FUN WITH FUNDAMENTALS

Profit and lost

Problem 188 — It's not what you say, it's how you say it, as this month's problem by Ying Gong of Portland, Ore., demonstrates.

"... and it is now my pleasure to declare a company-wide bonus of $300 for each employee — less taxes and miscellaneous corporate overhead expenses," intoned Horatio Puff, president of the venerable Lee Key Hydraulic Co. "The following disclosure statement shows the formula used to calculate the exact amount each employee will receive. It's a new style of accounting called the Reciprocating Method, meaning from me to all of you and from all of you to me! Each employee will receive the *reciprocal* of the following amount:"

$$\frac{5}{(700\times707)}+\frac{5}{(707\times714)}+$$

$$\frac{5}{(714\times721)}+\ \ldots\ +\frac{5}{(210{,}000\times210{,}007)}$$

Reduce the above expression to its simplest terms. How much does each employee really get?
Send your answer to:

Fun With Fundamentals
POWER TRANSMISSION DESIGN
1100 Superior Ave.
Cleveland, OH 44114-2543

Deadline is November 10. Good luck!

Technical consultant, Jack Couillard, Menasha, Wis.

Solution to last month's problem 187 — Your theories aren't hollow, if you **said the hollow shaft would work.** It will carry $^{15}/_{16}$ as much torque as the solid shaft. Here's the core of the matter:

Since allowable torque is related (directly) to the steel's allowable shear stress and polar moment of inertia, you should compare their polar moments of inertia.

Let:

D = OD of hollow and solid shafts, given as 4 in.

d = ID of hollow shaft, given as 2 in.

l = Length of both shafts, given as 60 in.

ρ = Density of steel, given as 0.284 lb/in.^{3}

J_H = Polar moment of inertia for hollow shaft, lb-in.^{2}

J_S = Polar moment of inertia for solid shaft, lb-in.^{2}

$$J_H = \frac{\pi}{32}\left(D^4 - d^4\right)$$

But $d = D \div 2$, therefore:

$$J_H = \frac{\pi}{32}\left[D^4 - \left(\frac{D}{2}\right)^4\right]$$

$$= \frac{\pi}{32}\left(\frac{16D^4}{16} - \frac{D^4}{16}\right)$$

$$= \frac{\pi}{32}\left(\frac{15}{16}D^4\right)$$

Divide J_H by J_S to get $^{15}/_{16}$.

Now for the extra credit. Multiply the volume of each shaft by ρ:

Let:

V_H = Volume of hollow shaft, in.^{3}

V_S = Volume of solid shaft, in.^{3}

w_H = Weight of hollow shaft, lb

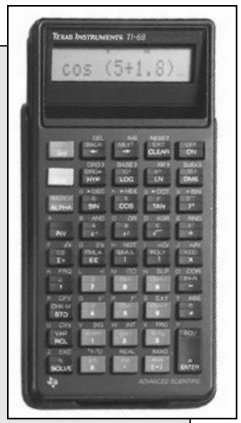
w_S = Weight of solid shaft, lb

$$w_S = V_S \times \rho = \pi R^2 l \rho = 214.13 \text{ lb}$$

$$w_H = V_H \times \rho$$

$$= \pi\left(R^2 - r^2\right)l\rho = 160.60 \text{ lb}$$

The weight savings is 53.53 lb, and DePouff gets his trophy!



Contest winner — Congratulations to Scott Wootten of Mercerville, N.J., who won our August contest by having his name drawn from the 110 contestants who answered correctly out of a total of 129 entrants for that month. A TI-68 calculator is in the mail to him. *A number of respondents assumed the shadows fell on opposite sides of the piller and answered 800 ft. These were also included in the drawing.*

The TI-68 Advanced Scientific Calculator by Texas Instruments can solve five simultaneous equations with real and complex coefficients and has 40 number functions that can be used in both the rectangular and polar coordinate systems. Other functions include formula programming, integration, and polynomial root finding. The calculator also features a last-equation replay function that lets you double-check your work.

To enter the contest, send your answer on a postcard or letter to POWER TRANSMISSION DESIGN, 1100 Superior Ave., Cleveland, OH 44114-2543.

You can also receive a TI-68 and credit in the magazine if you send in an *original* problem with solution, and we publish it.