1968

An experimental determination of the homogeneous nucleation rate of water vapor in argon and helium

Louis Benton Allen

AN EXPERIMENTAL DETERMINATION OF THE

HOMOGENEOUS NUCLEATION RATE OF WATER VAPOR

IN ARGON AND HELIUM

by

LOUIS BENTON ALLEN, JR.

A DISSERTATION

Presented to the Faculty of the Graduate School of the

UNIVERSITY OF MISSOURI AT ROLLA

In Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

in

Physics

1968

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Abstract

An expansion type cloud chamber was used to measure the nucleation rate of water vapor in an atmosphere of helium and argon. A careful study was made of the thermodynamic characteristics during the expansion so that the nucleation data could be interpreted with reasonable accuracy and consistency.

A fine wire thermocouple was used to measure the gas temperature during the course of an isentropic expansion in the dry chamber. When the finite heat capacity of the thermocouple is accounted for, it is found that there is almost perfect agreement with the temperature calculated from the equation of state and the pressure measurement. This establishes the expansion cloud chamber as the instrument with the most accurately known thermodynamic characteristics and the one where the supersaturation may be calculated with the greatest precision.

The homogeneous nucleation rate of water vapor in a helium atmosphere was measured as a function of temperature, supersaturation and sensitive time. It was found that there exists a form of heterogeneous nucleation occurring above the *ion limit* at about the *critical supersaturation* predicted by the classical Becker-Doring theory for homogeneous nucleation. This form of heterogeneous nucleation appears to occur upon chemically bonded centers whose concentration is very low and depends upon the vapor pressure before the expansion. The consistency of the number of these nucleating centers indicates that they may be a

neutral product of the action of natural radioactivity and cosmic rays.

A semiphenomenological theory was developed along the lines of the classical theory but which includes the chemical bond energy of the heterogeneous nucleating center. The *theory* predicts a different temperature dependence for the heterogeneous and homogeneous nucleation rates and at least qualitatively explains the essential features of the experimental data.

A considerable disparity in the temperature dependence of the critical supersaturation limit has existed for many years. The variation in the temperature dependence with nucleation rate as determined by the author's data shows: (a) that a large part of the disparity is due mainly to the interpretation of the experiments and (b) that the different temperature dependence of the heterogeneous and homogeneous nucleation rates is responsible for the different temperature dependences reported by the various experimenters.

It was definitely established that the nucleation rate of water vapor is higher in an argon atmosphere than in a helium atmosphere. This may be due to a disruption factor related to the higher velocity of the *light* helium atoms. It is, however, more likely due to the hydration of the argon atom into the critical cluster with a resultant increased stability in the critical clusters.

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CHAPTER I

STATEMENT OF THE PROBLEM

Man has long been studying the atmosphere, yet it is only in the last few years that technology has advanced to the point where a true understanding of atmospheric processes is possible. This understanding must be turned to useful ends if we are ever to forget the fear of storms, make the deserts bloom or to continue to have clean air to breathe. Of all the problems facing atmospheric scientists, perhaps the most fascinating is that of the action of water vapor in the atmosphere. Water vapor content determines the stability of atmospheric layers and exerts control on the energy balance in the atmosphere[1]. The details of the processes by which the size distribution of droplets in a cloud changes with time is not well understood.[2,3]

Before an understanding of complex processes may be attained, the most elementary and basic processes must be comprehended. Nucleation, the formation of new droplets, is not the simple process that it was once thought to be. Nucleation on particulate matter is a form of heterogeneous nucleation. Atmospheric nuclei serve to lower the energy barrier for condensation. Ions also serve to reduce the free energy of formation of clusters. In the absence of condensation nuclei and ions, droplets begin to form as a result of chance fluctuations at a supersaturation of 4.8 and higher. The latter has been termed homogeneous nucleation. Early experimental results,[4,5,6,7,8] observing the so-called critical limit for heterogeneous nucleation on smoke particles, dust particles, ions and homogeneous nucleation, showed that at least a qualitative explanation was provided by classical theory[9]. Classical theory is based on the idea that a barrier to nucleation exists and that statistical fluctuations carry the embryos over the barrier. A critical size of embryo is associated with the peak height of the free energy barrier. It now appears that a full understanding of homogeneous nucleation is required before the various forms of heterogeneous nucleation may be comprehended. Heterogeneous nucleation, which is the dominant form of nucleation found in nature, encompasses the features of homogeneous nucleation with the addition of extra interfacial energies which greatly complicate the problem.[10]

The semiphenomenological classical theory, developed by Farkas[11], Becker and Doring[12], Zeldovich[13], Frenkel[14] and others for the homogeneous nucleation of liquid drops, seemed at first to predict nucleation rates which showed good agreement with experiment. More definitive experimental data on the nucleation of water drops from the vapor by various groups, namely Volmer and Flood[15] and Powell[16], exhibit self consistency within themselves but display considerable disparity when intercompared. Attempts to compare results comprehensively[17,18,19,20] have only emphasized the pecular nature of homogeneous nucleation in water vapor.

The extent of renewed interest in nucleation phenomena is evidenced by the amount of recent theoretical activity[21-35]. This renewed interest also indicates a general lack of confidence in the classical nucleation theory. Moreover, there has been a resurgence of interest in the experimental measurement of homogeneous nucleation rates.[19,20,36-40]

Most experimental studies have observed the critical supersaturation limit only. The critical supersaturation limit is usually taken as that point where noticeable droplet formation occurs in the expansion chamber. This may be for nucleation rates of from one to one million droplets per cubic centimeter per second, depending upon the details of the observation system and the sensitive time of the apparatus. Due to the nature of most of the experiments where sensitive times and droplet densities are estimated only to an order of magnitude, a given experiment may be intrepreted differently by different authors.[20,36] Since both the estimates of sensitive times and drop densities are usually consistent for a given investigator, the temperature dependence is adequately determined but the nucleation rate to which it belongs is somewhat ambiguous.

Definitive experimental work must be done so that a comprehensive picture of the homogeneous nucleation process may be constructed for comparison with theory. It is the purpose of this study to provide a set of data overlapping that of several other experimenters and to provide the most extensive measurements possible, utilizing the capabilities of the highly automated and instrumented cloud chamber of this laboratory. The investigation undertaken by the author will experimentally determine the homogeneous nucleation rate as a function of sensitive time, supersaturation and temperature.

1-1. Instruments for measuring the nucleation rate. Nucleation theory specifically predicts the rate of formation of droplets as a function of supersaturation and temperature. It is the function of experimentation to verify the essential features of the theory. The nucleation rate is such an exceedingly steep function of increasing supersaturation that, in a rather crude manner of speaking, it exhibits a supersaturation at which the nucleation rate first becomes observable. This has become known as the *critical supersaturation*. Early work directed toward the confirmation of nucleation theory was done with the expansion cloud chamber which was used to measure the aforementioned critical supersaturation. This technique involved an estimation of droplet concentration. Moreover, it was necessary to estimate the nucleation period or sensitive time of the cloud chamber in order to convert the observations to a nucleation rate. Little advance in technique has been reported until recent years. It is improbable that any major developments in nucleation theory will evolve until more definitive experimental measurements are forthcoming. It is to this end that work in this laboratory has been directed.

Several experimental techniques are useful for studying nucleation phenomena. Each possesses its own characteristic advantages and disadvantages. All achieve a state of supersaturation either by adiabatic cooling or by nonisothermal vapor diffusion. The expansion cloud chamber employs the nonisothermal diffusion of vapor to produce supersaturation.

Nucleation phenomena have been studied by means of expansion nozzle techniques by Ruedy[41], Wegener[42] and Pouring[43]. The nozzle method has the advantage of providing a steady state observation. Pressure is measured as a function of position in the flow stream. Deviations from the characteristic isentropic flow indicate the presence of condensation. The complete removal of dust and ions is impractical, but under conditions of rapid production of the condition of supersaturation such high nucleation rates are achieved that any contribution due to heterogeneous nucleation is obscured. Because very high nucleation rates are associated with very small critical cluster sizes, it is improbable that nozzle experiments will be of value in evaluating a nucleation theory which is essentially a precatastropic theory. Moreover, it is likely that the liquid drop model breaks down for such small cluster sizes.

The diffusion chamber was invented in 1939 by Langsdorf[44], but it was not fully developed until the early 1950's.[45,46,47] The gas in the upper part of the chamber must be less dense than the gas in the lower part of the chamber in order to prevent convection currents. Most thermal diffusion chambers operate with the upper plate at the higher temperature. Franc and Herz[48] first described an inverted diffusion cloud chamber, a chamber with water vapor diffusing up from the bottom. A very light gas such as hydrogen or helium must be used for the atmosphere in order to maintain the stability of the system. Katz and Ostermier[39] have used the inverted diffusion chamber to measure the temperature dependence of the critical supersaturation ratio for a number of vapors. Since the determination of the supersaturation is dependent upon an accurate knowledge of the diffusion coefficients for the vapor through the non-condensible gas, they have resorted to measuring the diffusion coefficients over a wide range of temperatures themselves.

The primary advantage of the thermal diffusion chamber lies in the fact that it is a steady state device. However, the fact that the thermodynamic coordinates are changing continuously as a function of position between the parallel chamber plates presents a problem in the determination of the state of supersaturation. Moreover, only a thin layer of the chamber exists at a state of high supersaturation. The thermal diffusion chamber suffers from the disadvantage that it can measure only very small nucleation rates or the so-called critical supersaturation. It is most useful for measuring the temperature dependence of the critical supersaturation.

The expansion cloud chamber is the oldest device used for measuring nucleation rates. It was highly developed by nuclear physicists for the detection of ionizing particles. Moreover, it has undergone additional development in this laboratory as a tool for investigating nucleation and condensation phenomena.[47-52] Extensive studies of the thermodynamic characteristics of the expansion cloud chamber in this laboratory and in other laboratories make it the best understood of all devices available for studying nucleation phenomena. It can yield more information than any of the above mentioned instruments.

Expansion cloud chamber experiments have been customarily designed to yield only a measurement of the critical supersaturation, this is the simplest experiment which can be performed. The definition of the critical supersaturation, as it is used by a given investigator, is obviously influenced by the geometry of the observation system. Droplet densities have either been estimated visually or determined by light scattering techniques. Nucleation rates are estimated by making an educated guess for the sensitive time of the chamber, i.e. that time during which the bulk of the nucleation occurs.

The major advances made in this laboratory are the continuous measurement of the pressure throughout the expansion and the development of techniques for maintaining almost complete control over the expansion cycle. With proper instrumentation and automation, the expansion cloud chamber has an overwhelming advantage over other experimental methods in that nucleation measurements may be undertaken as a function of supersaturation, temperature and sensitive time. No other instrument has been used to measure the dependence of the nucleation rate upon either supersaturation or time. Such diversity of information makes it possible to distinguish more clearly between different types of nucleation schemes. For this reason, the expansion cloud chamber has been selected for this work.

CHAPTER II

EXPERIMENTAL TECHNIQUE

The cloud chamber used in this work was first put into operation in March, 1962 and has undergone continuous improvement since that time, Fig. 1. Great strides were made in regulating the temperature of the cloud chamber. A servo pressure regulation control system was develcped which made possible more accurate control over the starting pressure, thereby insuring accurate saturation at the starting temperature. A mechanical brake was added to the piston guide for damping out piston oscillations during the expansion. A program board was installed to facilitate the interconnection of the programming circuitry to the operating devices such as valves, lights, recorder, etc. These improvements were initiated in whole or in part by the author and contributed substantially to the success of the measurements made during the course of this work.

2-1. Temperature control. Allard[49] used a top to bottom gradient of one Centigrade degree in order to eliminate condensation on the top glass and side walls of the cloud chamber. It was felt that such a large gradient should not be necessary and that a gradient of several hundreths of a degree should suffice. Packwood[50], Schmitt[51], Dawbarn[52], Smith[53] and White[54] all attempted to reduce the magnitude of the graient without much success. Before the problem could be properly assessed, a set of thermocouples was constructed and mounted inside the cloud chamber. They were spaced one inch apart up the side wall and

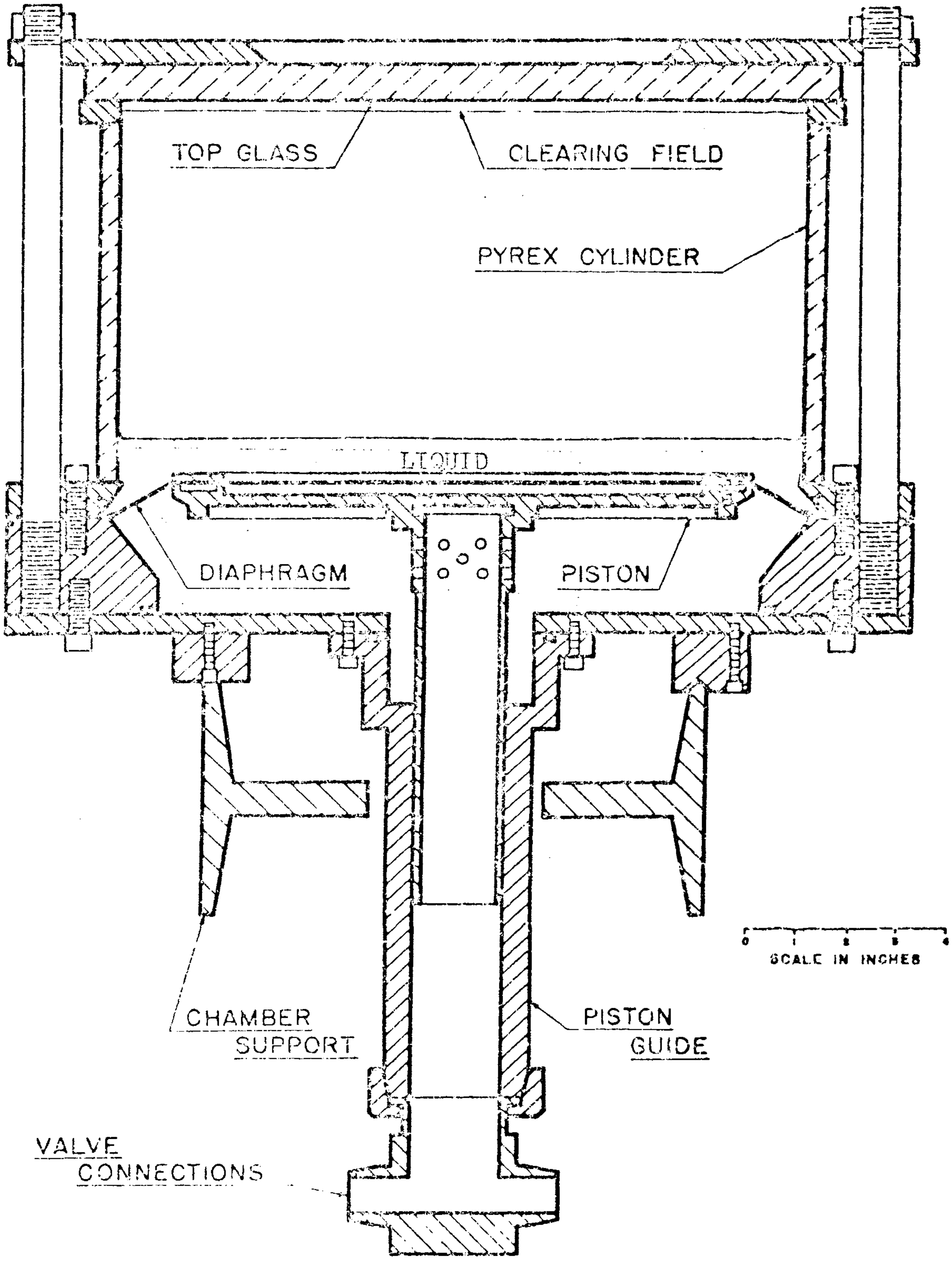


Fig. 1. The cloud chamber used for measuring homogeneous nucleation rates.

across the top. Comparison of temperatures on both sides of the top glass immediately indicated that there was more than one-half degree gradient through the glass. Moreover, about one-half degree difference in temperature existed between the center and the edge of the viewing window, see Fig. 2. The addition of another glass plate on top of the cloud chamber for added insulation did not remedy the problem. Fine heater wires were stretched across the viewing window for independent temperature control of the center of the top glass. One-half watt of heater power sufficed to eliminate the temperature variation across the top glass.

The vertical temperature gradient had to be reduced drastically. It was evident that the top half of the cylindrical wall was too cool. This allowed condensation to occur on the walls where the light beam from the flash lamps passed through the cylinder. This was very undesirable because the condensation scattered the light beam. Heater tapes were mounted just above the light beam. This tape nearly filled the space between the clearing field ring and the light beam. After a week of adjusting the voltages on the three side heaters and two top heaters, good temperature control of the interior chamber was achieved.

As the gradient was brought to less than one-tenth degree, uneven condensation occured at various parts of the chamber top and sides. This indicated that there were gradients across the chamber which were not previously recognized. Before this problem was solved: (a) the convection currents from the air conditioner had to be completely baffled from the chamber by draping one-quarter inch rubber sheet around the chamber frame and associated plumbing, (b) extra foam rubber was added around each of the four sides of the chamber and (c) four separate

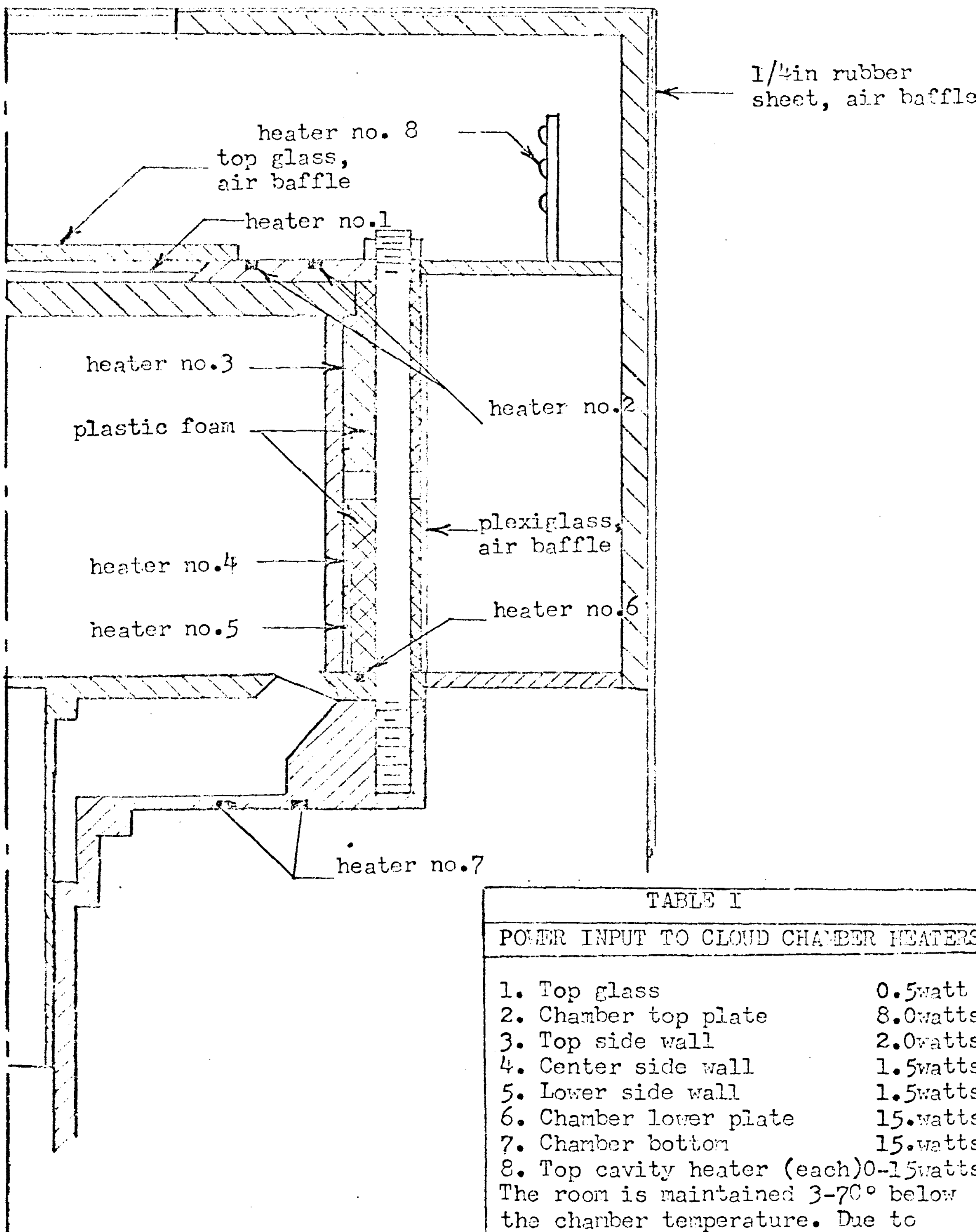


TABLE I

POWER INPUT TO CLOUD CHAMBER HEATERS

1. Top glass	0.5watt
2. Chamber top plate	8.0watts
3. Top side wall	2.0watts
4. Center side wall	1.5watts
5. Lower side wall	1.5watts
6. Chamber lower plate	15.watts
7. Chamber bottom	15.watts
8. Top cavity heater (each)	0-15watts

The room is maintained 3-7C° below the chamber temperature. Due to varying conditions, the above wattages are approximate.

Fig. 2. Arrangement of the cloud chamber heaters.

heaters were added in the top cavity, one on each of the four sides. Temperature gradients across the top cavity due to the forced air convection currents from the room air conditioner are eliminated by individually adjusting the power input to each of the four heaters. Elimination of the cross gradients is best accomplished by lowering the gradient and allowing slight condensation to take place on the top glass and sides. Observation of the condensation tells the location of the cooler areas.

During the regular cycling of the chamber, the temperature of the bottom of the chamber drifted out of control. This was due to the heat pumping action of the cycle. Elimination of this problem consisted of installing new heaters in the aluminum plate under the piston and controlling the temperature of the air coming into the manifold system.

The temperature control during the periods of data taking was not quite as good as the temperature control during the time when the thermocouples were installed in the chamber. Temperature control did not prove dependable enough to use a gradient under 0.05°C and a gradient of about 0.1°C was finally used for convenience. The temperature of the central volume of the cloud chamber in which measurements were being made was therefore known to within the same accuracy as the water temperature, ±0.05°C.

2-2. Pressure regulation. Leaks always occur in the plumbing under the cloud chamber. These leaks must be counteracted by letting excess air into the manifold system at a rate which exactly compensates for the leaks. Up to the time of this series of experiments, there had been no need for the initial pressure regulating system to be adjustable. The pressure regulator described by Allard consisted of a mercury manometer with platinum wire contacts which controlled a regulator valve. This system was naturally oscillatory; the best regulation possible after careful adjustment gave pressure oscillations of about 2 mmHg.

In the new control system a pressure transducer takes the place of the mercury manometer and a servo motor attached to a variable orifice valve, Fig. 3, does the regulating. A trickle of air is continously leaked into the manifold system as with the earlier system and the servo motor controls the valve opening so that the proper leak rate is established to maintain a constant pressure.

Some difficulty was encountered when trying to get the servo system to work. When the servo valve was allowed to pass by the completely "open position" and on to the completely "closed position" or vice versa, an oscillating condition occured. With this arrangement control could only be established when the system pressure was nearly regulated beforehand. Installation of a clutch and stops at the fully opened and fully closed positions eliminated this problem so that the servo system could bring the pressure to regulation from an expansion or compression configuration very quickly without disrupting the sense of the servo control.

It was also found that the location of the pressure transducer controlling the servo motor is critical. It must be located in the same pressure line as the servo valve and be very close to the orifice in order to avoid pressure oscillations. The same biasing technique is used with this transducer as with the pressure transducer in the sensitive volume. The starting pressure may now be held to within one mmHg with practically any volume of trickle air leaking into the manifold

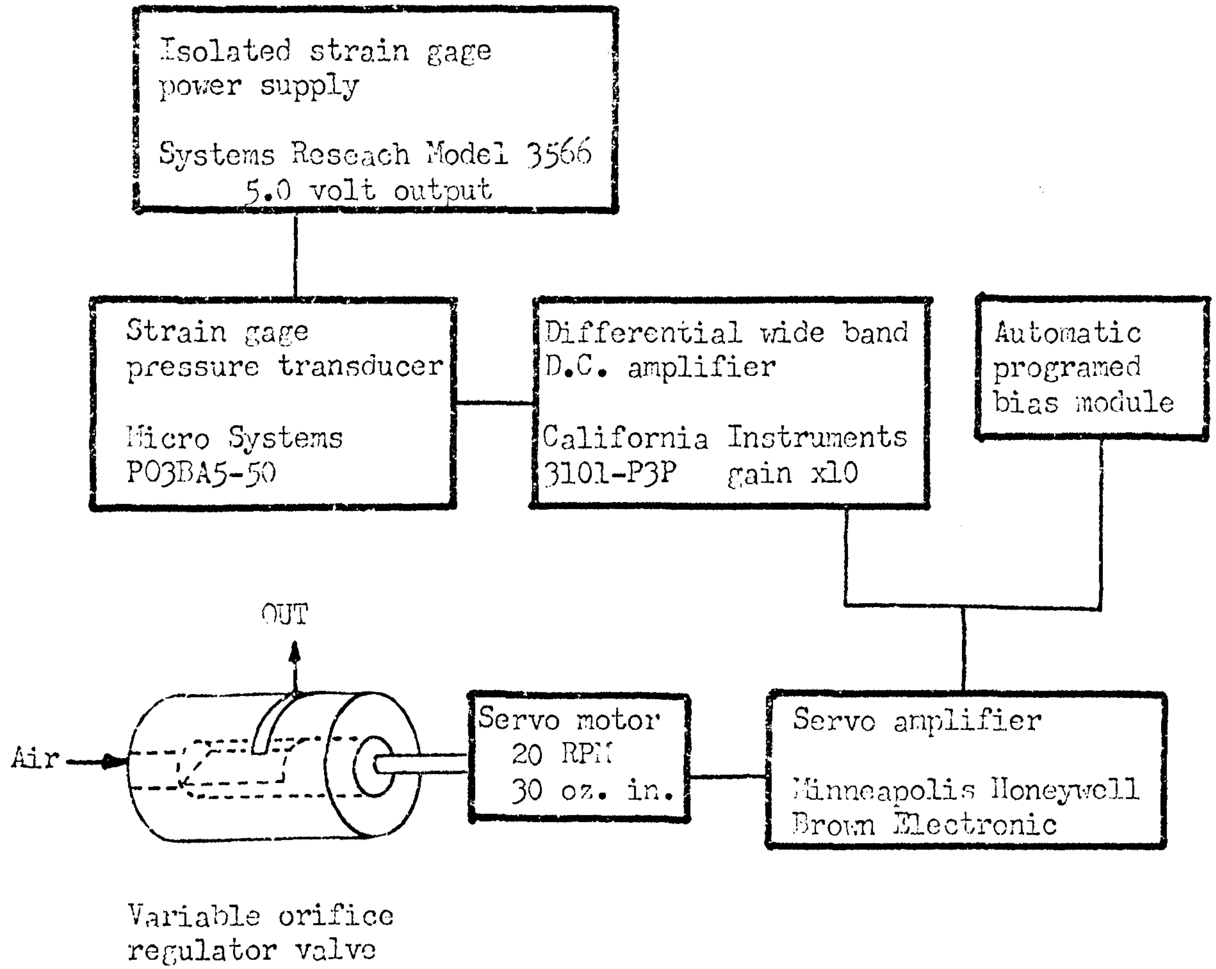


Fig. 3. Block diagram of the pressure regulation system.

system. Recovery is so good that recovery times of less than ten seconds are required to establish any given pressure. The regulating ability of this system seems to be limited only by the capability of the pressure transducer.

2-3. The pressure measuring system. The precision measurement of the pressure in the sensitive volume throughout the expansion is the most critical part of a nucleation experiment. If the supersaturation is to be determined within one percent accuracy, the pressure must be measured to within one mmHg. This requires much better resolution than can be obtained with an ordinary recording system. The stability of all components in the pressure measuring system must be of the order of 0.01 percent. The pressure measuring system employed in this work was essentially the same as that described by Packwood[50]. A block diagram of the pressure measuring system is shown in Fig. 4.

The pressure transducer is a one-quarter inch diameter, flush diaphragm, strain gauge type pressure transducer. Its diaphragm is mounted nearly flush with the inside cylindrical wall of the sensitive volume. It reads absolute pressure. The transducer is excited by a highly isolated transducer power supply which possesses 0.1 micromicrofarad capacitance between its output and power line sides. This specification is necessary to keep the common mode signal to the California Instruments wide band D.C. amplifier at a low level. Triply shielded twisted pair lead wires are used to interconnect all the units. Three separate mutually insulated shields are necessary to keep the A.C. noise level to a minimum. It was also necessary to mount the amplifier and the isolated power supply as close to the pressure transducer as possible.

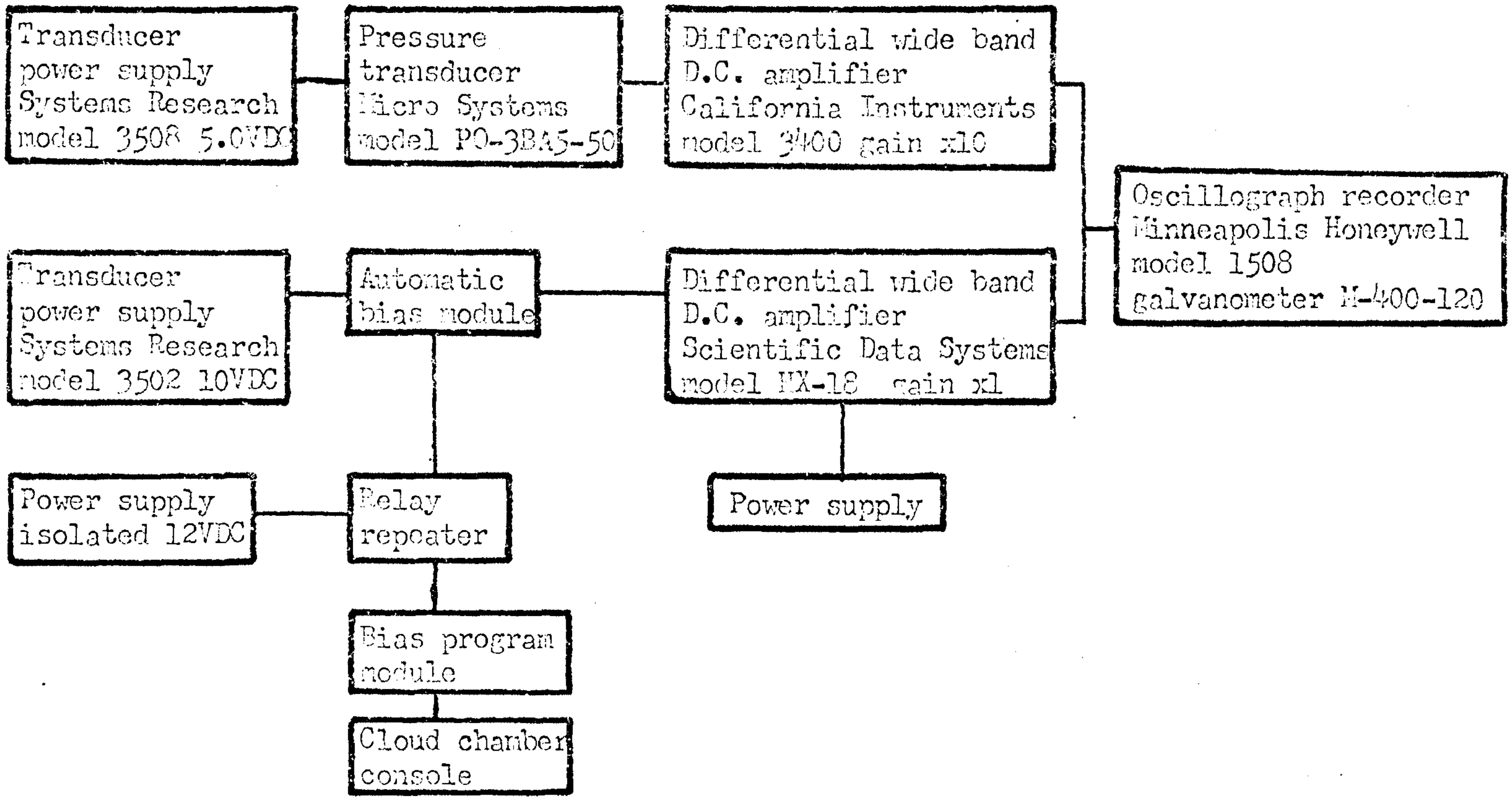


Fig. 4. Block diagram of the pressure measuring system.

In order to obtain the desired accuracy in the recorded pressure signal, a type of scale expansion system was employed. Approximately 1.2 volts D.C. signal emerges from the California Instruments amplifier. Most of this signal is biased out by a constant D.C. voltage from the automatic bias module, having a 0.01 ohm impedence. The remaining 40 millivolts signal is recorded by a light beam oscillograph. Four different bias levels are provided by the automatic bias module. The automatic bias module's circuitry maintains a high level of isolation from both power line and chassis ground. The peak to peak noise level in the recorded signal corresponds to about 0.5 mmHg. Figs. 5-7 show typical data output from the oscillogram.

2-4. Pressure calibration. Pressure calibration was greatly facilitated by the addition of a Texas Instruments Model 145 Pressure gage with a precision servo nulling readout. This type of gage uses a quartz spiral bourdon tube which exhibits no measureable hysteresis and retains its calibration indefinitely. The servo readout follows pressure changes automatically, allowing instant comparison of recorder and pressure gage readings. Hysteresis in the cloud chamber pressure transducer and in the recorder galvanometers presented a problem. The calibration of the pressure transducer had to be accomplished by approaching the desired calibration point in the same manner that the cloud chamber would reach that same point in a normal data taking cycle. Approximately the same magnitude of pressure excursion was used in the calibration procedure as in the data taking cycle. It is probable that some of the difficulties encountered by Allard[49] and Schmitt[51] resulted from improper calibration procedure.

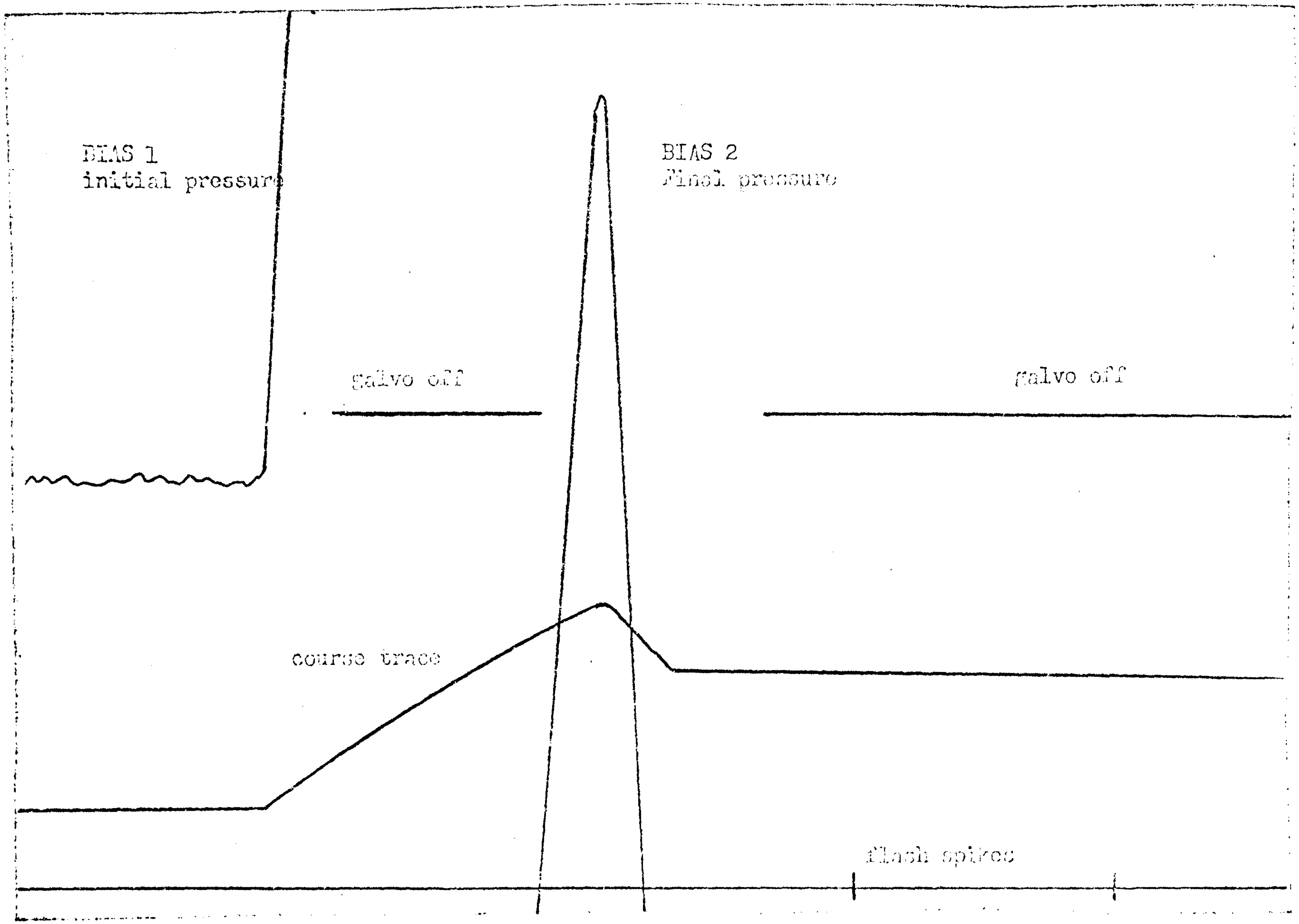


Fig. 5. Sample of visicorder data. Galvanometer sensitivity 9.0mm/in, chart speed 10in/sec.

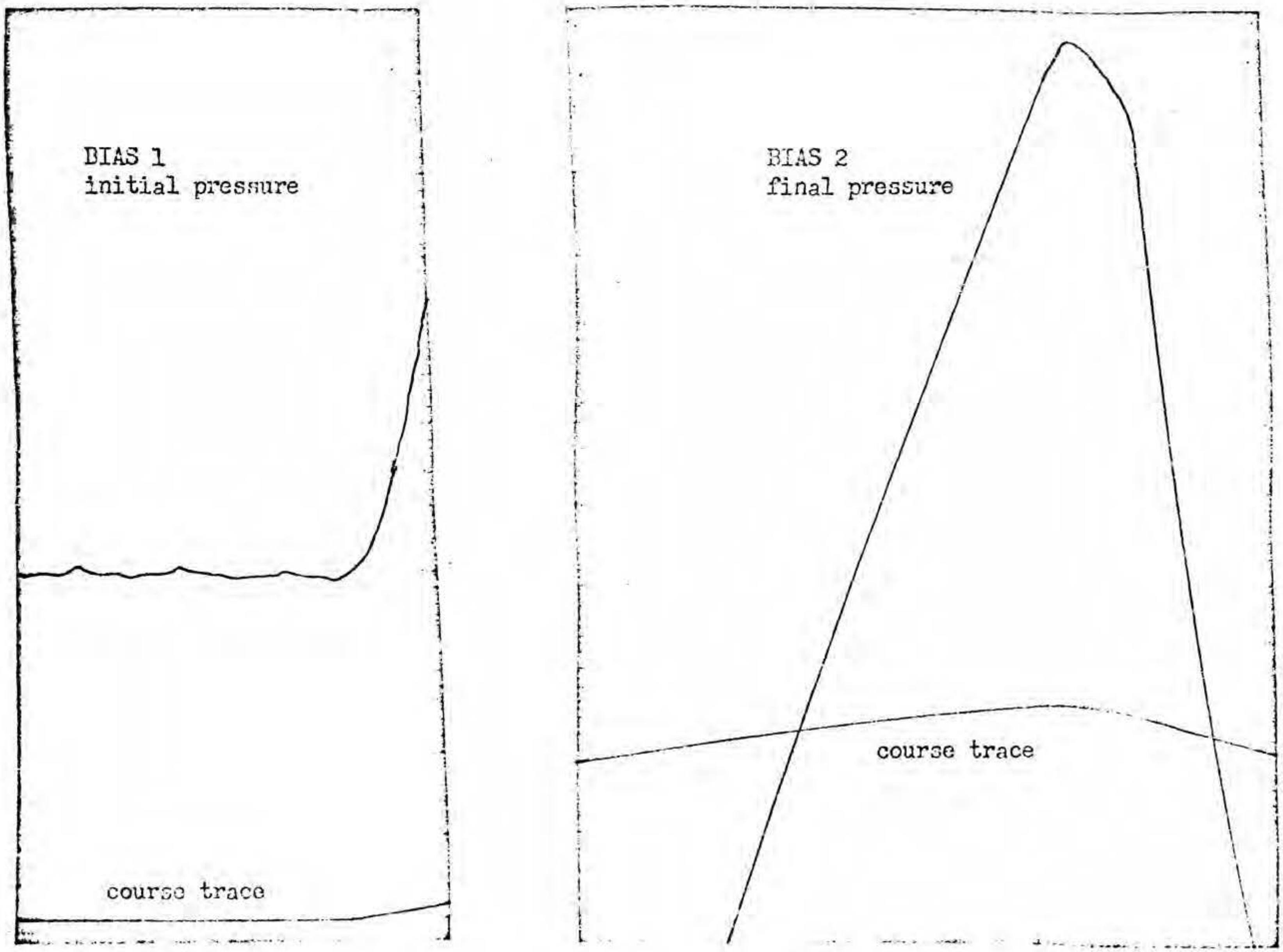


Fig. 6. Sample of visicorder data. Galvanometer sensitivity 9.0mm/in, chart speed 40in/sec.

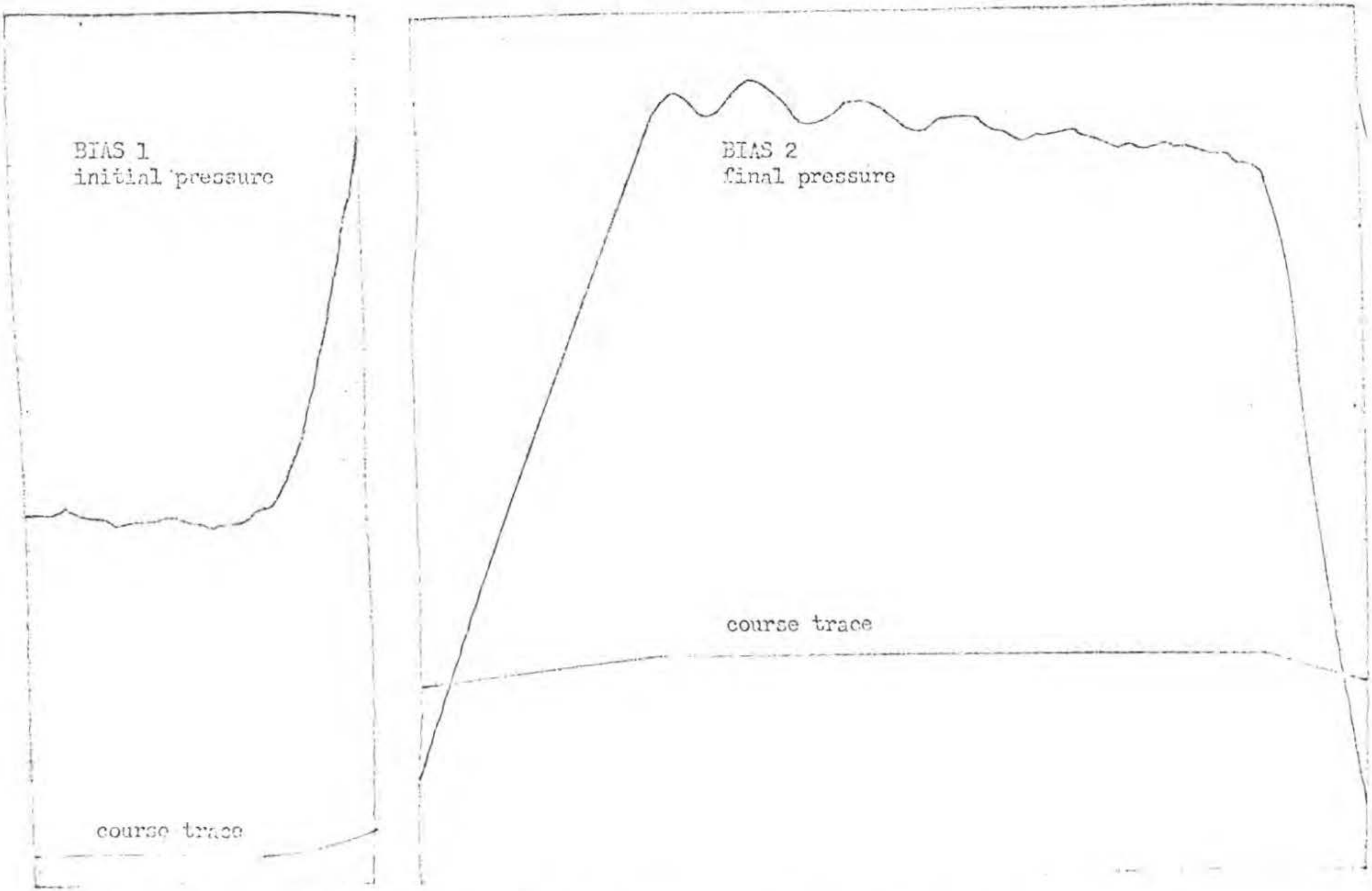


Fig. 7. Sample of visicorder data. Galvanometer sensitivity 9.0mm/in, chart speed 40in/sec.

As the chamber began cycling, the zero offset drifted for about an hour. It is believed that this is the result of the establishment of a slightly different operating temperature brought about by the heat pumping characteristics of the cloud chamber. Calibrations were run every fifteen minutes until three consecutive calibrations, identical to within 0.3 mmHg., were obtained. Thereafter, the calibration was repeated every half hour. Note that by judicous choice of cycle parameters this heat pumping can be almost eliminated.[56]

Since the pressure transducer used a semiconductor strain gage element, it is quite sensitive to changes in its ambient temperature. It was found that the equilibrium temperature of the strain gage element was dependent upon the thermal conductivity of the gas used in the cloud chamber. The calibrations for different gases differ slightly in their zero offset. However, the heat capacity of the pressure transducer was sufficiently large so that temperature changes during the expansion had a negligible effect on the transducer's calibration.

2-5. Photographic technique. In order to determine the nucleation rate, the number of droplets per cubic centimeter must be determined with considerable precision after the expansion. The necessity for imaging individual droplets places strict requirements on the illumination system and photographic technique. Conditions are accurately known only within the central region of the sensitive volume so only this portion is illuminated by means of a horizontal sheet of light whose vertical thickness is about one centimeter, see Fig. 8. Figs. 9 and 10 show the quality of the collimation of the light beam used in this work. The top and bottom edges of the beam exhibited a sharp cutoff in intensity. The droplets have diameters from ten to fifteen microns at the time

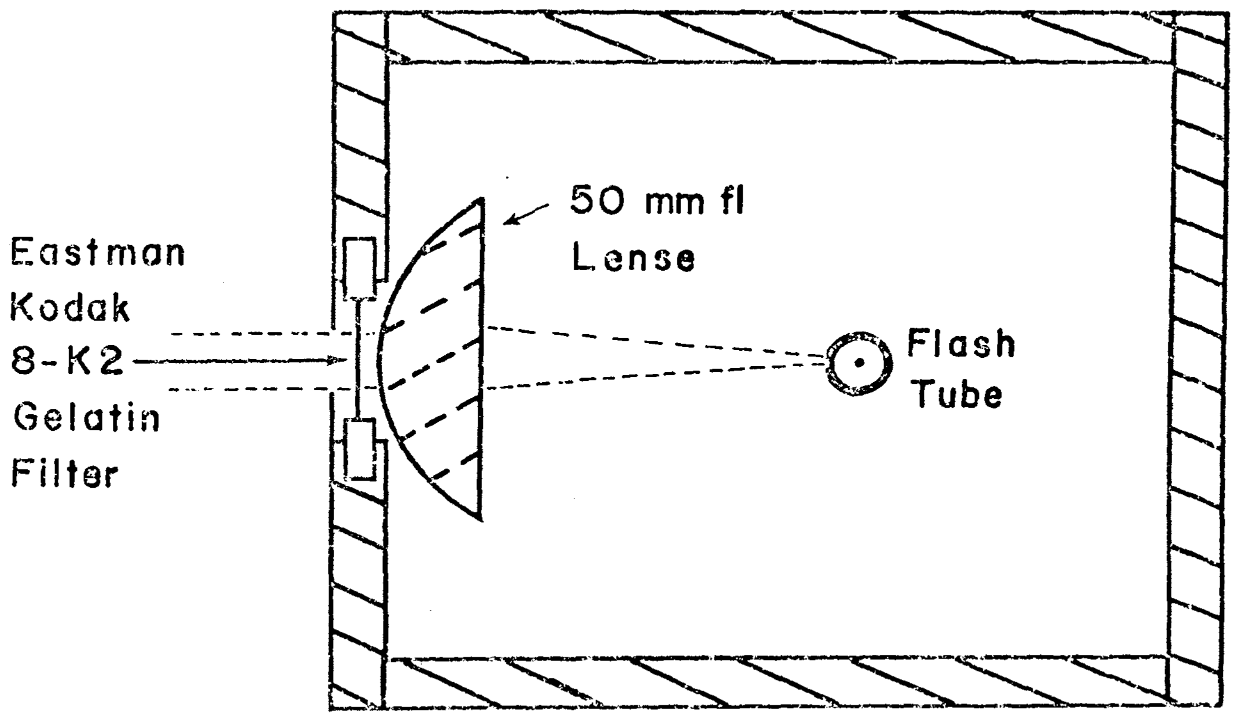


Fig. 3 Flash Tube Light Source

Lamp number 1: collimated July 18,1967 Louis Allen
Don Hoffman

LAMP NUMBER 1

6" from lamp

8" from lamp

10" from lamp

8" from lamp Sensitive paper (Kodak F-4)

Fig. 9.

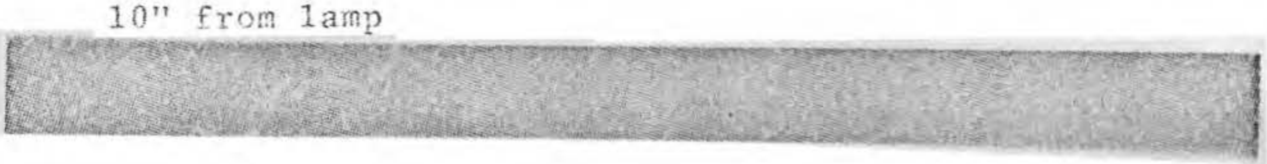
Lamp number 2; collimated July 19, 1967 by Louis Allen

LAMP NUMBER 2

6" from lamp

8".from lamp

10" from lamp



8" from lamp Sensitive paper (Kodak F-4)

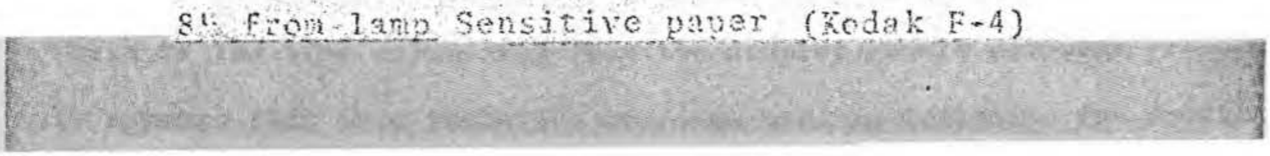


Fig. 10.

they are photographed. It was found that one lamp does not give sufficient illumination. Two lamps were flashed simultaneously on opposite sides of the cloud chamber. The total energy input to the lamps is about 800 joules. The camera was set eighteen inches above the beam. Sufficient intensity and depth of field were obtained with an f-stop setting of 3.5. A grid of wires spaced at one centimeter intervals was photographed and used for calibration of the field of view of the projected film. see Plate 1.

There is an optimum time for photographing the droplets after they are nucleated. Droplet growth is dependent upon several factors which were varied during the course of the experiment, namely supersaturation and the transport characteristics of the inert gas. The optimum time for photographing the droplets was experimentally determined in each case. Growth times varied from 0.05 second in helium at high temperatures to nearly half a second in argon at low temperatures. Plates 2 and 3 show typical homogeneous nucleation for several different droplet densities.

An anomoly showed up in the photographs which was not expected. Droplets photographed at precisely the time they are coming into visible size form rather large diffraction rings on the photograph. Pictures taken slightly later have sharply focused images. This is probably a case of Fraunhofer diffraction through the lens. A calculation assuming Fraunhofer diffraction gives droplet size of the order of ten microns which is the size calculated from the droplet growth computer program. It appears that this technique could be used to determine the droplet growth rate for an accurate verification of the droplet growth law, see Plate 4.

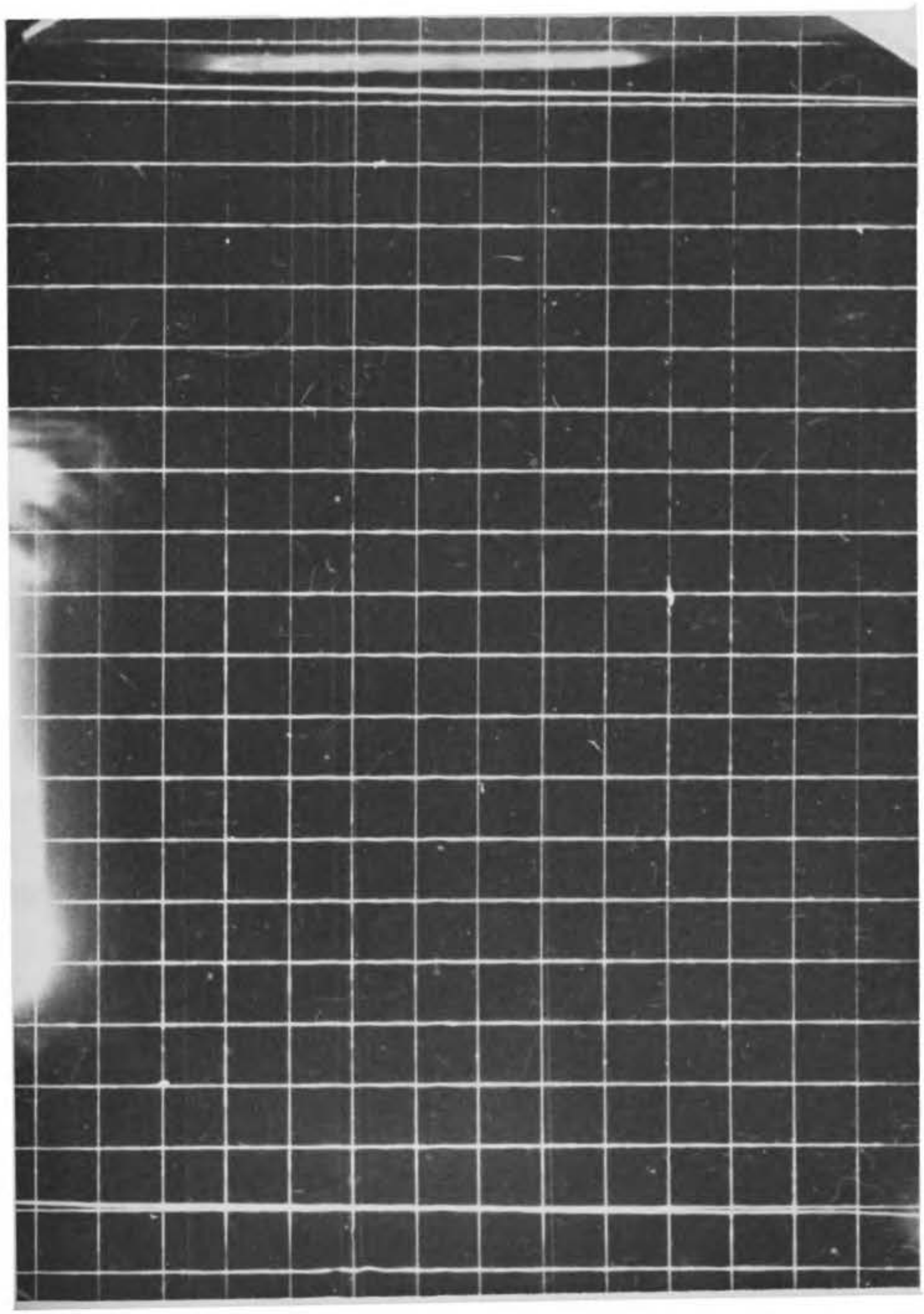
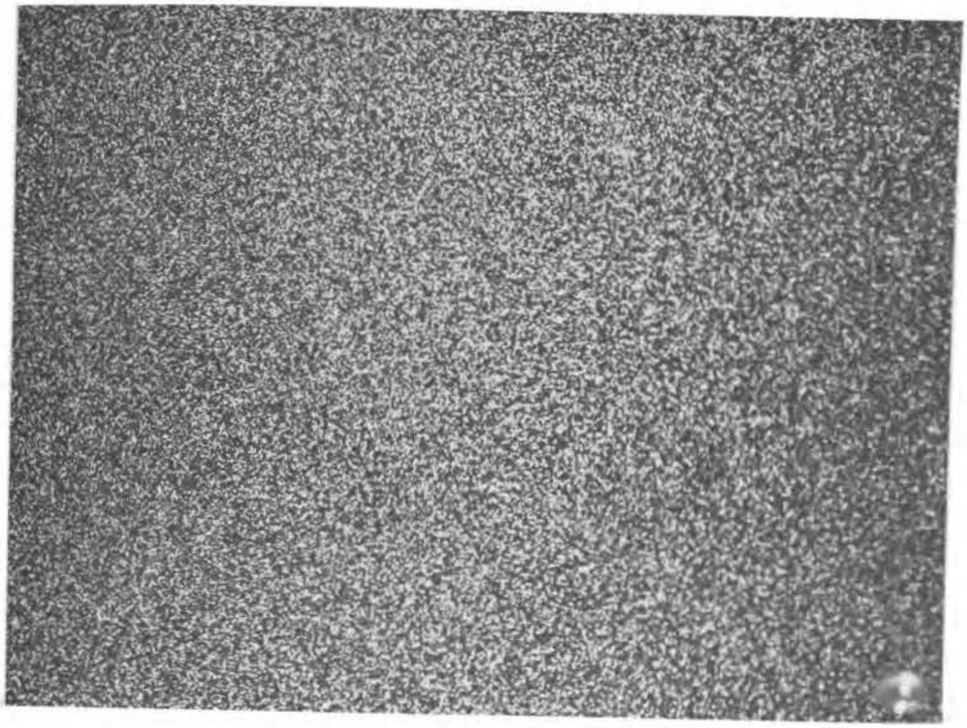


Plate 1. Grid used for calibrating the camera magnification. A 1 cm. grid made from .4 mil tungsten wire is placed in the sensitive volume of the chamber and photographed.



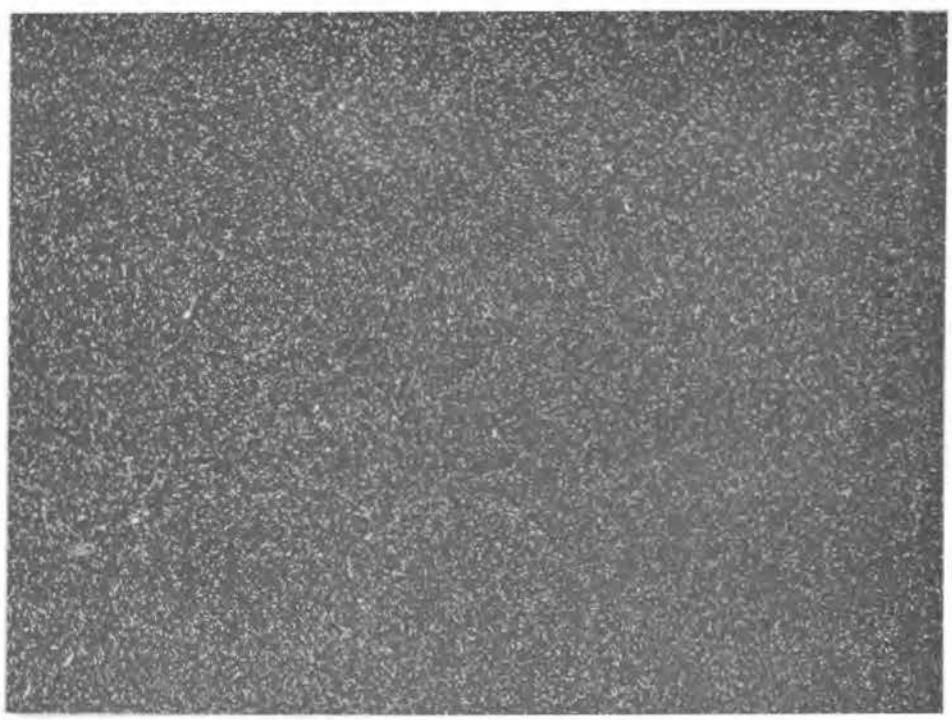
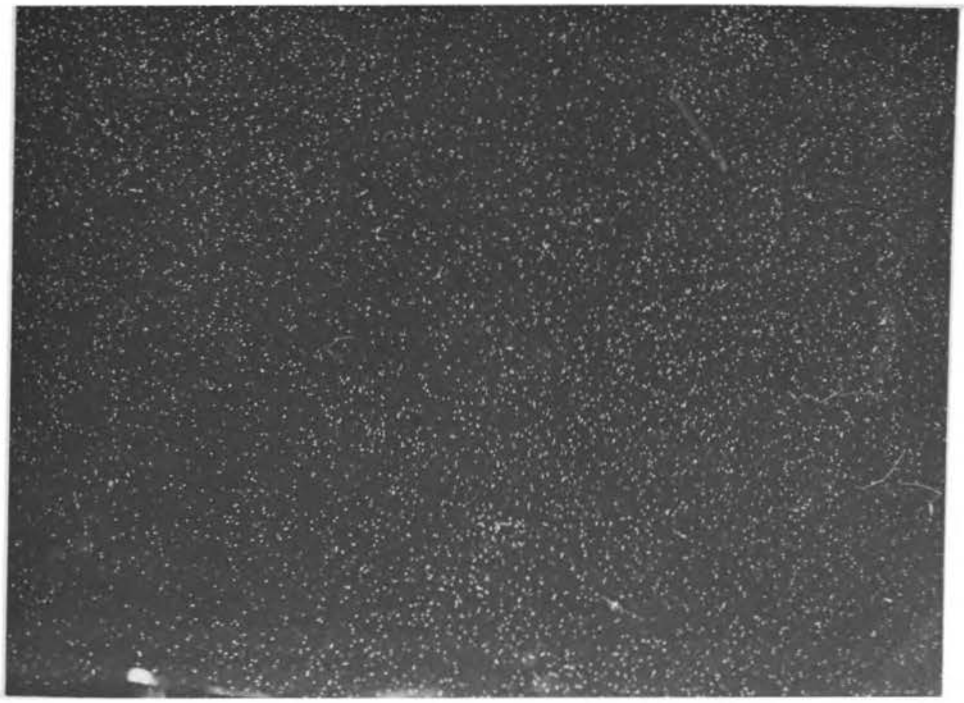


Plate 2. Nucleation. Examples of typical data are shown with the same magnification as the grid in Plate 1. Upper 250 drops/cm^3, lower 140 drops/cm^3.



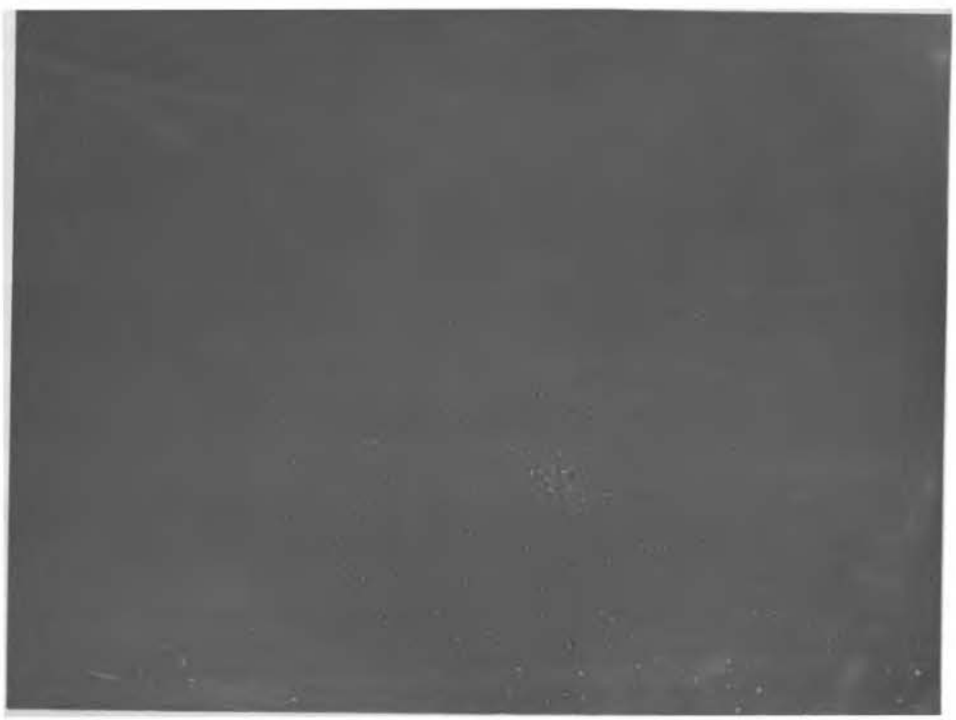


Plate 3. Nucleation. Examples of typical data are shown with the same magnification as the grid in Plate 1. Upper 42 drops/cm^3, lower 2.5 drops/cm^3.

