THE SPRING RESEARCH ASSOCIATION

AN EVALUATION OF THE SRA/SIRA SPRING GAUGING MACHINE

by

I. B. R. Elliott

Report No. 188

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SUMMARY

An automatic spring free length gauging and sorting machine has been developed by SIRA in conjunction with the SRA.

The machine operates on a go/no-go gauge principle using optics. The springs slide down a chute and pass through a series of light curtains which detect whether or not their free lengths are within the required tolerance band. They are then sorted by means of solenoid controlled deflectors into three separate batches depending upon whether or not they are undersize, within tolerance, or over-size. The 'accept' tolerance of the gauge was ±0.008 in, and there were no facilities for changing it easily. The B.S. 1726 tolerance for the test springs was 0.036 in.

Spring form errors caused variations in measurement of free length according to the orientation of the spring in the chute. This to some extent masked the accuracy of gauging.

The accuracy was such that about 70% of springs were sorted correctly, but this amount would increase if the 'accept' tolerance band was increased to ±0.015 in.

Dust did not appear to affect the performance of the optics, during the laboratory trials.

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1. INTRODUCTION

The principles and techniques of gauging are well known in engineering practice. However, the usual techniques of gauging cannot easily be applied to springs because of their flexible nature and their lack of a precise geometric or prismatic form.

Thus, the Scientific Instrument Research Association undertook, on behalf of The Spring Research Association, a programme of research in which a gauging machine was developed which did not rely on the usual methods of gauging but which used an optical system.

This report sets out the results and findings of an investigation into the performance of the SRA/SIRA machine.

2. GAUGING MACHINE

The gauging machine is shown in Figure 1. It consists of a framework and cabinet into which are built the gauging electronics, and an inclined 'V' guide down which the springs to be gauged are passed. Figure 2 shows the principle of the optical gauging.

An interruption of the first light curtain (not shown in Figure 2) registers the presence of a spring in the 'V' guide and resets the system. An interruption of the last light curtain (4) causes light curtains 2 and 3 to sense the presence of the end coil. (The light curtains are approximately 0.003 in thick.) The ideal spring would obstruct light curtain 3 but not 2; a short spring would obstruct neither, and a long spring both.

All rejected springs are intercepted by either of two deflectors which direct them into their respective boxes (long or short).

3. DESIGN OF SPRINGS GAUGED

The SRA/SIRA spring gauging machine was assessed using one spring design. The nominal design of the springs was as follows:-

Nominal Free length	1.825 in
Mean Diameter	1.0 in
Number of Coils	7
Wire Diameter	0.125 in

Ends closed but not ground

The machine was set by SIRA to gauge the nominal length of these springs.

4. PROCEDURE

From a selection of springs thirteen were chosen to cover a range of free lengths from approximately 1.800 in to 1.840 in. The variation in free length of each individual spring was accurately found by the use of the apparatus shown in Figures 3 and 5. This apparatus consisted of a 'V' guide (identical to the one used in the gauging machine) which accommodated two brass rollers, one fixed and the other controlled by a micrometer spindle. The rollers, and the springs being measured between them, were insulated from the 'V' guide. Contact between the rollers and the spring ends caused the resistance meter to show full scale deflection and at this point the micrometer reading was taken. Rotation of the springs about their longitudinal axes in the 'V' guide enabled any variations in free length due to bowing or any other effects to be found.

Each spring was passed through the gauging machine 200 times. A note was made of the number accepted (medium), and the numbers rejected (high and low).

5. RESULTS

Results of the experiment are given in Table I. Figure 4 shows the calibration curve which was derived from the tabulated results. The horizontal lines marked on the graph represent the free length variation of each spring (due to bad forming effects such as bowing) and the gauging machine decision.

6. DISCUSSION OF RESULTS

Figure 1 is the calibration curve of the SRA/SIRA gauge using unground springs. The parallel lines show the uncertainty in the measured length of each spring which depends upon its location in the 'V' slide. This is an essential part of the calibration curve because each of the springs has substantial measured length variations. Some of the springs had their end coils proud of the cylinder formed by the sides of the spring and this tended to lift the end of the spring off the 'V' groove. Figure 7 shows how a 0.010 in end coil error can increase the free length by approximately 0.006 in. Many springs were toroidal and thus gave different micrometer readings (and machine sorting) depending on which part of the bow of the spring sat in the 'V' groove.

The calibration curve shows that the set nominal length and tolerance are 1.817 in $\pm$0.008 in. Approximately 70% of springs within this tolerance range would be accepted.

