THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

THE EFFECT OF COILING SPEED, SWIFT TYPE AND BUNDLE WEIGHT ON FREE LENGTH VARIATION OF SPRINGS

by

M.S. Bayliss B.Eng.

Report No. 339

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SUMMARY

This work has been undertaken to investigate the effect of the speed of coiling, the type of wire swift and the weight of the wire bundles on free length variation of springs. In addition the effect of the cut-off dwell time on free length was investigated.

The results indicate that coiling speed and the type of swift do make small differences to the coiling accuracy. The length of the cut-off dwell time proved to be the most important factor on free length variation.

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1. INTRODUCTION

In the spring industry, as in most manufacturing industries, it is usually accepted that as the speed of a machine is increased beyond a certain value the larger the variation will be in the components produced. These variations are usually due to factors such as cam bounce, slack in bearings, flexure of the frame etc., which in a well designed and maintained machine should be minimal. Spring Auto Coilers, as currently made and used, are completely mechanical and hence will also be subject to the above limitations. Thus it is fair to assume that above a threshold speed the faster spring production is, the worse the coiling variation will be. The segment type coiler is probably less prone to variation because of its smoother wire feed and cut-off system compared with its clutch operated counter-part. The clutch operated machine must in addition suffer from a certain amount of slipping in its wire feed clutch because it is physically impossible to accelerate such a mechanism from zero to its feed speed instantaneously. Any irregular snatching or back tension from the wire swift can of course only worsen the slipping.

In the work reported here it was decided to investigate the effect of the coiling speed of a clutch type coiler and to see what effect various types of swifts available would have on free length tolerances.

2. SPRING DESIGN USED

The spring design chosen was a compromise between a spring which would highlight the effects of changes in the coiling speed, swift and bundle weight (i.e. large index and many turns), and the need for the design to be easily resettable many times with the minimum of movement to the tooling. In addition the amount of wire in the spring had to be limited so that a wide range of coiling speeds were available.

The design used was coiled from 1408C-R3 hard drawn wire to the following design:

Free length	= 15 mm
Mean coil diameter	= 6.5 mm
Wire diameter	= 0.7 mm
Spring Index	= 9
Total Number of Coils	= 8.5
Number of Working Coils	= 6.5
Ends closed but not ground	

3. EQUIPMENT USED

Coiling Machine: Wafios UFM8 and free running swifts

Additional Swifts:
a) Self braking Simplex Rapid Z1
b) Proportional control motorised Z2/S and
c) an on-off controlled motorised Schenker DHE600

Wire Bundles: These were in 1 Kg and 25 Kg lots, the former just being sufficient for a single run.

4. EXPERIMENTAL PROCEDURE

The experimental work was split into two parts to test various effects.

4.1 Test 1 The Effect of Coiling Speed, Swift Type and Bundle Together

The first test was carried out to determine what changes in variation would be caused by altering the coiling speed, swift type and the wire bundle weight. The coiling machine was set to maximum production speed (130 springs/min) then two other speeds selected at 60 and 100 springs/min between the fastest and the slowest speed of 20/min. A run of 1000 springs was made for each test after allowing 200 for settling in and the last 10 springs in every 100 collected for measuring. In each run a different combination of swift, speed and bundle weight was used. In all cases the machine was re-set at the beginning of each run to produce the required design. The feed roll pressures were also set to exert the same force on each test.

4.2 Test 2 The Effect of Cut-off Dwell Time

The second test was set up to investigate how the setting of the wire feed would affect coiling variation. With clutch coilers similar to that used, wire length is set by a combination of back gearing and cams. Thus various combinations will produce the same wire length but will also have the effect of changing the cut-off period. In other words a wire feed length may be set by different combinations and produce the same number of springs/min, but because one may have more cut-off time than the other its wire feed time must be shorter, so giving a higher actual coiling speed. The machine as set for the previous test had a dwell time of 11% of the total cycle time. After readjusting, the dwell time was increased to 65% with a maximum speed of 60 springs a minute.

Runs were made, resetting to the original spring design after each test, using the four swifts, two bundle weights, two speeds of 20 and 60/min and the two dwell times.

5. RESULTS

The springs were collected and their free length measured using a profile projector and the measurements noted. From these the standard deviation and the variances of each of the batches of ten and of the total 100 springs were calculated. This allowed the short term drift for each test to be determined and hence by taking three times these values the actual short term variation for 99.9% of the springs could be found.

The standard deviations of Test 1 were subject to an analysis of variance test to find the most significant variables. The results of this test can be seen in Table I.

