A REVIEW OF THE EXISTING REACTOR CONFINEMENT PROGRAM AT HANFORD

R. C. WALKER
General Electric Company, Hanford Atomic Products Operation, Richland, Wash.

ABSTRACT

This paper summarizes the current status of the confinement program relative to the existing production reactors at Hanford. Included is a description of the over-all system plus a more detailed review of the principal system components: 1) Fog Spray, 2) Filters, 3) Ventilation Control, and 4) the Electrical and Instrumentation being provided for necessary control and monitoring of the entire system. A brief outline of the associated testing and development programs is also included as well as several charts which more clearly delineate the physical and control aspects of the system.

INTRODUCTION

As many of you are aware, a project is now under way at Hanford to provide confinement facilities for both the eight existing reactors as well as the New Production Reactor. Mr. Pursel will be covering the design aspects of the NPR in a few minutes as a separate topic since there are many considerations which are not common to the two projects.

To begin with, it is important to note that these projects are both referred to as confinement rather than containment. This is because in neither case is the familiar containment sphere utilized; rather, the objective is to control the flow of the ventilation air to such an extent that it will be confined to definite paths which will insure that the exhaust air is routed through filters and other appropriate decontamination facilities prior to release from the stack. This approach is considered necessary due to the inherent massiveness of HAPO-type reactors and this will become more evident as some of the design features are illustrated; however, it is very important to realize that this is an entirely different concept for controlling fission product release than was utilized for Dresden, PWR, and many of the other recently completed reactors.

BASIC CRITERIA

Without getting into extensive discussion of the early Hanford confinement studies, it was concluded that, in consideration of immediate goals, it should be feasible to remove approximately 99.9% of the particulates, 50% of the halogens, but none of the noble gases which may be released from reactor incidents.

Accordingly, the basic features of the initial confinement facilities for the existing Hanford reactors will include:

1. A dense, finely atomized spray system within the rear face enclosure of each reactor which will remove some halogen vapors and particulates as well as afford some degree of decontamination, thermal cooling, and pressure control;

2. A filtering facility which will remove a very high percentage of all particulate matter from the exhaust ventilation air prior to release from the stack;

3. Space within the filter building facility for the future addition of a "dry" halogen collector; and

4. Suitable instrumentation which will monitor and record, where necessary, critical operating conditions.

In addition, it was decided to extend further study and testing toward:

1. The development of a suitable method for the "dry" removal of halogens which would provide decontamination factors of 20 or higher, and

2. Establishing the feasibility of sealing and/or structurally reinforcing the existing reactor buildings to withstand a nominal build-up of internal pressure such as may accompany higher order incidents.

GENERAL FACILITY LAYOUT

Before getting into some of the specific design details, it may be well to orient ourselves with the general facility layout. As noted on the first slide, (Figure I) the reactor block is located within the external reactor building structure such that there is a ventilated space between the block and the outside walls. While the eight existing reactors differ slightly, the layout shown is typical in principle. Without going into the details of how air is supplied to the ventilated areas, it will be seen that the air passes over the reactor block surfaces and is drawn into a common plenum on the suction side of the exhaust fans. In the past the fans have discharged the air directly to the stack; however, you will notice that the air will now be diverted through a filtering facility prior to this release.

The question may arise as to why the filters and their associated ductwork were not installed on the suction side of the fans. It is recognized that this method would have certain inherent advantages; however,

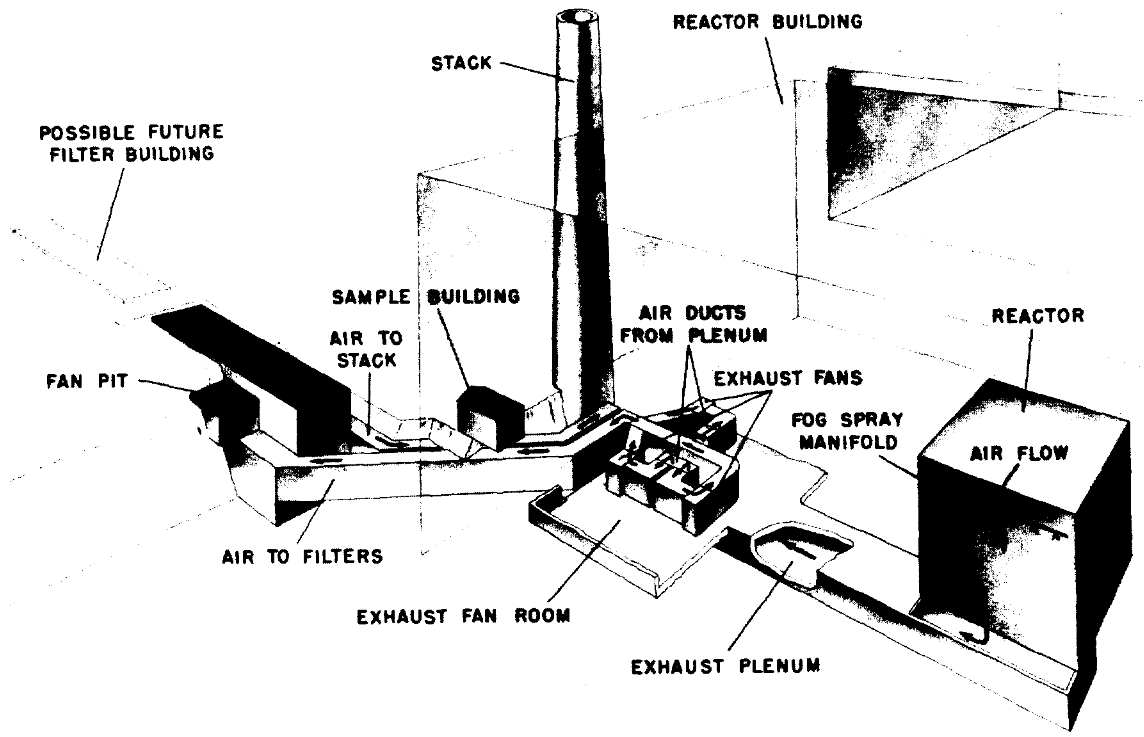

Fig. I—Facility layout.

