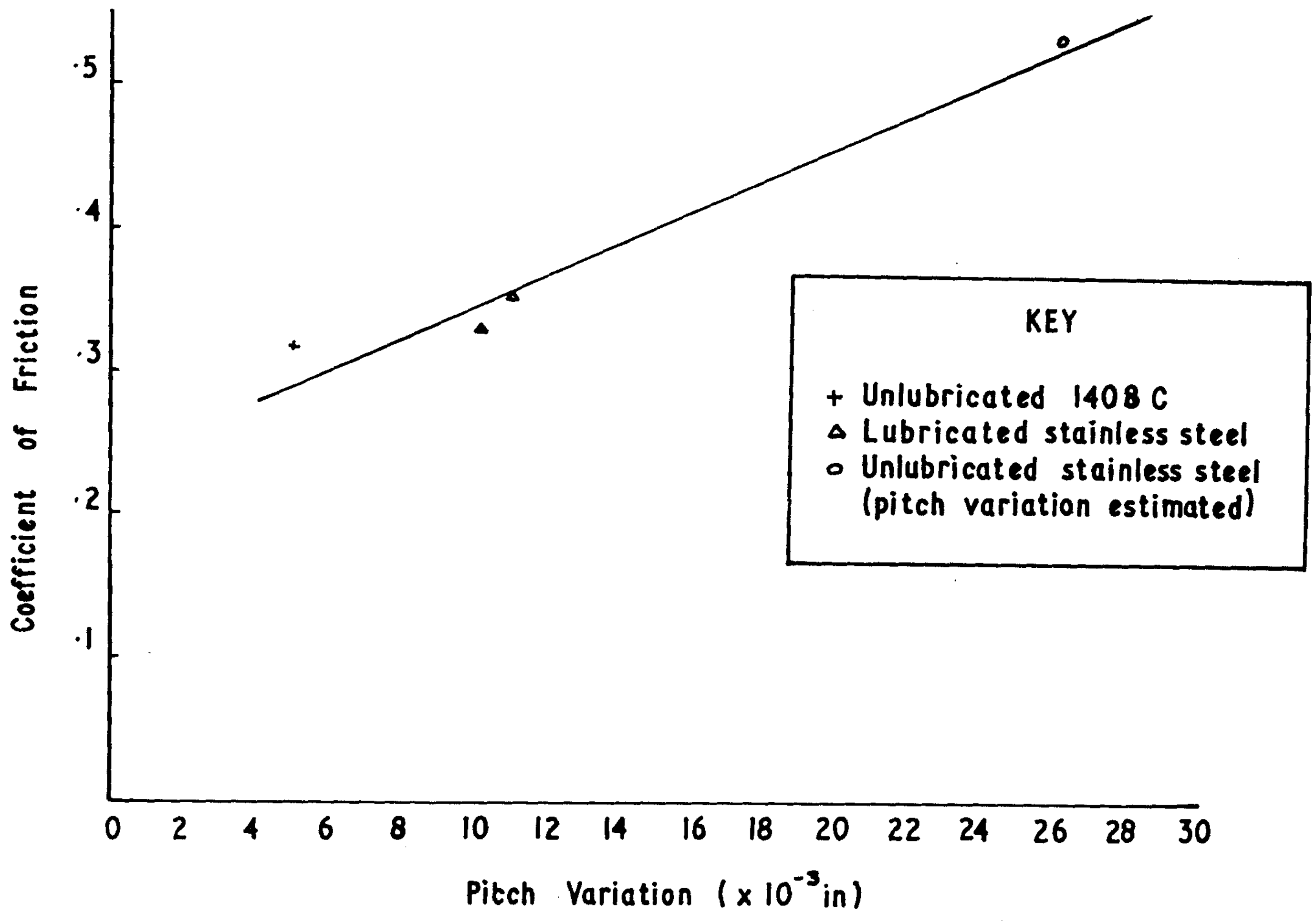

FIG. 6 APPROXIMATE RELATIONSHIP BETWEEN COEFFICIENT OF FRICTION AND PITCH VARIATION