ILLUSTRATIVE PROBLEM

V–8. The dimensions of a 6-in. 8.2-lb channel section may be taken as shown in Fig. 177*a*. The portion of the beam in front of the plane of the paper has been removed, and the force action of this removed portion includes a vertical shearing force of 1,000 lb acting down on the other portion of the beam behind the plane of the paper. Determine the shear flow distribution and plot the same; also determine the shearing forces carried by the web and the two flanges, and locate the shear center.

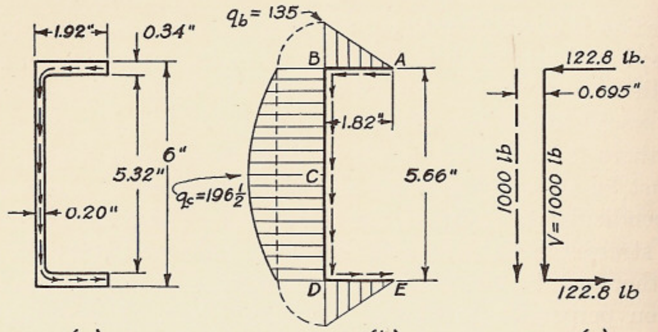

FIG. 177.

Solution.—The moment of inertia about the neutral axis 1–1 (the horizontal centroidal axis) is

$$(1.92)(6)^3/12 - (1.72)(5.32)^3/12 = 12.98 \text{ in.}^4$$

The shear flow may be considered as acting along the center line *ABCDE* of the flanges and web. (See Fig. 177*b*.) To get the shear flow at the corner *B*, one first calculates Q for AB; $Q = A\bar{y} = (1.82 \times 0.34)(2.83) = 1.75$. $q_b = VQ/I = (1{,}000)(1.75)/12.98 = 135$ lb per in. At the tip *A*, the shear flow is zero. At other points between *A* and *B*, it will be seen that Q, and hence q, varies linearly with the distance from *A*. From *B* to *C* to *D*, q varies along a parabolic arc as shown in Fig. 177*b*. At *C*, $Q = 1.75 + (2.83 \times 0.2)(2.83/2) = 2.55$ and $q_c = VQ/I = (1{,}000)(2.55)/12.98 = 196.5$ lb per in.

The mean shear flow in the web *BCD* is $135 + (\frac{2}{3})(196.5 - 135) = 176$ lb per in. The shearing force in the web is $(176)(5.66) = 997$ lb which should agree with $V = 1{,}000$ lb.

The mean shear flow in each flange is $135/2 = 67.5$ lb per in.; the shearing force in each flange is $(67.5)(1.82) = 122.8$ lb.

The force action of the nearer portion of the beam on the back portion is equivalent to a vertical web force of 1,000 lb and a couple $122.8 \times 5.66 = 695$ in. lb. (See Fig. 177*c*.) A single vertical force of 1,000 lb applied 0.695 in. to left of the web produces the same force action as the web force and flange couple. The point on the neutral axis through which this resultant passes is the desired shear center; hence $e = 0.695$ in.

PROBLEMS

555. Same as Ill. Prob. V–8 except the section is a 12-in. 20.7-lb channel. Total depth = 12 in.; flange width = 2.94 in.; average flange thickness = 0.50 in.; web thickness = 0.28 in.; $V = 12{,}830$ lb. *Answers.* $q_{corner} = 805$ lb per in.; $q_{max} = 1{,}267$ lb per in.; $e = 1{,}012$ in.

556. For the section shown in Fig. 178 show that the distance e from the center of the semi-circular arc to the center of twist is $e = 8/\pi$ to the left. If the vertical shearing force is assumed to be 1,257 lb, what is the maximum shearing stress s_{xy}? *Answer.* $(s_{xy})_{max} = 4{,}000$ psi.

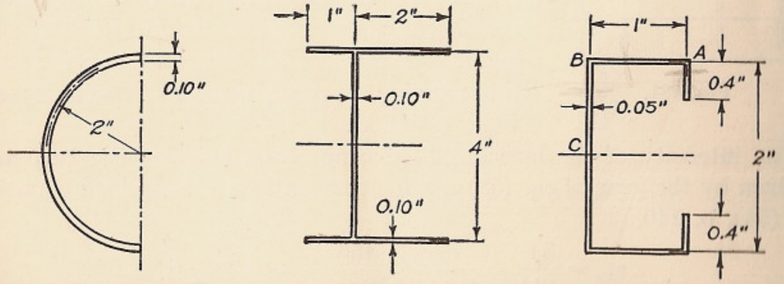

FIG. 178. FIG. 179. FIG. 180.

557. If the vertical shearing force acting on the section shown in Fig. 179 is 290 lb, construct a diagram showing the shear flow and locate the center of twist. *Answers.* At junctions of flanges and web, $q = 40$ and 20 lb per in.; $e = 0.415$ in. to left of web center.

558. If the vertical shearing force acting on the section shown in Fig. 180 is 15.96 lb, construct a diagram showing the shear flow and locate the center of twist. *Answers.* $q_A = 1.6$, $q_B = 6.6$, and $q_C = 9.1$ lb per in.; $e = 0.55$ in. to left of center of web.

47. The Spacing of Connections to Resist Horizontal Shear.—In engineering practice, beams built up of wood or metal are sometimes used and the stresses in them are usually calculated on the assumption that their parts are rigidly connected. The computation will then involve (*a*) the designing of the beam as a solid beam; (*b*) the designing and spacing of the elements or connections which unite the parts of the beam. In the first case, the formulas for solid beams are used, making an allowance for the effect of holes and slots by the use of reduced sections.

Let us consider a very simple case where two "two-by-four" wood studs (actually 1¾ in. thick by 3¾ in. wide) are spiked together to make a beam of approximately square cross section. "12-penny" spikes (0.192-in. diameter) are used, arranged in pairs as shown in Fig. 181.