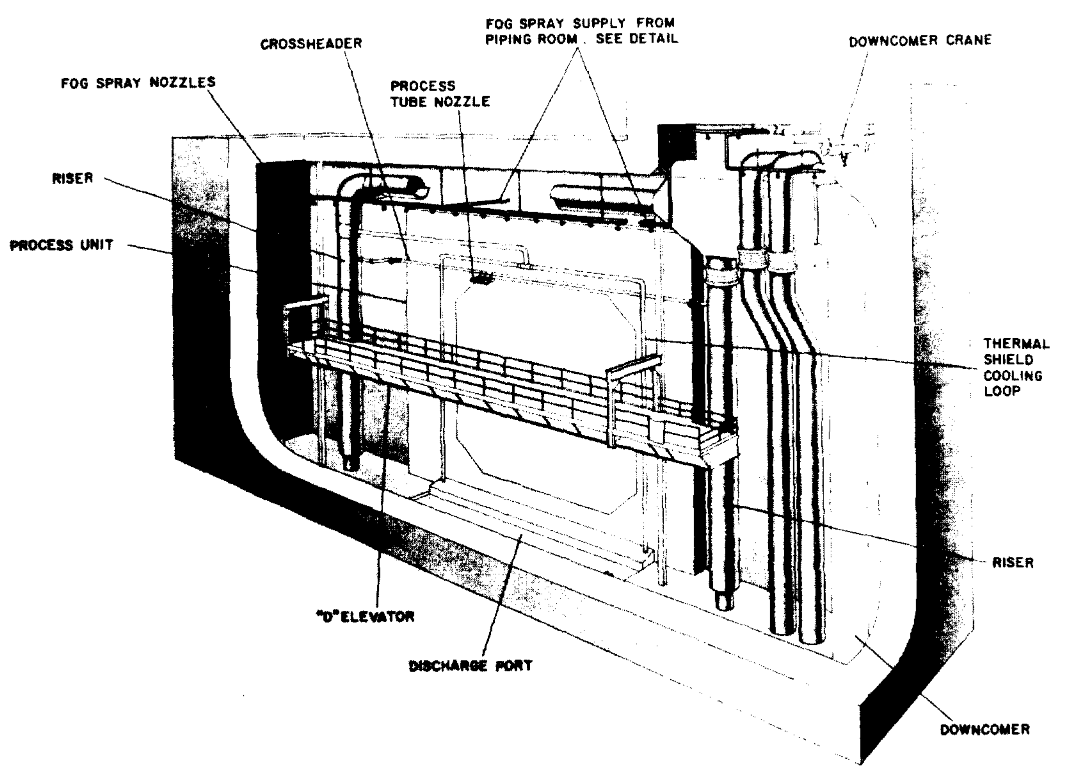

Fig. II—Fog spray system.

it was not done in this case since (1) the construction of the original buildings makes such a tie-in appear unfeasible, (2) all exhaust fans either are or will be shielded, and (3) we are satisfied that, by utilizing demonstrated techniques, our facility will be relatively easy to seal against the rather nominal static pressures which will occur.

The sample building houses the bulk of the instrumentation associated with the confinement facilities with the exception of a small portion which is located in the reactor building control room.

FOG SPRAY SYSTEM

It will be noted that there is a spray system located within the rear face enclosure which is designed for automatic or manual operation. This is shown in more detail on the next slide (Figure II).

Specifically, the spray system is designed for the multi-fold purpose of:

1. Absorbing a portion of the halogen vapors which may be given off during a uranium fire.

2. Condensing on and settling out a portion of the airborne particulate matter which may be released during slug fires or other gross contaminating incidents.

3. Washing down exposed surfaces within the rear face enclosure for removal of contaminated particles.

4. Providing some degree of thermal cooling to exposed fuel elements which may be lodged within the rear face enclosure.

5. Condensing any steam that may be formed to prevent unnecessary pressure build-up within the rear face enclosure.

The automatic control feature of the spray system is centered around a gamma scintillation detector which is located in the Sample Building. This detector is equipped to continuously monitor the reactor building exhaust air and is set to trip the spray system whenever the presence of radio-iodine is detected in the air-stream. Signals from the chamber are also continuously recorded on a strip chart recorder. During reactor shutdown or other periods when personnel may be within the rear enclosure, the spray system will not operate automatically until all personnel have evacuated the rear face area and the access doors have been closed.

A lock-type switch is located in the reactor building control room which has four positions in addition to the automatic position:

1. Automatic--Fog spray will be actuated upon a signal from the gamma scintillation detector provided rear face access doors are closed.

2. Normal On--System is manually actuated provided rear face access doors are closed.

3. Emergency On--System is manually actuated regardless of rear face door status.

4. Normal Off-System is manually shut off; however, this control will be overridden by a signal from the scintillation detector provided rear face doors are closed.

5. Emergency Off--System is manually shut off and completely by-passed.

FILTERING FACILITY

As is indicated on the next slide (Figure III), the filter building is of reinforced concrete construction and is almost entirely below grade. Although the normal radiation activity on the filters should be quite low, it was decided to utilize an underground installation since, (1) earth is cheap shielding; (2) the building and associated ductwork would cause less hindrance to movement of vehicles and personnel within the area; and (3) abandonment, in place, would be much simpler should this ever become necessary.

The volume of air being filtered is as high as 150,000 cfm in one area and the total number of filters are housed in two cells of the filter building, each of which can be individually isolated by means of a water seal pit from the exhaust air flow for filter replacement. Each filter building cell contains provisions for three banks of filters in series and each bank is composed of two halves, each of which is structurally integral units for ease of filter replacement.

The three banks of filters in each compartment will be roughing filters, fine or "absolute" filters, and halogen collectors, respectively, and all are designed on the basis that future filters and/or halogen collectors may be up to two feet in thickness. This flexibility was provided since design of the filter building structure ran concurrently with, and was completed prior to the completion of, the filter life tests which will be described by Mr. Wisehart in a few minutes.

The final selection of the roughing filter for this facility has not been made as of this time; however, it is expected that it will be a conventional filter of the dry strainer type for the purpose of protecting the second stage or fine filter. The fine filter is the key to the filtration system and will be the improved CWS type which is rated for continuous operation at 200°F at a relative humidity of 100 per cent. These, as you know, are commonly rated at an efficiency of 99.9 plus per cent when tested with 0.3 micron dioctyl-phthalate smoke. Initial resistance of these filters is approximately 1.0 inch w.g. when operated at rated capacity with air at standard conditions.

The third filter bank will not be installed initially but will be reserved for the future addition of a "dry" halogen removal system. This particular component is the subject of a testing contract which is now underway and will be further discussed later.

Design of all filter banks is based on normal filter replacement being accomplished by use of a portable crane and without access to the interior of the filter cells. In order to prevent contaminated material from blowing out of the filter cells during times when cell covers are removed for filter replacement, an exhauster is provided for creating a positive sweep of outside air into the cell opening which is then routed through the filters in service. After isolation of the filter cell from the ventilation air stream, start-up of exhauster to create a slightly negative pressure within the cell and removal of the cell cover, the filter bank will be withdrawn into a plastic bag for transporting to the burial ground.

While the probability of a serious incident is very low, an incident involving several tubes of fuel elements would no doubt contaminate the filters to the extent that replacement is somewhat problematical. Of

