STAEDTLER® No. 937 811E Engineer's Computation Pad

**77** The rigid square frame in Fig. 12-80 consists of the four side bars *AB*, *BC*, *CD*, and *DA* plus two diagonal bars *AC* and *BD*, which pass each other freely at *E*. By means of the turnbuckle *G*, bar *AB* is put under tension, as if its ends were subject to horizontal, outward forces $\vec{T}$ of magnitude 535 N. (a) Which of the other bars are in tension? What are the magnitudes of (b) the forces causing the tension in those bars and (c) the forces causing compression in the other bars? (*Hint:* Symmetry considerations can lead to considerable simplification in this problem.)

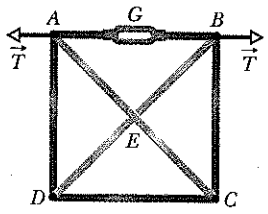
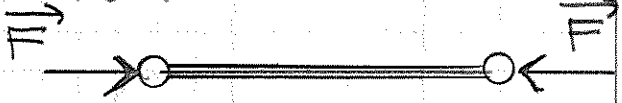



**FIG. 12-80** Problem 77.

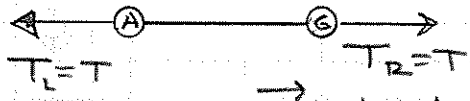
A LENGTH OF MATERIAL UNDER TENSION:




A LENGTH OF MATERIAL UNDER COMPRESSION:




AB IS UNDER TENSION BECAUSE THE TURNBUCKLE IS TIGHTENED, PULLING INWARD ON ITS ENDS, THEREFORE EQUILIBRIUM REQUIRES OUTWARD TENSION FORCES AT A & B ie. $F^{\text{net on AG}}_{\text{horizontal}} = T_L - T_R = 0$




CONSIDER THE NET FORCE AT THE POINT A; WHERE THERE IS A PIN HOLDING THE 3 BARS TOGETHER $\vec{F}^{\text{net on A}} = 0$

$F^{\text{net on A}}_{\text{HORIZONTAL}} = T_L - F\sin(\theta = 45°) = 0$ ($F$ IS EXERTED BY AC; $T_L$ FROM BAR AB; $F\sin45°$ FROM BAR AC)

$\Rightarrow F = T_L/\sin 45° = T\sqrt{2}$ (POINTS TO CENTER = E)

EQUILIBRIUM OF LENGTH AC:




$F^{\text{net on AC}}_{\text{diagonally}} = F_A - F_B = 0 \Rightarrow F_A = F_B = F \Rightarrow$ COMPRESSION

BY SYMMETRY BC IS UNDER THE SAME COMPESSION F

THEREFORE

BY SYMMETRY & EQUILIBRIUM WE HAVE THE SAME FORCES AT D & C AS WE HAVE AT A & B

THEREFORE: ALL SIDES ARE UNDER IDENTICAL TENSIONS

$T = 535\text{N}$

THEREFORE: BOTH DIAGONALS ARE SUBJECT TO IDENTICAL COMPRESSIONS $= T\sqrt{2} = 757\text{ N}$

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CONSIDER THE FORCES ON PIN A DUE TO THE 2 SIDEBARS & 1 DIAGONAL BAR