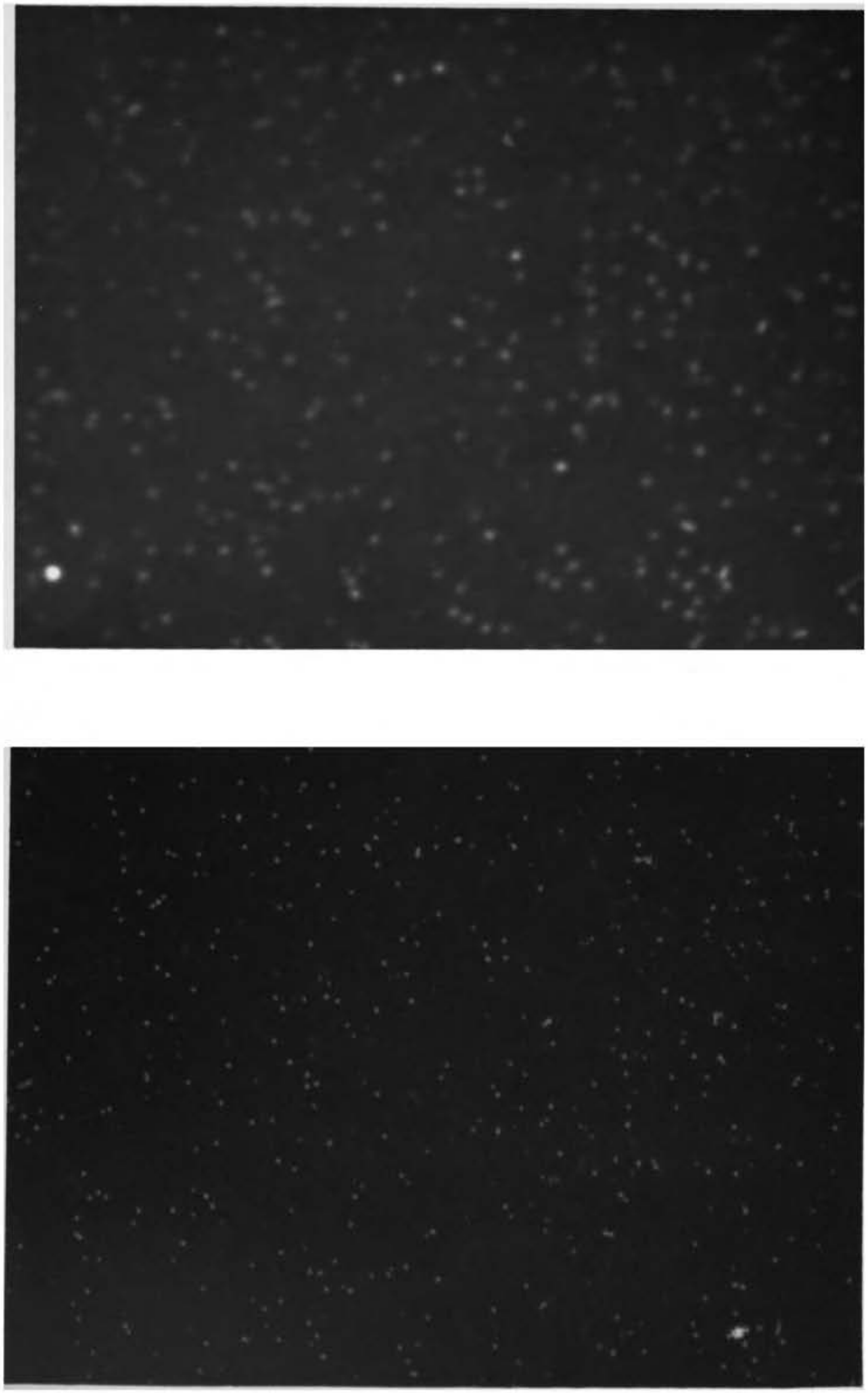
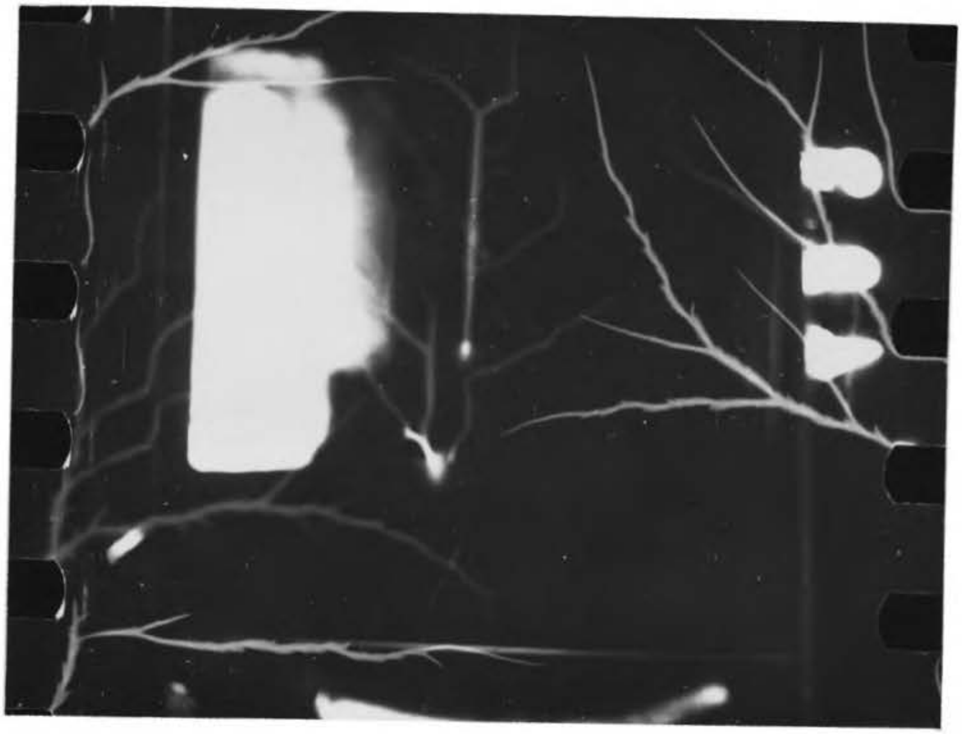


Plate 4. Diffraction from small droplets. The upper picture shows droplets as they appear when small enough to give noticeable diffraction rings on the film. The lower picture shows the same droplets 0.1 sec later.

Another strange effect showed up on the film developed on Feb. 8, 1968. Between some of the frames where the camera stopped, lines of static electricity or something similar sensitized the film. There is no shutter in the camera and the lines seem to have been catalyzed by light reflected onto the film. The static electricity itself was probably the result of strains induced into the emulsion by the motion of the film. During this particular data run the room and consequently the camera was maintained at 40°F. The atmosphere in the room was very dry. This particular combination of physical conditions is probably responsible for the effect. A developed print of this effect is shown compared with a normal print in Plate 5.

2-5.1. Film and development. Due to the very small area of the images, much denser blackening is required than in the case of ordinary photography. Moreover, grays are of no interest so that a fast, high contrast film can be employed. A degree of over development materially increases contrast and thereby the effective film speed. A wide range of results can be obtained with different film and developer combinations. Film and developer combinations which yield high speed and high contrast tend to yield a large grain size in the developed film. If the grain size becomes too large, the effective image diameter is increased.

Virtually all interesting film and developer combinations have been investigated in this laboratory, carefully noting the effective relative speeds and the maximum obtainable resolution. It was found that Eastman Kodak Linograph Shellburst film developed in Acufine film developer made by Baumann Photo-Chemical Corp. gives the greatest relative speed as well as a fine grain size. Eastman Kodak Tri-X is not quite as fast and gives considerably larger grain size.



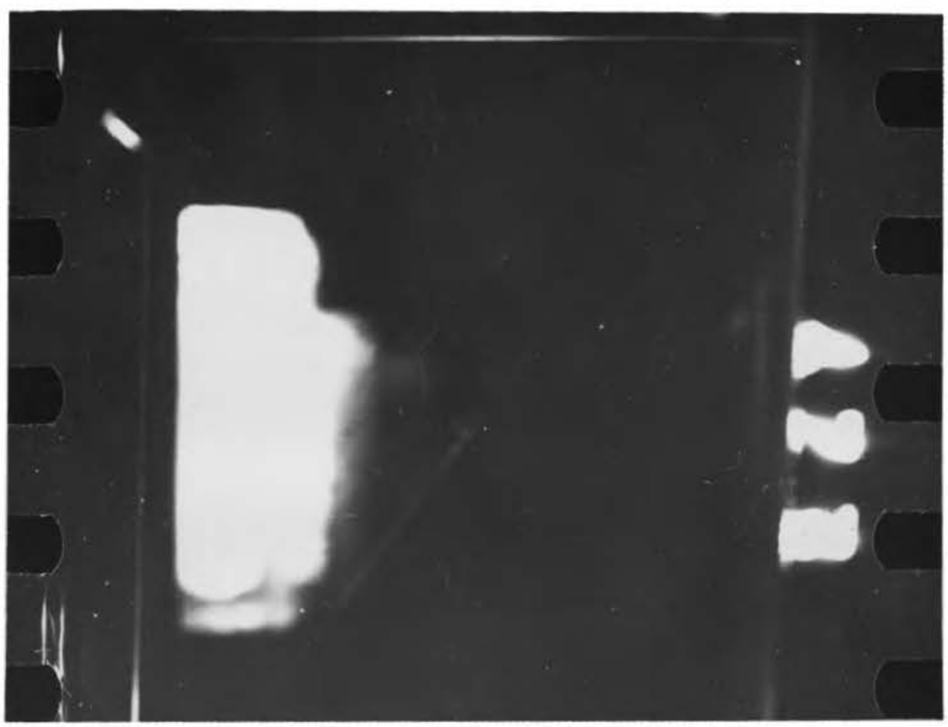


Plate 5. Static. Stresses in the emulsion of the film under certain conditions when developed display a lightning like effect which seems to be catalyzed by light. These are frames exposed during the waiting interal between expansions. This effect is shown compared to a normal frame.

A seven minute developing time is used in full strength developer at 20°C. An 18 minute developing time is used in half strength developer at 20°C when the Nikor developing machine is used.

2-6. The mechanical Brake. During the normal operation of the cloud chamber, the piston is in free suspension between the upper and lower gas volumes. Such a system is oscillatory. The original design of the cloud chamber used a hole plate suspended in the water volume for damping the piston oscillations. Although the hole plate did reduce the waves in the surface of the liquid pool, it was inefficient as a damping mechanism. A solenoid operated brake was connected to the guide cylinder. It was originally designed so that the braking action could be electrically controlled. However, it was found that it could be adjusted for a constant slight drag which was sufficient to critically damp the piston. Small oscillations in the rubber diaphragm were unavoidable. The remaining oscillations were so small, however, as to be insignificant.

2-7. Program board. A programming patch board was added to the cloud chamber in order to facilitate the programming of different experiments, see Plate 6. It was hoped that this would reduce the down time required for reprogramming and add to programming versitility. The program board contains 1632 contacts. These are used to interconnect the timing units with the control apparatus of the cloud chamber. A sequencing unit was installed in conjunction with the program board. This allows a sequence of up to ten expansions, each of which can be different. Moreover, a numbering system for the photographs is provided. The entire installation consists of more than 10,000 connections and three miles of wire.

A patchboard is wired for each type of experiment. As long as the patchboard remains intact, the experiment may be repeated at any time.

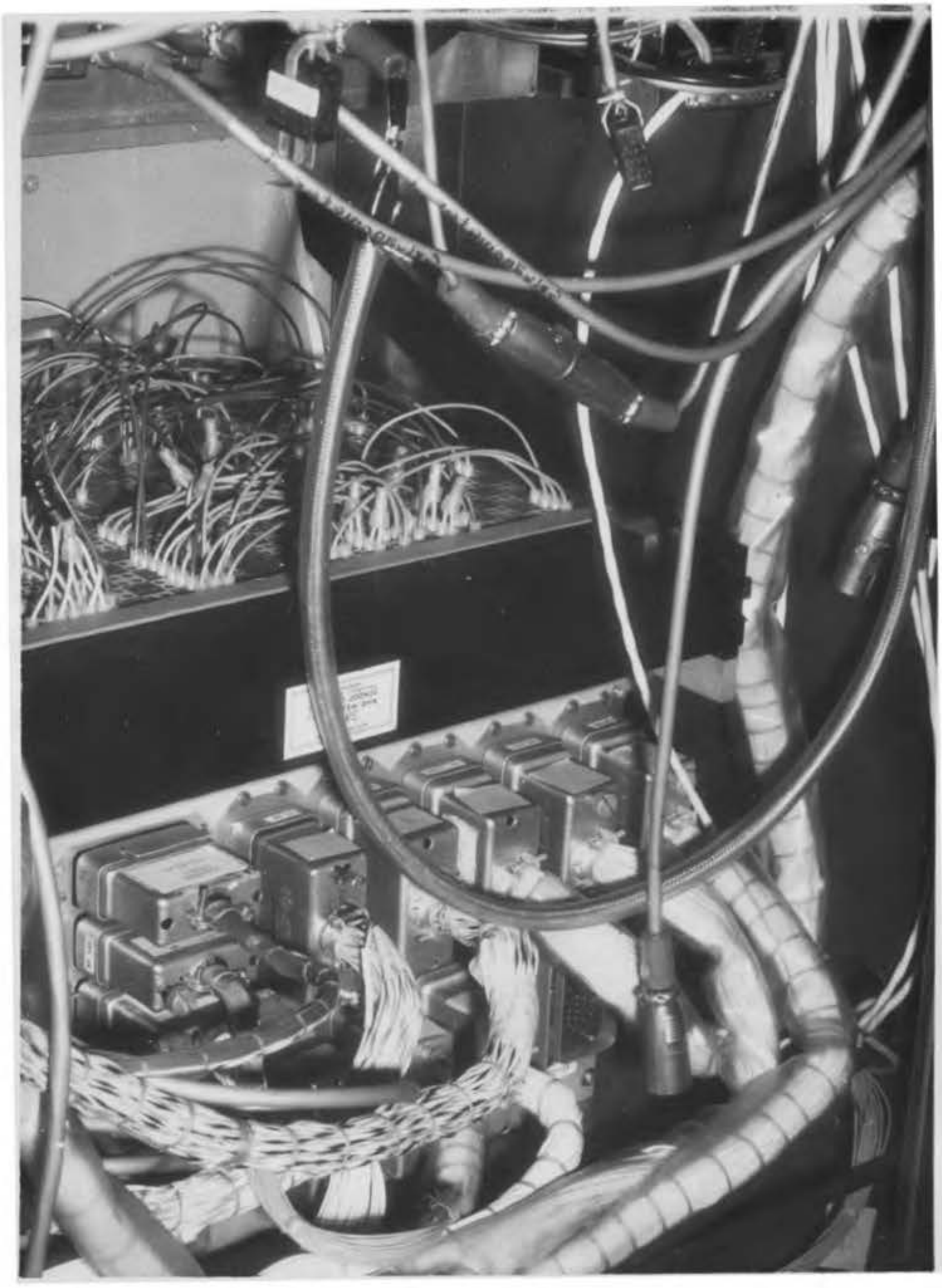


Plate 6. Program board. A rear view of the program board is shown. The patchboard used for the author's data is in place.

If two different experiments can use the same cloud chamber configuration, the appropriate program board may be installed and in a matter of minutes that experiment can be underway. This system makes more efficient use of the cloud chamber facility. It is also possible for several different cloud chambers to be run at alternate times using the same electronic control system and data processing equipment.

2-8. Purification of the water. For homogeneous nucleation rate measurements from supersaturated vapor, every effort must be made to obtain the purest possible vapor so that one may be reasonably assured that the nucleation is indeed homogeneous and not influenced by impurities. The purification of water is hampered by the fact that it is an almost "perfect" solvent. Under normal conditions water is saturated with silicates, various metal ions, and all atmospheric gases including carbon dioxide. Water has such an affinity for impurities that freshly distilled water left open to the atmosphere for a few minutes will not pass conductivity tests for purity. This is due mainly to dissolved gases.

Since the nucleation rate studies were to be done with water vapor in an atmosphere of a pure rare gas, a special purification procedure had to be devised to provide pure water free from not only dissolved solids and liquids, but free from contaminating gases. These gases might affect either the vapor pressure or bonding characteristics of the vapor molecules and modify the nucleation rate.

Various methods of purification were considered, including ion exchange techniques in conjunction with distillation. The final conclusion reached was that distillation is the most effective means of obtaining very pure water, provided that several stages are used with each stage performing a different function.

General distillation procedure was worked out with the aid of Dr. James L. Kassner, Sr., an expert in the field.

The first operations were devoted to eliminating organic compounds since these impurities were deemed to be the least desirable, the most likely to contaminate the vapor and the hardest to remove. One should keep in mind that the amount of a substance present doesn't have to be large in order to have a great number of molecules present. For instance, a tolerably good vacuum of 10^{-6} torr still has ten billion molecules per cubic centimeter. Compared to normal operating pressure, this level of impurity represents about 1×10^{-7} per cent at a total pressure of one atmosphere and only one impurity atom for each 10^{7} water molecules. Keeping impurity levels down to just a few molecules per critical embryo becomes impossible and one must settle for the greatest dilution of impurities possible.

Ordinary distilled water contains some organic matter. Tap water was used as the starting water since it requires no less treatment for purification then ordinary distilled water. Potassium permanganate (ten grams per liter) with enough potassium hydroxide to assure an alkaline solution (PH of about 8 or 9) was added to the water and left standing in five gallon glass stoppered jugs for a few days. This solution was then cooked for twelve hours and refluxed for twelve hours (that is boiled and recondensed into the same flask) in such a way that any volatile gases had ample opportunity to escape. Cooking and refluxing are done so that all of the organic compounds are broken up either into volatile gases which escape or else into nonvolatile compounds which are removable by distillation. Carbon ends up as potassium carbonate provided there is sufficient potassium hydroxide in the solution.

This liquid was then distilled through a two stage continuously running still at about one-fourth liter per hour, see Fig. 11 and Plate 7.

It should be noted that the water was taken through the distillation apparatus beginning with twenty gallon batches. The first few liters as well as the last few liters, from each batch at each stage were discarded in the sense that the water was not kept as pure water but used for cleaning bottles and flasks, see Fig 12, and other such procedures necessary to the successful operation of the stills. This technique requires that four gallons of water start through the still to get one gallon of pure water out.

This permangnate solution was distilled and redistilled immediately after refluxing. Both stills were then dismantled and thoroughly cleaned so that the second stage of purification could begin. A very small amount of phosphoric acid (ten ml in 3000 ml) was added to the first still and the entire batch run through the stills in the same manner that the permanganate solutions was run through the still. Phosphoric acid was added to form insoluable phosphates of the heavier elements present and to make the solution acid.

It is not commonly known, but very pure water has a tendency to superheat. Boiling beads of many different materials were tried. Without a single exception, either the substance did not aid the boiling or interacted with the water and dissolved. Substances tried included ceramic beads, glass beads, carbon chips, various stainless steels covar metal alloy and other materials. Covar worked nicely but dissolved very quickly. Pure nitrogen works very well as a nucleating agent when slowly bubbled through the liquid in the boiling flask. This method was prohibited in this experiment, however, since the purification had to eliminate gaseous impurities as well as dissolved liquids and solids. In fact,

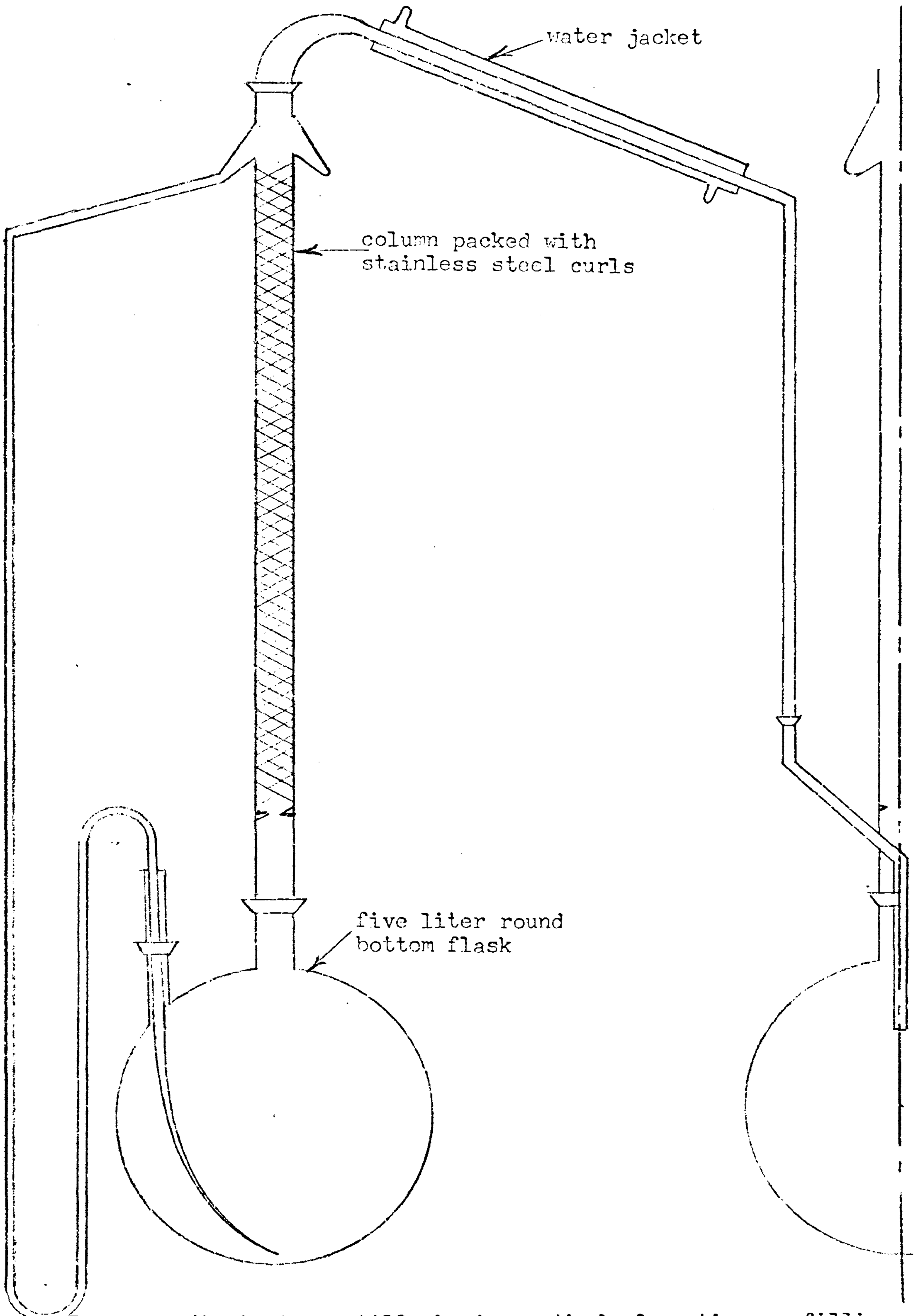


Fig. 11. first stage still showing method of continuous filling.

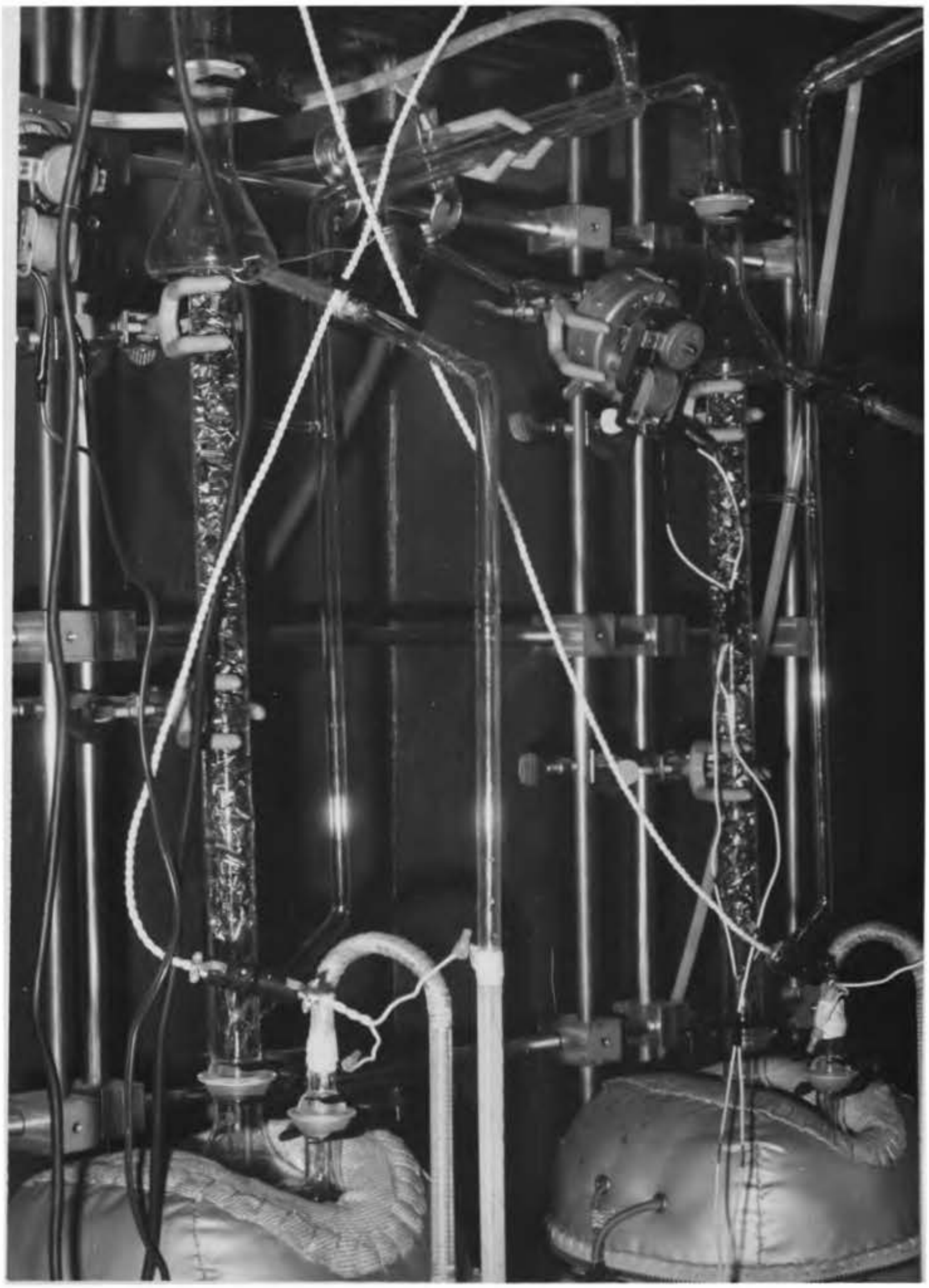


Plate 7. First stage still. The arrangement of the first stage still is shown. Water enters on the right and emerges on the left.

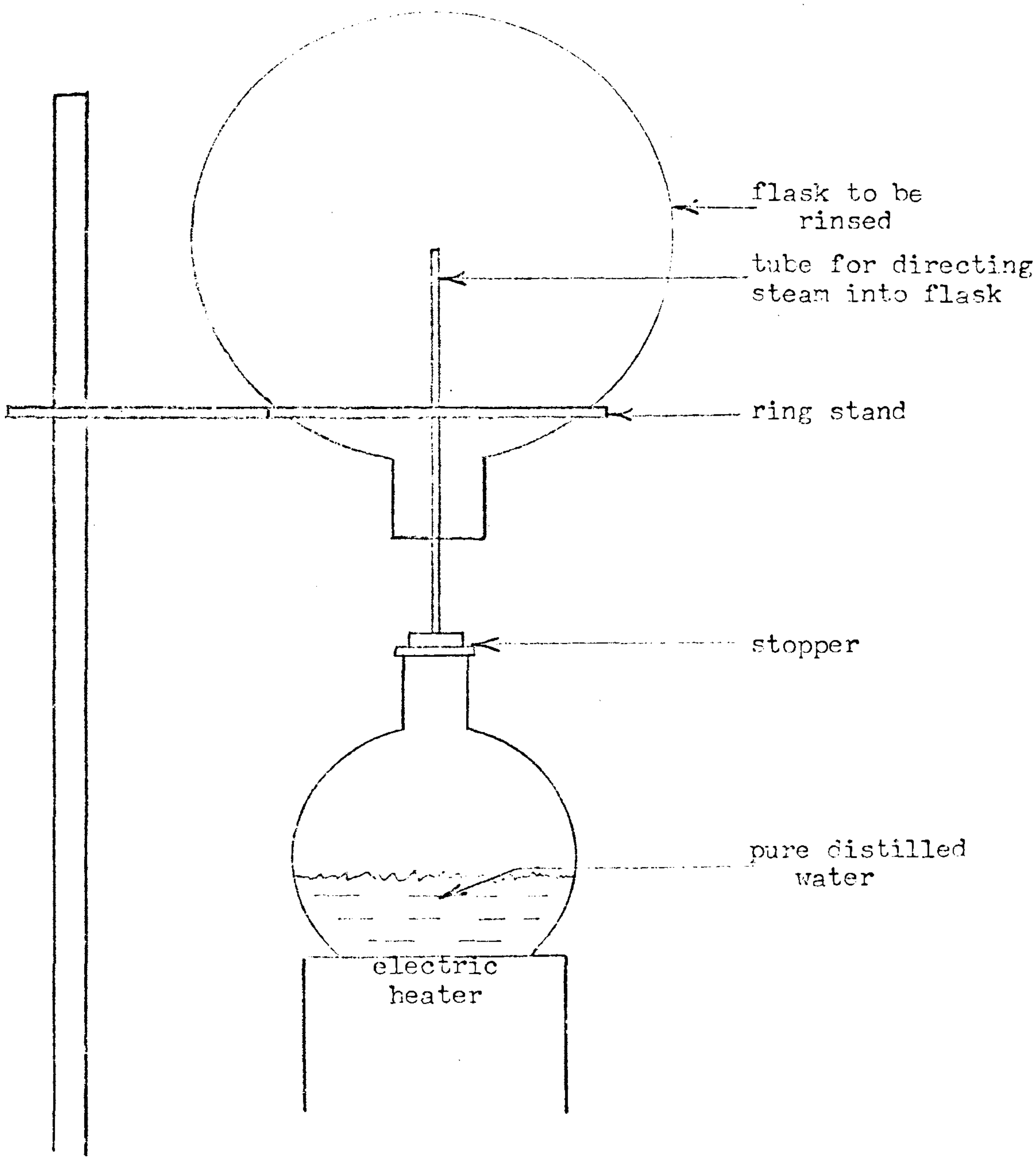


Fig. 12. Method of rinsing glassware. The flask is rinsed with pure water from condensing steam.

a system of steam generators had to be devised to keep the water in the stills agitated with superheated steam in order that purification beyond the first stage could be used with any degree of success, see Fig. 13.

The steam generator is simply a glass tube inserted in the boiling flask, drawn out to a point, bent into a double U shape and wrapped with a nichrome heater. A head of water is kept on the generator by condensing a small amount of water into the generator tube before it gets to the condensing column. This head is kept from flowing into the boiling flask by the nichrome heater which is adjusted so that about 200°C steam only enters the boiling flask.

No steam generator ever failed in service and they were kept in continuous operation for a period of two months which attests to the dependability of the steam generators. When distilling in the final stages of distillation, the need for the steam generators can be dramatically demonstrated by shutting off one and watching the temperature in the boiling flask rise degree by degree with no boiling. This is a dangerous procedure because the great amount of energy stored in the water is released with explosive force when boiling does begin again.

When a bubble of steam comes to the surface in the boiling flask, it bursts and sprays tiny water droplets in all directions, some of which are light enough to be carried into the condensing column. Smith[53] has shown that evaporating droplets do not evaporate completely. This is probably due to surface active materials which are concentrated in the surface. Thus, small re-evaporation nuclei which form as the result of the evaporation of sprays can effectively transport low vapor pressure organic materials through a still. This action effectively cancels part of any purification which might be effected by the distillation.

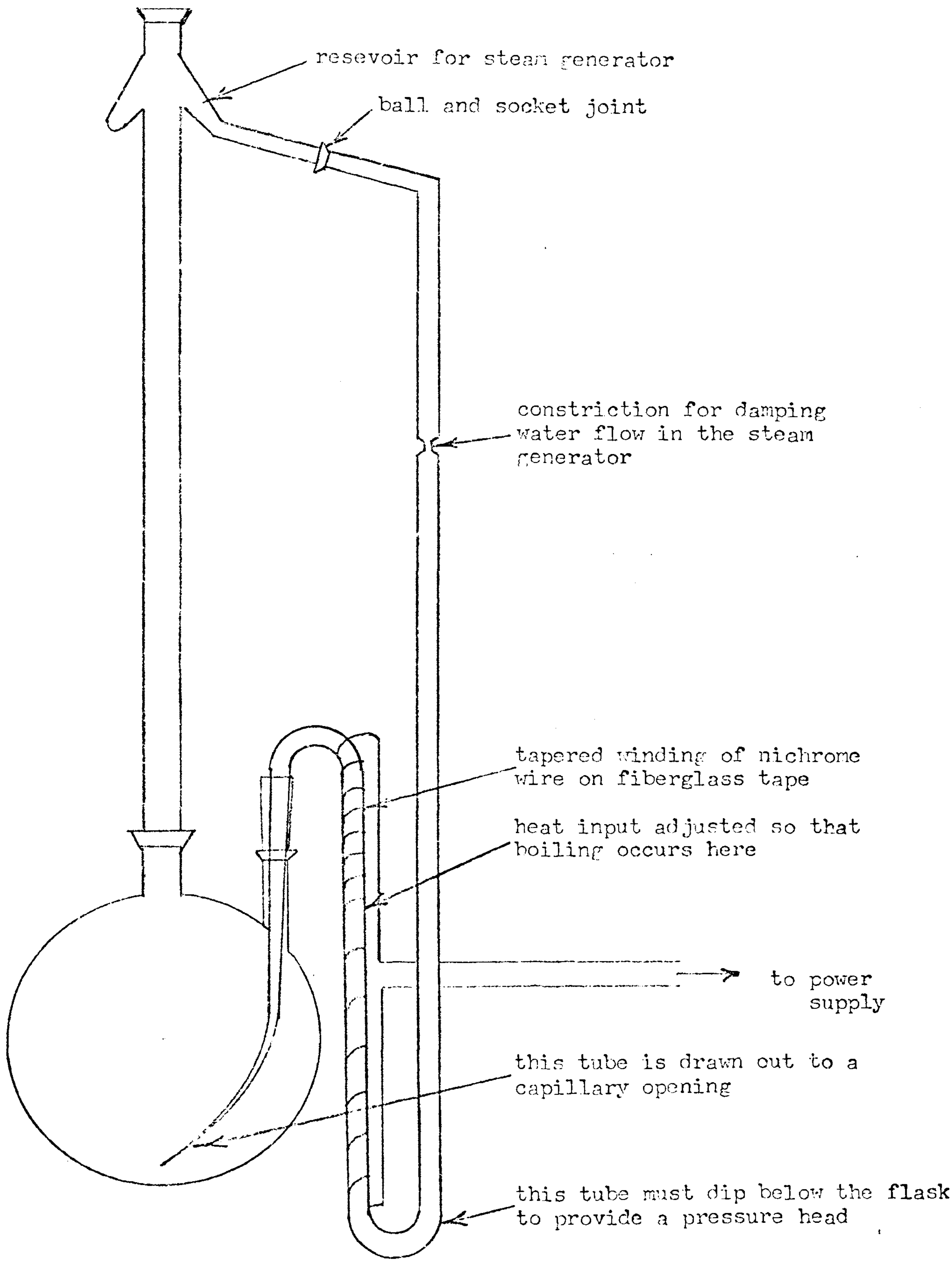


Fig. 13. The steam generator.

It was found that this problem could be effectively overcome by using small stainless steel chips closely packed in an 18 inch column above the boiling flask.

This method is especially effective when enough cooling is provided on the column containing the stainless steel chips so that sufficient water is condensed on the chips to continuously wash them clean. Resultant distillation rates are consequently lowered. The nuclei leaving the boiling pot are taken out by the chips of the column packing by both impaction and diffusion. Impaction requires a finite flow velocity and sharp edged plates while diffusion requires time and a small diffusion distance. The distillation rate was about one-fourth liter per hour.

A commercial Corning still was modified for use as an intermediate distillation unit before the water was put into the final stage, see Plate 8. The final stage is designed to remove the last traces of atmospheric gases. This intermediate distillation was considered necessary because the water was of necessity kept in ordinary glass jugs after the first two distillation stages.

The final stage of the distillation is not a continuous operation but a batch operation. This stage has a five gallon flask, so that a reasonable batch may be processed, see Plate 9. A single batch of this size suffices for any cloud chamber experiment yet devised in this laboratory. Water is continuously boiled and recondensed in the final stage while maintaining the pressure at five to ten pounds above atmospheric pressure. Gases dissolved in the water are released as the temperature rises and are allowed to leak out through a small capillary leak. This action is continued for two or three days or until about one-fourth of the water is lost to the atmosphere. For an operation of this

Plate 8. Corning still. A front view of the modified corning still is shown.

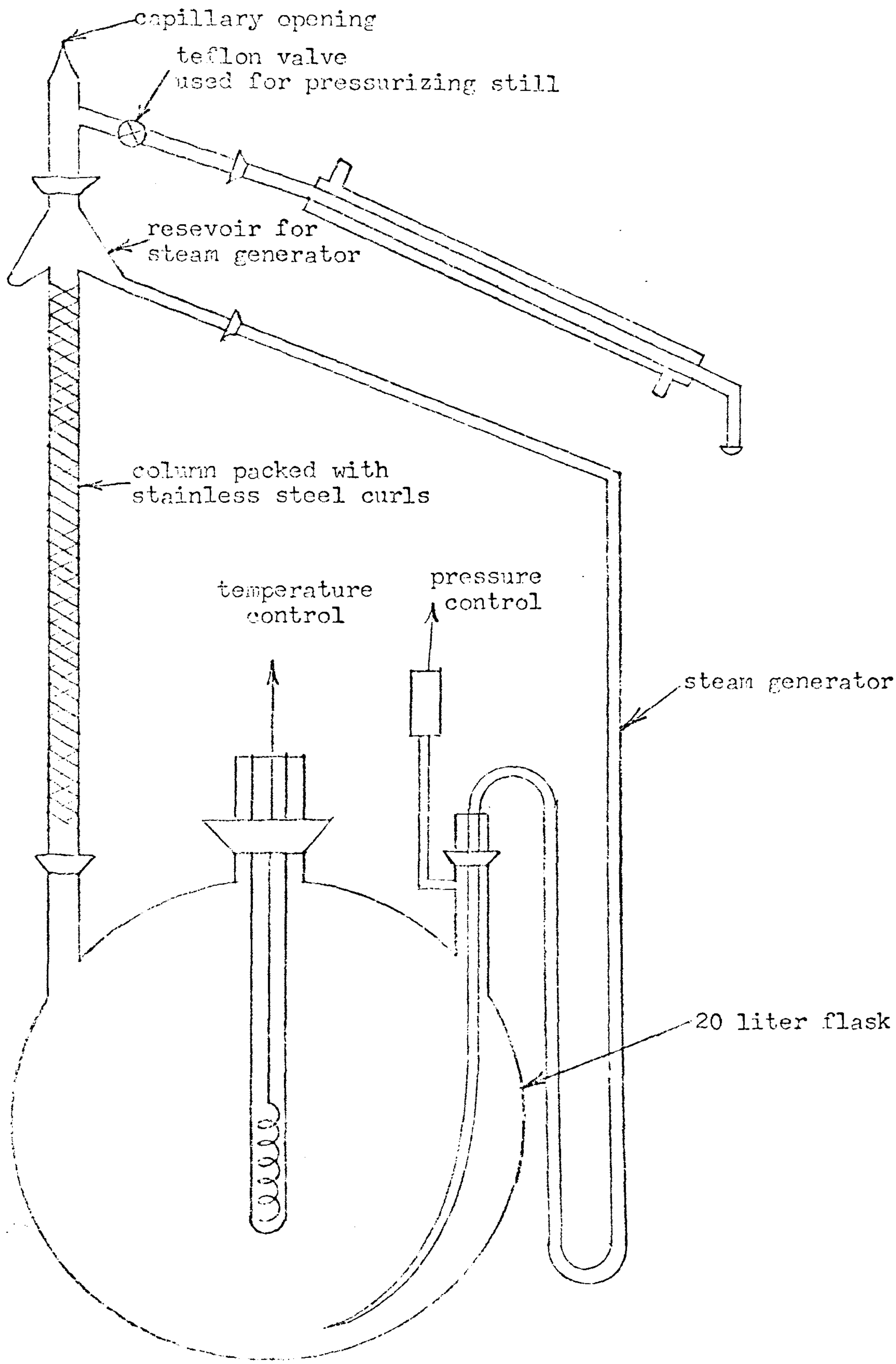


Fig. 14. Third stage still.

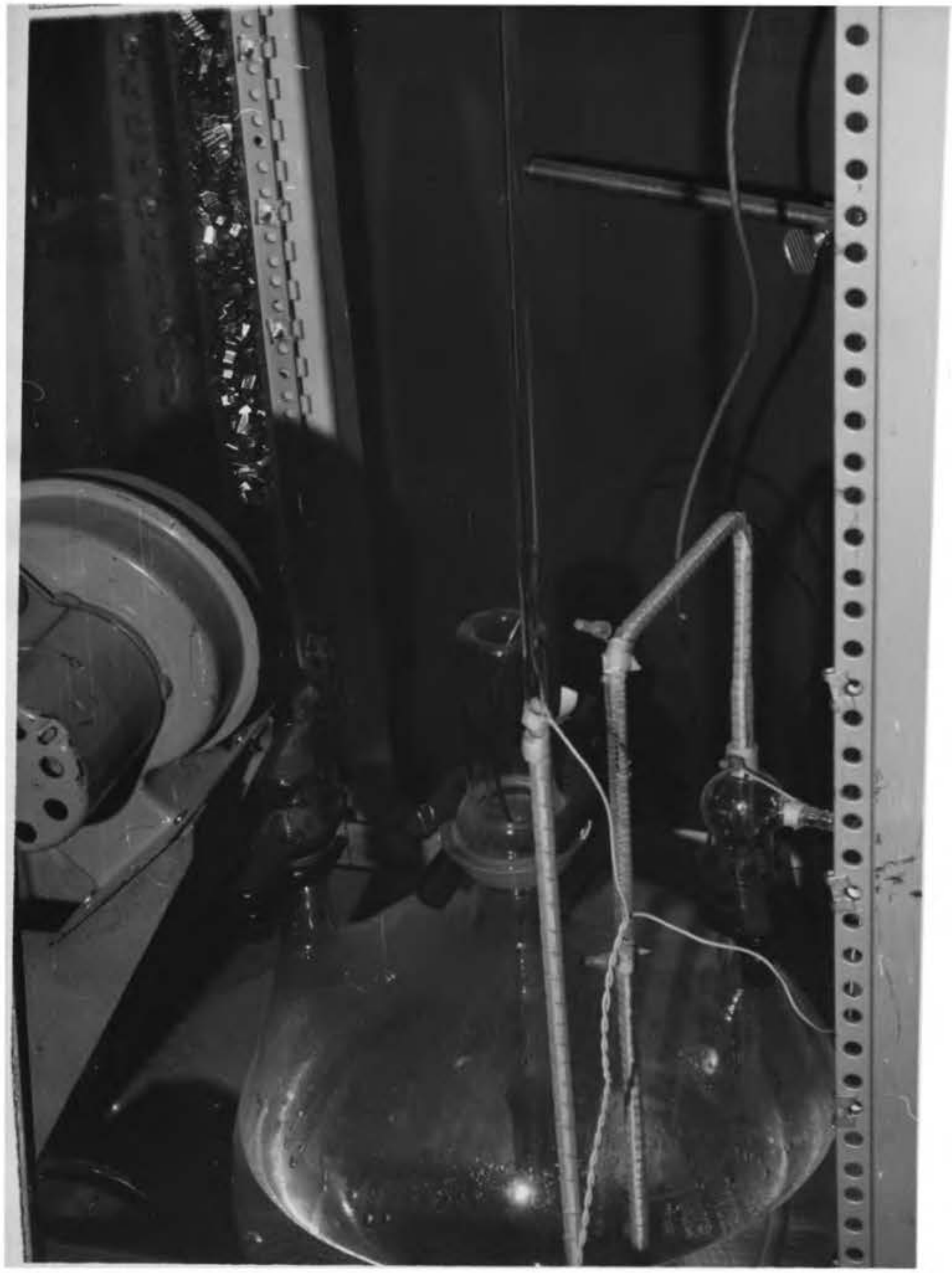


Plate 9. Third stage still. The lower part of the third stage still is shown. The packed column is on the left, the temperature sensor is in the center and the pressure sensor is out of the picture on the right.

type, continuous automatic pressure and temperature sensing are required to maintain safe operation. The pressure stays fairly constant because the temperature is held to a preset value of approximately 108°C.

Distillation from the final stage was done directly into a five gallon jug containing a helium atmosphere. There is no reason, however, the distillation could not be done directly into a vacuum bottle so that all gases are eliminated and the purest possible water obtained. Since the final distillation occurs in the cloud chamber, the materials dissolved from the glass are not troublesome. If the glass jugs are used for the same purpose for some time they may eventually become very clean.

A system of more automatic operation of the first stages than had been used is currently being incorporated into the system. Improvements include automatic filling and temperature control of the first stage stills. Other improvements include continuous conductivity and periodic mass spectographic checks of purity. There is every reason to believe that this distillation system is very effective.

2-9. Preparation of the chamber. The process of readying the cloud chamber for a particular data run begins several days in advance of the data taking process itself. Assuming that all equipment is in operating condition, the chamber is thermostated at the desired temperature. Room temperature must be kept five to ten Fahrenheit degrees below the chamber temperature for proper thermal regulation. Air tanks must be maintained at a temperature near that of the cloud chamber. Otherwise too much heat is pumped into or out of the lower drive chamber for good temperature stability. Some adjustment of heater controls is usually required to maintain proper heat input. The constant temperature bath which is used as a thermocouple reference is usually maintained within one-half degree of the cloud chamber temperature. These thermocouples are used to thermostat the cloud chamber.

In order to assure gas purity, the cloud chamber is flushed several times immediately before each data run. This procedure eliminated gaseous impurities which may have diffused from the glass walls or the water. If a change in the gas type was made, flushing was done on two consecutive days prior to operation of the chamber. This allowed time for the former gas to diffuse out of the water pool in the chamber.

Even though it would have been desirable to use new water for each set of data, this was not possible because of the difficulty in changing the water in the chamber. No check was made of water purity after the water was in the cloud chamber, but because of the close agreement of the data taken at widely spaced intervals, it is believed that neither water purity or gas purity affected the nucleation rates measurably during the course of the entire experiment. As discussed in the section on water purification, there is little hope of having an atmosphere which is completely free of gaseous impurities. Since the author's data corresponded so well with that of the other researchers in this laboratory who used various means of water purification, it is felt that water purity is not a problem in these experiments.

2-10. The cloud chamber program. For the measurement of homogeneous nucleation rates, the cloud chamber is programmed as shown in Fig. 15. Expansion AB requires about 0.2 sec. The interval BC can be varied from 0.01 sec. to about 1. sec. The slight compression CD reduces the supersaturation by an amount sufficient to stop all subsequent nucleation.

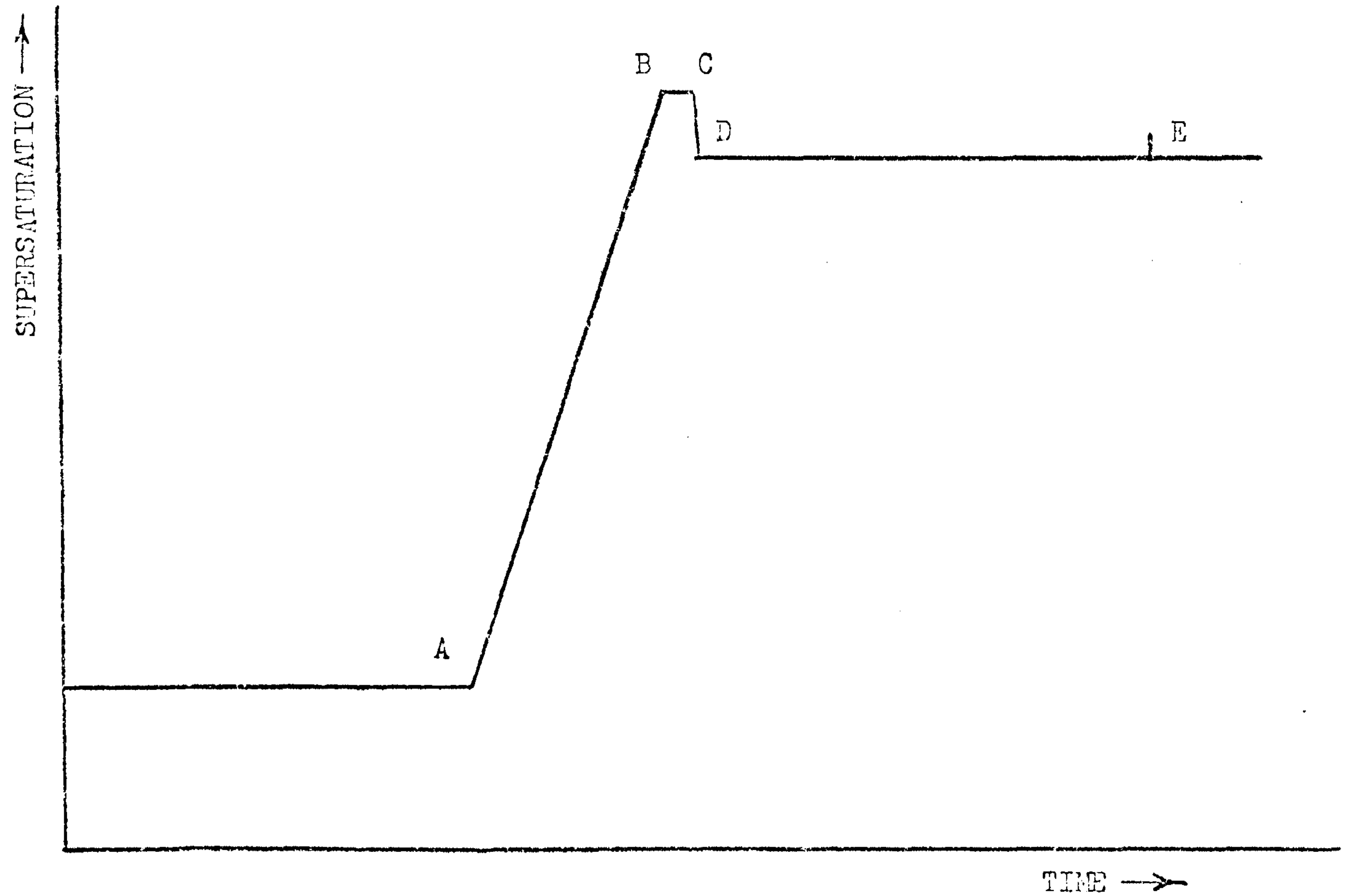


Fig. 15. Typical cloud chamber cycle.

After the droplets have had ample time to grow to photographable size, the xenon flash is triggered and the droplet density is photographed.

An electrostatic clearing field of 80 volts per cm. is used to sweep out ions which are produced in the cloud chamber between expansions. The clearing field is turned *off* just prior to the onset of condensation. Any tracks which are formed during the sensitive time of the chamber appear as easily recognizable ion tracks. Such tracks are carefully avoided when drop counts are made. Therefore, the data presented in the course of this work is not biased by the presence of ions.

Two cleaning expansions were used between data expansions to insure that re-evaporation nuclei had been eliminated. The second cleaning expansion was photographed in order to determine the background level. Except for additional sophistication in the experimental technique, the method employed is basically the same as that employed by Allard[49].

CHAPTER III

CLOUD CHAMBER THERMODYNAMICS

The most important piece of information to be extracted from the data for a cloud chamber expansion is the state of supersaturation of the atmosphere as a function of time during those parts of the cloud chamber cycle when nucleation is taking place. When the cloud chamber was used as a particle detector for high energy nuclear physics, the supersaturation needed to be controlled with only moderate accuracy so that drop formation occurred only on ions and an exact knowledge of the state of supersaturation was not necessary. In addition, it was useful to know for what period of time the cloud chamber was actually sensitive to the ions. Experiments measuring homogeneous nucleation rates and droplet growth are critically dependent upon an exact knowledge of the supersaturation as a function of time during the cloud chamber cycle.

There is no way to directly measure the water vapor content of the cloud chamber atmosphere during an expansion. The cloud chamber establishes a state of supersaturation by means of an adiabatic expansion as shown in Fig. 16. In the initial condition a noncondensible gas is saturated with water vapor at temperature T_1. The dashed line shows the course taken by an adiabatic expansion. At a representive time the water vapor pressure has been reduced from P_1 to P_2 by the expansion itself. The temperature has dropped from T_1 to T_2. The equilibrium vapor pressure corresponding to T_2 is P_2' so that the supersaturation ratio established by the expansion is P_2/P_2'.

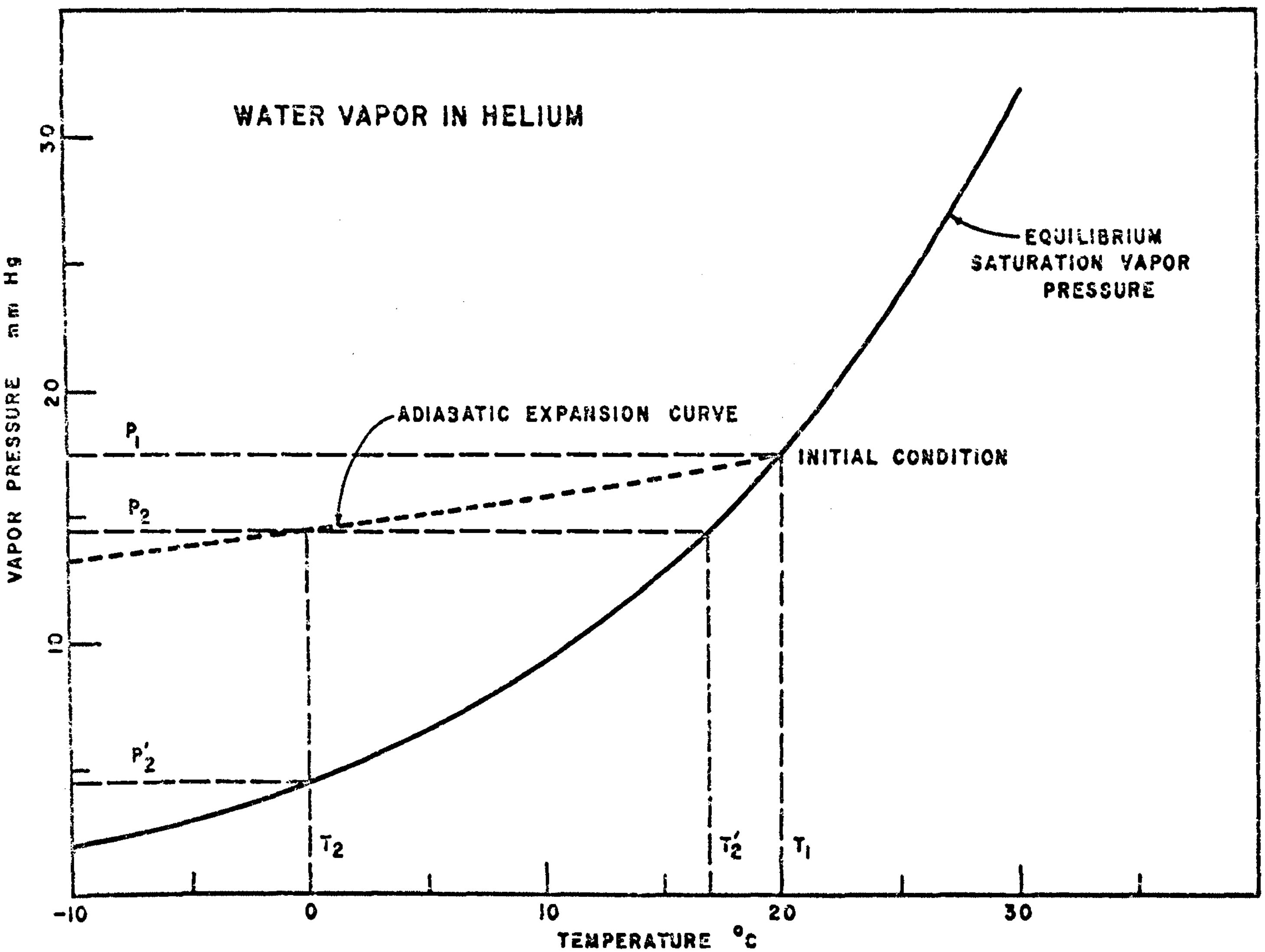


Fig. 16. Creation of supersaturation in helium and water vapor by means of an adiabatic expansion.

3-1. Measuring temperature directly. It had been hoped that an instrument could be developed which would measure temperature with sufficient speed and accuracy to permit its use in the cloud chamber. In recent years fine wire bolometers and fine wire thermocouples have been available which are seemingly fast enough to measure temperature accurately in an expanding gas. However, in a moist gas condensation occurs on the thermocouple, liberating the latent heat of condensation. The wet thermocouple tends to approach the equilibrium temperature T_2 shown in Fig. 16. The exact temperature of the thermocouple will depend upon the rate of change of conditions in the cloud chamber and upon the surface properties of the water film on the thermocouple. Moreover, surface conditions do not reproduce nicely and even this condensation does not take place reproducibly. The prospects for overcoming these effects are not favorable so that all temperature data must be obtained from other sources when the cloud chamber is in a supersaturated state.

3-2. Reliability of volume measurements. Packwood[50] has shown that calculations of temperature made from volume expansion ratios give erroneous results. This can be readily understood in terms of the thermodynamic processes taking place in the cloud chamber. During the expansion the walls of the apparatus remain at temperature T_1, Fig. 16. Since the interior gas is at a much lower temperature, T_2, and since the wet cloud chamber walls would have to be at temperature T_2' in order to be in equilibrium with the existing vapor density, P_2, the rapid diffusion of both heat and vapor takes place from the wet chamber surfaces while only the diffusion of heat takes place from the dry chamber surfaces. The net effect is that boundary layers (affected by diffusion processes) expand and thereby produce a compressive effect at the interior of the chamber.

The sensitive volume of the cloud chamber as a whole is nonuniform and it makes no sense to talk about the adiabaticity of the whole volume. In fact, volume measurements are useless because the computational complexity of dealing with the real nonuniform gas situation is unduly great.

If the expansion process is slow enough so that shock waves are not created, the pressure throughout the system will everywhere be the same. Moreover, diffusion processes are inherently slow so that a finite time is required for the central regions of the cloud chamber to be sensibly affected, Figs. 17 and 18. Even though the compressive effect has been active, the center of the chamber remains truly isentropic until actual diffusion reaches these regions in perceptible magnitude.

Ordinarily, the final temperature is calculated from one of the ideal gas relationships for a constant entropy process.

$$\begin{aligned} TV^{\gamma-1} &= \text{constant} \qquad (3\text{-}1) \\ PV^{\gamma} &= \text{constant} \\ TP^{(1-\gamma)/\gamma} &= \text{constant} \end{aligned}$$

The first two involve the volume and are not useful where great accuracy is required. Before using the last equation, however, an appropriate gamma for the equation must be known. Since the cloud chamber operates with a gas mixture, the difficulty in finding an appropriate gamma is magnified even more than for a single component gas system, Packwood[50] does a thorough analysis of error propagation and concludes that an error of 0.06 in the supersaturation (at a supersaturation of 5.0) produces an error of 100% in the nucleation rate. This can be caused by an error of only 0.005 in the composite gamma used in the ideal gas relationship.

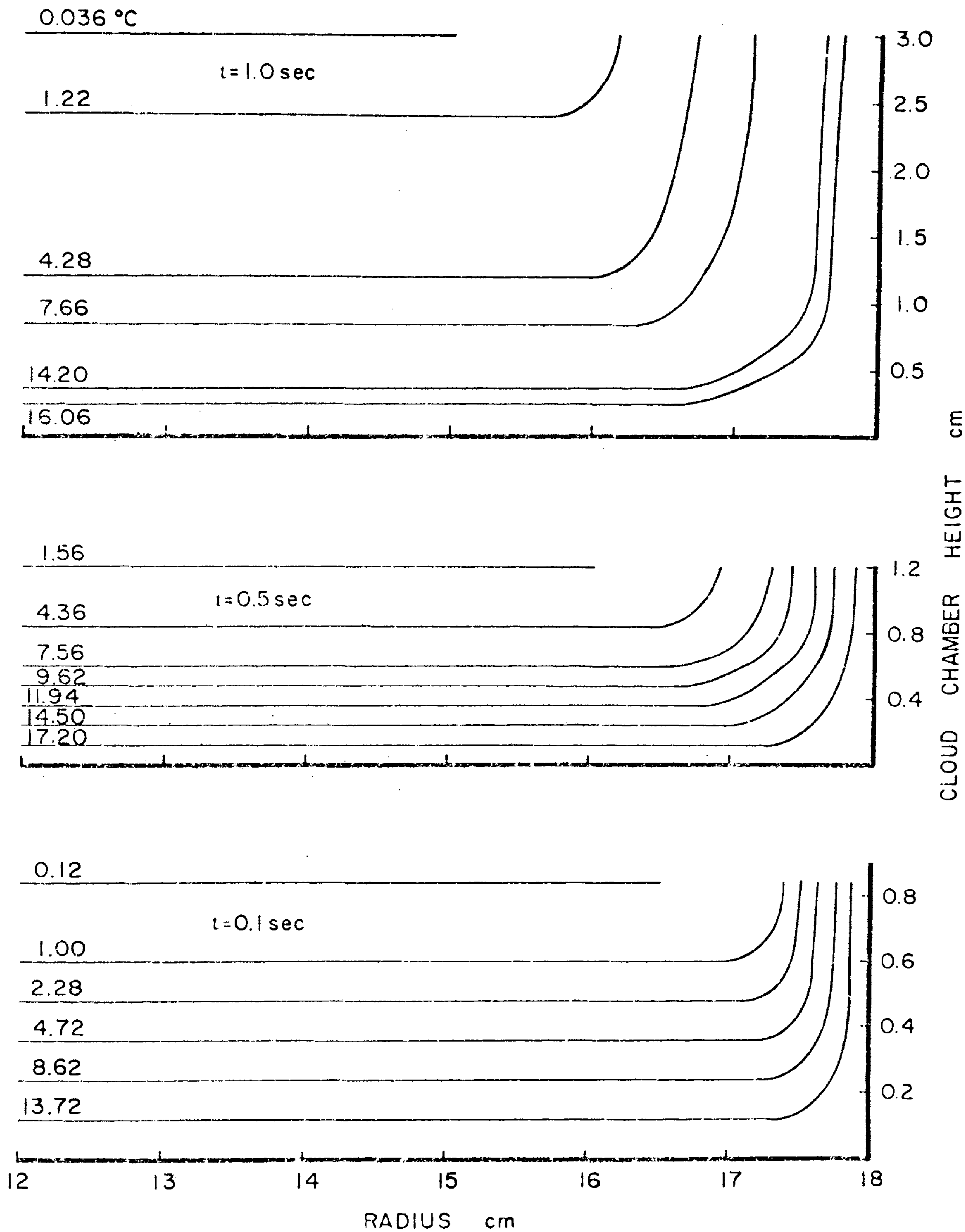


Fig. 17. Temperature Diffusion Profiles in a Finite Cylindrical Cloud Chamber.