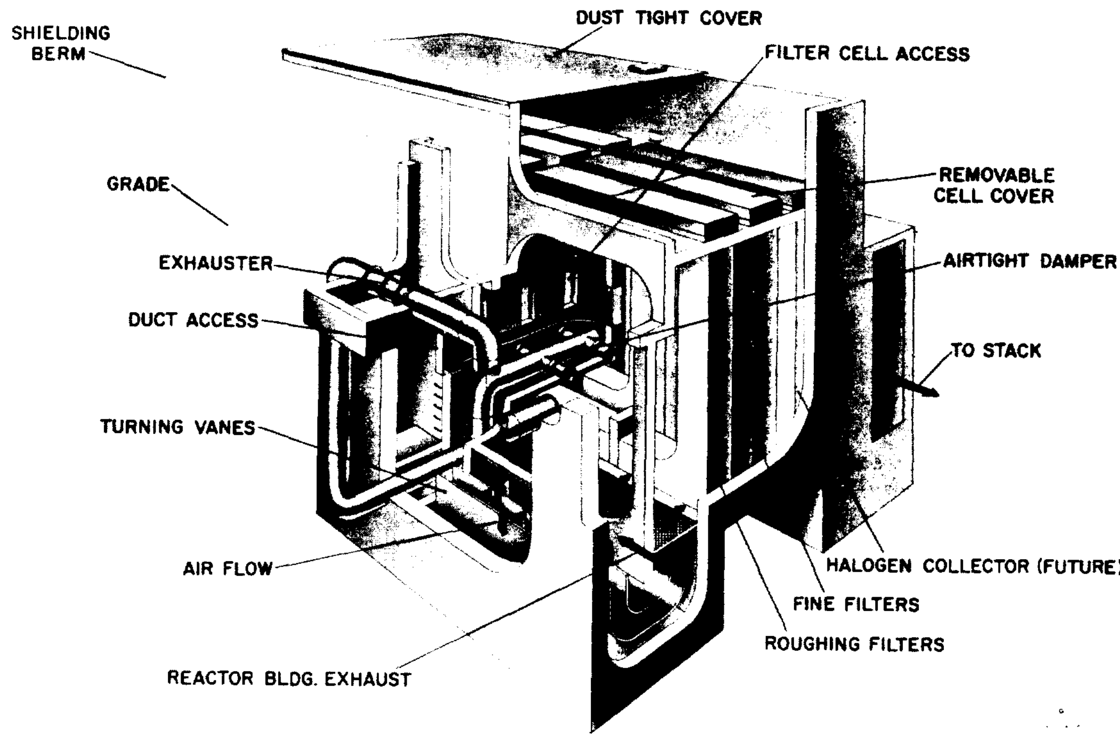

Fig. III—Filter building.

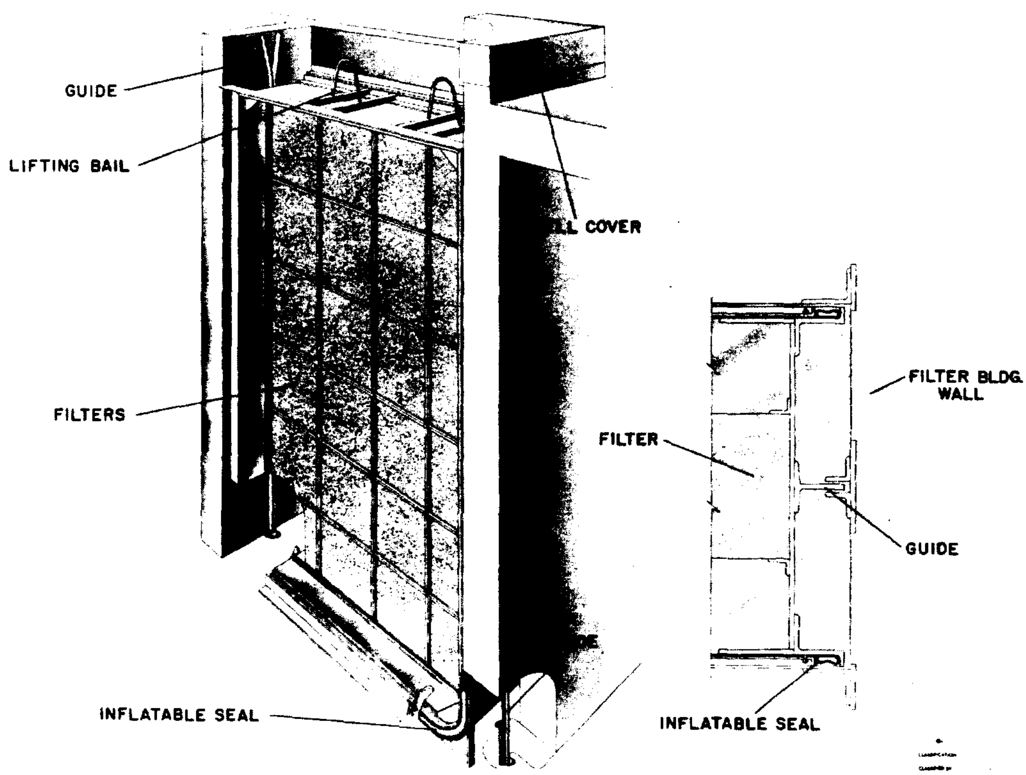

Fig. IV—Typical filter bank arrangement.

course, the incident itself would not dictate immediate replacement of the filters since they are well shielded. However, when the pressure drop through the filters had reached the point that would make continued operation of the ventilation system untenable, the decision must be made as to the relative feasibility of replacing the filters or constructing an entirely new filter building. To provide for this latter eventuality, filter building design has included means for making such an extension and space has been reserved for the possible new building.

The next slide (Figure IV) shows an enlarged isometric detail of the filter frame construction. Individual filters are mounted in the filter frame in a more or less conventional method, utilizing compression gaskets to provide the seal for individual units. Because of the requirement that filter replacement must be affected by semi-remote methods, the filter frame itself utilizes a continuous inflatable seal around the entire periphery of both the upstream and downstream faces. Following placement of the filter bank into the cell, seals will be inflated with instrument air and monitored continuously for leakage.

VENTILATION SYSTEM

Inasmuch as the confinement facilities are being added to an existing building, the criteria for modification of existing fans and system balancing are few:

1. Although there will be no change in normal ventilation flow, the addition of the filtering facilities will increase the static head of the system by about six inches w.g. This change in the system characteristic can generally be accommodated by increasing the speed and horsepower of the fan drives; however, new fans may be required in a few instances.

2. In order to insure that the exhaust ventilation air will, in fact, be "confined" and routed through the filtering facilities, the building ventilation balance must be checked to insure that the static pressure in zones which are potentially subject to gross contaminating incidents is maintained at a level sufficiently below atmospheric. Critical zones will be annunciated so that operating personnel will be immediately aware of any significant change in the ventilation balance.

3. Fan drive reliability must approach that of the reactor cooling system, since the entire confinement facility philosophy is based upon being able to insure that the air will pass through the filters. To this end, the electrical system to the fans is being examined and improved where necessary with automatic emergency fan drive power also being provided.

INSTRUMENTATION

The next slide (Figure V) shows an over-all engineering diagram of the confinement facilities and the associated instrumentation. Starting in the lower left hand corner, you will see the filtered water supply to the rear face fog spray system. Significant loss of pressure in this line will be annunciated as indicated. The fog spray valve is a normally closed valve which requires energization to open. Accordingly, the valve does not open upon loss of power and a manual by-pass valve is provided for this eventuality. Annunciation is provided to indicate flow regardless of how it is initiated.

Moving to the right, the air flow through the rear enclosure is depicted, with a pressure switch provided to annunciate a significant disruption of the ventilation balance.