TABLE I RESULT OF ANALYSIS OF VARIANCE OF THE DATA FROM TEST 1

Source	Sum of Squares	Degrees of Freedom	Variance Estimate	Variance Ratio	Significance
Total	180970	319			
Bundle Wt.	147	1	147	0.26	Nil
Speed	9526	3	3197	5.89	99.9%
Swift	4676	3	1559	2.89	95%
Sample	2924	9	325	0.60	Nil
Residual	163697	303	540		

In addition to the Analysis of Variance a Factorial Analysis was carried out on the data to test for interaction between variables. These results can be found in Table II.

TABLE II RESULTS OF FACTORIAL ANALYSIS ON DATA FOR TEST 1

Equipment Combination	Effect (mm)	
Abc	+ .053	Worst
abC	+ .013	
AbC	+ .013	
ABc	+ .005	
abc	0	
aBc	- .004	
aBC	- .030	
ABC	- .035	Best

Where A = high speed
B = controlled swift
C = heavy bundle weight
a = low speed
b = free running swift
c = light bundle weight

The results of Test 2 were also analysed by analysis of variance, the short term drifts being found and the significance of the variables calculated as shown in Table III.

TABLE III RESULT OF ANALYSIS OF VARIANCE OF DATA FROM TEST 2

Source	Sum of Squares	Degrees of Freedom	Variance Estimate	Variance Ratio	Significance
Total	2673	15			
Swift	140	3	47	.416	Nil
Dwell time	1388	1	1388	12.3	99%
Speed	19	1	19	.168	Nil
Residual	1126	10	113		

6. DISCUSSION OF RESULTS

The results of the analysis by variance of Test 1 can be found in Table I. Here it can be seen that the only significant variables are the speed of coiling and the type of swift. The speed of coiling being 99.9% significant and the swift type being 95% significant. The actual effect in terms of values can be seen in Table II. Here a factorial analysis has been used to show the interaction between the variables.

It can be clearly seen that the worst tolerances are obtained running at a high speed with a low bundle weight and uncontrolled swifts whilst the best tolerances were obtained using a high speed, heavy wire bundle and a controlled swift.

Thus it appears that if a controlled swift is used with a heavy wire bundle coiling speed makes very little difference. However, if an uncontrolled swift and a light wire bundle are used in conjunction with fast coiling speed then the variation increased considerably.

The results of Test 2 when subject to an analysis of variance show that the Dwell time is 99% significant and completely dominates both the swift type and coiling speed. Hence the cut-off dwell should always be minimised wherever possible.

It must be noted however that these numerical results can only be used for this particular combination of coiling machine, swift type, wire bundles and spring design as different equipment will undoubtedly produce different variations.

7. CONCLUSIONS

1. Free length variation can increase with coiling speed depending on swift type and bundle weight used.

2. The more sophisticated swifts contribute less to free length variation.

3. Wire bundle weight has no overall effect on free length variation except when certain combinations of equipment are used.

4. A long cut-off dwell time and hence high wire feed will produce greater free length variation.

8. ACKNOWLEDGEMENTS

The Association wishes to thank Schenker Maschinen A.G., Simplex Rapid and their U.K. Agents Colpro Engineering Limited and S.A.H. Machines Limited for their greatly appreciated assistance and loan of equipment for this work.

