Values for C_1 are given in the following table:

Total Included Angle, Degrees	5	7	10	20	30	40	50	60
C_1	0.20	0.15	0.16	0.35	0.65	0.80	0.92	1.0

PRESSURE CHANGES

The fundamental energy equation for standard air flow in a horizontal duct can be written[15]

$$H_1 + \left(\frac{V_1}{4005}\right)^2 = H_2 + \left(\frac{V_2}{4005}\right)^2 + \text{Loss of Pressure (head)} \qquad (12)$$

where

H_1 and H_2 = the static pressure (head) at two given points (1) and (2), inches of water.

$\left(\frac{V_1}{4005}\right)^2$ and $\left(\frac{V_2}{4005}\right)^2$ = the velocity pressure (head) at the same points, inches of water.

Equation 12 states that the mechanical energy at a given point (1) must be equal to the mechanical energy at another point (2), plus any dissipation of mechanical energy to internal energy (loss of pressure). Equation 12 is only valid, if no work is done by or upon the air between the sections (1) and (2), and if there is no heat transfer to or from the air.

In Equation 12, H is a measure of the potential energy and $\left(\frac{V}{4005}\right)^2$ a measure of the kinetic energy or energy of motion. The sum of static pressure and velocity pressure is called total (dynamic, impact) pressure, and is a measure of the total energy.

Static pressure and velocity pressure are mutually convertible, that is to say, static pressure may be transformed into velocity pressure, and vice versa. Every change in the cross-sectional area of a duct results in such a conversion of energy, which is always accompanied by some loss in efficiency, or loss in total pressure.

In the final analysis of pressure losses in ducts, shock losses are therefore due to accelerations and decelerations of the air stream as a whole. In a *converging* duct, the air velocity will be accelerated; some pressure head will be converted into velocity pressure. This conversion is generally a stable and efficient process, the energy losses are small, and there is no eddy formation.

In an *expanding* duct section on the other hand, the air will be decelerated and an opposing pressure gradient is required to reduce the velocity. If the angle of divergence is appreciable, the flow becomes unstable, there is danger of separation of the flow from the duct wall, and large energy losses and eddy formation are possible.[16]

In order to keep losses in an expanding duct section to a minimum and to convert the velocity pressure efficiently into static pressure, the angle of divergence should be kept small.[17] Theoretically, it might seem possible to increase the duct area so gradually that the reduction in velocity and accompanying loss of velocity pressure would occur reversibly, and thus permit 100 per cent conversion to static pressure. Such an ideal application of the principle of *static regain* in duct design is, of course, impossible

for various reasons[18] such as: the necessity of using sections of uniform diameter because of cost, the need for using ducts of dimensions varying in full inches, the changing of duct sizes mainly at branch connections, and the inevitable loss due to turbulence. The principle of static pressure regain is, however, of importance in the economical design of duct systems.

Fig. 7 shows the application of static pressure regain to a simple fan and discharge duct.[19] The fan in the upper part of the figure has a free inlet and discharges air through a straight duct, the diameter of which is equal to the fan outlet. The total pressure which must be provided by the fan is therefore the sum of the pressure that is necessary to overcome the friction in the duct (no shock pressure loss), plus the velocity pressure which in this case is the same at any location along the length of the duct.

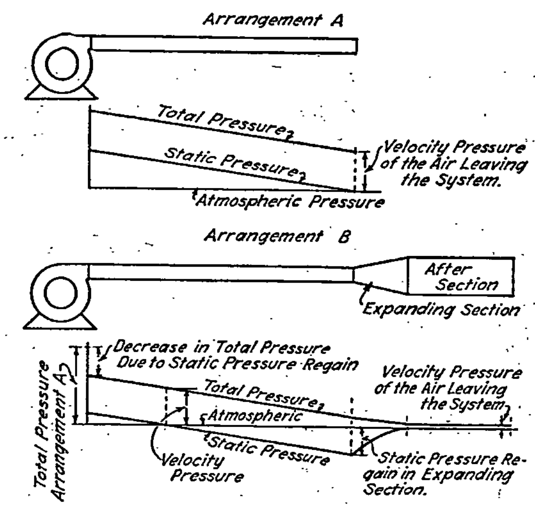

Fig. 7. Application of Static Pressure Regain to a Simple Fan and Discharge Duct

In arrangement B in the lower part of Fig. 7, a diverging section, with after section, has been added to the straight duct. The velocity in the diverging section is therefore decreased, and velocity pressure converted into static pressure before the air is released to the atmosphere. It can be seen that in case B, the total pressure at the fan outlet is less than in case A, and thus a saving in horsepower can be effected.

The regain in static pressure h_r in an abruptly expanded section is the difference in the velocity pressures of the small and the large duct, minus the shock pressure loss (Equation 6):

$$h_r = \left[\frac{v_1^2}{2g} - \frac{v_2^2}{2g}\right] - \left[\frac{(v_1 - v_2)^2}{2g}\right] \qquad (13)$$

or simplified

$$h_r = \frac{v_1 v_2 - v_2^2}{g} = \frac{v_2(v_1 - v_2)}{g} \qquad (14)$$