area actually occupied by the air flow, for convenience they are divided into two general classes—those caused by *changes in direction* of the duct and those caused by *changes in cross-sectional area* of the duct. Conduit transitions are representative of changes in cross-sectional area and bends (elbows) are representative of changes in direction of the duct.

Shock losses vary substantially as the square of the velocity of the air flow and are therefore conveniently expressed as a fraction of the velocity head.

$$h_v = c\,\frac{v^2}{2g} \tag{4}$$

where

h_v = the total shock pressure loss, inches of water.
v = velocity of air, feet per second.

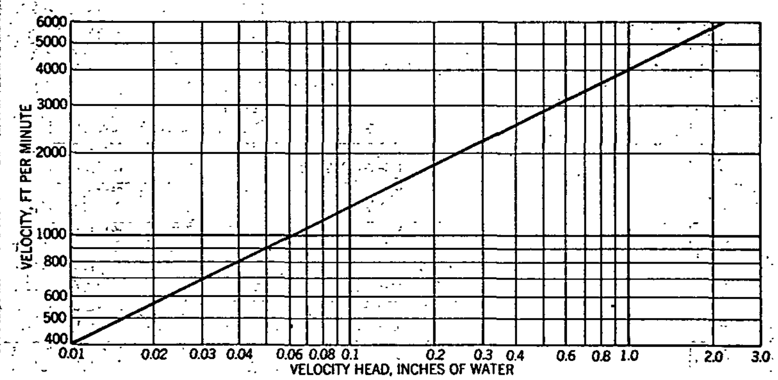

FIG. 3. RELATION BETWEEN VELOCITY AND VELOCITY HEAD FOR STANDARD AIR

$\frac{v^2}{2g}$ = the velocity pressure corresponding to the mean velocity of flow, inches of water.
c = an empirical factor based on experiments and termed shock factor or loss coefficient.

It can be seen from Equation 4 that the shock factor is independent of both density and the unit used and that it represents the number of velocity heads lost at the conduit transition or bend. Values of the shock factor for various duct elements are sometimes tabulated[6,7]. It should be kept in mind, however, that absolutely reliable shock factors have not yet been fully established for all duct elements and that difficulties have been encountered in correlating experimental data of different investigators. A comprehensive study of the loss factors of duct elements is being conducted by the A.S.H.V.E. Research Laboratory for the purpose of obtaining exact data.

For standard air Equation 4 changes to:

$$H_v = C\left(\frac{V_m}{4005}\right)^2 \tag{5}$$

where

H_v = total shock pressure loss, inches of water.
V_m = velocity of air stream, feet per minute.
C = an experimentally determined constant (shock loss coefficient).

Fig. 3 which shows diagrammatically the relation of velocity pressure to velocity for standard air ($V_m = 4005\sqrt{H_v}$) can be conveniently used to find the total shock pressure loss for any duct element with known shock loss coefficient C.

Shock losses are independent of the roughness of the duct walls and therefore cannot be computed correctly as friction losses. It is neverthe-

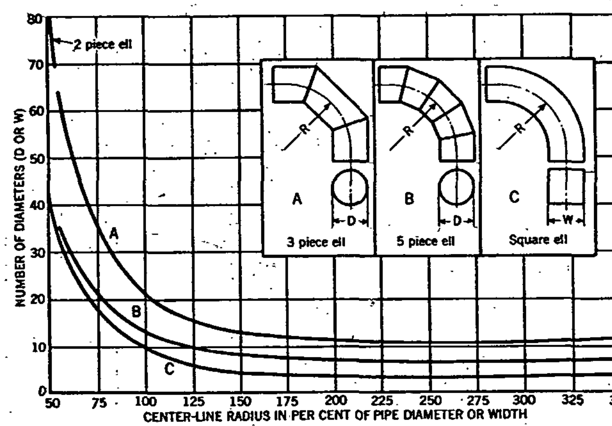

FIG. 4. LOSS OF PRESSURE IN ELBOWS

less customary to express the dynamic and friction losses in duct sections or elements in equivalent length of duct in feet or in diameters to facilitate their computation as friction losses. Formulas have been developed for expressing these relations[8].

PRESSURE LOSSES IN ELBOWS

It is customary to express the dynamic and friction losses in elbows as equal to a number of diameters of round pipe, or a number of widths of rectangular pipe, or equivalent length of duct[9]. The curves in Fig. 4 give the number of diameters or widths of pipe which have a frictional resistance equivalent to the pressure drop in the elbows. Curves B and C are based on tests of round and square elbows[10] of ordinary good sheet metal construction.

Values obtained from Curve A should be used when there is any doubt as to quality of duct construction. It is suggested that this curve be used for rectangular elbows and five-piece elbows as it will thus allow an additional factor of safety without seriously affecting the design.

As indicated in Fig. 4, long radius elbows will offer much less resistance to the flow of air than short radius elbows. Experience has shown that