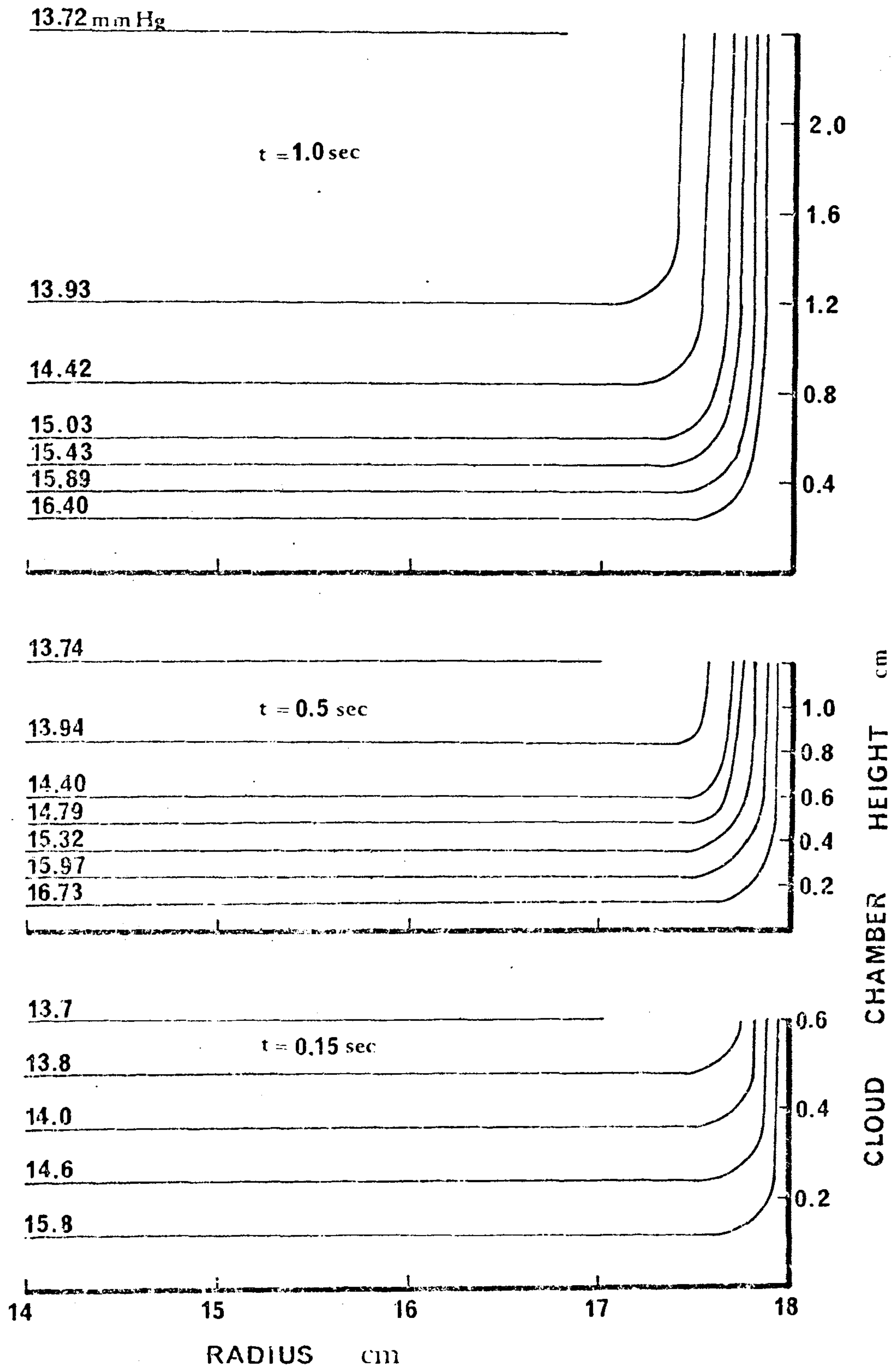


Fig. 18. Vapor Diffusion Profiles in a Finite Cylindrical Cloud Chamber.

3-3. Method of Richarz. Therefore, if the third of Eqs. (3-1) is to be employed, a gamma which is averaged over the range of thermodynamic coordinates must be employed. Methods for surmounting this difficulty are discussed in the following section. Richarz[55] derived a relationship for determining the composite gamma of a system of two noninteracting gases when the respective partial pressures and gammas are known. The following is a variation of the translation of his procedure as given by Laby[7].

Assign a mass of 1 to the mixture so that each component is $1-\mu$ and μ respectively. Let the densities by ρ, ρ', ρ'' which are understood to be measured under standard conditions. The specific heats at constant volume are C_v, C_v', C_v'', and the ratio of the specific heats γ, γ' and γ''.

Conservation of energy requires

$$C_v = C_v'(1-\mu) + \mu C_v'' = C_v' + \mu(C_v''-C_v') \tag{3-2}$$

The specific volume of the mixture is

$$\frac{1}{\rho} = \frac{1}{\rho'}(1-\mu) + \mu\frac{1}{\rho''} = \frac{1}{\rho'} + \mu\left(\frac{1}{\rho''}-\frac{1}{\rho'}\right) \tag{3-3}$$

Let C_p, C_p', C_p'' be the specific heats at constant pressure

$$C_p - C_v = \frac{R}{JM} = \frac{1}{\rho} K \qquad (K= \text{constant}) \tag{3-4}$$

since M is proportional to ρ, and R and J are constant

whence $$\frac{1}{\gamma-1} = C_v K, \qquad \frac{1}{\gamma-1} = \rho' C_v' K', \qquad \frac{1}{\gamma''-1} = \rho'' C_v'' K'' \tag{3-5}$$

Now eliminate μ in Eqs. (3-2) and (3-3)

$$C_v(\rho''-\rho') = (\rho-\rho')\rho''C_v'' + (\rho''-\rho)\rho'C_v' \tag{3-6}$$

and by Eq. (3-5)

$$\frac{1}{\gamma-1} = \frac{\rho-\rho'}{\rho''-\rho'}\,\frac{1}{\gamma''-1} + \frac{\rho''-\rho}{\rho''-\rho'}\,\frac{1}{\gamma'-1} \tag{3-7}$$

This equation looks at first sight to be most adaptable to the conditions of cloud chamber work. The problem which arises is that gamma (even for the most ideal gas, helium) is a function of the thermodynamic co-ordinates to such an extent that it is not constant over the range of even a typical 30° expansion.

3-4. Temperature-entropy diagram method. Accurate temperature calculations have been made using a method devised by Schmitt[51] and Dawbarn[52]. This method makes use of the temperature-pressure-entropy diagrams for the individual components of the gas. The expected temperature change during the expansion is determined by interpolating between isobars on a line of constant entropy. This temperature change allows one to calculate a gamma which is automatically averaged over the thermodynamic co-ordinates (sometimes referred to as an effective adiabatic index). The formula of Richarz is then used to calculate the composite adiabatic index. This procedure neglects the entropy of mixing and the exchange of energy between the component gases. As a result the method gives good results only when one of the gases is the dominant species.

Another method which should be even more accurate involves making a composite entropy diagram for the gas mixture and finding the temperature directly from the diagram. This latter method has the serious drawback in that these composite entropy diagrams are very cumbersome to make and a new diagram is needed every time the initial temperature is changed since the mole fraction of vapor changes with temperature. In addition, this method is not adaptable for use with a high speed digital computer so all work has to be done by hand.

3-5. Comparison of methods of temperature determination. All temperature calculations ultimately come from an equation of state for the gas. Equations of state use three variables to completely describe the gas. Cloud chamber expansions are adiabatic so one of the variables used must be entropy. It may be set equal to a constant during the calculation. Derivations of these equations are given in standard thermodynamics texts.[57,58] Pressure, temperature and entropy are the variables chosen when pressure is measured during the cloud chamber expansion.

The most accurate method is that which integrates directly the equation

$$ds = C_p \frac{dT}{T} - \left(\frac{\partial V}{\partial T}\right)_p dP \qquad (3\text{-}8)$$

This equation refers to one mole of a single gas. For a gas mixture the mole fractions n_1 and n_2 are used where $n_1+n_2=1$ and the total entropy change is the sum of the individual entropy changes.

$$ds = n_1 ds_1 + n_2 ds_2 \qquad (3\text{-}9)$$

During an expansion

$$ds = 0 = n_1 ds_1 + n_2 ds_2 \qquad (3\text{-}10)$$

A numerical solution of this equation including the most accurate values of the heat capacities and compressibilities, $(\partial V/\partial T)_p$, has been used to provide calculations of temperature. Calculations of temperature using Richarz's method for average gamma as described by Kassner and Schmitt[37] were also used and compared with the results of the preceding method. It is concluded that there is essentially no difference in the results obtained with the two methods.

When immediate calculations are needed and no computing machine is available, the graphical method of temperature determination is useful. This makes the graphical method very adaptable to uses involving Aitken nuclei counters because of the independence from office machines.

The course of a perfectly adiabatic expansion is a vertical line on the entropy diagram. Latent heat is easily accounted for through the definition of entropy $ds=dQ/T$. When using air, there is so little difference in the diagram with a small mole fraction change that small changes in the mole fraction due to droplet growth are negligible.

Use of this technique complete with droplet growth corrections is outlined in detail by Kassner[59] et al. Refering to the diagram, Fig. 19, the expansion begins at the top of the diagram proceded straight down to point A where a correction is made for vapor depletion (negligibly small at this time). At points B and C the corrections for latent heat begin to be sizable. An excessively large droplet concentration, 10,000 droplets per cm^3 was assumed in the calculation to make the effects show up vividly. Comparison of this method with the exact integration technique shows essentially no difference in accuracy.

In conclusion, any of the three basic methods of temperature calculations may be used with confidence. Each has its advantages and disadvantages depending upon the situation. Richarz's method for average gamma is most useful where a desk calculator is used and vapor

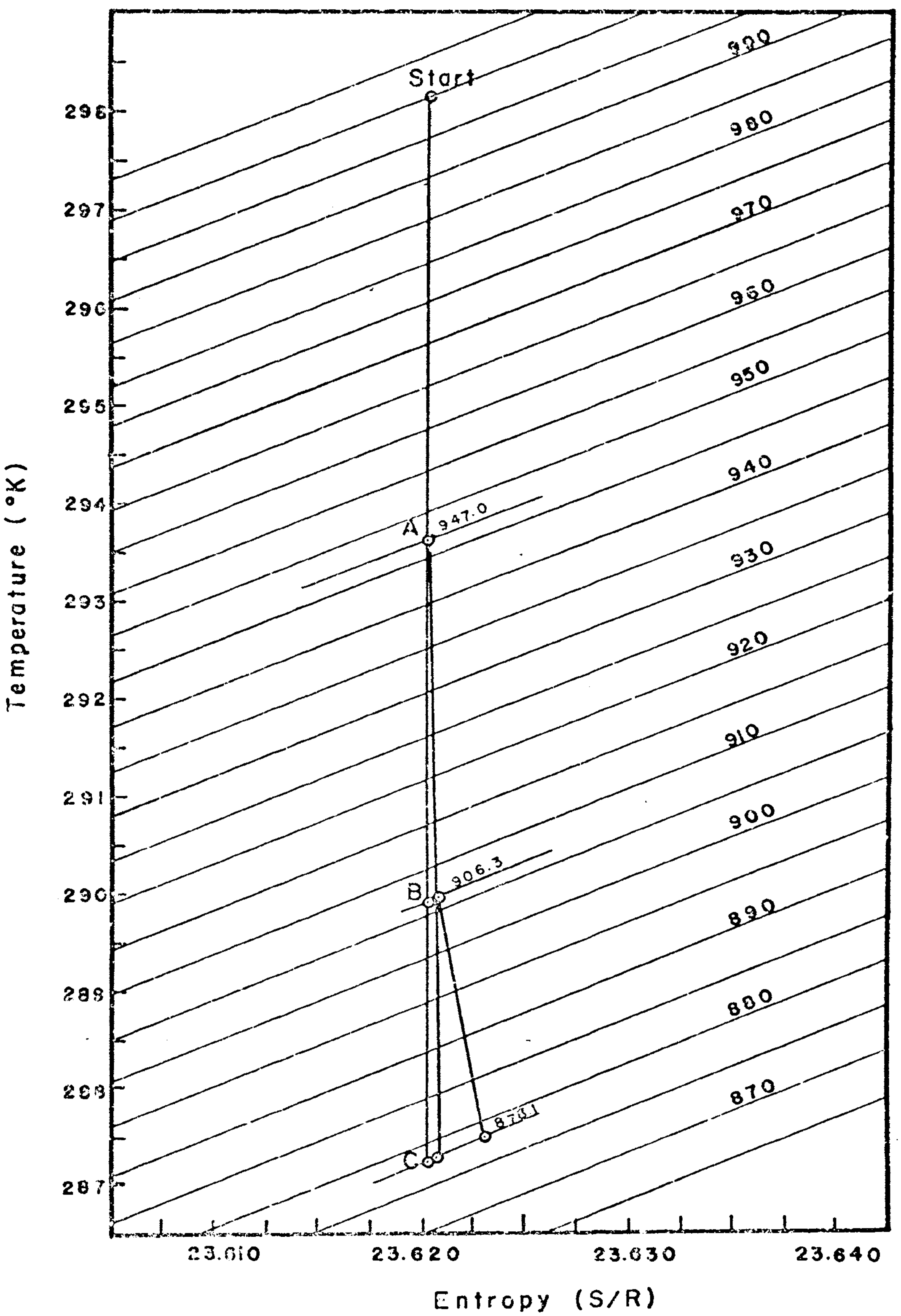


Fig.19. Determination of the True Temperature from the Temperature – Pressure – Entropy Diagram.

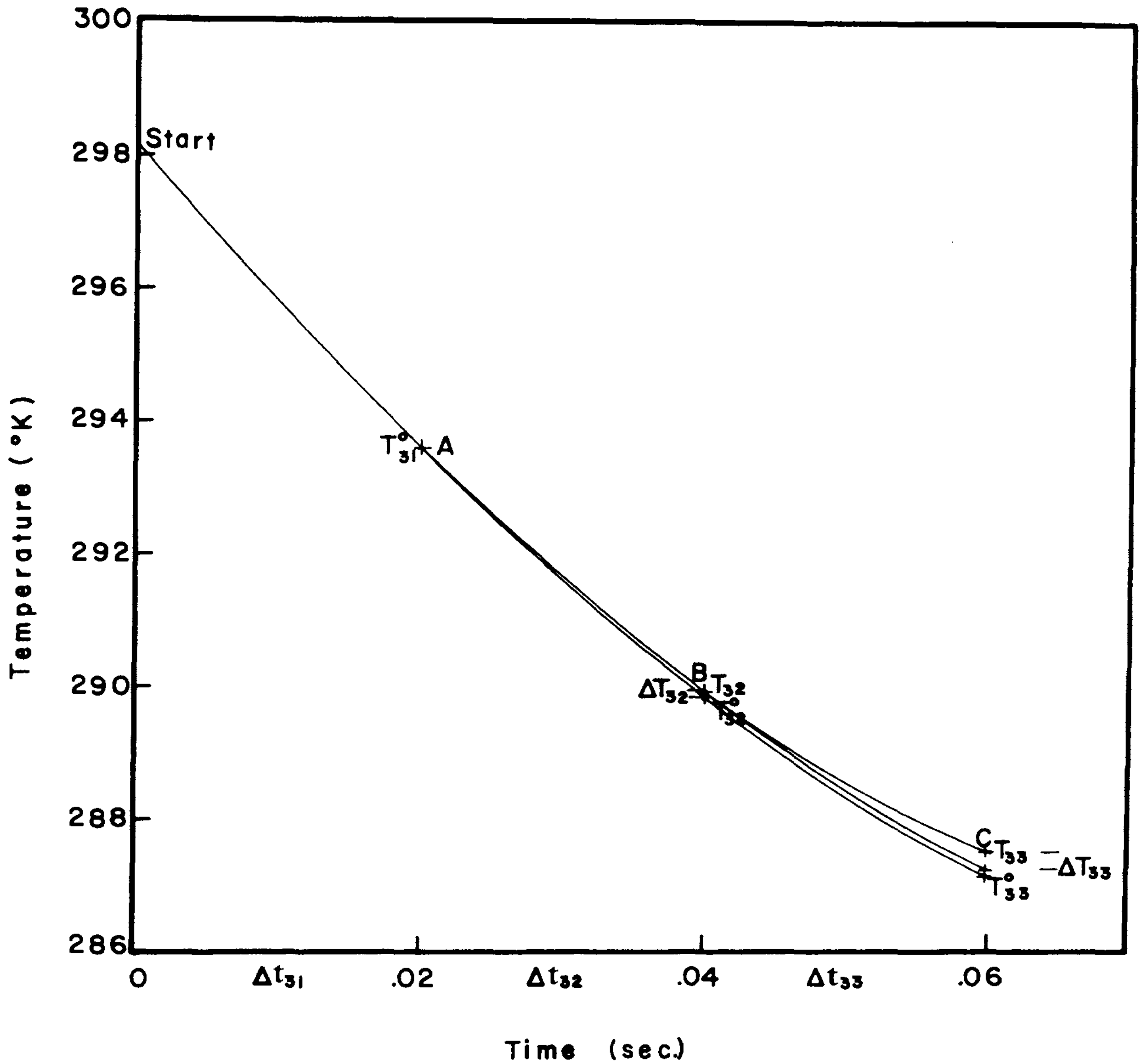


Fig. 20. Determination of the True Temperature by the Entropy Method. The Diagram Corresponds to the Expansion Shown in Fig. 19.

depletion effects are negligible. The graphical technique requires a tedious plotting of a new entropy diagram for each new mole ratio, but is very adaptable where no calculating machines are available and where the same initial conditions are used. The exact numerical integration technique is not adaptable to hand calculations, but is the only method easily programmable for large computing machines when taking all corrections into account. It appears that all three techniques will continue to be used as each has its own range of usefulness making it uniquely adaptable to a given situation.

3-6. Experimental test of equations of state and measuring techniques. Use of temperature entropy diagrams requires knowledge of entropy values to quite high accuracy. These values have ordinarily been derived by differentiating the equation of state which is risky at best. There is not and has been no doubt that the accuracy of these equations of state is quite good. The following question arises. Since the derived functions such as heat capacity and entropy are obtained by taking first and second order derivatives, just what accuracy is retained in these derived functions? F. Din[60] most aptly states the problem in his work on argon:

> The first differential coefficient was difficult enough to derive even with nominal accuracy whilst values derived for the second differential co-efficient were uncertain in the extreme. It was decided to perservere and values of
>
> $$\left(\frac{\partial r}{\partial t}\right)_p, \quad \left(\frac{\partial^2 r}{\partial T^2}\right)_p \quad \text{and} \quad T\left(\frac{\partial^2 r}{\partial T^2}\right)_p$$
>
> were derived, tabulated and smoothed, values of C_p, entropy and enthalpy were then calculated by integration and it was immediately apparent that they were untenable. They showed

considerable irregularities when plotted and were in no sense systematic.

Considering that the data for argon is perhaps the most accurate and consistent of that for any gas, also that argon is the most ideal of all gases after helium and neon, it is not difficult to imagine inconsistencies arising in the entropy tables.

It was decided that in order to obtain good results with nucleation work, dependable data on the various gases in the cloud chamber must be obtained. The aim was to take sufficient data to check the existing data. It was felt that the accuracy that could be obtained with static measurements was not better than had been obtained by other experimenters, for instance in the case of argon at Leiden by Crommelin and Onnes[61] and coworkers, at Reichsanstalt by Hobborn,[62] by Masson[63,64] and coworkers, at the Van der Walls laboratory by Michels[65] and coworkers and by Bridgman[66,67]. Therefore, a means was sought to exploit the advantages of the cloud chamber. Data would not be taken recording pressure, volume and temperature, but recording only pressure and temperature during a constant entropy process. Data of this type plotted on a temperature entropy diagram, should yield a vertical line if our results are consistent with the diagram.

The remaining question is, just what sort of accuracy must an experiment provide so that the data obtained is of equal or better quality than the published data. A true error analysis of published data is difficult to carry out. One can judge, however, from the number of significant figures published in a table, the confidence with which an author rates his calculations. This confidence is expressed by publishing one more significant figure than the accuracy of the computations would indicate. This is a necessary evil, however, in order that internal consistency might be obtained. Using this criterion, the data taken should exceed the accuracy of published data if pressure measurements are maintained to an accuracy of 0.5 mmHg and temperature measurements to 0.05 C°.

With very little modification, the Wilson expansion chamber of this laboratory may be used for making thermodynamic measurements. Temperature and pressure are recorded during an expansion or compression of a gas under conditions of constant entropy. These measurements must be made with extreme accuracy and speed.

3-6.1 Obtaining a pure atmosphere. A new cloud chamber was constructed for this work. It has the advantage of a larger available piston motion so that sizable volume ratios might be obtained without partially filling the sensitive volume with water.

Assembly of the new cloud chamber was done with the greatest care. Every bolt, nut and screw was cleaned with the same care that one would use in a hospital surgical room. The sensitive volume was exposed only to the rubber diaphram, O-ring seals, stainless steel and glass.

In order that no water vapor or other volatile material enter the chamber, a dry ice and acetone cold trap was installed in the inlet line to the sensitive volume. This cold trap was kept in operation at all times during the period from assembly of the chamber to the completion of the data taking. Each time a new gas or gas mixture was used, a flushing operation was performed which virtually eliminated all traces of the former gas. A vacuum pump was used to remove as much gas as possible. New gas was then run into the chamber so that the final pressure was about three atmospheres. This gives a flushing action whereby three-fourths of the gas is removed each time so that the remaining gas of the former kind after filling is about twenty-five percent of the total. Usually eight flushing operations of this type were performed for each gas exchange with the result that the purity of the gas as it came from the cylinder was the determining factor in its purity in the cloud chamber.

A pressure transducer such as is used in this laboratory has a natural frequency of 40,000 Hertz. The oscillograph galvanometers have the slowest response of any component in the pressure detection system with a flat response from zero to 240 cycles per second (Heiland type M400-120, 8.62 MV/in, undamped natural frequency 400 cycles per second). Amplifier frequency response is good enough that no difference in gain is noticed for a d.c. signal or a ten kilocycle signal. The net result of the pressure detection system is that pressures are measured to ±0.02 percent accuracy with a time response which is short compared to anything happening in the cloud chamber.

The thermocouple employed in these measurements was designed to minimize thermal pertubations due to the thermocouple itself while maintaining the lowest possible resistance. The thermocouple is shown in Fig. 21 and its position in the cloud chamber in Fig. 22. It is necessary to maintain the lowest possible resistances for the thermocouple element since the noise level at the output of the amplifier is roughly proportional to the input impedence. In the case of chromel-alumel the output is of the order of forty microvolts per degree centigrade. In order to read a temperature to one-hundreth of a degree, it is therefore necessary to know the voltage coming from the thermocouple to better than one microvolt.

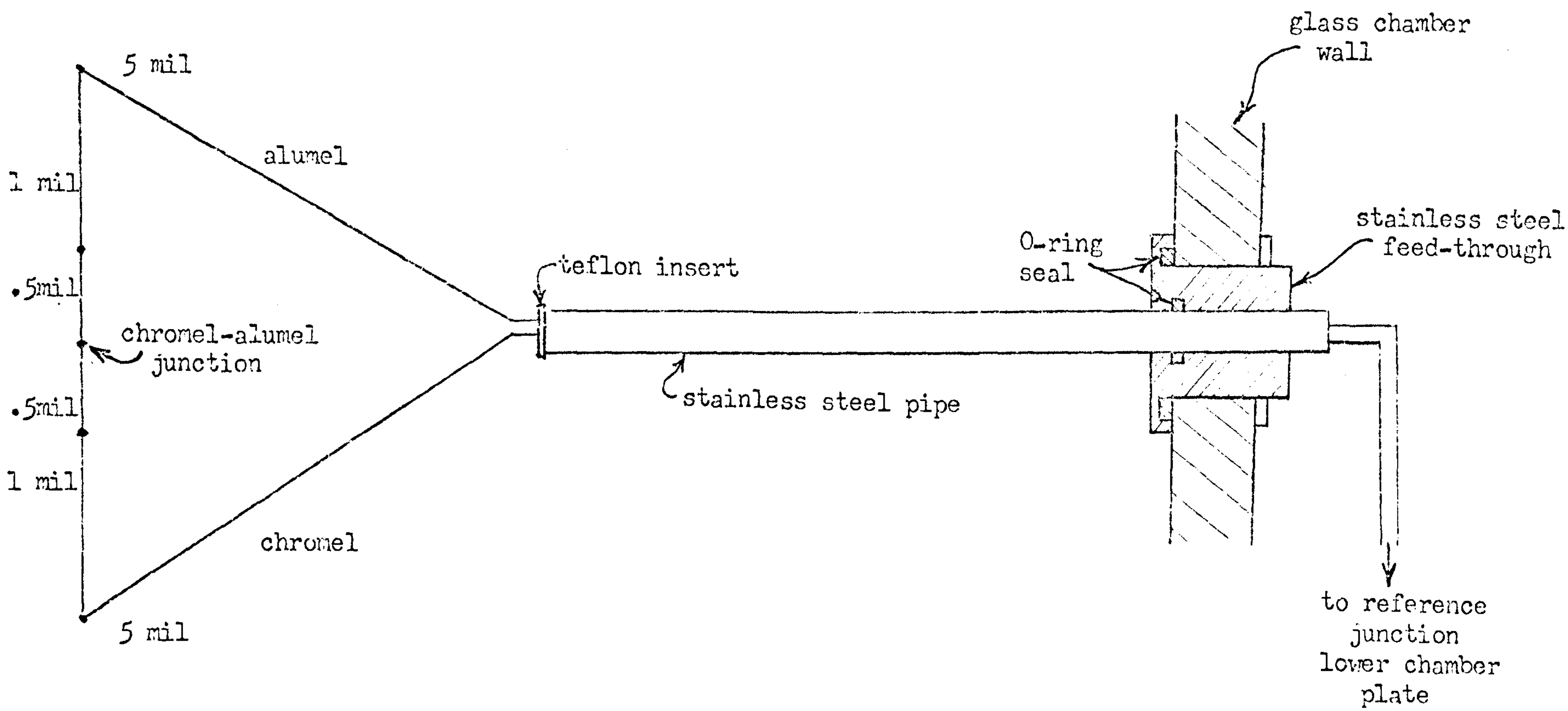


Fig. 21. Thermocouple used for measuring the gas temperature.

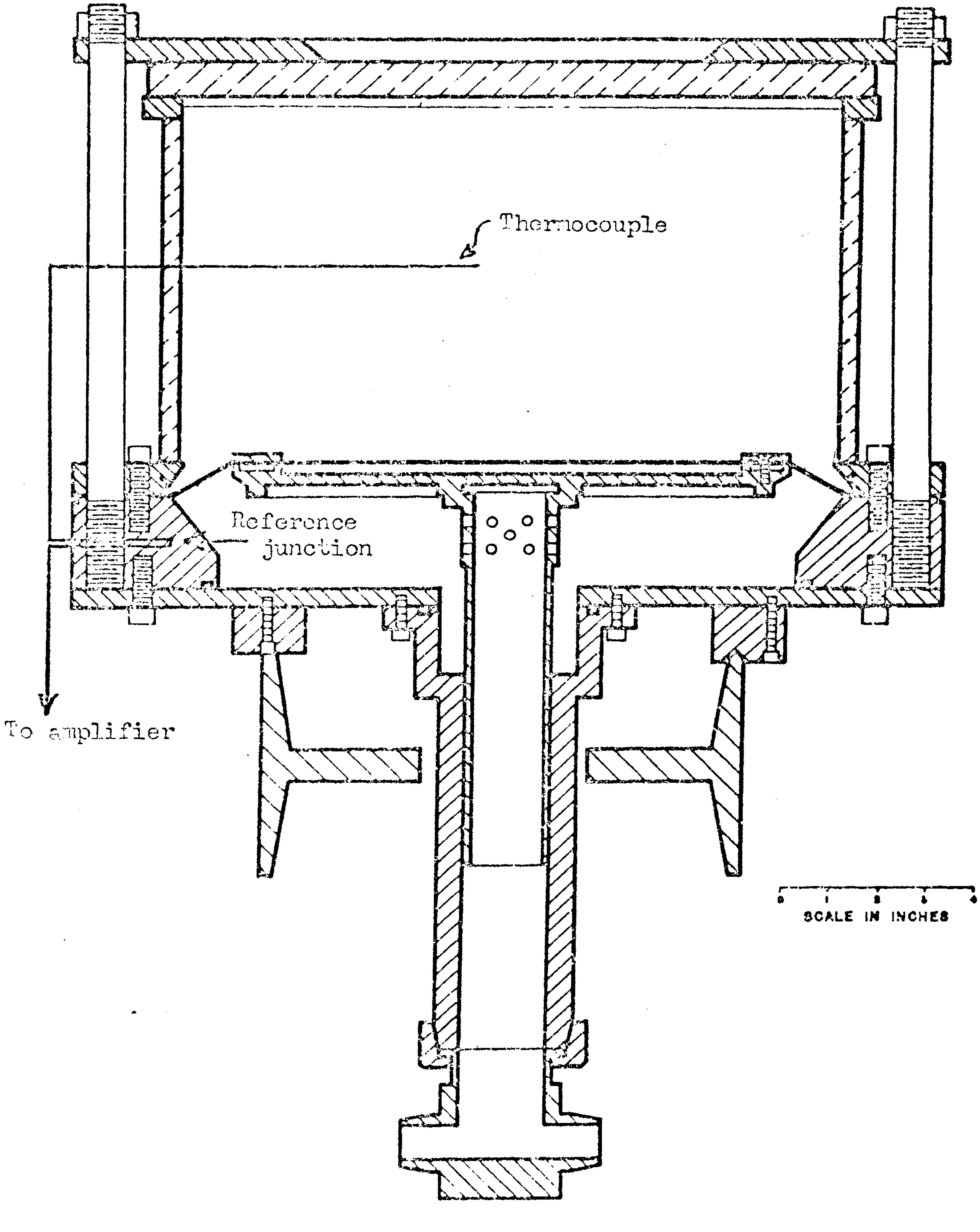


Fig. 22. The cloud chamber used for measuring gas temperature with a thermocouple.

Considering that wide band d.c. amplifiers generally have a noise level referred to the input of the order of tens of microvolts it is easy to see the difficulty in trying to accurately read an output signal to one microvolt. The Model 3101 California Instruments amplifiers used in this laboratory have a rated noise level of seven microvolts referenced to input. Four amplifiers were available so a complete check of each was made to determine which had the lowest noise level in the circuit configuration used with the thermocouple. The amplifiers were run in the potentiometric mode since it showed consistently lower noise levels than the differential mode.

Noise level tests with shorted input were made and recorded for each amplifier. It turned out that two of the amplifiers just met specifications while two were significantly better. Of the other two, one had a noise level of five microvolts peak to peak. The thermocouple used has a resistance of approximately 390 ohms. This value of carbon resistor was then placed across the input of each amplifier and a check made on the noise level. As expected, the noise level was higher, but only by about two microvolts in the case of the lower noise amplifier. A triply shielded twisted pair cable 25 feet long was constructed which has three 95 percent coverage shields. This cable was attached to the amplifier input and shorted, at the other end. Shorted at the end, it gave practically no noise increase, but with the 390 ohm resistor in place, the noise level was intolerable. It was therefore decided that the amplifier must be placed as closely as possible to the thermocouple so that stray capacitive pickup would be minimized.

After the thermocouple was installed and connected to the amplifier, several configurations of grounding the shields were tried. At best, the noise level referred to the input was down to about eight microvolts peak to peak. This included about five microvolts due to the amplifier, one microvolt due to the bias module and two microvolts due to stray pickup by the thermocouple.

It should also be mentioned that the thermocouple hanging out in the center of the cloud chamber as it did, acted as a very good antenna, picking up signals from every valve and a.c. power line in the vicinity. There was no alternative but to encase all operating valves in a copper-clad one-sixteenth inch iron case. Even the sola transformer operating the amplifier had to be moved from under the chamber. When all these changes were made, the noise level was again down to about eight micro-volts peak to peak of mostly sixty cycle noise with some 400 cycle noise from the chopper in the amplifier.

Luckily, the noise peaks from the pressure signal and from the temperature signal were in phase. There also was a flat place in the signal between each peak which corresponded to a period of zero noise level. Because of this, even though noise was present in the signal, readings were taken every 1/120 second during the quiet period of the noise cycle, thereby achieving the same effect as if the noise were a factor of ten smaller. One disadvantage of this is that in order to get a large number of data points on each run, the expansion or compression time had to be increased almost to the limit. A block diagram of the temperature measuring system is given in Fig. 23.

3-7. Thermal characteristics of fine wire thermocouples. The output response of fine wire thermocouples to a changing environment created by an expanding gas is more complex than many investigators have recognized. The seemingly instantaneous response to a fast expansion

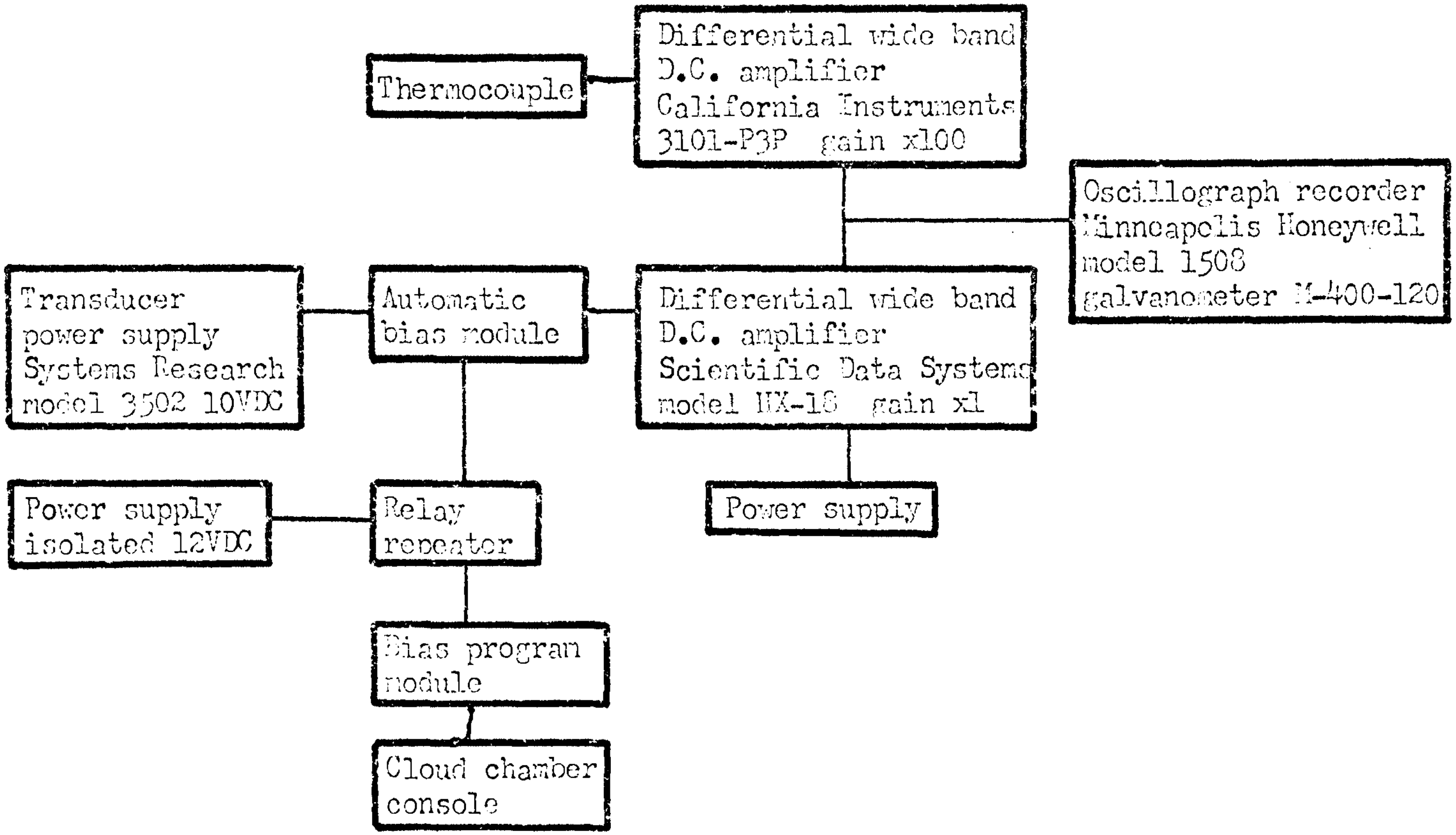


Fig. 23. Block diagram of the temperature measuring system.

has been erroneously assumed to be indicative of the accuracy with which the thermocouple follows the temperature change. It was the purpose of this investigation to place the interpretation of fine wire thermocouple measurements on a sound basis. The commercial availability of 0.0005 in. dia. thermocouple wire and the relative ease with which thermocouples can be fabricated from this size material strongly recommend it for temperature measurements. However, data taken in an expansion cloud chamber with such fine wire thermocouples indicated that the thermal capacity of the thermocouple itself was not negligible.

Let us look briefly at the physical situation. The thermocouple is initially in thermal equilibrium with the gas. Suddenly the gas temperature begins to decrease. The thermocouple wire has a finite thermal capacity and must communicate its excess heat to the surrounding gas by diffusion.

If the expansion proceeds at a constant rate, the temperature of the surrounding medium drops nearly linearly and the thermocouple becomes a steady source of heat just as surely as if it were being heated with an electrical current. Now under these circumstances the rate of diffusion of heat away from the thermocouple will adjust itself so that a steady-state condition exists, i.e. heat diffuses away from the thermocouple just as fast as it is being developed in the thermocouple (to use the electrical analogy). The establishment of the steady-state requires of the order of 10^{-4} sec. and so we see a very fast response to sudden environmental changes. But the temperature being indicated by the thermocouple is not the true temperature of the gas.

The question then arises, how far off are the temperature readings? This point cannot be resolved by experiment alone. First let us determine the speed with which temperature equilibrium is attained within the thermocouple wire itself. The solution to this problem is given by Churchill.[68]

$$T(r,t) = 1-2 \sum_{n=1}^{\infty} \frac{J_0(\alpha_n r/r_0)}{\alpha_n J_1(\alpha_n)} e^{-\left(\alpha_n^2 \frac{\kappa}{C_p} \frac{t}{r_0^2}\right)} \qquad (3\text{-}11)$$

where κ is the thermal conductivity, C_p is the heat capacity, r_0 is the radius of the thermocouple and the α_n are the zeros of the Bessel functions. $\alpha_1 = 2.405$, $\alpha_2 = 5.520$, $\alpha_3 = 8.654$ and $\alpha_4 = 11.79$. The chromel-alumel thermocouples used were made from 0.005 in. dia. wire. It is seen that a perturbation on the outside of the thermocouple is felt at the center with a half life of 3.0 microsec. After ten microsec. the center is within two percent and after 100 microsec it is within 10^{-8} percent of the outside temperature. Therefore, the relaxation time of the thermocouple itself is completely negligible. This is, of course, one necessary ingredient for fast response.

The calculation of the heat flow from the thermocouple surface out through the gas is much more difficult because the radial symmetry is lost when the gas begins to move past the thermocouple as it does in expansion cloud chambers. However, in this case the gas velocity is small and laminar flow may be assumed.[69,70]

Since things are everywhere the same in the direction of the axis of the *stretched out* thermocouple wire, the problem reduces to a two dimensional heat flow problem.

$$C_p \frac{\partial T}{\partial t} = \kappa_g \frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + f(x,y,\dot{x},t) \qquad (3\text{-}12)$$

where C_p is the heat capacity of the gas at constant pressure and κ_g is the thermal conductivity of the gas. ($f(x,y,\acute{x},t)$ is a source function which allows for varying expansion speeds and also allows for the motion of the thermocouple through the gas. Only numerical solutions of this problem were attempted.

Figs. 24 and 25 show the results for an expansion in dry argon. The 0.0005 in. dia. (12 microns) thermocouple was located 3 in. from the top glass. The evacuated chamber was filled with tank argon which was passed through a liquid nitrogen cold trap to insure its dryness. Note that Fig. 25 indicates close agreement between the theoretically predicted thermocouple temperature and the measured thermocouple temperature. The difference is about 1.5 C° after a short time for a gas velocity of 2 cm/sec. Clearly, the fast response of the thermocouple is no indication of the accuracy with which it reads the gas temperature.

A simple calculation shows that the heat capacity of the wire is sufficient to cause a 0.1 C° rise in temperature in a cylinder of gas with a radius of 0.3 cm. This is only misleading since the small gradients make the dispersal of the evolved heat very slow.

Israel and Nix[71] investigated the thermodynamic processes in the Pollak counter by inserting a fine wire thermocouple into the dry chamber, Fig. 26. They reported only a fraction of the temperature change expected from a calculation of the temperature drop by means of the adiabatic law. This result is exactly what one would expect from the foregoing analysis.

Moreover, their Fig. 2 showed a peculiar anomaly at a time of 1.5 sec. One can explain this feature as follows. At the end of the expansion the thermocouple still has a heated gas mass surrounding it and so it reads a temperature which is too high. The heating of the gas adjacent to the walls excites convection currents which take a moment to get started. At 1.5 sec. after the expansion the convective motion sweeps the heated gas surrounding the thermocouple away, allowing it to read a temperature which more closely approximates the true temperature. The temperature readings from about 2 sec. on should more closely approximate true values and an extrapolation of this part of the curve back to the time immediately after the expansion gives more nearly the temperature drop brought about by the expansion.

In conclusion, we might say that thermocouple measurements of gas temperature present a degree of complexity which has not been generally recognized. The actual response of the fine wire thermocouple (as opposed to the speed with which it responds to a sudden change in its environment) is very slow. Moreover, the equations of state for the gases tested check very well against the data obtained in these experiments.

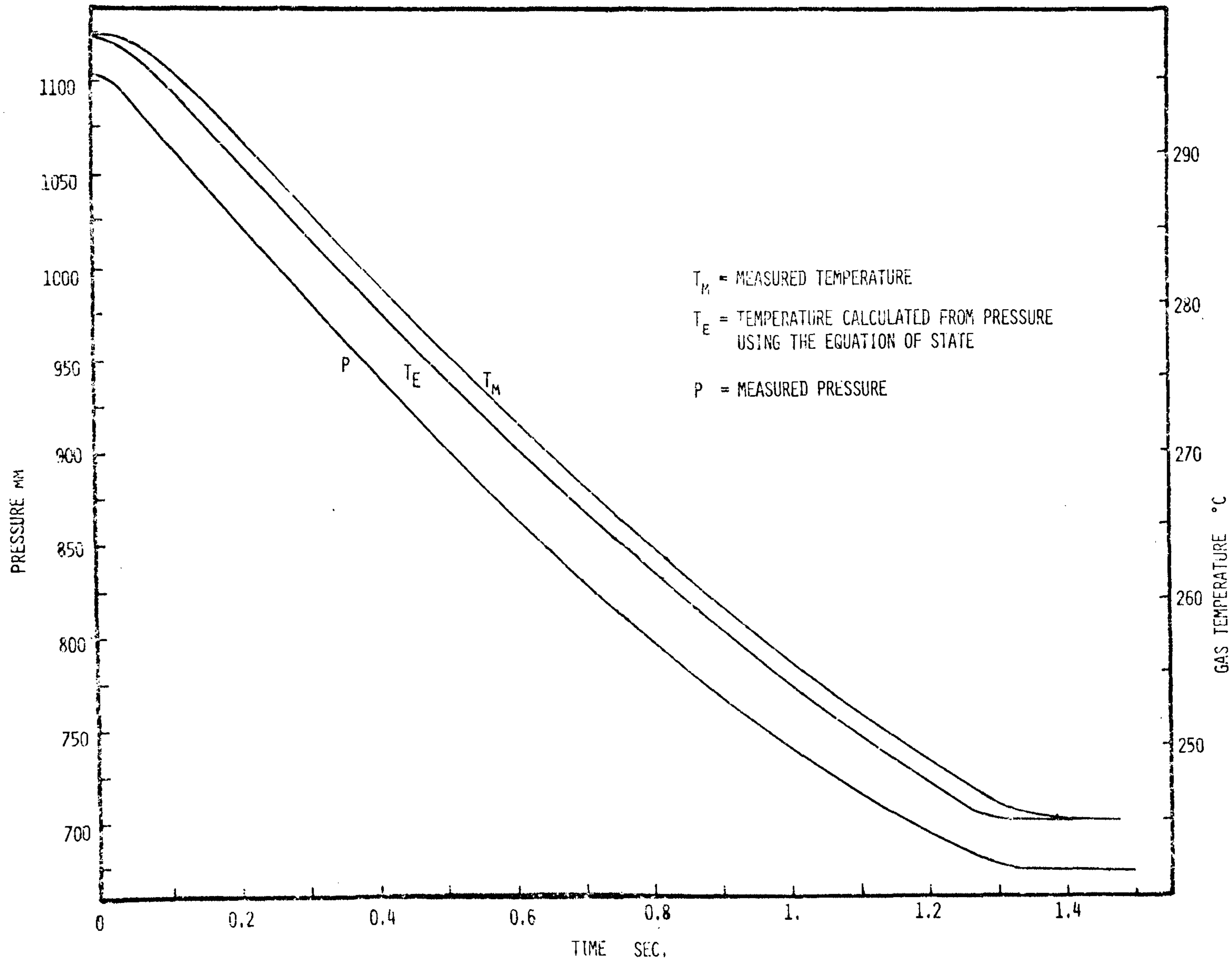


Fig. 24. Measured temperature and pressure in dry argon.

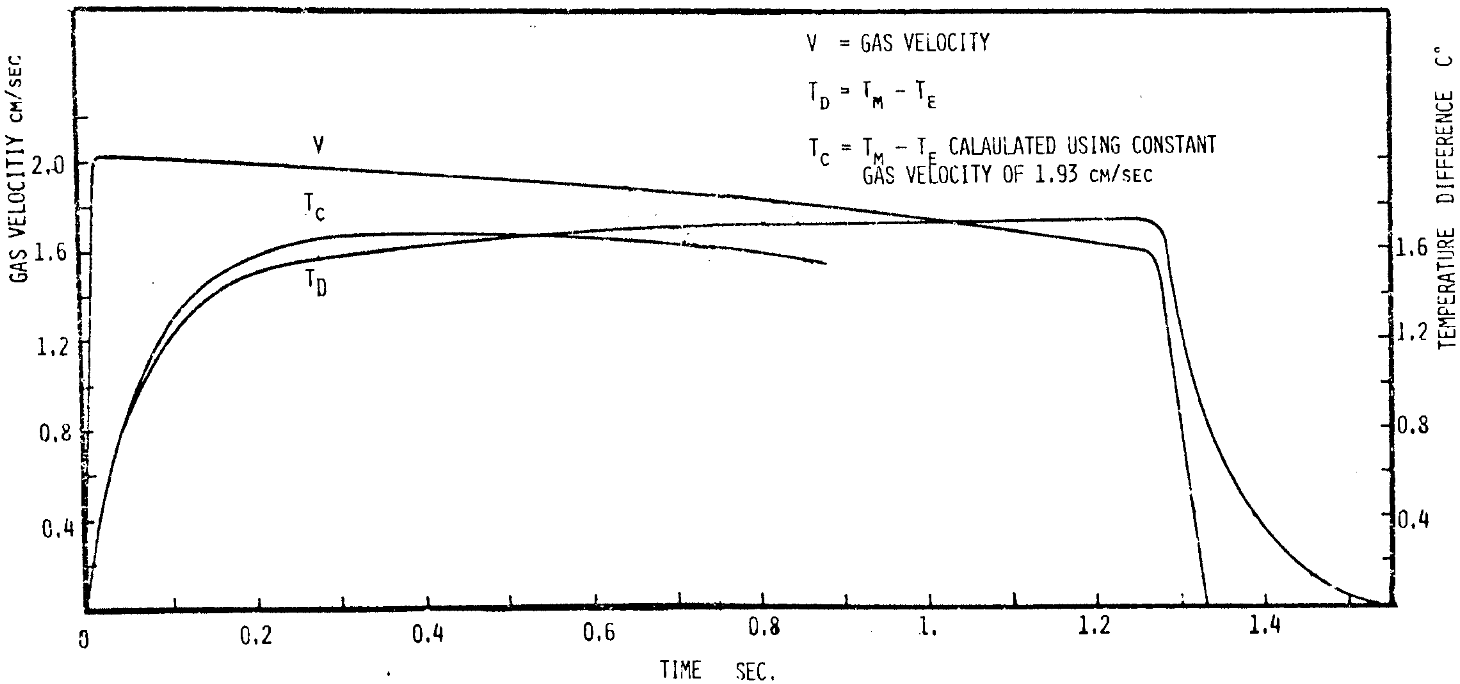


Fig. 25. Temperature difference for the expansion shown in Fig. 24.

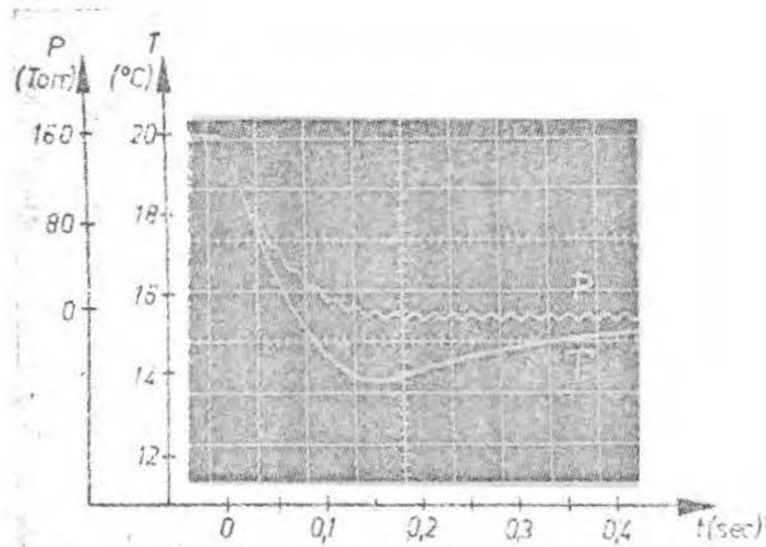


FIG. 1. — Variation of pressure P and temperature T during a dry adiabatic expansion in the condensation nuclei counter of Pollak.

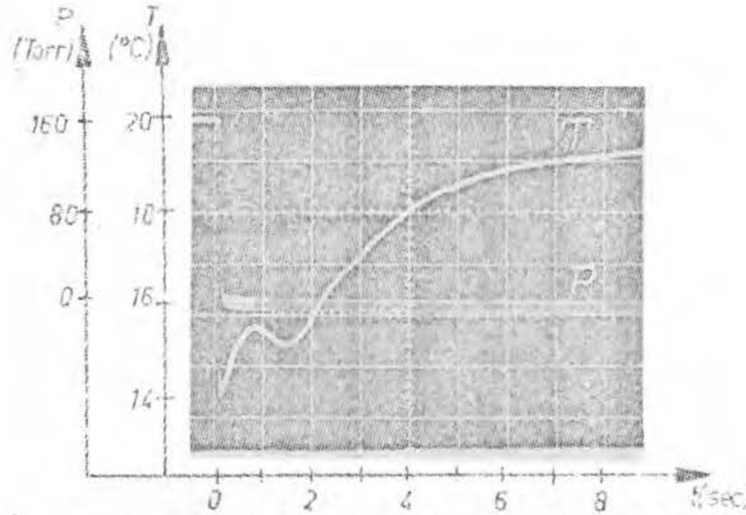


FIG. 2. — Record of the reheating in the condensation nuclei counter. P : pressure ; T : temperature.

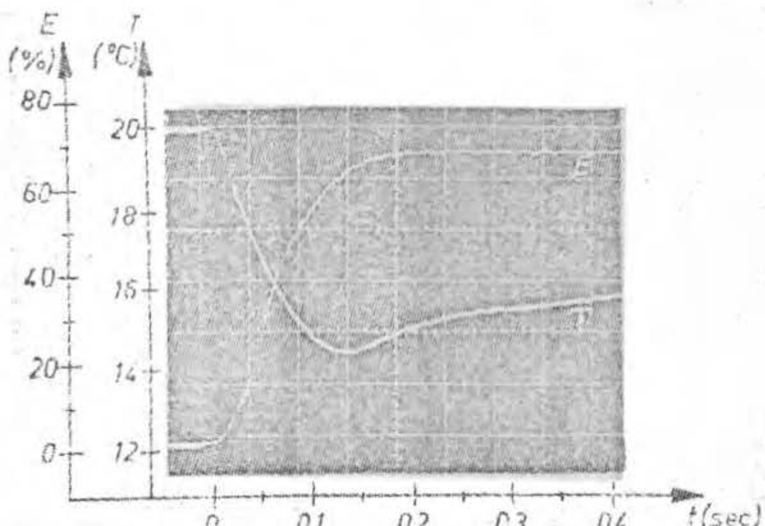


FIG. 3. — Variation of temperature T and extinction E of light.

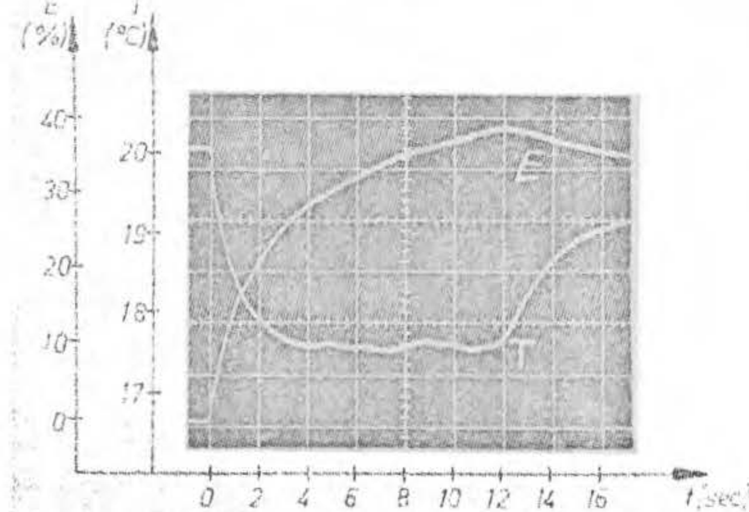


FIG. 4. — Variation of temperature T and extinction E during an extended expansion.

Fig. 26. Data of Israel and Nix.

CHAPTER IV

NUCLEATION MEASUREMENTS

The first homogeneous nucleation measurements to be made in this laboratory were made by Allard and Kassner.[20] Later, additional measurements were made by Kassner and Schmitt[37] with some improvements in technique and data analysis. One of the principal problems was related to the inability to adequately account for the various aspects of droplet growth: bulk depletion of available vapor, effect of diffusion profiles around growing droplets on subsequent nucleation (dead space) and competition for the available vapor supply by closely spaced droplets. Droplet growth measurements are conspicuously lacking and much effort has been expended in studying these effects.

The author has attempted to elucidate the disparity which exists in the literature on the nucleation rate of water vapor by providing comprehensive measurements of the nucleation rate as a function of supersaturation, temperature and sensitive time. Fig. 27 shows data representing the average nucleation rate as a function of average supersaturation for narrow nucleating pulses of sensitive time 0.01 sec. The circles represent data in argon while the crosses represent data in helium, both for an initial starting temperature of 22.5°C. Note that the data in Argon are noticeably and reproducibly higher. Dawbarn[52] first observed this effect in this laboratory. Classical theory predicts no effect on the nucleation rate due to the nature of the non-condensible gas. This effect might be the manifestation of the alteration in the free energy of the critical cluster due to the inclusion of an argon

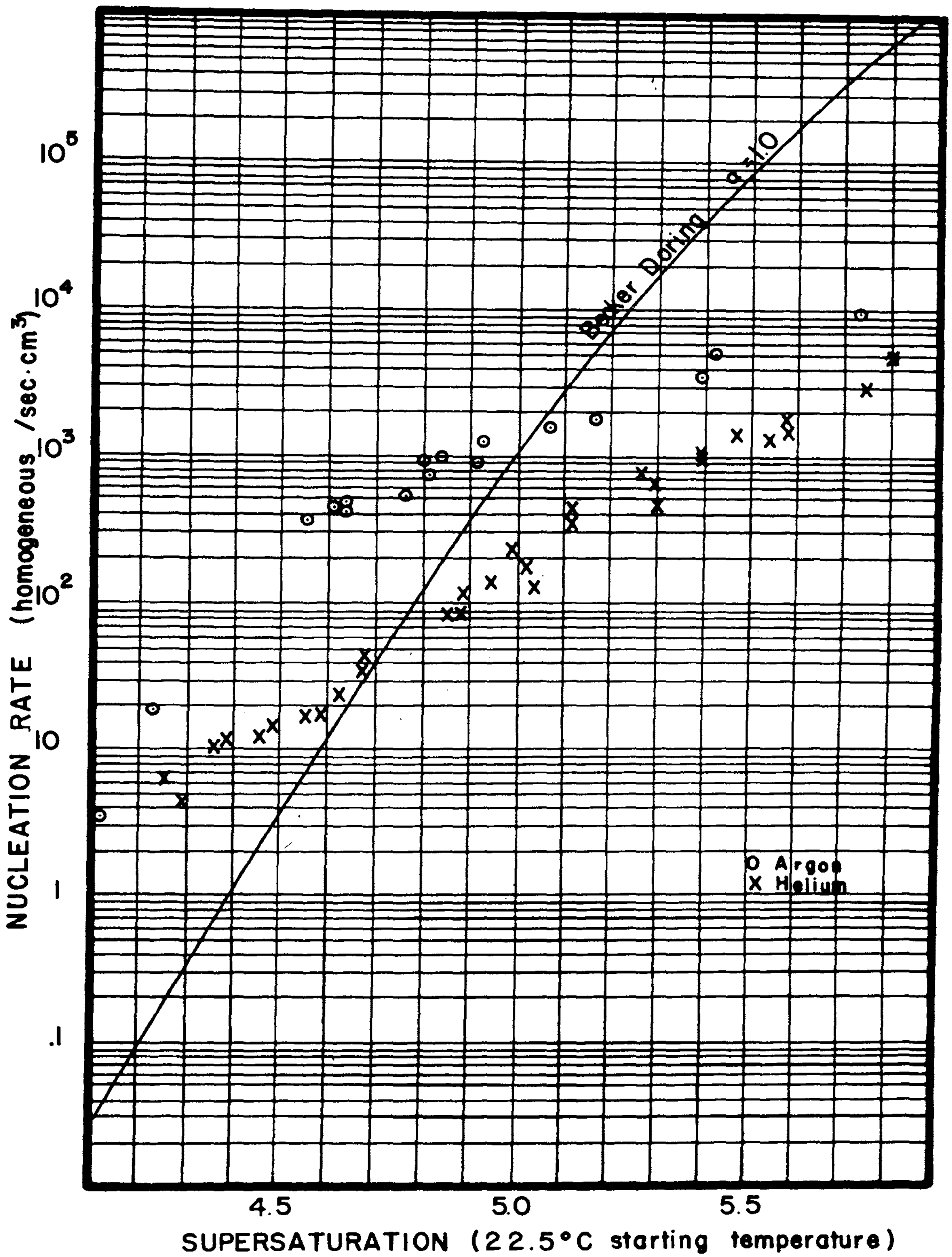


Fig. 27. Comparison of the nucleation rate in argon and helium.

atom in a clathrate like structure of water molecules in the embryo. Pauling[72,73] has hypothesized such a hydration scheme for xenon in the bulk water structure. Fig. 28 shows a possible arrangement of 20 molecules when an ion is included in the cluster. Fig. 29 shows a possible arrangement of 24 neutral molecules into a clathrate like structure. These two arrangements are dodecahedral and tetrakaidecahedral respectively and are the smallest possible configurations where each oxygen molecule has three hydrogen bonds and the bond angles are maintained near the normal bond angle. If such a configuration actually exists, these structures should be particularly stable and there should be a minimum in the free energy curve for these particular configurations.

Parunge and Lodge[74] have measured the effect of nonpolar gases upon the freezing point of supercooled water. Their water was of sufficient purity that small droplets normally froze at -16°C. Their data is reproduced in Fig. 30. It is seen that there is a definite ordering of the water molecules due to the presence of the inert gas. Claussen and Polglase[77] have suggested that the larger voids required in the liquid by krypton and xenon might well be dodecahedral or tetrakaidecahedral, thereby accounting for the discontinuity in the freezing points. If the critical cluster for nucleation of the liquid from the vapor is of the clathrate structure, krypton and xenon might well fit into the critical cluster. This would result in a sizeable lowering of the free energy of the cluster and the nucleation rate of water vapor in these gases would be correspondingly increased.

Fig. 31 shows the number of droplets nucleated per cubic centimeter as a function of peak supersaturation for the narrowest possible pulses. Both the 12.5°C and 22.5°C data exhibit prominent inflections while the 31°C data gives the indication that an inflection may exist

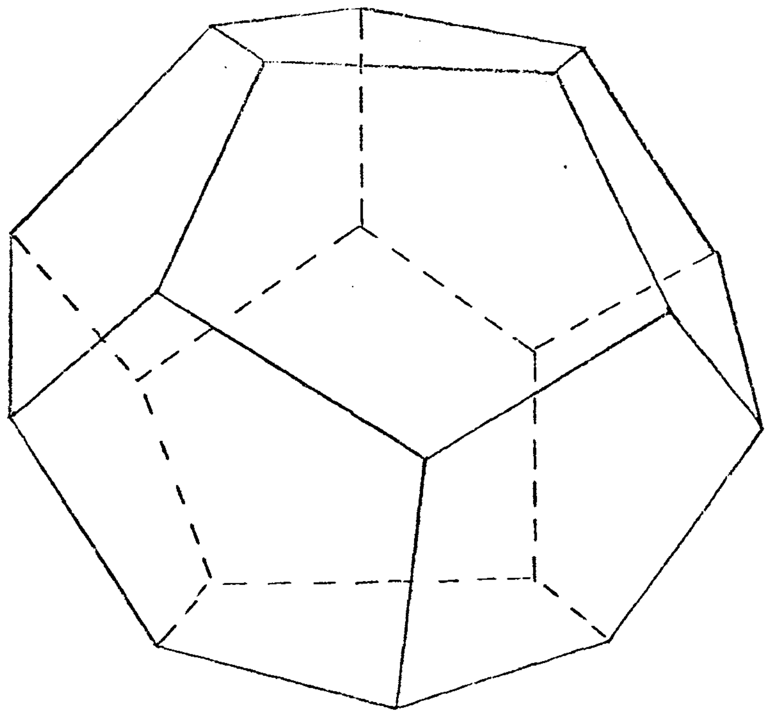


Fig. 28. The arrangement of hydrogen bonds for twenty water molecules in a dodecahedral configuration.

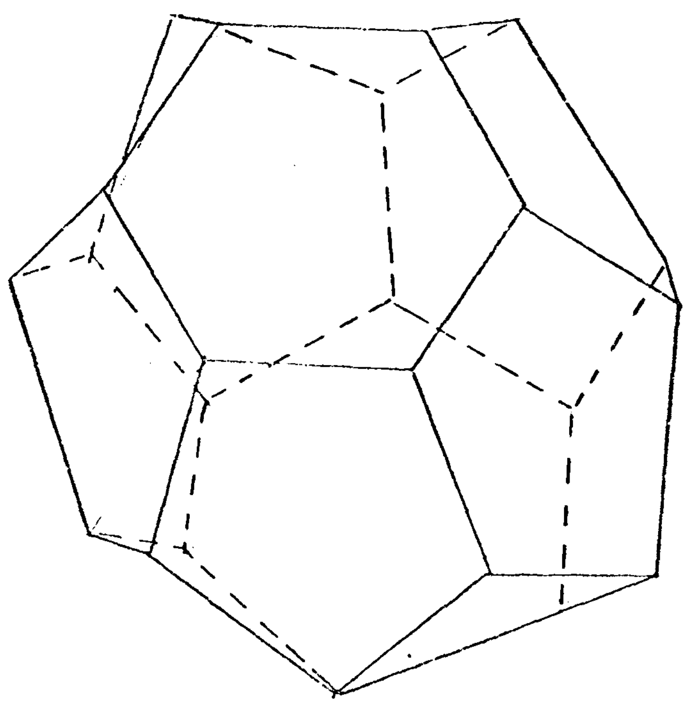


Fig. 29. The arrangement of hydrogen bonds for twenty-four water molecules in a tetrakaidecahedral configuration.