The ideal calibration curve for a gauge is shown in Figure 6. This type of calibration curve can be achieved by "go/no-go" gauges assuming that each of the components gauged has one unique size.

The above mentioned spring form errors may have given rise to vibration and rocking of the springs as they passed down the guide.

The speed at which springs could be gauged was about one every second. The design of the apparatus should lend itself to automation principles, that is, using the machine on a production line with automatic feeders etc. For the duration of the experiment (which involved more than 2500 passes) dust and wear did not apparently affect the performance of the gauge.

The British Standard Specification (B.S. 1726) lays down a tolerance for the spring design used of ±0.036 in. The calibration curve of the gauging machine indicates that an effective gauging tolerance of ±0.008 in had been set. A wider tolerance, of ±0.015 in, which is now considered to be more suitable, would improve the accuracy of sorting.

7. CONCLUSIONS

1. The machine is satisfactory for the purpose of separating engine valve springs into three batches for grinding.

2. Unlike some gauging machines which gauge the spring free lengths whilst they are attached to the coiling machine, this gauge is not restricted to one coiling machine and it can also be used to gauge springs which have been ground.

3. In its present form, the setting up procedure for this machine is much too laborious for commercial use.

4. Approximately 70% of springs within the set tolerance were gauged as 'accepted' and approximately 80% of springs outside the set tolerance were rejected.

5. A wider gauging tolerance more in keeping with the design of the spring is needed in order to gain a more realistic assessment of the accuracy of the gauging machine.

6. The accuracy of the gauging machine did not appear to be affected by wear or dust during the laboratory trials.

7. Inconsistent gauging can be caused by variation in measured free length according to the orientation of the spring in the chute.

NOTE

As further development work is necessary before the machine can be considered suitable for production use, and as there are now other machines available which will measure and control the length of springs produced by an automatic coiling machine, it is not intended to continue development at this time.

However, the machine could be used to advantage within the spring manufacturing industry, in particular for sorting springs prior to grinding. The Association would be pleased to lend the machine to any Member who may wish to use it.

TABLE I RESULTS OF GAUGING

SPRING NO.	MEASURED SIZE RANGE (INCHES)	GAUGING DECISION		
		LONG	ACCEPTED	SHORT
1	1.793-1.798	1	14	85
2	1.798-1.802	1	7	92
3	1.802-1.807	1	21	78
4	1.806-1.810	1	42	57
5	1.808-1.812	1	65	34
6	1.810-1.815	3	73	24
7	1.811-1.816	16	58	26
8	1.816-1.820	18	72	10
9	1.820-1.824	27	67	6
10	1.823-1.827	59	38	3
11	1.826-1.831	65	34	1
12	1.832-1.836	83	17	0
13	1.834-1.838	80	20	0