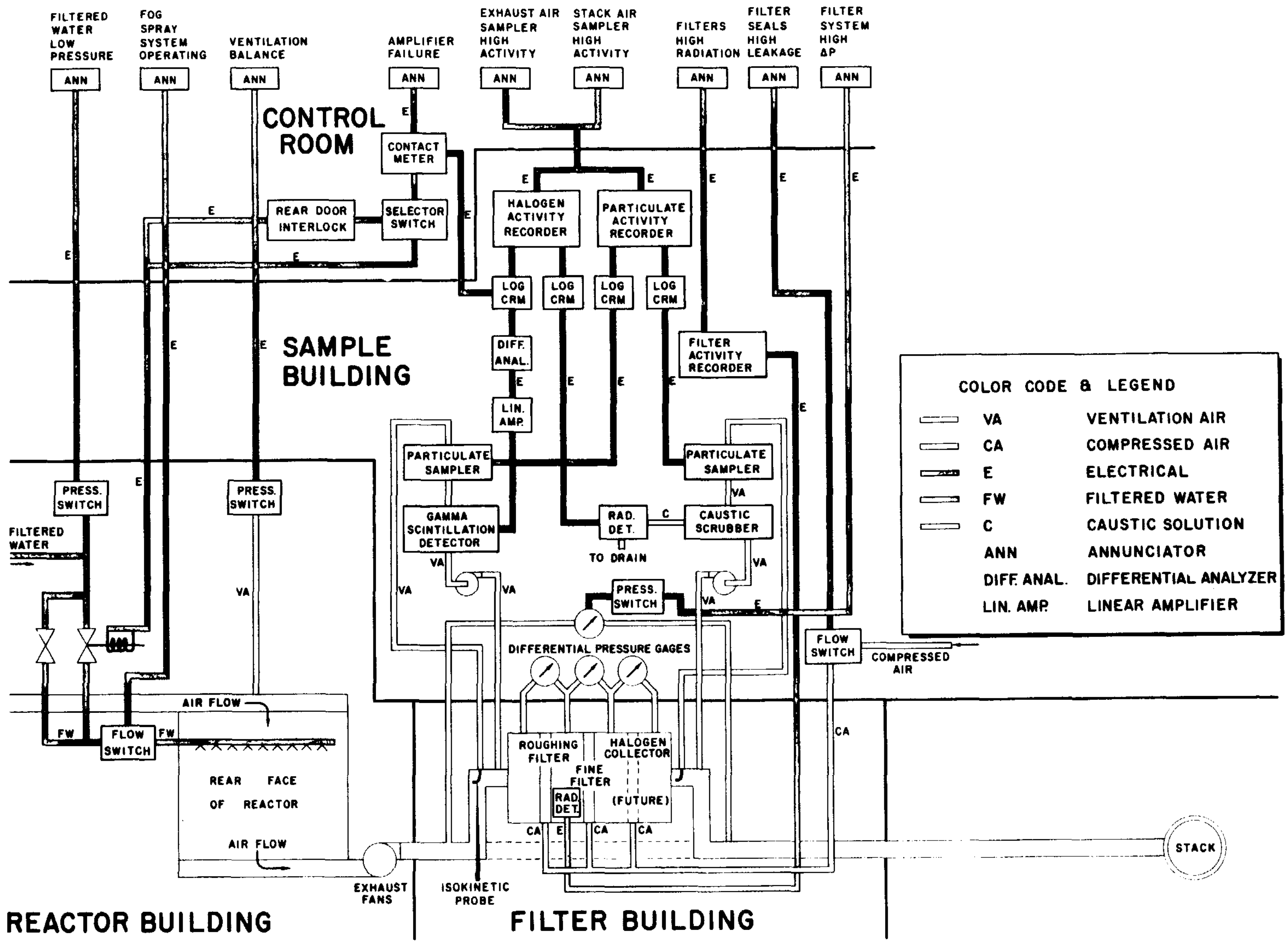

Fig. V — Engineering flow diagram.

After the air leaves the exhaust fans but prior to reaching the filter building, an isokinetic probe is mounted in the duct which draws a continuous sample of the exhaust air. This air sample is routed through a particulate sampler of the strip filter type and then through a gamma scintillation detector before being discharged back into the main airstream. The electrical signal from the two sampling devices is directed to recorders through the use of suitable instrumentation and annunciation is provided for high activity. It will now be seen that the electrical impulse from the gamma scintillation detector also provides the signal to the contact meter and through the selector switch for selected operation of the fog spray system. Failure of electronic components will give a downscale trip of the contact meter which will be annunciated but which will not actuate the spray system.

Within the filter building proper, there are three essential monitoring systems. One of these is a set of differential pressure gauges which are common to all filter installations. An additional feature is an annunciator for high total system drop. This is provided as a more positive method of insuring that filters will be replaced before the ventilation system balance is significantly affected.

Also in the filter building is a radiation detector which allows remote indication and recording of filter activity. Finally, there is a network of air lines to the inflatable seals on the filter frames. Leakage of any individual seal will be accompanied by air flow through the flow switch which is annunciated. By valving, the defective seal can be determined.

Downstream of the filter building, a second isokinetic probe is mounted for the purpose of sampling the air which will be discharged from the stack. This is basically the same system as is used for sampling the air upstream of the filter building with the exception of the caustic scrubber which is utilized instead of the gamma scintillation detector for halogen sampling and recording.

TESTING PROGRAM

The testing program in support of the existing reactor confinement project consists essentially of design tests or tests of specific components rather than development tests in which a component or system is developed from basic criteria. I will mention some of these briefly but will gladly discuss them further during the discussion period as time permits.

1. Rear Face Fog Spray Nozzle Spacing - This test was for the purpose of determining a suitable nozzle type and orientation for adequate spray coverage. Four different nozzles were tested with the final decision to use Rockwood Sprinkler Co. Model L-11A nozzles at a spacing of 10 feet and at an operating pressure of 40-60 psig which gives a total flow of about 400 gpm.

2. Exhaust Air Filter Frame Seal - This test is for the purpose of determining the sealing characteristics of the proposed inflatable filter frame seal. Testing is partially completed and the only significant problem which has been encountered has to do with the quality of the splice in the seal. The seals will be extruded from 50 durometer Hypalon 40 which is rigid enough to prevent effective sealing at low internal pressures unless the splice is fairly smooth. Accordingly, testing is being extended to include additional specimens.

3. Filter Life Tests - These are the tests which will be described by Mr. Wisehart in a few minutes, so for the moment, I will

only mention that the purpose of the tests is to determine the optimum combination of roughing and fine filters for best economic life.

4. Halogen Collector Test Program - This is by far, the most extensive (and expensive) test program being performed as part of the design activities connected with reactor confinement. Basically, the test is merely for the purpose of evaluating the effectiveness of several candidate halogen collectors which have been proven on laboratory scale, but certain complications exist through the use of trace amounts of radioiodine. Both the controlled injection of the tracer and the sampling techniques associated with this test are relatively difficult and, therefore, costly. These tests are just getting underway at the A. D. Little Co., and there are no reportable results as yet. The components being tested are (1) activated charcoal in the configuration of a particulate filter, (2) silver-coated copper mesh, (3) molecular sieve, and (4) the particulate filters themselves.

5. ORNL Irradiated Uranium Burning Tests - Because of the noticeable lack of basic quantitative data regarding the fission product release from various types of reactor incidents, Mr. G. W. Parker has performed several controlled burning experiments. Irradiated HAPO fuel was utilized for these tests and the data obtained is in general agreement with that previously obtained with trace irradiated material except that the burning rate is significantly higher. Since these tests were of a design test nature and confined to selected parameters, a more general program of this nature is now being continued at Hanford.