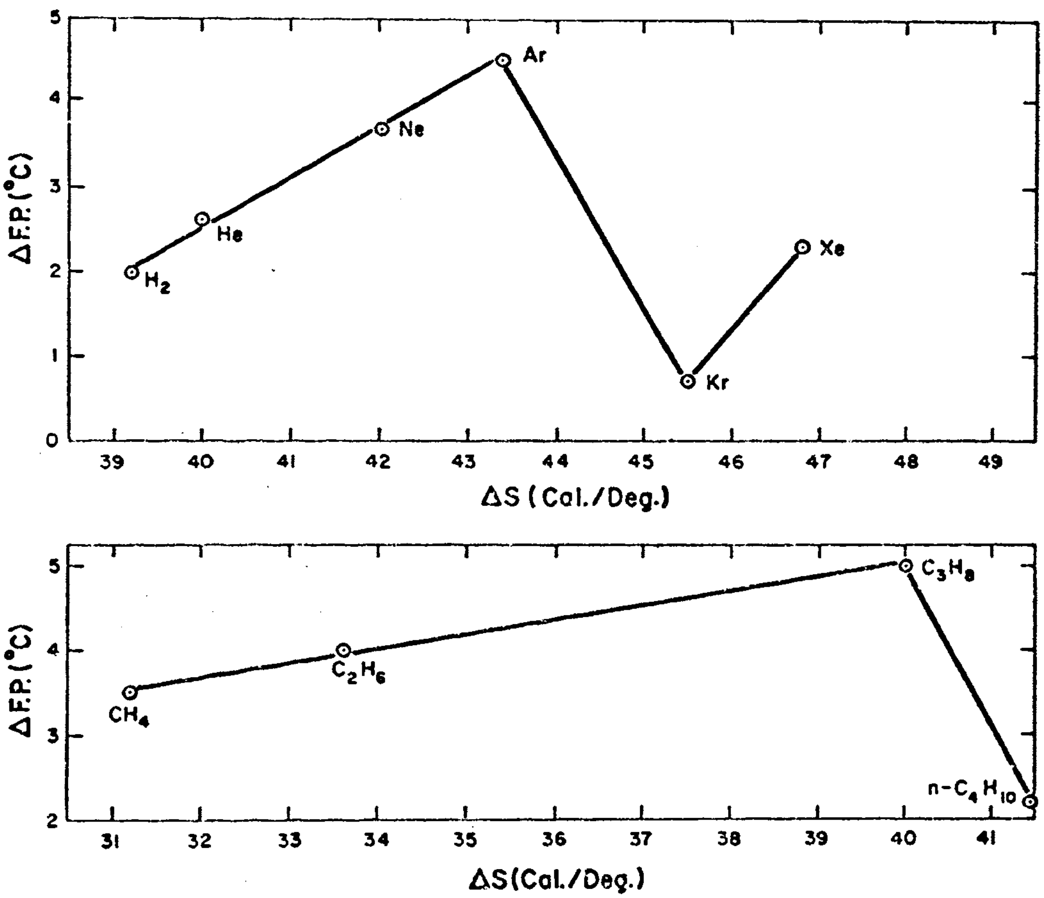


FIG. 1. Increase in the temperature of spontaneous freezing of 0.1-ml drops of solutions of two series of non-polar gases, compared with "pure" water, plotted against the entropies of hydration of the solute gases.

Fig. 30. Data of Parungo and Lodge.

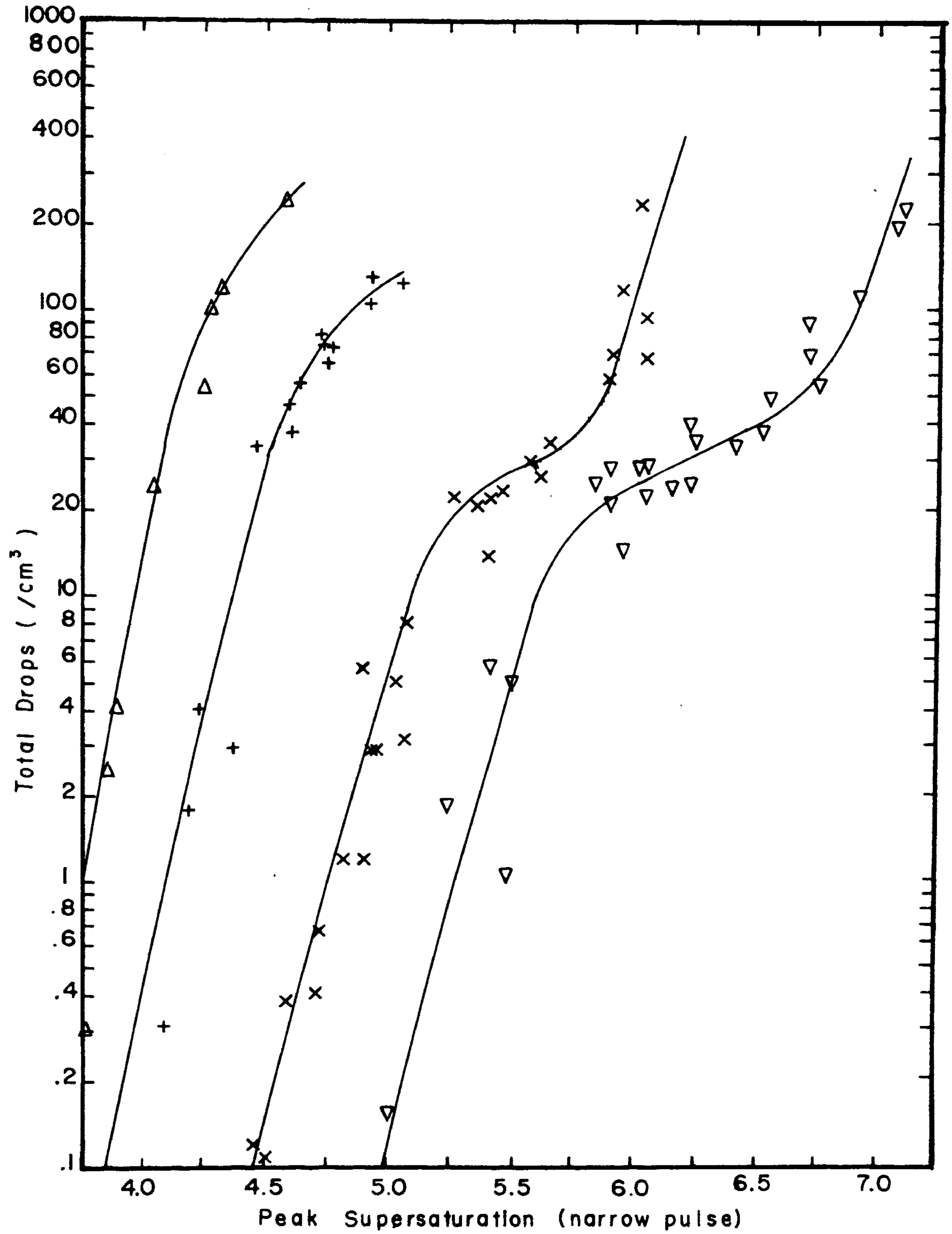


Fig. 31. Number of droplets nucleated as a function of peak supersaturation. The starting temperature is (Δ) 41.5°C, (+) 32.5°C, (x) 22.5°C and (∇) 12.5°C.

for higher droplet densities than could be measured in this experiment. If the number of droplets (corresponding to the plateau of the inflection for the 12.5° and 22.5° curves and the number estimated where the shoulder might lie for the other two helium curves) are compared, it is found that the number is nearly proportional to the initial vapor pressure of water in each case. Schuster[75] has measured the nucleation rate of water vapor in an argon atmosphere as a function of supersaturation with an initial temperature of 24°C. using light scattering techniques. His data agrees reasonably well with the author's both in slope and magnitude. His data reproduced in Fig. 32 shows slight evidence of an inflection at about the same point as the author's.

Fig. 33 is a correlation of the author's data with temperature dependence data found in the literature. Curve No. 1 is the author's data for an estimated droplet density of 100 drops/cm^3 or a nucleation rate of 10,000 drops/cm^{3}sec. Curve No. 2 is the corresponding data for 1 drop/cm^3 or a nucleation rate of 100 drops/cm^{3}sec. The dashed lines represent the path of the adiabatic expansion of the cloud chamber for the four sets of data. Curve No. 3 is the data of Volmer and Flood[15] for a rate of 4 drops/cm^{3}sec as estimated by Allard and Kassner.[20] The latter corresponds very closely to the author's data for a rate of 1 drop/cm^{3}sec both in magnitude and in slope. The ϕ's represent Powell's data for an estimated nucleation rate of 10^5 drops/cm^{3}sec. The author's data, extrapolated to this nucleation rate, agrees reasonably well with that of Powell both in magnitude and in slope. Curve No. 4 represents the homogeneous nucleation rate data of Sander and Damkohler[76] for their estimated rate of 1 drop/cm^{3}sec. The θ's are Powell's ion limit data.

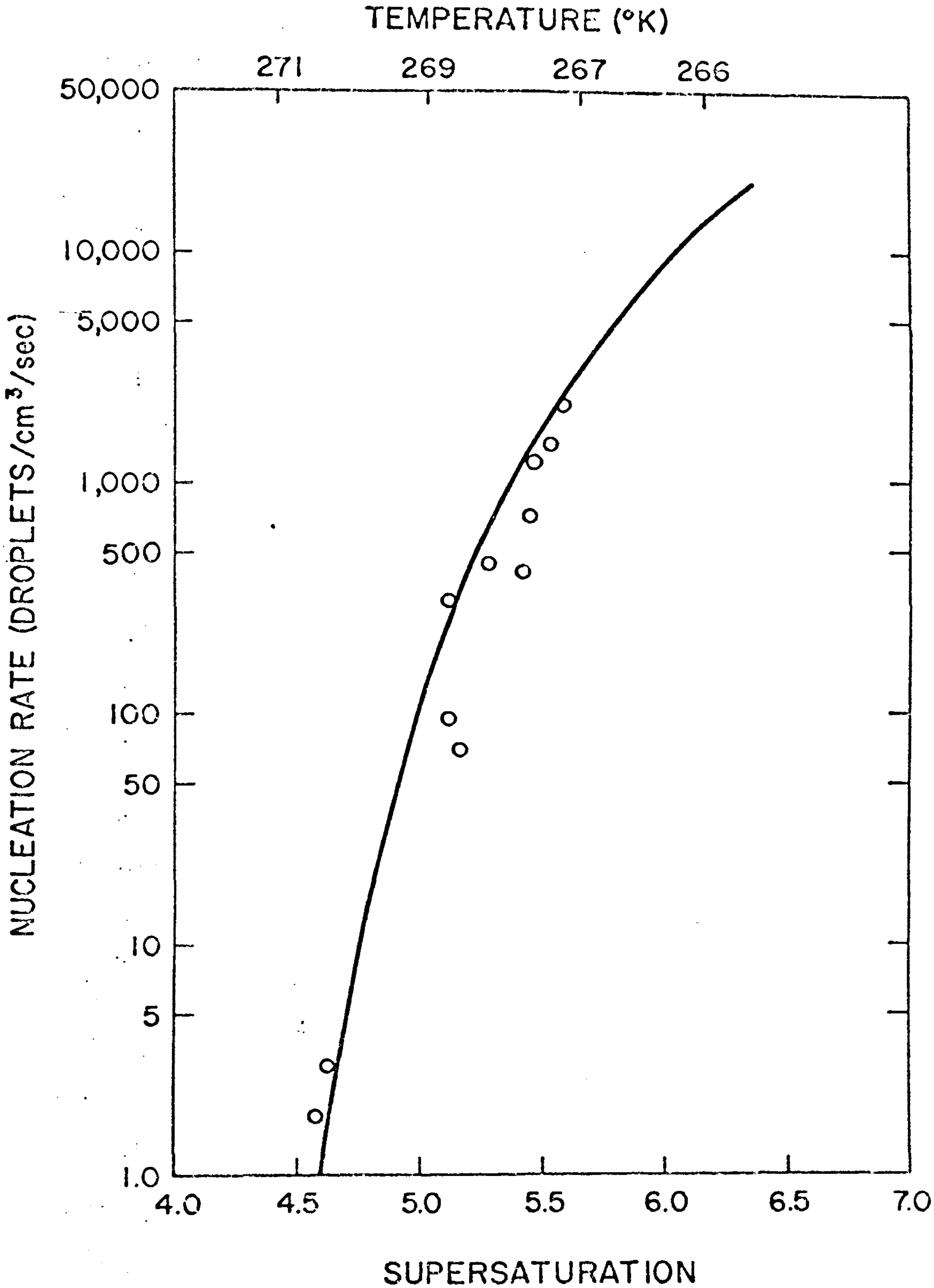


FIGURE 5-5 Variation of Modified Nucleation Rate with Supersaturation and Temperature

Fig. 32. Data of Schuster.

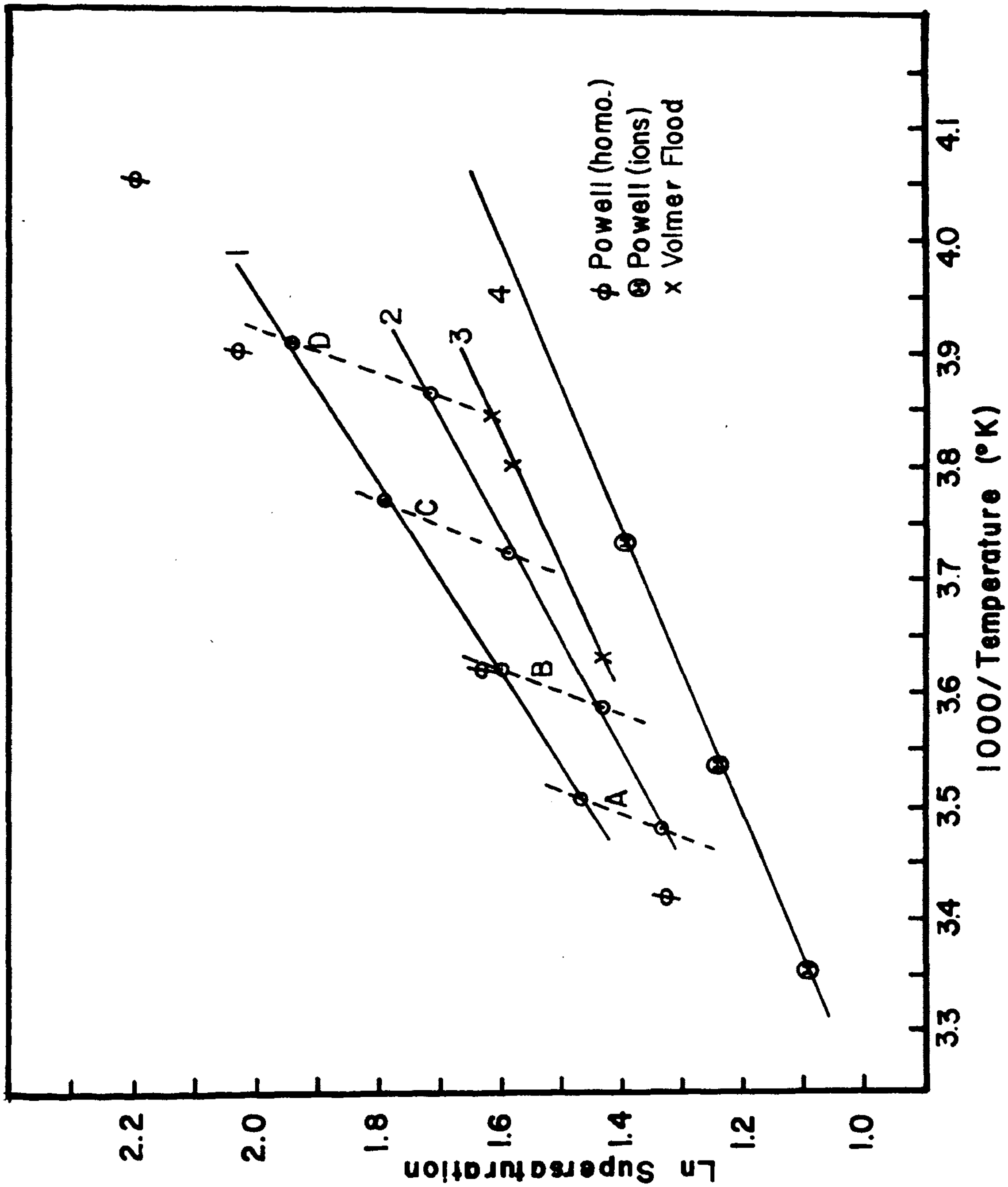


Fig. 33. Temperature dependence of the nucleation rate. The dashed curves are the paths of the adiabatic expansion for starting temperatures of (A) 41.0°C, (B) 32.5°C, (C) 22.5°C and (D) 12.5°C. Line (1) represents the author's data for 10,000 drops/cm³ sec, line (2) is the author's data for 100 drops/cm³ sec, line (3) is the data of Volmer and Flood and line (4) is the homogeneous nucleation data of Sander and Damkohler.

It is impossible to reconcile Sander and Dankohler's consistently low results unless they actually observed nucleation on ions. Curve No. 4 also agrees well with our results for nucleation on ions.

Fig. 34 shows the decrease in the measured nucleation rate as a function of time for supersaturations of 4.4, 4.9, 5.2 and 5.6. The dotted lines are the expected decrease resulting from the effects of droplet growth as calculated using the method given in the following chapter. It is seen that the decrease in the nucleation rate cannot be due to the effects of droplet growth. Moreover, the greatest deviation occurs at the supersaturation corresponding to the inflection in the curve of Fig. 31. In the data where the initial temperature of the cloud chamber was 12.5°C, the cut-off in the nucleation process with increasing sensitive time is even more pronounced. In this case, everything that is going to nucleate does so in the first 0.01 sec. for supersaturations between 6.0 and 6.5. Because of the unexpected nature of this data, both the 12.5°C and 22.5°C data were repeated several weeks after the initial data was taken. There was complete agreement with the previous data for both temperatures so it was felt that the data were accurate.

It is the cut-off phenomenon which indicates the presence of a heterogeneous nucleating agent. This effect is clearly not due to nucleation on ions. A clearing field of 80V/cm is maintained until the beginning of the expansion. Old ions are swept out and ion tracks show clearly at a much lower supersaturation.

Nucleation rate measurements have been carried out in this laboratory since 1960 and the results have all been self-consistent. The purity of the helium-water vapor system used in the experiments has varied widely without any change in the results. Water purification methods

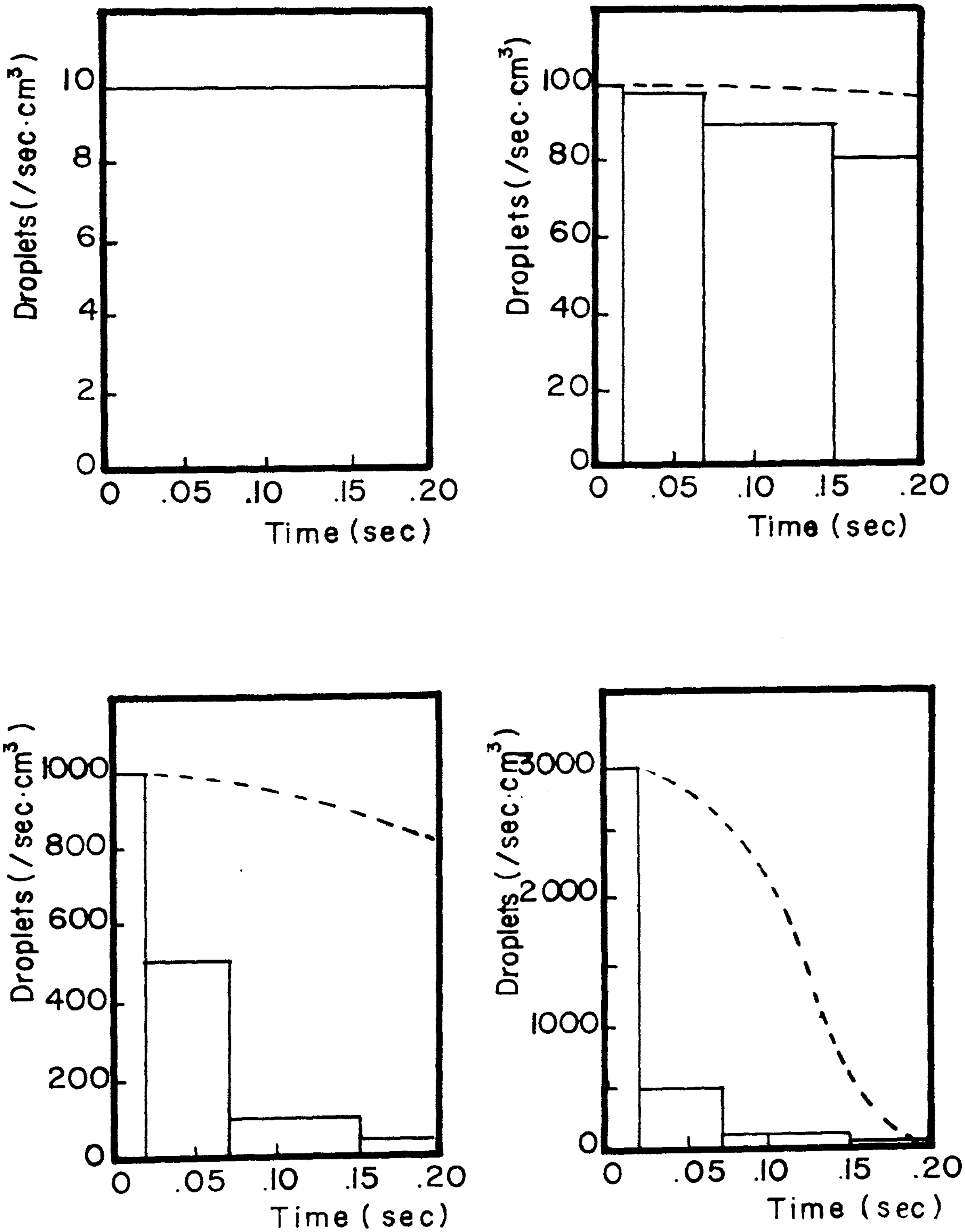


Fig. 34. Nucleation rate as a function of time. The starting temperature is 22.5°C and the supersaturations are left to right respectively 4.4, 4.9, 5.2, and 5.6.

have included deionization columns, ordinary glass distillation systems, distillation columns preceded by a charcoal absorption cell and the method described in Chapter II. None of these have produced any variance in the results. It is difficult to imagine any ordinary impurity which would be present with the observed consistency and in the small concentrations observed in these experiments (30 to 100 molecules/cm^3). Because the concentration of the impurity varies in proportion to the initial vapor pressure of the water, it seems likely that this particular nucleating agent is a neutral product formed through the action of ionizing radiation on the water vapor.

The data in the literature seems to be separable into two basic groups. One, such as the data of Volmer and Flood,[15] where measurements have been made yielding very small droplet densities and another, such as the data of Powell,[16] where measurements have yielded large droplet densities, see Fig. 33. Both of these are in good general agreement with the author's results, so it seems likely that the other observations have also recorded the same effect. Moreover, this mode of heterogeneous nucleation retains many of the characterististics of the homogeneous nucleation process and possesses a critical supersaturation limit very close to that predicted by the Becker-Doring theory. The similarity with the homogeneous nucleation process gives a clue as to the nature of the process.

Since the normal rate of ionization is due to both cosmic rays and natural radioactivity, the rate of production of molecules of the nucleating agent would be expected to be fairly constant with the largest fluctuations being due to cosmic ray showers. Cloud chambers cycling at a regular rate would be expected to experience about the same buildup between expansions whereas devices operating with irregular cycle times could easily experience large deviations in results. The scatter of data points experienced in this work near and below the plateau is reminiscent of that found by Allard[49] in his data for nucleation on random ionization. It is believed that this may explain the scatter of results displayed by Katz and Ostermier[39] for water since they probably cycled their diffusion chamber at irregular intervals.

4-1. Theory. In classical nucleation theory it is assumed that small clusters of water vapor molecules possess the properties of bulk water, i.e. they have a definite temperature and their surface may be characterized by the bulk surface tension for water. When a vapor molecule impinges upon a cluster, a quantity of Gibbs free energy, kTlnS, is released in the transformation from gas to liquid, assuming that the cluster may be considered as bulk water. However, the volume of the cluster must increase with the addition of each molecule so that some of the above energy goes into the creation of new surface, the total surface free energy of the cluster of radius r being $4\pi r^2\sigma$. Hence, the energy of formation of a homogeneous cluster is

$$\Delta G_h = -NkT\ln S + 4\pi r^2\sigma \qquad (4\text{-}1)$$

$$= -4/3\ \pi r^2 n_L \ln S + 4\pi r^2\sigma$$

where N is the number of molecules in the cluster, k is Boltzmann's constant, T is the absolute temperature of the gas, S is the supersaturation, σ is the surface tension and n_L is the molecular density of liquid water.

Since the volume has an r^3 dependence and the surface has an r^2 dependence, there is always a maximum point in the plot of free energy against radius. The radius to which the maximum free energy belongs is called the *critical radius* and is found by differentiating the Gibbs free energy. The critical radius

$$r^* = 2\sigma/n_L kT \ln S \tag{4-2}$$

so that the free energy ΔG^* of the critical cluster becomes

$$\Delta G^* = 4/3\ \pi r^{*3} n_L kT \ln S + 4\pi r^{*2}\sigma \tag{4-3}$$

$$= \frac{16\pi\sigma^3}{3[n_L kT \ln S]^2} \tag{4-4}$$

where $4/3\ \pi r^{*3} n_L$ is the number of molecules in the critical cluster.

It is conjectured that a chemical reaction may take place between a molecule of the heterogeneous nucleating agent and a water molecule. It is also assumed that clustering proceeds upon this complex chemical entity in much the same way that it does upon the clusters in the homogeneous case. The energy of formation of a heterogeneous cluster, i.e. a cluster including the chemical bond of energy ε, is

$$\Delta G_\varepsilon = -4/3\ \pi r^3 n_L kT \ln S + 4\pi r^2\sigma - \varepsilon \tag{4-5}$$

It is seen that because the ε term is independent of radius, the critical radius of the heterogeneous cluster is identical with that of the homogeneous cluster (neglecting the size of the single chemically active molecule) so that

$$r^* = 2\sigma/n_L kT \ln S \tag{4-6}$$

and

$$\Delta G^*_\varepsilon = \frac{16\pi\sigma^3}{3(n_L kT \ln S)^2} - \varepsilon \tag{4-7}$$

The free energy of a cluster as a function of radius is shown in Fig. 35 for both the case of the homogeneous and the heterogeneous clusters.

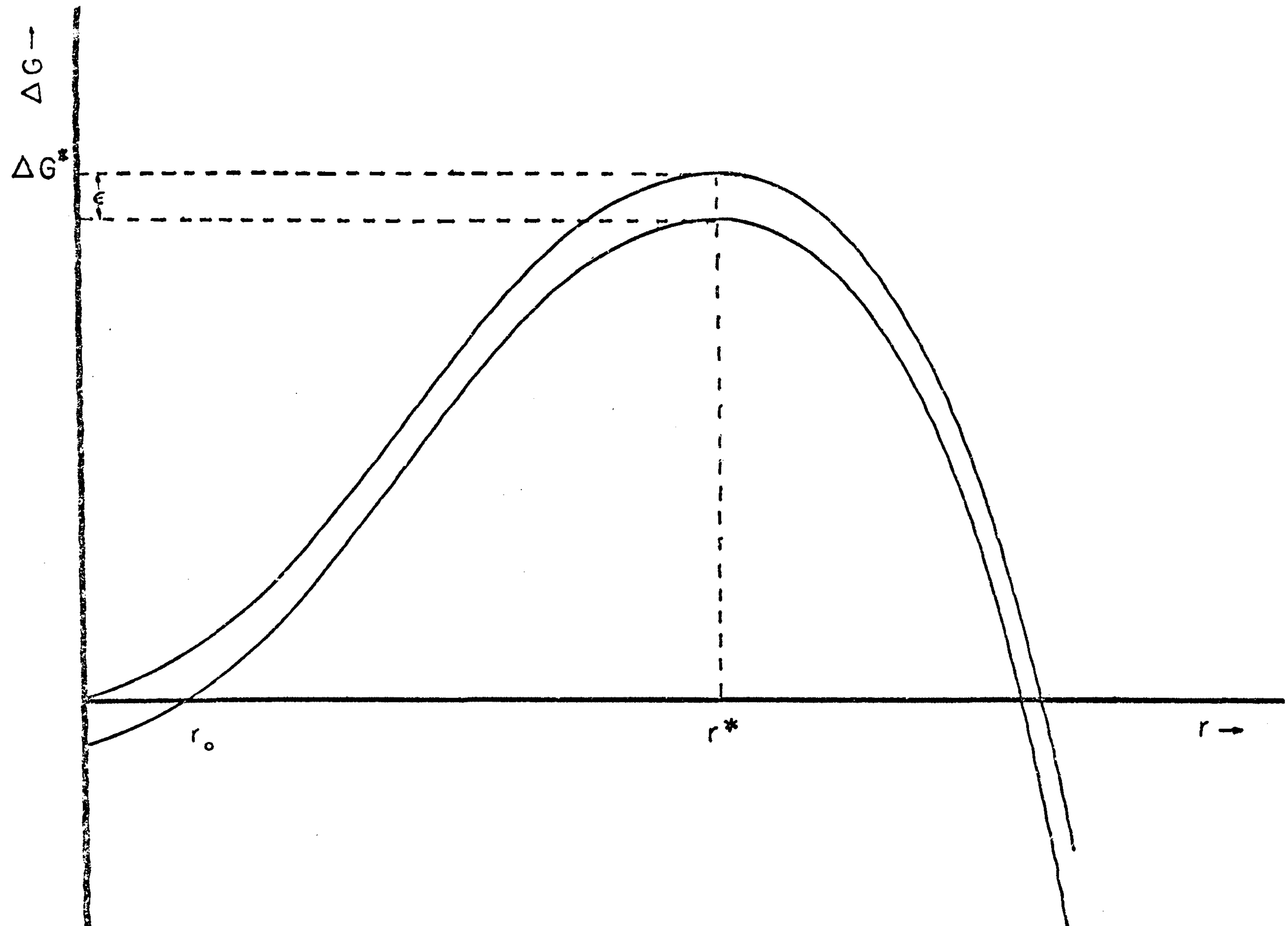


Fig. 35. Gibbs free energy vs. radius.

A small stable cluster of radius r_c exists at saturation which serves to give the heterogeneous clusters a slight head start in the fluctuation process. The author is fully aware of the shortcomings of the classical liquid drop theory and in particular the difficulties which arise when the theory is applied to very small clusters.

The gas is assumed to obey a Boltzmann type distribution law. It is therefore assumed that the probability of occurrence of a process is determined by the energy required to establish the process, i.e.,

$$P = \exp(-\Delta G/kT) \tag{4-8}$$

where P is the probability of occurrence of a cluster whose free energy of formation is ΔG, k is Boltzmann's constant and T is the absolute temperature. If N_o is the density of monomer water molecules in the gas and N_ε is the density of the heterogeneous nucleating centers, the expected density of clusters of size g of both the homogeneous and the heterogeneous types, N_{gh} and $N_{g\varepsilon}$, is

$$N_{gh} = N_o \exp(-\Delta G_h/kT) \tag{4-9}$$

$$N_{g\varepsilon} = N_\varepsilon \exp(-\Delta G_\varepsilon/kT) \tag{4-10}$$

Fig. 36 shows how the number, N_{gh}, of clusters of size g varies with g. The minimum of the curve is the critical cluster size. The distribution is assumed to cut off at a value of g slightly larger than g* (say about 2g*, the exact value is not critical) so that an infinite supply of vapor is not required to maintain the distribution. It is assumed that each cluster which becomes larger than g* by the aquisition of another vapor molecule becomes a free growing droplet and will continue to grow to macroscopic size. In the classical theory, which is a precatastrophic

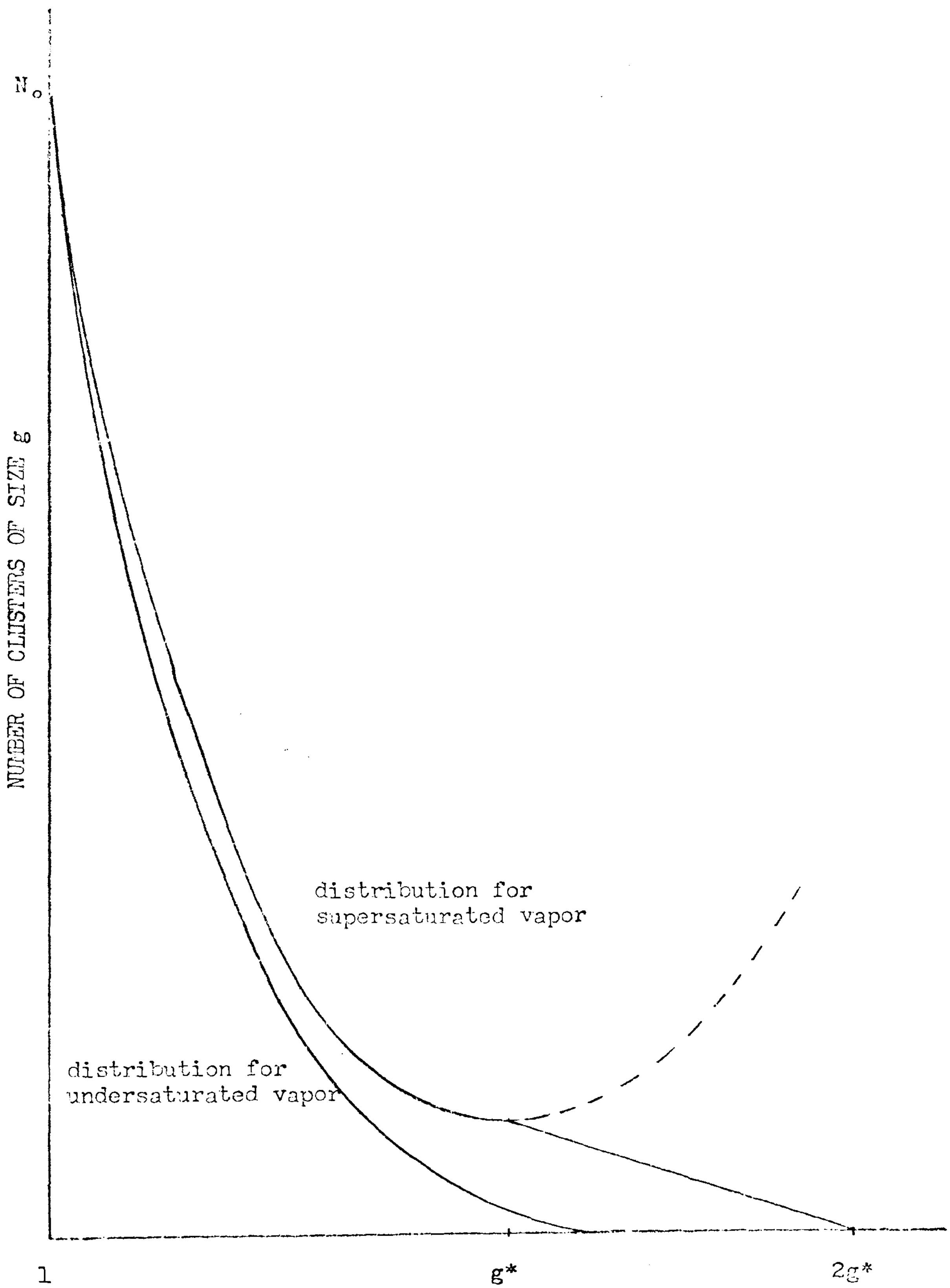


Fig. 36. Distribution of clusters.

theory, these droplets are assumed to be broken up by a Maxwell demon and returned to the vapor as monomers so that a steady state is maintained. The nucleation rate is the number of droplets growing larger than the critical size per unit time. Therefore, the nucleation rate is the product of the number of critical size clusters and the probability of the critical cluster acquiring another molecule. Hence

$$J_h = \frac{p\ 4\pi r^{*2}}{(2\pi mkT)^{1/2}} N_o \exp-\left(\frac{16\pi\sigma^3}{3kT(n_L kT \ln S)^2}\right) \tag{4-11}$$

$$J_\varepsilon = \frac{p\ 4\pi r^{*2}}{(2\pi mkT)^{1/2}} N_\varepsilon \exp-\left(\frac{16\pi\sigma^3}{3kT(n_L kT \ln S)^2} - \frac{\varepsilon}{kT}\right) \tag{4-12}$$

where p is the vapor pressure ofthe water and m is the mass of a water molecule.

It is assumed that the number density of monomer water molecules, N_o, is so large that its value does not change sensibly during the nucleating process. N_ε is much smaller, however, and the supply of these heterogeneous nucleating agents is quickly depleted. Therefore, a situation analogous to that of radioactive decay in nuclear physics exists.

$$-\frac{dN_\varepsilon}{dt} = P_\varepsilon N_\varepsilon \tag{4-13}$$

where $P_\varepsilon = J_\varepsilon / N_\varepsilon$.

This equation is integrated from time t=0 to time t=t and from the initial density $N_{\varepsilon o}$ to instantaneous density N_ε.

$$\int_{N_{\varepsilon o}}^{N_\varepsilon} \frac{dN_\varepsilon}{N_\varepsilon} = -\int_0^t P_\varepsilon dt \tag{4-14}$$

$$N_\varepsilon = N_{\varepsilon o} \exp-(P_\varepsilon t) \tag{4-15}$$

The total nucleation rate is the sum of the homogeneous and hetergeneous nucleation rates

$$J = J_n + J_\varepsilon \tag{4-16}$$

$$= \frac{p4\pi r^{*2}}{(2\pi mkT)^{1/2}}\left[\exp-\frac{16\pi\sigma^3}{3kT[n_LkT\ln S]^2}\right]\left[N_o+N_{\varepsilon o}\exp(-P_\varepsilon t+\frac{\varepsilon}{kT})\right]$$

The second term in the right hand bracket is the heterogeneous contribution to the nucleation rate. Fig. 37 shows how the nucleation rate varies with supersaturation. The dotted line is the path taken by the cloud chamber during an expansion. Depletion of the heterogeneous nucleating centers brings the rate down to that of the purely homogeneous level in a short time.

If the classical liquid drop model is assumed to be valid, one can surmise several things about the free energies and cluster sizes from the data. Putting the free energy into the form of Eq. (4-3) instead oftthat of Eq. (4-4) brings out the dependence of the critical cluster size and surface energy terms more clearly.

$$J = \frac{p\ 4\pi r^{*2}}{(2\pi mkT)^{1/2}}\left[S^{(\frac{4}{3}\pi r^{*3}n_L)}\exp-4\pi r^2\sigma/kT\right]\left[N_o+N_{\varepsilon o}\exp(-P_\varepsilon t+\frac{\varepsilon}{kT})\right] \tag{4-18}$$

It is seen that the slope of the curve on a plot of lnJ vs. S for constant temperature will give the number of molecules in the critical cluster, $4/3\pi r^{*3}n_L$. This would indicate that the critical size may only be 35 and not the 80 predicted by the Kelvin-Thompson equation. This is not surprising since it has been shown[78] that the surface tension of small drops should be lower than that of the bulk liquid. If this is the case experiments, such as those using nozzles for which it is predicted

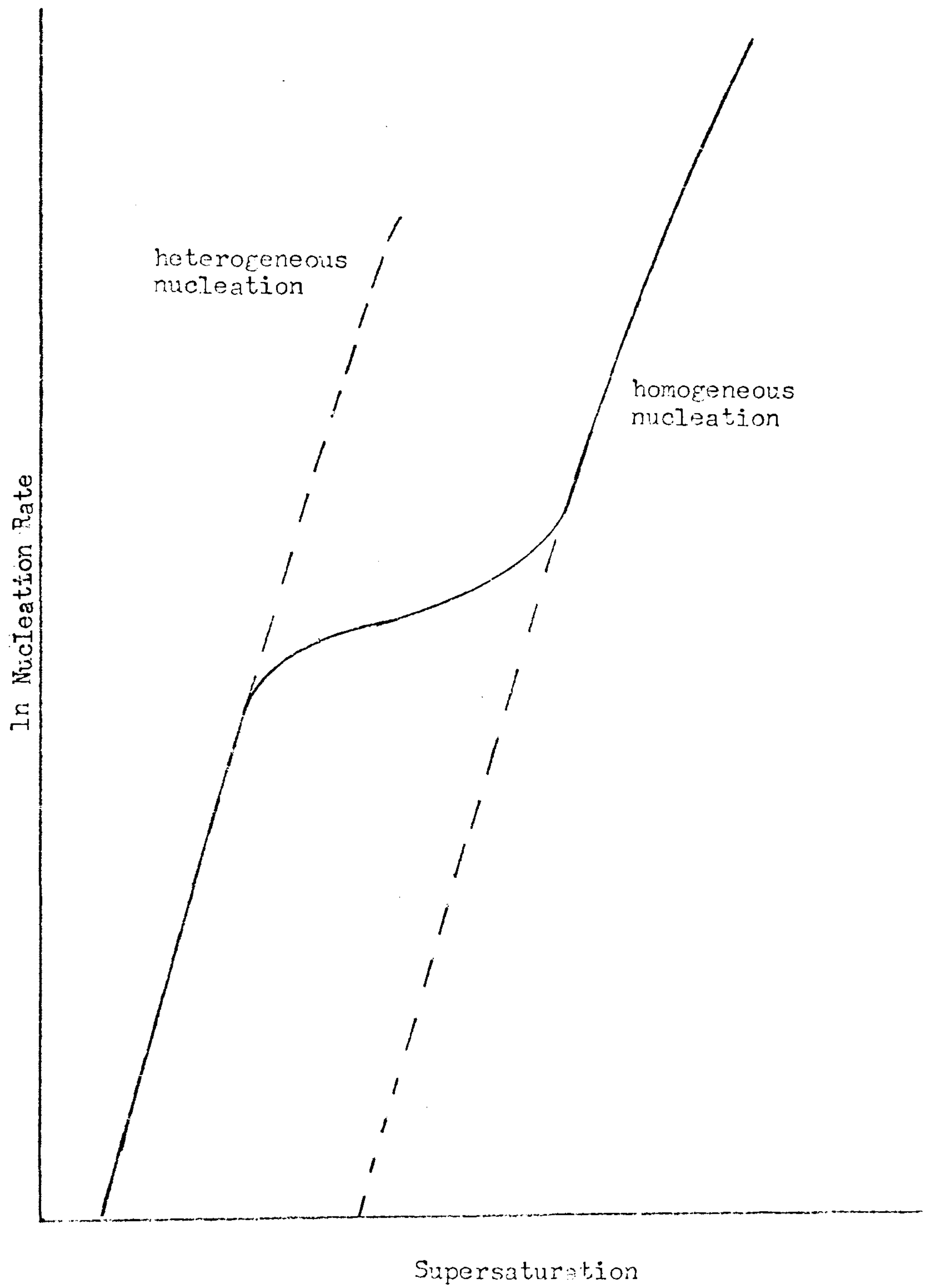


Fig. 37. Comparison of homogeneous and heterogeneous nucleation rates. The solid curve is the total nucleation rate observed in the cloud chamber.

critical cluster sizes are of less than ten molecules, must be reconsidered.

It is also seen that the slope of the plot of lnS vs. 1/T gives the surface energy per molecule in the critical cluster which differs in the two cases. The slope of the curves for the homogeneous and heterogeneous nucleation must be different because the heterogeneous slope has included in it an extra $\varepsilon/(4/3\pi r^{*3}n_L)$ term. Moreover, the theory of this chapter predicts a smaller slope for the case of heterogeneous nucleation which is in agreement with experimental data. There is also the additional effect due to the initial vapor pressure of the water vapor which is another temperature dependence which must be included when intercomparing data of different starting temperatures.

CHAPTER V

DROPLET GROWTH

In order to assess the effects of droplet growth upon the nucleating vapor, a detailed calculation is required which accounts for vapor depletion, release of latent heat and the effect of the nonuniform vapor and temperature profiles around the growing drop. An exact calculation is impossible without resorting to the theory of nonuniform gases. Computational complexity of such considerations are discouraging. It is apparent that a simpler version of the theory will be quite adequate for the purposes of this work provided that the depletion of vapor and the evolution of latent heat never become a dominating effect.

The problem of the diffusional growth of liquid droplets from the vapor has been considered by numerous investigators. Frisch and Collins[79] extended the range of validity down to droplets whose diameter was of the order of magnitude of the mean free path of the gas molecules. They relegated the entire thermal diffusion process to a simple accommodation coefficient which would appear to lose the complex interdependencies of the thermal diffusion process on other physical parameters.

Bagge, Becker and Bekow[80] formulated a solution for the mass flux which connects continuously to the surface of the drop via a connection with kinetic theory. However, they do not follow similar considerations in the case of thermal transport. Mason[81] takes into account kinetic interactions with the surface by deriving a modified diffusion coefficient. Although it seems to be implicitly implied, he makes no mention of the concept of either a temperature or vapor jump at the surface of the drop.

Beucher[82] develops a purely kinetic treatment of droplet growth which is valid down to the size of the critical nucleus defined by nucleation theory. He finds that the heat capacity of the droplet accounts for about half as much power as the creation of new surface, both effects dying out simultaneously at about twice the critical radius.

Neiburger and Chien[83] calculated droplet growth assuming macroscopic diffusion processes. They accounted for curvature, hygroscopicity and heating caused by the release of latent heat. They, however, neglected the effective modification of the diffusion coefficients at the droplet surface and, hence, did not account for a temperature or vapor density "jump" at the droplet surface.

Schuster[75] calculated droplet growth taking into account the effects of double diffusion of heat and vapor. He assumes, for simplicity, that the shape of the diffusion profile outside the droplet may be described by the function $1 - \exp(-R_0/r)$ where R_0 is a parameter of the order of the mean free path. This function is used to calculate the vapor density at a point just outside the surface of the droplet. He used kinetic theory to calculate the actual rate of growth of the droplet. His solution is iterated through time in much the same manner as the author's. This technique in conjunction with a series approximation for the above mentioned exponential allows the problem to be solved in closed form.

Carstens[84] intercompares the predictions of the steady state and the non-steady state versions of the diffusion droplet growth theory. It was found that a cellular approach to the quasi-steady state theory very closely approximates the nonsteady state theory. Reiss and La Mer[85] demonstrated the effectiveness of the cellular model but only considered vapor diffusion. More recently the cellular model has been used by Zung[86] to describe the evaporation of clouds and sprays. Smith[53] described the evaporation of very small water droplets utilizing a kinetic connection at the droplet surface. However, he did not use a cellular model.

Carstens and Kassner[87] discuss in some detail various aspects of droplet growth theory as they apply to cloud chamber measurements. The droplet growth theory utilized in this work is largely based upon their conclusions.

5-1. Droplet growth equations. Most cloud chamber experiments are arranged such that droplet growth occurs in a medium composed of a vapor in dilute solution with an inert gas. Vapor diffusion and thermal diffusion are both controlled by the nature of the inert gas. In the region where droplet radii are much larger than the mean free path of the gas molecules, the quasi-steady state diffusion equations constitute an adequate description of droplet growth.

$$\nabla^2\rho = K_\rho(t) \tag{5-1}$$

$$\nabla^2 T = K_T(t) \tag{5-2}$$

where ρ and T are the vapor density and temperature and $K_\rho(t)$ and $K_T(t)$ are homogeneous source functions which account for changes in the bulk vapor and temperature of the gaseous system brought about by external means.

Power balance is required at the droplet surface. The latent heat liberated by the condensing flux of vapor molecules must be carried away by the process of thermal diffusion which is accomplished principally by the noncondensible gas under our particular conditions. It is assumed that the droplet maintains a uniform temperature throughout its interior and that the steady state temperature of the droplet is always maintained.

$$DL\frac{d\rho}{dr}\bigg|_{r=a} = \kappa\frac{dT}{dr}\bigg|_{r=a} \tag{5-3}$$

where D and κ are the mass and thermal diffusion coefficients respectively, L is the latent heat of condensation and a is the radius of the drop. The contribution of surface free energy and the thermal capacity of the drop are negligible throughout the region of interest in this work.

The specification of the outer boundary condition requires some physical insight. The principal defect in the steady state theory lies in the fact that the diffusion profiles prematurely extend to infinity. Since we expect to be able to calculate the diffusion profiles outside the droplet for the purpose of calculating the dead space, it is desirable to employ the cellular model. The imposition of an impermeable sphere of radius R which serves as the reservoir for heat and vapor for a droplet, eliminates to a large extent the errors in the diffusion profiles introduced through the use of the quasi-steady state equations.

For a truly isolated drop, R should be chosen so that the integral of the vapor depletion throughout the vapor density profile gives the mass of the drop. Under such a constraint $\rho(R)$ would remain constant throughout droplet growth and R would be moved out indefinitely as growth proceeds. Similar arguments apply to the thermal diffusion process, in general R(T) and R(ρ) being different. However, where a system of droplets exists the period of such isolation is short lived and the R spheres for different droplets begin to overlap. At this point a type of averaged competition for the available vapor becomes active. Strictly speaking, a distribution of R's should be employed such that the $\frac{d\rho}{dT}\Big|_R$ are the same for all droplets. However, Kassner and Carstens[88] have shown that the distribution of R's does not appreciably affect droplet growth rates until droplet densities exceed 10^6 drops/cm^3. Therefore, it is feasible to use the same size impermeable sphere for all droplets, requiring only that the volume of these spheres fill all space. Fig. 38 illustrates the mechanics of choosing the radius of the impermeable sphere.

When the drop size is of the order of the mean free path, λ, its growth is dependent upon kinetic theory. A connection may be established between the macroscopic and microscopic regimes by equating the corresponding flux expressions:

$$D\frac{d\rho}{dr}\bigg|_{r=a} = [I_v - I_c]\delta \qquad (5\text{-}4)$$

$$\kappa\frac{dT}{dr}\bigg|_{r=a} = [I_g C_g \delta_g + I_\rho C_\rho \delta_\rho]\Delta T \qquad (5\text{-}5)$$

where ΔT = the temperature jump between drop and vapor at the liquid-vapor interface, C_v = the specific heat per molecule of the vapor, C_g = the specific heat per molecule of the non-condensible gas, δ_g = the average proportion of energy transfer between the non-condensible gas and the liquid surface molecules, δ_v = the average proportion of energy transfer between the vapor and the liquid surface molecules, δ = the sticking probability of the vapor molecules on the liquid surface. I_g = the flux of non-condensible gas molecules impinging on the drop surface, I_c = the flux of vapor molecules condensing on the surface of the drop as if it were in an equilibrium atmosphere, I_ρ = the flux of vapor molecules impinging on the drop surface.

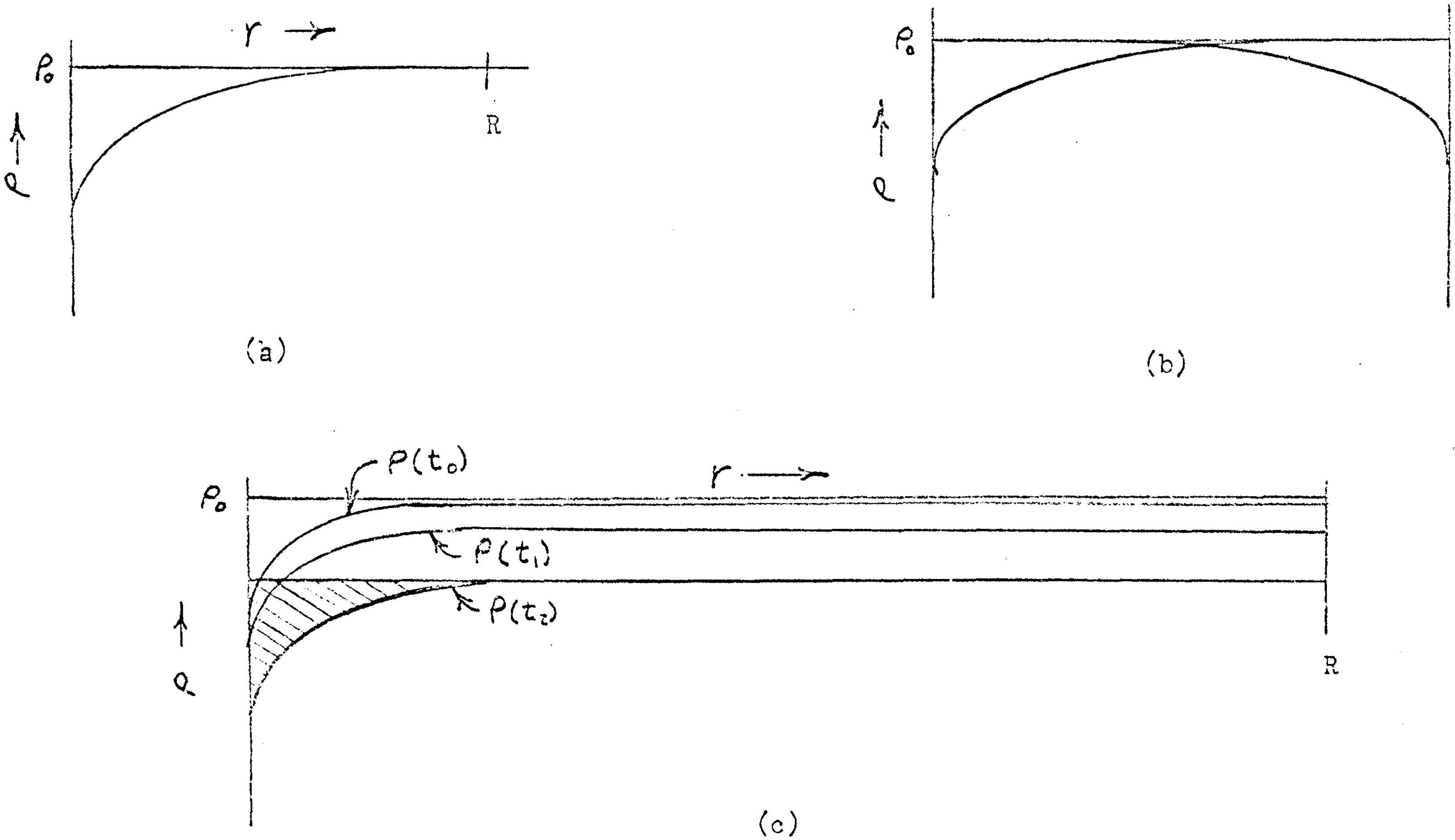


Fig. 38. Choosing the radius of the impermeable sphere. When droplets do not compete for vapor, the radius R of the impermeable sphere is chosen so that there is no vapor depletion at R. Fig. a. When droplets are closely spaced this is not possible, Fig. b. A practical solution chooses R, not so that $\frac{\partial \rho}{\partial t}\Big|_R = 0$, but so that $\frac{\partial \rho}{\partial r}\Big|_R = 0$ and bulk corrections are made for vapor depletion (the error in the correction is the shaded area in Fig. c).

The existence of a temperature jump at the surface of the drop implies that the droplet is unable to maintain the equilibrium vapor pressure immediately outside its surface. Both a temperature jump and a vapor density jump exist.

$$\Delta T = T^{eq}(a) - T(a) \tag{5-5}$$

$$\Delta\rho = \rho^{eq}(a) - \rho(a) \tag{5-6}$$

It is assumed that $I_\rho C_\rho \Delta T$ may be neglected because of the dilutness of the vapor. Then Eq. (5-4) and (5-5) become:

$$D\left.\frac{d\rho}{dr}\right|_{r=a} = 1/4\{-\bar{v}_V[T^{eq}(a)]\rho^{eq}(a) + \bar{v}_V[T(a)]\rho(a)\}\delta \tag{5-7}$$

$$\kappa\left.\frac{dT}{dr}\right|_{r=a} = 1/4\ \rho_g\bar{v}_g[T(a)]\Delta T C_g\delta_g \tag{5-8}$$

where $\bar{v}_g(T)$ = the average molecular velocity of the non-condensible gas at the temperature T, and $\bar{v}_V(T)$ = the average molecular velocity of the vapor at temperature T.

The solutions of Eq. (5-1) and (5-2) in terms of the boundary values are for the steady state:

$$\rho(r) = \frac{R-r}{R-a}\,\frac{a}{r}[\rho(a) - \rho(R)] + \rho(R) \tag{5-9}$$

$$T(r) = \frac{R-r}{R-a}\,\frac{a}{r}[T(a) - T(R)] + T(R) \tag{5-10}$$

These solutions substituted into the power balance equation give:

$$\frac{\rho(R) - \rho(a)}{T(a) - T(R)} = \frac{\kappa}{LD} \tag{5-11}$$

The steady state solutions also give for Eqs. (5-7) and (5-8):

$$\rho(a) = \frac{\frac{R}{R-a}\,\frac{4D}{a}\,\rho(R) + \bar{v}_v[T^{eq}(a)]\rho^{eq}(a)\,\delta}{\frac{R}{R-a}\,\frac{4D}{a} + \bar{v}_v[T(a)][1+\frac{\Delta T}{T^{eq}(a)}]^{1/2}\delta} \tag{5-12}$$

$$T(a) = \frac{\frac{R}{R-a}\,\frac{4D}{a}\,T(R) + \bar{v}_g[T^{eq}(a)]\,\delta_g}{\frac{R}{R-a}\,\frac{4D}{a} + \bar{v}_g[T(a)][1+\frac{\Delta T}{T^{eq}(a)}]^{1/2}\delta_g} \tag{5-13}$$

To obtain the asymtotic behavior of $\rho(a)$ and $T(a)$

let
$$D = \gamma\bar{v}_v\lambda_v$$
$$K = \gamma'\pi_g\bar{v}_g\lambda_g$$

where γ and γ' are constants of the order unity, λ_v and λ_g are the mean free paths of the vapor and non-condensible gas.

Eqs. (5-12) and (5-13) reduce to

$$\rho(a) = \frac{\frac{R}{R-a}4\gamma(\lambda_v/a)\,\rho(R) + \rho^{eq}(a)\,\delta}{\frac{R}{R-a}4\gamma(\lambda_v/a) + [1+\frac{\Delta T}{T^{eq}(a)}]^{1/2}\delta} \tag{5-14}$$

$$T(a) = \frac{\frac{R}{R-a}\left(\frac{8}{5}\gamma'\right)\frac{\lambda_g}{a}\,T(R) + T^{eq}(a)\,\delta_g}{\frac{R}{R-a}\,\frac{\lambda_g}{a}\left(\frac{8}{5}\gamma'\right) + [1+\frac{\Delta T}{T^{eq}(a)}]^{1/2}\delta_g} \tag{5-15}$$

These equations are simplified by the approximation $[1+\frac{\Delta T}{T^{eq}(a)}]^{1/2} \approx 1$ and substitution of n and n' for the remaining variables and constants gives

$$\rho(a) = \frac{n\,\rho(R) + \rho^{eq}(a)}{1 + n} \tag{5-16}$$

$$T(a) = \frac{n'T(R) + T^{eq}(a)}{1 + n'} \tag{5-17}$$

In the limit that the mean free path is much smaller than the droplet radius:

$$\lim_{a/\lambda_g \to \infty} T(a) = T^{eq}(R)$$

$$\lim_{a/\lambda_v \to \infty} \rho(a) = \rho(R)$$

These imply the absence of local vapor depletion.

Another relationship is provided by the Kelvin-Thompson equation which takes into account the change in equilibrium vapor density with drop radius.

$$a = \frac{2\sigma}{\rho RT} \Big/ \ln\frac{\rho(a)}{\rho^{eq}(R)}$$

or

$$\frac{\rho(a)}{\rho^{eq}(R)} = \exp\left(\frac{2\sigma}{a\rho RT}\right) = \exp\left(\frac{B}{aT}\right)$$

where σ = the surface tension, ρ = the density of the condensed vapor, R = the gas constant.

This equation when combined with the Clausius-Claperyon equation (integrated for an ideal gas) gives:

$$\rho^{eq}(a) = \frac{\rho^{eq}(R)T(R)}{T^{eq}(a)} \exp\left(a_0\frac{T^{eq}(a)-T(R)}{T^{eq}(a)T(R)}\right)\exp\left(\frac{B}{aT^{eq}(a)}\right) \quad (5\text{-}18)$$

where a_0 = QM/R, Q = the latent heat of condensation, M = the molecule weight of the vapor.

There is also the equation relating mass influx to droplet growth.

$$\frac{d}{dt}\left(\rho\frac{4}{3}\pi a^3\right) = 4\pi a^2 D\nabla\rho\Big|_{r=a}$$

or

$$a\,\frac{da}{dt} = \frac{RD}{R-a}\,[\rho(R)-\rho(a)] \quad (5\text{-}19)$$

The droplet growth process has now been defined in terms of the variables a, $\rho(a)$, $\rho^{eq}(a)$, $T(a)$, and $T^{eq}(a)$ by the Eqs. (5-11), (5-16), (5-17), (5-18), and (5-19).

5-2. Solution of the droplet growth equations. A solution of the droplet growth equations may be obtained as follows. The power balance Eq. (5-11) is combined with the first continuity Eq. (5-16) to eliminate $\rho(a)$.

$$\rho(a) = \frac{n\rho(R)+\rho^{eq}(a)}{n+1} = \rho(R) + \frac{k}{LD}[T(R)-T(a)] \qquad (5\text{-}20)$$

Now combine Eq. (5-17) with the above to eliminate $T(a)$.

$$T(a) = \frac{LD}{k(n+1)}\rho(R) - \frac{LD}{k(n+1)}\rho^{eq}(a) + T(R) = \frac{n'T(R)+T^{eq}(a)}{n'+1}$$

$$\rho(a)^{eq} = \frac{k}{LD}\frac{n+1}{n'+1}\left(T(R) - T^{eq}(a)\right) + \rho(R) \qquad (5\text{-}21)$$

$$= \frac{\rho^{eq}(R)T(R)}{T^{eq}(a)} \exp\left(a_0\frac{T^{eq}(a)-T(R)}{T^{eq}(a)T(R)}\right) \exp\left(\frac{B}{aT^{eq}(a)}\right)$$

$$T^{eq}(a)\left[\rho(R)+\frac{k}{LD}\left(\frac{n+1}{n'+1}\right)T(R)\right] - \frac{k}{LD}\left(\frac{n+1}{n'+1}\right)T^{eq}(a)^2 - \rho^{eq}(R)T(R)$$

$$\cdot\exp\left(\frac{a_0}{T(R)}\right)\exp\left(\frac{\frac{B}{a}-a_0}{T^{eq}(a)}\right) = 0 \qquad (5\text{-}22)$$

Eq. (5-22) gives the relationship between vapor density and temperature at the droplet surface.

The integrated form of Eq. (5-19) is

$$t_1 - t_2 = \int_{a_1}^{a_2}\frac{R-a}{RD}\,\frac{r\,dr}{[\rho(R)-\rho(r)]} \qquad (5\text{-}23)$$

Knowing the droplet size at time t_1, the droplet size at time t_2 is determined as follows. A trial value of radius a_2 is picked and a gaussian-quadrature method of integration is used to evaluate t_2. If the calculated value of t_2 is not sufficiently close to the real value of t_2, a new trial value of a_2, picked by a bisection scheme, is used as the new upper limit of the integration. In the integration, values of $\rho(r)$ are determined from the steady state solutions in conjunction with the connection equations and Eq. (5-22). This process is easily carried out with an electronic computer.

Analysis of an actual data expansion from a cloud chamber is complicated by the fact that the narrowest possible pulse of supersaturation is so long that many different sizes of droplets are growing simultaneously. The procedure used to simplify this situation is to divide the supersaturation pulse into many small time increments. Each time increment is then assumed to have a constant supersaturation which is the actual value of supersaturation in the middle of the time step. Droplets are nucleated all during the time step but are assumed to all be born at the center of the time step so that they all have the same age and size.

5-3. Dead space calculation. A new radius of the impermeable sphere must be calculated after each time increment. This is because the population of droplets increases during each time increment so that a smaller volume is available for the impermeable sphere after each new family of droplets is born.

An approximate family population, AN_i, for the ith time interval is computed for the new family each time by using the bulk values of supersaturation and temperature. The exact population of the new family is computed by integrating the nucleation rate law over the volume of the impermeable spheres for all the preexisting families. Hence, the number in the ith family, N_i, is

$$N_i = \sum_{j=1}^{i-1} N_j \int_{a_j}^{R} \text{Rate } 4\pi r^2 dr \Delta t \tag{5-24}$$

where Δt = the duration of the time step.

