# Chapter I

# INTRODUCTION



## 1.1. Statement of the Problem

It is well-known that a cyclone occurs when the central area of the air has a lower air pressure than the surroundings. This phenomenon gives rise to the idea of designing a device which causes the motion of air simulating cyclonic action. The device designed has a low air pressure at the center of the motion. If a pipe is connected to the divice at the center of a cyclone, the low air pressure (vacuum) in the pipe can be used to suck some materials into the device. Then these materials can be conveyed to the desired destination.

The purpose of this research is to design the device mentioned previously and to study some of its characteristics. The device will be called "CYCLONE" in this thesis. The word "Cyclone" is capitalized when it is mentioned as the divice to distinguish it from the other meanings. The Cyclone will be used to transport materials from one place to another. Therefore, it may be called, according to its function , "CYCLONE CONVEYOR".

However, so far as the survey has been done it is apparent that the study of cyclone used as a conveyor has not been investigated. Therefore, it may be regarded as the first study on this subject.

## 1.2 Pneumatic Conveyor[2,5,6,7]

Before introducing a system of a Cyclone conveyor, it is necessary to describe briefly systems of pneumatic conveyor, since it will be clear later that the system of the Cyclone conveyor may be said to be one of pneumatic conveying systems.

The term "pneumatic conveyor" is commonly used to describe methods of transporting bulk materials by means of compressed air power, negative or positive. There are no available industrial standards that define the terms used to describe various type of pneumatic conveying systems. However, three commercially available systems are recognizable :

(i) Material-into-air-stream system

In these systems material enters a stream of air under either negative or positive pressure, or is induced into the stream of air by vacuum. These comprise the familiar so-called pressure systems, negative pressure or vacuum systems, and variations of them, such as the combination vacuum-pressure and loop systems.

(ii) Air- mixing systems

In these systems air and material are intermixed simultaneously at the entrance of the conveying line. These systems resemble the first type, in which material enters an air stream, except that air and material are intimately intermixed in a special type of feeder at the entrance to the conveying line, resulting in a denser stream of material than is otherwise possible to obtain.

(iii) Air-into-material (Blower-tank)

In these systems air enters into a mass of material to cause flow. The operating pressures of the systems range from 10 to several hundred pounds per squre inch, depending upon the applications. These comprise the familiar pressure-tank bulk trailer systems and less familiar in-plant blow-tank systems.

The material-into-air-stream type of system is the most versatile of the three types of systems and can handle a wide variety of materials over a wide range of conveying velocities. The velocities can be reduced sufficiently to handle many friable materials without breakage, and many abrasive materials without excessive erosion of piping and equipment. In addition, the low material-to-air-ratio used permits handling of materials with a minimum of contact between particles. This makes the system ideal for handling a variety of particle shapes and sizes without blockage of the conveying line.

Only the further details of the material-into-air-stream system will be described here. Three types of systems-vacuum system, pressure system, and combination vacuum-pressure system-which are based on this principle, are as follows :

The nagative pressure, or vacuum, system (see Fig. 1-1)