SUMMARY

As you have noticed, there is nothing particularly unique about any of the components which go to make up the confinement system. Rather, the emphasis has been to arrange the components in a manner which will considerably reduce the environment hazards associated with inadvertent fission product release and to do so in a manner which will have the least possible effect on the continuity of normal production operations. Design of the facilities is essentially complete as of this time and it may be noted that the only problems of significance have been a result of the accelerated program with its associated overlapping of scoping, testing, detail design, and construction rather than matters regarding technical feasibility.

If there are questions or comments of general interest, I will be happy to try to answer them during the discussion period and if someone has questions of a more detailed nature, I will be available at the close of this session. Thank you very much for your attention.

PRELIMINARY REPORT OF ACCELERATED LIFE TESTS ON CERTAIN AIR-CLEANING FILTER MEDIA

D. E. WISEHART
Industrial Hygiene Operation, General Electric Co., Richland, Wash.

A study has been initiated to gain information pertinent to the performance of certain air-cleaning filter media. The purpose of the study is to obtain data on performance of available filter media that will aid in the proper selection of filters for air cleaning purposes. This preliminary report concerns study objectives, test equipment, and certain results that have been obtained to date.

Factors to be considered in selecting air-cleaning filters are filter efficiency, filter life and resistance of the media to humid atmospheres.

The toxicity, concentration and location of the aerosol contaminant will determine the filter efficiency required and to some extent initial and replacement costs as such costs tend to be proportional to filter efficiency. Filter life dictates when replacement is necessary, if the contaminant aerosol is radioactive, replacement may be costly, difficult and hazardous and long filter life becomes extremely desirable. Another factor that determines filter selection is the effect of atmospheres containing large amounts of water vapor or other substances that may weaken the filter media.

The objective of this study then is to gain information that will prompt optimum filter selection with regards to efficiency, filter life and resistance to humid atmospheres.

Obviously the optimum test to determine a filter's performance for a certain situation would be to place the filter in actual operation and observe its efficiency and loading characteristics over a period of months or years. However, in this event, one has been committed to filter selection and may not have installed the optimum unit. Also, low efficiency filters may be used in a location where high efficiency air cleaning is necessary. Thus, for this study, time limitations necessitated some sort of accelerated life tests to provide a means of comparing filter units and combinations of prefilters and absolute filters.

Test Procedure:

The test procedure used consists essentially of first generating a test aerosol and then passing it through a filter media or a combination of filter media and measuring the filter loadings and efficiencies obtained.

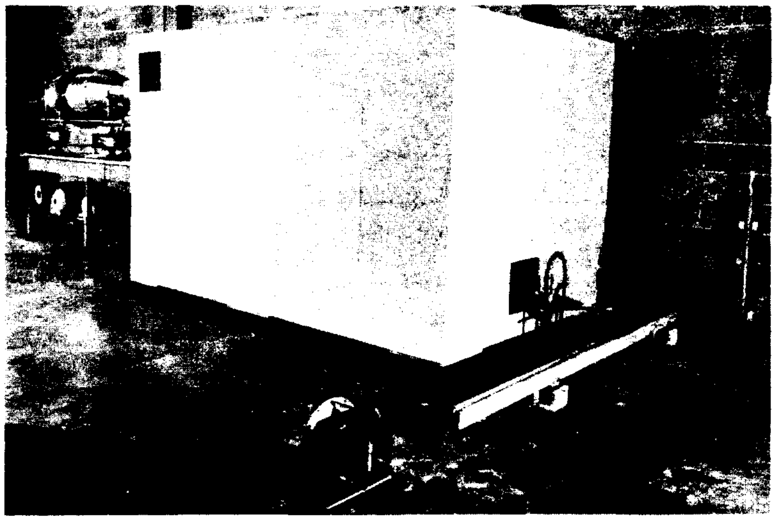

Fig. I—Dust generating apparatus.

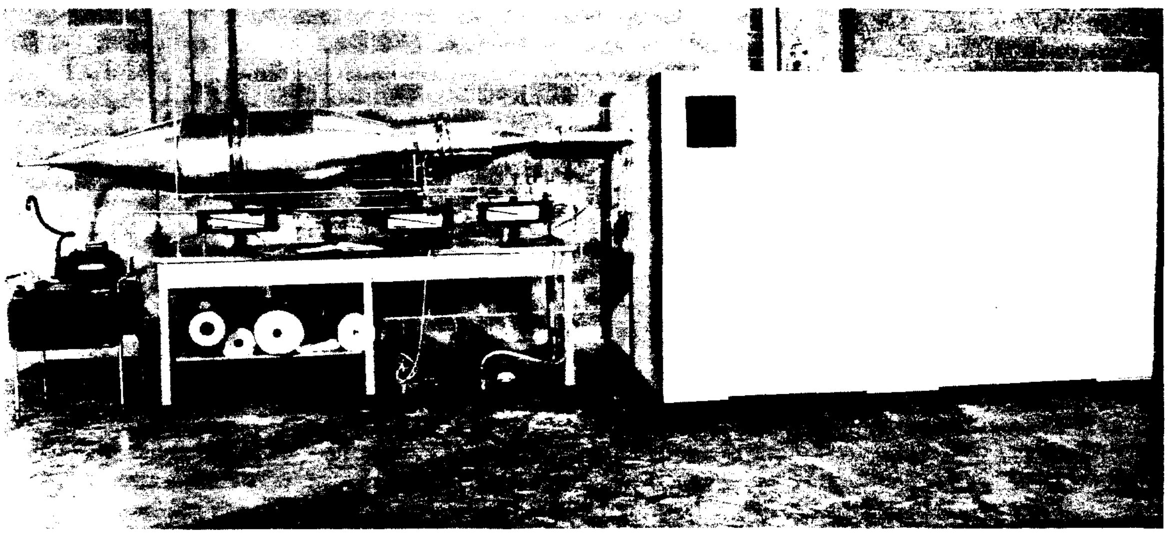

Fig. II—Filter test assembly.

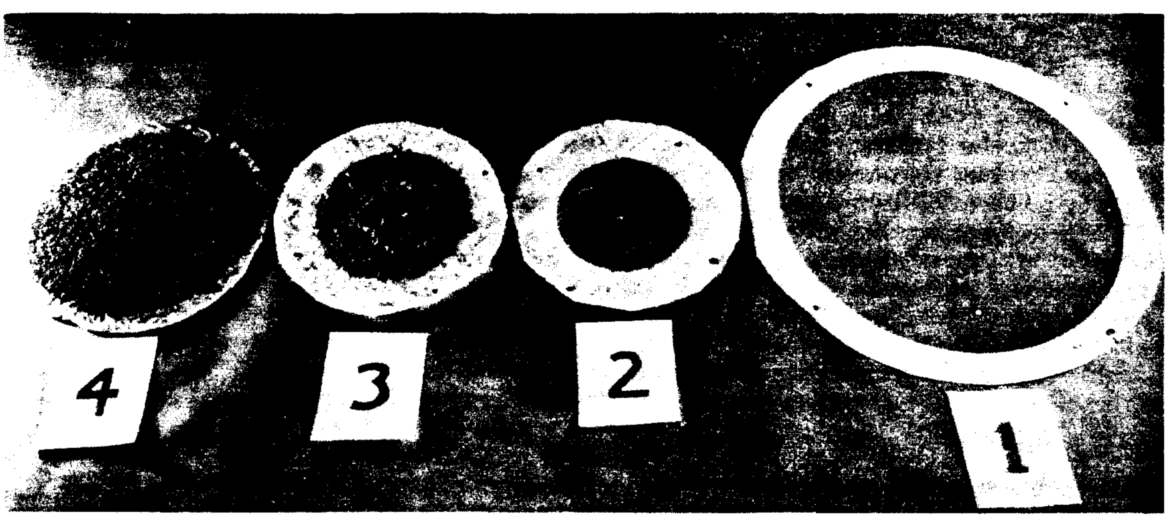

Fig. III—Test media.