Knowing N_i, the total droplet population is calculated

$$N_T = \sum_{j=1}^{i} N_j \tag{5-25}$$

The radius of the impermeable spheres is then calculated for the (i+1)th time step.

$$N_T \frac{4}{3}\pi R^3 = 1 \tag{5-26}$$

A dead space, V_D, is defined to be the volume around the droplets which would have no nucleation if the bulk values are used to calculate the nucleation rate and the total drops nucleated in a step is to be the value calculated using the exact profile, see Eq. (5-24).

$$V_D = 1 - \frac{N_i}{AN_i} \tag{5-27}$$

The average radius of the dead space, r_D, is then defined by the relation

$$4/3\ \pi r_D^3 = V_D\ 4/3\ \pi R^3$$

$$r_D = V_D^{1/3} R \tag{5-28}$$

The concept of dead space is useful as it is an indication of the extent to which the nonuniformity in the vapor and temperature distributions outside the droplets affects the whole volume. As long as the dead space is small, there is little doubt as to the validity of the droplet growth calculations. When dead space rises to a significant percentage of the total volume, the assumptions made concerning the impermeable spheres must be questioned. Moreover, the dead space is used to correct nucleation rates since no new nucleation occurs within the dead space.

5-4. The computer solution. A computer with moderate storage capacity is required for data analysis using the technique outlined in the preceding sections. A new family of droplets is born each time step and information such as radius, surface temperature, gas temperature at the surface, vapor density at the surface and dead volume must be kept for each family. The actual computer program used in this work follows the procedure outlined above. Numerical integrations and solutions are carried out with sufficient accuracy that errors from this are negligible. Because of the increasing number of families which must be accounted for with each additional time step, computer time rises as the square of the number of time steps in the calculation. Figs. 39-45 are sample plots of values calculated by the computer for one data expansion. A sample computer printout is given in Appendix III.

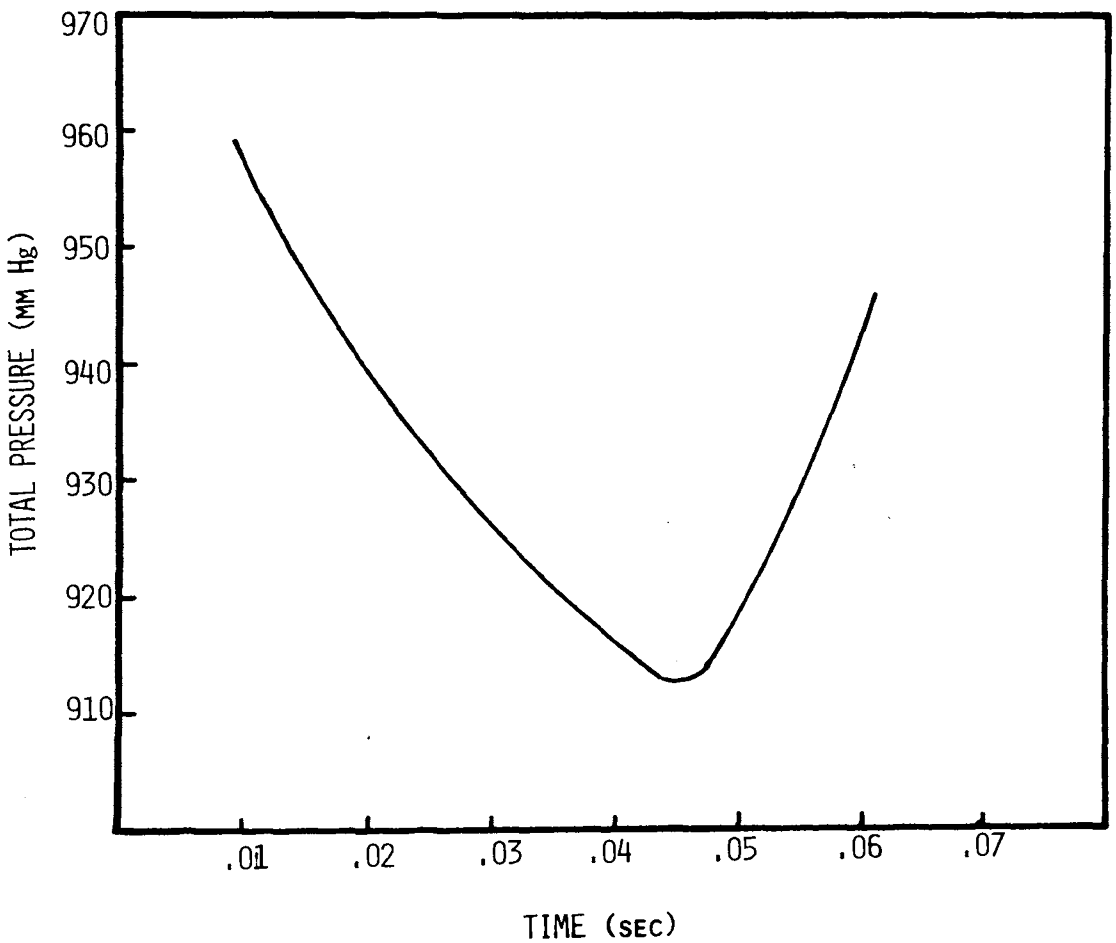


Fig. 39. Pressure vs. time.

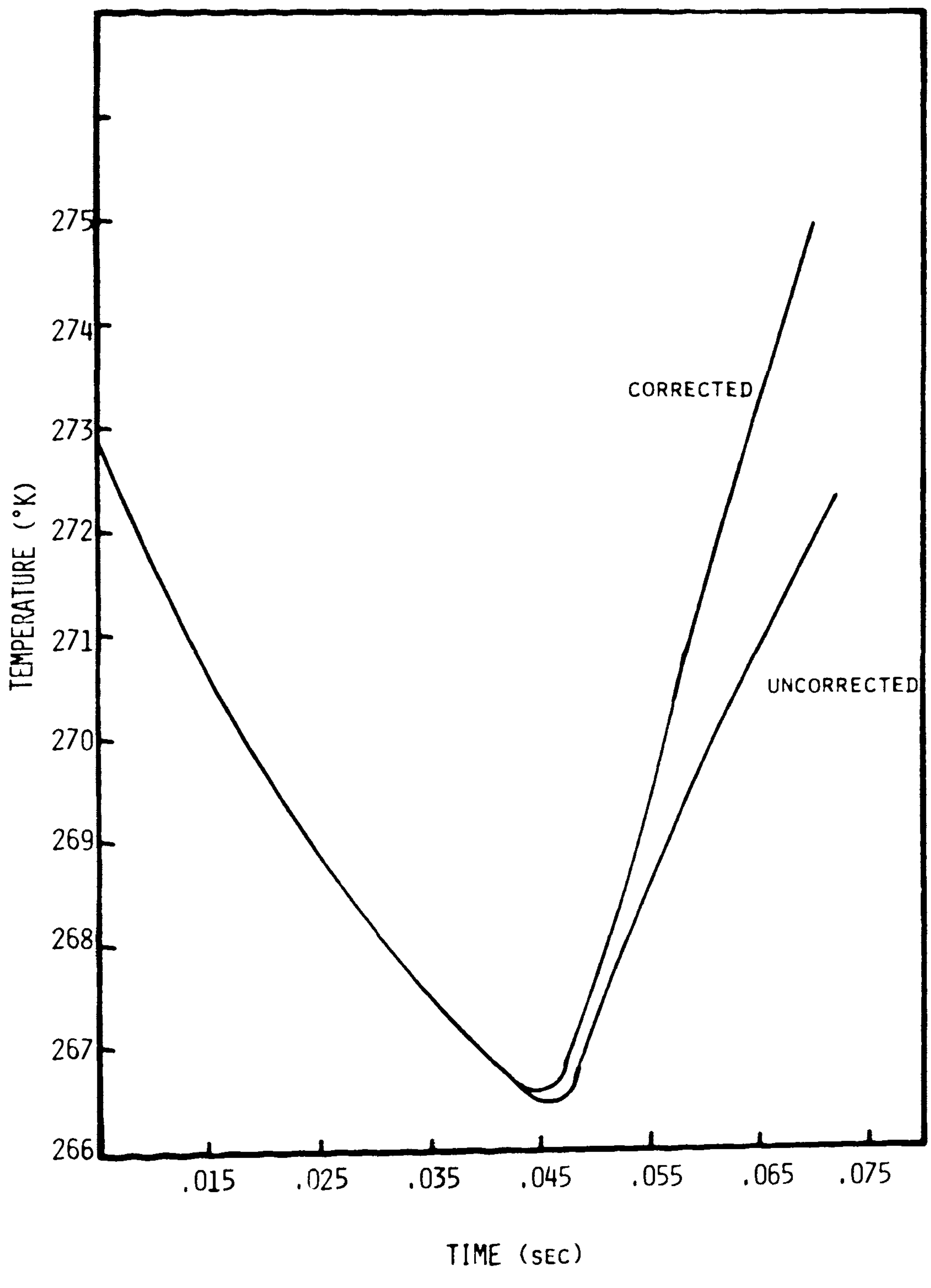


Fig. 40. Temperature vs. time for the expansion of Fig. 39.

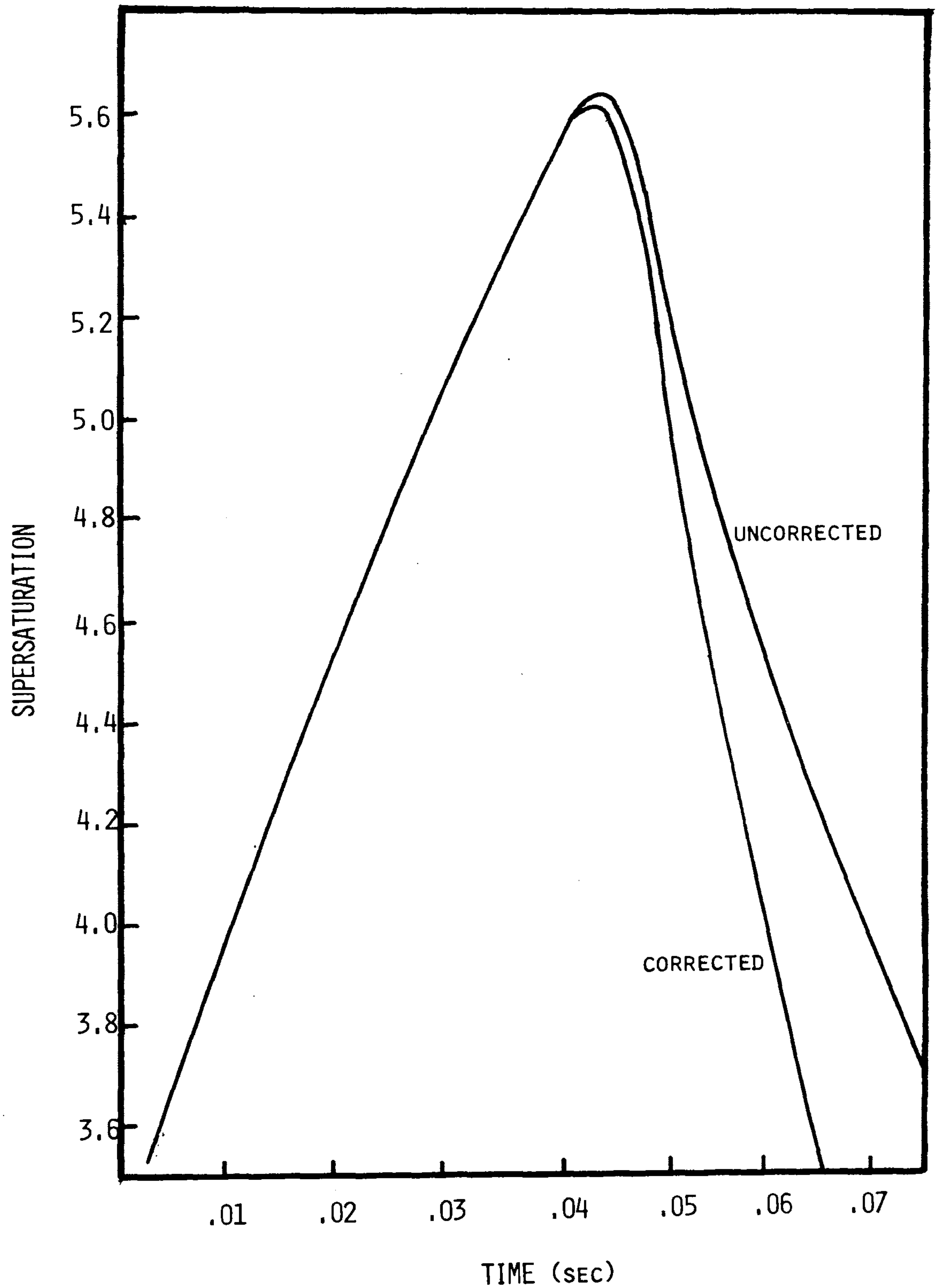


Fig. 41. Supersaturation vs. time for the expansion of Fig. 39.

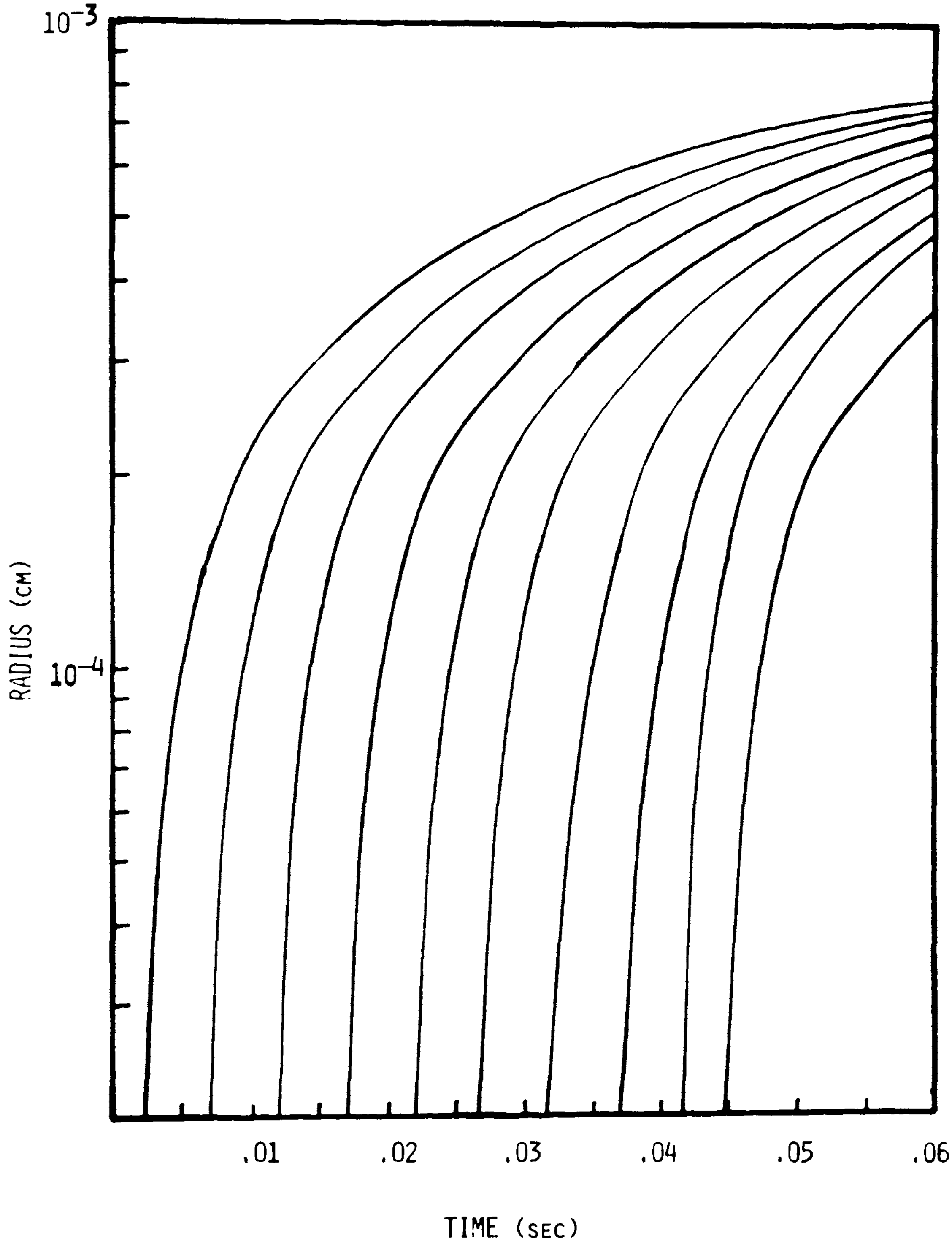


Fig. 42. Radius vs. time for the expansion of Fig. 39.

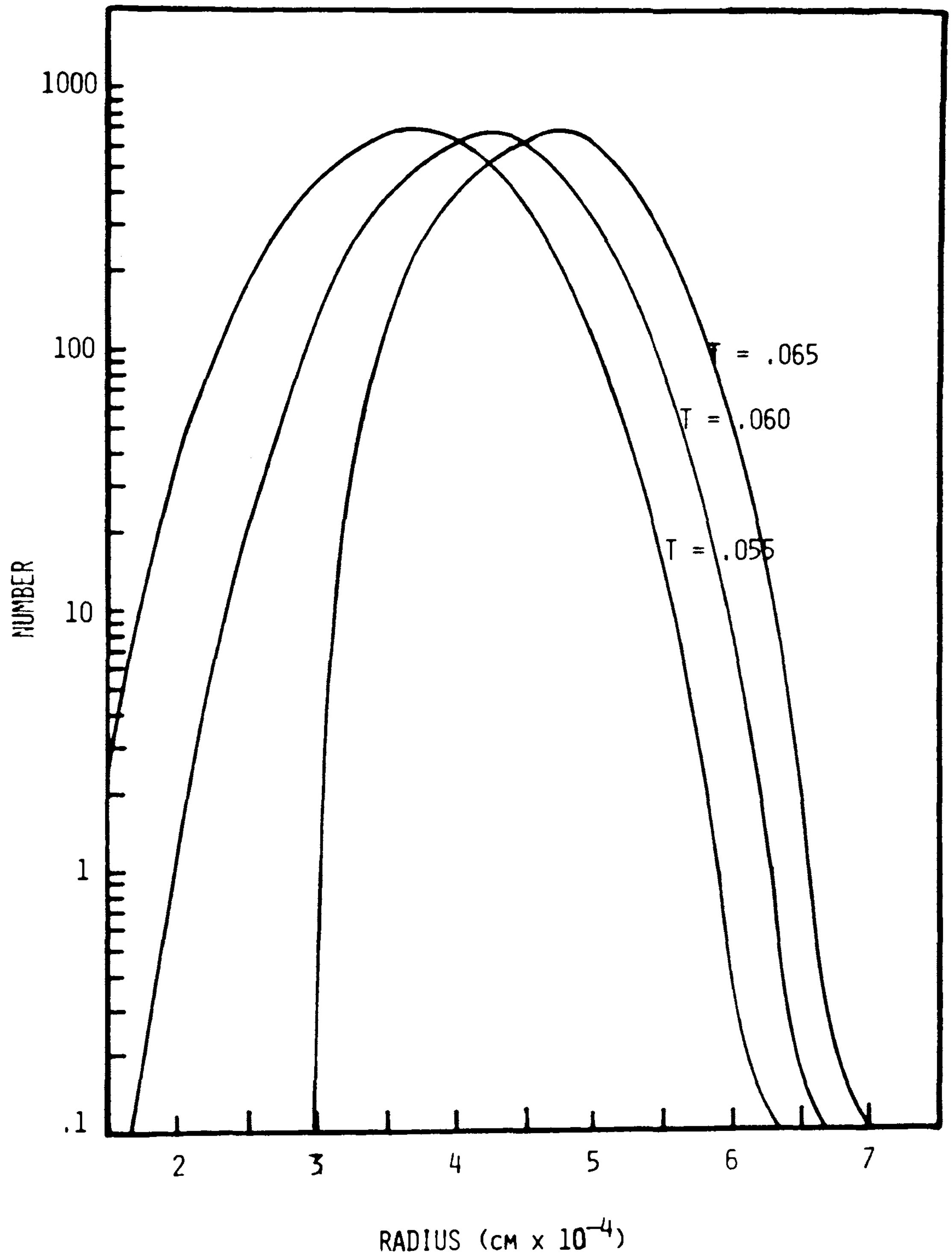


Fig. 43. Number vs. radius for the expansion of Fig. 39.

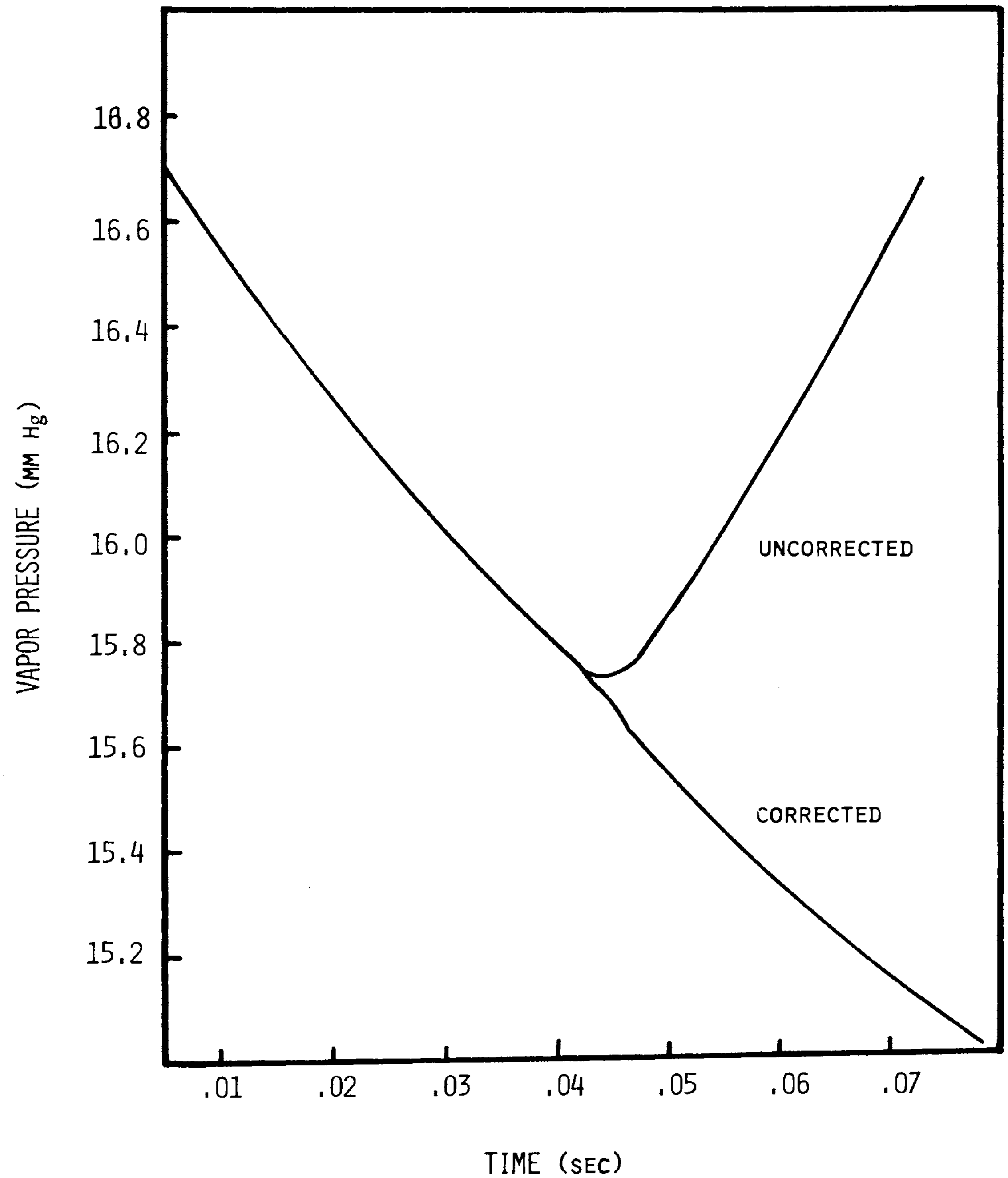


Fig. 44. Vapor pressure vs. time for the expansion of Fig. 39.

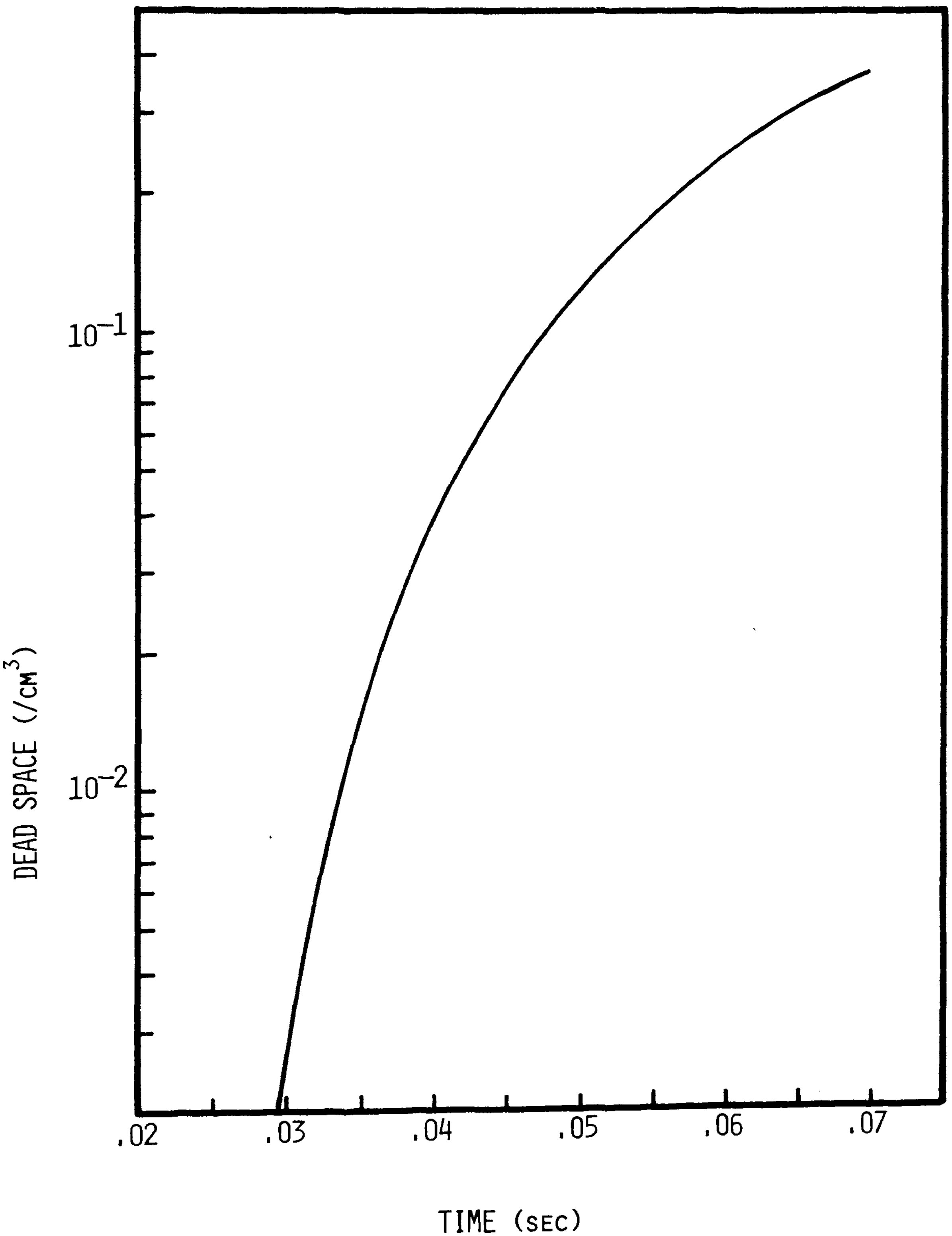


Fig. 45. Dead space for the expansion of Fig. 39.

CHAPTER VI

SUMMARY

The expansion cloud chamber has been developed into a precision instrument, capable of yielding definitive information concerning nucleation and growth of water droplets.

The gas temperature was measured in the dry chamber during the course of an isentropic expansion. It was found that the finite heat capacity is not negligible and must be accounted for. A computer program was developed which solves the problem of heat flow from the thermocouple. When the measured gas temperature is compared with that calculated from the pressure measurement using Eq. (3-1) it is found that there is almost perfect agreement. With some refinement of technique, the expansion chamber, using the same method of measuring temperature and pressure as in this work, could be used to accurately calculate the heat capacity of the gas through the relationship:

$$C_p = T\left(\frac{\partial V}{\partial T}\right)_p \left(\frac{\partial P}{\partial T}\right)_s$$

This method of calculation of the heat capacity is potentially more accurate than any now available.

The nucleation rate was measured as a function of temperature, supersaturation and sensitive time for water vapor in a helium atmosphere. It was found that there exists a form of heterogeneous nucleation occurring above the ion limit at about the supersaturation predicted by the Becker-Doring theory for homogeneous nucleation. This form of heterogeneous nucleation appears to occur upon chemically bonded centers whose concentration is very low and depends upon the vapor pressure prior to the expansion. The consistency of the number of these nucleating centers indicates that they may be the neutral product of natural radioactivity and cosmic rays. Experiments are planned to test this hypothesis by dosing the cloud chamber with x-rays and checking to see if the number of nucleating centers is increased.

A semiphenomenological theory was developed along the lines of the classical theory but which includes the chemical bond energy of the heterogeneous nucleating center. The theory predicts a different temperature dependence for the heterogeneous and homogeneous nucleation rates and at least qualitatively explains the essential features of the data. Modifications in the photographic technique are under way which will allow an extension of the data to higher and lower droplet densities. If the liquid drop theory satisfactorily describes the nucleation of water vapor, then: (a) the measured temperature dependence of the nucleation rate will yeild the free energy per molecule in the critical embryo and (b) the supersaturation dependence will yeild the number of molecules in the critical cluster.

A considerable disparity has existed in the temperature dependence of the critical supersaturation as reported by various experimenters. This disparity has been in large part resolved by properly interpreting the data in terms of the theory derived for the heterogeneous nucleation.

It was definitely established that the nucleation rate of water vapor is higher in an argon atmosphere than in a helium atmosphere. This may be related to a disruptive factor due to the higher velocity of the helium atoms. It is however more likely due to the hydration of the argon atoms into the critical cluster. Such a hydration has been hypothized for krypton and xenon in liquid water. These two gases have been obtained so that the same nucleation experiment may be performed in an atmosphere of each of these. If such a hydration is involved the nucleation rate will be considerably higher in these gases.

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APPENDIX I

VARIATION OF PHYSICAL PARAMETERS

Because of the wide variation in the thermodynamic coordinates during the course of these experiments several of the physical parameters which are normally considered to be constant must be included as variables in the calculations in order that sufficient accuracy may be obtained. The variation of some of these parameters are discussed in the following paragraphs.

I-1. Equilibrium vapor pressure of water. A least squares fit was used for the vapor pressure of water[89], see Fig. 46.

Below 25°C

$$p = 4.58192 + .333075T + .010758T^2 + .196622\times10^{-3}T^3 + .216663\times10^{-5}T^4 + .211191\times10^{-7}T^5$$

Between 20°C and 60°C

$$p = 5.92556 + .139239T + .0215602T^2 - .94144\times10^{-4}T^3 + .59993\times10^{-5}T^4$$

where p is the vapor pressure in mmHg and T is the temperature in degrees Centigrade.

I-2. Surface tension of water. Data are available for only the temperature dependence of the surface tension of water.[89] A linear approximation is satisfactory for the range of interest in this work, see Fig. 47.

$$\sigma = 116.459 - .149228T$$

where σ is the surface tension in dynes per centimeter and T is the absolute temperature in degrees Kelvin.

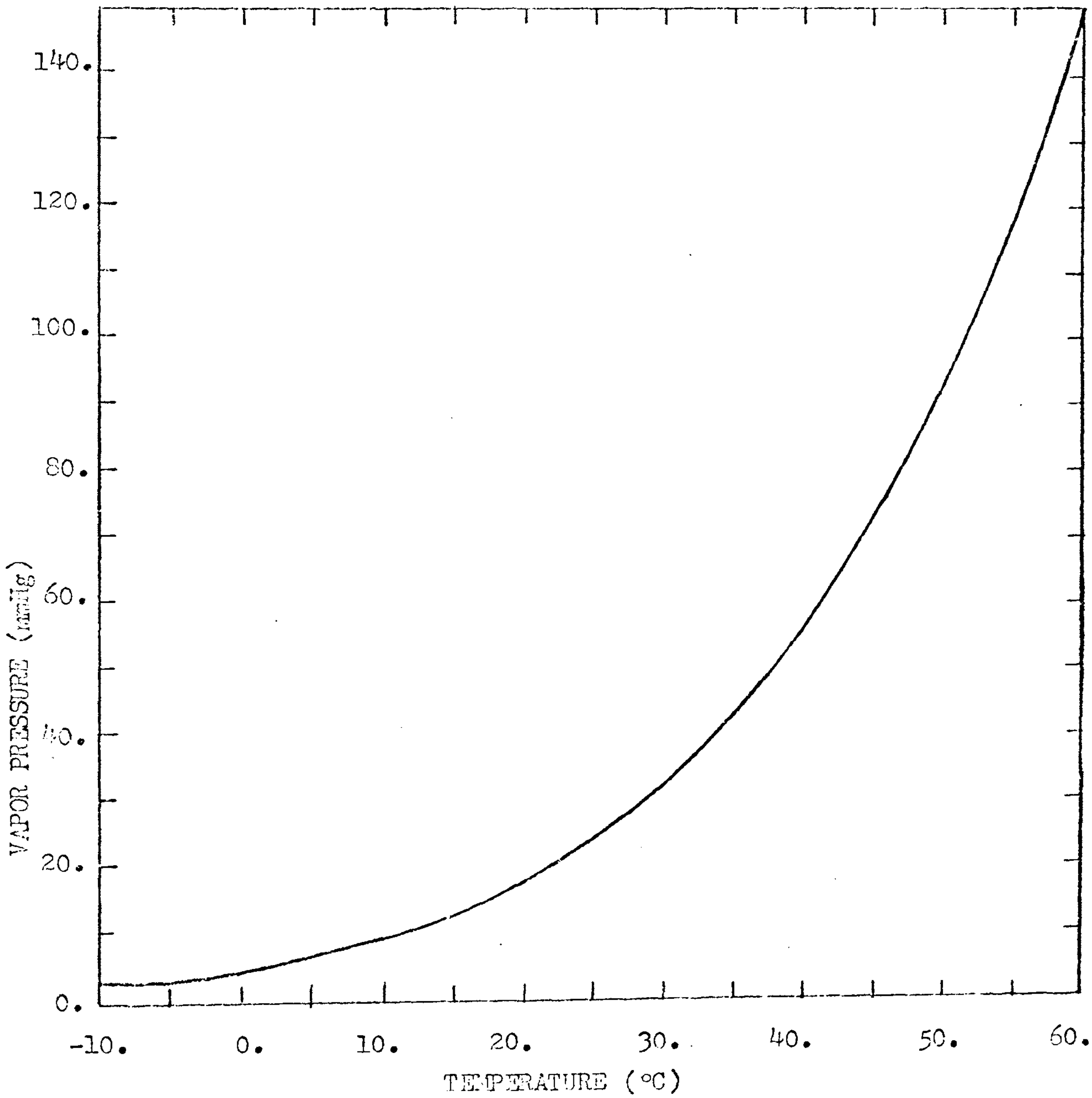

Fig. 46. Equilibrium vapor pressure of water.

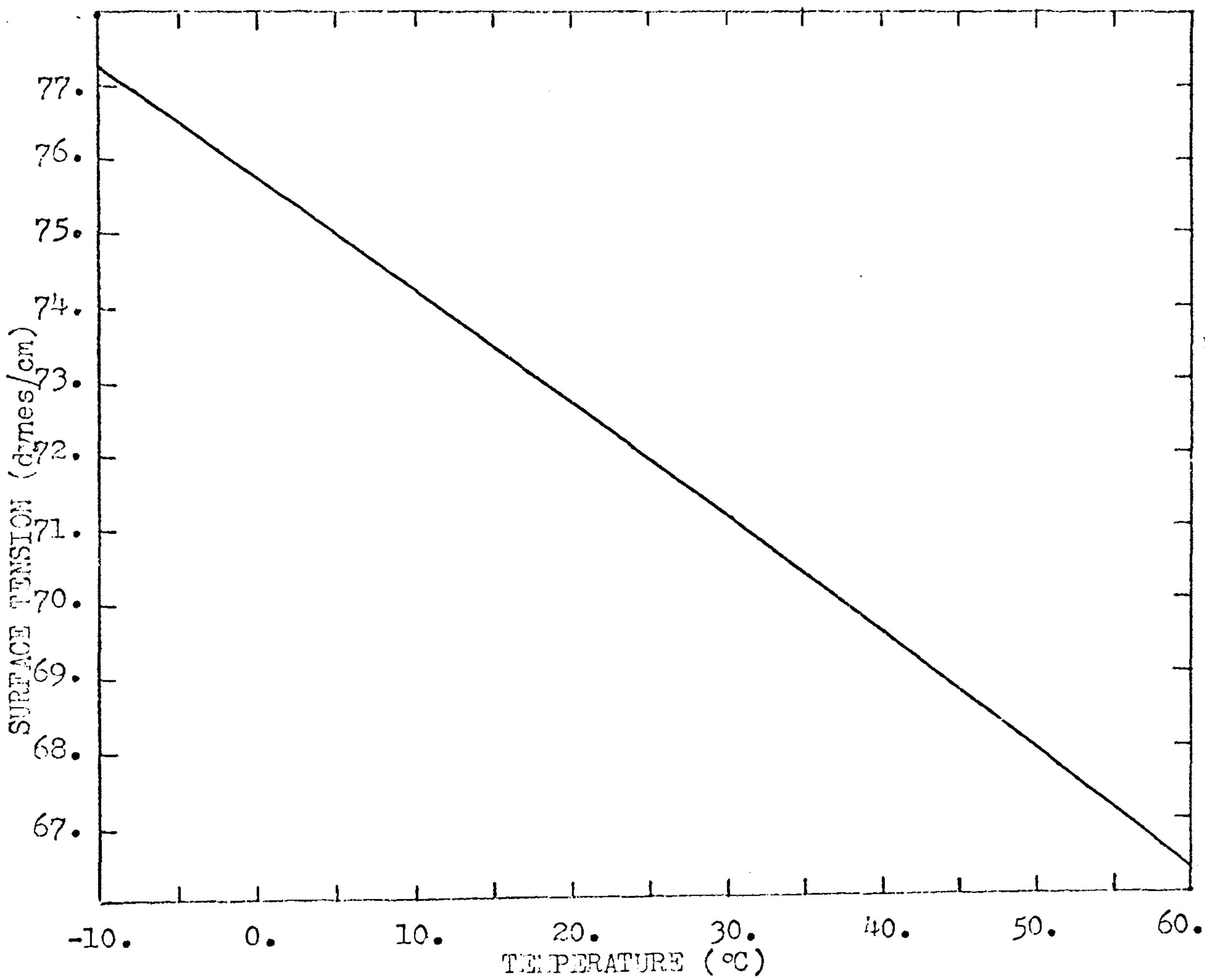

Fig. 47. Surface tension of water.

I-3. Latent heat of vaporization of water. A linear least squares fit was used for the latent heat of vaporization of water[89], see Fig. 48.

$$Q = 746.1 - .55T$$

where Q is the latent heat in calories per gram and T is the absolute temperature in degrees Kelvin.

I-4. Heat capacity and compressibility of water vapor. The best available compilation of water vapor entropy data is that of Vukalovitch.[90] The interpolated values of Cp, where Cp is the constant pressure heat capacity divided by the ideal gas constant, are given in Table II. Figs. 49 and 50 show plots of this data. There is a definite discontinuity around 340°K and 23.8 mmHg. Because of this the best curve fit is divided into three expressions.

For any pressure above 340°K

$$Cp = 3.1611$$

Below 23.8 mmHg and below 340°K

$$Cp = 2.9611 + .01201(T-240.)$$

Above 23.8 mmHg and below 340°K

$$Cp = 2.9611 + .01234(T-240.) + \left(\frac{28.2-p}{14.71}\right)[.1958 + .00082(T-240.)]$$

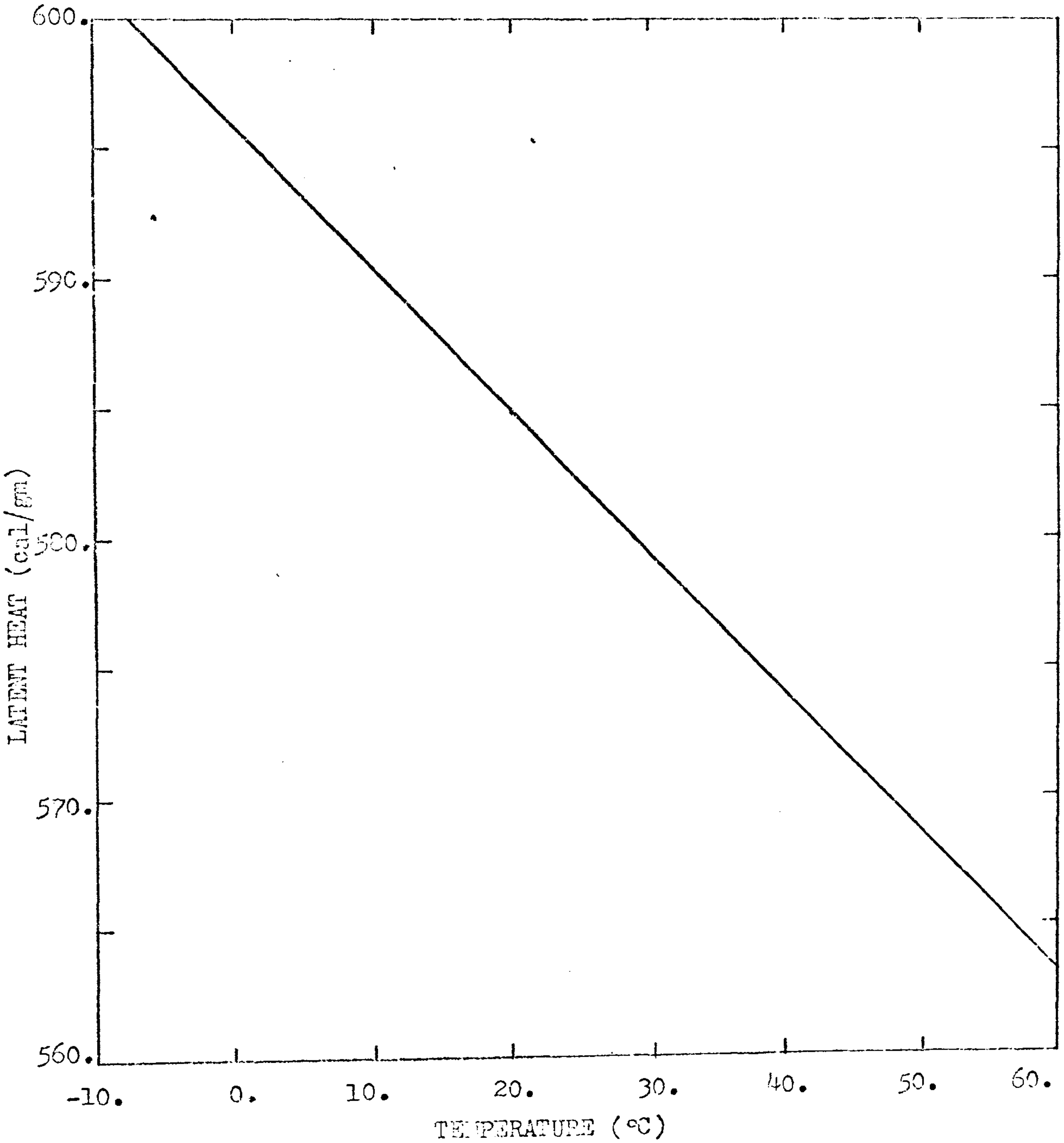

Fig. 48. Latent heat of vaporization of water.

TABLE II. The heat capacity of water vapor.

p mmHg / T°K	7.3559	14.71118	22.0667	29.42236	36.778
240	3.1790	3.0919	2.9832	2.9611	2.9611
250	3.3115	3.2207	3.1075	3.0845	3.0845
260	3.4440	3.3496	3.2318	3.2079	3.2079
270	3.5764	3.4784	3.3561	3.3313	3.3313
280	3.7089	3.6072	3.4804	3.4546	3.4546
290	3.8414	3.7361	3.6047	3.5780	3.5780
300	3.9738	3.8649	3.7290	3.7014	3.7014
310	4.1063	3.9937	3.8533	3.8248	3.8248
320	4.2388	4.0646	3.9776	3.9482	3.9482
330	4.3712	4.1019	4.1019	4.0418	4.0418
340	4.5037	4.1337	4.1953	4.1395	4.1395
350	4.1281	4.1279	4.1598	4.1599	4.1279
360	4.3767	4.1479	4.1807	4.1807	4.1479
370	4.0936	4.1288	4.0952	4.0955	4.1288

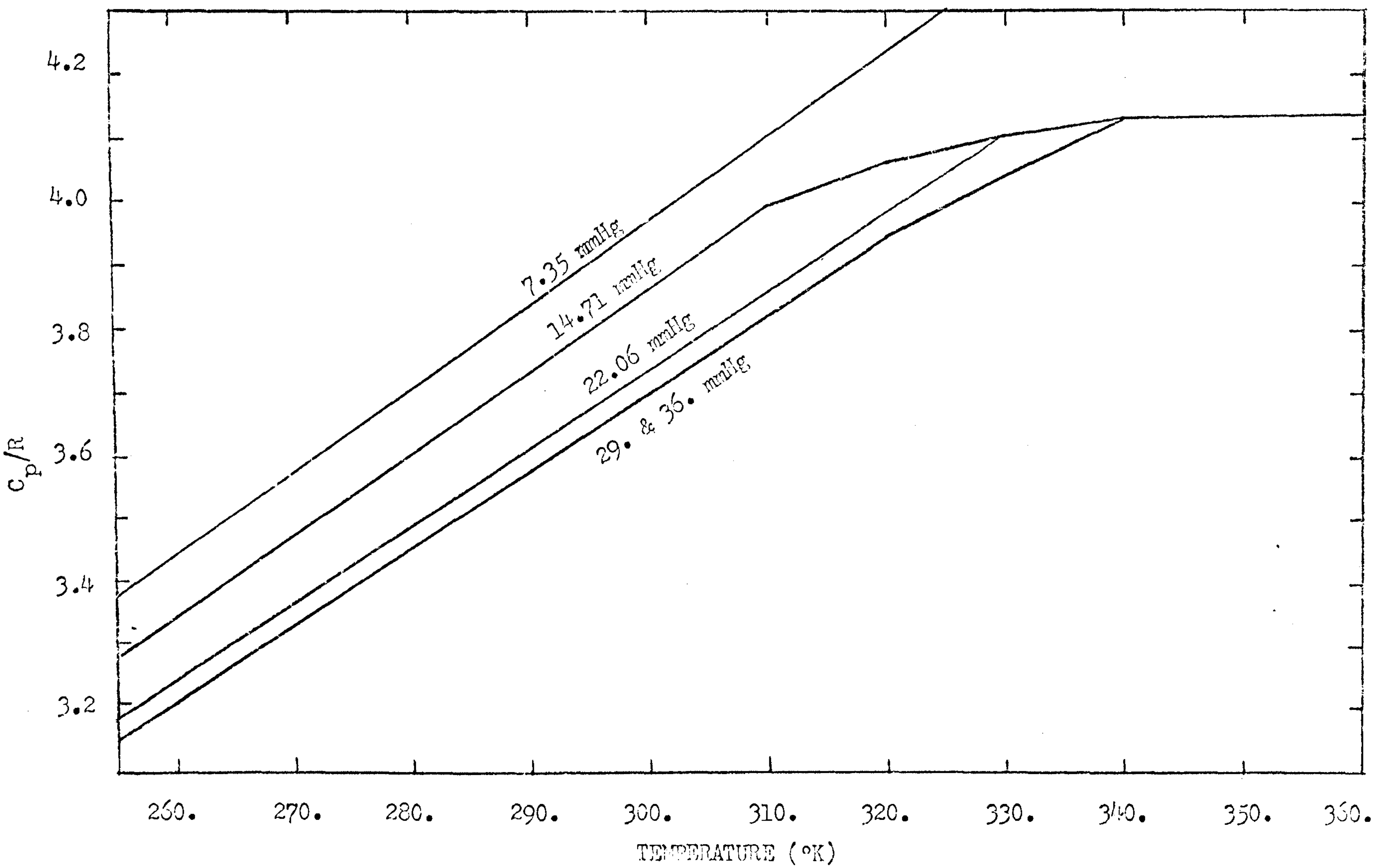

Fig. 49. Heat capacity of water vapor.

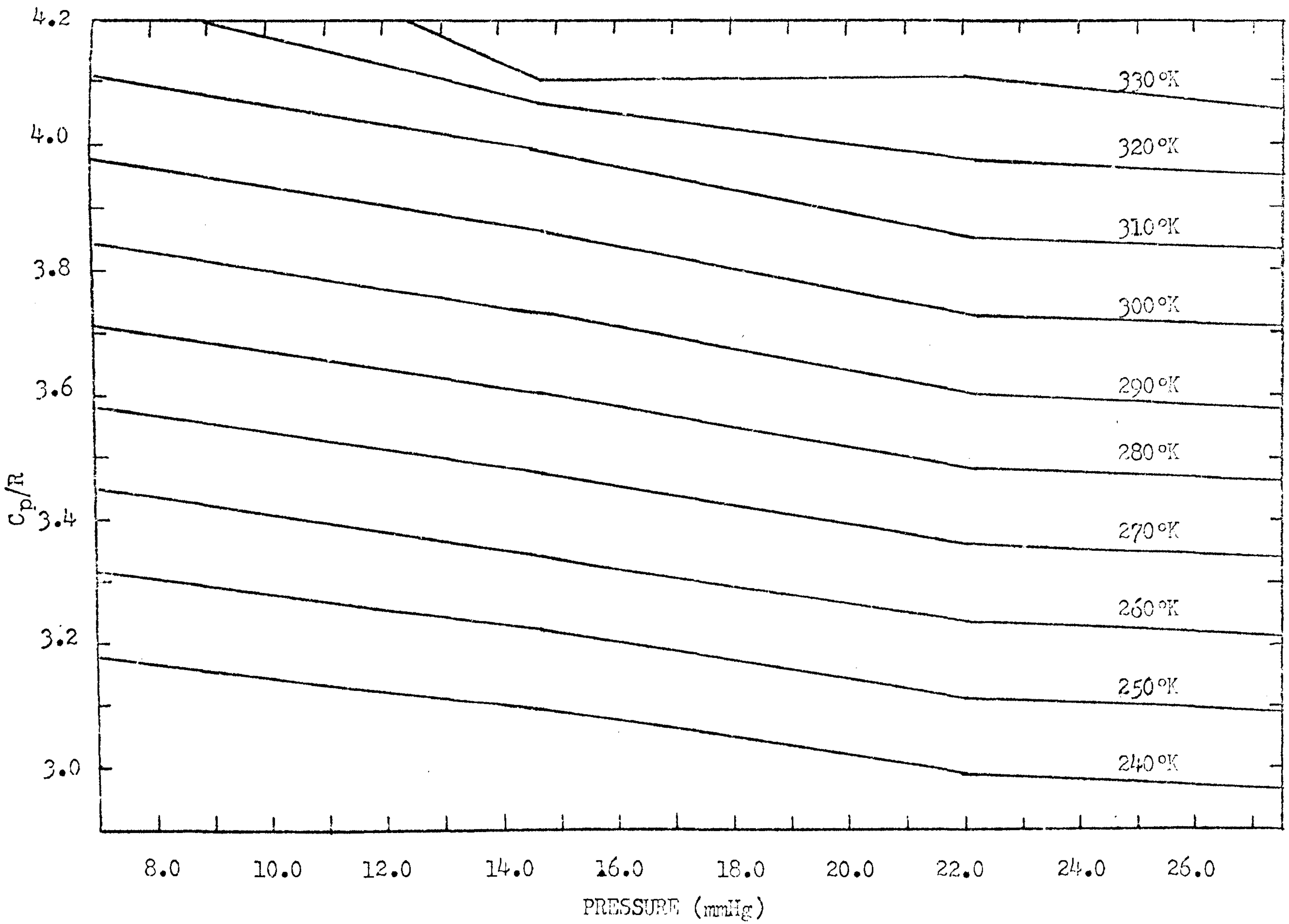

Fig. 50. Heat capacity of water vapor.

The compressibility, $z = (\partial V/\partial T)_p$, is plotted in Fig. 51. There is a negligible pressure dependence.

Below 235°K

$$z = 1.005 + .00054(T-325.)$$

Above 235°K

$$z = 1.005$$

I-5. Thermal conductivity of Helium. A linear relationship was used for the thermal conductivity of Helium as a function of temperature.[91,92] The pressure variation is insignificant.

$$k = 4300 + 35T$$

where k is the thermal conductivity of helium in ergs per degree second centimeter and T is the absolute temperature in degrees Kelvin.

I-6. Heat capacity and compressibility of Helium, Argon, Nitrogen and Air. In making accurate calculations of temperature as discussed in Chapter 3 it is essential that the heat capacity and compressibility of the atmospheric gases be included as variables in the calculation. For that reason values of heat capacity, compressibility and the constant $(\gamma-1)/\gamma$ which is used in the isintropic ideal gas law, Eq. (3-1), have been tabulated for Argon, Nitrogen and air from data taken from NBS Circular #564.[93] Helium is so nearly ideal at the temperature and pressure used in this work that it may be considered ideal for all practical purposes.

The heat capacity is plotted in unitless numbers as Cp/R where R is the ideal gas constant. The compressibility is $PV/RT + T\left(\frac{\partial(PV/RT)}{\partial T}\right)_p$

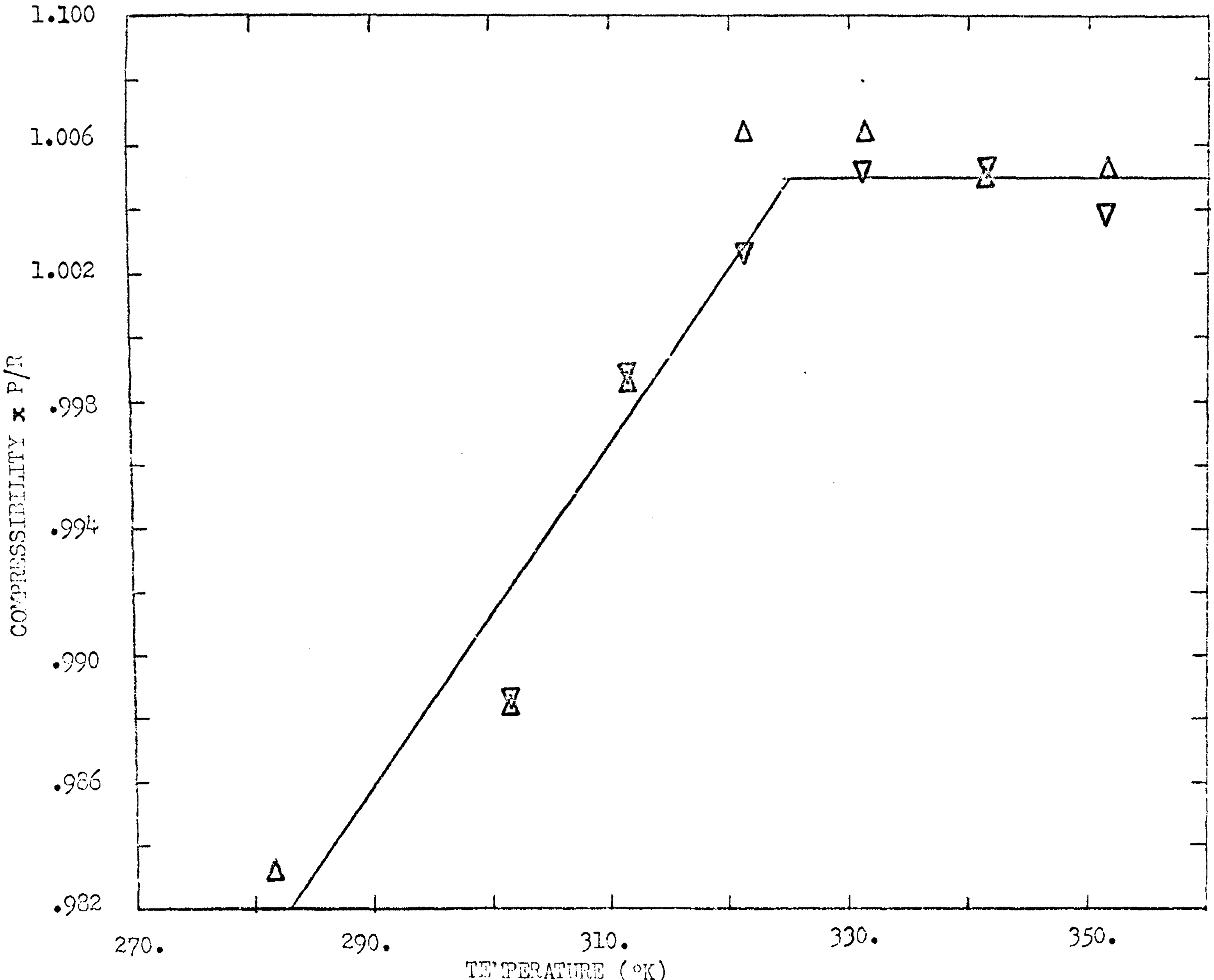

Fig. 51. Compressibility of water vapor. The line is the value of $\left(\frac{P\partial V}{R\partial T}\right)_P$ used in the calculations. Δ are calculated values for 10 mmHg and ∇ are calculated values for 22 mmHg.

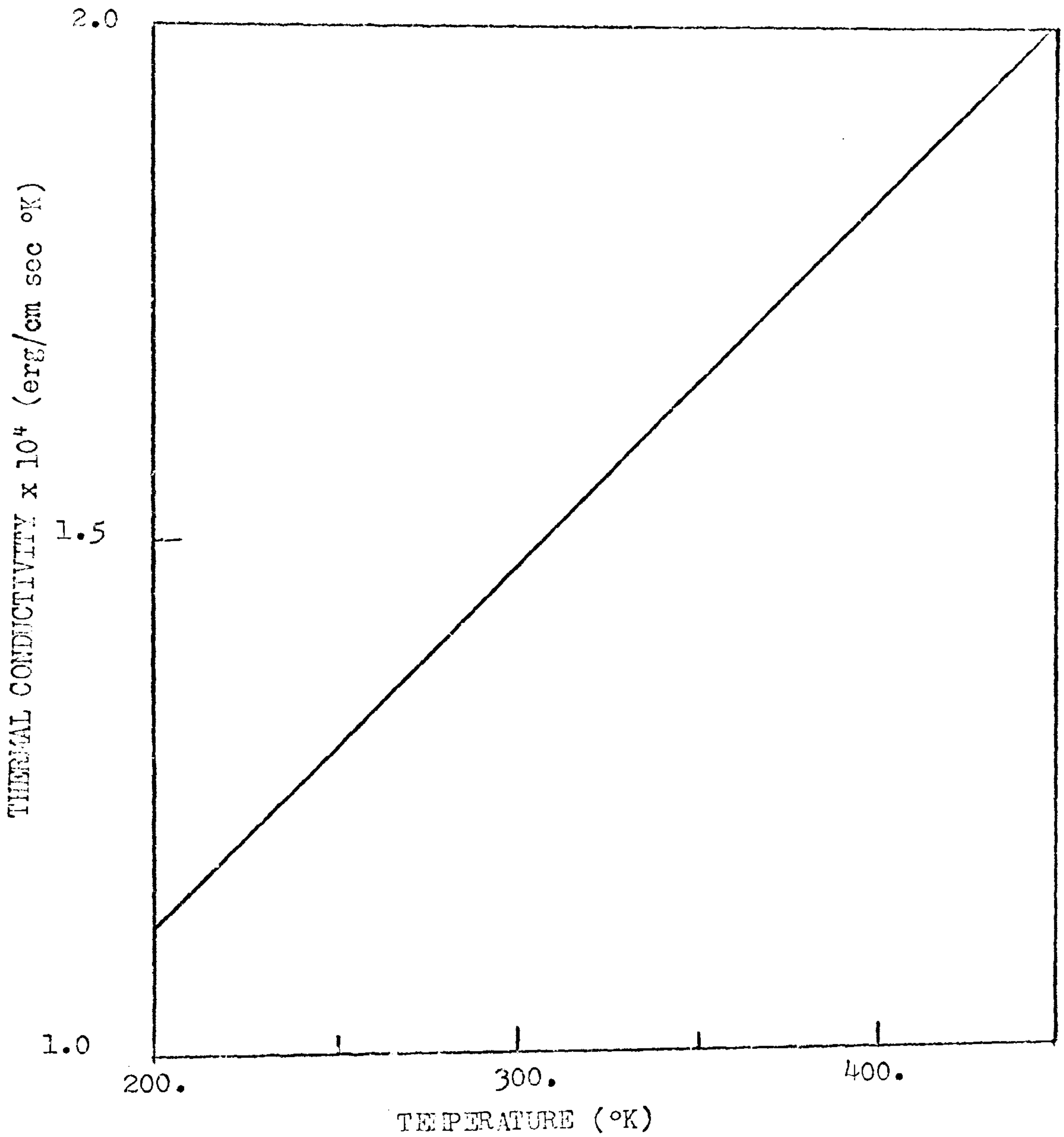

Fig. 52. Thermal conductivity of helium.

where P is pressure, V is volume and T is the absolute temperature. The adiabatic constant is the compressibility divided by the heat capacity.

TABLE III. Compressibility, heat capacity and adiabatic constant of Argon.

Compressibility

T°K \ p atm	.7	1.0	1.5	2.0
245	1.00264	1.00391	1.005912	1.00804
295	1.00173	1.00256	1.00390	1.00526
345	1.00119	1.00180	1.00270	1.00360

Heat Capacity

T°K \ p atm	.7	1.0	1.5	2.0
245	2.5065	2.5092	2.5139	2.5187
295	2.5042	2.5059	2.5089	2.5119
345	2.5029	2.5042	2.5063	2.5083

Adiabatic Constant

T°K \ p atm	.7	1.0	1.5	2.0
245	.40002	.40009	.40014	.40025
295	.40002	.40008	.40013	.40020
345	.40001	.40005	.40007	.40011

TABLE IV. Compressibility, heat capacity and adiabatic constant of Nitrogen.

Compressibility

p atm / T°K	.7	1.0	1.5	2.0
245	1.00257	1.00377	1.00578	1.00755
295	1.00161	1.00242	1.00349	1.00486
345	1.00109	1.00181	1.00255	1.00365

Heat Capacity

p atm / T°K	.7	1.0	1.5	2.0
245	3.5072	3.5098	3.5141	3.5184
295	3.5066	3.5082	3.5110	3.5138
345	3.5098	3.5110	3.5129	3.5149

Adiabatic Constant

p atm / T°K	.7	1.0	1.5	2.0
245	.28586	.28599	.28621	.28636
295	.28563	.28575	.28581	.28588
345	.28522	.28533	.28539	.28554

TABLE V. Compressibility, heat capacity and adiabatic constant of Air.

Compressibility

p atm / T°K	.7	1.0	1.5	2.0
245	1.00246	1.00386	1.00579	1.00748
295	1.00182	1.00260	1.00390	1.00520
345	1.00103	1.00172	1.00241	1.00344

Heat Capacity

p atm / T°K	.7	1.0	1.5	2.0
245	3.50015	3.50275	3.50712	3.51148
295	3.50365	3.5053	3.5081	3.5109
345	3.51345	3.5147	3.5163	3.5186

Adiabatic Constant

p atm / T°K	.7	1.0	1.5	2.0
245	.2864	.2866	.2868	.2869
295	.2859	.2860	.2862	.2863
345	.2849	.2850	.2851	.2852

I-7. Diffusion coefficient for water vapor in helium. No experimental data were available for water vapor diffusing through helium. Therefore, a theoretical expression due to Jeans[94] was used. The resultant equation is approximately a linear function in the region of interest.

$$D = .000946T + .291$$

where D is the diffusion coefficient in cm^2/sec and T is the temperature in degrees Kelvin.

APPENDIX II

COMPUTER SOLUTION OF THE HEAT FLOW EQUATION FOR A CYLINDRICAL WIRE

The heat capacity of a thermocouple is very large in comparison to the heat capacity of a gas. Therefore, when the gas temperature is changing the thermocouple may not be at the same temperature as the gas. For this reason, an exact calculation of the heat flow from the thermocouple must be performed.

Due to the difficulty involved in incorporating a time dependent source term into an analytic solution of the heat flow equation, it was decided to seek only a numerical solution. Moreover, a different analytic solution is required for each set of boundary conditions, whereas the numerical solution, once it is properly programmed, will work for any set of boundary conditions.

