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THE SPRING SPECIALISTS

F. S. Ratcliffe (ROCHDALE) LIMITED

CRAWFORD SPRING WORKS · ROCHDALE

Ratcliffe's Spring Calculating Slide Rule

INSTRUCTIONS FOR USE

GENERAL

Like all Slide Rules for effecting multiplication and division it carries logarithmic scales. The scales are specially arranged to enable the normal calculations involved in the design of helical tension and compression springs to be carried out at one setting. The rule has two slides—the upper for stress and load calculations and the lower for rate calculations. Each slide has scales in conjunction with the adjacent scales on the stock of the rule. The two slides are used quite independently. All the dimensions are in inches and lbs. The rule carries a cursor having an index line and a scale for stress correction.

STRESS AND LOAD CALCULATIONS (Upper Slide)

The upper scale on the stock marked " D " is for the Mean Diameter of the coils of the spring.

The upper scale on the slide marked " d " is for the Diameter of the wire.

The lower scale on the slide marked " w " is for the load.

The lower scale on the stock marked " f " is for the stress in the wire.

The central scale on the slide marked " d c " is for the diameter of the wire and is used in conjunction with the " D " scale to find the spring index " c " when making stress corrections by means of Wahl's Correction Factor referred to later.

At any setting of the slide a series of values of " d " coincides with a series of " D."

Selecting any pair of coincident values of these two quantities, the stress resulting from any load on scale " w " is shown in coincidence with it on scale " f."

The problem of spring design presents itself in many forms. Perhaps the most usual is to have the Mean Diameter " D " and the load " w " specified and then to have to find a value of the wire diameter " d " to give a safe value of the stress " f."

Take as an example a spring required to carry a load of 200 lbs. with coils of $1\frac{1}{2}''$ Mean Diameter.

Assume a working stress of 80,000 p.s.i.

Set 200 lbs. on scale " w " opposite 80,000 p.s.i. on scale " f."

Under 1.5 on scale " D " read 0.232″ on scale " d."

The nearest standard wire gauge size is No. 4 SWG = 0.232″ diameter, as shown on the Table on the back of the rule.

If the problem is presented in any other form it is only necessary to remember that of the four variables affecting the load and stress, three must be known or assumed and the fourth can then be read directly by setting the slide so that two of the known values coincide on their respective scales. Then the unknown will be found on the appropriate scale opposite the third known value. Thus whatever form it takes the load problem can be solved with the one setting of the rule.

WAHL'S STRESS CORRECTION

The fact that the wire is bent into a coil increases the maximum stress and the bigger the wire diameter in relation to the Mean Diameter of the coil, the greater the effect.

Wahl's Correction Factor shows how much the stress is increased for each value of the ratio—

$$\frac{\text{Mean Diameter of Coil}}{\text{Wire Diameter}}$$

This ratio is usually referred to as the Spring Index and denoted by the letter " c."

To apply the correction the first step is to find the value of the ratio.

For this purpose the central scale on the upper slide is marked " d c " for wire diameter. Its basic length is the same as that of the " D " scale so that direct division can be done.

Setting the index line on the cursor to the Mean Diameter on the " D " scale, bring the value of the wire diameter on scale " d c " under the index line of the cursor. Move the cursor to 1.0 (arrowhead) on scale " d c " and read the value of " c " under the cursor index on scale " D."

On the cursor a short scale is engraved and marked " c." It extend from ∞ on the left to 3 on the right.

Now re-set the slide in the position for stress and load calculation as described above and bring the index of the cursor over the required value of the load on scale " w." The *corrected stress* will be read on scale " f " under the graduation of the cursor corresponding to the value of " c."

Graduation 5 on the scale for " c " coincides with the index line of the cursor so that if the value of " c " happens to be 5 there is no correction to make.

(P.T.O.

If the values of " D " and " d " are both known (as when checking the design of an existing spring) the value of " c " can be found before making the initial stress calculation, thus saving one setting of the rule.

RATE CALCULATION

Turning to the rate slide and its associated scales, the scale on the stock above the slide is marked " Dl " for the Mean Diameter of the coil.

The upper scale on the slide is marked " dl " for wire diameter.

The lower scale on the slide is marked " R " for the rate of the spring in lbs. per inch of deflection.

The scale on the stock next to the lower edge of the slide is marked " n " for the number of " free coils " of effective turns."

As in the case of load and stress calculations, at any setting of the slide there is a series of coincident values of " D " and " d." For any such pair of coincident values the number of free coils " n " needed to give a required rate " R " can be read on the " n " scale opposite the required value on the " R " scale.

Alternatively, the rate may be read on the " R " scale opposite any particular number of free coils on the " n " scale.

As an example consider a spring with the same dimensions as that quoted above and assume the spring is required to have a rate of 250 lbs. per inch.

Set 0.232 on the " dl " scale opposite 1.5 on the " Dl " scale.

Under 250 on the " R " scale read 5 on the " n " scale.

As for the load and stress problem there are four variables in the rate problem. Any three may be known or assumed. By bringing two of them into coincidence on the slide and stock the possible values of the other two can be read from any pair of coincident graduations on the other two scales.

FREE LENGTH

It often occurs, especially during manufacturing operations, that it is required to know the free length of a spring in order that it may carry a specified load " w " at a specified length " l." The free length is of course the deflection under load " w " plus the specified length " l."

$$\text{The deflection } \triangle = \frac{w}{R}$$

To calculate this deflection the " n " scale may be used to represent " w."

Remembering that the " n " scale runs from right to left, graduation 1 on scale " R " must be placed against the value of the load " w " on scale " n." The deflection $\triangle$ is then read on scale " n " against the rate of the spring on scale " R." The deflection $\triangle$ so found added to the specified length " l " gives the free length.

Taking again as an example the spring referred to above, assume that the length is specified to be $2\frac{1}{4}''$ under a load of 200 lbs. Place 1 on scale " R " against 200 on scale " n." Under the rate 250 on scale " R " read 0.8″ on scale " n." This is the deflection and the free length is

$$2.25+0.8=3.05''$$

BACK OF RULE

On the back of the rule brief instructions for use are given ; also Two Tables and a Graph.

The first Table gives the diameters and certain physical properties of High Quality Hard Drawn Spring Wire to British Standard Specification No. STA3 and indicates appropriate working stresses for static loads.

For sizes above O.S.W.G. the figures refer to wire to British Standard Specification No. STA2b, hardened and tempered after coiling.

The second Table gives multipliers to enable the results obtained with the rule to be converted for use with other materials and for wire of square section.

The Graph gives the safe working range of stress for springs subject to varying loads, such as the valve springs of internal combustion engines. A curve is given for each value of the maximum safe static stress quoted in the Table.

The safe range of stress for any given maximum working stress is then shown by the vertical height to the curve for the relevant maximum safe statis stress.

For example, a spring made from wire of 16 SWG complying with B.S./STA3 will safely carry a static stress of 100,000 p.s.i. If the maximum working stress in a particular application is 65,000 p.s.i. the Graph shows that the safe range of stress between maximum and minimum working loads is 30,000 p.s.i.

N.B—In reading the 'n' scale remember that it runs from right to left. In reading intermediate graduations they must be referred to the numbered graduations to the right and not to the left as in the usual scales running from left to right.