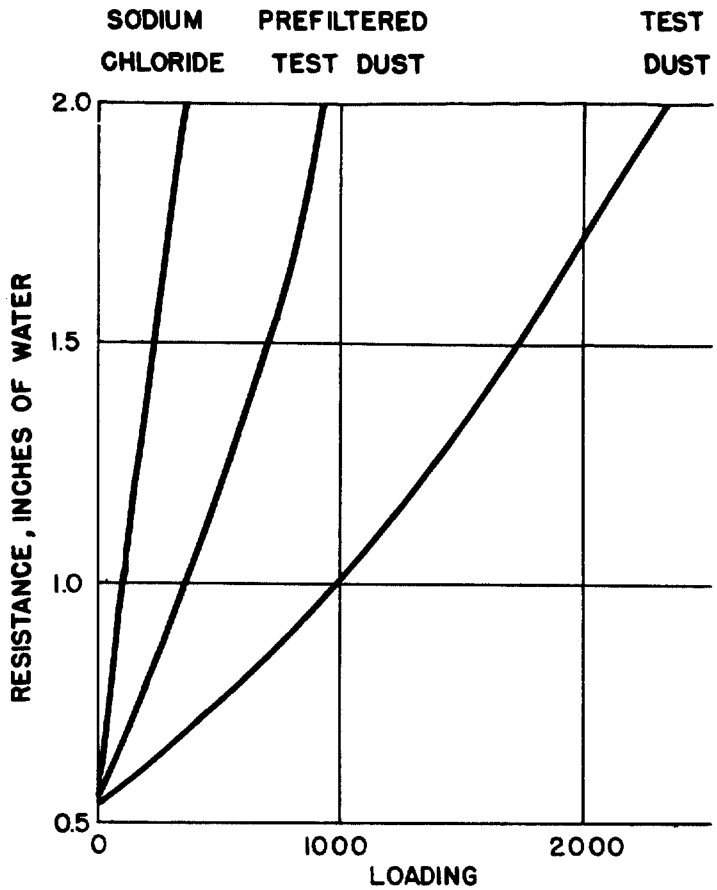

Figure IV

LIFE CURVES FOR AEROSOLVE 35 FILTERS

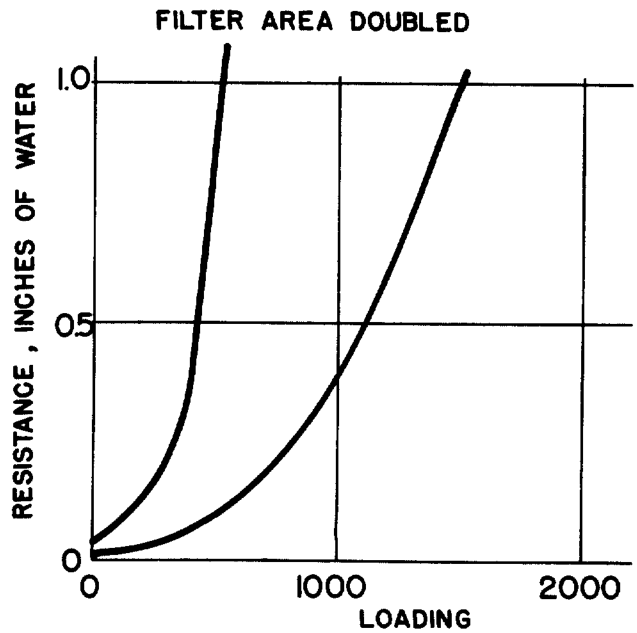

Figure V

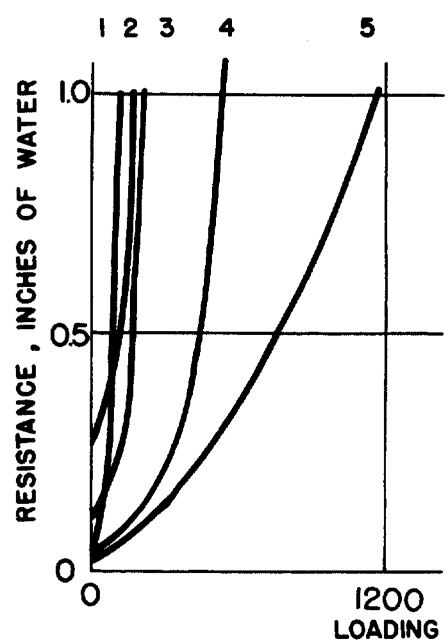

Figure VI

The aerosols used consisted of a test dust, prefiltered test dust and sodium chloride particles. The apparatus used to generate the test dust is shown in Figure I. Attic dust that has been passed through a 65 mesh screen is placed in a trough placed on rollers. The trough is drawn past a clock mechanism at the rate of two feet per hour. Suction is provided by an air ejector which transports the dust into the bottom of the settling chamber which collects slightly more than 99 per cent of the dust. The portion of dust passing through the settling chamber was used as a test dust. The prefiltered test dust used is the effluent dust obtained by passing the test dust through a roughing filter. The sodium chloride aerosol used was generated by vaporizing the salt with a hot nichrome wire coil. Particle size analysis performed of the test aerosols indicated mass mean diameters of 5.5 microns for the test dust, 2 microns for the prefiltered dust and 0.5 microns for the sodium chloride aerosol.

The filter test assembly used is shown in Figure II. It consists of a series of expanded sections for various prefilter and absolute filter media. Actual filtering areas are controlled by placing plate orifices and expanded sections between the flanges. Pressure taps and isokinetic sampling probes are placed upstream and downstream of the flanges. Also, sampling holes are present for obtaining relative humidity measurements. The test apparatus is scaled by a factor of 0.01. Controlled relative humidities are obtained by mixing steam with the influent air of the test assembly.

Test Results

Several types of media that have been loaded with the test dust are shown in Figure III. For the purpose of these tests, prefilter media are loaded to 1 inch of water pressure drop and absolute filter media is loaded to 2 inches of water pressure drop.

The results obtained by loading 5 prefilter media with test dust are shown in Figure IV. The pressure drop is plotted versus relative loading. From a loading standpoint the lifes of the various prefilters vary considerably.

The effect of doubling the filtering area of a prefilter while holding the air flow constant is shown in Figure V. The dust holding capacity is increased by about 2.8. This demonstrates the gain in life-loading by utilizing filter units of greater capacity then indicated by design airflows.

The effect of particle size on the dust holding capacity of ultra filter media is indicated in Figure VI. The capacity for test dust is 2.5 times that for the prefiltered dust and 6.2 times that for the sodium chloride dust.

