USE of the SLIDE RULE

OF ASSOCIATED SPRING CORPORATION

for EXTENSION, COMPRESSION AND TORSION SPRINGS

This slide rule has been designed to facilitate the use of the formulas most commonly used for ordinary compression, extension and torsion springs, these being as follows:

For Compression and Extension Springs

$$P=\frac{fGd^4}{8ND^3} \quad \text{and} \quad P=\frac{\pi Sd^3}{8D} \quad \text{for round wire}$$

$$P=\frac{fGd^4}{5.58ND^3} \quad \text{and} \quad P=\frac{Sd^3}{2.4D} \quad \text{for square wire}$$

For Torsion Springs

$$M=\frac{Ed^4T}{10.8ND} \quad \text{and} \quad M=\frac{\pi Sd^3}{32} \quad \text{for round wire}$$

$$M=\frac{Ed^4T}{6.8ND} \quad \text{and} \quad M=\frac{Sd^3}{6} \quad \text{for square wire}$$

in which,

P = Load in pounds
G = Torsional Modulus
S = Stress in lbs. per sq. inch
D = Mean diameter of coil in inches
d = Diameter of round (or side of square) wire in inches
f = Deflection in inches
N = Number of active coils
M = Moment or torque in inch pounds
E = Modulus of elasticity
T = Number of turns spring can give

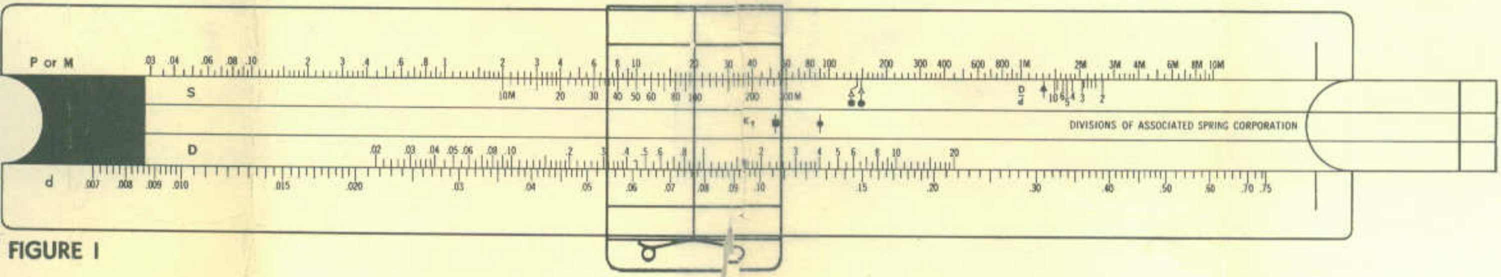

FIGURE I

• • • • • • COMPRESSION SPRINGS--Round Wire • • • • • •

For modulus values, allowable stresses and the amount of initial tension and general spring design, consult the data given in the Handbooks published by the Divisions of the Associated Spring Corporation.

The relation of the various scales on this slide rule makes it possible to read directly the variables in any simple spring. One side (Figure I) indicates the stress, for any load or torque, on any combination of dimensions within the range of the divisions on the rule. The other side (Figure II) indicates the load required to deflect a compression or extension spring one inch, or a torsion spring one turn, for any combination of wire size, coil diameter and number of active coils, within the range of sizes indicated by the divisions on the rule.

Some practice will be necessary to handle the divisions readily, but examples will illustrate the procedure.

Example 1

Find the stress exerted by a 50 lb. load on a spring of .125″ diameter wire having a 1″ mean diameter.

On the stress side of the rule, set 1″ on the D scale directly over .125″ on the d scale and under the 50 lbs. on the P scale read the stress of 65,000 lbs. per sq. inch.

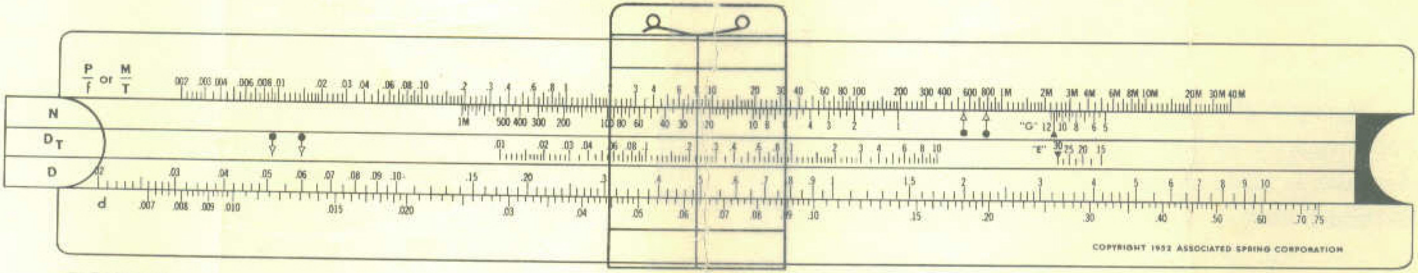

FIGURE II

Example 2

With the above wire diameter and mean diameter find the rate per inch of deflection given by a spring with 3.5 active coils.