In an iterative numerical solution, one assumes that the partial derivative may be approximated by finite differences.[95,96] Intervals in space and time are picked small enough so that the temperature function may be assumed linear between them. Thus, the x-axis is divided into equal small increments with the points designated as T(1), T(2)···T(N). Stepping forward in time gives a function varying in time. Thus, T(n,1), T(n,2)···T(n,M), where one is looking at the time variation of the function T at the n<u>th</u> point along the x-axis.

The space derivative at the k<u>th</u> point along the x-axis, T(k,r), may be taken in a forward or backward direction.

$$\frac{\partial T(k,t)}{\partial x} = \frac{T(k+1,t) - T(k,t)}{\Delta x} \qquad \text{(II-1)}$$

is the forward derivative where Δx is the x-distance between lattice points. Similarly,

$$\frac{\partial T(k,t)}{\partial x} = \frac{T(k,t) - T(k-1,t)}{\Delta x} \tag{II-2}$$

is the backward derivative.

Second derivatives are taken in a similar manner.

$$\frac{\partial^2 T}{\partial x} = \frac{\partial}{\partial x}\left(\frac{\partial T}{\partial x}\right) = \frac{\dfrac{T(k+1,t) - T(k,t)}{\Delta x} - \dfrac{T(k,t) - T(k-1),t)}{\Delta x}}{\Delta x} \tag{II-3}$$

$$= \frac{T(k+1,t) - 2T(k,t) + T(k-1,t)}{(\Delta x)^2}$$

Before going to the full two dimensional equation, let us simplify by letting $\Delta x = h$, $\Delta y = h$, $\Delta t = k$

r = x coordinate, s = y coordinate, t = time coordinate. Eq. (3-12) becomes

$$\frac{T(r,s,t+1) - T(r,s,t)}{k} = \frac{K}{C_p h^2} [T(r+1,s,t)+T(r-1,s,t)+T(r,s-1,t)$$
$$+T(r,s+1,t)-T(r,s,t)] + f(x,y,x,t) \tag{II-4}$$

With the equation cast into this form, it is seen that, if one knows the value of the function T at a point and the points immediately surrounding it at a time t, then the value of the function T may be calculated for a short time Δt in the future. This technique is used at all the points in the region of interest and repeated until the time of interest is reached.

Extreme caution must be exercised in picking the h and k to be used in the approximations. Due to the iterative nature of the solution, when a time interval k (long enough for an equilibrium to be reached in the space interval h) is used, the approximation for short time in the differential equation is invalidated. If a large enough value of k is picked so that there is even a slight error in one time interval, the error tends to compile in successive time intervals. This is known as an exponential instability and the solution diverges exponentially from the true solution.

Fox[9] has a good treatment of this problem. He shows that for $K/C_p = 1$

$$\frac{\Delta t}{(\Delta x)^2} \leq \frac{5}{2}$$

this is about three times the relaxation time of a square in the lattice.

Argon at room temperature has these possible values of h and k.

TABLE VI. Possible values of h and k for Argon

sec	$.625\times10^{-6}$	$.25\times10^{-5}$	1×10^{-5}	4×10^{-5}	16×10^{-5}	6.4×10^{-4}	2.56×10^{-3}
cm	.000625	.00125	.0025	.005	.01	.02	.04

Referring to the chart, a square the size of the thermocouple cross section requires time increments of the order of one microsecond. A problem arises when one considers that the mesh must extend outward to 0.3 cm from the thermocouple and the integration must take the time through a period of one second. In order that the problem could be solved with a finite size, finite speed computer, a grid mesh was set up with increasing mesh size as the points recede from the thermocouple, see Fig. 53.

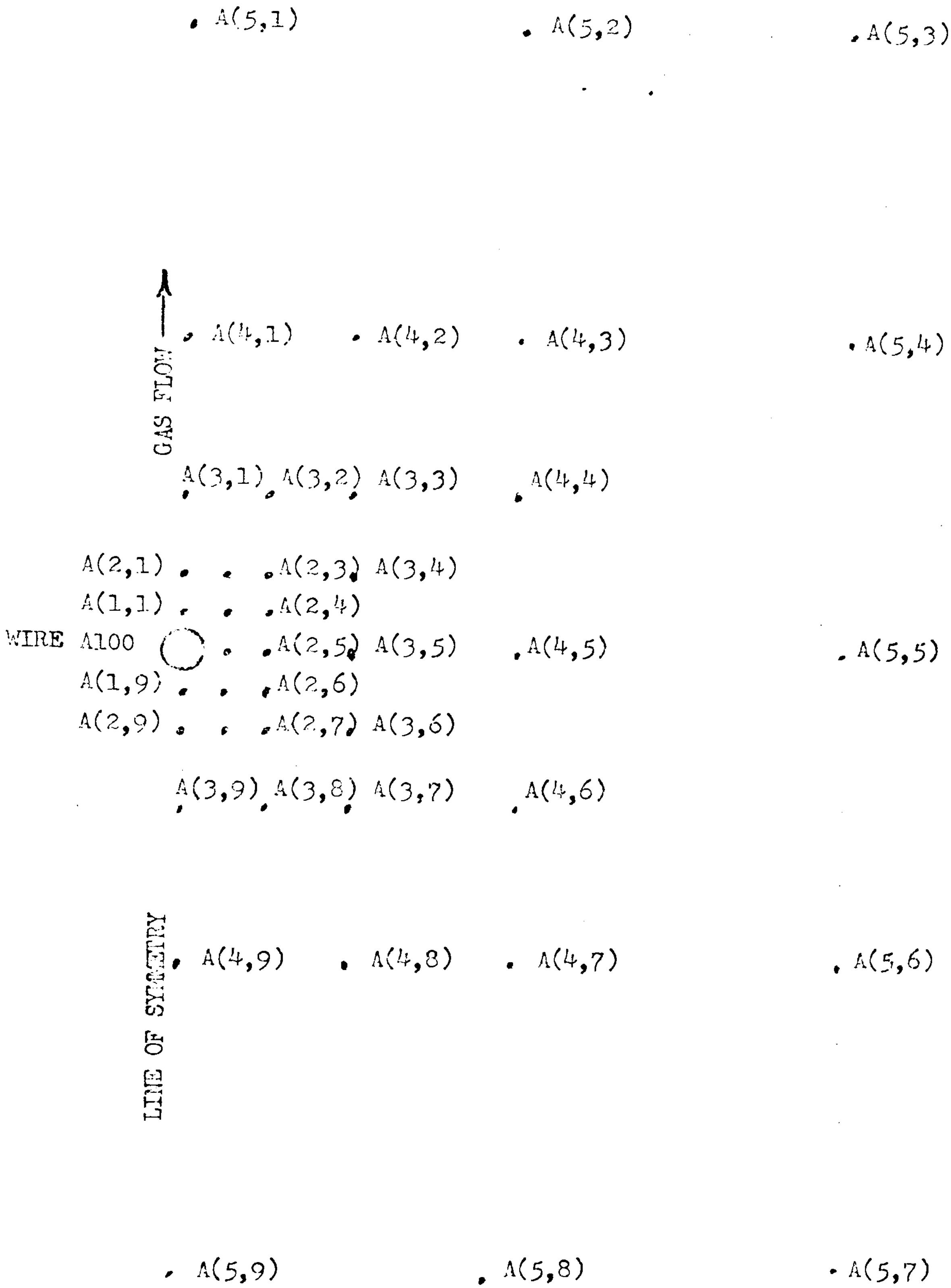

Fig. 53. Mesh used for thermocouple heat flow calculation. The mesh extends outward to the 10th row. The spacing is: row 1-.000675cm, row 2-.000675cm, row 3-.00125cm, row 4-.0025cm.

This technique allows small space intervals near the thermocouple where it is necessary and large space-time intervals in the outlying area. The net result of this technique is that a medium speed, medium capacity computer is sufficient to solve a problem normally suited to a much larger machine. Accuracy is not sacrificed with this technique. Table VII gives a sample of the computer output. Fig. 54 shows the temperature profile around the thermocouple for the expansion shown in Figs. 24 and 25.

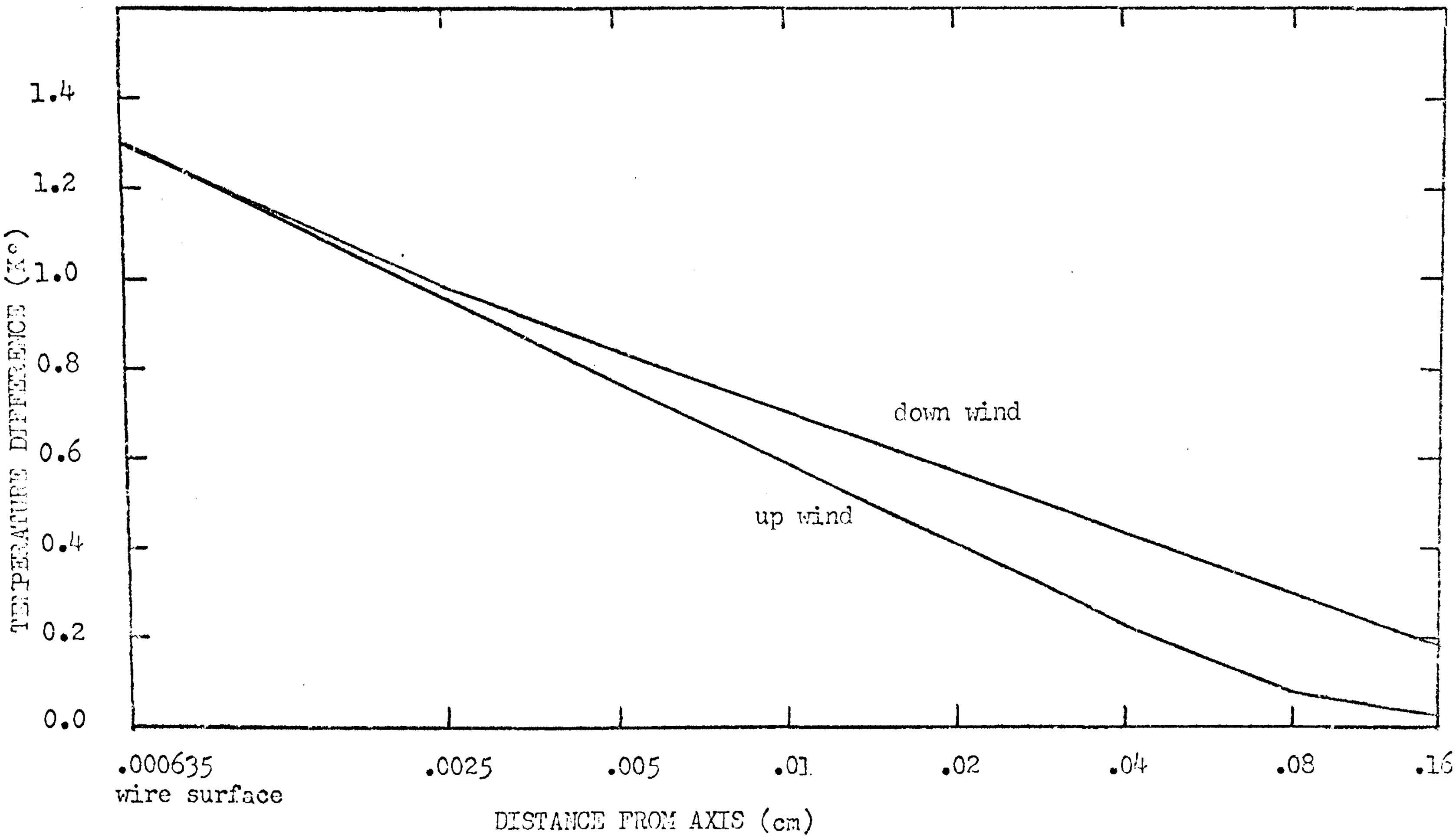

Fig. 54. Temperature profile around the thermocouple.

II-1. Computer program for calculation of the thermal lag of the thermocouple.

```
C      PROGRAM FOR CALCULATING THERMAL LAG OF THERMOCOUPLE
       DOUBLE PRECISION A(10,9),DA(10,9),DT,T,P,A100
       DOUBLE PRECISION VC(9),VC1,VC2,VC3,VC4,VC5,VC6
C      READ IN INITIAL CONDITIONS
       READ(1,100)P,T
   100 FORMAT ( 2E18.8)
       N=0
       A100=T
       DO 99 I=1,10
       DO 99 J=1,9
       A(I,J)=T
    99 DA(I,J)=0.0
       DO 8 I8=1,4
       DO 7 I7=1,4
       DO 6 I6=1,4
       DO 5 I5=1,4
C      K, CP (ARGON( DT=1E-5, DX=.0025CM. CP1= HEAT CAPACITY OF WIRE
       CP=(.06032+.000398*P)*P/T
       XK=3.905E-05+(T-273.15)*1.715E-07
       CP1=.18798
       XKH=1.6
       C=(XK/CP)*XKH
       C1=(XK/(CP+CP1))*XKH
       DO 4 I4=1,4
       N=N+1
       VEL=(-(N-1)*(64.E-5)*(.216)+2.03)*1.E-5
       VC(1)=1.0-(VEL/0.0025)
       DO 15 IX=2,9
    15 VC(IX)=1.-2.*(1.-VC(IX-1))
       DO 3 I3=1,4
       DO 2 I2=1,4
       DO 1 I1=1,4
C      HEAT FLOW CORRECTION AREA NUMBER ONE
       DA(1,1)=C*(A(2,1)+2*A(1,3)+A100-4*A(1,1))
       DA(1,3)=C*(A(1,1)+A(2,2)+A(2,4)+A(1,5)-4*A(1,3))
       DA(1,5)=C*(A100+A(1,3)+A(2,5)+A(1,7)-4*A(1,5))
       DA(1,7)=C*(A(1,9)+A(1,5)+A(2,6)+A(2,8)-4*A(1,7))
       DA(1,9)=C*(A100+2*A(1,7)+A(2,9)-4*A(1,9))
       A100=C1*(A(1,1)+2*A(1,5)+A(1,9)-4*A100)+A100
       DO 61 IL =1,9,2
    61 A(1,IL)=DA(1,IL)+A(1,IL)
C      TEMPERATURE CHANGE IN ENTIRE MATRIX DUE TO VOLUME CHANGE
       DT=-.087486*T*VEL
       T=T+DT
       P=P+P*2.49981*DT/T
       A100=A100+CP*DT/CP1
       DO 98 IL=1,9
       DO 98 JL=1,9
    98 A(IL,JL)=A(IL,JL)+DT
       VC1=VC(1)
       VC2=1.-VC1
       A(1,1)=VC1*A(1,1)+VC2*A100
       A(1,3)=VC1*A(1,3)+VC2*A(1,5)
       A(1,5)=VC1*A(1,5)+VC2*A(1,7)
       A(1,7)=A(1,7)*VC1+VC2*A(2,8)
       A(1,9)=VC1*A(1,9)+VC2*A(2,9)
     1 CONTINUE
       CALL DADEL(DA,A,C,2,VC)
     2 CONTINUE
       CALL DADEL(DA,A,C,3,VC)
     3 CONTINUE
       CALL DADEL(DA,A,C,4,VC)
     4 CONTINUE
       P1=P*760.
```

```
      TIME=N*64.E-5
      ADEL=A100-A(9,1)
      WRITE (3,101)I,PI,A(9,1),TIME,ADEL
      WRITE (3,102)A(8,1),A(7,1),A(6,1),A(5,1),A(4,1),
     1A(3,1),A(2,1),A(1,1),A100,A(1,9),A(2,9),A(3,9),A(4,9),A(5,9),
     2A(6,9),A(7,9),A(8,9)
      CALL DADEL(DA,A,C,5,VC)
    5 CONTINUE
      CALL DADEL(DA,A,C,6,VC)
    6 CONTINUE
      CALL DADEL(DA,A,C,7,VC)
    7 CONTINUE
      CALL DADEL(DA,A,C,8,VC)
    8 CONTINUE
  101 FORMAT(/F7.2,F7.1,F7.2,F7.4,F7.2)
  102 FORMAT (17F7.2).
      CALL EXIT
      END

      SUBROUTINE DADEL(DA,A,C,I,VC)
C     TEMPERATURE CORRECTION DUE TO HEAT FLOW BEYOND CENTRAL AREA
       DOUBLE PRECISION A(10,9),DA(10,9),DI,T,P,A100
      DOUBLE PRECISION VC(9),VC1,VC2,VC3,VC4,VC5,VC6
      DA(I,1)=C*(2*A(I,2)+A(I-1,1)+.5*A(I+1,1)-3.5*A(I,1))
      DA(I,2)=C*(A(I,1)+A(I,3)+A(I-1,3)+.25*(A(I+1,1)+A(I+1,2))
     1-3.5*A(I,2))
      DA(I,3)=C*(A(I,2)+A(I,4)+.5*(A(I+1,4)+A(I+1,2))-3*A(I,3))
      DA(I,4)=C*(A(I,3)+A(I,5)+A(I-1,3)+.25*(A(I+1,4)+A(I+1,5))
     1-3.5*A(I,4))
      DA(I,5)=C*(A(I-1,5)+A(I,4)+A(I,6)+0.5*A(I+1,5)-3.5*A(I,5))
      DA(I,6)=C*(A(I-1,7)+A(I,5)+A(I,7)+0.25*(A(I+1,5)+A(I+1,6))
     1-3.5*A(I,6))
      DA(I,7)=C*(A(I,8)+A(I,6)+0.5*(A(I+1,6)+A(I+1,8))-3.0*A(I,7))
      DA(I,8)=C*(A(I,9)+A(I-1,7)+A(I,7)+0.25*(A(I+1,8)+A(I+1,9))
     1-3.5*A(I,8))
      DA(I,9)=C*(A(I-1,9)+2*A(I,8)+0.5*A(I+1,9)-3.5*A(I,9))
      DO 10 JA=1,9
   10 A(I,JA)=A(I,JA)+DA(I,JA)
      VC3=VC(I)
      VC4=1.-VC3
      VC6=.5*VC4
      VC5=1.-VC6
      A(I,1)=VC3*A(I,1)+VC4*A(I-1,1)
      A(I,2)=VC3*A(I,2)+VC4*A(I-1,3)
      A(I,3)=VC3*A(I,3)+VC4*A(I,4)
      A(I,4)=VC3*A(I,4)+VC4*A(I,5)
      A(I,5)=VC3*A(I,5)+VC4*A(I,6)
      A(I,6)=VC3*A(I,6)+VC4*A(I,7)
      A(I,7)=VC5*A(I,7)+VC6*A(I+1,8)
      A(I,8)=VC5*A(I,8)+VC6*.5*(A(I+1,8)+A(I+1,9))
      A(I,9)=VC5*A(I,9)+VC6*A(I+1,9)
      RETURN
      END
```

TABLE VII

OUTPUT OF THERMOCOUPLE HEAT FLOW COMPUTER PROGRAM

Print out is in this order:

Gas temperature, Pressure, A(9,1), Time, Temperature difference

A(8,1)	A(7,1)	A(6,1)	A(5,1)	A(4,1)	A(3,1)	A(2,1)	A(1,1)	A100	A(1,9)	A(2,9)	A(3,9)	A(4,9)	A(5,9)	A(6,9)	A(7,9)	A(8,9)
289.74	1027.1	289.74	0.1587	1.41												
289.74	289.99	290.15	290.28	290.41	290.55	290.69	290.82	291.14	290.78	290.61	290.42	290.21	290.01	289.85	289.76	289.74
289.61	1025.9	289.61	0.1613	1.41												
289.61	289.86	290.02	290.15	290.29	290.42	290.56	290.69	291.02	290.65	290.48	290.29	290.09	289.88	289.72	289.63	289.61
289.48	1024.8	289.48	0.1638	1.41												
289.48	289.73	289.89	290.03	290.16	290.30	290.43	290.57	290.89	290.52	290.35	290.16	289.96	289.75	289.59	289.50	289.48
289.35	1023.6	289.35	0.1664	1.41												
289.67	289.66	289.77	289.90	290.03	290.17	290.31	290.44	290.76	290.40	290.22	290.04	289.83	289.63	289.46	289.37	289.35
289.22	1022.5	289.22	0.1690	1.42												
289.54	289.53	289.64	289.77	289.91	290.04	290.18	290.31	290.64	290.27	290.10	289.91	289.70	289.50	289.33	289.25	289.22
289.09	1021.4	289.09	0.1715	1.42												
289.41	289.41	289.51	289.65	289.78	289.92	290.05	290.19	290.51	290.14	289.97	289.78	289.58	289.37	289.20	289.12	289.09
288.96	1020.2	288.96	0.1741	1.42												
289.28	289.28	289.38	289.52	289.66	289.79	289.93	290.06	290.38	290.02	289.84	289.66	289.45	289.24	289.07	288.99	288.96
288.83	1019.1	288.83	0.1766	1.42												
289.15	289.15	289.27	289.39	289.53	289.66	289.80	289.93	290.26	289.89	289.72	289.53	289.32	289.12	288.95	288.86	288.84
288.70	1017.9	288.70	0.1792	1.43												
289.02	289.02	289.14	289.27	289.40	289.54	289.67	289.81	290.13	289.76	289.59	289.40	289.20	288.99	288.82	288.73	288.71
288.58	1016.8	288.58	0.1818	1.43												
288.90	288.89	289.01	289.14	289.28	289.41	289.55	289.68	290.00	289.64	289.46	289.28	289.07	288.86	288.69	288.60	288.58
288.45	1015.7	288.45	0.1843	1.43												
288.77	288.76	288.88	289.02	289.15	289.28	289.42	289.56	289.88	289.51	289.34	289.15	288.94	288.73	288.56	288.47	288.45
288.32	1014.5	288.32	0.1869	1.43												
288.64	288.63	288.77	288.89	289.02	289.16	289.29	289.43	289.75	289.38	289.21	289.02	288.82	288.61	288.44	288.34	288.32
288.19	1013.4	288.19	0.1894	1.44												
288.51	288.50	288.64	288.76	288.90	289.03	289.17	289.30	289.63	289.26	289.08	288.90	288.69	288.48	288.31	288.22	288.19
288.06	1012.3	288.06	0.1920	1.44												
288.38	288.38	288.51	288.64	288.77	288.91	289.04	289.18	289.50	289.13	288.96	288.77	288.56	288.35	288.18	288.09	288.06
287.93	1011.2	287.93	0.1946	1.44												
288.25	288.25	288.38	288.51	288.64	288.78	288.91	289.05	289.37	289.00	288.83	288.64	288.44	288.23	288.05	287.96	287.94
287.81	1010.0	287.81	0.1971	1.44												
288.12	288.12	288.26	288.38	288.52	288.65	288.79	288.92	289.25	288.88	288.71	288.52	288.31	288.10	287.93	287.83	287.81
287.68	1008.9	287.68	0.1997	1.44												
288.00	287.99	288.13	288.26	288.39	288.53	288.66	288.80	289.12	288.75	288.58	288.39	288.18	287.97	287.80	287.70	287.68
287.55	1007.8	287.55	0.2022	1.45												
287.87	287.86	288.01	288.13	288.27	288.40	288.54	288.67	288.99	288.62	288.45	288.26	288.06	287.85	287.67	287.57	287.55
287.42	1006.7	287.42	0.2048	1.45												
287.74	287.74	287.88	288.01	288.14	288.27	288.41	288.54	288.87	288.50	288.33	288.14	287.93	287.72	287.55	287.45	287.42
287.29	1005.6	287.29	0.2074	1.45												
287.61	287.67	287.76	287.88	288.01	288.15	288.28	288.42	288.74	288.37	288.20	288.01	287.80	287.59	287.42	287.33	287.30
287.17	1004.4	287.17	0.2099	1.45												
287.49	287.54	287.63	287.76	287.89	288.02	288.16	288.29	288.62	288.25	288.07	287.88	287.68	287.47	287.29	287.20	287.17

APPENDIX III

COMPUTER SOLUTION OF THE DROPLET GROWTH EQUATIONS

```
10CT67                                    IBM OS/360 BASIC FORTRAN IV (E) COMPILATION

    C    LOUIS R. ALLEN          102A NORWOOD HALL
    C     GENERALIZED NUCLEATION RATE RATE PROGRAM
    C COPY 2
    C     RATE LAW = FARLEY RATE LAW
          REAL K
          DIMENSION AC(50),A1(50),A2(50),CNT(50)
          DIMENSION CT(10),WT(10)
          WRITE(3,1021)
     1020 FORMAT(5I10)
     1021 FORMAT(5F14.6)
          READ (1,1020) IIQ
          READ (1,1021) (CT(II),II=1,IIQ),(WT(JJ),JJ=1,IIQ)
          READ(1,1021)WTMOS,WTMVP,PI,RGAS,RG,RW,CC,GAMU,RMM,K
          READ(1,1020) IN
          DO 205 L=1,IN
          READ (1,1020) IQ,NEXP
          WRITE(3,1022) NEXP,IQ
     1022 FORMAT(40X,'EXPANSION NUMBER  =',I5,10X,I5,'  DATA POINTS',////)
          READ (1,1021)P0,T0
          CALL VPREQ(T0,VP0)
          READ (1,1021) P1,TIME1
          AT0=T0
          AVP0=VP0
          DT1=TIME1
          CNTOT=0.
          ACNTOT=0.
    C   NAMES HEADED BY A ARE UNCORRECTED VALUES
          M1=0
          IQ1=IQ-2
          DO 200 I=1,IQ1
          CALL TCALC(P0,P1,T0,T1,VP0,VP1)
          CALL TCALC(P0,P1,AT0,AT1,AVP0,AVP1)
          CALL VPREQ(T1,VPEQ)
          SUPR=VP1/VPEQ
          CALL VPREQ (AT1,VPEQ)
          ASUPR= AVP1/VPEQ
          READ (1,1021)  P2,TIME2
          DT2=TIME2-TIME1
          DT=(DT1+DT2)*.5
          IF(SUPR-1.0)96,96,110
      110 IF(M1)111,91,111
       96 WRITE(3,1014)SUPR,VP1,VPEQ
     1014 FORMAT(/,' END OF PROGRAM---SUPERSATION CUT-OFF AT  ',F20.4,'   AN
         1 VAPOR PRESSURES OF ',2F10.4)
       92 IQ2=IQ1-I
          IF(IQ2)205,205,97
       97 DO 93 J1=1,IQ2
          READ (1,1021)P2,TIME2
          WRITE(3,1028)
     1028 FORMAT(//,' THE REMAINING DATA CARDS ARE THE FOLLOWING:',/)
       93 WRITE(3,1029)P2,TIME2
     1029 FORMAT(F20.2,F15.6)
          WRITE(3,1030)
```

```
1003 FORMAT(////)
     GO TO 206
  81 CALL ARATE (AT1,AVP1,ASUPR,ARATE)
     ACNT=ARATE*DT
     ACNTOT=ACNTOT+ACNT
     CALL CRATE (T1,VP1,SUPR,RATE)
     CNT=RATE*DT
     CNT(I)=0
     CN=0
     WRITE(3,1000) I
1000 FORMAT('  TIME INTERVAL NO.',I4,//)
     WRITE(3,1002) P1,DT
1002 FORMAT(4X,'PRESSURE   =',F10.3,'  MM HG',10X,'DURATION OF THIS STEP
    1  =',F10.6,'  SECONDS',///)
     IF(CNTOT-1.)98,97,97
  98 CNT(I)=(1.-CNTOT)*RATE*DT
     WRITE(3,1015) CNT(I)
  97 WRITE(3,1003)
1003 FORMAT(8X,'FAMILY',5X,'INITIAL RADIUS',6X,'FINAL RADIUS',6X,'VP OF
    1 DROP SUR',6X,'TEMP OF DROP SUR',6X,'GAS TEMP AT DROP',6X,'DROPS F
    1ORMED',/)
1015 FORMAT('       DROPS NUCLEATED IN THE FREE VOLUME  =',F15.6,//)
     IM=I
 111 DO 80 J=1,IM
C    FIRST APPROXIMATION OF A2(J)
     IF(I-J) 20,21,20
  21 A1(J)=1.0E-05
     DAJ=    A1(J)
     A2(J)=10*A1(J)
     GO TO 22
  20 DAJ=(A1(J)-A0(J))*0.1
     A2(J)=.5*(A1(J)-A0(J))+A1(J)
  22 CONTINUE
     CK=0
     N=-1
     KAM=0
     DT=0
   6 SUM=0
     KAM=KAM+1
     DO 14 II=1,II0
     RU=.5*((A2(J)-A1(J))*RT(II)+A2(J)+A1(J))
     CALL TGRAD(K,PT,RGAS,RG,RW,NT,CAMU,RMM,P1,T1,VP1,RU,WTMVP,WTMGS,
    1TEQ,TEA,VPA)
     CALL CNLAT(TEA,Q)
     CALL THERMC(TEA,THERM,THERME)
  14 SUM =SUM+0.5*(A2(J)-A1(J))*WT(II)*RU*Q/(THERM*(TEA-T1))
     IF  (I-1)  16,16,17
  16 DT=DT2*.5
     GO TO 18
  17 DT=(DT1+DT2)*.5
  18 CONTINUE
C    CHECK ERROR, APPLY BISECTION METHOD OF ITERATION
     IF(ABS(SUM-DT)-DT/50.)10,10,1
   1 IF(SUM-DT)2,10,4
   2 IF(CK)3,3,7
   3 CK=1.
     GO TO 8
   4 IF(CK)7,5,5
   5 CK=-1.
   8 N=N+1
   7 A2(J)=A2(J)+2.*CK*DAJ/(2.**(N+1))
     GO TO 6
  10 CALL TGRAD(K,PT,RGAS,RG,RW,NT,CAMU,RMM,P1,T1,VP1,A2(J),WTMVP,
    1WTMGS,TEQ,TEA,VPA)
     IF(N1)114,113,114
 114 CN=0.
     CNT(I)=0.
     RATE=0.
     ARATE=0.
     GO TO 84
C    CALCULATION OF DEAD VOLUME
 113 IF(J-I)81,83,83
```

```
 83 IF(I-1) 86,84,86
 85 CN=0.
    GO TO 94
 86 CNT(I)=CNTA
    GO TO 94
 81 RATIO =A1(J)/(R-A1(J))
    SUM=0.0
    DO 82 II=1,110
    X=.5*((R-A1(J))*Z(II) + A1(J)+R)
    TF=RATIO*(TFA-T1)*(R-X)/X+T1
    CALL VPREQ(TF ,VPEQ)
    VP=(RATIO*(R-X)*(TFA*VPA-T1*VP1)/X+T1*VP1)/TF
    SR=VP/VPEQ
    CALL NRATE(TF,VP,SR,RATA)
 82 SUM = SUM + 4.*PI*RATA*X*X*(R-A1(J))*.5*DT*WT(II)
    CN=CNT(J)*SUM
    CNT(I)=CNT(I)+CN
 94 CONTINUE
    CALL VPREQ(TFO,VP)
    WRITE(3,1003) J,A1(J),A2(J),VP,TFO,TFA,CN
1003 FORMAT(I9,F23.8,F13.9,F16.4,F22.4,F22.4,F22.9)
 90 CONTINUE
    IF(M1)107,115,107
115 CNTOT=CNT(I)+CNTOT
    IF(CNT(I)/CNTOT -1.E-10)94,95,95
 94 WRITE(3,1027)  CNTOT,CNT(I)
    M1=1
1027 FORMAT(//,5X,'PROGRAM CUT-OFF SINCE TOTAL DROP COUNT,',E16.6,',
   1EAR EXCEEDS DROP COUNT IN THIS STEP,',E16.6,'.')
    GO TO 107
 95 VD=1.-CNT(I)/CLTA
C   SET R FOR NEXT TIME INTERVAL
    WRITE(3,1010) VD
    IF(CNTOT-1.)106,105,106
105 R =0.62
    GO TO 107
106 R =(3./(4.*PI*CNTOT))**(.333333)
107 CONTINUE
    DRH=0.0
    DO 85 J=1,IM
 85 DRH=(4./3.)*PI*CNT(J)*(A2(J)**3-A1(J)**3) + DRH
    CALL CHLAT(T1,HEAT)
    Q=DRH*HEAT
    DTEMP=2.*Q*RGAS*T1/(P1*RAM*5.*1.9872)
    DVP=DRH*RGAS*T1/(RAM*VTMVP)
    T1=T1+DTEMP
    VP1=VP1-DVP
1025 FORMAT(5X,'TEMPERATURE CORRECTION       =',E16.6,//)
1010 FORMAT(//,5X,'DEAD VOLUME                     =',E16.6)
1026 FORMAT(5X,'VAPOR PRESSURE CORRECTION  =',E16.6)
1023 FORMAT(5X,'LATENT HEAT RELEASED          =',E16.6)
1024 FORMAT(5X,'VAPOR DEPLETION                =',E16.6)
    WRITE(3,1024) DRH
    WRITE(3,1023) Q
    WRITE(3,1026) DVP
    WRITE(3,1025) DTEMP
    WRITE(3,1004)
1004 FORMAT(20X,'TEMPERATURE',8X,'VAPOR PRESSURE',5X,'SUPERSATURATION',
   14X,'NUCLEATION RATE',5X,'DROPS THIS STEP',5X,'TOTAL DROPS',///)
    WRITE(3,1005) AT1,AVP1,ASUPR,ARATE,ACNT,ACNTOT
1005 FORMAT(2X,'ADIABATIC',5X,F15.4,F19.4,F20.6,E20.8,E20.8,E20.8)
    WRITE (3,1006) T1,VP1,SUPR,RATE,CNT(I),CNTOT
1006 FORMAT(2X,'CORRECTED',5X,F15.4,F19.4,F20.6,E20.8,E20.8,E20.8)
    WRITE(3,1007)
1007 FORMAT(///,1X,'END OF THIS TIME INTERVAL',////)
    T0=T1
    VP0=VP1
    P0=P1
    P1=P2
    AT0=AT1
    AVP0=AVP1
    TIME1=TIME2
```

```
      PI1=PI2
      DO 100 IX=1,IM
      A0(IX)=A1(IX)
  100 A1(IX)=A2(IX)
  200 CONTINUE
  206 WRITE(2,1021)
 1021 FORMAT(1H1)
      STOP
      END
```

```
      SUBROUTINE TCRAD(K,PI,RGAS,RG,RW,NT,CAMU,RMM,P,T,VPR,AP,WT1VP,
     1RTMGS,TEQ,TEA,VPA)
      REAL K
      X=T+10.
      CALL VPREQ(T,VPEQ)
C     DIFFUSION COEFFICIENT(CM**2/SEC) AS A F OF T AND MF RATIOS AND MOL WEIGH
      AD=.00046*T + .021
      CALL THERMC(T,THERM,THERME)
      ETA=4.*AD*SQRT(WT1VP*PI/(8.*RGAS*T))/AP
      ETAP=4.*THERME*SQRT(RTMGS*PI*T/(2.*RGAS))/((P-VPR)*RMM*AP)
      CALL CNLAT(T,Q)
      A=(ETA+1.)*THERM/(Q*AD*(ETAP+1.))
      B=-WT1VP*VPR*RMM/(RGAS*T) - A*T
      AA=Q*WT1VP/1.9872
      C=VPEQ*RMM*WT1VP*EXP(AA/T)/RGAS
      CALL SIGMA(T,SUR)
      RTA=2.*SUR*WT1VP*CAMU/K
      D=RTA/AP - AA
      N=1
    5 F =A*X*X+B*X+C*EXP(D/X)
      FP = 2.*A*X+B-C*D*EXP(D/X)/(X*X)
      DX = -F/FP
      IF (ABS(DX)-.001) 1,1,2
    2 IF(N-20 )4,4,3
    4 X=X+DX
      N=N+1
      GO TO 5
    3 WRITE(2,1000)
 1000 FORMAT(' DID NOT CONVERGE')
    1 TEQ=X
      TEA=(ETAP*T+TEQ)/(ETAP+1.)
      VPA=TEA*(VPR/T+RGAS*THERM*(T-TEA)/(Q*AD*RMM*WT1VP))
      NT=NT+N
      RETURN
      END
```

```
      SUBROUTINE VPREQ(T,VPEQ)
C     CALCULATION OF EQUILIBRIUM VAPOR PRESSURE OF WATER
      TC=T-273.15
      VPEQ=4.58102+TC*.333075+TC**2*.010758+TC**3*1.96622E-4
     1+TC**4*.21663E-5+TC**5*.211191E-7
      RETURN
      END
```

```
      SUBROUTINE CNLAT (T,HEAT)
      HEAT=746.1-.55*T
      RETURN
      END
```

```
      SUBROUTINE SIGMA(T,SIG)
      SIG=116.459-.149229*T
      RETURN
      END
```

```
      SUBROUTINE TCALC (P1,P2,T1,T2,VP1,VP2)
      DOUBLE PRECISION P,T
      REAL MFW,MFG,MWG
      MFW=VP1/P1
      MFG=1-MFW
      MWG=MFW/MFG
      DPTOT=P2-P1
      N=ABS(10.*DPTOT)
      IF(N) 2,2,3
    2 DP=DPTOT
      N=1
      GO TO 4
    3 DP=DPTOT/N
    4 DVP=MFW*DP
      DPG=MFG*DP
      RG=1.0
      CPG=2.5
      T=T1
      P=P1
      DO 1 IN=1,N
      P=P+DP
      VP=P*MFW
      PG=P*MFG
      T2=T
      CALL HCAP (T2,VP,CPW,RW)
    1 T=T+T*(RG*DPG/PG+(RWG*RW*DVP/VP))/(CPG+MWG*CPW)
      T2=T
      RETURN
      END
      SUBROUTINE HCAP (T,P2,CP2,R2)
CALCULATION OF R AND CP FOR WATER VAPOR.
      IF(T-240.) 3,4,4
    4 CP2=2.1611
      GO TO 7
    3 IF(P2-28.8) 5,5,6
    6 CP2=2.061+(T-240.)*.01201
      GO TO 7
    5 CP2=2.0611+(T-240.)*.01234+
     1((28.8-P2)/14.71)*(.1053+(T-240.)*.00202)
    7 CONTINUE
      IF(T-325) 8,9,9
    8 R2=1.005+.00054*(T-325.)
      GO TO 10
    9 R2=1.005
   10 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE THERMC (T,THERM,THERME)
THERMAL CONDUCTIVITY (CAL/DEG SEC CM) AS A FUNCTION OF T(DEG K)
HELIUM
      THERME=.43E+04+.0035E+04*T
      THERM=THERME/4.186E+07
      RETURN
      END
```

TABLE VIII. OUTPUT OF THE DROPLET GROWTH COMPUTER PROGRAM

Units are: Length-cm, Volume-cm^3, Temperature-°K, Pressure-mmHg, Heat-cal, Time-sec.

TIME INTERVAL NO. 6

PRESSURE = 531.700 MM HG DURATION OF THIS STEP = 0.005000 SECONDS

FAMILY	INITIAL RADIUS	FINAL RADIUS	VP OF DROP SUR	TEMP OF DROP SUR	GAS TEMP AT DROP
1	0.34902502E-03	0.39214152E-03	2.8291	266.6368	265.2322
2	0.30332198E-03	0.35021548E-03	2.8448	266.7595	265.1548
3	0.25266479E-03	0.30776625E-03	2.8653	266.9533	265.0552
4	0.18849994E-03	0.25394978E-03	2.8992	267.0073	264.8906
5	0.94999981E-04	0.18849994E-03	2.9619	267.2878	264.5898
6	0.99999997E-05	0.97499271E-04	3.1465	268.0842	263.7239

DEAD VOLUME = 0.234604E-02
VAPOR DEPLETION = 0.760119E-10
LATENT HEAT RELEASED = 0.459717E-07
VAPOR PRESSURE CORRECTION = 0.682545E-04
TEMPERATURE CORRECTION = 0.140180E-03

TOTAL DROPS

ADIABATIC	0.40492125E 01
CORRECTED	0.40402241E 01

	TEMPERATURE	VAPOR PRESSURE	SUPERSATURATION	NUCLEATION RATE	DROPS THIS STEP
ADIABATIC	259.3093	8.5261	5.395782	0.41817090E 03	0.20908537E 01
CORRECTED	259.3093	8.5259	5.395754	0.41813574E 03	0.20857735E 01

END OF THIS TIME INTERVAL

TIME INTERVAL NO. 7

PRESSURE = 527.400 MM HG DURATION OF THIS STEP = 0.005000 SECONDS

FAMILY	INITIAL RADIUS	FINAL RADIUS	VP OF DROP SUR	TEMP OF DROP SUR	GAS TEMP AT DROP
1	0.39214152E-03	0.43093716E-03	2.7320	266.2312	264.8770
2	0.35021548E-03	0.39355944E-03	2.7437	266.2869	264.8184
3	0.30776625E-03	0.35460228E-03	2.7583	266.3562	264.7458
4	0.25394978E-03	0.30352187E-03	2.7792	266.4546	264.6423
5	0.18849994E-03	0.25628693E-03	2.8121	266.6084	264.4807
6	0.97499271E-04	0.19156237E-03	2.8724	266.8857	264.1868
7	0.99999997E-05	0.97499271E-04	3.0598	267.7153	263.2954

DEAD VOLUME = 0.337493E-02
VAPOR DEPLETION = 0.166227E-09
LATENT HEAT RELEASED = 0.100350E-06
VAPOR PRESSURE CORRECTION = 0.149998E-03
TEMPERATURE CORRECTION = 0.351421E-03

TOTAL DROPS

ADIABATIC	0.76828156E 01
CORRECTED	0.76607838E 01

	TEMPERATURE	VAPOR PRESSURE	SUPERSATURATION	NUCLEATION RATE	DROPS THIS STEP
ADIABATIC	258.8216	8.4967	5.585413	0.72672095E 03	0.36336031E 01
CORRECTED	258.8202	8.4964	5.585338	0.72656421E 03	0.36205597E 01

0.010	965.0	272.42	3.81
0.015	955.3	271.73	4.00
0.020	952.7	271.09	4.17
0.025	948.0	270.56	4.31
0.028	945.9	270.31	4.39
0.031	944.0	270.24	4.39
0.034	944.6	270.40	4.35
0.040	946.5	270.40	4.36
0.041	945.7	270.39	4.39
0.046	945.7	270.30	4.39
0.049	947.6	270.52	4.33
0.050	951.0	270.90	4.22
0.055	964.0	272.59	3.79

EXP. NO. 744 0,1 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1125.7	295.65	1.00
0.005	976.9	273.77	3.51
0.010	968.2	272.80	3.74
0.015	960.1	271.99	3.96
0.020	955.6	271.39	4.09
0.025	949.9	270.74	4.26
0.030	944.6	270.14	4.43
0.032	943.6	270.03	4.47
0.035	943.7	270.04	4.46
0.039	945.2	270.21	4.42
0.041	943.7	270.04	4.46
0.045	958.3	271.35	4.10

EXP. NO. 747 1,0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1126.3	295.65	1.00
0.005	977.0	273.73	3.52
0.010	969.6	272.79	3.74
0.015	961.1	271.95	3.94
0.020	955.1	271.27	4.12
0.025	950.2	270.72	4.27
0.030	947.3	270.35	4.37
0.034	947.0	270.36	4.37
0.038	947.6	270.43	4.35
0.044	946.7	270.32	4.39
0.049	946.9	270.31	4.39
0.054	948.0	270.47	4.34
0.059	949.4	270.52	4.33
0.064	947.1	270.37	4.37
0.069	947.5	270.41	4.36
0.080	948.6	270.54	4.32
0.090	948.6	270.54	4.32
0.100	949.2	270.61	4.30
0.110	949.0	270.59	4.31
0.115	949.9	270.69	4.29
0.120	952.5	270.98	4.20
0.125	963.2	272.18	3.89

EXP. NO. 749 0.6 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1126.5	295.65	1.00
0.005	977.2	273.73	3.52
0.010	970.3	272.94	3.70
0.015	962.9	272.12	3.90
0.020	954.7	271.44	4.09
0.025	951.0	270.99	4.23
0.030	949.7	270.42	4.34
0.034	948.1	270.46	4.34
0.038	948.6	270.52	4.33
0.043	947.2	270.36	4.37
0.046	946.9	270.32	4.38
0.052	948.0	270.45	4.35
0.057	949.3	270.59	4.31
0.065	947.9	270.44	4.35
0.075	949.4	270.63	4.29
0.085	949.9	270.54	4.32
0.095	949.7	270.64	4.29
0.105	949.7	270.64	4.29
0.115	951.6	270.75	4.26
0.120	953.9	271.09	4.20
0.125	964.0	272.26	3.97

EXP. NO. 752 0,9 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1125.6	295.65	1.00
0.005	977.0	273.79	3.51
0.010	964.6	272.63	3.78
0.015	959.0	271.78	3.98
0.020	952.0	271.10	4.17
0.025	947.0	270.52	4.33
0.030	942.9	269.94	4.49
0.035	939.5	269.57	4.60
0.038	941.0	269.63	4.59
0.043	941.9	269.72	4.56
0.048	939.0	269.61	4.59
0.054	939.0	269.61	4.59
0.065	941.2	269.76	4.55
0.075	941.6	269.91	4.53
0.085	941.5	269.80	4.54
0.095	942.2	269.99	4.51
0.105	942.2	269.92	4.51
0.115	942.4	269.90	4.51
0.120	944.9	270.09	4.45
0.125	953.0	271.10	4.17

EXP. NO. 754 1,5 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1125.9	295.65	1.00
0.005	976.9	273.75	3.52
0.010	968.0	272.86	3.72
0.015	960.0	271.96	3.94
0.020	954.7	271.27	4.12
0.025	950.0	270.73	4.27
0.030	944.0	270.16	4.43
0.035	941.0	269.71	4.56
0.040	941.6	269.72	4.54
0.045	940.9	269.69	4.57

TIME	PRESS	TEMP	SUPR
[illegible]	[illegible]	269.5[illegible]	4.60
[illegible]	041.1	[illegible]	4.56
[illegible]	041.4	[illegible]	4.55
[illegible]	041.6	269.01	4.53
[illegible]	041.[illegible]	269.80	4.52
[illegible]	042.[illegible]	269.[illegible]0	4.51
0.11[illegible]	043.[illegible]	269.95	4.52
0.116	042.8	269.[illegible]2	4.50
0.12[illegible]	042.0	269.0[illegible]	4.50
0.128	042.4	269.00	4.42
0.145	044.0	270.3[illegible]	4.37
0.1[illegible]	041.4	272.[illegible]2	3.93

EXP. NO. 762 0.4 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.6	295.65	1.00
0.005	074.3	273.01	3.51
0.010	067.0	272.0[illegible]	3.74
0.015	059.2	271.[illegible]	3.95
0.020	053.2	271.[illegible]3	4.13
0.025	048.6	270.62	4.30
0.030	043.5	270.11	4.44
0.034	041.0	269.83	4.53
0.036	04[illegible].5	269.77	4.54
0.038	041.0	269.93	4.53
0.042	042.0	269.[illegible]4	4.49
0.045	045.0	270.[illegible]	4.39
0.050	052.4	271.[illegible]	3.99

EXP. NO. 757 0.7 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.0	295.65	1.00
0.005	070.7	273.73	3.52
0.010	071.1	273.0[illegible]	3.40
0.015	061.7	272.65	3.92
0.020	055.2	271.22	4.11
0.025	050.1	270.75	4.26
0.030	046.7	270.13	4.44
0.035	04[illegible].3	269.63	4.53
0.040	039.5	269.54	4.61
0.045	04[illegible].[illegible]	269.65	4.59
0.050	039.4	269.53	4.42
0.062	040.[illegible]	269.52	4.57
0.07[illegible]	04[illegible].[illegible]	269.62	4.50
0.07[illegible]	041.4	269.74	4.55
[illegible]	041.2	269.73	4.55
[illegible]	041.2	269.74	4.55
0.10[illegible]	042.0	269.92	4.53
0.10[illegible]	045.5	270.22	4.41
0.110	050.1	271.65	4.02

EXP. NO. 764 0.7 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.0	295.65	1.00
0.005	076.2	272.77	3.51
0.010	064.6	272.47	3.92
0.015	055.7	271.6[illegible]	4.[illegible]4
0.020	050.2	270.95	4.24
0.026	045.3	270.20	4.39
0.030	039.7	269.65	4.58
0.034	036.9	269.[illegible]	4.68
0.036	035.6	269.22	4.71
0.038	036.7	269.31	4.68
0.042	037.0	269.35	4.67
0.046	038.2	269.49	4.63
0.050	047.1	270.50	4.33
0.057	041.2	272.[illegible]0	3.91
0.066	054.1	271.20	4.12
0.076	041.8	272.15	3.90
0.086	055.4	271.46	4.07

EXP. NO. 75[illegible] 0.6 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.2	295.65	1.00
0.005	070.2	272.63	3.54
0.010	066.0	272.60	3.78
0.015	060.5	271.76	3.99
0.020	052.4	271.07	4.18
0.025	047.0	270.55	4.32
0.030	042.6	269.96	4.49
0.034	039.0	269.65	4.59
0.038	04[illegible].4	269.71	4.53
0.043	04[illegible].4	269.71	4.56
0.047	039.2	269.58	4.60
0.051	039.5	269.60	4.59
0.056	040.4	269.71	4.56
0.060	041.7	269.85	4.52
0.065	044.0	270.45	4.35
0.070	042.0	272.15	3.89

EXP. NO. 767 1.2 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.4	295.65	1.00
0.005	070.0	272.60	3.53
0.010	063.0	272.25	3.87
0.015	054.4	271.28	4.12
0.020	042.1	270.56	4.31
0.025	042.3	269.91	4.50
0.030	037.3	269.24	4.67
0.032	033.5	269.0[illegible]	4.81
0.036	031.7	269.6[illegible]	4.83
0.038	031.3	269.65	4.89
0.040	032.4	269.77	4.85
0.043	040.3	269.63	4.57
0.046	043.2	270.57	4.31
0.050	053.8	271.77	3.90
0.055	060.1	272.93	3.71

EXP. NO. 77[illegible] 1,2 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.6	295.65	1.00
0.005	975.0	272.66	3.54
0.010	963.2	272.25	3.97
0.015	954.9	271.32	4.11
0.020	949.6	270.60	4.30
0.025	942.7	269.93	4.49
0.030	937.4	269.33	4.69
0.032	935.5	269.11	4.74
0.035	932.2	268.92	4.90
0.038	934.5	269.[illegible]	4.73
0.041	939.0	269.40	4.66
0.045	946.0	270.41	4.36
0.050	960.2	271.02	3.95

EXP. NO. 77[illegible] 3,0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.6	295.65	1.00
0.005	975.0	272.65	3.54
0.010	961.7	272.14	3.93
0.015	952.[illegible]	271.14	4.15
0.020	946.[illegible]	270.24	4.37
0.025	940.1	269.49	4.57
0.030	934.9	269.1[illegible]	4.75
0.034	931.9	268.76	4.84
0.037	931.7	268.73	4.86
0.040	932.[illegible]	268.77	4.85
0.044	931.[illegible]	268.75	4.86
0.047	930.4	268.40	4.90
0.050	930.8	268.87	4.72
0.052	931.3	268.62	4.72
0.056	934.1	269.01	4.72
0.060	940.4	269.72	4.56
0.065	952.1	271.[illegible]5	4.13
0.070	961.9	272.14	3.9[illegible]

EXP. NO. 772 3,2 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.5	295.65	1.00
0.005	975.6	272.65	3.54
0.010	961.1	272.02	3.93
0.015	952.4	271.04	4.18
0.020	945.5	270.26	4.40
0.025	939.6	269.50	4.63
0.030	935.3	269.10	4.75
0.035	930.[illegible]	268.48	4.95
0.037	927.9	268.24	5.02
0.040	927.0	268.15	5.06
0.042	927.4	268.22	5.03
0.044	931.0	268.61	4.90
0.048	941.0	269.85	4.52
0.055	954.3	271.26	4.13
0.060	961.4	272.06	3.92

EXP. NO. 77[illegible] 5.0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1192.4	295.65	1.00
0.005	974.7	272.74	3.52
0.010	959.[illegible]	271.87	3.97
0.015	949.1	270.85	4.23
0.020	943.[illegible]	270.17	4.43
0.025	937.4	269.55	4.61
0.030	933.1	269.04	4.77
0.035	929.4	268.61	4.90
0.038	92[illegible]	268.51	4.94
0.042	92[illegible]	268.54	4.92
0.045	923.[illegible]	268.45	4.95
0.048	924.[illegible]	268.31	5.00
0.051	924.5	268.29	5.01
0.054	927.[illegible]	268.40	4.97
0.057	931.1	268.91	4.84
0.060	936.[illegible]	269.27	4.66
0.065	949.5	270.70	4.25
0.070	957.9	271.95	3.97

EXP. NO. 774 3.0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.[illegible]	295.65	1.00
0.005	975.5	272.69	3.53
0.010	961.1	272.07	3.92
0.015	953.1	271.17	4.15
0.020	944.6	270.20	4.42
0.025	940.[illegible]	269.63	4.57
0.030	934.6	269.06	4.76
0.034	931.1	268.66	4.89
0.037	930.[illegible]	268.54	4.93
0.040	930.[illegible]	268.54	4.93
0.043	931.1	268.66	4.89
0.046	929.7	268.62	4.90
0.049	932.1	268.55	4.92
0.051	929.2	268.44	4.96
0.054	929.4	268.58	4.91
0.058	935.2	269.13	4.74
0.062	948.7	270.67	4.29
0.070	964.[illegible]	272.39	3.83

EXP. NO. 7[illegible]2 12,4 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.7	295.65	1.00
0.005	968.6	272.04	3.7[illegible]
0.010	956.6	271.[illegible]	4.04
0.015	947.7	270.59	4.31
0.020	940.9	269.[illegible]	4.53
0.025	935.[illegible]	269.24	4.7[illegible]
0.030	931.[illegible]	268.70	4.97
0.035	927.0	268.22	5.03
0.039	925.4	268.15	5.05
0.042	927.[illegible]	268.29	5.01
0.047	926.7	268.19	5.04
0.051	924.0	267.99	5.11
0.055	925.5	268.05	5.09
0.060	927.3	268.25	5.02

0.085	927.2	268.22	5.03
0.090	926.2	268.07	5.07
0.095	927.0	268.22	5.03
0.100	929.2	268.27	4.99
0.105	934.7	268.41	4.97
0.110	936.2	269.61	4.59
0.115	953.5	271.24	4.13
0.120	962.2	272.22	3.99

EXP. NO. 784 32.0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1125.7	295.65	1.00
0.005	967.5	272.72	3.75
0.010	956.7	271.61	4.06
0.015	946.0	270.53	4.32
0.020	941.2	269.75	4.55
0.025	934.2	269.18	4.72
0.030	931.3	268.42	4.90
0.035	926.6	268.08	5.08
0.040	923.0	267.67	5.22
0.045	921.4	267.49	5.29
0.050	920.9	267.41	5.31
0.054	919.9	267.19	5.39
0.060	918.5	267.15	5.40
0.062	919.0	267.31	5.34
0.066	920.4	267.37	5.32
0.070	920.1	267.33	5.34
0.075	919.5	267.26	5.36
0.080	920.5	267.39	5.32
0.085	921.3	267.47	5.29
0.090	920.5	267.32	5.32
0.095	920.7	267.40	5.31
0.100	921.5	267.49	5.28
0.105	925.0	267.90	5.14
0.110	935.4	269.09	4.75
0.115	949.1	270.53	4.32
0.120	958.0	271.65	4.02
0.125	966.2	272.64	3.77

EXP. NO. 789 16.5 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1124.6	295.65	1.00
0.005	968.4	272.02	3.71
0.010	958.2	271.78	3.99
0.015	949.7	270.92	4.24
0.020	942.0	270.05	4.46
0.025	936.2	269.35	4.67
0.030	931.7	268.77	4.85
0.035	927.9	268.23	4.99
0.040	927.7	268.21	5.00
0.045	927.9	268.32	5.00
0.050	925.4	268.04	5.09
0.055	925.6	268.07	5.08
0.060	927.1	268.24	5.02
0.065	926.3	268.20	5.04
0.070	925.6	268.07	5.08
0.075	927.2	268.25	5.02
0.080	927.0	268.33	4.99
0.085	927.0	268.23	5.03
0.090	927.1	268.24	5.03

0.095	929.2	269.36	4.99
0.100	929.0	269.14	4.99
0.105	927.2	268.24	5.02
0.110	927.2	268.24	5.02
0.115	928.8	268.70	4.97
0.120	929.3	268.77	4.93
0.125	929.4	268.30	4.90
0.130	929.0	268.44	4.96
0.135	929.1	268.47	4.95
0.140	932.8	268.51	4.93
0.145	935.4	269.10	4.72
0.150	940.6	270.20	4.25
0.155	951.4	272.14	3.90

EXP. NO. 782 8.1 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1124.3	295.65	1.00
0.005	974.4	272.62	3.55
0.010	954.0	271.42	4.03
0.015	945.6	270.30	4.27
0.020	939.2	269.65	4.59
0.025	932.2	268.97	4.79
0.030	926.7	268.45	4.95
0.032	927.1	268.27	5.02
0.036	927.0	269.26	4.99
0.039	928.2	269.30	4.97
0.042	929.1	269.28	4.93
0.045	926.7	268.22	5.03
0.048	926.2	268.16	5.05
0.051	927.1	268.27	5.02
0.055	931.4	269.79	4.85
0.060	942.4	270.01	4.47
0.065	955.2	271.52	4.06

EXP. NO. 794 14.0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1135.3	295.65	1.00
0.005	974.2	273.52	3.57
0.010	964.0	272.27	3.94
0.015	955.5	270.95	4.24
0.020	945.0	270.31	4.32
0.025	937.7	269.30	4.65
0.030	933.0	269.06	4.70
0.035	929.3	268.43	4.95
0.040	925.2	267.97	5.12
0.043	921.5	267.53	5.27
0.047	920.6	267.43	5.30
0.051	921.5	267.53	5.27
0.055	925.1	268.06	5.09
0.060	943.4	269.70	4.56
0.065	952.0	271.01	4.19
0.070	963.5	272.31	3.86

EXP. NO. 7[illegible]7 34.8 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.7	295.65	1.00
0.005	979.2	273.03	3.69
0.010	960.6	271.83	3.93
0.015	947.0	270.51	4.33
0.020	933.1	269.51	4.62
0.025	930.0	269.26	4.70
0.030	926.7	268.03	5.07
0.035	921.5	267.50	5.28
0.040	916.3	266.35	5.47
0.043	913.0	265.50	5.60
0.045	913.0	265.51	5.64
0.047	913.4	265.56	5.62
0.050	919.5	267.26	5.36
0.055	932.0	268.79	4.84
0.060	942.0	269.94	4.52
0.065	951.2	270.80	4.23
0.070	961.1	272.20	3.93

EXP. NO. 8[illegible]4 29.2 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.2	295.65	1.00
0.005	972.2	273.41	3.65
0.010	965.9	272.50	3.79
0.015	957.5	271.60	4.01
0.020	953.4	271.17	4.14
0.025	949.4	270.44	4.29
0.030	943.5	270.04	4.44
0.035	938.6	269.50	4.62
0.040	934.0	269.00	4.79
0.045	929.1	268.41	4.97
0.050	924.9	267.92	5.13
0.055	920.4	267.41	5.31
0.060	916.1	266.92	5.49
0.062	914.1	266.60	5.57
0.065	913.0	266.66	5.58
0.067	914.2	266.60	5.57
0.070	917.7	267.10	5.42
0.075	929.3	268.44	4.96
0.080	941.2	269.90	4.54
0.085	952.5	271.08	4.17
0.090	962.5	272.22	3.85

EXP. NO. 7[illegible]0 27.0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.8	295.65	1.00
0.005	975.0	273.55	3.56
0.010	966.7	272.62	3.78
0.015	956.0	271.42	4.08
0.020	945.1	270.19	4.42
0.025	934.8	269.24	4.70
0.030	930.1	268.49	4.85
0.035	924.0	267.87	5.15
0.040	920.1	267.22	5.34
0.043	917.0	266.97	5.47
0.045	916.6	266.92	5.49
0.048	917.1	266.98	5.46
0.051	918.2	267.10	5.42
0.055	922.0	267.64	5.23
0.060	935.0	269.14	4.74
0.065	946.6	270.26	4.37
0.070	959.4	271.60	4.01

EXP. NO. 8[illegible]7 59. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.2	295.65	1.00
0.005	972.0	273.36	3.61
0.010	964.2	272.46	3.82
0.015	958.0	271.69	4.01
0.020	952.5	271.07	4.17
0.025	947.2	270.47	4.34
0.030	941.7	269.85	4.52
0.035	936.6	269.24	4.70
0.040	932.1	268.75	4.86
0.045	927.6	268.23	5.03
0.050	922.5	267.75	5.19
0.055	919.0	267.24	5.37
0.060	913.8	266.64	5.59
0.062	911.3	266.23	5.74
0.064	909.1	265.93	5.84
0.068	907.0	265.94	5.86
0.070	909.0	266.06	5.81
0.073	915.8	266.87	5.50
0.076	923.8	267.79	5.19
0.080	932.6	268.90	4.94
0.085	941.0	269.87	4.51
0.090	951.2	270.93	4.21
0.095	962.4	272.19	3.89

EXP. NO. 8[illegible]2 21.7 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.8	295.65	1.00
0.005	974.0	273.44	3.59
0.010	952.0	270.97	4.29
0.015	942.0	269.94	4.49
0.020	935.3	269.07	4.76
0.025	930.4	268.51	4.94
0.030	925.3	267.99	5.11
0.035	921.5	267.49	5.29
0.038	920.3	267.35	5.33
0.041	920.4	267.36	5.33
0.044	920.7	267.39	5.31
0.047	920.5	267.37	5.32
0.050	921.3	267.46	5.29
0.055	929.4	268.39	4.97
0.060	943.7	270.03	4.47
0.065	954.5	271.25	4.13
0.070	963.4	272.25	3.87

EXP. NO. 8[illegible]9 118. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.1	295.65	1.00
0.005	972.9	273.47	3.58
0.010	964.4	272.54	3.80
0.015	957.2	271.71	4.01
0.020	951.0	271.11	4.16
0.025	946.7	270.52	4.33
0.030	941.3	269.91	4.50

0.035	936.6	269.27	4.66
0.040	[illegible]	268.26	4.93
0.045	927.4	268.32	5.00
0.050	923.3	267.95	5.16
0.055	919.0	267.34	5.33
0.060	914.0	266.77	5.54
0.065	909.2	266.21	5.75
0.068	906.2	265.87	5.89
0.071	905.1	265.73	5.94
0.073	906.6	265.91	5.87
0.076	911.4	266.47	5.65
0.080	924.3	265.44	5.28
0.085	932.4	268.01	4.81
0.090	941.2	269.90	4.51
0.095	952.4	271.17	4.15
0.100	961.5	272.19	3.83

[illegible]	914.[illegible]	265.[illegible]	5.94
0.085	[illegible]	26[illegible].76	5.83
[illegible]	911.1	26[illegible].[illegible]7	5.69
0.092	922.7	267.93	5.16
0.095	931.[illegible]	268.67	4.39
0.100	940.[illegible]	269.70	4.54
0.105	940.8	270.21	4.25
0.110	96[illegible].1	271.07	3.94

EXP. NO. 212 28.2 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1134.5	295.65	1.00
0.005	971.2	273.25	3.63
0.010	962.2	272.25	3.87
0.015	956.6	271.54	4.05
0.020	951.2	271.01	4.19
0.025	946.2	270.42	4.35
0.030	942.0	270.07	4.46
0.035	938.5	269.21	4.71
0.040	930.0	268.67	4.88
0.045	924.2	268.14	5.06
0.050	921.3	267.64	5.23
0.055	917.5	267.14	5.41
0.058	914.1	266.75	5.55
0.062	913.0	266.62	5.60
0.065	913.8	266.71	5.56
0.069	915.7	266.93	5.48
0.074	922.0	267.66	5.22
0.080	927.3	269.42	4.65
0.085	943.[illegible]	270.63	4.29
[illegible]	956.5	271.59	4.04

EXP. NO. 214 263. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1134.8	295.65	1.00
0.005	971.2	273.22	3.64
0.010	962.2	272.21	3.88
0.015	956.1	271.52	4.05
0.020	951.3	270.98	4.20
0.025	946.3	270.41	4.35
0.030	940.7	269.78	4.54
0.035	936.0	269.24	4.70
0.040	931.3	268.70	4.87
0.045	926.9	268.20	5.04
0.050	922.6	267.72	5.21
0.055	918.2	267.19	5.39
0.060	913.1	266.60	5.60
0.065	908.7	266.09	5.80
0.070	905.1	265.67	5.97
0.073	903.9	265.53	6.02
0.076	904.1	265.55	6.01
0.079	904.9	265.65	5.98