The purchaser of filters for air cleaning purposes normally does not have adequate information to select the optimum units available from manufacturers for his particular air cleaning problem. Accelerated life tests of the type described in this report should indicate relative lines and efficiencies of filter units available and aid in optimizing selection.

THE T-SONDE, A LOW LEVEL AIR TEMPERATURE MEASURING DEVICE

C. RAY DICKSON and HARRY R. MANSFIELD
United States Weather Bureau, Idaho Falls, Idaho

I. Introduction

A system to study the temperature-height relationship in the atmosphere to heights of 1500-2000 meters above the ground has been proposed. Meteorological towers and tethered blimps have been employed for such studies, but each has its height limitation. The U. S. Weather Bureau radiosonde system which observes pressure and humidity as well as temperature is more elaborate and expensive than is believed required. An economical system employing modified radiosondes and simpler receiving equipment has been tested recently by the Weather Bureau at the National Reactor Testing Station. The purpose of this paper is to describe the system and to discuss its performance.

II. Description and Operation

The T-Sonde system consists essentially of a radio transmitter and thermistor and gound receiving equipment. The transmitter (Signal Corps T69F/AMT-2) consists of the tube 5910 for the relaxation oscillator, the tube JRP-5703 for the radio frequency oscillator, and a single rod antenna. This transmitter emits a frequency modulated signal with a basic frequency of 403 mc. The type of modulation is the relaxation (squegging) oscillator with a dipole, end fed antenna.

The transmitter was modified by removing the external plug and cord and a permanent jumper was put across the "on" switch from the power supply. The precision fixed resistor which was originally in series with the temperature sensing element was removed, and two ML 405 thermistors were placed in series to form the new temperature sensing element. The two thermistors in series increase the total resistance thereby improving the accuracy. Finally, the leads were brought out for connecting to the thermistor and the cover was replaced on the unit.

Equipment at the receiving station includes a radio receiver, an oscilloscope with an elliptical sweep, and a carefully calibrated audio oscillator. The oscilloscope sweep frequency is derived from the audio oscillator, and the T-Sonde subcarrier signal is fed from the receiver to the vertical amplifier of the oscilloscope. In operation, the receiver is tuned to the carrier frequency of 403 mc and the audio oscillator controlling the oscilloscope sweep frequency is adjusted to cause the mark for the T-Sonde subcarrier to stand motionless on the scope's face. Under this condition the T-Sonde subcarrier and audio oscillator frequencies are synchronized. The subcarrier frequency can then be read from the dial of the audio oscillator and referred to the calibration curve for conversion to a temperature reading.

The components of the receiving station are relatively inexpensive. The receiver, a Navy RDO type with a frequency range of 38-1000 mc, was obtained for $75 and the RDJ pulse analyzer and oscilloscope cost $50. The transmitters were obtained from surplus property for $1 each and were modified at a cost of $3 each.

III. Calibration

An antenna was fitted and power was supplied to the transmitter. After a brief period of warm up for stabilization, the carrier frequency was calibrated at 403 mc with the temperature measuring element (ML 405 thermistors) attached. The element was connected to a transmitter and then placed into a calibration medium, which was a quantity of xylene whose temperature can be effectively varied from -20 to 100 C. As the xylene bath was changed through a range of temperature from -18 to 50 C., simultaneous readings both of temperature and transmitted frequency were recorded. Calibration curves were then drawn for specific transmitter-thermistor combinations.

In general a liquid bath can be held to a closer temperature tolerance than an air environment. It allows more power to be dissipated in the thermistor, it has a much higher thermal conductivity which allows more rapid stabilization of test units, and because of its greater thermal inertia, remains closer on temperature after the entrance of a test fixture holding one or more thermistors. A standard kinematic viscosity type thermometer made to American Society of Testing Material specifications was used to obtain the temperature of the test bath.

Since the T-Sonde transmitters are modified standard radiosondes, the resulting error of the T-Sonde should be quite similar to that of the radiosonde whose over-all probable error is $\pm$ 0.5 C. The error due to the lag constant of the thermistor will be reduced with the T-Sonde, because the ascent rate will be reduced to approximately one-third that of the 300 meters per minute ascent of the normal radiosonde. Finally, the error introduced by frequency drift of the oscillator will be minimized with the T-Sonde because of the reduced time of the flight and the limited range of temperature observed.

IV. Vehicle

The T-Sonde package consisting of transmitter, thermistor, and battery pack weighs 15 ounces and can be conveniently carried aloft with a helium filled 100 gram pilot balloon. The battery pack consists of two 45-volt Radio B batteries (miniatures), one $22\frac{1}{2}$ volt

B battery (miniature), six $1\frac{1}{2}$ volt pen light batteries for a total of $112\frac{1}{2}$ volts of B batteries and 9 volts of A batteries with an approximate operating life of 45-60 minutes. Tracking the balloon by the double theodolite method provides means of computing the heights of the balloon at one minute intervals following release and also allows computation of wind direction and speed for given levels. The addition of a standard radiosonde reel, which has had the pendulum increased in length to give a longer period for the string to unwind, and a paper parachute increases the weight of the train to 22 ounces, but provides a means of cut off and recovery without seriously over inflating the 100 gram balloon. The components of one T-Sonde package and flight vehicle are shown in Figure 1.

Fig. 1—Components of the T-Sonde.

The reel is secured to the balloon and the T-Sonde unit is suspended from the parachute. A line from the apex of the parachute is wound on the reel. The length of line wound on the rachet-controlled reel to attain the desired height was determined by experience by varying the inflation of the balloon with a given pay load. The parachute and T-Sonde descend when the line is reeled off to permit eventual recovery of the transmitter, thermistor and parachute. When lead-acid standard radiosonde 6-cell type batteries are substituted, the pay load was increased to 35 ounces. The greater pay load required inflation of the 100 gram balloon to near the burst limit to provide an ascent rate of 100 meters per minute. Hence, for fifteen-minute flights of 1500 meters with the greater pay load, 300 gram balloons are more desirable.

The T-Sonde is essentially an all weather system restricted only by extensive low clouds. The use of a tethered balloon is more seriously restricted by strong winds, which make handling the balloon difficult as well as limiting the height attained.

V. Performance

Examination of the T-Sonde data for the initial flights has been encouraging. Plots of temperature versus height display curves which are as expected for the particular time of day. Figure 2 illustrates the character of the temperature-height curves obtained by the system. The temperature lapse rate shown is that which normally is expected at early morning hours with clear skies in summer months. The nocturnal temperature inversion of the preceding night can be seen from Figure 2. It is the purpose of the program to investigate the height and intensity of such stable atmospheric layers and to relate the temperature distribution to the intensity of turbulence in the boundary layer atmosphere.

The growth of the nocturnal inversion may be seen in Figure 3. The temperature-height curves of this figure illustrate the changing temperature distribution on a clear night resulting from nocturnal terrestrial radiation and turbulent heat exchange within the layer nearest the ground. From midnight to sunrise the layers nearest the ground are cooled as the radiational heat loss continues.