On the rate per inch side of the rule set 1″ on the D scale directly over .125″ on the d scale and above the 3.5 active coils on the N scale find the r.p.i. of 100 lbs.

Example 3

Suppose it is desired to work out a compression spring which will compress 2″ and have a rate of 10 lbs. per inch with a stress at 20 lbs. not over 100,000 lbs. per sq. inch.

Set 100,000 lbs. per sq. inch on the S scale opposite 20 lbs. on the P scale (see Figure I). Then any combination of wire size on the d scale with a mean diameter of coil as shown directly opposite on the D scale, will fit the conditions. (Note, however, that many combinations will appear in such a setting which are physically impossible dimensionally.) For best proportions the mean diameter D should be 6.5 to 8.5 times the wire diameter d, so for commercially available wire diameters, the choice would lie between .058″ diameter wire and .383″ mean diameter, or .063″ diameter wire and .490″ mean diameter. Let us assume the latter. Now turn the rule over using the opposite side and set the mean diameter D of .490″ at .063″ wire diameter on the d scale (see Figure II). Opposite 10 lbs. on the $\frac{P}{f}$ scale read the number of active coils as 19 on the N scale. Adding 2 to this for one closing coil or dead coil at each end, we have 21 total coils.

COMPRESSION SPRINGS--Square Wire

The same process applies to springs of square wire; however, after the initial setting of mean diameter and wire diameter is made on each side of the rule, the hairline on the cursor should be set on the round wire character (⌽) on the N or S scales and the sliding scale moved until the square wire character (⎅) is under the hairline. The final reading is made after this correction.

EXTENSION SPRINGS

The rule settings are the same for extension springs as for compression springs. Extension springs are usually coiled with initial tension and after enough load is applied to an extension spring to balance the initial tension, the load and deflection follow the same relationships as in a compression spring. In figuring maximum stress the initial tension load must be added to the load produced by deflection, and the stress calculated for the total.

MODULUS CORRECTION

The graduations of the slide rule (for compression and extension spring calculations) are all based on a torsional modulus of 11,500,000 for steel wire. When any other material is to be used, correction can be made for the difference in modulus by using the small scale shown as G on the slide. After the mean diameter has been set over the wire diameter, set the hairline of the cursor on the 11,500,000 figure on the G scale which is indicated by the arrow and move the slide until the correct modulus figure is under the hairline. Then all combinations of dimensions are corrected for the lower modulus.

WAHL'S STRESS CORRECTION FACTOR

In designs where fatigue is an important factor in compression or extension springs the additional stress, due to the curvature of the wire and the shear load, must be considered. This will vary with the ratio of the mean diameter to the wire diameter $\left(\frac{D}{d}\right)$. In order to make this correction on the slide rule, the stress is first calculated for the required load with the given wire diameter and mean diameter. The hairline on the cursor is then set on the arrow shown on the $\frac{D}{d}$ scale, which is on the extreme right of the S scale, and the slide is moved until the ratio under the hairline corresponds to the $\frac{D}{d}$ ratio of the spring being calculated. The corrected stress can then be read directly under the required load. A more detailed explanation of this correction factor is given in the Handbooks of the Associated Spring Corporation.