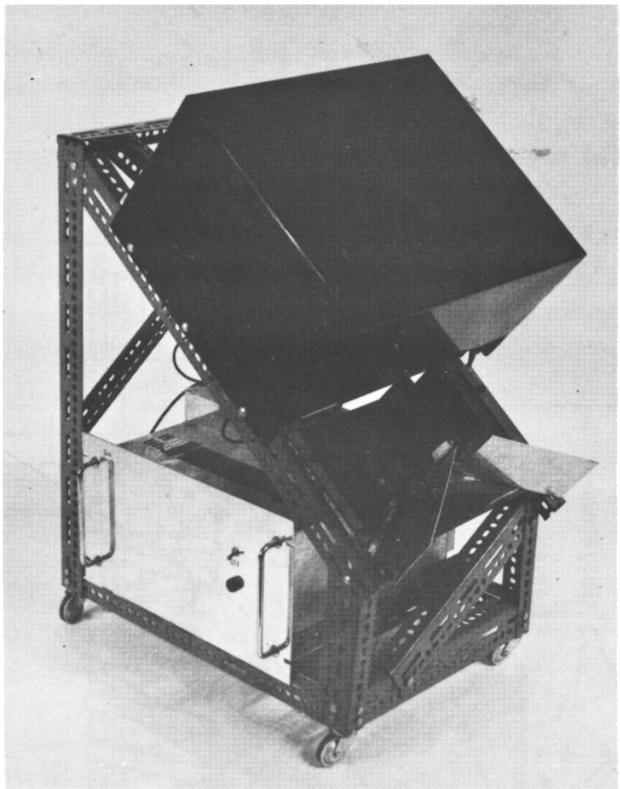


FIGURE 1. SIRA GAUGE

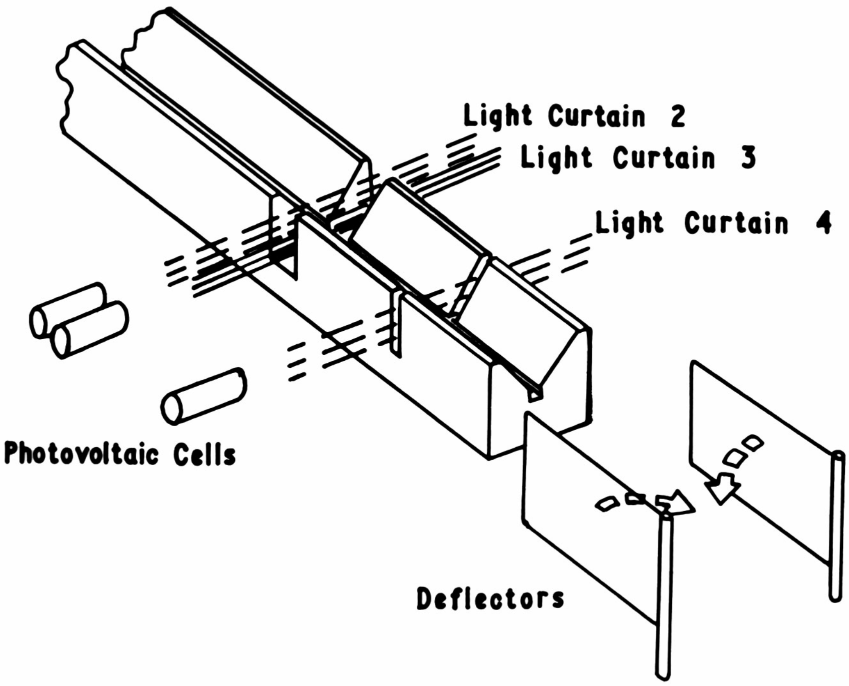


FIGURE 2. GAUGING OPTICS

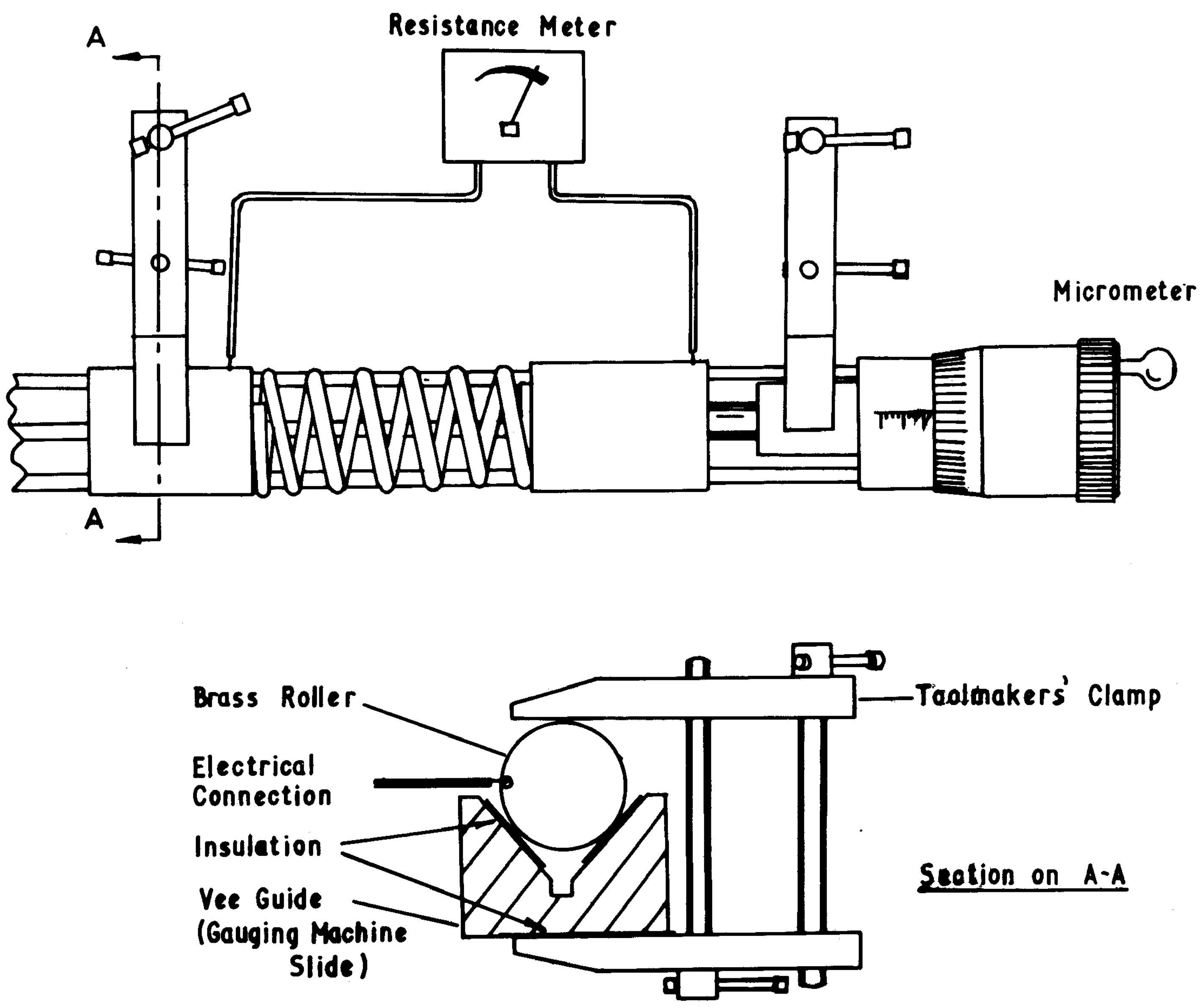


FIG. 3 APPARATUS FOR ACCURATE SPRING MEASUREMENT

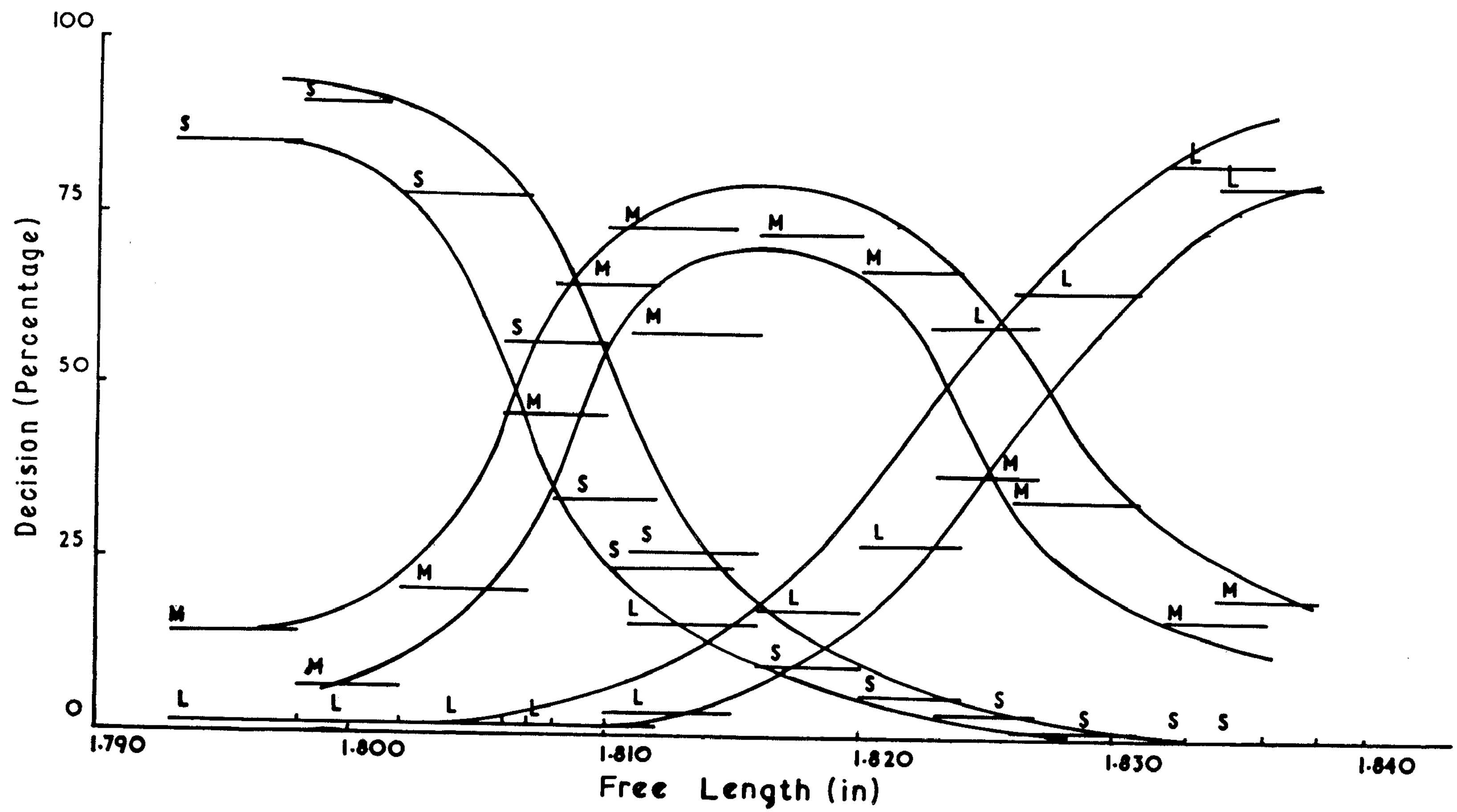