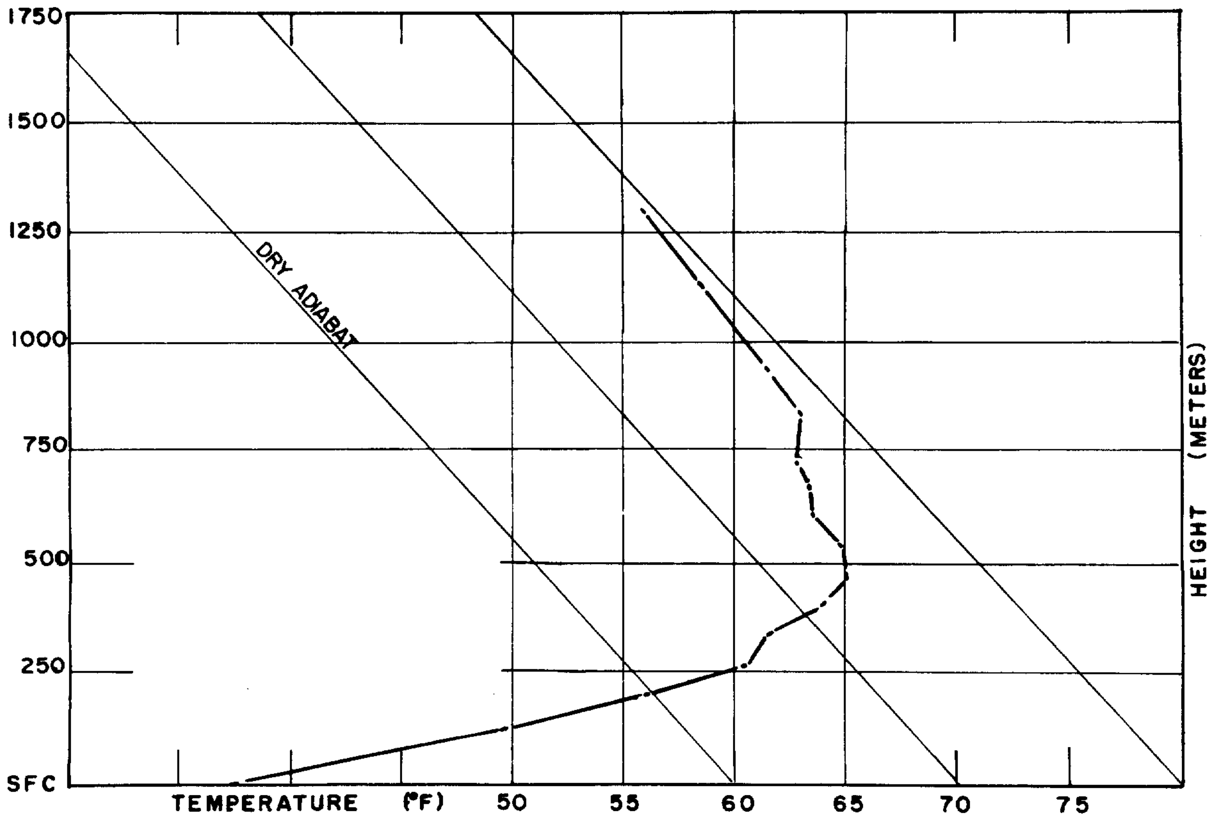

Fig. 2—Details of a nocturnal inversion resulting from a T-sonde flight.

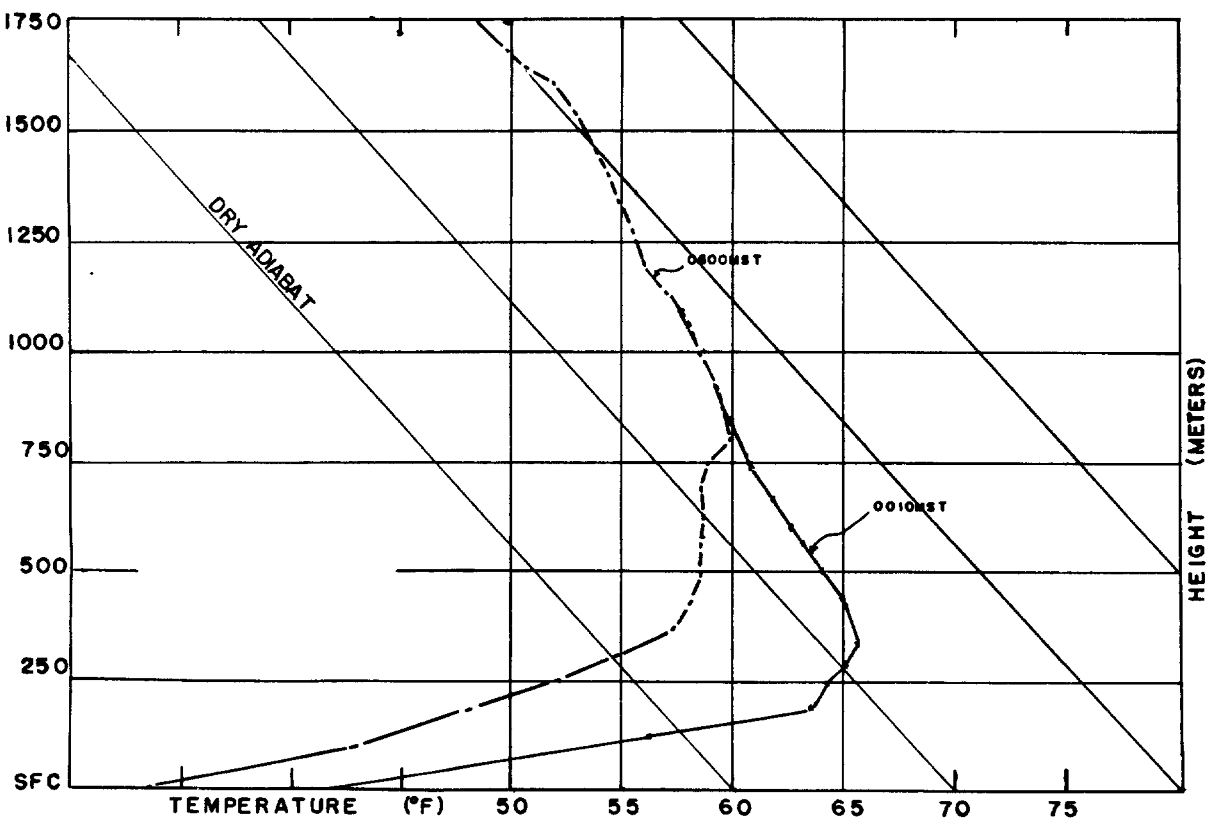

Fig. 3—Growth of a nocturnal inversion.

During this time the height of the top of the inversion increased from 275 to 800 meters. It is apparent that the greatest cooling occurs in the first 250-300 meters; however, sufficient heat loss occurs at higher levels to cause the growth of stable layers to 500-800 meters. Cooling in the region 250-800 meters has been best explained by the mechanism of turbulent heat transfer from the top of the inversion to the ground where it is effectively dissipated by the radiation process.

It is concluded that the system observes the temperature of elevated layers with reasonable accuracy, and that the resulting temperature height curves derived from the soundings for different time of days are consistent with radiation and turbulent phenomena in the lower atmosphere. It then appears that the performance of the system is good to show the complete temperature structure of the lower atmosphere.