For Use of Slide Rule for TORSION SPRINGS
see following pages

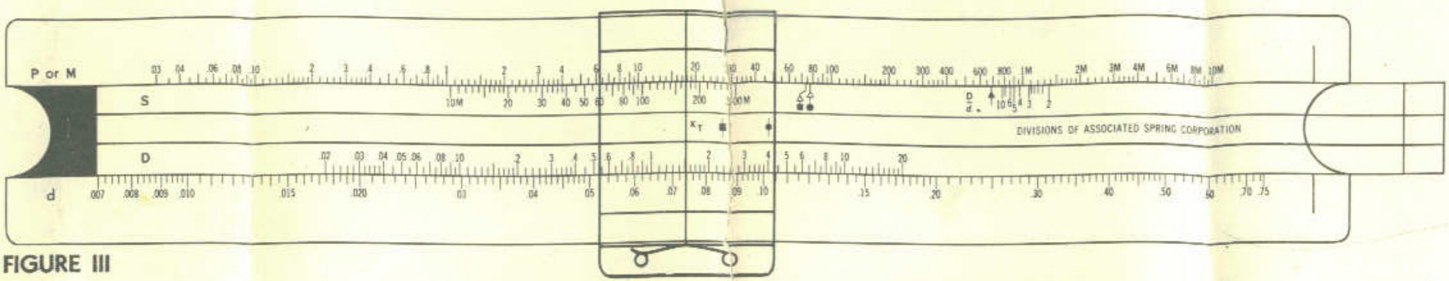

FIGURE III

• • • • • • • TORSION SPRINGS--Round Wire • • • • • • •

In the solution of torsion springs on this slide rule the D scales as shown on both sides of the rule are not used. Instead of these scales the D_T and K_T scales are used.

Suppose a torsion spring is required that will carry 18 inch pounds torque with 270° deflection, work over a $\frac{13}{16}$″ diameter shaft and have a maximum stress of 170,000 lbs. per sq. inch.

On the stress side of the rule set 170,000 lbs. per sq. inch on the S scale opposite 18 inch pounds on the M scale (see Figure III) and find the wire diameter on the d scale directly below the round wire character (⧫) on the K_T scale. This reading indicates a .102″ wire diameter, however, the nearest gauge of oil-tempered wire is .105″ diameter. To correct the stress reading for .105″ diameter wire set the round wire character directly over the .105″ diameter wire and find the stress of 158,000 lbs. per sq. inch directly opposite the 18 inch pounds torque.

Since the required torque is 18 inch pounds for 270° deflection, the torque per turn, or $\frac{M}{T}$, is 24 inch pounds. The diameter must be large enough to work over a $\frac{13}{16}$″ diameter shaft. We can assume a 1″ mean diameter as this would still allow the spring to be free on a $\frac{13}{16}$″ diameter shaft when wound up 270°.

Set the 1″ mean diameter on the D_T scale directly over the .105″ diameter wire on the d scale (see Figure IV) and find the number of coils as 14 on the N scale directly below the required 24 inch pounds per turn on the $\frac{M}{T}$ scale.

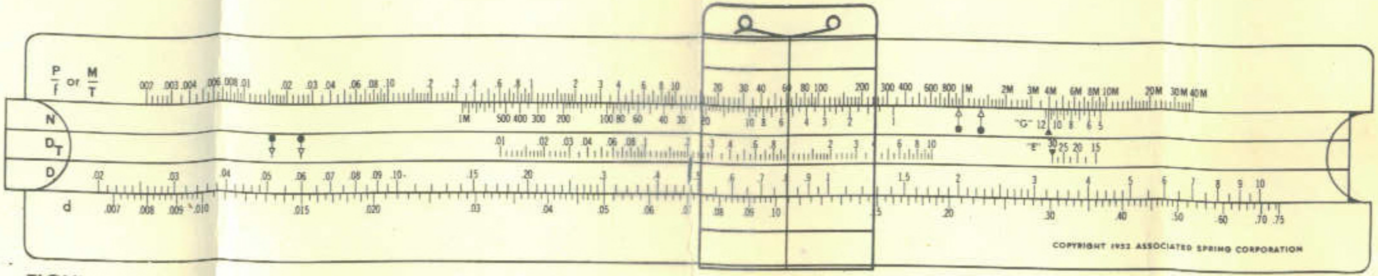

FIGURE IV

TORSION SPRINGS--Square Wire

For torsion springs of square wire the same procedure is used, but on the stress side of the rule the square wire character (■) on the K_T scale is set directly over the wire size and the S scale will then show the stress for any given torque within the limits of the rule. The correction for torque per turn is made on the left-hand side of the D_T scale. After the mean diameter is set over the wire size, set the hairline on the cursor over the round wire character (●) then move the slide until the square wire character (■) is under the hairline. The rule then shows the corrected torque per turn $\left(\frac{M}{T}\right)$ for any given number of coils.

MODULUS CORRECTION

The graduations of the slide rule (for torsion spring calculations) are based on a modulus of elasticity of 30,000,000, which is the modulus for most steel wires. When a material of some other modulus is used, the correction is made on the E scale which is on the right-hand of the D_T sc has been set directly over the wire diameter on the d scale, set the hairline on the cursor over the 30,000,000 figure on the E scale, which is indicated by an arrow, then move the slide until the correct modulus is under the hairline. The rule then shows the correct torque per turn for any given number of coils.

For allowable stresses, moduli and other information see the Handbooks of the Associated Spring Corporation which give much more detailed information than can be given in a pamphlet of this size.

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