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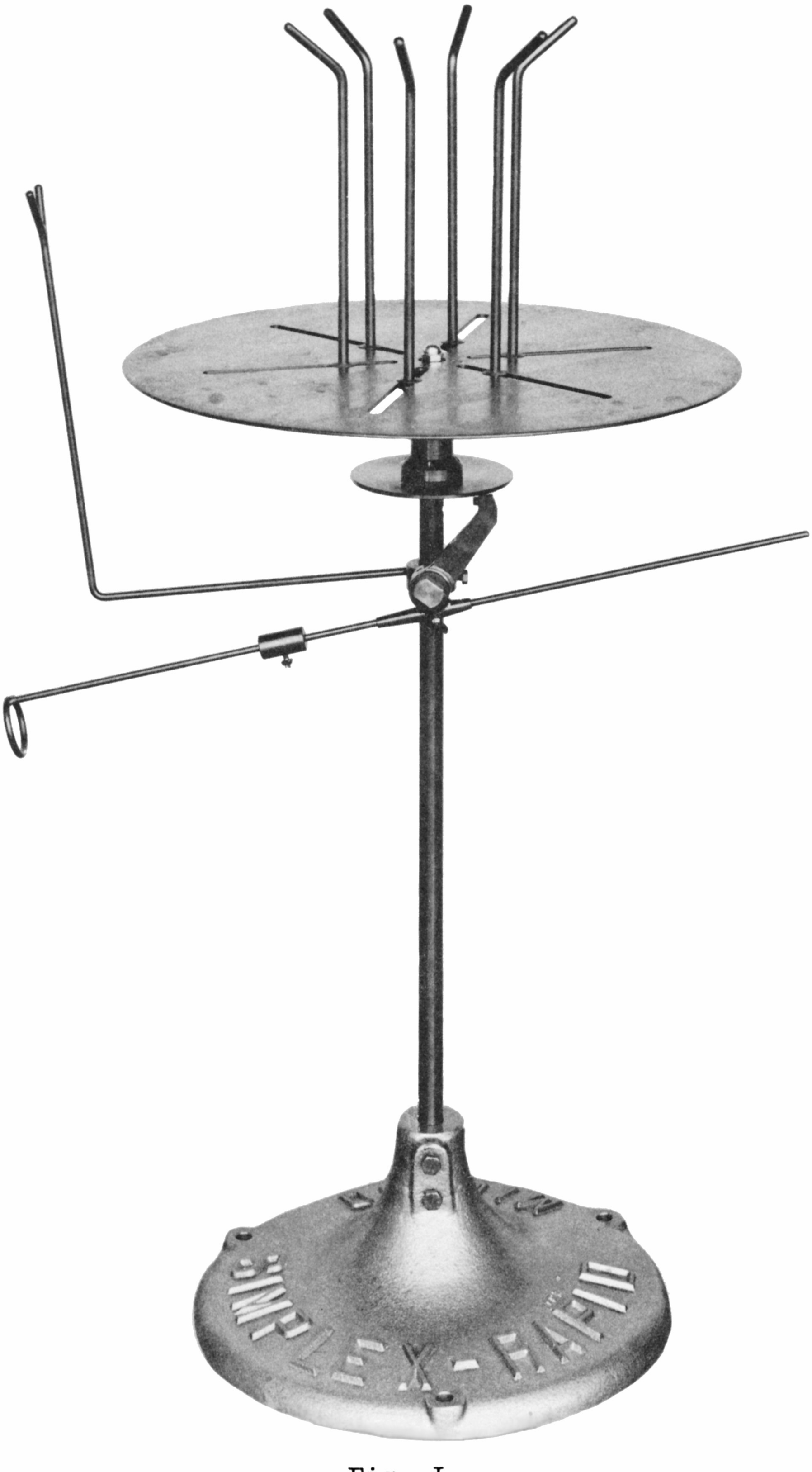