FIG.4 CALIBRATION CURVE FOR SIRA GAUGE USING UNGROUND SPRINGS

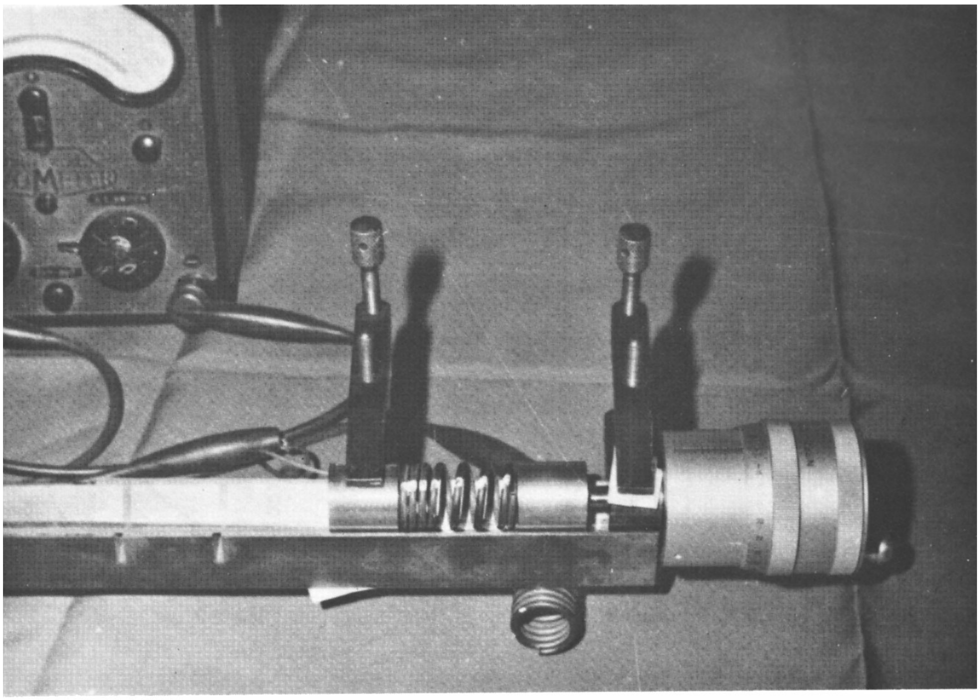


FIG. 5 SPRING MEASUREMENT

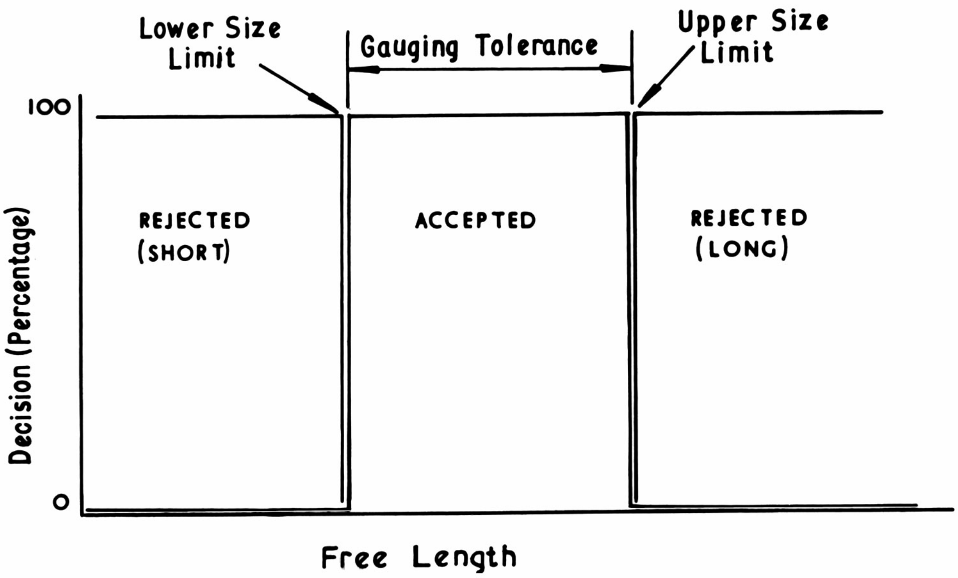
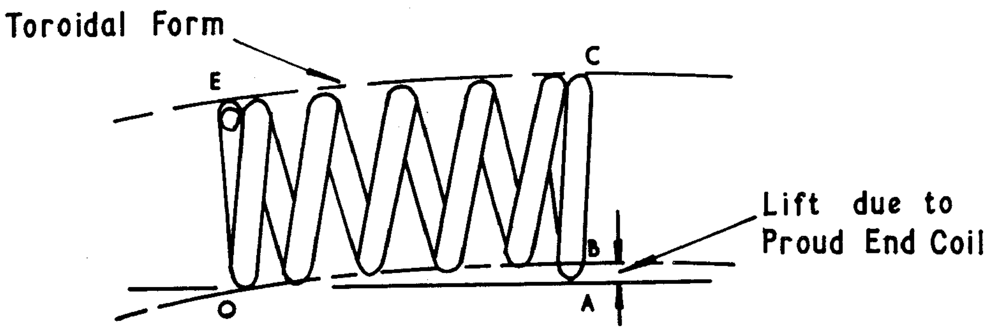
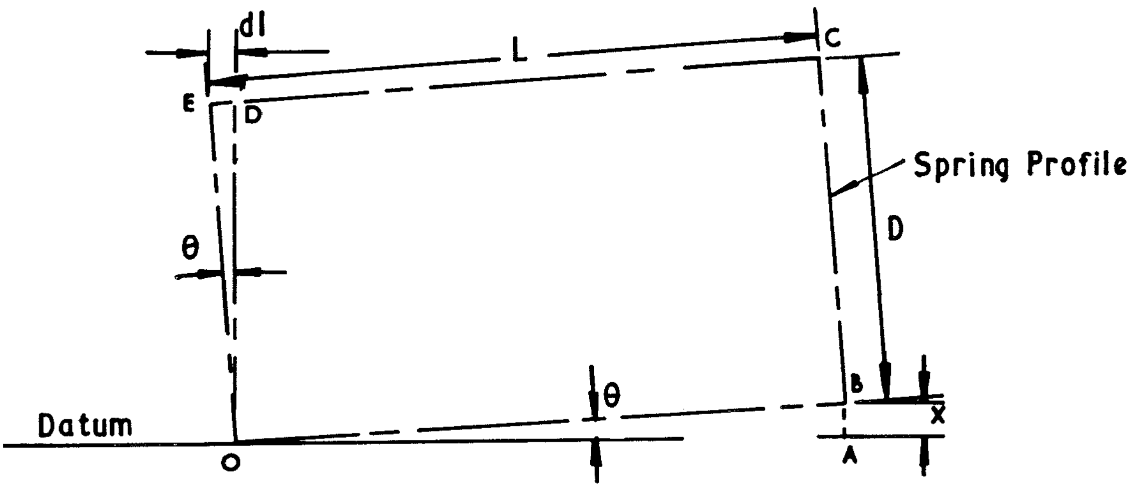


FIG. 6 IDEAL CALIBRATION CURVE FOR 'NO-GO' TYPE GAUGE



Spring Form Errors Which Give Rise To Poor Gauging



Triangles OAB and ODE are similar

$$\therefore \frac{BA}{OB} = \frac{ED}{OE} \quad \text{or} \quad \frac{x}{L} = \frac{dl}{D}$$

If $L = 1{\cdot}5\,\text{in}$, $D = 1{\cdot}0\,\text{in}$, $x = 0{\cdot}010\,\text{in}$:

$$\text{Increase in length } dl = \frac{0{\cdot}010 \times 1{\cdot}0}{1{\cdot}5} = 0{\cdot}006\,\text{in.}$$

FIG. 7 ERRORS OF SPRING FORM AND THEIR EFFECT ON GAUGING