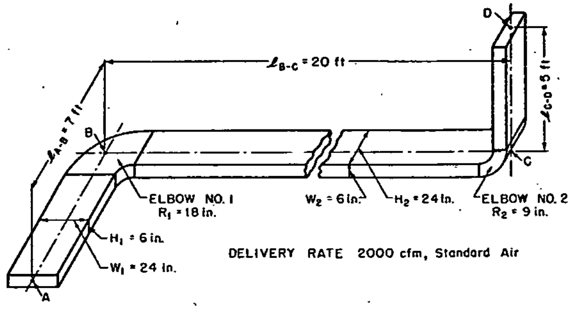


FIG. 7. PORTION OF DUCT SYSTEM FOR EXAMPLE 3

forms will produce a substantial saving in pressure loss. The addition of vanes or splitters divides an elbow into parallel channels, each having more favorable radius and aspect ratios than the original elbow. Values of additional equivalent length $L$, for elbows of square cross-section having various vane forms and combinations, may be found from Table 3 in which values of $L/W$ are shown.

## LOSSES DUE TO AREA CHANGES

Area changes in ducts, generally unavoidable, are necessitated frequently by the building construction or changes in the volume of air carried. Experimental investigations[14,15] of pressure changes, and pressure losses at changes of the area of duct cross-sections, indicate that the excess pressure loss over the normal friction loss is a dynamic loss due to a faster stream expanding into a slower stream, as determined by the actual areas occupied by the flow rather than the areas of the duct. No perceptible dynamic loss is due to the converging of the air stream itself where the flow is contracted, but the air stream continues to converge beyond the edge of the contraction and reaches a minimum at the *vena contracta*. This contraction of the air stream is shown in Fig. 8. For contraction, therefore, the dynamic loss is caused by expansion from the vena contracta to the full area following the contraction. Enlargement in area may be considered as a special condition of general expansion following contraction. Fig. 8 illustrates (a) abrupt enlargement and (b) abrupt contraction.

For a sudden symmetrical enlargement, a theoretical expression for the loss is:

$$h_e = \left(1 - \frac{A_1}{A_2}\right)^2 \frac{v_1^2}{2g} = \frac{(v_1 - v_2)^2}{2g} \qquad (6)$$

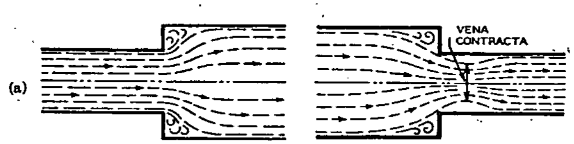


FIG. 8. AIR FLOW AT ABRUPT ENLARGEMENT OR CONTRACTION OF AIR STREAM



or for standard air:

$$H_e = \left(1 - \frac{A_1}{A_2}\right)^2 \left(\frac{V_1}{4005}\right)^2 = \left(\frac{V_1 - V_2}{4005}\right)^2 \qquad (7)$$

*where*

$h_e$ = pressure loss due to sudden enlargement, feet of fluid flowing.
$H_e$ = pressure loss due to sudden enlargement, based on standard air, inches of water.

TABLE 3. PRESSURE LOSS IN VANED ELBOWS OF SQUARE CROSS-SECTION EXRESSED IN ADDITIONAL EQUIVALENT DUCT LENGTH[a, b]

*Additional Equivalent Length L = Duct Width W, in Feet, Multiplied by L/W Values Shown*

| MITER ELBOW | | | | | | | |
|---|---|---|---|---|---|---|---|
| $R_1$, W | $R_1/W$ | 0 | .2 | .4 | .6 | .8 | 1.0 |
| | $L/W$ | 70 | 34 | 28 | 33 | 54 | 60 |
| $R_1$, $R_2$, $R_3$ | $R_1/W$ | 0 | .2 | .3 | .2 | .3 | |
| | $R_2/W$ | 0 | .4 | .5 | .4 | .5 | |
| | $R_3/W$ | 0 | 0 | 0 | .6 | .7 | |
| | $L/W$ | 70 | 22 | 22 | 18 | 20 | |

| A | B | C |
|---|---|---|
| L/W = 20 | 14 | 15 |
| **D** | **E** | **F** |
| L/W = 15 | 28 | 70 |

| ELBOWS WITH VARIOUS RADIUS RATIOS | | | | | | | |
|---|---|---|---|---|---|---|---|
| R/W = 0.5 ($R_1$, W) | $R_1/W$ | 0 | .2 | .4 | .6 | .8 | 1.0 |
| | $L/W$ | 60 | 20 | 19 | 24 | 30 | 60 |
| R/W = 0.5 ($R_1$, $R_2$) | $R_1/W$ | 0 | .2 | .3 | .4 | .5 | .6 |
| | $R_2/W$ | 0 | .4 | .5 | .6 | .7 | .8 |
| | $L/W$ | 60 | 16 | 19 | 20 | 21 | 24 |
| R/W = 0.7 ($R_1$) | $R_1/W$ | 0 | .4 | .6 | .8 | 1.0 | 1.2 |
| | $L/W$ | 24 | 13 | 12 | 14 | 21 | 24 |
| R/W = 1.0 ($R_1$) | $R_1/W$ | 0 | .7 | .8 | .9 | 1.0 | 1.2 |
| | $L/W$ | 10 | 8.0 | 8.0 | 7.4 | 7.2 | 7.4 |

[a] These values are based upon vane test data of Reference 13 which have been modified by the findings of Reference 9.

[b] Vanes: A = a large number of small arc vanes; B = a small number of large arc vanes; C = hollow vanes having different outside and inside curvature; D = four vanes with radius of 0.4 $W$; E = single splitter with radius of 0.5 $W$; F = no vanes or splitters.

$v_1$ = velocity in the inlet duct, feet per second.
$v_2$ = velocity in the outlet duct, feet per second.
$V_1$ = velocity of standard air in the inlet duct, feet per minute.
$V_2$ = velocity of standard air in the outlet duct, feet per minute.
$A_1$ = area of the inlet duct, square feet.
$A_2$ = area of the outlet duct, square feet.

The loss for a sudden symmetrical contraction, $h_c$ can similarly be expressed as

$$h_c = \left(1 - \frac{A_2'}{A_1}\right)^2 \frac{(v_2')^2}{2g} \qquad (8)$$