EXP. NO. 217 30. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.[illegible]	295.65	1.00
0.005	973.7	273.49	3.58
0.010	966.4	272.64	3.77
0.015	960.1	271.96	3.94
0.020	955.6	271.39	4.09
0.025	949.8	270.72	4.25
0.030	944.9	270.23	4.41
0.035	939.6	269.61	4.59
0.040	934.0	269.10	4.75
0.045	930.4	268.60	4.90
0.050	926.1	268.00	5.08
0.055	921.9	267.59	5.25
0.060	919.0	267.15	5.40
0.063	914.5	266.98	5.44
0.066	917.0	267.04	5.44
0.070	917.3	267.07	5.43
0.073	916.2	266.84	5.49
0.076	915.8	266.90	5.49
0.080	916.7	267.00	5.46
0.085	921.7	267.55	5.25
0.090	934.2	269.02	4.77
0.095	945.1	270.24	4.40
0.100	955.7	271.44	4.07

EXP. NO. 21[illegible] 53. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.6	295.65	1.00
0.005	972.7	273.31	3.52
0.010	964.0	272.44	3.77
0.015	958.7	271.74	4.00
0.020	953.2	271.12	4.16
0.025	947.1	270.55	4.32
0.030	943.3	270.00	4.48
0.035	938.7	269.45	4.63
0.040	933.7	268.91	4.81
0.045	929.1	268.38	4.98
0.050	926.5	267.84	5.12
0.055	[illegible]	267.42	5.30
0.060	916.5	266.93	5.48
0.063	914.0	266.64	5.59
0.066	913.5	266.50	5.61
0.070	914.2	266.66	5.55
0.074	913.2	266.54	5.63
0.078	912.8	266.50	5.64
0.082	912.0	266.52	5.64
0.086	914.1	266.65	5.59
0.090	914.5	266.69	5.57
0.095	913.9	266.62	5.60
0.100	914.1	266.65	5.59

0.100	915.3	267.25	5.37
0.105	931.2	268.64	4.88
0.110	944.4	270.12	4.44
0.115	953.4	271.14	4.16
0.120	964.1	272.35	3.85

EXP. NO. 922 31. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.1	295.65	1.00
0.005	971.9	273.25	3.61
0.010	965.8	272.69	3.77
0.015	960.1	272.04	3.92
0.020	954.7	271.43	4.08
0.025	947.6	270.85	4.23
0.030	945.0	270.33	4.38
0.035	941.2	269.90	4.54
0.040	935.2	269.21	4.71
0.045	930.2	268.61	4.90
0.050	925.4	268.09	5.08
0.055	921.5	267.64	5.23
0.060	917.9	267.22	5.38
0.065	917.3	267.15	5.40
0.070	918.0	267.23	5.37
0.075	916.7	267.11	5.42
0.080	917.3	267.15	5.40
0.085	919.5	267.29	5.35
0.090	919.5	267.29	5.35
0.095	917.1	267.24	5.37
0.100	919.0	267.35	5.33
0.105	919.4	267.39	5.31
0.110	919.0	267.35	5.33
0.115	919.4	267.39	5.31
0.120	919.9	267.44	5.30
0.125	922.4	267.74	5.19
0.130	932.4	268.87	4.91
0.135	944.4	270.26	4.40
0.140	954.3	271.38	4.09

EXP. NO. 924 52. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.4	295.65	1.00
0.005	972.6	273.52	3.57
0.010	967.6	272.85	3.72
0.015	960.7	272.08	3.91
0.020	956.6	271.62	4.03
0.025	950.2	270.90	4.22
0.030	948.8	270.73	4.27
0.035	940.0	269.73	4.55
0.040	935.0	269.16	4.73
0.045	930.0	268.60	4.91
0.050	926.5	268.19	5.04
0.055	922.1	267.68	5.21
0.060	917.6	267.16	5.40
0.065	913.6	266.70	5.57
0.070	913.5	266.69	5.57
0.075	913.6	266.70	5.57
0.080	912.9	266.62	5.60
0.085	913.7	266.71	5.56
0.090	914.6	266.81	5.53
0.095	914.3	266.78	5.54
0.100	914.4	266.79	5.53
0.105	915.3	266.8[illegible]	5.5[illegible]
0.110	915.4	266.91	5.49
0.115	915.4	266.91	5.49
0.120	915.4	266.91	5.49
0.125	916.1	266.99	5.45
0.130	916.2	267.00	5.44
0.135	916.1	266.99	5.46
0.140	916.4	267.02	5.45
0.145	919.2	267.34	5.33
0.150	929.6	268.54	4.92
0.155	942.7	270.04	4.46
0.160	953.5	271.26	4.12

EXP. NO. 927 26. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.1	295.65	1.00
0.005	965.6	272.57	3.79
0.010	960.2	271.96	3.94
0.015	953.3	271.19	4.15
0.020	949.3	270.73	4.27
0.025	945.7	270.32	4.38
0.030	942.1	269.91	4.50
0.035	936.0	269.21	4.71
0.040	932.2	268.79	4.84
0.045	927.3	268.22	5.03
0.050	924.5	267.90	5.14
0.055	921.3	267.53	5.27
0.060	921.2	267.53	5.27
0.065	922.1	267.62	5.24
0.070	921.3	267.53	5.27
0.075	921.9	267.59	5.25
0.080	922.9	267.70	5.21
0.085	922.9	267.70	5.21
0.090	922.1	267.62	5.24
0.095	923.0	267.72	5.20
0.100	923.9	267.82	5.16
0.105	923.0	267.72	5.20
0.110	922.7	267.69	5.21
0.115	923.8	267.81	5.17
0.120	924.4	267.89	5.14
0.125	923.8	267.81	5.17
0.130	923.8	267.81	5.17
0.135	924.3	267.92	5.13
0.140	924.7	267.92	5.13
0.145	924.4	267.88	5.15
0.150	924.6	267.90	5.14
0.155	925.5	268.01	5.10
0.160	925.2	267.97	5.11
0.165	926.4	268.11	5.07
0.170	933.2	268.89	4.81
0.175	953.8	271.23	4.13

EXP. NO. 517 4.2 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1172.9	295.65	1.00
0.004	951.4	271.44	4.08
0.012	944.6	270.67	4.29
0.020	935.9	269.68	4.57
0.028	931.9	269.22	4.71

0.036	934.5	269.51	4.62
0.044	931.8	269.22	4.71
0.052	932.7	269.31	4.68
0.060	935.5	269.57	4.60
0.068	933.6	269.39	4.66
0.076	934.4	269.50	4.62
0.084	935.3	269.60	4.59
0.092	933.0	269.44	4.64
0.100	935.8	269.46	4.53
0.108	935.0	269.67	4.57
0.116	935.1	269.58	4.60
0.124	936.8	269.78	4.54
0.132	936.0	269.79	4.54
0.140	946.0	270.03	4.21

0.065	926.7	268.74	4.86
0.070	925.3	268.60	4.91
0.075	925.9	268.64	4.90
0.080	926.0	268.77	4.85
0.085	926.5	268.77	4.85
0.090	926.4	268.71	4.87
0.095	926.7	268.74	4.86
0.100	927.2	268.80	4.84
0.105	927.1	268.70	4.85
0.110	926.7	268.74	4.86
0.115	927.1	268.78	4.85
0.120	927.0	268.88	4.82
0.125	929.3	269.03	4.80
0.130	929.7	269.07	4.79
0.135	927.4	268.92	4.83
0.140	927.8	268.97	4.82
0.145	929.4	269.06	4.79
0.150	929.6	268.96	4.79
0.155	928.5	269.05	4.79
0.160	929.2	269.03	4.77
0.165	929.6	269.06	4.79
0.170	930.1	269.12	4.77
0.175	928.9	269.05	4.79
0.180	929.5	269.06	4.76
0.185	929.5	269.05	4.79
0.190	930.0	269.01	4.78
0.195	930.1	269.13	4.74
0.200	930.0	269.12	4.74
0.205	930.8	269.21	4.71
0.210	934.4	269.63	4.59
0.215	946.3	270.08	4.20

EXP. NO. 519 4.0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1179.2	295.65	1.00
0.005	951.4	271.50	4.06
0.010	945.3	270.91	4.25
0.015	940.2	270.23	4.41
0.020	935.2	269.74	4.55
0.025	933.0	269.51	4.62
0.030	935.8	269.73	4.56
0.035	936.2	269.78	4.54
0.040	934.6	269.59	4.60
0.045	935.0	269.63	4.59
0.050	936.8	269.84	4.52
0.055	937.3	269.90	4.51
0.060	936.2	269.77	4.54
0.065	936.5	269.81	4.53
0.070	937.4	269.91	4.50
0.075	937.9	269.97	4.49
0.080	937.7	269.94	4.49
0.085	936.7	269.83	4.53
0.090	937.3	269.90	4.51
0.095	937.8	269.95	4.49
0.100	938.2	270.00	4.48
0.105	937.3	269.90	4.51
0.110	937.4	269.91	4.50
0.115	938.4	270.02	4.47
0.120	938.2	270.01	4.47
0.125	937.7	269.94	4.49
0.130	943.3	270.53	4.31

EXP. NO. 522 21. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1173.5	295.65	1.00
0.005	951.4	271.57	4.04
0.010	946.1	270.97	4.20
0.015	940.8	270.36	4.37
0.020	935.7	269.78	4.54
0.025	931.3	269.27	4.69
0.030	927.4	268.83	4.83
0.035	924.8	268.53	4.93
0.040	926.0	268.65	4.89
0.045	924.6	268.50	4.94
0.050	924.6	268.50	4.94
0.055	924.8	268.53	4.93
0.060	925.8	268.64	4.89

EXP. NO. 524 31. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1173.2	295.65	1.00
0.005	951.4	271.50	4.06
0.010	945.0	270.90	4.23
0.015	940.4	270.25	4.40
0.020	935.8	269.73	4.56
0.025	931.1	269.19	4.72
0.030	926.0	268.70	4.87
0.035	925.3	268.52	4.93
0.040	926.5	268.66	4.89
0.045	925.4	268.55	4.92
0.050	925.4	268.52	4.93
0.055	925.4	268.53	4.93
0.060	927.0	268.72	4.87
0.065	927.1	268.72	4.87
0.070	925.5	268.54	4.92
0.075	925.5	268.54	4.92
0.080	927.6	268.79	4.85
0.085	927.2	268.74	4.86
0.090	926.4	268.65	4.89
0.095	927.0	268.71	4.87
0.100	[illegible]	268.93	4.83
0.105	927.0	268.92	4.84
0.110	927.2	268.74	4.86
0.115	927.6	268.79	4.85
0.120	928.1	268.84	4.83
0.125	927.9	268.82	4.84
0.130	928.3	268.86	4.82
0.135	927.9	268.81	4.84
0.140	929.1	268.94	4.83
0.145	929.9	269.05	4.76
0.150	928.2	268.85	4.83
0.155	928.1	268.84	4.83

0.160	930.4	269.00	4.78
0.165	930.7	269.02	4.77
0.170	930.0	268.94	4.80
0.175	933.2	269.07	4.73
0.180	930.1	269.07	4.76
0.185	933.0	269.06	4.76
0.190	929.0	269.05	4.76
0.195	930.1	269.07	4.76
0.200	937.6	269.13	4.74
0.205	926.7	268.68	4.83
0.210	936.0	269.75	4.55

0.050	930.5	269.09	4.72
0.055	932.2	269.04	4.77
0.060	931.0	269.01	4.78
0.065	931.0	269.06	4.78
0.070	931.8	269.00	4.78
0.075	932.1	269.14	4.73
0.080	932.0	269.10	4.72
0.085	932.0	269.13	4.74
0.090	932.6	269.10	4.75
0.095	933.2	269.17	4.73
0.100	934.0	269.25	4.70
0.105	933.4	269.22	4.72
0.110	932.1	269.14	4.73
0.115	932.5	269.19	4.72
0.120	934.6	269.31	4.68
0.125	933.0	269.22	4.71
0.130	933.7	269.21	4.71
0.135	939.4	269.86	4.52

EXP. NO. 527 0,3 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1191.2	295.65	1.00
0.005	951.4	271.22	4.11
0.010	947.2	270.85	4.24
0.015	941.9	270.23	4.41
0.020	937.2	269.71	4.56
0.022	935.4	269.50	4.62
0.024	934.1	269.35	4.67
0.025	933.9	269.33	4.68
0.026	933.6	269.29	4.69
0.028	937.8	269.77	4.54
0.030	941.4	270.19	4.42
0.032	945.9	270.70	4.28

EXP. NO. 5[illegible] 48, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1180.4	295.65	1.00
0.005	951.4	271.30	4.10
0.010	946.7	270.96	4.23
0.015	942.2	270.35	4.37
0.020	937.5	269.71	4.53
0.025	932.7	269.26	4.70
0.030	927.5	268.66	4.89
0.035	922.6	268.10	5.07
0.040	920.0	267.80	5.17
0.045	920.6	267.87	5.15
0.050	919.7	267.76	5.19
0.055	918.7	267.65	5.23
0.060	919.5	267.74	5.19
0.065	920.6	267.87	5.15
0.070	920.7	267.88	5.15
0.075	919.7	267.74	5.19
0.080	920.6	267.87	5.15
0.085	921.7	267.99	5.11
0.090	921.3	267.95	5.12
0.095	920.6	267.87	5.15
0.100	921.6	267.98	5.11
0.105	922.3	268.06	5.08
0.110	921.4	267.96	5.12
0.115	920.8	267.89	5.14
0.120	922.0	268.03	5.10
0.125	922.7	268.11	5.07
0.130	922.5	268.09	5.08
0.135	926.7	268.57	4.92
0.140	942.0	270.32	4.38

EXP. NO. 529 5,7 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1131.0	295.65	1.00
0.005	951.4	271.34	4.10
0.010	946.9	270.92	4.24
0.015	942.0	270.27	4.40
0.020	936.9	269.69	4.57
0.025	932.4	269.17	4.72
0.028	930.1	268.91	4.81
0.030	928.7	268.75	4.85
0.032	929.1	268.79	4.84
0.034	932.4	269.17	4.72
0.036	935.0	269.47	4.63
0.038	940.7	270.12	4.44

EXP. NO. 534 7,8 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1192.2	295.65	1.00
0.005	951.4	271.23	4.13
0.010	946.7	270.70	4.28
0.015	941.9	270.15	4.43
0.020	937.7	269.67	4.57
0.025	933.2	269.16	4.73
0.030	930.9	268.89	4.81
0.035	932.2	269.04	4.77
0.040	931.8	269.00	4.78
0.045	930.0	268.79	4.85

EXP. NO. 542 12,2 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1175.5	295.65	1.00
0.005	951.4	271.81	3.98
0.010	947.7	271.30	4.09
0.015	943.0	270.95	4.21
0.020	939.2	270.42	4.36
0.025	934.9	269.92	4.50
0.030	929.2	269.27	4.69

0.035	926.2	269.02	4.90
0.040	925.0	269.00	4.91
0.045	926.0	269.00	4.91
0.050	924.4	268.72	4.97
0.055	925.5	268.34	4.33
0.060	927.1	269.03	4.77
0.065	927.2	269.04	4.77
0.070	926.3	268.93	4.80
0.075	926.2	269.03	4.80
0.080	927.7	269.10	4.75
0.085	927.9	269.11	4.74
0.090	926.5	269.06	4.79
0.095	927.0	269.02	4.77
0.100	928.1	269.14	4.73
0.105	928.2	269.15	4.73
0.110	927.1	269.03	4.77
0.115	927.9	269.11	4.74
0.120	929.7	269.21	4.71
0.125	929.7	269.21	4.71
0.130	928.1	269.14	4.73
0.135	928.4	269.20	4.72
0.140	924.5	269.98	4.51
0.145	944.2	271.00	4.19
0.200	927.9	269.10	4.75
0.205	928.4	269.16	4.73
0.210	928.2	269.13	4.74
0.215	928.3	269.14	4.73
0.220	927.7	269.07	4.76

EXP. NO. 544 18. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1176.1	295.65	1.00
0.005	951.4	271.70	3.99
0.010	947.2	271.22	4.11
0.015	942.5	270.78	4.26
0.020	937.7	270.23	4.41
0.025	933.2	269.71	4.55
0.030	929.9	269.21	4.71
0.035	924.3	268.69	4.88
0.040	922.7	268.50	4.94
0.045	922.0	268.44	4.99
0.050	922.7	268.50	4.94
0.055	922.0	268.42	4.96
0.060	922.9	268.63	4.90
0.065	924.5	268.71	4.87
0.070	923.3	268.57	4.92
0.075	923.4	268.58	4.91
0.080	924.7	268.73	4.86
0.085	924.6	268.72	4.87
0.090	924.2	268.68	4.88
0.095	924.0	268.65	4.89
0.100	925.1	268.78	4.85
0.105	925.5	268.82	4.83
0.110	925.3	268.80	4.84
0.115	925.0	268.77	4.85
0.120	925.9	268.87	4.82
0.125	926.2	268.90	4.81
0.130	925.4	268.81	4.84
0.135	925.2	268.79	4.85
0.140	926.1	268.89	4.81
0.145	925.9	268.86	4.82
0.150	925.7	268.85	4.83
0.155	926.2	268.90	4.81
0.160	927.0	268.99	4.78
0.165	927.0	268.99	4.78
0.170	927.0	268.99	4.78
0.175	926.9	268.98	4.78
0.180	927.0	268.99	4.78
0.185	927.4	269.04	4.77
0.190	927.3	269.03	4.77
0.195	927.1	269.01	4.78

EXP. NO. 547 20.7 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1177.9	295.65	1.00
0.005	951.4	271.62	4.03
0.010	946.1	271.02	4.19
0.015	941.4	270.49	4.34
0.020	936.8	269.97	4.49
0.025	932.6	269.48	4.63
0.030	928.1	269.06	4.79
0.035	924.2	268.51	4.94
0.040	924.1	268.50	4.94
0.045	924.3	268.52	4.93
0.050	921.5	268.20	5.04
0.055	921.7	268.22	5.03
0.060	924.4	268.53	4.93
0.065	924.6	268.56	4.92
0.070	922.4	268.32	5.00
0.075	922.9	268.36	4.98
0.080	924.9	268.59	4.91
0.085	925.2	268.62	4.90
0.090	923.9	268.47	4.95
0.095	923.8	268.46	4.95
0.100	925.0	268.60	4.91
0.105	925.9	268.60	4.88
0.110	924.6	268.55	4.92
0.115	924.6	268.55	4.92
0.120	925.4	268.65	4.89
0.125	926.3	268.75	4.86
0.130	925.4	268.65	4.89
0.135	925.6	268.67	4.88
0.140	926.6	268.78	4.85
0.145	926.9	268.82	4.84
0.150	926.6	268.78	4.85
0.155	926.0	268.72	4.87
0.160	927.0	268.83	4.83
0.165	927.4	268.88	4.82
0.170	927.0	268.83	4.83
0.175	927.0	268.83	4.83
0.180	927.4	268.88	4.82
0.185	929.1	269.06	4.79
0.190	927.8	268.92	4.80
0.195	927.1	268.84	4.83
0.200	927.7	269.01	4.81
0.205	929.6	269.01	4.77
0.210	928.1	268.96	4.79
0.215	929.0	269.06	4.76
0.220	939.4	270.25	4.40

EXP. NO. 549 29. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1177.7	295.65	1.00
0.005	951.4	271.44	4.02
0.010	945.6	270.98	4.20
0.015	941.4	270.50	4.33

[illegible]	034.6	269.06	4.49
[illegible]	032.0	269.43	4.65
[illegible]	027.7	268.93	4.80
[illegible]	022.0	268.38	4.99
[illegible]	019.2	267.95	5.12
[illegible]	017.8	267.70	5.18
[illegible]	016.6	267.68	5.21
[illegible]	017.2	267.72	5.22
[illegible]	017.5	267.90	5.17
[illegible]	019.4	268.00	5.11
[illegible]	024.7	268.59	4.91
[illegible]	032.2	270.14	4.44

EXP. NO. 562 23.4 DROPS/CC

TIME	PRESS	TEMP	SUPP
	1174.7	295.65	1.00
0.005	051.4	271.73	4.00
0.010	046.7	271.23	4.14
0.015	041.5	270.65	4.29
0.020	035.0	270.08	4.45
0.025	031.4	269.45	4.64
0.030	026.5	268.93	4.80
0.035	022.0	268.47	4.95
0.040	019.4	267.95	5.12
0.045	016.2	267.71	5.21
0.050	015.5	267.61	5.24
0.055	015.1	267.57	5.25
0.060	015.4	267.64	5.24
0.065	017.0	267.76	5.19
0.070	023.7	268.56	4.92
0.075	035.0	269.64	4.49
0.080	044.2	270.92	4.21

EXP. NO. 563 33.7 DROPS/CC

TIME	PRESS	TEMP	SUPP
	1197.2	295.65	1.00
0.005	051.4	270.79	4.26
0.010	047.0	270.38	4.37
0.015	042.6	269.78	4.54
0.020	038.7	269.25	4.70
0.025	033.6	268.74	4.86
0.030	029.0	268.22	5.03
0.035	024.0	267.75	5.19
0.040	024.7	267.73	5.20
0.045	024.7	267.72	5.20
0.050	021.3	267.40	5.31
0.055	022.2	267.44	5.30
0.060	024.4	267.60	5.21
0.065	025.2	267.72	5.18
0.070	023.4	267.53	5.25
0.075	023.3	267.57	5.25
0.080	025.2	267.90	5.17
0.085	025.6	267.93	5.16
0.090	024.3	267.59	5.21
0.095	024.0	267.65	5.23
0.100	025.7	267.84	5.15
0.105	026.2	267.91	5.14
0.110	025.0	267.76	5.19
0.115	024.7	267.73	5.20
0.120	026.4	267.92	5.13
0.125	026.6	267.95	5.12
0.130	026.3	267.91	5.14
0.135	027.1	268.00	5.10
0.140	030.9	268.43	4.96
0.145	043.0	269.82	4.53

EXP. NO. 564 47. DROPS/CC

TIME	PRESS	TEMP	SUPP
	1126.3	295.65	1.00
0.005	051.4	270.86	4.23
0.010	046.9	270.34	4.39
0.015	041.9	269.78	4.54
0.020	037.3	269.25	4.70
0.025	032.7	268.73	4.86
0.030	028.4	268.24	5.03
0.035	023.0	267.72	5.20
0.040	020.1	267.28	5.36
0.045	020.1	267.28	5.36
0.050	019.7	267.23	5.37
0.055	019.6	267.22	5.38
0.060	017.7	267.00	5.46
0.065	019.2	267.17	5.39
0.070	019.5	267.21	5.39
0.075	018.4	267.08	5.43
0.080	018.5	267.09	5.42
0.085	020.3	267.30	5.35
0.090	020.1	267.28	5.36
0.095	018.9	267.13	5.41
0.100	019.7	267.23	5.37
0.105	021.3	267.42	5.31
0.110	020.7	267.35	5.33
0.115	020.2	267.29	5.35
0.120	020.8	267.36	5.33
0.125	021.6	267.45	5.30
0.130	021.4	267.43	5.30
0.135	021.4	267.43	5.30
0.140	017.3	267.01	5.45
0.145	023.6	267.68	5.21

EXP. NO. 567 61.5 DROPS/CC

TIME	PRESS	TEMP	SUPP
	1154.4	295.65	1.00
0.005	051.4	270.95	4.24
0.010	049.0	270.46	4.34
0.015	042.0	269.88	4.51
0.020	038.0	269.33	4.68
0.025	033.5	268.81	4.84
0.030	029.0	268.30	5.01
0.035	023.8	267.70	5.21
0.040	019.3	267.18	5.39
0.045	017.6	266.98	5.44
0.050	018.4	267.07	5.43
0.055	017.7	266.99	5.46
0.060	017.6	266.91	5.47
0.065	018.3	267.06	5.43
0.070	019.6	267.21	5.39
0.075	019.0	267.14	5.40
0.080	018.2	267.05	5.44
0.085	019.4	267.19	5.39
0.090	019.4	267.19	5.39

0.095	019.8	267.20	5.38
0.100	019.0	267.12	5.41
0.105	020.0	267.20	5.38
0.110	021.0	267.27	5.32
0.115	020.2	267.20	5.35
0.120	020.2	267.29	5.36
0.125	021.0	267.40	5.29
0.130	021.6	267.44	5.30
0.135	021.4	267.42	5.31
0.140	023.6	267.67	5.22
0.145	028.4	268.03	4.77

EXP. NO. 572 18.0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1197.3	295.65	1.03
0.005	051.4	270.77	4.25
0.010	047.1	270.29	4.39
0.015	041.0	269.69	4.57
0.020	037.9	269.22	4.71
0.025	033.9	269.65	4.89
0.030	023.8	268.13	5.04
0.035	027.3	268.02	5.10
0.040	023.3	268.13	5.06
0.045	026.2	267.90	5.14
0.050	025.5	267.91	5.17
0.055	027.3	268.02	5.12
0.060	019.1	267.07	5.43
0.065	027.1	268.00	5.11
0.070	027.0	267.98	5.11
0.075	027.7	268.06	5.08
0.080	029.1	268.22	5.03
0.085	028.7	268.18	5.04
0.090	027.0	268.00	5.08
0.095	028.3	268.13	5.06
0.100	029.5	268.27	5.01
0.105	029.7	268.29	5.01
0.110	029.0	268.21	5.03
0.115	029.1	268.22	5.03
0.120	030.4	268.37	4.98
0.125	030.9	268.43	4.96
0.130	029.0	268.21	5.03
0.135	029.7	268.29	5.01
0.140	030.9	268.42	4.97
0.145	031.2	268.46	4.95
0.150	030.6	268.39	4.97
0.155	030.7	268.41	4.97
0.160	031.2	268.46	4.95
0.165	031.7	268.52	4.93
0.170	031.5	268.50	4.94
0.175	031.4	268.49	4.94
0.180	031.9	268.54	4.92
0.185	032.5	268.61	4.90
0.190	032.0	268.55	4.92
0.195	032.0	268.55	4.92
0.200	032.7	268.63	4.90
0.205	033.4	268.71	4.87
0.210	033.2	268.69	4.88
0.215	034.5	268.84	4.83

EXP. NO. 574 37. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1197.9	295.65	1.09
0.005	051.4	270.72	4.30
0.010	047.2	270.23	4.47
0.015	042.7	269.50	4.62
0.020	036.5	269.06	4.79
0.025	033.0	268.69	4.93
0.030	026.5	267.96	5.09
0.035	026.4	267.57	5.25
0.040	021.0	267.05	5.36
0.045	022.9	267.27	5.32
0.050	021.0	267.26	5.36
0.055	020.4	267.10	5.42
0.060	021.5	267.02	5.42
0.065	022.6	267.33	5.34
0.070	022.4	267.31	5.34
0.075	021.6	267.22	5.38
0.080	021.9	267.25	5.36
0.085	023.2	267.40	5.31
0.090	023.3	267.41	5.31
0.095	022.5	267.32	5.34
0.100	022.7	267.35	5.33
0.105	023.9	267.47	5.29
0.110	024.4	267.54	5.26
0.115	023.7	267.46	5.29
0.120	023.9	267.49	5.28
0.125	024.7	267.57	5.25
0.130	025.3	267.63	5.23
0.135	024.6	267.54	5.26
0.140	024.6	267.54	5.26
0.145	025.5	267.67	5.22
0.150	025.8	267.70	5.21
0.155	025.8	267.72	5.21
0.160	025.4	267.65	5.22
0.165	026.6	267.79	5.18
0.170	027.0	267.83	5.16
0.175	026.9	267.83	5.16
0.180	026.3	267.76	5.17
0.185	027.1	267.85	5.16
0.190	027.0	267.83	5.13
0.195	027.4	267.89	5.14
0.200	027.9	267.96	5.15
0.205	027.0	267.94	5.13
0.210	029.4	268.00	5.11
0.215	029.4	268.11	5.07
0.220	042.5	269.61	4.59

EXP. NO. 57[illegible] 23.7 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1197.9	295.65	1.09
0.005	051.4	270.72	4.27
0.010	047.1	270.22	4.41
0.015	041.7	269.62	4.59
0.020	036.7	269.05	4.76
0.025	032.4	268.56	4.92
0.030	028.2	268.08	5.09
0.035	023.8	267.57	5.25
0.040	019.0	267.12	5.41
0.042	019.2	267.04	5.44
0.044	019.7	267.12	5.42
0.046	022.9	267.42	5.30
0.050	033.7	268.71	4.87
0.055	045.3	270.03	4.47

EXP. NO. 582 22,0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1186.9	295.65	1.00
0.005	951.4	270.70	4.28
0.010	944.7	270.17	4.43
0.015	941.5	269.59	4.60
0.020	934.6	269.02	4.77
0.025	932.3	268.53	4.93
0.030	928.1	268.05	5.09
0.035	923.9	267.55	5.26
0.038	921.1	267.24	5.37
0.040	920.7	267.20	5.39
0.042	921.6	267.30	5.35
0.045	926.0	267.81	5.17
0.050	932.6	269.36	4.67

EXP. NO. 584 20,2 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1188.6	295.65	1.00
0.005	951.4	270.63	4.30
0.010	945.9	270.00	4.49
0.015	940.5	269.39	4.66
0.020	935.7	268.85	4.83
0.025	931.5	268.37	4.98
0.030	927.5	267.91	5.14
0.035	924.7	267.59	5.25
0.038	925.3	267.65	5.22
0.041	925.6	267.69	5.21
0.044	924.4	267.57	5.25
0.047	923.1	267.40	5.31
0.050	922.1	267.29	5.35
0.055	922.6	267.39	5.32
0.060	924.2	267.53	5.27
0.065	926.1	267.75	5.19
0.070	929.6	268.15	5.06
0.075	945.9	270.01	4.47

EXP. NO. 587 20,0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1187.9	295.65	1.00
0.005	951.4	270.71	4.27
0.010	947.1	270.22	4.41
0.015	942.2	269.67	4.57
0.020	936.7	269.04	4.77
0.025	932.7	268.58	4.91
0.030	928.7	268.13	5.06
0.035	925.6	267.77	5.18
0.040	926.3	267.85	5.16
0.045	925.9	267.79	5.18
0.050	924.2	267.61	5.24
0.055	924.8	267.69	5.22
0.060	926.8	267.91	5.14
0.065	926.8	267.91	5.14
0.070	925.4	267.75	5.19
0.075	926.0	267.81	5.17
0.080	927.5	267.99	5.11
0.085	927.4	267.98	5.11
0.090	926.5	267.87	5.15
0.095	926.9	267.92	5.13
0.100	927.8	268.02	5.10
0.105	929.0	268.17	5.06
0.110	927.4	268.00	5.11
0.115	927.5	268.00	5.11
0.120	928.2	268.14	5.06
0.125	929.1	268.17	5.05
0.130	929.3	268.19	5.03
0.135	930.1	268.29	5.01
0.140	944.1	269.89	4.51

EXP. NO. 592 69, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1189.4	295.65	1.00
0.005	951.4	270.58	4.31
0.010	944.2	269.99	4.43
0.015	940.7	269.36	4.57
0.020	935.9	268.92	4.74
0.025	931.7	268.32	4.99
0.030	927.1	267.81	5.17
0.035	922.0	267.32	5.34
0.040	918.3	266.79	5.53
0.045	913.7	266.26	5.73
0.050	910.1	265.84	5.90
0.055	911.3	265.99	5.84
0.060	911.2	265.97	5.85
0.065	910.1	265.84	5.90
0.070	911.3	265.99	5.84
0.075	912.5	266.12	5.79
0.080	912.1	266.08	5.81
0.085	911.7	266.03	5.82
0.090	912.0	266.17	5.77
0.095	913.3	266.21	5.75
0.100	913.1	266.19	5.76
0.105	913.0	266.19	5.77
0.110	913.8	266.27	5.73
0.115	914.6	266.36	5.69
0.120	914.2	266.32	5.71
0.125	914.1	266.31	5.72
0.130	915.4	266.46	5.66
0.135	916.[illegible]	266.53	5.63
0.140	915.4	266.46	5.66
0.145	918.1	266.77	5.54
0.150	923.7	268.56	4.92
0.155	946.7	270.04	4.46

EXP. NO. 594 44,7 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1189.[illegible]	295.65	1.00
0.005	951.4	270.52	4.33
0.010	945.6	269.88	4.51
0.015	940.5	269.29	4.69
0.020	935.8	268.75	4.86
0.025	931.4	268.25	5.02
0.030	927.0	267.74	5.19
0.035	922.9	267.27	5.36
0.040	918.2	266.73	5.56
0.045	914.9	266.35	5.70
0.050	915.6	266.43	5.67
0.055	915.4	266.41	5.68
0.060	913.6	266.20	5.76

0.065	914.9	267.24	5.71
0.070	914.9	266.57	5.62
0.075	916.1	266.40	5.65
0.080	915.9	266.26	5.73
0.085	916.0	266.47	5.65
0.090	917.4	266.66	5.58
0.095	916.5	266.53	5.63
0.100	916.0	266.47	5.65
0.105	917.5	266.65	5.59
0.110	918.2	266.73	5.56
0.115	917.7	266.67	5.58
0.120	917.5	266.65	5.59
0.125	919.4	266.75	5.55
0.130	919.1	266.83	5.52
0.135	919.9	266.90	5.53
0.140	918.6	266.77	5.54
0.145	921.8	267.14	5.41
0.150	937.4	268.93	4.90

EXP. NO. 587 36.3 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1129.5	295.65	1.00
0.005	951.4	270.57	4.31
0.010	944.1	269.97	4.40
0.015	940.7	269.35	4.67
0.020	935.9	268.81	4.84
0.025	931.3	268.28	5.01
0.030	931.0	268.25	5.02
0.035	922.6	267.29	5.35
0.040	919.0	266.87	5.51
0.045	919.4	266.91	5.49
0.050	920.0	266.98	5.46
0.055	919.2	266.90	5.50
0.060	919.3	266.90	5.49
0.065	920.7	267.06	5.43
0.070	921.2	267.12	5.41
0.075	920.2	267.00	5.46
0.080	920.6	267.05	5.44
0.085	921.9	267.20	5.38
0.090	922.0	267.21	5.38
0.095	921.1	267.11	5.42
0.100	921.4	267.14	5.41
0.105	922.6	267.29	5.36
0.110	922.5	267.29	5.36
0.115	922.3	267.24	5.37
0.120	922.6	267.29	5.36
0.125	923.1	267.34	5.34
0.130	923.9	267.43	5.30
0.135	923.4	267.37	5.32
0.140	923.3	267.36	5.33
0.145	924.2	267.46	5.29
0.150	924.7	267.52	5.27
0.155	924.1	267.45	5.29
0.160	924.1	267.45	5.29
0.165	925.2	267.59	5.25
0.170	925.2	267.59	5.25
0.175	924.9	267.54	5.26
0.180	925.4	267.60	5.24
0.185	926.0	267.67	5.22
0.190	926.1	267.68	5.21
0.195	925.9	267.66	5.22
0.200	926.1	267.68	5.21
0.205	927.0	267.78	5.18
0.210	927.1	267.79	5.18
0.215	927.1	267.79	5.18
0.220	927.2	267.81	5.17
0.225	930.9	268.23	5.03

EXP. NO. 6[illegible] 68.6 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1129.9	295.65	1.00
0.005	951.4	271.42	4.30
0.010	942.9	270.24	4.41
0.015	942.4	269.62	4.60
0.020	937.4	269.05	4.76
0.025	927.1	268.54	4.93
0.030	929.1	268.09	5.08
0.035	924.3	267.53	5.27
0.040	919.2	266.94	5.49
0.045	915.7	266.46	5.66
0.050	910.4	265.92	5.97
0.055	907.5	265.50	6.02
0.060	904.3	265.45	6.06
0.065	907.2	265.55	6.02
0.070	905.7	265.29	6.09
0.075	905.5	265.25	6.10
0.080	907.1	265.54	6.02
0.085	907.9	265.42	5.99
0.090	907.2	265.55	6.02
0.095	907.5	265.59	6.00
0.100	909.3	265.74	5.94
0.105	909.4	265.81	5.91
0.110	909.0	265.76	5.93
0.115	909.5	265.82	5.91
0.120	911.2	266.01	5.83
0.125	911.3	266.02	5.83
0.130	911.1	266.00	5.83
0.135	912.0	266.11	5.79
0.140	912.6	266.20	5.77
0.145	913.3	266.24	5.74
0.150	913.4	266.27	5.73
0.155	914.8	266.43	5.67
0.160	915.4	266.50	5.64
0.165	915.3	266.49	5.65
0.170	915.9	266.56	5.62
0.175	917.0	266.69	5.57
0.180	917.4	266.73	5.56
0.185	917.7	266.77	5.54
0.190	918.5	266.86	5.51
0.195	919.2	266.94	5.49
0.200	919.7	267.00	5.46
0.205	920.0	267.03	5.45
0.210	920.6	267.10	5.42
0.215	921.5	267.20	5.38
0.220	921.1	267.14	5.40
0.225	922.3	267.29	5.35
0.230	923.3	267.41	5.31
0.235	929.1	268.08	5.08
0.240	944.3	269.81	4.53

EXP. NO. 607 98. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1191.3	295.65	1.00
0.005	951.4	270.40	4.36
0.010	944.1	269.60	4.52
0.015	941.5	269.17	4.73
0.020	935.5	268.40	4.91
0.025	931.2	268.11	5.07
0.030	926.7	267.50	5.25
0.035	922.1	267.06	5.43
0.040	917.9	266.57	5.62
0.045	913.9	266.10	5.79
0.050	913.4	266.06	5.81

TIME	PRESS	TEMP	SUPR
0.055	015.0	266.24	5.74
0.060	012.0	265.62	5.86
0.065	011.0	265.00	5.88
0.070	014.1	266.14	5.79
0.075	014.4	266.17	5.77
0.080	013.0	266.03	5.82
0.085	013.2	266.03	5.82
0.090	014.0	266.22	5.75
0.095	014.0	266.25	5.75
0.100	013.4	266.26	5.81
0.105	014.1	266.14	5.79
0.110	015.6	266.20	5.72
0.115	015.7	266.32	5.71
0.120	015.0	266.24	5.74
0.125	014.0	266.13	5.79
0.130	015.0	266.24	5.74
0.135	015.2	266.28	5.73
0.140	014.1	266.14	5.78
0.145	012.0	266.00	5.84
0.150	017.2	266.50	5.64
0.155	023.6	267.81	5.17
0.160	042.0	269.11	4.74

EXP. NO. [illegible] 96. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1191.0	295.65	1.00
0.005	051.4	270.35	4.37
0.010	046.5	269.83	4.53
0.015	041.7	269.25	4.70
0.020	036.7	268.69	4.88
0.025	031.9	268.12	5.06
0.030	027.1	267.59	5.25
0.035	021.7	266.96	5.47
0.040	017.5	266.48	5.65
0.045	013.0	266.06	5.91
0.050	010.3	265.65	5.98
0.053	008.9	265.47	5.95
0.055	000.7	265.46	6.05
0.057	000.2	265.52	6.03
0.060	000.7	265.59	6.01
0.064	000.0	265.60	6.00
0.067	010.9	265.71	5.95
0.070	020.1	266.79	5.54
0.075	032.1	268.15	5.05
0.080	043.4	269.44	4.64

EXP. NO. 612 69. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.9	295.65	1.00
0.005	951.4	273.98	4.20
0.010	945.9	270.36	4.37
0.015	940.7	269.77	4.54
0.020	935.5	269.18	4.72
0.025	930.5	268.60	4.91
0.030	925.5	268.03	5.10
0.035	921.1	267.52	5.27
0.040	916.5	266.99	5.46
0.045	912.3	266.50	5.64
0.050	908.7	266.08	5.80
0.055	905.2	265.68	5.97

TIME	PRESS	TEMP	SUPR
0.058	003.3	265.45	5.26
0.061	000.0	260.77	5.03
0.064	014.1	260.71	5.56
0.070	026.5	259.14	5.06
0.075	031.0	260.62	4.80
0.080	041.0	260.80	4.51

EXP. NO. 414 194. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1196.6	295.65	1.00
0.005	051.4	271.00	4.24
0.010	046.7	270.30	4.30
0.015	040.1	269.55	4.61
0.020	035.0	268.56	4.79
0.025	029.0	268.39	4.98
0.030	024.6	267.77	5.18
0.035	020.2	267.26	5.36
0.040	015.0	266.77	5.54
0.045	011.5	266.26	5.74
0.050	007.0	265.77	5.93
0.055	002.0	265.37	6.09
0.058	000.4	264.06	6.26
0.061	000.5	264.86	6.21
0.064	000.5	264.09	6.26
0.067	004.7	265.47	6.05
0.070	015.4	266.73	5.56
0.075	025.4	267.96	5.15
0.080	036.0	269.09	4.75

EXP. NO. [illegible] 10.8 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1182.8	255.65	1.00
0.005	047.4	263.59	3.99
0.010	061.6	262.05	4.17
0.015	055.5	262.29	4.37
0.020	050.1	261.49	4.56
0.025	045.5	261.19	4.72
0.030	040.1	260.50	4.92
0.035	036.2	260.16	5.08
0.040	031.6	259.65	5.27
0.043	026.2	259.39	5.37
0.045	029.5	259.30	5.42
0.047	030.1	259.48	5.33
0.050	033.0	260.35	5.01
0.055	053.9	262.10	4.43

EXP. NO. 312 7.8 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1182.1	295.65	1.00
0.005	067.4	263.73	3.95
0.010	061.1	263.04	4.15
0.015	055.7	262.45	4.32
0.020	050.0	261.83	4.51
0.025	045.0	261.29	4.69
0.030	039.0	260.72	4.88
0.035	035.5	260.23	5.05
0.040	031.3	259.76	5.22
0.043	029.7	259.58	5.29
0.045	030.5	259.67	5.26
0.050	038.8	260.59	4.92
0.055	053.4	262.20	4.40

EXP. NO. 317 2.9 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1191.3	285.65	1.00
0.005	967.4	263.80	3.93
0.010	959.0	262.99	4.19
0.015	952.0	262.22	4.39
0.020	946.4	261.83	4.51
0.025	944.2	261.26	4.70
0.030	940.1	260.81	4.85
0.035	936.6	260.42	4.98
0.036	936.0	260.35	5.01
0.037	936.4	260.42	4.99
0.040	937.2	260.55	4.94
0.045	955.3	262.49	4.31

EXP. NO. 310 5.6 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1175.3	285.65	1.00
0.005	967.4	263.45	4.03
0.010	961.4	262.81	4.21
0.015	955.8	262.18	4.40
0.020	950.4	261.59	4.59
0.025	945.1	261.01	4.73
0.030	939.4	260.38	5.00
0.035	935.0	259.89	5.17
0.039	932.0	259.62	5.27
0.041	933.4	259.71	5.24
0.045	942.9	260.76	4.86
0.050	958.0	262.42	4.33

EXP. NO. 322 9.5 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1192.0	285.65	1.00
0.005	967.4	262.95	4.17
0.010	961.4	262.30	4.37
0.015	955.2	261.69	4.55
0.020	950.4	261.13	4.75
0.025	944.0	260.50	4.96
0.030	940.0	259.96	5.15
0.035	936.9	259.60	5.29
0.040	937.0	259.72	5.24
0.045	937.8	259.71	5.24
0.050	935.8	259.49	5.32
0.055	935.5	259.46	5.34
0.060	936.2	259.60	5.28
0.065	938.4	259.78	5.22
0.070	937.6	259.69	5.25
0.075	939.3	259.77	5.22
0.080	947.5	260.78	4.86

EXP. NO. 324 24.8 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1191.5	285.65	1.00
0.005	967.4	262.57	4.17
0.010	962.0	262.01	4.36
0.015	956.2	261.68	4.55
0.020	951.0	261.11	4.74
0.025	945.6	260.52	4.95
0.030	940.1	260.03	5.17
0.035	935.7	259.42	5.35
0.040	931.2	259.02	5.54
0.043	930.2	259.00	5.50
0.046	931.3	259.04	5.54
0.050	933.0	259.13	5.47
0.055	932.7	259.10	5.48
0.060	932.1	259.09	5.51
0.065	931.7	259.00	5.52
0.070	932.9	259.11	5.47
0.075	933.7	259.21	5.44
0.080	933.5	259.18	5.44
0.085	933.2	259.15	5.46
0.090	933.4	259.17	5.45
0.095	934.4	259.28	5.41
0.100	934.5	259.30	5.40
0.105	935.7	259.43	5.35
0.110	944.2	260.36	5.00

EXP. NO. 327 7.6 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1190.0	285.65	1.00
0.005	967.4	263.12	4.12
0.010	961.3	262.46	4.32
0.015	955.4	261.91	4.52
0.020	950.0	261.22	4.71
0.025	945.2	260.60	4.89
0.030	939.0	260.11	5.09
0.035	936.0	259.79	5.22
0.040	939.3	260.03	5.16
0.045	937.0	259.90	5.18
0.050	935.8	259.66	5.26
0.055	935.3	259.60	5.29
0.060	936.2	259.70	5.25
0.065	937.6	259.96	5.19
0.070	937.6	259.96	5.19
0.075	937.3	259.91	5.20
0.080	936.9	259.77	5.22
0.085	937.9	259.98	5.19
0.090	938.6	259.97	5.15
0.095	938.5	259.95	5.15
0.100	938.7	259.98	5.14
0.105	948.6	261.07	4.76

EXP. NO. 329 33. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1192.0	285.65	1.00
0.005	967.4	263.17	4.12
0.010	961.9	262.52	4.30
0.015	955.7	261.95	4.51

0.020	952.4	261.27	4.69
0.025	943.5	260.74	4.97
0.030	939.0	260.11	5.09
0.035	935.2	259.59	5.29
0.040	930.4	259.08	5.48
0.045	927.9	258.77	5.61
0.050	923.5	258.96	5.53
0.055	923.0	259.00	5.52
0.060	923.6	258.86	5.57
0.065	928.3	258.83	5.59
0.070	920.4	258.95	5.54
0.075	920.0	259.09	5.49
0.080	920.6	259.03	5.47
0.085	929.1	259.03	5.51
0.090	920.0	259.01	5.51
0.095	920.0	259.10	5.48
0.100	931.4	259.19	5.44
0.105	931.5	259.12	5.45
0.110	931.6	259.19	5.44
0.115	940.2	260.14	5.08
0.120	955.4	261.93	4.51

0.066	915.0	257.45	6.19
0.070	923.6	258.07	5.57
0.075	940.7	259.21	5.04
0.080	947.9	260.96	4.79
0.085	955.1	261.00	4.49

EXP. NO. 332 34, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1193.7	295.65	1.00
0.005	967.4	263.15	4.12
0.010	961.4	262.49	4.31
0.015	955.1	261.81	4.52
0.020	949.3	261.17	4.72
0.025	944.0	260.50	4.92
0.030	939.5	259.88	5.14
0.035	934.0	259.48	5.33
0.040	929.2	259.05	5.54
0.045	924.2	258.40	5.76
0.050	919.0	257.92	6.02
0.055	915.3	257.40	6.20
0.057	914.4	257.30	6.25
0.060	915.4	257.41	6.20
0.065	926.0	258.72	5.64
0.070	935.2	260.26	5.11
0.075	947.1	260.93	4.81
0.080	953.4	261.62	4.58

EXP. NO. 334 49, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1199.0	295.65	1.00
0.005	967.4	263.13	4.12
0.010	959.5	262.27	4.37
0.015	953.4	261.60	4.59
0.020	949.2	261.03	4.77
0.025	941.9	260.34	5.01
0.030	936.6	259.75	5.23
0.035	931.9	259.23	5.42
0.040	926.6	258.65	5.66
0.045	922.0	258.13	5.98
0.050	917.0	257.57	6.12
0.055	912.9	257.11	6.34
0.059	909.9	256.78	6.50
0.060	909.0	256.68	6.55
0.063	909.2	256.78	6.50

EXP. NO. 337 53, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1198.0	295.65	1.00
0.005	967.4	263.21	4.10
0.010	958.7	262.37	4.34
0.015	952.7	261.60	4.58
0.020	946.7	260.96	4.80
0.025	941.2	260.34	5.01
0.030	935.9	259.75	5.23
0.035	931.0	259.21	5.43
0.040	925.6	258.61	5.67
0.045	920.6	258.05	5.91
0.050	916.2	257.56	6.13
0.055	911.7	257.04	6.36
0.060	907.5	256.58	6.59
0.062	905.0	256.40	6.69
0.064	904.7	256.27	6.75
0.067	905.6	256.37	6.70
0.070	910.5	256.92	6.43
0.075	923.7	258.51	5.72
0.080	933.4	259.45	5.33
0.085	939.0	260.09	5.11
0.090	940.1	261.21	4.71

EXP. NO. 339 110, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1137.9	295.65	1.00
0.005	967.4	262.22	4.09
0.010	956.0	262.09	4.43
0.015	949.2	261.24	4.70
0.020	942.7	260.52	4.95
0.025	936.9	259.87	5.18
0.030	931.7	259.31	5.40
0.035	927.4	258.83	5.53
0.040	921.7	258.20	5.75
0.045	916.9	257.66	6.00
0.050	912.7	257.10	6.33
0.055	908.5	256.71	6.53
0.060	904.4	256.25	6.76
0.065	901.8	255.96	6.91
0.066	901.4	255.93	6.92
0.068	902.3	256.01	6.88
0.070	904.7	256.28	6.74
0.075	915.7	257.52	6.15
0.080	926.9	258.76	5.41
0.085	934.0	259.66	5.24
0.090	945.0	260.78	4.96
0.095	956.1	261.00	4.46

EXP. NO. 342 40. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1197.5	295.65	1.00
0.005	967.4	263.25	4.09
0.010	960.1	262.46	4.32
0.015	953.0	261.78	4.53
0.020	947.2	261.11	4.74
0.025	942.8	260.56	4.93
0.030	937.6	259.99	5.14
0.035	932.5	259.42	5.35
0.040	927.3	259.04	5.50
0.045	922.7	258.33	5.79
0.050	917.7	257.77	6.03
0.055	914.2	257.29	6.21
0.057	913.7	257.22	6.24
0.060	914.4	257.40	6.22
0.061	916.3	257.62	6.10
0.065	923.0	258.47	5.74
0.070	935.2	260.06	5.11
0.075	940.5	261.32	4.68
0.080	958.2	262.25	4.38

EXP. NO. 349 48, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1197.9	295.65	1.00
0.005	967.4	263.22	4.10
0.010	962.0	262.63	4.27
0.015	955.2	261.90	4.49
0.020	950.2	261.26	4.67
0.025	945.1	260.78	4.86
0.030	939.4	260.15	5.08
0.035	934.2	259.65	5.26
0.040	929.7	259.09	5.49
0.045	924.7	258.52	5.71
0.050	919.5	257.94	5.96
0.055	916.0	257.53	6.15
0.060	912.4	257.14	6.32
0.065	913.3	257.26	6.27
0.070	913.0	257.21	6.24
0.075	912.6	257.17	6.21
0.080	912.0	257.10	6.34
0.085	913.1	257.22	6.29
0.090	914.7	257.40	6.20
0.095	914.4	257.37	6.22
0.100	914.7	257.40	6.20
0.105	914.9	257.41	6.20
0.110	914.6	257.39	6.21
0.115	915.5	257.49	6.16
0.120	915.5	257.49	6.16
0.125	916.4	257.61	6.11
0.130	927.5	258.83	5.59
0.135	943.7	260.62	4.91
0.140	954.3	261.70	4.53

EXP. NO. 344 26, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1197.4	295.65	1.00
0.005	967.4	263.24	4.09
0.010	962.0	262.75	4.23
0.015	957.4	262.15	4.41
0.020	952.4	261.61	4.58
0.025	947.2	261.04	4.77
0.030	941.1	260.37	5.00
0.035	936.5	259.86	5.19
0.040	931.5	259.30	5.40
0.045	925.0	258.68	5.65
0.050	922.5	258.30	5.80
0.051	921.4	258.18	5.86
0.054	923.0	258.36	5.78
0.057	927.0	258.88	5.56
0.060	939.4	260.19	5.07
0.065	951.8	261.54	4.60
0.070	957.9	262.21	4.39

EXP. NO. 352 28, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1199.8	295.65	1.00
0.005	967.4	263.14	4.12
0.010	961.9	262.53	4.33
0.015	955.7	261.96	4.52
0.020	952.5	261.23	4.62
0.025	945.5	260.75	4.87
0.030	939.8	260.12	5.09
0.035	935.1	259.40	5.28
0.040	930.1	259.04	5.50
0.045	924.7	258.44	5.75
0.050	919.0	257.91	5.97
0.053	914.2	257.72	6.06
0.056	917.7	257.89	5.98
0.060	923.7	258.80	5.56
0.065	945.0	260.70	4.95
0.070	954.4	261.72	4.55

EXP. NO. 347 29. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1197.6	295.65	1.00
0.005	967.4	263.24	4.09
0.010	962.0	262.66	4.26
0.015	955.7	261.97	4.47
0.020	950.3	261.38	4.66
0.025	945.4	260.84	4.84
0.030	939.8	260.22	5.05
0.035	935.0	259.69	5.25
0.040	930.0	259.14	5.46
0.045	924.7	258.55	5.70
0.050	920.0	258.02	5.92
0.053	917.8	257.78	6.03
0.057	919.1	257.92	5.97
0.060	925.7	258.66	5.66
0.065	941.9	260.45	4.97
0.070	951.6	261.52	4.61
0.075	958.6	262.28	4.37

EXP. NO. 354 5,1 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1199.0	295.65	1.00
0.005	967.4	263.21	4.10
0.010	962.6	262.69	4.25
0.015	957.1	262.09	4.43
0.020	951.9	261.52	4.61
0.025	947.2	261.00	4.78

0.036	941.6	260.30	5.00
0.038	934.7	259.84	5.19
0.040	931.9	259.71	5.30
0.042	930.1	259.11	5.47
0.045	929.5	259.05	5.50
0.046	930.1	259.11	5.47
0.048	934.6	259.51	5.33
0.052	944.2	260.00	4.82
0.055	957.7	262.15	4.41

EXP. NO. 357 1.3 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1189.2	285.65	1.00
0.005	967.4	263.19	4.10
0.010	961.6	262.56	4.29
0.015	955.5	261.89	4.49
0.020	950.1	261.32	4.68
0.025	945.4	260.79	4.86
0.030	940.1	260.22	5.06
0.035	934.6	259.81	5.21
0.036	935.2	259.77	5.22
0.038	936.9	259.85	5.19
0.041	939.5	260.02	5.13
0.045	944.4	260.70	4.99

EXP. NO. 358 28. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1188.3	285.65	1.00
0.005	967.4	263.18	4.11
0.010	961.9	262.59	4.23
0.015	954.9	261.91	4.52
0.020	949.3	261.21	4.71
0.025	944.5	260.48	4.90
0.030	939.7	260.04	5.12
0.035	933.7	259.40	5.33
0.040	929.3	258.89	5.56
0.045	923.9	258.94	5.54
0.050	921.0	258.07	5.90
0.055	922.9	258.27	5.82
0.060	922.4	258.34	5.79
0.065	921.3	258.17	5.86
0.070	921.5	258.13	5.88
0.075	922.4	258.23	5.84
0.080	923.9	258.40	5.76
0.085	923.9	258.40	5.76
0.090	923.4	258.34	5.79
0.095	922.9	258.29	5.81
0.100	923.6	258.36	5.78
0.105	924.7	258.48	5.73
0.110	925.9	258.62	5.67
0.115	935.2	259.65	5.26
0.120	950.0	261.28	4.69

EXP. NO. 362 26. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.0	285.65	1.00
0.005	967.4	263.13	4.12
0.010	962.4	262.58	4.28
0.015	956.7	261.94	4.47
0.020	951.4	261.32	4.65
0.025	944.7	260.87	4.83
0.030	940.9	260.22	5.06
0.035	934.2	259.72	5.24
0.040	931.5	259.16	5.44
0.045	927.9	258.40	5.64
0.050	926.9	258.67	5.65
0.055	929.3	258.83	5.58
0.060	927.9	258.79	5.61
0.065	926.8	258.67	5.65
0.070	927.2	258.71	5.63
0.075	929.5	258.86	5.57
0.080	929.9	258.90	5.56
0.085	929.5	258.86	5.58
0.090	928.3	258.83	5.59
0.095	929.5	258.86	5.58
0.100	929.4	258.96	5.54
0.105	930.1	259.03	5.50
0.110	936.2	259.71	5.24
0.115	953.4	261.60	4.58

EXP. NO. 429 20.9 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.1	285.65	1.00
0.005	962.5	263.02	4.15
0.008	952.9	261.97	4.47
0.016	943.8	260.97	4.79
0.024	935.5	260.05	5.11
0.032	927.7	259.19	5.44
0.036	922.0	258.55	5.70
0.040	919.9	258.32	5.80
0.044	917.7	258.07	5.90
0.048	921.3	258.47	5.73
0.052	933.4	259.82	5.20
0.056	949.7	261.51	4.61

EXP. NO. 432 14.5 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.4	285.65	1.00
0.005	959.1	262.51	4.30
0.010	953.2	261.88	4.46
0.015	947.7	261.37	4.66
0.020	942.7	260.82	4.84
0.025	937.1	260.20	5.06
0.030	931.7	259.60	5.28
0.035	927.1	259.09	5.48
0.040	921.6	258.48	5.73
0.044	918.1	258.09	5.90
0.046	916.8	257.94	5.96
0.048	919.3	258.11	5.99
0.052	923.5	258.69	5.64
0.055	931.4	259.57	5.29
0.060	943.3	260.89	4.82

EXP. NO. 434 37.5 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1192.0	285.65	1.00
0.005	962.5	262.04	4.15
0.010	956.9	262.31	4.36
0.015	949.9	261.65	4.57
0.020	944.1	261.02	4.78
0.025	939.1	260.47	4.97
0.030	932.7	259.76	5.22
0.035	927.6	259.19	5.44
0.040	922.9	258.67	5.65
0.045	917.9	258.10	5.80
0.050	912.2	257.47	6.17
0.055	909.4	257.15	6.32
0.060	910.6	257.29	6.25
0.065	911.2	257.35	6.22
0.070	911.1	257.34	6.23
0.075	910.8	257.32	6.24
0.080	911.5	257.39	6.21
0.085	912.3	257.48	6.17
0.090	912.0	257.44	6.19
0.095	914.0	257.67	6.08
0.100	924.0	258.73	5.60
0.105	941.7	260.75	4.87
0.110	956.6	262.39	4.34

EXP. NO. 437 33.5 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.0	285.65	1.00
0.005	962.5	262.04	4.18
0.010	957.3	262.37	4.34
0.015	951.3	261.72	4.55
0.020	945.0	261.12	4.74
0.025	940.2	260.40	4.96
0.030	934.4	259.95	5.19
0.035	929.2	259.23	5.43
0.040	923.5	258.64	5.66
0.045	918.3	258.06	5.91
0.050	913.7	257.54	6.14
0.055	914.0	257.58	6.12
0.060	915.4	257.72	6.05
0.065	915.0	257.60	6.07
0.070	915.2	257.69	6.07
0.075	915.7	257.71	6.06
0.080	916.0	257.80	6.02
0.085	916.0	257.80	6.02
0.090	916.0	257.80	6.02
0.095	918.2	258.05	5.91
0.100	921.9	259.57	5.29
0.105	944.6	261.20	4.72

EXP. NO. 439 22.5 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.3	285.65	1.00
0.005	962.5	262.91	4.18
0.010	957.0	262.31	4.36
0.015	951.8	261.74	4.54
0.020	945.6	261.06	4.76
0.025	939.9	260.43	4.98
0.030	934.3	259.92	5.20
0.035	928.9	259.25	5.42
0.040	924.2	258.70	5.64
0.045	919.6	258.06	5.91
0.047	916.2	257.90	6.02
0.049	916.7	257.74	6.05
0.051	917.3	257.82	5.97
0.053	921.7	258.41	5.76
0.055	924.6	258.76	5.63
0.060	943.6	260.94	4.84
0.065	957.0	262.21	4.36

EXP. NO. 442 23.5 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1184.7	285.65	1.00
0.005	962.5	262.07	4.17
0.010	957.0	262.27	4.35
0.015	950.9	261.70	4.55
0.020	944.7	261.02	4.78
0.025	939.1	260.40	4.99
0.030	932.4	259.77	5.22
0.035	928.0	259.17	5.45
0.040	922.9	258.59	5.69
0.045	917.9	258.03	5.92
0.049	914.1	257.61	6.11
0.051	913.1	257.50	6.16
0.053	914.1	257.61	6.11
0.056	920.4	258.32	5.80
0.060	923.6	258.70	5.71
0.065	945.2	261.19	4.72

EXP. NO. 444 38. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1192.0	285.65	1.00
0.005	962.5	262.04	4.15
0.010	956.0	262.42	4.33
0.015	950.7	261.75	4.54
0.020	944.7	261.05	4.75
0.025	939.4	260.41	4.99
0.030	933.5	259.85	5.19
0.035	929.1	259.23	5.42
0.040	922.6	258.64	5.67
0.045	917.8	258.10	5.90
0.050	912.5	257.50	6.16
0.054	908.9	257.13	6.34
0.056	907.7	256.95	6.41
0.058	909.1	257.21	6.30
0.061	913.8	257.65	6.20
0.065	925.1	258.91	5.55
0.070	941.1	260.69	4.90
0.075	950.2	261.69	4.56

EXP. NO. 447 75. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.6	285.65	1.00
0.005	962.5	262.93	4.16
0.010	955.2	262.18	4.40
0.015	949.2	261.52	4.61
0.020	943.5	260.90	4.82
0.025	937.9	260.27	5.03
0.030	932.7	259.70	5.25
0.035	927.4	259.11	5.47
0.040	921.7	258.47	5.73
0.045	916.7	257.91	5.97
0.050	911.6	257.33	6.24
0.055	907.2	256.94	6.47
0.060	905.[illegible]	256.60	6.59
0.065	906.6	256.76	6.50
0.070	906.0	256.80	6.49
0.075	906.5	256.74	6.53
0.080	906.7	256.79	6.49
0.085	907.0	256.82	6.49
0.090	907.6	256.89	6.44
0.095	907.6	256.89	6.44
0.100	907.5	256.88	6.45
0.105	907.7	256.90	6.44
0.110	908.5	256.99	6.40
0.115	909.4	257.09	6.35
0.120	919.2	258.10	5.85
0.125	929.4	259.[illegible]3	5.39
0.130	951.0	261.91	4.52

EXP. NO. 4[illegible] 47. DROPS/CC

TIME	PRESS	TEMP	SUPR
	119[illegible].6	285.65	1.00
0.005	962.5	26[illegible].[illegible]	4.14
0.010	957.0	262.46	4.32
0.015	950.6	261.76	4.53
0.020	944.7	261.11	4.74
0.025	939.2	260.51	4.95
0.030	934.0	259.93	5.16
0.035	929.1	259.39	5.37
0.040	923.3	258.74	5.62
0.045	918.3	258.19	5.86
0.050	912.4	257.53	6.11
0.055	909.1	257.14	6.32
0.060	907.6	256.91	6.43
0.065	909.0	257.12	6.33
0.070	909.3	257.17	6.31
0.075	909.0	257.13	6.32
0.080	909.2	257.16	6.32
0.085	909.6	257.20	6.30
0.090	910.0	257.25	6.27
0.095	910.3	257.29	6.26
0.100	910.3	257.28	6.26
0.105	910.4	257.29	6.25
0.110	911.[illegible]	257.36	6.22
0.115	911.6	257.42	6.19
0.120	916.9	258.01	6.03
0.125	930.1	259.42	5.32
0.130	946.9	261.34	4.67

EXP. NO. 449 78. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1183.7	285.65	1.00
0.005	962.5	263.05	4.14
0.010	955.9	262.33	4.35
0.015	950.4	261.73	4.54
0.020	944.9	261.13	4.74
0.025	939.4	260.52	4.95
0.030	934.1	259.93	5.16
0.035	928.9	259.35	5.38
0.040	923.5	258.75	5.62
0.045	917.5	258.10	5.85
0.050	913.5	257.63	6.10
0.055	909.0	257.11	6.34
0.060	905.3	256.71	6.53
0.065	906.4	256.83	6.47
0.070	907.1	256.91	6.43
0.075	906.8	256.83	6.45
0.080	906.9	256.89	6.44
0.085	907.4	256.94	6.42
0.090	907.9	257.00	6.39
0.095	908.2	257.03	6.37
0.100	908.2	257.05	6.37
0.105	908.4	257.06	6.35
0.110	909.0	257.11	6.34
0.115	909.2	257.15	6.32
0.120	913.2	257.60	6.11
0.125	926.1	259.04	5.5[illegible]
0.130	944.1	261.04	4.77