Fig. I

Simplex Rapid Z-1

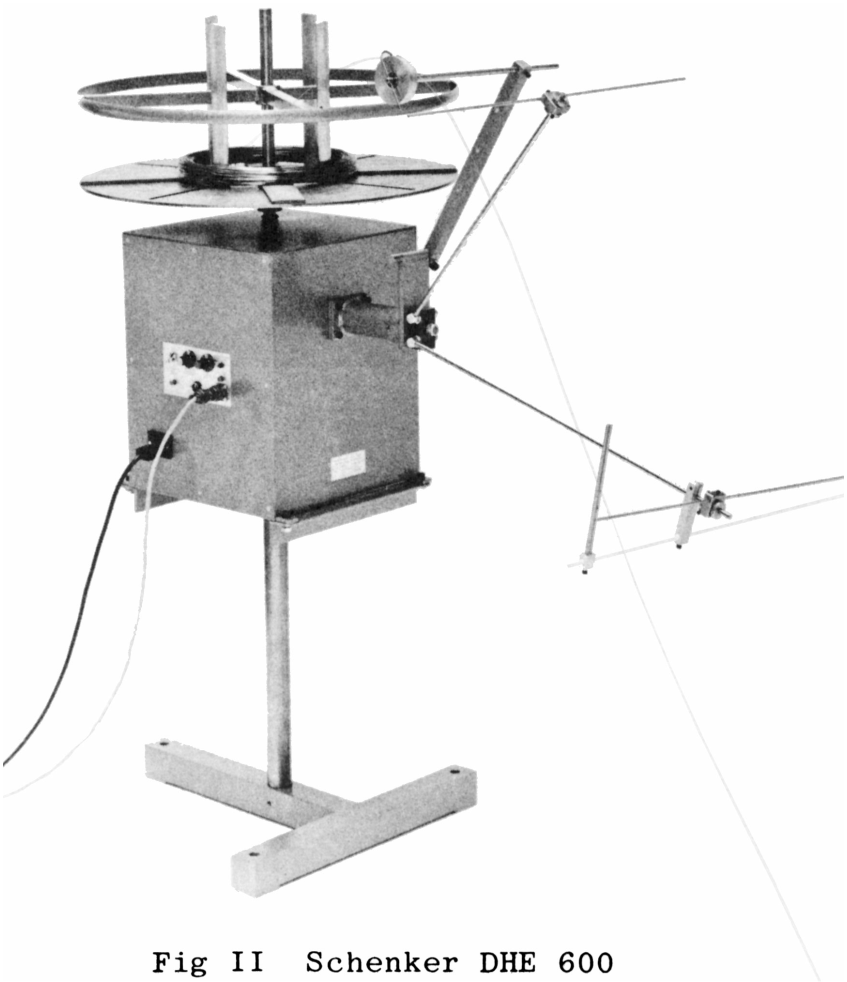

Fig II Schenker DHE 600

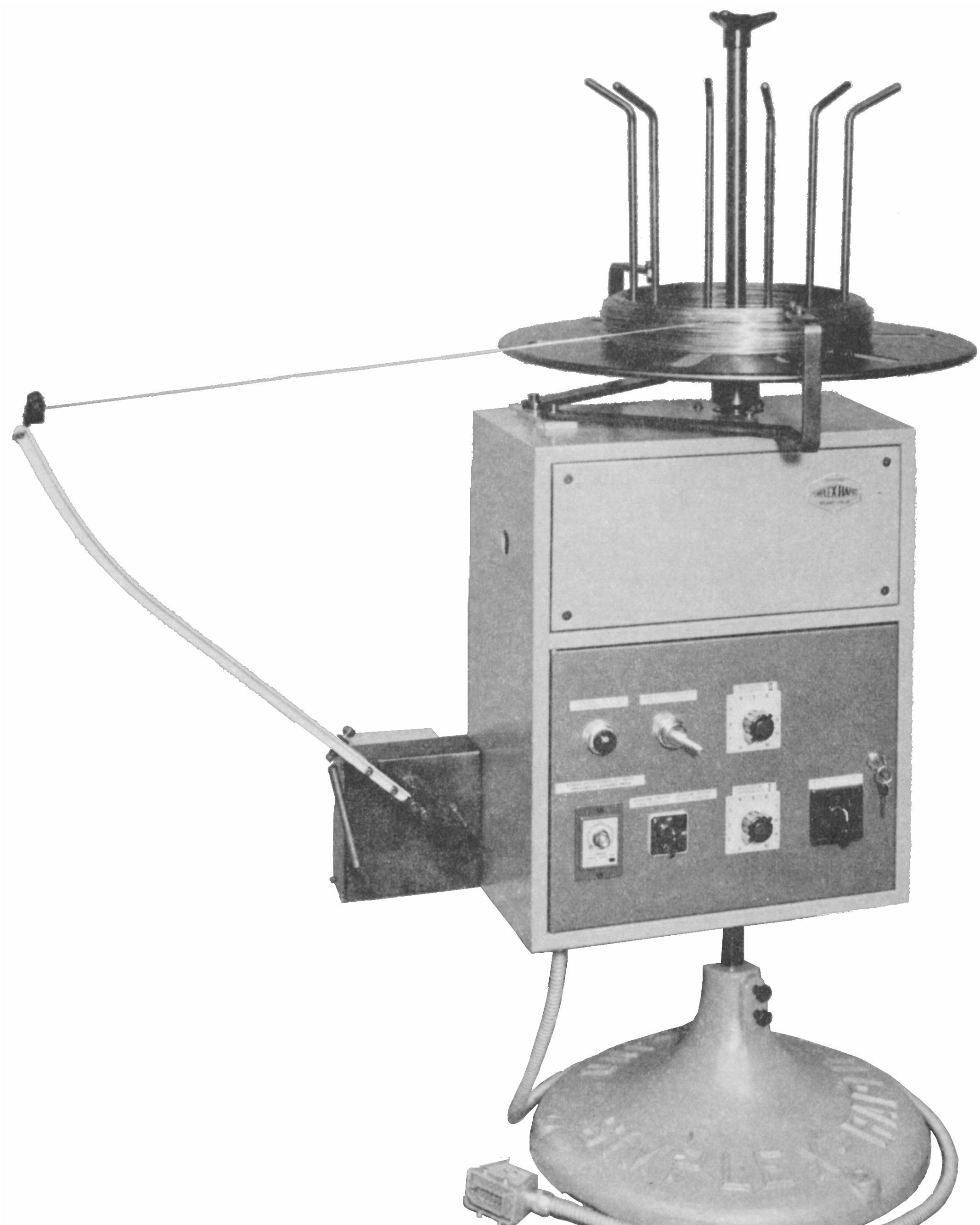

Fig III Simplex Rapid Z-2S