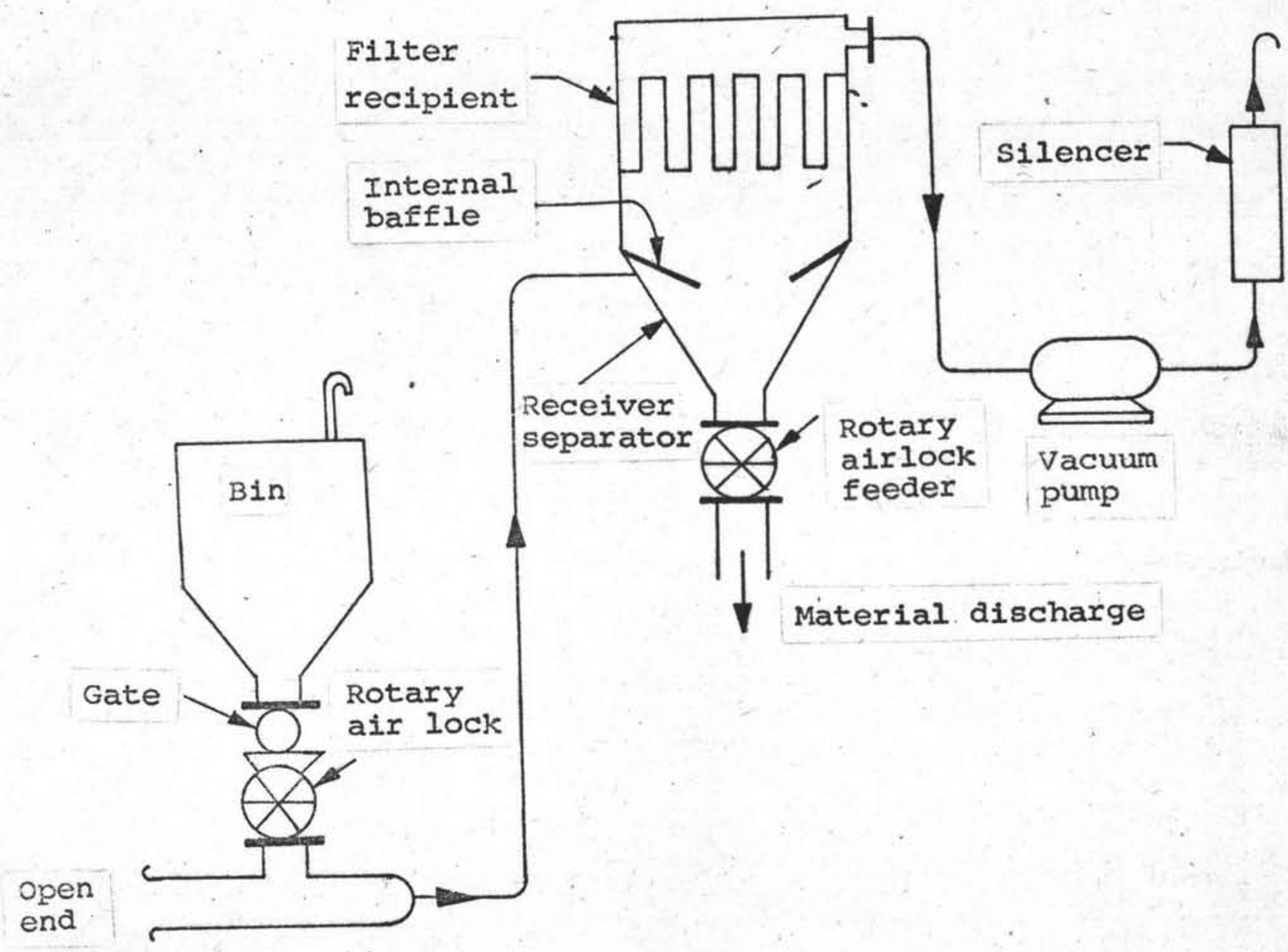


Fig. 1-1 NEGATIVE-PRESSURE, OR VACUUM SYSTEM

is used when conveying from a multiplicity of pickup points or points of origin to a single delivery destination. A high - velocity airstream is established in the conveying line by air entering the suction side of positive-displacement or centrifugal blower. Material is drawn directly into a pick up nozzle,or hopper. It may be entered via a rotary airlock feeder supplied with material by gravity or by mechanical conveyor.
The airstream then conveys the material to a receiver-separator from which the material is discharged through a second rotary airlock feeder to one or more storage bins. The conveying air passes through a dust filter and the vacuum producer(or pump), and then to atmosphere. In this system, blowers used as vacuum pumps are limited to a vacuum of about 13 in Hg.

