Chapter 1

INTRODUCTION AND SCOPE OF THE WORK

1.1 INTRODUCTION

Many devices have been developed for measuring the concentration of condensation nuclei and cloud condensation nuclei (hereafter referred to as C.C.N.), but none of them satisfies all the requirement of modern atmospheric physics. The actual supersaturation obtained in counters based on air cooling by adiabatic expansion no longer corresponds to that calculated from dry adiabatic equations. Experimental works initiated by different workers \cite{1,2,3} must obviously be continued and theoretical studies are also necessary to solve this problem. The limitation of isothermal method or chemical diffusion method is that the supersaturation in this chamber may seriously be effected when it is employed to measure the concentration of condensation nuclei. In fact the gaseous hydrogen chloride or its aqueous solution usually interact with the C.C.N. particle, i.e. substances in the nucleus composition mainly into oxides or carbonates. Due to this interaction the supersaturation over droplet containing dissolve substances will be much lower than that calculated from theoretical formula. Twomey \cite{37} discussed the limitation of chemical diffusion chamber. The different temperature method or thermal diffusion chamber (hereafter referred to as T.D.C.) is considered to be a most powerful tool in cloud physics for investigating the Supersaturation Spectra and concentration of cloud condensation nuclei. Though the thermal diffusion chamber has the unique advantage of producing a wide range of controllable Supersaturation, however the chamber has some
operational problems which need to be carefully examined before the measurement of C.C.N. particle concentration. The nonsteady state behaviour of a thermal diffusion chamber is a major problem in the measurement of C.C.N. concentration. It is characterized by two type of transients viz. thermal and hydrodynamical. Both of these transients can be avoided if the sample is not introduced in to the chamber at the bottom plate temperature and saturated at that temperature and the sample should be introduced in a laminor flow [5]. The effect of thermal transient under different cases of sample entry is discussed in detail in Chapter IV. In general supersaturation profile inside any standard thermal diffusion chamber is not measured directly. Instead it is computed on the basis of temperature measurement on the two surfaces of thermal diffusion chamber as there exist no direct method of measurement of supersaturation. Lasar back scatter technique [6, 7] is a solution to this problem for the remote measurement of relative humidity. Unfortunately this measurement of study goes beyond the scope of the present thesis.

In general the techniques which are generally adopted for measuring the C.C.N. concentration inside any type of cloud chamber (namely chemical diffusion, thermal diffusion etc.) are as follows (i) Droplet trapping on a support [8] (ii) Photographing the C.C.N. particle [9] (iii) Photoelectric method [10] (iv) Lasar scatter technique [11] (v) Direct observation through a microscopic lens and then use of some emperical formula [4]. The last method is reliable and is adopted in the present work.

1.2 SCOPE OF THE WORK

The aim of the present thesis is to design and develop a fully
automatic thermal diffusion chamber for the simulation of cloud in the laboratory and also to estimate the C.C.N. concentration at different supersaturation as well as in different time of the day. As the present problem can not be discussed in isolation without referring certain other techniques of simulation of cloud in the laboratory. So in Chapter 2, we talk about different method of simulation of cloud in the laboratory namely, the adiabatic air cooling by expansion, the isothermal or chemical diffusion and also the method of different temperature. In order to study the cloud nuclei spectra in the laboratory one has to establish different low supersaturation and also to count the cloud condensation nuclei (C.C.N) at each low supersaturation. So Chapter 3 mainly deals with the development of thermal diffusion chamber. For effective simulation of cloud nuclei spectra of low supersaturation inside the chamber, an automatic temperature controller is designed, developed and calibrated. This method is described in detail in Section 3.3. For the measurement of maximum supersaturation in the centre of T.D.C. for a particular C.C.N. count the actual value of upper and lower surface temperature of T.D.C. is required. For this purpose an electronic method of temperature measurement is adopted and is described in detail in Section 3.4. As the transient behaviour inside the T.D.C. is a major problem in the measurement of cloud nuclei spectra so in Chapter 4, a detail study of the transient behaviour of different physical parameters of our thermal diffusion chamber is made. This problem requires the computation of the solutions of the one dimensional partial differential equations of vapour diffusion and heat conduction under appropriate initial and boundary conditions. These problems are efficiently carried out with
the help of I.B.M 1620 computer available in the computer centre of the Institute of Tropical Meteorology. The computer programme was written by the author and are described in Appendix I. The numerical solutions of the fundamental formulas viz. $K$ and $\alpha$ of the best fitted line which describe the relationship between the C.C.N. concentration against supersaturation are given in details in Appendix II. The details of the computer programme for such determination is also included in Appendix II. Other parts of Chapter 4 deals with the actual observation on C.C.N. concentration at different supersaturation and also day time variation of C.C.N. particle for a particular supersaturation. All these observation are compared with those of ther workers. Chapter 5 deals with some important portable applications of thermal diffusion chamber in connection with its lasar scatter study. The summary of the whole thesis and all its important conclusions of theoretical and experimental results are discussed in Chapter 6.