EXP. NO. 457 348. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1183.1	285.65	1.00
0.005	962.5	263.11	4.12
0.010	958.4	262.66	4.26
0.015	952.1	261.97	4.47
0.020	946.9	261.40	4.65
0.025	941.4	260.82	4.85
0.030	936.5	260.25	5.04
0.035	931.3	259.67	5.26
0.040	925.0	259.[illegible]	5.48
0.045	920.0	258.50	5.72
0.050	915.7	257.93	5.96
0.055	910.3	257.32	6.24
0.060	905.1	256.74	6.52
0.065	900.5	256.15	6.81
0.07[illegible]	893.9	255.45	7.12
0.074	89[illegible].5	255.[illegible]8	7.40
0.07[illegible]	889.2	25[illegible].[illegible]3	7.54
0.0[illegible]	8[illegible]3.7	254.93	7.42
0.085	89[illegible].5	255.08	7.40
0.090	891.[illegible]	255.24	7.31
0.095	893.[illegible]	255.36	7.24
0.100	894.[illegible]	255.51	7.15
0.105	895.6	255.65	7.08
0.110	896.[illegible]	255.8[illegible]	7.00
0.115	89[illegible].0	255.93	6.93
0.120	900.2	256.[illegible]8	6.85
0.125	90[illegible].7	256.24	6.77
0.130	913.1	257.64	6.09
0.135	925.6	259.04	5.50
0.140	937.[illegible]	260.40	4.99
0.145	950.3	261.77	4.53

EXP. NO. 460 69, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1191.0	235.65	1.00
0.005	962.5	263.21	4.13
0.010	952.6	262.22	4.30
0.015	946.6	261.46	4.63
0.020	940.7	260.22	4.84
0.025	935.3	[illegible]	5.05
0.030	931.2	259.66	5.24
0.035	925.6	259.14	5.46
0.040	920.0	258.52	5.71
0.045	915.1	257.97	5.95
0.050	910.0	257.39	6.21
0.055	905.7	256.91	6.43
0.059	901.7	256.46	6.66
0.061	900.7	256.24	6.71
0.063	901.7	256.46	6.66
0.065	905.3	256.86	6.45
0.070	921.7	258.71	5.64
0.075	934.0	260.19	5.07
0.080	949.0	261.62	4.58
0.085	965.5	262.45	4.32

EXP. NO. 462 228, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1197.0	235.65	1.00
0.005	962.5	262.76	4.23
0.010	953.7	261.90	4.52
0.015	946.4	261.00	4.79
0.020	940.1	260.31	5.02
0.025	934.2	259.67	5.26
0.030	929.5	259.13	5.46
0.035	924.9	258.61	5.68
0.040	919.4	258.01	5.93
0.045	914.0	257.40	6.20
0.050	909.2	256.76	6.51
0.055	904.1	256.29	6.74
0.060	900.0	255.71	7.05
0.063	897.5	255.54	7.14
0.066	[illegible]	255.71	7.05
0.070	910.4	257.02	6.32
0.075	924.0	258.85	5.70
0.080	939.4	260.23	5.25
0.085	949.7	261.25	4.70
0.090	956.6	262.12	4.42

EXP. NO. 464 198, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1197.6	235.65	1.00
0.005	962.5	262.71	4.24
0.010	953.7	261.75	4.54
0.015	946.5	260.96	4.80
0.020	935.8	259.73	5.22
0.025	934.6	259.65	5.27
0.030	929.6	259.09	5.48
0.035	924.6	258.54	5.71
0.040	919.8	258.00	5.93
0.045	914.6	257.42	6.19
0.050	909.9	256.79	6.49
[illegible]	[illegible]	[illegible]	6.74
[illegible]	[illegible]	[illegible]	7.05
0.062	902.3	255.50	7.12
0.065	900.1	255.47	7.07
0.070	910.2	257.15	6.32
0.075	[illegible]	[illegible]	[illegible]
[illegible]	941.[illegible]	[illegible]	4.92
0.085	952.0	261.44	4.64
0.090	959.3	262.25	4.38

EXP. NO. 467 37, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1197.4	235.65	1.00
0.005	962.5	262.73	4.24
0.010	955.3	261.94	4.48
0.015	[illegible]	261.36	4.65
0.020	944.0	[illegible]	[illegible]
0.025	933.1	260.05	5.12
0.030	[illegible]	259.48	5.33
0.035	[illegible]	259.03	5.54
0.040	[illegible]	258.35	5.78
0.045	918.4	257.96	6.00
0.050	913.1	257.27	6.26
0.054	[illegible]	256.91	6.44
0.056	[illegible]	256.76	6.51
0.059	[illegible]	256.97	6.45
[illegible]	[illegible]	[illegible]	6.30
0.065	922.0	259.24	5.82
0.070	935.2	259.73	5.24
0.075	945.2	260.93	4.84
0.080	[illegible]	261.63	4.55

EXP. NO. 466 89, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1196.6	235.65	1.00
0.005	962.5	262.90	4.22
0.010	956.4	262.12	4.42
0.015	950.7	261.51	4.61
0.020	944.0	260.96	4.83
0.025	936.5	[illegible]	5.03
0.030	934.1	259.69	5.25
0.035	928.9	[illegible]	5.49
0.040	923.0	258.5[illegible]	5.72
0.045	918.0	[illegible]	5.94
0.050	913.2	257.41	6.20
0.055	[illegible]	256.91	6.43
0.060	[illegible]	256.47	6.65
0.065	[illegible]	256.61	6.63
0.070	[illegible]	256.49	6.64
0.075	904.4	256.25	6.71
0.080	904.9	256.40	6.68
0.085	905.4	256.47	6.65
0.090	906.1	256.55	6.61
0.095	906.1	256.55	6.61
0.100	906.0	256.53	6.62
0.105	906.2	256.56	6.61
0.110	906.0	256.64	6.57
0.115	906.9	256.64	6.57
0.120	906.9	256.64	6.57
0.125	907.5	256.70	6.53

0.130	907.7	256.73	6.52
0.135	907.7	256.73	6.52
0.140	908.1	256.77	6.50
0.145	908.5	256.82	6.48
0.150	908.5	256.82	6.48
0.155	908.4	256.80	6.48
0.160	912.3	257.24	6.28
0.165	924.6	258.62	5.67
0.170	942.3	260.59	4.93
0.175	954.9	261.96	4.47

EXP. NO. 472 44, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1196.0	285.65	1.00
0.005	962.5	262.77	4.22
0.010	959.2	262.30	4.36
0.015	952.2	261.64	4.57
0.020	946.7	261.04	4.77
0.025	940.9	260.40	4.99
0.030	936.6	259.92	5.20
0.035	930.5	259.25	5.42
0.040	925.0	258.64	5.66
0.045	920.5	258.14	5.87
0.050	915.2	257.65	6.14
0.055	911.6	257.14	6.32
0.060	911.0	257.07	6.36
0.065	911.6	257.14	6.32
0.070	909.7	256.93	6.43
0.075	909.7	256.93	6.43
0.080	910.0	256.96	6.41
0.085	910.6	257.02	6.38
0.090	911.0	257.07	6.36
0.095	910.9	257.05	6.37
0.100	910.9	257.06	6.36
0.105	910.9	257.06	6.36
0.110	911.6	257.14	6.32
0.115	911.5	257.13	6.33
0.120	911.5	257.13	6.33
0.125	912.0	257.18	6.30
0.130	912.1	257.20	6.30
0.135	912.1	257.20	6.30
0.140	912.5	257.24	6.28
0.145	912.8	257.27	6.26
0.150	912.7	257.26	6.27
0.155	913.3	257.33	6.24
0.160	919.3	257.99	5.98
0.165	931.2	259.30	5.36
0.170	949.4	261.34	4.67

EXP. NO. 474 36, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1197.5	285.65	1.00
0.005	962.5	262.72	4.24
0.010	957.1	262.13	4.42
0.015	950.9	261.45	4.63
0.020	945.3	260.84	4.84
0.025	940.5	260.31	5.02
0.030	935.2	259.72	5.24
0.035	930.0	259.15	5.46
0.040	924.6	258.54	5.70
0.045	920.0	258.03	5.92
0.050	913.9	257.40	6.15
0.055	911.6	257.14	6.32
0.060	912.4	257.23	6.28
0.065	912.8	257.26	6.26
0.070	912.7	257.21	6.29
0.075	913.2	257.27	6.26
0.080	913.5	257.30	6.25
0.085	913.9	257.35	6.23
0.090	914.1	257.37	6.22
0.095	914.2	257.39	6.21
0.100	914.3	257.39	6.21
0.105	914.7	257.44	6.19
0.110	914.9	257.46	6.18
0.115	915.0	257.47	6.17
0.120	915.4	257.51	6.15
0.125	915.6	257.54	6.14
0.130	915.5	257.52	6.15
0.135	915.6	257.54	6.14
0.140	916.0	257.58	6.12
0.145	915.9	257.56	6.13
0.150	916.0	257.58	6.12
0.155	917.7	257.77	6.04
0.160	927.3	258.84	5.59
0.165	942.0	260.52	4.93

EXP. NO. 477 36, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.7	285.65	1.00
0.005	962.5	262.70	4.22
0.010	956.0	262.05	4.43
0.015	950.7	261.42	4.64
0.020	943.0	260.64	4.93
0.025	940.1	260.23	5.01
0.030	934.6	259.73	5.24
0.035	930.0	259.22	5.43
0.040	924.4	258.58	5.68
0.045	919.5	258.04	5.92
0.050	914.4	257.47	6.17
0.055	910.7	257.06	6.36
0.060	910.2	257.00	6.39
0.065	911.2	257.12	6.33
0.070	910.7	257.06	6.36
0.075	911.6	257.16	6.32
0.080	911.6	257.16	6.32
0.085	912.5	257.26	6.27
0.090	912.6	257.27	6.26
0.095	912.6	257.27	6.26
0.100	913.0	257.31	6.24
0.105	913.2	257.34	6.23
0.110	913.3	257.35	6.23
0.115	913.3	257.35	6.23
0.120	913.7	257.39	6.21
0.125	913.7	257.39	6.21
0.130	913.9	257.40	6.20
0.135	914.3	257.46	6.18
0.140	914.2	257.45	6.18
0.145	914.5	257.49	6.17
0.150	915.2	257.56	6.13
0.155	920.5	258.15	5.87
0.160	937.7	260.06	5.11

EXP. NO. 479 21, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1196.8	285.65	1.00
0.005	962.5	262.79	4.22
0.010	957.4	262.22	4.39
0.015	951.5	261.58	4.59
0.020	946.4	261.02	4.78
0.025	940.8	260.40	4.99
0.030	935.9	259.86	5.19
0.035	931.0	259.32	5.39
0.040	925.6	258.75	5.62
0.045	921.5	258.26	5.82
0.050	920.4	258.16	5.87
0.055	921.7	258.20	5.81
0.060	922.0	258.21	5.80
0.065	921.3	258.24	5.83
0.070	922.0	258.31	5.80
0.075	922.3	258.35	5.78
0.080	922.2	258.34	5.79
0.085	922.5	258.37	5.78
0.090	922.8	258.40	5.76
0.095	922.9	258.40	5.76
0.100	923.4	258.47	5.73
0.105	923.5	258.48	5.73
0.110	923.5	258.49	5.73
0.115	923.8	258.51	5.72
0.120	924.0	258.54	5.71
0.125	923.9	258.53	5.71
0.130	924.1	258.55	5.70
0.135	924.3	258.57	5.69
0.140	924.3	258.57	5.69
0.145	924.3	258.57	5.69
0.150	925.0	258.76	5.61
0.155	934.3	259.60	5.25
0.160	961.7	261.60	4.59

EXP. NO. 492 22, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1196.4	285.65	1.00
0.005	962.5	262.82	4.21
0.010	957.1	262.23	4.37
0.015	951.5	261.61	4.58
0.020	946.0	261.11	4.75
0.025	941.9	260.55	4.94
0.030	936.4	259.97	5.14
0.035	931.9	259.44	5.34
0.040	926.6	258.86	5.57
0.045	921.6	258.31	5.80
0.050	917.0	257.89	5.98
0.055	918.5	257.96	5.95
0.060	918.2	257.92	5.97
0.065	916.9	257.79	6.03
0.070	917.8	257.89	5.99
0.075	918.3	257.94	5.96
0.080	919.5	257.96	5.95
0.085	919.4	257.97	5.95
0.090	918.9	258.00	5.93
0.095	919.0	258.01	5.93
0.100	919.1	258.02	5.92
0.105	919.3	258.05	5.91
0.110	919.4	258.06	5.91
0.115	919.5	258.07	5.90
0.120	919.9	258.11	5.89
0.125	919.9	258.11	5.89
0.130	919.9	258.11	5.89
0.135	920.4	258.17	5.86
0.140	920.5	258.18	5.86
0.145	921.5	258.19	5.86
0.150	921.0	258.26	5.82
0.155	925.4	258.76	5.62
0.160	939.5	260.19	5.07

EXP. NO. 484 24, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1196.7	285.65	1.00
0.005	962.5	262.79	4.22
0.010	957.6	262.26	4.39
0.015	952.1	261.65	4.57
0.020	947.3	261.13	4.74
0.025	942.2	260.57	4.93
0.030	936.6	259.95	5.15
0.035	931.7	259.40	5.35
0.040	926.7	258.85	5.58
0.045	921.5	258.27	5.82
0.050	916.2	257.67	6.09
0.055	913.0	257.32	6.24
0.060	913.5	257.37	6.22
0.065	913.7	257.39	6.21
0.070	913.4	257.36	6.22
0.075	913.4	257.36	6.22
0.080	913.7	257.39	6.21
0.085	914.6	257.49	6.16
0.090	914.5	257.48	6.16
0.095	914.5	257.48	6.16
0.100	914.9	257.53	6.14
0.105	915.1	257.55	6.13
0.110	915.2	257.56	6.13
0.115	915.3	257.57	6.12
0.120	915.7	257.62	6.10
0.125	915.6	257.61	6.11
0.130	915.9	257.64	6.09
0.135	916.1	257.66	6.08
0.140	916.2	257.67	6.08
0.145	916.2	257.67	6.08
0.150	917.0	257.76	6.04
0.155	921.9	258.30	5.81
0.160	936.3	259.91	5.17

EXP. NO. 487 29, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1197.5	285.65	1.00
0.005	962.5	262.72	4.24
0.010	956.6	262.09	4.43
0.015	951.1	261.47	4.63
0.020	945.9	260.90	4.82
0.025	941.1	260.37	5.00
0.030	935.9	259.79	5.21
0.035	930.6	259.21	5.43
0.040	925.3	258.62	5.67
0.045	920.5	258.09	5.90
0.050	915.5	257.53	6.14
0.055	913.5	257.30	6.25
0.060	914.4	257.40	6.20
0.065	914.4	257.40	6.20
0.070	914.3	257.39	6.21

0.075	914.9	257.45	6.18
0.080	915.0	257.47	6.17
0.085	915.4	257.51	6.15
0.090	915.5	257.53	6.15
0.095	915.6	257.53	6.15
0.100	915.9	257.56	6.13
0.105	916.0	257.58	6.12
0.110	916.1	257.60	6.12
0.115	916.0	257.59	6.12
0.120	916.6	257.65	6.09
0.125	916.6	257.65	6.09
0.130	916.6	257.65	6.09
0.135	917.1	257.70	6.06
0.140	917.3	257.73	6.05
0.145	917.4	257.74	6.05
0.150	917.9	257.78	6.03
0.155	922.0	258.25	5.83
0.160	935.8	259.79	5.21
0.165	954.7	261.86	4.50

EXP. NO. 824 38, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1199.6	305.65	1.00
0.005	991.5	283.22	3.27
0.010	975.5	282.53	3.40
0.015	968.8	281.76	3.56
0.020	963.5	281.15	3.69
0.025	958.1	280.53	3.83
0.030	952.1	279.93	3.99
0.035	948.3	279.39	4.10
0.040	944.1	278.90	4.22
0.045	939.9	278.28	4.38
0.050	934.2	277.74	4.53
0.055	932.2	277.50	4.60
0.059	932.6	277.55	4.58
0.061	933.3	277.63	4.56
0.065	937.4	278.11	4.43
0.070	950.5	279.64	4.04
0.075	964.7	281.29	3.66
0.080	973.2	282.27	3.46

EXP. NO. 8[illegible]7 51, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1190.2	305.65	1.00
0.005	981.5	283.26	3.26
0.010	976.7	282.71	3.37
0.015	970.4	281.98	3.51
0.020	966.3	281.51	3.61
0.025	959.9	280.77	3.77
0.030	953.4	280.04	3.94
0.035	949.3	279.54	4.06
0.040	944.9	279.03	4.19
0.045	939.9	278.44	4.34
0.050	935.1	277.98	4.49
0.055	931.7	277.48	4.60
0.056	931.3	277.43	4.62
0.059	931.7	277.48	4.60
0.062	932.7	277.55	4.58
0.065	935.2	277.89	4.49
0.070	945.0	279.13	4.15

0.095	[illegible]	[illegible]	3.79
0.100	961.[illegible]	[illegible]	3.74

EXP. NO. [illegible] 131, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.2	305.65	1.00
0.005	981.6	283.73	3.13
0.010	975.7	282.96	3.30
0.015	969.9	282.28	3.45
0.020	963.1	281.41	3.59
0.025	957.9	281.00	3.72
0.030	952.1	280.34	3.87
0.035	947.5	279.80	4.00
0.040	943.1	279.29	4.13
0.045	939.5	278.75	4.26
0.050	933.0	278.10	4.43
0.055	928.3	277.54	4.59
0.060	923.6	276.90	4.74
0.063	920.6	276.63	4.85
0.066	918.7	276.40	4.92
0.068	919.6	276.49	4.89
0.071	924.1	277.05	4.73
0.075	934.2	278.24	4.39
0.080	943.2	279.31	4.12
0.085	948.0	280.08	3.93
0.090	962.1	281.49	3.62
0.095	972.5	282.49	3.37

EXP. NO. [illegible] 124, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1185.9	305.65	1.00
0.005	981.5	283.58	3.20
0.010	973.1	282.84	3.34
0.015	967.9	282.02	3.51
0.020	961.3	281.31	3.66
0.025	957.1	280.77	3.78
0.030	951.6	280.13	3.92
0.035	947.7	279.67	4.03
0.040	942.3	279.16	4.16
0.045	939.9	278.64	4.29
0.050	933.2	277.97	4.47
0.055	928.1	277.37	4.63
0.060	923.5	276.93	4.79
0.065	919.7	276.32	4.94
0.068	916.3	275.97	5.05
0.072	917.9	276.16	4.99
0.075	924.1	277.13	4.70
0.080	938.6	278.65	4.[illegible]
0.085	945.5	279.42	4.09
0.090	956.5	280.73	3.73
0.095	969.5	282.20	3.47

EXP. NO. [illegible] 83, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1125.0	305.65	1.00
0.005	981.5	283.75	3.17
0.010	977.0	283.23	3.27
0.015	973.5	282.50	3.41
0.020	964.9	281.94	3.54
0.025	959.4	281.20	3.69
0.030	953.5	280.52	3.83
0.035	949.9	279.99	3.96
0.040	944.7	279.49	4.07
0.045	940.8	279.03	4.19
0.050	934.7	278.32	4.37
0.055	930.0	277.74	4.52
0.060	925.9	277.27	4.66
0.063	924.2	277.09	4.72
0.066	925.3	277.21	4.68
0.07	933.3	278.15	4.42
0.075	944.1	279.65	4.04
0.080	954.8	280.67	3.80
0.085	964.7	281.81	3.55

EXP. NO. [illegible] 77, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1126.4	305.65	1.00
0.005	981.5	283.61	3.20
0.010	975.0	282.87	3.34
0.015	969.4	282.11	3.49
0.020	962.9	281.47	3.62
0.025	957.4	280.94	3.76
0.030	951.7	280.19	3.91
0.035	947.7	279.71	4.02
0.040	943.3	279.16	4.16
0.045	938.5	278.63	4.29
0.050	932.9	277.97	4.47
0.055	928.5	277.44	4.61
0.059	925.6	277.11	4.71
0.061	924.9	277.03	4.73
0.063	925.6	277.11	4.71
0.066	927.1	277.20	4.66
0.070	934.0	278.10	4.43
0.075	946.8	279.60	4.05
0.080	957.8	280.88	3.75
0.085	967.1	281.96	3.52

EXP. NO. [illegible] 107, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1197.0	305.65	1.00
0.005	981.5	283.56	3.21
0.010	912.6	275.51	5.20
0.015	969.0	282.12	3.49
0.020	963.8	281.52	3.61
0.025	959.7	280.93	3.74
0.030	953.6	280.34	3.87
0.035	948.7	279.77	4.01
0.040	944.6	279.29	4.12
0.045	940.2	278.78	4.25
0.050	934.9	278.15	4.42
0.055	930.1	277.59	4.57
0.060	926.1	277.00	4.74
0.062	921.0	276.53	4.88
0.066	922.2	276.42	4.91
0.069	921.9	276.62	4.85
0.071	927.0	277.24	4.44
0.075	940.9	278.85	4.24
0.080	950.2	279.94	3.97
0.085	959.7	281.05	3.71
0.090	973.9	282.67	3.38

EXP. NO. [illegible] 47, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1196.8	305.65	1.00
0.005	981.5	283.58	3.23
0.010	974.9	282.81	3.35
0.015	969.5	282.20	3.47
0.020	964.3	281.60	3.59
0.025	959.2	281.01	3.72
0.030	953.5	280.35	3.87
0.035	949.4	279.87	3.98
0.040	944.7	279.32	4.12
0.045	939.8	278.75	4.26
0.050	935.5	278.24	4.39
0.055	931.0	277.71	4.54
0.058	929.3	277.51	4.59
0.061	931.0	277.71	4.54
0.065	941.2	278.91	4.22
0.070	952.6	280.24	3.90
0.075	961.9	281.22	3.65
0.080	972.8	282.59	3.39

EXP. NO. [illegible] 4,0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1185.7	305.65	1.00
0.005	981.6	283.69	3.13
0.010	977.4	283.24	3.27
0.015	972.3	282.63	3.39
0.020	966.7	281.08	3.52
0.025	961.2	281.35	3.65
0.030	956.4	280.73	3.77
0.035	951.3	280.23	3.90
0.040	946.0	279.68	4.03
0.045	942.7	279.19	4.15
0.049	940.4	278.92	4.22
0.052	939.7	278.84	4.24
0.056	940.3	278.91	4.22
0.060	945.0	279.46	4.08
0.065	952.2	281.00	3.73
0.070	971.0	282.48	3.42

EXP. NO. [illegible] 34, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.6	305.65	1.00
0.005	981.5	283.79	3.16

0.010	975.3	283.00	3.30
0.015	969.3	282.45	3.42
0.020	964.9	281.87	3.54
0.025	959.0	281.22	3.68
0.030	953.8	280.50	3.82
0.035	949.9	280.13	3.92
0.040	945.8	279.60	4.05
0.045	943.7	279.06	4.18
0.050	936.4	278.55	4.31
0.055	932.6	278.11	4.43
0.057	932.1	278.05	4.45
0.060	934.9	278.20	4.39
0.065	945.5	279.42	4.04
0.070	962.1	281.32	3.65
0.075	969.8	282.44	3.42

EXP. NO. 014 1,8 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1156.5	305.65	1.00
0.005	981.5	283.60	3.20
0.010	976.1	282.90	3.32
0.015	971.0	282.30	3.43
0.020	965.0	281.70	3.57
0.025	959.9	281.10	3.70
0.030	954.6	280.50	3.84
0.035	950.3	280.00	3.95
0.040	946.9	279.47	4.09
0.045	943.0	279.14	4.16
0.046	942.6	279.10	4.17
0.049	943.1	279.15	4.16
0.052	943.6	279.21	4.14
0.055	944.9	279.36	4.11
0.060	952.5	280.25	3.89
0.065	969.0	282.16	3.48

EXP. NO. 009 75, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.0	305.65	1.00
0.005	981.5	283.75	3.17
0.010	974.0	282.99	3.31
0.015	968.3	282.23	3.46
0.020	963.0	281.62	3.59
0.025	956.0	280.91	3.74
0.030	951.3	280.26	3.89
0.035	947.2	279.78	4.00
0.040	943.2	279.33	4.12
0.045	939.1	278.72	4.27
0.050	933.4	278.16	4.41
0.055	929.7	277.61	4.57
0.060	924.2	277.09	4.72
0.062	922.9	276.92	4.76
0.065	924.7	277.14	4.70
0.070	936.4	278.52	4.32
0.075	948.3	279.91	3.97
0.080	956.4	280.85	3.76
0.085	967.9	282.18	3.47

EXP. NO. 017 3,0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1196.0	305.65	1.00
0.005	981.5	283.75	3.17
0.010	977.2	283.26	3.26
0.015	972.2	282.68	3.37
0.020	967.1	282.09	3.49
0.025	961.6	281.46	3.63
0.030	956.5	280.87	3.75
0.035	951.7	280.31	3.88
0.040	947.0	279.76	4.01
0.045	943.0	279.29	4.12
0.048	940.4	278.99	4.20
0.051	938.5	278.88	4.23
0.054	935.2	278.38	4.35
0.057	941.7	279.14	4.16
0.060	946.6	279.71	4.02
0.065	959.3	281.19	3.68
0.070	972.0	282.66	3.38

EXP. NO. 012 67, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.0	305.65	1.00
0.005	981.5	283.76	3.17
0.010	974.9	282.99	3.31
0.015	968.2	282.23	3.46
0.020	963.1	281.64	3.59
0.025	957.0	281.04	3.72
0.030	952.5	280.41	3.86
0.035	947.6	279.84	3.99
0.040	943.7	279.38	4.10
0.045	938.3	278.81	4.25
0.050	933.9	278.22	4.40
0.055	928.3	277.69	4.54
0.060	925.2	277.20	4.68
0.063	923.3	276.98	4.75
0.066	926.4	277.35	4.64
0.070	934.6	278.31	4.37
0.075	946.6	279.72	4.02
0.080	955.0	280.70	3.79
0.085	966.4	282.02	3.51

EXP. NO. 019 0,3 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.0	305.65	1.00
0.005	981.5	283.76	3.17
0.010	977.6	283.31	3.25
0.015	972.3	282.70	3.37
0.020	967.4	282.14	3.48
0.025	962.5	281.57	3.60
0.030	955.9	280.81	3.74
0.035	952.0	280.35	3.82
0.040	954.1	280.60	3.81
0.045	953.2	280.50	3.84
0.050	951.1	280.25	3.90
0.055	952.1	280.36	3.87
0.060	953.0	280.57	3.82
0.065	953.3	280.50	3.84
0.070	952.4	280.40	3.86
0.075	953.6	280.54	3.83
0.080	956.8	280.91	3.74
0.085	967.7	282.17	3.48

EXP. NO. 022 1,2 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1193.6	305.65	1.00
0.005	981.5	283.89	3.15
0.010	974.8	283.11	3.29
0.015	970.1	282.57	3.40
0.020	966.3	282.12	3.48
0.025	961.1	281.53	3.61
0.030	955.7	280.85	3.76
0.035	950.9	280.34	3.87
0.040	946.6	279.84	3.99
0.045	943.5	279.48	4.08
0.050	944.0	279.65	4.04
0.055	944.5	279.60	4.05
0.060	943.1	279.43	4.09
0.065	944.3	279.58	4.05
0.070	945.6	279.73	4.02
0.075	944.9	279.65	4.04
0.080	946.7	279.86	3.99
0.085	961.0	281.52	3.61
0.090	975.2	283.16	3.28

0.035	951.7	280.50	3.82
0.040	951.7	280.50	3.82
0.045	952.4	280.67	3.80
0.050	951.4	280.59	3.82
0.055	951.6	280.58	3.82
0.060	952.0	280.73	3.78
0.065	953.5	280.80	3.77
0.070	952.4	280.67	3.80
0.075	952.7	280.71	3.79
0.080	953.6	280.91	3.77
0.085	953.6	280.91	3.77
0.090	952.9	280.72	3.79
0.095	952.5	280.90	3.77
0.100	954.6	280.93	3.74
0.105	954.0	280.86	3.76
0.110	953.4	280.79	3.77
0.115	954.5	280.92	3.74
0.120	954.9	280.96	3.73
0.125	954.5	280.92	3.74
0.130	954.2	280.89	3.75
0.135	956.4	281.14	3.69
0.145	965.9	282.23	3.47

EXP. NO. 024 0,2 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1192.2	305.65	1.00
0.005	981.5	284.01	3.12
0.010	977.0	283.52	3.21
0.015	972.2	283.05	3.32
0.020	966.7	282.31	3.45
0.025	961.1	281.66	3.58
0.030	956.1	281.09	3.71
0.035	952.7	280.65	3.79
0.040	951.0	280.60	3.82
0.045	952.6	280.70	3.79
0.050	952.1	280.62	3.81
0.055	951.6	280.56	3.82
0.060	952.6	280.69	3.80
0.065	952.6	280.79	3.77
0.070	952.7	280.69	3.79
0.075	952.3	280.64	3.80
0.080	953.6	280.79	3.77
0.085	954.1	280.85	3.76
0.090	953.0	280.72	3.79
0.095	953.4	280.77	3.78
0.100	954.6	280.91	3.74
0.105	954.5	280.90	3.75
0.110	953.8	280.81	3.77
0.115	955.0	281.06	3.71
0.120	966.0	282.22	3.47

EXP. NO. 029 0,2 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1192.0	305.65	1.00
0.005	981.5	283.05	3.14
0.010	957.2	281.15	3.69
0.015	970.0	282.63	3.39
0.020	965.6	282.12	3.49
0.025	962.3	281.74	3.57
0.030	962.5	281.76	3.56
0.035	962.4	281.75	3.56
0.040	961.2	281.61	3.59
0.045	961.5	281.64	3.59
0.050	962.0	281.81	3.55
0.055	963.4	281.86	3.54
0.060	962.2	281.74	3.57
0.065	962.3	281.74	3.57
0.070	963.7	281.90	3.53
0.075	964.5	281.99	3.51
0.080	963.6	281.82	3.55
0.085	962.0	281.81	3.55
0.090	964.7	282.01	3.51
0.095	964.6	282.00	3.51
0.100	963.4	281.86	3.54
0.105	963.6	281.90	3.54
0.110	964.9	282.02	3.51
0.115	964.6	282.00	3.51
0.120	964.2	281.95	3.52
0.125	964.7	282.01	3.51
0.130	970.6	282.69	3.37

EXP. NO. 027 0,3 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1192.0	305.65	1.00
0.005	981.5	284.03	3.12
0.010	975.9	283.39	3.24
0.015	971.3	282.86	3.34
0.020	966.5	282.31	3.45
0.025	960.7	281.64	3.59
0.030	955.8	281.07	3.71

EXP. NO. 032 0,3 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.6	305.65	1.00
0.005	981.5	283.49	3.18
0.010	977.8	283.27	3.26
0.015	972.4	282.65	3.38
0.020	968.0	282.14	3.48

0.025	962.5	281.51	3.61
0.030	957.2	280.90	3.75
0.035	955.0	280.73	3.72
0.040	956.3	280.85	3.76
0.045	955.5	280.60	3.79
0.050	954.0	280.62	3.81
0.055	956.2	280.79	3.77
0.060	957.3	280.90	3.75
0.065	956.2	280.70	3.77
0.070	955.0	280.74	3.78
0.075	957.1	280.92	3.75
0.080	958.0	280.98	3.73
0.085	957.0	280.87	3.75
0.090	956.3	280.70	3.77
0.095	958.1	280.90	3.73
0.100	959.9	281.08	3.71
0.105	957.6	280.94	3.74
0.110	957.2	280.80	3.75
0.115	958.8	281.08	3.71
0.120	959.1	281.11	3.70
0.125	958.0	281.00	3.71
0.130	957.8	280.95	3.73
0.135	961.0	281.33	3.65
0.140	971.4	282.53	3.40

EXP. NO. 00[illegible] **189,** DROPS/CC

TIME	PRESS	TEMP	SUPR
	1120.3	314.15	1.00
0.005	970.0	291.03	3.13
0.010	970.0	290.20	3.27
0.015	964.5	289.45	3.41
0.020	959.0	289.01	3.51
0.025	954.2	288.23	3.65
0.030	948.3	287.53	3.79
0.035	942.7	286.95	3.91
0.040	937.0	286.20	4.07
0.045	933.3	285.74	4.20
0.050	931.2	285.40	4.26
0.055	932.3	285.62	4.22
0.060	931.0	285.46	4.26
0.065	930.1	285.25	4.29
0.070	932.1	285.50	4.23
0.075	933.1	285.71	4.20
0.080	932.2	285.62	4.22
0.085	932.4	285.63	4.22
0.090	935.2	285.96	4.14
0.095	944.0	287.12	3.90
0.100	958.0	288.69	3.55
0.105	968.4	290.02	3.31

EXP. NO. 0[illegible] **114,** DROPS/CC

TIME	PRESS	TEMP	SUPR
	1126.0	305.65	1.00
0.005	971.5	283.57	3.21
0.010	970.2	283.06	3.34
0.015	969.5	282.19	3.47
0.020	964.0	281.56	3.60
0.025	959.0	280.93	3.73
0.030	952.7	280.25	3.88
0.035	947.7	279.67	4.03
0.040	943.3	279.15	4.16
0.045	939.0	278.63	4.29
0.050	933.5	278.00	4.45
0.055	929.1	277.49	4.60
0.060	924.7	276.96	4.75
0.065	920.6	276.47	4.90
0.067	920.0	276.40	4.92
0.070	921.5	276.58	4.86
0.075	921.8	276.61	4.85
0.080	920.9	276.51	4.88
0.085	921.4	276.59	4.86
0.090	923.0	276.76	4.81
0.095	922.6	276.71	4.82
0.100	921.9	276.61	4.85
0.105	923.8	276.85	4.79
0.110	924.6	276.95	4.76
0.115	923.7	276.84	4.79
0.120	924.3	276.91	4.77
0.125	925.0	277.10	4.71
0.130	926.0	277.11	4.71
0.135	925.3	277.03	4.73
0.140	926.3	277.15	4.70
0.145	927.5	277.29	4.66
0.150	927.0	277.23	4.67
0.155	927.4	277.28	4.66
0.160	932.1	277.92	4.50
0.165	944.3	279.26	4.13
0.170	955.9	280.61	3.81
0.175	964.9	281.65	3.59
0.180	974.2	282.73	3.37

EXP. NO. 0[illegible]7 **245,** DROPS/CC

TIME	PRESS	TEMP	SUPR
	1180.0	314.15	1.00
0.005	979.0	291.06	3.12
0.010	973.0	290.50	3.22
0.015	966.0	289.76	3.35
0.020	962.0	289.19	3.46
0.025	956.6	288.54	3.58
0.030	950.0	287.86	3.72
0.035	945.0	287.27	3.85
0.040	941.0	286.69	3.98
0.045	935.5	286.03	4.13
0.050	931.1	285.50	4.25
0.055	927.1	285.02	4.37
0.060	922.5	284.46	4.51
0.063	920.4	284.21	4.58
0.066	922.7	284.49	4.51
0.070	934.4	285.90	4.16
0.075	944.2	287.21	3.94
0.080	953.6	288.10	3.66
0.085	964.7	290.50	3.40

EXP. NO. 0[illegible] **112,** DROPS/CC

TIME	PRESS	TEMP	SUPR
	1180.2	314.15	1.00
0.005	978.0	291.04	3.12
0.010	973.0	290.45	3.23
0.015	967.2	289.77	3.35
0.020	961.5	289.14	3.47
0.025	956.7	288.54	3.59
0.030	952.0	287.98	3.70
0.035	946.5	287.37	3.83
0.040	941.3	286.71	3.97
0.045	936.8	286.17	4.09

0.050	932.1	285.63	4.23
0.055	929.1	285.24	4.31
0.058	931.0	285.47	4.25
0.060	934.4	285.98	4.16
0.065	949.9	287.61	3.78
0.070	959.6	288.88	3.52
0.075	971.0	290.22	3.27

0.035	945.9	287.22	3.86
0.040	946.0	287.21	3.86
0.043	939.4	286.41	4.04
0.046	941.3	286.63	3.99
0.050	943.5	287.02	3.92
0.055	953.9	288.25	3.64
0.060	966.9	289.77	3.35

EXP. NO. 2 105, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1180.0	314.15	1.00
0.005	979.0	291.06	3.12
0.010	972.1	290.37	3.24
0.015	966.4	289.70	3.36
0.020	960.5	289.09	3.49
0.025	955.5	288.41	3.61
0.030	950.1	287.77	3.74
0.035	944.7	287.07	3.89
0.040	938.9	286.44	4.03
0.045	934.2	285.97	4.14
0.048	931.6	285.56	4.24
0.050	930.4	285.42	4.27
0.053	932.0	285.61	4.23
0.056	936.0	286.20	4.09
0.060	947.5	287.46	3.81
0.065	960.4	288.99	3.50

EXP. NO. 9 2,5 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1138.0	314.15	1.00
0.005	978.0	291.07	3.12
0.010	972.0	290.47	3.23
0.015	967.2	289.89	3.34
0.020	962.3	289.22	3.45
0.025	957.4	288.65	3.56
0.030	952.1	288.02	3.69
0.035	947.8	287.51	3.80
0.039	946.6	287.37	3.83
0.042	947.5	287.47	3.80
0.044	948.1	287.54	3.79
0.047	948.6	287.63	3.77
0.050	952.2	288.03	3.69
0.055	965.0	289.65	3.37

EXP. NO. 4 55, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1138.5	314.15	1.00
0.005	979.0	291.11	3.12
0.010	972.7	290.49	3.22
0.015	966.4	289.75	3.36
0.020	961.0	289.11	3.47
0.025	956.4	288.57	3.59
0.030	950.0	287.92	3.71
0.035	945.4	287.26	3.85
0.040	940.4	286.66	3.98
0.045	931.0	285.61	4.23
0.048	932.0	285.65	4.21
0.051	931.4	285.59	4.23
0.055	942.0	286.86	3.94
0.060	953.9	288.27	3.64
0.065	966.6	289.77	3.35

EXP. NO. 12 4,3 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1138.0	314.15	1.00
0.005	979.0	291.07	3.12
0.010	972.0	290.37	3.24
0.015	966.5	289.77	3.36
0.020	961.3	289.11	3.47
0.025	956.2	288.51	3.59
0.030	951.1	287.90	3.71
0.035	946.7	287.38	3.82
0.038	944.6	287.13	3.88
0.040	944.0	287.06	3.89
0.042	944.5	287.12	3.88
0.045	947.0	287.52	3.79
0.050	958.0	288.92	3.53

EXP. NO. 7 25, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1138.7	314.15	1.00
0.005	978.0	291.09	3.12
0.010	972.5	290.44	3.23
0.015	966.7	289.76	3.35
0.020	961.6	289.16	3.46
0.025	956.0	288.50	3.59
0.030	950.1	287.80	3.74

EXP. NO. 14 2,9 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1190.0	314.15	1.00
0.005	978.0	291.06	3.14
0.010	972.4	290.31	3.25
0.015	967.2	289.70	3.36
0.020	962.5	289.14	3.47
0.025	957.0	288.50	3.59
0.030	952.9	288.00	3.70
0.035	950.0	287.67	3.76
0.040	951.7	287.75	3.75
0.045	952.0	287.67	3.76
0.050	948.6	287.50	3.80

0.055	949.3	287.59	3.78
0.060	950.9	287.74	3.74
0.065	951.1	287.90	3.74
0.070	949.6	287.62	3.77
0.075	951.1	287.68	3.76
0.080	951.9	287.80	3.72
0.085	952.7	287.93	3.73
0.090	959.9	288.84	3.53

EXP. NO. 17 5,4 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1139.0	314.15	1.00
0.005	979.0	291.04	3.12
0.010	973.6	290.54	3.21
0.015	969.7	290.07	3.31
0.020	964.0	289.42	3.42
0.025	959.8	288.80	3.53
0.030	953.7	288.20	3.65
0.035	949.9	287.75	3.75
0.040	948.2	287.55	3.79
0.045	949.0	287.64	3.77
0.050	947.6	287.48	3.80
0.055	947.0	287.40	3.82
0.060	949.2	287.55	3.79
0.065	949.7	287.72	3.75
0.070	949.6	287.59	3.78
0.075	947.6	287.47	3.80
0.080	949.4	287.49	3.76
0.085	950.6	287.93	3.73
0.090	949.1	287.65	3.77
0.095	949.7	287.60	3.78
0.100	950.3	287.70	3.74
0.105	951.1	287.90	3.72
0.110	953.5	288.17	3.66
0.115	969.1	289.90	3.33

EXP. NO. 19 1.2 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1199.2	314.15	1.00
0.005	978.0	291.04	3.13
0.010	972.5	290.40	3.24
0.015	967.5	289.91	3.34
0.020	962.3	289.20	3.46
0.025	957.2	288.60	3.57
0.030	952.9	288.09	3.68
0.035	951.1	287.87	3.72
0.040	957.2	288.59	3.57
0.045	951.9	287.96	3.70
0.050	951.1	287.87	3.72
0.055	951.9	287.96	3.70
0.060	953.0	288.10	3.67
0.065	953.0	288.10	3.67
0.070	952.0	287.98	3.70
0.075	952.6	288.05	3.68
0.080	953.9	288.19	3.66
0.085	953.8	288.19	3.66
0.090	952.7	288.06	3.68
0.095	953.2	288.12	3.67
0.100	954.6	288.29	3.64
0.105	959.7	288.89	3.52

EXP. NO. 22 0.6 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1199.2	314.15	1.00
0.005	978.0	291.04	3.13
0.010	973.5	290.51	3.22
0.015	969.0	289.97	3.31
0.020	963.0	289.30	3.43
0.025	959.0	288.81	3.53
0.030	956.4	288.50	3.59
0.035	957.2	288.67	3.56
0.040	957.6	288.64	3.57
0.045	956.4	288.50	3.60
0.050	957.0	288.57	3.58
0.055	958.2	288.71	3.55
0.060	958.7	288.77	3.54
0.065	957.9	288.69	3.56
0.070	957.8	288.67	3.56
0.075	959.0	288.81	3.53
0.080	959.8	288.90	3.51
0.085	958.3	288.78	3.54
0.090	958.7	288.77	3.54
0.095	959.9	288.90	3.52
0.100	960.3	289.06	3.50
0.105	959.3	288.94	3.53
0.110	959.2	288.93	3.53
0.115	967.0	289.75	3.36
0.120	960.7	289.01	3.49
0.125	968.0	289.96	3.33

EXP. NO. 24 0.3 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1198.9	314.15	1.00
0.005	978.0	291.07	3.12
0.010	974.0	290.60	3.20
0.015	969.0	290.01	3.31
0.020	962.7	289.29	3.42
0.025	958.9	288.82	3.52
0.030	954.9	288.35	3.62
0.035	953.2	288.15	3.66
0.040	954.0	288.25	3.64
0.045	953.0	288.13	3.67
0.050	952.2	288.03	3.69
0.055	952.7	288.08	3.68
0.060	954.5	288.30	3.63
0.065	954.2	288.27	3.64
0.070	953.0	288.13	3.67
0.075	953.0	288.23	3.65
0.080	955.4	288.41	3.61
0.085	955.2	288.39	3.62
0.090	954.0	288.24	3.65
0.095	954.9	288.24	3.63
0.100	955.7	288.44	3.60
0.105	955.5	288.42	3.61
0.110	954.7	288.33	3.63
0.115	955.1	288.37	3.62
0.120	956.0	288.43	3.60
0.125	961.5	289.13	3.47

EXP. NO. 27 0.5 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1189.5	314.15	1.00
0.005	979.0	291.01	3.13
0.010	972.0	290.21	3.25
0.015	966.4	289.65	3.37
0.020	962.0	289.24	3.45
0.025	963.7	289.33	3.43
0.030	964.6	289.44	3.41
0.035	963.8	289.34	3.43
0.040	963.2	289.27	3.44
0.045	964.0	289.37	3.43
0.050	965.2	289.51	3.40
0.055	965.1	289.50	3.40
0.060	964.0	289.37	3.43
0.065	963.7	289.33	3.43
0.070	961.3	289.05	3.49
0.075	966.0	289.60	3.38
0.080	964.7	289.45	3.41
0.085	964.7	289.45	3.41
0.090	965.1	289.61	3.38
0.095	966.2	289.63	3.38
0.100	966.0	289.60	3.38
0.105	965.7	289.57	3.39
0.110	966.2	289.63	3.38
0.115	970.0	290.07	3.30

EXP. NO. 34 26. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1189.5	314.15	1.00
0.005	976.0	291.07	3.12
0.010	973.0	290.49	3.22
0.015	967.2	289.90	3.34
0.020	962.1	289.26	3.46
0.025	957.5	288.66	3.56
0.030	951.0	287.90	3.72
0.035	946.2	287.23	3.84
0.040	941.8	286.70	3.95
0.045	940.3	286.41	3.99
0.050	941.2	286.72	3.97
0.055	940.6	286.65	3.98
0.060	940.2	286.60	4.00
0.065	941.1	286.71	3.97
0.070	940.0	286.52	4.00
0.075	941.5	286.74	3.96
0.080	941.1	286.71	3.97
0.085	942.5	286.88	3.93
0.090	944.2	287.13	3.89
0.095	950.6	287.94	3.73
0.100	965.5	289.60	3.38

EXP. NO. 29 42. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1189.5	314.15	1.00
0.005	979.0	291.01	3.13
0.010	972.7	290.39	3.24
0.015	966.0	289.71	3.36
0.020	962.2	289.16	3.47
0.025	958.2	288.69	3.56
0.030	952.0	287.95	3.70
0.035	947.3	287.39	3.82
0.040	942.4	286.91	3.95
0.045	939.0	286.51	4.02
0.050	941.4	286.69	3.98
0.055	940.7	286.61	3.99
0.060	939.6	286.47	4.02
0.065	941.3	286.69	3.98
0.070	942.2	286.80	3.95
0.075	941.2	286.65	3.98
0.080	941.0	286.64	3.99
0.085	942.9	286.96	3.94
0.090	943.0	286.88	3.93
0.095	941.9	286.75	3.96
0.100	942.2	286.79	3.95
0.105	943.6	286.95	3.92
0.110	943.6	286.95	3.92
0.115	942.2	286.90	3.93
0.120	942.5	286.94	3.92
0.125	944.3	287.03	3.90
0.130	947.5	287.41	3.82
0.135	958.3	288.69	3.56

EXP. NO. 37 20. DROPS/CC

TIME	PRESS	TEMP	SUPR
	1189.5	314.15	1.00
0.005	979.0	291.06	3.12
0.010	972.2	290.28	3.24
0.015	965.9	289.64	3.37
0.020	961.0	289.06	3.48
0.025	956.7	288.55	3.58
0.030	950.3	287.86	3.72
0.035	945.4	287.24	3.86
0.040	941.8	286.79	3.95
0.045	941.5	286.75	3.95
0.050	942.5	286.87	3.94
0.055	941.0	286.60	3.98
0.060	941.0	286.78	3.95
0.065	942.5	286.87	3.94
0.070	943.4	287.03	3.91
0.075	942.9	287.00	3.93
0.080	942.6	286.98	3.93
0.085	943.9	287.02	3.90
0.090	944.1	287.06	3.89
0.095	949.9	287.74	3.75
0.100	965.3	289.57	3.39

TABLE X

ARGON DATA

EXP. NO. 949 — 65.0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.1	295.65	1.00
0.005	995.5	274.99	3.29
0.010	991.0	274.34	3.39
0.015	978.3	273.74	3.52
0.020	969.9	273.14	3.66
0.025	965.6	272.66	3.77
0.030	960.5	272.09	3.91
0.035	955.7	271.54	4.05
0.040	951.4	271.06	4.18
0.045	946.1	270.46	4.34
0.050	940.9	269.95	4.52
0.055	936.0	269.30	4.69
0.060	931.7	268.81	4.84
0.065	929.5	268.44	4.96
0.070	929.6	268.57	4.92
0.075	929.5	268.56	4.92
0.080	929.2	268.41	4.97
0.085	929.3	268.48	4.95
0.090	930.3	268.65	4.89
0.095	929.7	268.58	4.91
0.100	929.9	268.48	4.95
0.105	930.0	268.62	4.90
0.110	930.6	268.68	4.88
0.115	931.0	268.73	4.86
0.120	944.4	269.90	4.53
0.125	955.0	271.46	4.07
0.130	965.1	272.60	3.79
0.135	972.3	273.51	3.57

EXP. NO. 954 — 29.0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1187.1	295.65	1.00
0.005	985.5	274.62	3.34
0.010	981.2	274.12	3.44
0.015	974.9	273.41	3.59
0.020	969.4	272.93	3.73
0.025	964.6	272.27	3.86
0.030	959.2	271.66	4.02
0.035	954.0	271.08	4.17
0.040	949.7	270.59	4.31
0.045	944.4	269.99	4.48
0.050	939.8	269.35	4.67
0.055	935.1	268.92	4.80
0.060	934.4	268.95	4.83
0.065	934.5	268.94	4.82
0.070	933.4	268.74	4.86
0.075	939.7	269.45	4.64
0.080	953.0	270.94	4.20
0.085	964.0	272.27	3.87
0.090	973.0	273.31	3.62

EXP. NO. 952 — 45.0 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1183.8	295.65	1.00
0.005	985.9	274.94	3.27
0.010	980.0	274.29	3.40
0.015	974.2	273.65	3.54
0.020	969.0	273.06	3.67
0.025	964.0	272.50	3.81
0.030	959.1	271.95	3.94
0.035	954.0	271.38	4.09
0.040	949.1	270.82	4.24
0.045	943.8	270.22	4.41
0.050	939.3	269.59	4.60
0.055	934.1	269.11	4.74
0.060	931.4	268.80	4.84
0.065	932.6	268.94	4.80
0.070	932.1	268.90	4.81
0.075	931.0	268.76	4.86
0.080	931.9	268.96	4.82
0.085	932.6	268.94	4.80
0.090	932.1	268.88	4.82
0.095	931.6	268.83	4.83
0.100	932.9	268.98	4.79
0.105	935.9	269.31	4.68
0.110	945.0	270.36	4.37
0.115	959.4	271.09	3.94
0.120	969.4	272.11	3.66
0.125	978.5	274.12	3.44

EXP. NO. 957 — 6.7 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1197.3	295.65	1.00
0.005	985.5	274.53	3.34
0.010	982.6	274.26	3.41
0.015	975.9	273.51	3.57
0.020	970.6	272.92	3.71
0.025	965.6	272.36	3.84
0.030	960.4	271.72	3.99
0.035	955.2	271.19	4.14
0.040	950.0	270.71	4.27
0.045	945.0	270.13	4.44
0.050	940.2	269.40	4.63
0.052	939.5	269.41	4.65
0.055	940.4	269.52	4.52
0.060	951.4	270.76	4.26
0.065	964.0	272.23	3.86
0.070	971.5	273.02	3.58

EXP. NO. 959 — 8.5 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.2	295.65	1.00
0.005	985.5	274.71	3.30
0.010	980.2	274.19	3.42
0.015	974.9	273.58	3.55
0.020	969.5	272.99	3.69
0.025	964.6	272.44	3.82
0.030	959.8	271.90	3.96
0.035	954.6	271.32	4.11
0.040	950.4	270.84	4.24
0.045	945.5	270.29	4.39

0.040	940.0	269.66	4.58
0.045	939.0	269.42	4.64
0.050	937.3	270.35	4.67
0.055	937.7	269.40	4.65
0.060	944.6	270.18	4.42
0.065	945.0	270.23	4.41
0.070	961.3	272.07	3.91
0.075	969.7	272.90	3.71
0.080	976.6	273.78	3.51

EXP. NO. 864 0.4 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1185.6	295.65	1.00
0.005	995.5	274.74	3.31
0.010	990.5	274.18	3.42
0.015	975.1	273.58	3.56
0.020	970.7	273.09	3.67
0.025	965.3	272.40	3.81
0.030	960.4	271.94	3.95
0.035	955.7	271.41	4.09
0.040	951.0	270.87	4.23
0.041	950.2	270.73	4.25
0.042	949.6	270.72	4.27
0.045	950.4	270.81	4.25
0.050	962.3	271.92	3.95
0.055	971.8	273.21	3.64
0.060	978.4	273.95	3.47

EXP. NO. 869 0.3 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1185.0	295.65	1.00
0.005	985.5	274.79	3.29
0.010	980.7	274.26	3.41
0.015	975.0	273.63	3.55
0.020	969.2	273.04	3.68
0.025	964.9	272.48	3.81
0.030	960.1	271.96	3.94
0.035	956.0	271.49	4.06
0.040	953.1	271.17	4.15
0.045	953.0	271.26	4.12
0.050	954.5	271.32	4.11
0.055	952.9	271.14	4.16
0.060	952.6	271.11	4.16
0.065	954.3	271.30	4.11
0.070	954.9	271.36	4.10
0.075	953.5	271.21	4.14
0.080	953.8	271.24	4.13
0.085	959.6	271.90	3.96
0.090	976.2	273.76	3.52

EXP. NO. 872 0.2 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1186.2	295.65	1.00
0.005	985.5	274.68	3.32
0.010	978.7	273.93	3.48
0.015	972.5	273.24	3.63
0.020	965.5	272.70	3.74
0.025	966.2	272.53	3.80
0.030	967.2	272.71	3.76
0.035	968.5	272.72	3.74
0.040	967.0	272.62	3.78
0.045	966.3	272.54	3.80
0.050	967.3	272.71	3.76
0.055	968.0	272.82	3.73
0.060	969.3	272.77	3.74
0.065	967.1	272.63	3.78
0.070	967.3	272.65	3.77
0.075	969.6	272.80	3.74
0.080	969.8	272.92	3.73
0.085	969.4	272.73	3.74
0.090	967.3	272.71	3.76
0.095	969.0	272.73	3.75
0.100	969.3	272.88	3.72
0.105	969.7	272.92	3.71
0.110	973.1	273.20	3.62

EXP. NO. 874 0.1 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1185.9	295.65	1.00
0.005	985.5	274.72	3.31
0.010	979.3	274.03	3.46
0.015	977.2	273.80	3.51
0.020	978.4	273.93	3.48
0.030	978.4	273.93	3.49
0.040	977.7	273.55	3.59
0.050	979.7	274.07	3.45
0.060	979.4	273.93	3.48
0.070	979.5	274.05	3.45
0.080	979.7	274.07	3.45
0.090	979.6	274.06	3.45
0.100	980.5	274.16	3.43
0.110	979.9	274.10	3.44
0.120	980.2	274.13	3.44
0.130	980.2	274.13	3.44

EXP. NO. 877 14,1 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1185.5	295.65	1.00
0.005	985.5	274.75	3.30
0.010	980.0	274.14	3.43
0.015	974.0	273.47	3.59
0.020	969.3	272.94	3.70
0.025	964.3	272.39	3.84
0.030	959.2	271.91	3.98
0.035	954.5	271.28	4.12
0.040	949.3	270.69	4.28
0.045	943.9	270.07	4.46
0.050	939.2	269.54	4.61
0.055	936.9	269.28	4.69
0.060	937.9	269.39	4.66
0.065	938.8	269.50	4.63
0.070	943.1	269.99	4.49
0.075	957.8	271.65	4.02
0.080	972.5	273.07	3.67
0.085	978.6	273.98	3.47

EXP. NO. 275   49, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1186.2	295.65	1.00
0.005	985.5	274.48	3.32
0.010	980.4	274.12	3.44
0.015	975.3	273.55	3.56
0.020	969.9	272.95	3.70
0.025	964.8	272.37	3.84
0.030	960.0	271.84	3.97
0.035	955.7	271.25	4.10
0.040	950.4	270.75	4.26
0.045	945.1	270.15	4.43
0.050	940.0	269.57	4.60
0.055	935.2	269.02	4.77
0.060	931.0	268.54	4.92
0.065	926.9	268.07	5.08
0.070	924.1	267.75	5.19
0.075	930.9	268.53	4.93
0.080	943.2	269.93	4.49
0.085	950.4	270.75	4.26
0.090	959.7	271.69	4.01
0.095	970.7	273.03	3.68

EXP. NO. 282   56, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1193.7	295.65	1.00
0.005	985.5	274.91	3.27
0.014	978.0	274.19	3.42
0.020	972.4	273.45	3.53
0.025	969.5	273.02	3.68
0.030	964.2	272.54	3.80
0.035	959.9	271.94	3.95
0.040	954.0	271.39	4.09
0.045	949.6	270.78	4.26
0.050	943.3	270.17	4.43
0.055	939.0	269.69	4.57
0.060	935.0	269.23	4.71
0.065	930.2	268.68	4.88
0.070	925.0	268.08	5.09
0.075	919.8	267.49	5.29
0.079	918.2	267.29	5.35
0.080	919.6	267.45	5.29
0.085	929.2	269.56	4.92
0.090	941.9	270.01	4.47
0.095	950.7	271.01	4.19
0.100	960.0	272.06	3.92
0.110	970.4	273.23	3.64
0.115	980.3	274.33	3.39

EXP. NO. 334   49, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1191.6	295.65	1.00
0.005	985.5	275.11	3.23
0.010	976.7	274.13	3.44
0.015	970.0	273.38	3.60
0.020	964.1	272.72	3.76
0.025	958.6	272.10	3.91
0.030	953.1	271.48	4.07
0.035	947.9	270.89	4.22
0.040	943.3	270.36	4.37
0.045	939.1	269.80	4.51
0.050	934.4	269.35	4.67
0.055	929.9	268.82	4.84
0.060	925.0	268.27	5.01
0.065	921.5	267.76	5.15
0.070	925.0	267.27	5.22
0.075	936.8	269.62	4.59
0.080	947.7	270.96	4.23
0.085	956.9	271.90	3.96
0.090	968.5	273.21	3.64
0.095	977.9	274.26	3.41

EXP. NO. 287   71, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1194.7	295.65	1.00
0.005	985.5	273.90	3.48
0.010	980.0	273.29	3.62
0.015	975.0	272.74	3.75
0.020	969.5	272.13	3.90
0.025	964.6	271.58	4.04
0.030	958.9	270.94	4.21
0.035	953.5	270.33	4.38
0.040	948.3	269.75	4.55
0.045	942.9	269.13	4.74
0.050	939.2	268.71	4.87
0.055	935.5	268.20	5.01
0.060	931.2	267.78	5.18
0.065	926.0	267.21	5.38
0.069	924.3	267.01	5.45
0.071	924.3	267.01	5.45
0.074	926.5	267.26	5.36
0.077	933.9	268.11	5.07
0.080	940.6	268.97	4.82
0.085	951.8	270.14	4.44
0.090	962.2	271.31	4.11
0.095	972.1	272.41	3.83

EXP. NO. 289   182, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1196.9	295.65	1.00
0.005	985.5	273.70	3.53
0.010	977.3	272.90	3.74
0.015	970.6	272.05	3.92
0.020	964.5	271.37	4.10
0.025	958.5	270.70	4.29
0.030	953.1	270.09	4.45
0.035	948.1	269.53	4.62
0.040	942.9	268.84	4.80
0.045	938.0	268.30	4.98
0.050	934.0	267.93	5.13
0.055	929.6	267.42	5.30
0.060	924.4	266.93	5.52
0.065	919.3	266.24	5.74
0.070	916.6	265.93	5.86
0.075	923.7	266.75	5.55
0.080	935.8	268.13	5.06
0.085	946.4	269.33	4.68
0.090	955.0	270.40	4.36
0.095	965.3	271.46	4.07
0.100	974.8	272.51	3.81

EXP. NO. 892 146, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1199.9	295.65	1.00
0.005	985.5	273.53	3.57
0.010	977.9	272.68	3.77
0.015	972.1	272.05	3.92
0.020	966.1	271.39	4.09
0.025	961.1	270.92	4.24
0.030	956.7	270.32	4.38
0.035	952.9	269.89	4.51
0.040	948.7	269.42	4.65
0.045	944.6	268.94	4.79
0.050	940.1	268.45	4.95
0.055	934.4	267.80	5.17
0.060	928.4	267.12	5.41
0.065	923.8	266.59	5.61
0.068	922.6	266.45	5.66
0.070	923.2	266.52	5.63
0.075	931.6	267.48	5.28
0.080	942.4	268.71	4.97
0.085	951.5	269.74	4.55
0.090	962.1	270.93	4.21
0.095	974.9	272.35	3.84

EXP. NO. 894 97, DROPS/CC

TIME	PRESS	TEMP	SUPR
	1199.1	295.65	1.00
0.005	985.5	274.41	3.37
0.010	977.2	273.51	3.57
0.015	970.5	272.75	3.75
0.020	964.8	272.11	3.90
0.025	959.4	271.50	4.06
0.030	954.0	270.90	4.22
0.035	949.1	270.34	4.38
0.040	943.2	269.67	4.57
0.045	938.6	269.15	4.73
0.050	934.7	268.70	4.87
0.055	930.7	268.25	5.02
0.060	926.5	267.77	5.18
0.065	921.1	267.14	5.40
0.070	915.9	266.53	5.63
0.071	915.4	266.49	5.65
0.072	915.9	266.53	5.63
0.075	920.3	267.05	5.44
0.080	933.3	268.54	4.92
0.085	942.4	269.58	4.60
0.090	951.1	270.57	4.31
0.095	962.2	271.92	3.98
0.100	971.4	272.55	3.73

EXP. NO. 897 15,4 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1196.1	295.65	1.00
0.005	985.5	274.69	3.32
0.010	978.4	273.90	3.48
0.015	971.6	273.15	3.66
0.020	966.4	272.56	3.79
0.025	962.5	272.13	3.90
0.030	957.6	271.57	4.04

0.040	[illegible]	270.92	4.24
0.045	947.6	270.44	4.35
0.050	943.1	269.93	4.50
0.055	939.5	269.52	4.62
0.060	936.5	269.15	4.72
0.064	935.9	269.10	4.75
0.067	936.2	269.15	4.73
0.070	939.5	269.52	4.62
0.075	943.6	270.56	4.32
0.080	957.1	271.52	4.06
0.085	963.1	272.19	3.79
0.090	975.0	273.52	3.57

EXP. NO. 899 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1195.6	295.65	1.00
0.005	985.5	274.74	3.31
0.010	970.0	273.91	3.69
0.015	965.0	272.45	3.82
0.020	960.2	271.91	3.95
0.025	954.2	271.24	4.13
0.030	948.6	270.69	4.30
0.035	944.6	270.15	4.43
0.040	941.2	269.76	4.55
0.045	938.3	269.43	4.64
0.050	934.9	269.04	4.75
0.053	933.2	268.95	4.93
0.056	935.7	269.13	4.74
0.060	932.5	268.77	4.95
0.065	944.9	270.17	4.43
0.070	947.3	270.45	4.34
0.075	953.1	271.11	4.16
0.080	959.2	271.80	3.98
0.085	969.3	272.93	3.71

EXP. NO. 902 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1196.0	295.65	1.00
0.005	985.5	274.70	3.31
0.010	979.6	274.05	3.45
0.015	974.1	273.43	3.59
0.020	969.3	272.90	3.71
0.025	964.2	272.33	3.85
0.030	959.6	271.91	3.98
0.035	954.9	271.27	4.12
0.040	949.6	270.63	4.29
0.045	945.9	270.25	4.40
0.050	942.2	269.94	4.52
0.052	941.5	269.76	4.55
0.055	943.1	269.94	4.49
0.060	952.1	270.96	4.20
0.065	962.7	272.16	3.89
0.070	970.2	273.[illegible]	3.69

EXP. NO. 904 DROPS/CC

TIME	PRESS	TEMP	SUPR
	1186.2	295.65	1.00
0.005	985.5	274.63	3.32
0.010	979.8	274.05	3.45
0.015	974.9	273.49	3.58
0.020	969.8	272.93	3.70
0.025	964.5	272.34	3.85
0.030	960.1	271.85	3.97
0.035	955.9	271.37	4.09
0.040	950.9	270.80	4.25
0.045	946.4	270.30	4.39
0.050	942.6	269.87	4.51
0.052	941.0	269.70	4.54
0.055	943.1	269.92	4.50
0.060	954.0	271.16	4.15
0.065	964.0	272.28	3.86
0.070	970.0	272.96	3.70

VITA

The author was born on October 5, 1940 in Forbes, Missouri, the eldest son of Mr. and Mrs. Louis B. Allen, Sr. He graduated from the Public High School in Savannah, Missouri in 1958 and entered the Missouri School of Mines where he held a Harry Kessler Scholarship for two years. He worked for the Missouri State Highway Department for a year, then reentered the Missouri School of Mines. He graduated with a B.S. in Physics in June 1963, a M.S. in Physics in June 1964 and has continued work toward the doctorate. He has held a teaching assistantship, a three year National Defense Education Act fellowship and a National Science Foundation Research Fellowship.

The author is married to the former Miss Barbara Leonard of St. Joseph, Missouri. They have three daughters, Trina, Wendy and Laura.