In the positive-pressure system, or pressure system, a high velocity air stream is established in the conveying line by the air discharged form a positive-displacement or centrifugal blower through an injector fitting (see Fig. 1-2). Material is withdrawn from a storage vessel by gravity or mechanical conveyors and is delivered to a rotary airlock feeder. The feeder then discharges the material into the airstream, which transports it through a pipeline to a vented receiver. Between the outlet of the blower or other appurtenances, piping is used to deliver the air to the material intake of the system. In this piping a check value should be installed. The purpose of this check value is to prevent blowback of material and air into the blower in the event of a power failure or other mulfunction. This

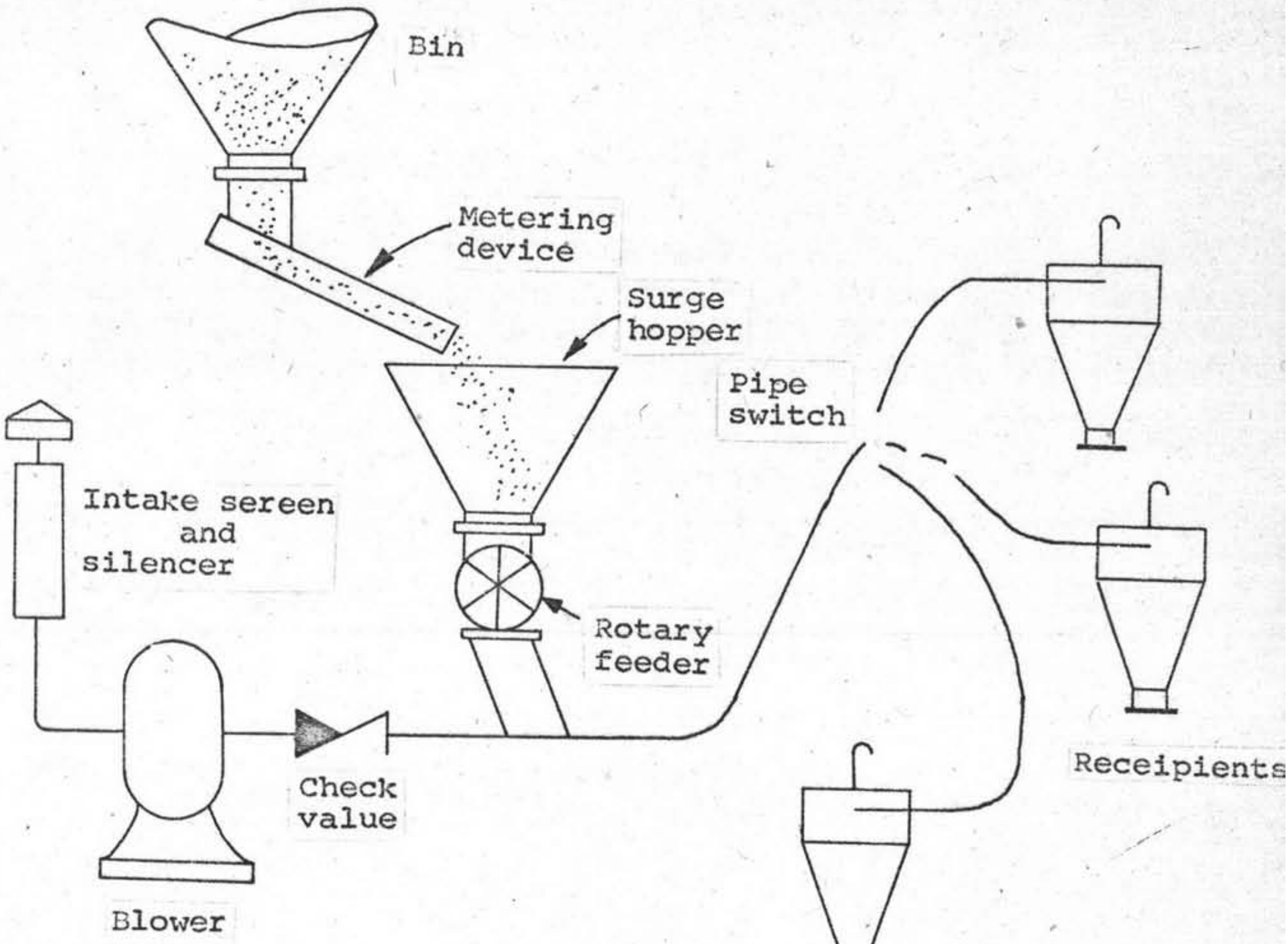


Fig. 1-2 POSITIVE-PRESSUR, OR PRESSURE SYSTEM

system is generally applied when material must be delivered to number of widely separate receivers located at considerable distance from the source of supply.

The combination vacuum-pressure system is used to perform two functional operations simultaneously-namely, pickup of material from each of several sources of supply and discharge to each of several delivery locations. Another use is where vacuum unloading of transports is required, along with pressure deliverly to several locations. The material is drawn directly into a negative-pressure system and taken out by a receiver-separator discharging the air to a vacuum producer as described above. After discharge from the vacuum system, the pressure system can be any of the types-low, medium, or high-depending on the materials being conveyed and the distance to be transversed.

The original vacuum-pressure system is one that uses the positive pressure as a combination exhauster-blower. This system (see Fig. 1-3), however, has limited use since the combined load, vacuum and pressure across the blower is limited to the maximum allowable differential, this machine is subjected to, normally 12 psig. Since the maximum vacuum used in that leg of the system is usually 12 in Hg.(6 lb for all practical purposes), the maximum pressure, therefore, is limited to 6 psig. If higher pressure are required, the vacuum side would have to be designed to operate at lower vacuum, thus staying within the allowable differential across the blower.

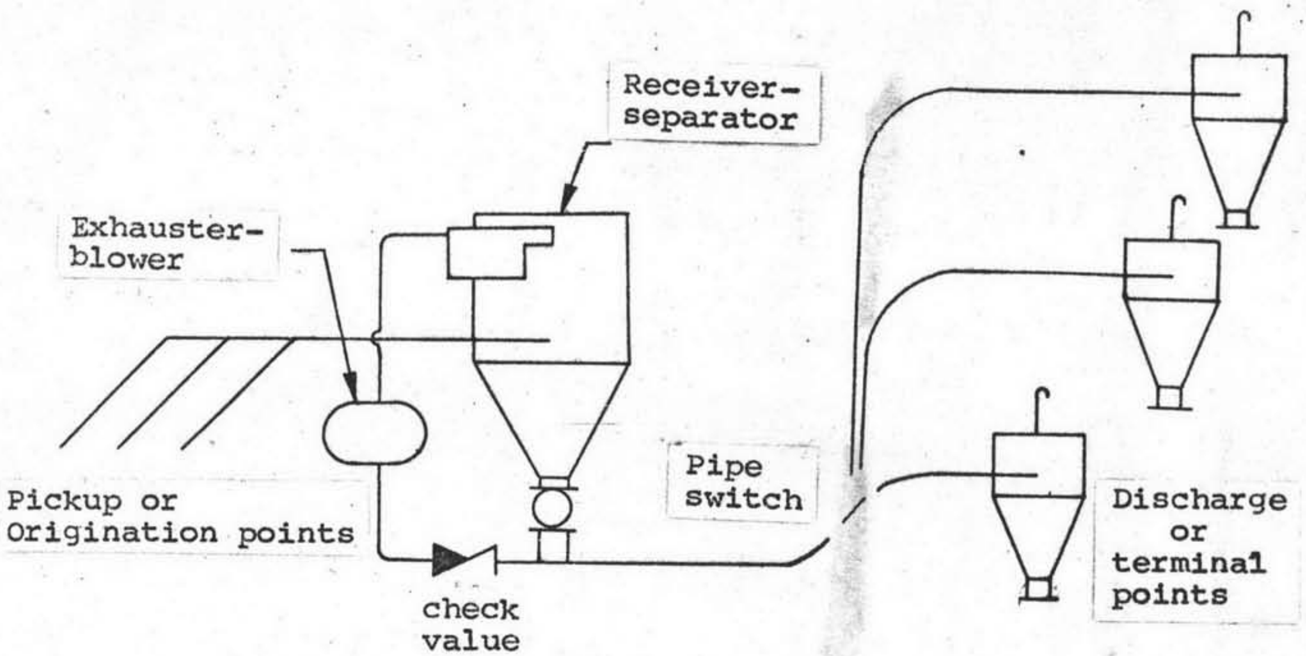


Fig. 1-3 COMBINATION VACUUM-PRESSURE SYSTEM USING

A SINGLE BLOWER

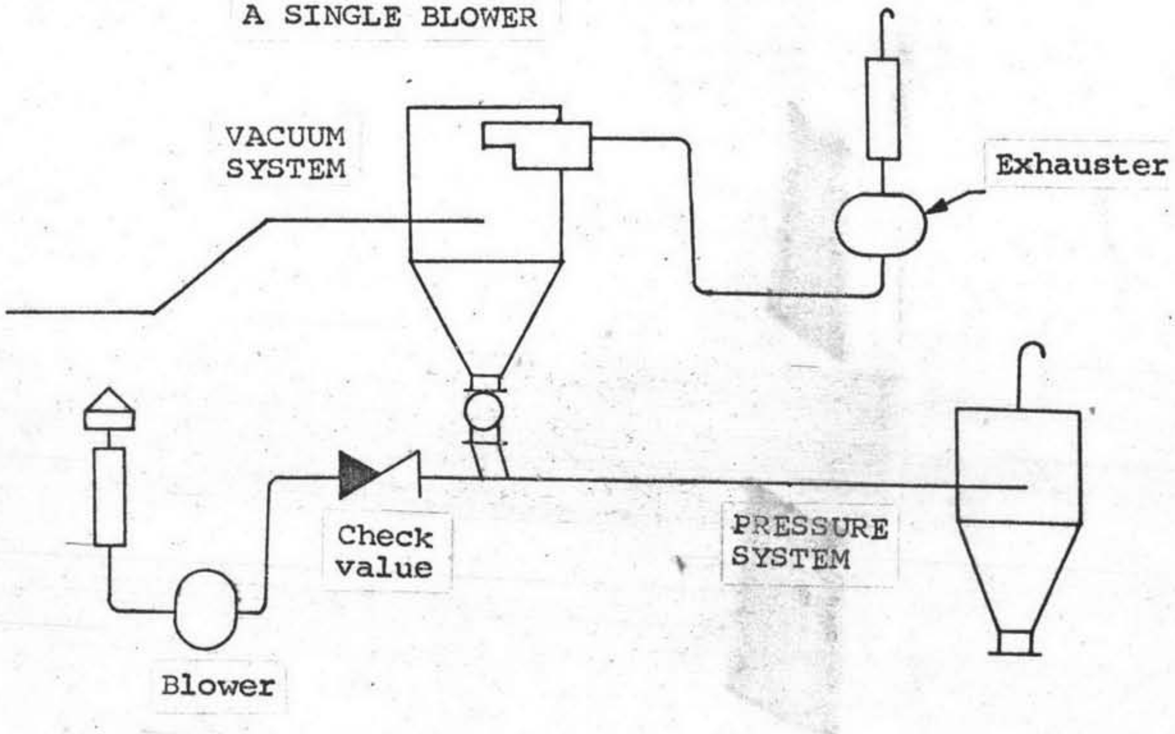


Fig. 1-4 COMBINATION VACUUM-PRESSURE SYSTEM USING

SEPARATE BLOWERS

To avoid this restriction, the two legs of the system are completely divorced, making the vacuum and pressure systems separate entities (see Fig. 1-4). They are, however, interlock to prevent mulfunction of either one in relation to the other. It is at this point that any type of pressure system could be used, though mostly low-and medium-pressure systems are used.

## 1-3 Scope of Research

The Cyclone, as designed, is an inverted cone with an apexing cut at a certain diameter. The bottom-end diameter of the Cyclone is kept constant at 7.5 cm and the sizes of an inlet nozzle, a discharge pipe, and a suction pipe are also constant. Twenty Cyclones with variable half cone angles and Cyclone heights are built. The half cone angle is defined as the "CYCLONE ANGLE" from now on. The Cyclone angles are varied at 0,5,10,15, and 20 degrees with constant Cyclone heights. At each constant Cyclone angle the Cyclone heights will be varied at 7.5,15,30, and 45 cm respectively.

The first stage of experimentation is to study vacuum production in Cyclones. The experiments will give Cyclone characteristics, when the Cyclone angles and the Cyclone heights are changed. These experimental results will give information as to what Cyclone angle and Cyclone height will produce the maximum vacuum in the Cyclone. The greater the vacuum in the Cyclone, the greater the rate of conveying of materials.

In the last stage some Cyclones, which are likely to convey a greater amount of materials, are used to convey sand, cane-sugar, and tapioca.